The Evolution of Civilian Nuclear Regulation in India: International Nuclear Regulatory Framework, Crisis Learning and Strategic Imperatives

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DECLARATION

I declare that the thesis entitled "**The Evolution of Civilian Nuclear Regulation in India: International Nuclear Regulatory Framework, Crisis Learning and Strategic Imperatives**" submitted by me for the award of the degree of **Doctor of Philosophy** of Jawaharlal Nehru University is my own work. The thesis has not been submitted for any other degree of this University or any other university.

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CERTIFICATE

We recommend that this thesis be placed before the examiners for evaluation.

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To the space which has been most liberating,

where I found 'home'

- *Dedicated to Jawaharlal Nehru University*

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ABBREVIATIONS

ACPSR	:	Advisory Committee for Project Safety Review
AEA	:	Atomic Energy Act
AEET	:	Atomic Energy Establishment Trombay
AERB	:	Atomic Energy Regulatory Board
AEC	:	Atomic Energy Commission
AG	:	Australia Group
AHWR	:	Advanced Heavy Water Reactor
BARC	:	Bhabha Atomic Research Centre
BEFA	:	BARC Facilities Employees Association
BHAVINI	:	Bharatiya Nabhikiya Vidyut Nigam Limited
BoG	:	Board of Governors
BSC	:	BARC Safety Committee
BWR	:	Boiling Water Reactor
CAG	:	Comptroller and Auditor General
CMG	:	Crisis Management Group
CNS	:	Convention on Nuclear Safety
CPPNM	:	Convention on the Physical Protection of Nuclear Material
CSA	:	Comprehensive Safeguards Agreement
CTBT	:	Comprehensive Test Ban Treaty
DAE	:	Department of Atomic Energy
DG	:	Director General
DRP	:	Directorate of Radiation protection
EAC	:	Expert Appraisal Committee
ERC	:	Emergency Response Centre
EPR	:	Emergency preparedness and Response
ESL	:	Environment Survey laboratory
E&R	:	Enrichment & Reprocessing
Euratom	:	European Atomic Energy Community
FBR	:	Fast breeder Reactor
FBTR	:	Fast breeder Test Reactor
FCF	:	Fuel Cycle Facility
FMCT	:	Fissile material Cut-off Treaty

GCNEP	:	Global Centre for Nuclear Energy Partnership
GICNT	:	Global Initiative to Combat Nuclear Terrorism
HBNI	:	Homi Bhabha National Institute
HEU	:	High-Enriched Uranium
HPD	:	Health Physics Division
HPU	:	Health Physics Unit
IAEA	:	International Atomic Energy Agency
INES	:	International Nuclear and Radiological Event Scale
INFCIRC	:	Information Circular
INSAG	:	International Nuclear Safety Advisory Group
INPO	:	Institute of Nuclear Power Operations
IPPAS	:	International Physical Protection Advisory Service
INSServ	:	International Nuclear Security Advisory Service
IPPAS	:	International Physical Protection Advisory Service
IRA	:	Independent Regulatory Agency
IRRS	:	Integrated Regulatory Review Service
ITDB	:	Illicit Trafficking Database
LWR	:	Light Water Reactor
MAPS	:	Madras Atomic Power Station
MEA	:	Ministry of External Affairs
MoEFCC	:	Ministry of Environment, Forest & Climate Change
MoU	:	Memorandum of Understanding
MRDS	:	Mobile Radiation Detection System
MTCR	:	Missiles Technology Control Regime
MWe	:	Megawatt-electrical
MWt	:	Megawatt-electrical
NCA	:	Nuclear Cooperation Agreement
NCPW	:	National Control and Planning Wing
NDMA	:	National Disaster Management Group
NEA	:	Nuclear Energy Agency
NIA	:	National Investigative Agency
NPCIL	:	Nuclear Power Corporation of India Limited
NPP	:	Nuclear Power Plant
NPT	:	Non-Proliferation Treaty

NSG	:	Nuclear suppliers Group
NSRA	:	Nuclear Safety Regulatory Authority
NTI	:	Nuclear Threat initiative
NWS	:	Nuclear Weapon State
NNWS	:	Non-nuclear Weapon State
NODRS	:	National Occupational Dose Registry System
NSS	:	Nuclear Security Summit
OECD	:	Organisation for Economic Co-operation and Development
OPSD	:	Operating Plant Safety Division
OSART	:	Operational Safety Advisory Review Teams
PAC	:	Public Accounts Committee
PDSC	:	Project Design Safety Committee
PFBR	:	Prototype Fast breeder reactor
PHWR	:	Pressurized Heavy Water Reactor
PIL	:	Public Interest Litigation
PM	:	Prime Minister
PMO	:	Prime-minister’s Office
PNE	:	Peaceful Nuclear Explosion
PPED	:	Power Projects Engineering Division
PNRA	:	Pakistan Nuclear Regulatory Authority
PREFER	:	Power Reactor Fuel Reprocessing Plant
PROSPER	:	Peer Review of Operational Safety Performance Experience
PSI	:	Proliferation Security Initiative
PWR	:	Pressurized Water Reactor
RAPS	:	Rajasthan Atomic Power Station
RPR	:	Radiation Protection Rules
RRC	:	Reactor Research Centre
RSD	:	Radiological Safety Division
RSO	:	Radiological Safety Officer
SARCAR	:	Safety Review Committee for Applications of Radiations
SARCOP	:	Safety Review Committee for Operating Plants
SCART	:	Safety Culture Assessment Review Team
SCOMET	:	Special Chemicals, Organisms, Materials, Equipment and Technologies

SEC	:	Site Evaluation Committee
SORC	:	Station Operation Review Committee
SRC	:	Safety Review Committee
SRI	:	safety research Institute
SSAC	:	State System of Accounting and Control
SSC	:	Site Selection Committee
TAPS	:	Tarapur Atomic Power Station
TIFR	:	Tata Institute of Fundamental Research
TMI	:	Three Mile Island
TSO	:	Technical Support Organizations
UAPA	:	Unlawful Activities Prevention Act
UGC	:	University Grants Commission
UK	:	United Kingdom
UN	:	United Nations
UNAEC	:	United Nations Atomic Energy Commission
UNGA	:	United Nations General Assembly
UNODC	:	United Nations Office of Drugs and Crime
UNSCR	:	United Nations Security Council Resolution
USA	:	United States of America
USSR	:	Union of Soviet Socialist Republic
WANO	:	World Association of Nuclear Operators
WMD	:	Weapons of Mass Destruction

Chapter: 1

Introduction

"The voyage of discovery lies not in seeking new horizons but in looking with new eyes"

- Marcel Proust (The Prisoner 1923)

Production of nuclear energy is an economic task and therefore like any other business enterprise is susceptible to the desire for increasing profit margins. Cost considerations sometimes cause deliberate or inadvertent compromises in the safety credentials of units engaged in the arduous task. The highly technical nature of nuclear science and technology demands good theoretical and practical knowledge and skills to run the industry safely and effectively. Though the advancement in scientific knowledge in the field have generated numerous patterns and guidelines for safe operations, research is still evolving in different kinds of reactor technology, making the experimental operations specifically, more susceptible to accidents. At the same time, the possibilities of human error and negligence, howsoever remote, cannot be over-ruled completely. Nuclear technology, because of its dual use nature and serious radioactive implications for lives in case of accidents, remains one of the most heavily guarded areas. In order to ensure crisis-proof operations of nuclear industry, there is a universal recognition of the need for an autonomous regulatory body that can effectively monitor and regulate the safety rules compliance by producers and operators of nuclear energy. Regulation as a concept implies an administrative set up which privileges and accords more disciplinary power to a regulatory body over its regulated clientele, be it a public or a private institution. It involves the relation of a power hierarchy between the two parties with respect to each other. The ways and mechanisms of ensuring regulation, however, differ widely depending on a multitude of factors, namely public-private status, constitutional status of regulatory body, degree of autonomy etc. to name a few.

The objective of this thesis is to study the evolving institutional structure and mechanisms in the field of civilian nuclear regulation in India. Situated at the intersection of nuclear politics and organisational studies, this thesis looks at factors which impinge upon the autonomy of India's civilian nuclear regulatory body and evaluates it within the broader conceptual parameters laid down in the international domain. It proposes to re-visit the nuclear regulatory discourse in India in a holistic manner through institutional analysis, focusing on structural transformations catering to the authority relations, power allocation and formalization achieved by the regulatory body. It will include the regulatory practices and mechanisms that evolved since the beginning of nuclear energy programme in India i.e. the latter half of 1940s to present.

This thesis is an attempt to study the structure, direction, causality, mechanisms and rationale associated with the evolution of the Indian nuclear regulatory body as an organisation integrated and placed within the broader institutional structure of nuclear establishment. Regulation as an institution in itself has undergone specific modifications with respect to nuclear discourse and its organisational manifestation in the form of the Atomic Energy Regulatory Board (AERB) therefore represents just one of the junctures, albeit an immensely one of the most important one, in civilian nuclear regulatory evolution. To understand it, this study has undertaken an analysis of the historical evolution of nuclear regulation in India, which precedes the establishment of the AERB, and extends beyond it. An institutional understanding of the AERB and corresponding implications will be analysed- both in terms of enabling organisational structures and organisation culture sociology that inform and shape the nuclear institutions, including the regulatory body.

The central puzzle addressed in this work is this: despite a long history of civilian nuclear operations in India, why has India not developed an independent regulatory body to review its civilian nuclear facilities? In essence, this thesis discusses factors underlining change as well as resistance to change in the Indian nuclear regulatory framework since the inception of Indian nuclear energy programme.

Additionally, the thesis is driven by the following questions:

1. What are the mechanisms of civilian nuclear regulation in India?
2. What role do international treaties and conventions play in regulating India's civilian nuclear programme?
3. What factors/ reasons explain Indian non-compliance with some of the instruments of international nuclear regulatory mechanisms?
4. What has been the nature of evolution of civilian nuclear regulation in India?

5. In what ways the pursuit of nuclear weapon programme contributed positively or adversely to the nature and expansion of civilian nuclear energy programme in India?

Before explaining the structural plan of the thesis, this chapter would first discuss the concepts associated with regulation. While all the other chapters deal specifically with civilian nuclear regulation in the Indian context (along with international one), this chapter will provide the theoretical and conceptual premise, analytical tools and working definitions to help analyse the nature, form and functional characteristics of the Indian nuclear regulatory regime.

For the sake of analytical clarity, this chapter is divided into four major sections. The first section will discuss the conceptual underpinnings of the term ‘regulation’. It would also discuss concepts, tools, mechanisms and standard practices prevalent in the theory and practice of regulation. The second section will deal with civilian nuclear regulation specifically. The third section, in order to introduce the central theme of analysis, will utilize the tools and concepts from the first two sections to reflect upon the nature of AERB. The fourth section will discuss the rational, definition, scope and structure of the thesis.

1.1. Regulation: Conceptual Understanding

This section intends to analyse the concept of regulation and to discuss the viable practices, mechanisms, and norms that are accepted as regulatory in nature. It also discusses major arguments and debates that characterize regulatory regimes in terms of their structures, roles and effectiveness. This section is further divided into the following sub-sections in order to chart out the nature of debates in regulatory field, with each section reflecting major points of contention among scholars in this field:

1) Concept of ‘regulation’

2) Regulatory practices and modalities

3) Self-regulation: a form of regulation

4) Phenomenon of Regulatory capture

5) Independent Regulatory Commissions: Administrative Structures

6) Public-Private divide in the conceptual understanding of 'regulation'

Conceptual Premises of the Term Regulation

Conceptual literature on 'regulation' spans across many disciplines like economics, sociology, administrative sciences etc. There is no definite consensus on one particular definition of regulation and the concept itself has evolved over a period of time depending on the socio-economic environment and disciplinary setting in which it evolved. The literature review here covers the different normative and conceptual understanding of the term and the associated debates.

The notion of regulation has primarily been borrowed from economics where it meant to provide a solution to the state vs. market dichotomy. The roots of the concept of regulation can be traced to the Laissez faire conception of the state, popular in the 19th century where the dominant logic of capitalism forced a system of organisation which favoured relative autonomy of market from the state.

However, state would be essential to secure the atmosphere for a fair competition through standard business practices, to regiment property rights and create confidence in the fairness of economic rules. A "vibrant capitalism is dependent upon, and even constituted by, sensible regulation" (Balleisen and Moss 2009: 7). Regulation is also a constitutive element of the market helping in constitution of property rights (North 1990) and even as a source of competitiveness (Porter 1991). So, while on one hand, state would be instrumental in providing law and order without which market cannot function and on the other hand, it would be required to lend support with institutionalization of market rules and behaviour. Also, a fear of market failure too drove the need for certain kind of regulation of market by the state. This transformation marked the shift form a free market state economy to what is known as a 'welfare' state or a 'providing' state, more popular since the mid to late 20th century (Bartle & Vass: 2005, Braithwaite 2006).

Regulation hints to a situation or a possibility of situation of market failure which was understood as enough justification for state intervention in the decades of 1950s, 60s and even 70s in U.S. (Balleisen and Moss 2009). Need for regulation has often been justified on following accounts:

a) market failure (inefficient market due to factors like asymmetry of information, irrational actor and so on) (Stiglitz 2009b).

b) distributive justice (Stiglitz 2009a)

c) environmental and equity challenges in a society (OECD 2012: 20).

The focus of regulation also expanded to include distributional outcomes and democratic aspirations apart from economic efficiency (Balleisen and Moss 2009, Stiglitz 2009, Carpenter 2009). It also led to a broadening of understanding with respect to the formal and informal actors who could be associated with regulation. System of Government regulators and business as regulated clientele gave way to inclusion of a range of third parties like industry association, NGOs, self-regulatory mechanisms and even the press (Balleisen and Moss 2009). This diversity in regulatory groups required diversification of regulatory practices too (discussed later in the section on regulatory practices and modalities).

Regulation is conceived as "a form of intervention seeking to enforce, constrain, shape or simply guide practices of one kind or another" (Krawchenko 2012: 1). Selznick defines regulation as "sustained and focused control excised by a public agency over activities that are socially-valued" (Scott 2006: 653).

Black (2012: 9) posits "regulation is the sustained and focused attempt to alter the behaviour of others according to defined standards or purposes with the intention of producing a broadly identified outcome or outcomes, which may involve mechanisms of standard setting, information-gathering and behaviour modification". To understand a regulatory process, Fainsod (1940) argues that one needs to understand the interaction at three levels: the conditioning factors which shape the context of regulation, associated parties involved in regulation and the mechanisms of regulatory control like political instruments.

While the debates on need, nature and degree of regulation in political economy remains contested, there are other disciplinary understandings of the term as well. For example, in sociological studies, 'regulation' as a social tool has been considered by Scott as one of the components of institutions as opposed to the two other components namely, cognitive and normative. He argues, "Institutions consist of cognitive, normative, and regulative structures and activities that provide stability and meaning to social behaviour. Institutions are transported by various carriers – cultures, structures, and routines – and they operate at multiple levels of jurisdiction” (Scott 1995: 33). Regulative processes such as rule setting, monitoring, and sanctioning activities can have both formal written rules as well as informal, unwritten codes of conduct. Institutions are mainly seen as regulations, which act as constraints on individual activity. Also, there is an emerging literature on regulation as an administrative concept which keeps social and/or economic regulation as objective and enumerates on practices, mechanisms and tools that determine the effectiveness of regulation in specific contexts. As a legal instrument, it is considered as a tool of governance especially by legal scholars. Regulation can take form of legislation which is enforceable by courts or be laid down by administrative bodies constituted for the same. Minogue (2005: 200) presents a rudimentary disciplinary understanding of the concept of regulation:

Command and control regulation	Rules and institutions	Institutions and Policy Process	Social Processes and Social Interests
Narrow..........			..........Broad
Economists	Lawyers	Political Scientists	Social scientists

Figure- 1.1. Regulatory Spectrum

Source: Minogue, M. (2005), “Apples and Oranges: Problems in the Analysis of Comparative Governance”, The Quarterly Review of Economics and Finance (45)

As the diagram shows, the concept of regulation assumes more informal, tacit and broad interpretations as it moves from left to right on the spectrum above. However, as the focus of this thesis pertains primarily to civilian nuclear regulation in India, this chapter will focus on ‘regulation’ in a more administrative and legalistic sense. Rest of the conceptual section, therefore, will discuss the major debates that pertain to nature, practices, models and tools of regulatory bodies. Though these debates reflect administrative structuring and organisation of regulatory bodies, they have developed through an interaction among different disciplinary understandings of the concept of regulation.

Overall, the purpose of regulation essentially is to boost public confidence in working of the system. Initially, regulation was conceived primarily in an economic sense where government deliberated on the ways, need and nature of regulatory conditions to be imposed on market involving private business interests. However, later it expanded to cover regulation of government enterprises as well where needs for efficiency, transparency and accountability were no less pertinent (public-private distinction in matters of regulation will be discussed in a later sub-section). With an increased need for state interference in the matters of safety, health, labour and environmental domains, the debates have been vigorous on the questions of modes and viability of regulatory practices. These domains widely seen as 'social', as opposed to 'economic' regulation have led to an increasing research in devising new and specific regulatory practices for them to be effective. Regulation is termed "economic when it deals with price, entry, exit, and service of an industry, while it is termed "social" when it concerns non-economic issues such as health and safety (Meier 1985 quoted in Gilardi 2005:140).

Understandings of regulation as they emerged in the political economy domain are distinct and varied.[1] Excessive regulation and command and control model of regulation have come under increasing questioning with the onslaught of neo-liberal ideology. This has given a boost to demands for what is known as 'deregulation' or 'self-regulation' which is the subject matter of next sub-section.

Is Self- Regulation a Mode of Regulation?

This section will discuss major arguments related to inclusion of 'self-regulation' as a type of regulatory mechanism.

Traditionally, role of the state has been central to the process of regulation. One finds an increasing discussion on effectiveness of command-and-control government regulation in preventing market failure as policy makers themselves are susceptible to interest groups politics, corruption and incompetence (Stiglitz 2009a, Braithwaite 1982, OECD 1995) in the 1970s (especially in the West). Bureaucratic 'Command and control' mode has been discredited by many economists especially in the favour of decentralized decision-making (Schultze 1977, Moran 2001).

At the same time, problems like regulatory overload, increasing adoption of neo-liberal ideology and resistance from multi-national firms in an increasingly globalized world have undermined the popularity of command and control type government regulation

[1]The term regulation is hard to define not only because it means different meanings to different people but also because its meaning has changed over a period of time and while new characteristics have been pointed out, the old ones have not lost their significance. The term also means different things as per political orientation (Ayres and Braithwaite 1992: 158). For example, for the free market advocates, regulation implies interventionist and authoritarian hand of the state that stifles free market advances and constrains people's liberties. In a leftist sense, it means a domination of the elite primarily economic elite in a rule based orderly manner that subtly perpetuates class distinction. Marxist understanding, in fact, goes beyond the legalistic-statist understanding and through a structural analysis reflects that regulation is neither wholly deliberate nor automatic (Krawchenko 2012).

(Gunningham and Rees 1997). All these factors have given a boost to drives for deregulation as well as private governance involving self-regulation (Balleisen 2009, Michael 1995). This, however, does not mean that before 1970s, self-regulatory mechanisms did not exist.

A disenchantment with government regulation and move towards deregulation has been witnessed in the form of proliferation of several self-governing mechanisms in private sector (Balleisen 2009). 'Ethics and Compliance' departments within corporations, internal corporate regulators addressing environmental degradation, food contaminations and such activities are examples of such governance. Such self-regulation has been termed as 'Management regulation' too (Coglianese and Lazer 2003). These involve mechanisms like naming and shaming, expelling violators from industry associations, imposition of fines and so on if firms do not comply with their broad responsibilities (Garvin 1983). Governments, too, in order to promote entrepreneur economy based on self-responsibility and choice have favoured self-regulation as one of the underpinning of deregulation (Russell and Brannan 2016, Du Gay and Salaman 1992).

However, the discourse of 'self-regulation' too requires a sanction or support or even threat of the regulatory state/ general law (Gunningham and Rees 1997). So, in a way, even self-regulation can be thought of as one of the 'instruments' that can be deployed by the regulatory state (Bartle &Vass 2005). Self-regulation typologies broadly, among others, include

a) Delegated regulation- where state delegates the detailed implementation and achievements of regulatory functions to the industries and private bodies (Vass and Bartle 2005- they posit a few more types, discussed shortly).

b) De-regulation- broadly defined as "those initiatives that seek to repeal or diminish regulatory requirements in various regulated communities, or to diminish the capacity of government agencies to develop, administer and enforce regulatory programs" (Swenarchuk and Muldoon 1996: 2).

c) Co-regulation - implies regulation by both private and state actors, is also included as a type of self-regulation (Heesen-Lacle and Meuwese 2007).

Another concept that has gained popularity with the decline of command and control regulation of the government is that of ‘responsive regulation’ which basically opposes ‘one size fits all’ approach of regulation (Nonet and Selznick 1978, Ayres and Braithwaite 1992). It argues that different industry structures have different degree and sense of morality, responsibility and institutionalization and therefore a regulatory policy should be “responsive to industry structure” and shaped accordingly (Ayres and Braithwaite 1992: 4).

Self-regulation is traditionally and single dimensionally conceived as a point on spectrum between no regulation and standard statutory regulation (Bartle and Vass 2005).

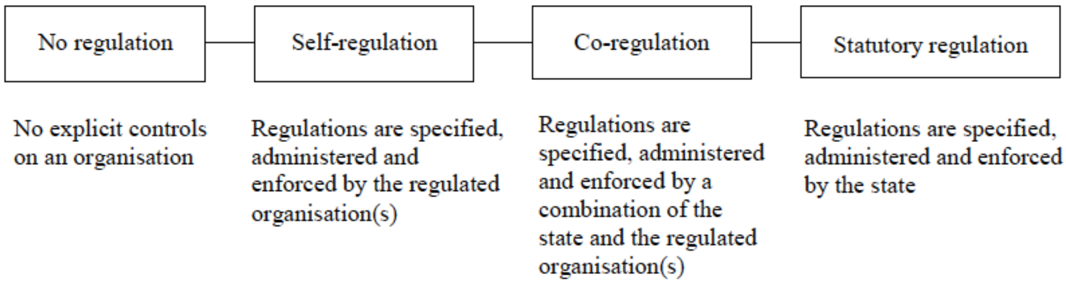

Figure- 1.2. Major Types of Regulation

Source: Self-regulation and the Regulatory State-A Survey of Policy and Practice, University of BATH, Ian Bartle and Peter Vass 2005: 1

Bartle and Vass (2005) specify five categories of self-regulation:

1) Co-operative: co-operation between regulator and regulated on the operation of statutory regulation.

2) Delegated: the delegation of the implementation of statutory regulation by a public authority to self-regulatory bodies.

3) Devolved: the devolution of statutory powers to self-regulatory bodies, often thought of as ‘statutory self-regulation’, i.e. the specification of self-regulatory schemes in statute.

4) Facilitated: self-regulation explicitly supported by the state in some way but where the scheme itself is not backed by statute.

5) Tacit: close to ‘pure’ self-regulation. There is little explicit state support, but the state’s implicit role can be influential (Bartle and Vass (2005: 2)

It is important to note here that the role of the state is legally defined and central in the first three categories.

Generally, regulation involves some sort of delegation as regulatory agencies often need to deal with complex technical issues. Such delegation, however, raises concerns about democratic rule-making and accountability, given the phenomenon of regulatory capture (discussed in a later sub-section). Self-regulation has also been criticized as misguided attempts at public goals, for being anti-democratic, for being used as a strategy to evade public accountability and stringent government regulation, and even as a mechanism to protect one's own business against potential competitors (Belleisen 2009).

Ian Ayres and John Braithwaite (1992: 6), while deliberating on the merits of self-regulation and command-and-control regulation, propose 'enforced self-regulation' as a creative middle option. It requires regulated organisations to establish a machinery for comprehensive internal review, while the external regulator can operate only at the top ladder of the bureaucratic pyramid. The firms then would devise their own rules which would be publicly ratified. As far as enforcement is concerned, firms should do it on their own but in case of failure, the rules will be publicly enforced. However, they also caution that such a strategy should not be judged as optimal kind of regulation without taking historical, legal, constitutional and cultural context of such an invocation (Ayres and Braithwaite 1992: 101).

Regulatory Practices and Modalities

This section will discuss the empirical manifestation of regulation in form of practices that are widely accepted as 'regulatory' in nature. Regulatory practices vary along many dimensions including composition, criteria of independence of regulatory bodies from their regulated clientele, separation of regulatory and other management functions like funding, policy advising etc., formality and legality of regulatory bodies and extent of viable regulatory mandates in different fields.

Regulatory mechanisms, can take various forms: "information (disclosure) requirements, proscriptions (things firms may not do), or mandates (things firms must do)" (Stiglitz 2009a: 8). Taxation, civil liability for tort, prohibition of particular goods or services, rule-making and inspection regimes, delegated regulatory over-sight, self-regulation and so on also constitute regulatory mechanisms (Balleisen and Moss 2009).

They can also include being "official whistle-blower, stirring public debates on lapses or problems, role of 'terminator' (able to close down a failing organisation), impose financial charges and disqualifications from office" (Hood et al. 1999: 9), formal censures of individuals or organisations, carrying out initial stages of litigations, naming and shaming, affecting budgetary allocations, moral suasions or even simply chartering public debates on certain issues etc.

This range of methods adopted by regulators can vary. These can include attempts at persuasion, efforts to re-educate, scare or even "throwing the book" at non-compliant regulatee (Hood and Scott 2000). Health and safety commission (n.d.) in UK enlists its regulatory methods to include partnership with interested parties, motivating senior managers, (motivating higher ups in) supply chain, design and supply, sector and industry-wide initiatives, working with those at risks, education and awareness, inspections and enforcement, intermediaries, encouraging best practices, recognising good performance, investigation of complaints and issues raised.

Hood *et al.* (1999: 10) caution that one should specify the beginning and end of what is perceived by regulation. They argue against including the direct 'chain of command' management relationships and the controls available to chief executive or internal audit or review unless conducted by an outside organisation. On the other hand, informal opinions or purely advice-giving exercises too are not considered as regulation (Hood and Scott 1996), though it may constitute the context in which regulation operates. However, the border between regulation and advice is not free of problems in this context. There is also the problem of delineating what constitutes internal and external regulations in certain situations, for example, when the executive officer welcomes arms' length regulators in order to gear up the staff for better performance and standard setting. Laughlin and Broadbent (1998: 428) cite the examples of head teachers in schools who would look forward to an outside inspection to 'pull staff up'.

A related issue then is the composition of regulatory agencies i.e. how close the 'regulators' should be to the 'regulated'. In certain sectors the regulators are picked from the same professional-social background as the regulated clients like in the nuclear field. So, the gamekeepers and poachers are from the same group and their roles might be reversed over their working life times (Hood *et al.* 1999: 11). While some scholars see this as a factor for effective regulation as regulators coming from the same professional field as regulatee would "talk the same language and know where the bodies are buried" (Hood and Scott 2000: 8). On the other hand, some hold that strict separation between the two is better for effective regulation. Black's theory of 'relational distance' i.e. the social distance between the regulated body and the regulator (1976)- proposes that the "closer the regulator is to the regulatee in social or professional terms, the more informal and sympathetic will be the behaviour of the former towards the latter" (Hood and Scott 2000: 10). This may cause the problem of 'revolving door policy' (will be discussed later in this chapter). However, in certain other sectors and especially in recent years, this principle was opposed, with reactions against "cosy inbred professional communities" inside public services such as education" etc. (Hood 1999: 7). Hood *et al.* in their study on British regulatory systems in different governmental sectors found that in many cases (there were exceptions too) "the more distant such regulators were from their 'clients' in professional-social backgrounds, the more regulatory they tended to be in the sense of more formal and more rule bound" (Hood et al. 1999: 8). There is also a general opinion that regulators are more independent in economic than social regulation.

There are also wide debates on whether the commissions should be multi membered or single headed and on relative distribution of power and functions within the commission (Robinson 1971). Regulatory agencies are in many forms and sizes. Some are commission modelled i.e. a group of coequal heads who make decisions by voting on formal proposals much like legislatures or are headed by a single administrative head (Noll 1985). While some have judicial powers and act as the first courts of arbitration, others do not have it and for arbitration move to regular courts established by the statutes. Some have very narrow responsibilities as they deal with a particular industry while others have wider mandates spanning across sectors.

The Phenomenon of Regulatory Capture

This section will address one of the debates in the realm of regulation pertaining to the phenomenon of 'regulatory capture' which is seen as 'failure' or 'death' of a regulatory body (according to life-cycle theories of organisational change discussed in detail in the fourth chapter), indicating regulatory failure arising out of undue influence from the regulatee.[2]

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[2]Regulatory capture, especially in recent decades, has been often cited as a problem ailing nuclear regulation in general.

Regulatory capture as a concept is used to describe a phenomenon where "… a particular sector of the industry, subject to the regulatory regime, has acquired persistent influence disproportionate to the balance of interests envisaged when the regulatory system was established." (Baxter 2011: 176). In such cases, a regulatory agency is dominated by vested interests of the regulated party, affecting wider public interests adversely. Regulated industry exerts a disproportionate influence over policy making and/or execution. It has become a common vice affecting modern day regulation (Moss and Oye 2009). In terms of susceptibility to regulatory capture, some scholars have argued that "A regulatory commission that regulates a single group with convergent interests may have great difficulty withstanding the constant pressure to bend regulations to the benefit of the group rather than the public" (Warren 2009: 16).

There are various means by which regulatory capture can occur like dominant business lobbies, ideology of administrators/ legislators, funding issues especially with proliferating responsibilities causing further strains, self-interests of actors, procedural obstacles, 'revolving door problem' (post-retirement opportunities from industry can cause imperatives for favourable relations while in service) (Shapiro 2012), 'rule making ossification' (Pierce 1996), information capture (Shapiro 2012; Levine 1990), asymmetry in representation of various groups (Latin 1991), 'dis-positionalism (public apathy viewing agency actors as self-interested and biased leading to trust deficit) ultimately leading to 'deep capture'(Hanson & Yosi 2003: 129) etc.

Avoiding regulatory capture or regulatory 'failures' requires an art of designing these bodies in a manner which is less prone to be captured or abused. Also, a higher degree of transparency and mechanisms of multiple oversight reduces the scope of regulatory capture. Stiglitz (2009a) argues that multiple mechanisms of oversight are preferable over a unified regulatory structure for a more evolved and complex environment with higher risks of regulatory capture than conventional simplistic model. Cost of regulatory failure often are lower than cost of duplication (overlapping objectives of multiple regulatory bodies). Critics, however have contested this and argued that fault lines among regulators have major downsides for effective regulation (Warren 2009).

Baxter (2011) cautions that just because the result (of a regulatory policy) is supported by a powerful and organised group, it does not necessarily translate into a wrong-doing. Also, it is difficult to establish in cases where there is no clear cut pervasive picture of dominating interests being transformed into policy measures. And the definition of regulatory capture in terms of being harmful to public interests is also then open to dubious interpretations as even the term ‘public interest’ is not clear and precise (Shapiro 2012).

Independent Regulatory Agencies (IRAs): Administrative Structures

As debates on regulation focussed on the nature and limits of state (government) intervention in ensuring effective functioning of the market, great amount of thought went in conceptualizing viable administrative structures to carry out regulatory functions in an autonomous manner. Such structures were supposed to be independent so as to regulate private actors while ensuring that regulator itself remained impervious to undue influences from industry and other interest groups. This section will discuss the evolution of IRAs in American context which became a forerunner to proliferation of similar regulatory bodies in other countries.

IRAs came into being since the progressive movement and the New Deal period in the U.S.A. when government felt the need to dissociate economic reform measures from the onslaught of political pressure. It was to institute a certain professional, specialized and neutral, administrative mechanisms that could operate unaffected by the sectarian party interests and political pressures in the domain of business regulation. However, since 1960s the American IRAs innovatively expanded into the social regulation sector as well, supervising a wide range of issues like safety and environment protection beyond their original economic remit (Tsai 2014).

Debates address a variety of issues relating to regulatory bodies, for instance, viability of a constitutional and legal nature, problems of independence of these regulatory agencies, problem of merger of incompatible powers, structure and personnel issues and also administrative techniques and procedures to be adopted for different programs (Cushman 1941). While the Congress gave regulatory power to these independent agencies, the regular executive departments were not debarred from carrying out certain mandates of regulation. These IRAs were given the authority to explore, formulate and administer policies of regulation, investigate and prosecute business misconduct and like courts, to pronounce upon the individual rights and liabilities based on statutes in cases. Stevens (1944) argues that the power to conduct investigations with its necessary legal implementation and the power to require reports are commonly regarded as the two of the most important powers of any regulatory agency. However, these specifics have been worked out differently in different contexts.

While the IRAs were created by the legislature to enhance autonomy and efficiency in the regulatory domains, their appointing authority was President and neither the President nor the Congress had clear cut mandate over these agencies. Though the President appointed the commissioners, these were to be confirmed by the congress and the new independent agencies provided for the restrictions on removal if not legal compulsions (Mcbain 1926).

In 1955 in a classic of the critical genre, political scientist Marver Bernstein concluded:

> [T]he commissions have not been satisfactory instruments of governmental regulation of business. They have been founded on a basically undemocratic concept of the political process and have helped to perpetuate naive notions about regulation of business, the virtues of group decision, and the uses of expertness. By insulating themselves from popular political forces, the commissions have subjected themselves to undue influence from the regulated groups and tend to become protective spokesmen for the industries which they regulate. (Bernstein 1955: 293).

The committee recommendations on reforming federal executive in United States have dealt with such issues in details at different times. There were: the report of the President's Committee on Administrative Management in 1937 during Roosevelt era (Brownlow Committee Report), two Hoover Commission studies during Truman and Eisenhower years, a report on regulatory commissions to the President elect by J. Landis during Kennedy and Johnson era and Ash committee report (1971) during Nixon administration. The Brownlow committee attacked independent commissions as the "headless 'fourth branch' of the government, a haphazard deposit of irresponsible agencies and uncoordinated powers" (The President's Committee on Administrative Management 1937: 36). It proposed a departmentalization of independent commissions with separate sections for administrative and judicial responsibilities. In effect, it implied subverting the authority of the IRA within government departments.

Scholars like Cushman (1941) proposed more accountability of the commissions to the President for 'administrative efficiency'. While Jaffe (1939) criticized it for little factual documentation of finding of irresponsibility and biasness, Fainsod (1940) considered the report as myopic for focussing so much on the relationship between commissions and the President.

The First Hoover Commission (1949) however, supported the role of regulation commissions in administration and proposed measures to make it more efficient. It majorly focussed on vesting responsibility in the authority of chairmen and make them removable only for a cause.

The Second Hoover Commission (1955) dealt with improving internal procedures and separating the functions of prosecution and decision-making. It proposed that an administrative court could be created with three specialized sections, namely, for taxes, trade and labour. The Task force suggested that adjudication by an independent executive tribunal, completely separated from investigation and prosecution might work for initial days and later it could be appropriated by a special jurisdiction court. It could ultimately be entrusted to general courts. All these steps would be determined by the stage of development of the regulatory process. However, such separation of adjudication from administration has also been criticized to cause inefficiency especially where adjudication can lead to striking compromises (Nutting 1955 cited in Bernstein 1972).

The Landis report (1960) emphasized on the importance of appointing better qualified commissioners and on delegating some of the decision-making power to the subordinate staff. It proposed a 10-year term for the commissioners and suggested that the coordinating officers for transportation, communications and energy and an office for the Oversight of Regulatory Agencies could be placed within the President's executive office (Bernstein 1972).

The Ash council report (1971) saw these commissions as causing economic inefficiency and proposed among various measures transferring the agency to the executive branch, replacing the commissions with single administrative heads, streamlining the decision-making process and combining regulatory agencies with related responsibilities into single agencies (Noll 1985).

Another important debate pertains to the arguments of regulatory capture i.e. the regulatory commissions begin to develop protective orientations towards the views and interests of the clientele and reflect them in the policies. The debate then centres on the question as to which of the two i.e. regulatory agencies within the department or that of IRAs are more prone to regulatory capture? Jaffe for example, suggests that industry orientation "is much less a disease of certain administrations than a condition endemic in any agency or set of agencies which seek to perform such a task" (Jaffe 1954: 1113). Seidmen (1970) suggests that as agencies are based on narrow constituencies, they would more be inclined to safeguard and advance certain economic interests. Robinson (1971), on the other hand, supports the view that interest group representation is more likely to be reflected in the agencies within the executive departments than the independent commissions and that being directly under the President and thus closer to national policy meant better regulatory effectiveness of the agencies in regulation. Bernstein (1972) however argues that no conclusion can be drawn about this particular facet because there have not been much study and that results would vary from agency to agency and also temporal factors.

Bernstein (1972) argues that new regulatory agencies need to be infused with innovative measures to ensure compliance with regulations or else effective regulatory programmes will suffer due to the familiar dichotomy of promotion and regulation invested in the same agency. He thus concludes that one should try to answer certain primary questions systematically in the first place like “for a given set of objectives, what combination of statutory provisions; regulatory powers, processes, and techniques; incentives and sanctions; political leadership; and administrative resources is likely to achieve results that approximate the goals of a regulatory program” (Bernstein 1972: 26).

In sum, there is no consensus on the specific nature, mandate, forms and structure of the IRA’s. The ‘autonomy’ component of such administrative structures warrant an unhindered functioning of regulatory bodies without interference from the government of the day. This, however, to some extent, has gone against the grain of democratic and accountable functioning of IRAs themselves and therefore has faced resistance from other government wings too.

In terms of relevance to this thesis, this section has tried to understand the novelties and difficulties that US policy-makers faced in establishing IRAs. Deciphering adequate structural firewalls to prevent regulatory capture is a practical constraint. Knowing constraints in the way of effective regulation helps providing a context to the central puzzle of the thesis relating to non-autonomous nature of Indian civilian nuclear regulatory body.

Public Private Divide in the Conceptual Understanding of 'Regulation'

This section addresses the debate on similarity and differences in regulation of public sector vis-à-vis private sector. This section is relevant as civilian nuclear regulation which is the central theme of this thesis, is *mostly* in the domain of government run nuclear industry.

There is a vast literature available on regulating the private sector, However, the same cannot be said when it comes to the literature on regulation within the public sector. The idea of setting up independent regulatory bodies, especially at an arms' length from the public bodies, regulating rules and standards for them, has not sunk into administrative modules in a big way. In fact, the idea of regulation as it has developed in the private sector cannot be evoked into public sector without substantial tailoring. The constitutional mandate of separation of power and system of checks and balance between the legislature, executive and judiciary is often perceived as adequate guarantee for regulating the public bodies (as they are a department/ministry/wing within any of these three) (Hood and Scott 2000). Further, there is a tendency in the public sector to appropriate self-regulation as formal government regulation which is often shielded from scrutiny of the public. However, only if one is looking into the organisation and regulation of these public bodies on a case by case basis, can one come across not only the inadequacy of these measures but also an intriguing urge to look into the similarities and differences between public and private sectors in the field of regulation both theoretically and practically. Hood *et al.* (1999) argue,

> Like regulation of business, regulation of government often works in conjunction with 'allies' inside departments or agencies, in that the concerns of the regulator are often reflected in a set of special units within departments (like safety committees), and often with allies in the outside world too, such as the 'humanity lobbies' in the case of prison inspection (Hood et al. 1999: 10).

Regulation of government offices often involves specific departmental units like safety committees that resonate the concerns of regulatory (Hood et al. 1999).

There are other important differences between regulation in private and public sectors too. One such issue is compliance cost. While it is a general practice in business regulation to estimate these costs especially since New Public Management, less attention has been paid to it in the public sector. One must then delineate between the public spending and the regulatory costs. Hood *et al.* (1999: 27) in their analysis of regulatory costs in certain sectors in Britain, categorically included such costs as incurred for carrying out interaction between regulator and regulated, information access, consultation with the regulator, on visits and inspections.

This is not to say that there is no concept of regulation in public sector at all apart from constitutional dictums. There is an emerging yet substantive body of literature on this theme. Paul Light (1993) highlights different forms of accountability in government especially ‘compliance accountability’ (here managers are subjected to detailed rules and suffer with sanctions for non-compliance) with ‘performance accountability’ (managers are incentivised for goal-achievement). The latter is the theme of New Public Management in Administrative Studies. So, there is on one hand, freedom and incentive to manage and on the other, the act of regulation to make managers comply.

Hood et al. (1999) conceptualize ‘regulation inside government’ to satisfy following three criteria:

- One bureaucracy aims to shape the activities of another;
- There is some degree of organisational separation between the ‘regulating’ bureaucracy and the ‘regulatee’;
- The ‘regulator’ has some kind of official mandate to scrutinize the behaviour of the ‘regulatee’ and seek to change it (Hood et al. 1999: 8).

While ‘oversight’ as a command-and-control technique (Hood et al. 1999: 14) is a common regulatory method for both public and private sectors, Hood et al. (1999) posit three more types of popular mechanisms for regulation inside government:

1) Competition- Though it is inspector free control, there is an emphasis on promoting competition within and among bureaucracies as the onus of effective regulation then is not on overseers or top executive officer but among bureaucrats themselves to comply with the government’s rules and standards (Horn 1995). Public choice theory also sees competition as a very effective tool for regulation and rather more successful than through oversight. Similarly, competition for turf, budget and limelight etc. are important motivators here (Niskanen 1971).

2) Mutuality- it is regulation through a committee, board or collegium like structures where individual bias is over ruled through group dynamics.

3) Contrived Randomness- key employees are unpredictably get postings around the system so as to prevent employees from involving in organised corruption or scams like practices as this particular uncertainty about being on either side of the fence would act detrimental to such motives.

Table- 1.1. Four major types of control in public sector regulation

Contrived Randomness	**Oversight**
Works by unpredictable processes! combination of people to deter corruption, or anti-system behaviour *Example: selection by lot, rotation of staff around institutions*	Works by: monitoring direction of individuals from a point of authority *Example: Audit and inspection systems*
Competition	**Mutuality**
Works by fostering rivalry among individuals *Example: League tables of better and worse performers*	Works by exposing individuals to horizontal influence from other individuals *Example: Pairing police officers on patrol*

Source: Hood, C. et al. (2004), *Controlling modern Government: Variety, Commonality and Change*, Massachusetts: Edward Elgar Publishing Limited, p. 7

However, these modes are variously mixed and matched in real practices across different sectors and thus hybrids of these modes as regulatory models are also equally popular. Hood *et al.* (1999) have classified public regulatory bodies into seven categories:

1) Public Audit Bodies: They mainly monitor and enforce probity and efficiency values.

2) Professional Inspectors: Oversee specific services, monitor performance and might also enforce standards in a specialized domain.

3) Ombudsmen: Mainly handle individual grievances;

4) Central Agency Regulators: Located in central departments or agencies and implement the central rules.

5) Funder cum Regulators: they set and monitor the enforcement of provisions of public services by local public bodies. The latter may be partially or fully funded

by the regulators. Audit and inspection both are common tools here (Hood *et al.*: 1999).

6) Departmental Regulators: these are placed within the organization that they are supposed to regulate. They set standards and monitor behaviour of the executive (civil service executives) and other public bodies.

7) Central Regulator of local public bodies: Central govt. department regulators.

As of regulatory methods, Hood *et al.* (1999) discuss them under five categories:

1) Inspection: Visits to the worksite for direct observation.

2) Audit: investigation of financial regularity and accurate book keeping, at times extending to compulsory examination of documentary records to assess performance.

3) Certification: 'Declaration of fitness or quality of some individual, organisation or object'.

4) Authorization: Overseer grants permission for certain course of action if has to be taken to be valid.

5) Adjudication or mediation: Assessment of complaints and disputes.

These are not completely exclusive categories and regulators may use more than one tool at the same time. These processes may involve interaction between regulator and the regulated many a times.

Overall, one can observe that regulation in government bodies is different from that in private sector in substantive ways. While the fundamental objectives and modalities remain the same, it seems easier to create a non-partisan body with robust accountability and effectiveness for regulating private sector than for government bodies. Unless backed by explicit statute and clear hierarchical flow of authority structures, the boundaries between the regulated and regulator may turn fuzzy.

As opposed to the general conceptual approaches towards regulation as discussed, the next section will examine the specific case of regulation in nuclear establishment.

1.2. Regulation in the Civilian Nuclear Industry

Having discussed the conceptual understandings of ‘regulation’ and various debates that characterize the field of regulation, this section will discuss the concept of civilian nuclear regulation which has associated itself primarily with health and safety concerns rather than economic concerns in general. It will also situate Indian civilian nuclear regulation, most prominently manifested in the functioning of the AERB, within these conceptual premises.

The most comprehensive accounts and concepts in the field of nuclear regulation have been formulated by the International Atomic Energy Agency (IAEA) internationally and have been adopted at the national level. The term ‘nuclear regulation’ however, has not been defined in any IAEA document. The concept of a regulatory body has been proposed though. This conceptualization has been discussed in broad terms and emanate from a more functional perspective than a conscious attempt to conceptualize a regulatory body in its own merit. The IAEA documents, therefore, specify certain general characteristics and requirements and leave the details and specific arrangement to the wishes of the state.

Convention on Nuclear Safety 1994, which applies to *all* (emphasis added) nuclear installations, clarifies under Article 2 that

> …“regulatory body” means for each Contracting Party anybody or bodies given the legal authority by that Contracting Party to grant licenses and to regulate the siting, design, construction, commissioning, operation or decommissioning of nuclear installations (International Atomic Energy Agency 1994: 2).

International Nuclear Safety Advisory Group (INSAG)-17 guidelines on ‘Independence in Regulatory Decision-making’ (2003) highlights three main functions:

1) to develop and enact a set of appropriate, comprehensive and sound regulations;
2) to verify compliance with such regulation; and
3) in the event of a departure from licensing conditions, malpractice or wrongdoing by those persons/ organisation sunder regulatory oversight, to enforce the established regulations by imposing the appropriate corrective measures (INSAG-17, 2003:1).

This conceptualization under INSAG-17 therefore, broadens the range of regulatory responsibilities.

Under Article 8 of the CNS, it also mandated that the regulatory body be provided with *adequate authority, competence* and financial and human *resources* to fulfil its assigned responsibilities and an *effective separation* between the functions of the regulatory body and those of any other body or organisation concerned with the promotion or utilization of nuclear energy is ensured (emphasis added). INSAG-17 provides that "it must be independent of the organisations that it regulates, whether these are state owned or privately owned" (INSAG-17, 2003: 2).

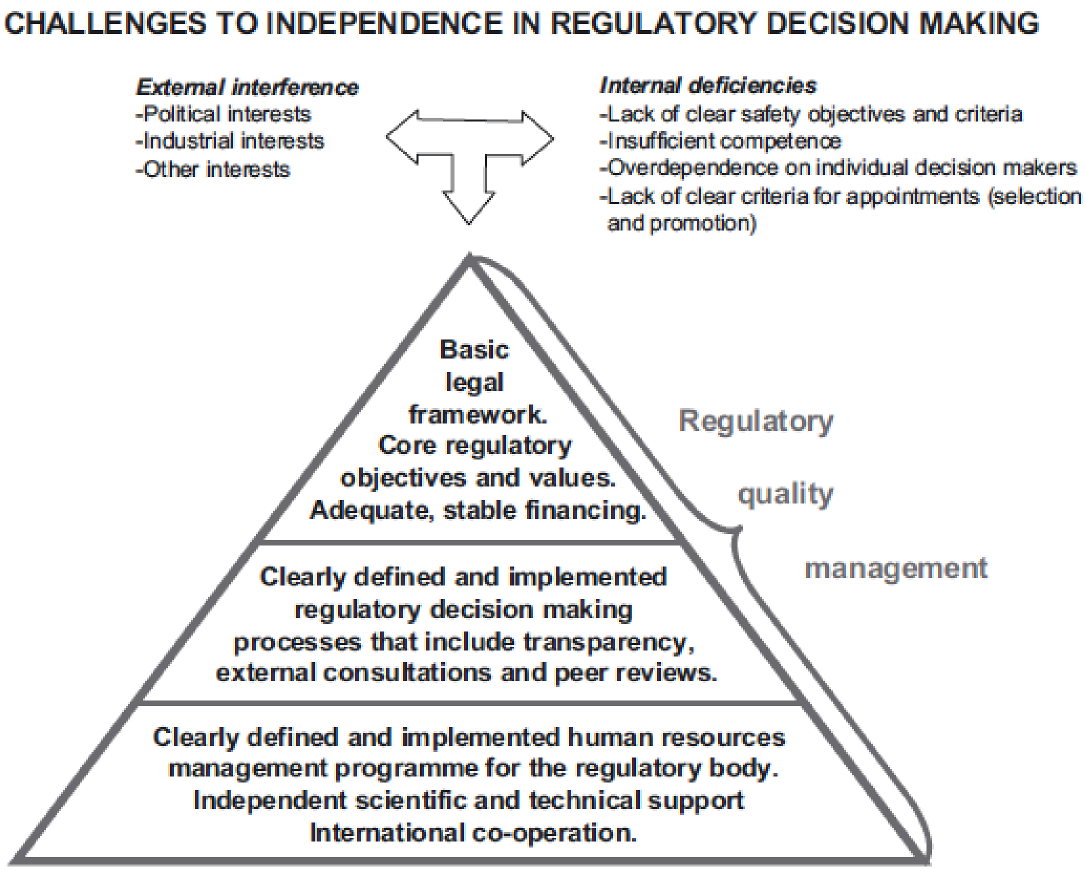

Figure 1.3. Challenges to independence in regulatory decision-making

Source: INSAG-17, (2003: 5), Independence in Regulatory Decision Making, Austria, IAEA

These principles have also been upheld in the Joint Convention on the Safety of Spent Fuel Management, the Code of Conduct on the Safety and Security of Radioactive Sources 2004, the Safety of Radioactive Waste Management (Article 20) and the Amendment to the Convention on the Physical Protection of Nuclear Material 2005. However, military facilities are excluded from purview of most of these conventions. While these conventions emphasize on an effective separation between the twin functions of promotion and regulation, they have also advocated the independence of regulatory agency along with the need for adequate autonomy, staffing, funding and legal mandate to carry out its functions efficiently and effectively.

(INSAG)-17 offers following recommendations, over and above the ones specified by CNS in order to ensure independence of a regulatory body:

- Insusceptibility to unwarranted external influences, but the existence of appropriate mechanisms for external professional dialogue and consultation, with both licensees and independent experts, along with appropriate mechanisms for dialogue with the public;

- Decisions taken on the basis of science and proven technology and relevant experience, accompanied by clear explanations of the reasoning underpinning the decisions;

- Consistency and predictability, in relation to clear safety objectives and related legal and technical criteria;

- Transparency and traceability (INSAG-17, 2003: 2-3).

The IAEA's "Handbook on Nuclear Law" does not specify the procedure for appointment of regulatory authority but argues that the head of regulatory body should not be removed at the discretion of higher executive without showing the cause. However, if a separation of the main regulating and decision-making functions exist, the subordinate placing of a regulatory agency would not undermine its autonomy. "The process of designating and removing the head of a regulatory body is not determinative of the body's independence, but it is an indication of how the safety function is viewed in the state concerned" (Stoiber *et al.* 2010: 27). It further elaborates,

> Some states may place the regulatory body under the supervision of a parent organisation, such as a government department or a ministry. The fact that the regulatory body is located within the administrative structure of another organisation or is supervised by it, does not necessarily mean that the regulatory body lacks independence. The question is whether the necessary effective separation or effective independence of key regulatory functions and decision making exists. That question can be answered only after an evaluation of the detailed provisions determining how the practical work of the two organisations is conducted (Stoiber et al. 2010: 27).

But, if the parent organisation which is supervising the regulatory body, is charged with conduct or promotion of nuclear activities, questions will be raised on the autonomy and/or separation of regulatory functions.

> If it is responsible for nuclear energy development, situations could arise in which the parent organisation is called upon to take decisions, for example, about the establishment of facilities using nuclear techniques. In such situations, administrative measures would have to be taken in order to ensure that safety related decisions of the regulatory body are effectively independent of or separate from developmental or promotional decision making (Stoiber et al. 2010: 27).

Furthermore, a regulatory body shall have authority to provide information on crisis events. It shall have necessary authority to offer corresponding safety judgement at the licensed facilities under its purview without requiring an approval from any other organisation. A negation of these, raises questions on autonomy and transparency of the regulatory body.

Professional expert pool independent of the regulated industry and independent sources of regulatory budget through legislature or government are also required to help carry out the nuclear regulatory functions effectively and efficiently. Regarding rule adjudicatory functions, it says that the national legal system should institute a process of appeals. A hierarchical set of administrative bodies or a judiciary can hold such responsibility. Finally, apart from such administrative requirements, states also need to ensure that the regulatory functions hold credibility in public's eyes. This would require non-political and partisan appointment of the head of the regulatory body, with adequate competence, knowledge and technical skills. The AERB while fulfilling some of these criteria falls short of some others. Such nuances will be discussed in detail in chapter three.

IAEA defines nuclear law as:

> [t]he body of special legal norms created to regulate the conduct of legal or natural persons engaged in activities related to fissionable materials, ionizing radiation and exposure to natural sources of radiation (International Atomic Energy Agency 2003: 4).

The fundamental principles or basic concepts in nuclear law relate to: 1) the safety principle (Prevention and protection); 2) the security principle (of nuclear material); 3) the responsibility principle; 4) the permission principle; 5) the continuous control principle; 6) the compensation principle; 7) the sustainable development principle; 8) the compliance principle; 9) the independence principle; 10) the transparency principle and 11) the international cooperation principle. These provide the broader normative principles that should be kept in mind while handling nuclear operations and regulation.

The Nuclear Energy Agency (NEA) characterizes an effective nuclear regulatory body with following attributes:[3] "safety focus and safety culture, independence, competence and openness and transparency, clear and consistent regulation, consistent and balanced decision-making, accountability, strong organisational capability, continuous improvement, peer review and international involvement, efficiency and credibility, trust and respect" (Cameron 2017). However, even the NEA does not propose any model or structural and administrative specifics for devising a nuclear regulatory body.

IAEA manuals and codes, however, are not binding on states. The conventions too, need a commitment under bilateral or multilateral agreements for effective implementation, which is a common lacuna with most of the IAEA conventions. The international documents on regulatory frameworks specify the general characteristics and requirements and leave the finer details and specific arrangement to particular states. The specifics of these guidelines can therefore be tailored by the state "according to its own legislative framework including its constitutional and legal framework, cultural traditions, scientific, technical and industrial capacities, and financial and human resources" (Stoiber et al. 2010: viii). Thus, they fail to develop a unified document on the essential characteristics of such frameworks to be complied with by the states. While the non-adoption of 'one size fits all' approach is lauded for being sensitive to the sovereign attributes of states, it gives scope to a range of discretionary practices in the field of civilian nuclear management.

In sum, one can observe that though nuclear regulation has been a subject-matter of international deliberation, there is a lack of consensus on specific operational details and criteria. As the international domain offers little guidance on operationalization of parameters denoting autonomy and there is no conceptual model of nuclear regulation in international or Indian domain, this study will employ the tools and insights from administrative theories on regulation to evaluate AERB, as outlined in section one of this chapter.

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[3]It is a specialized agency of the OECD, established in 1958, comprising of government representatives of industrialized countries (31), based in Paris and "facilitates co-operation among countries with advanced nuclear technology infrastructures to seek excellence in nuclear safety, technology, science, environment and law" (NEA 2018, USNRC 2018).

After having examined both- general concepts of regulation and the specific ones on civilian nuclear regulation, this study will adopt following specifications to evaluate and qualify the autonomy and efficacy of AERB:

1) Institutional separation between the twin functions of promotion and regulation- constitutional mandate and administrative structure.
2) Staffing principles- adequacy of staff, in terms of inclusion of external members and availability of external resource pool, qualification criteria and so on.
3) Nature of appointing authority- nature of oversight, composition of appointing body, constitutional mandate.
4) Funding provisions.
5) Nature of accountability.
6) Kinds of regulatory functions assigned to it: a) broadly in terms of safety, security and safeguards and b) narrowly, in terms of licensing, inspections, crisis situations and so on.
7) Nature of enforcement, reporting and verification authority granted to it.
8) Provisions for its own technical research and development.
9) Nature of linkages with international nuclear regulatory framework
10) Nature of civil-military duality on regulatory body and its autonomy.

These factors will be helpful in characterizing the nature of Indian nuclear regulatory regime in terms of a) structure; b) nature of change; c) Causality; d) mechanisms, e) guiding principles/rationale and f) organisational culture.

The next section briefly introduces the India nuclear regulatory body i.e. AERB in order to provide a context for rationale of this thesis.

1.3. Civilian Nuclear Regulation in the Indian Context

In India, under section 27 of the Atomic Energy Act 1962, the Atomic Energy Regulatory Board (AERB) was set up on November 15, 1983 for carrying out the regulation of activities involving nuclear radioactivity. Under the subsequent acts, the AERB exercises mandate over consenting at regulatory stages, safety review and assessment, prescriptions of dose limits, inspections, enforcement, penalties for violation, issuance of safety codes and standards, emergency preparedness provisions, etc. However, the primary responsibilities for safety and security of nuclear material in India lie with the individual operators i.e. the Nuclear Power Corporation of India Limited (NPCIL) and the Bharatiya Nabhikiya Vidyut Nigam Limited (BHAVINI) (the government agencies managing the nuclear facilities for power generation as of now) (Jacob and Mishra 2015).

Indian civilian nuclear regulatory regime is characterized by predominant influence of the state/government. Functioning of Indian nuclear establishment is only partially public given its role in nuclear weapons programme. This opaque functioning has also extended to the civilian facilities to some extent. Regulation, therefore, is entirely in the hands of state designated and controlled bodies. Civil society has been questioning the adequacy of nuclear regulatory framework in India but larger public opinion on nuclear regulation remains fragmented and ill-informed.

The initial phases of energy generation in India focused on increasing the share of nuclear energy in country's total power generation. The 1948 Atomic Energy Act and then the 1962 Atomic Energy Acts were more in the nature of empowerment and facilitation than regulation (regulation, however, remains the underlying component of any law in general). It specified the powers and mandates of the nuclear governing body and monopolized it all under one authority. The AERB, therefore, has not been created by an explicit statute dedicated to regulatory function. Officially, however, certain sections of the enabling 1962 AE act have been cited as the basis of authority to regulate. These have been delegated to the regulatory body through an executive order.

The initial years of nuclear operations before the establishment of the AERB demonstrated the characteristics of facilitated self-regulation, where government did not formulate a policy on regulation of nuclear infrastructure and units and did not create a statutory body for the same. It, however, allowed the system of committees that the nuclear establishment created to observe safety credentials, without creating the specific statutory backing for the same. When the AERB was established in 1983, the mandate of implied regulatory powers was delegated to it.

As far as regulatory practices are concerned, the AERB has authority to adopt following measures under section 17 of the AE act 1962, depending on its assessment (Department of Atomic Energy 2010):

a) to shut down a plant or lower down its operational rating temporarily if safety credentials are not adequate, or some safety concerns crop up.

b) authority to issue and deny the licenses at different stages of power plant

c) impose fines on violations for non-compliance (some violations punishable with an imprisonment terms up to five years).

d) issue notice to the concerned officials and disqualify, suspend or withdraw his/her license to handle nuclear operations

e) issue written directives for compliance to the requirements

f) demand modifications in the design and operational practices

g) conduct routine and surprise inspections, and follow-ups on their recommendations

h) advise measures for improvement in safety credentials

i) devise codes and guidelines in matters of safety

It, however, does not have a policy-formulation mandate and the decision-making bodies within the DAE, generally do not involve AERB, unless the matter relates to regulatory function. It adopts inspections, certification, authorization and punishments to carry out its mandate. These are discussed in detail in the third chapter. Any adjudication is to be handled by the Atomic Energy Commission. However, in practice, the general courts too, have taken upon this task as evident in various public interest litigations (PILs).

The AERB lies primarily in the category of departmental regulators, though with mandate over the industry actors which too, are government corportions. Mandate of auditing the nuclear corporations does not lie with the regulatory body. Auditing of corporation is performed by the Comptroller and Auditor General (CAG) (discussed more in the third chapter). There is no concept of regulatory cost in Indian nuclear establishment as the regulator and operators- all are government entities. All the regulatory expenditures therefore are charged on public exchequer. The national regulatory authority reviews the safety preparedness of nuclear industry, but not its cost effectiveness.

The AERB has inspectors specializing in different expertise like radiation protection and monitor operator’s compliance in their respective competences. The public audit bodies for nuclear affairs is the CAG, which audits the specified nuclear installations alone and not all the units (defence related nuclear installations are outside its purview).

Indian nuclear regulatory system appears to follow the mutuality mode of regulation where the regulatory board at the highest level has members from outside the establishment. At lower levels too, the regulatory committees comprise of members from the nuclear industry and also external members apart from the regulatory ones, in order to provide more neutral perspective and credibility.

The AERB works with an approach of insider, which basically means that problems are communicated to the concerned units directly. In case there is an incident involving radioactivity, the AERB may issue public notifications. In case of Indian regulatory body, an incident happening within a nuclear installation is reported by the AERB without an approval from any other body first. The ones happening outside /away from these facilities, however, is notified by the DAE, which is mandated to promote nuclear related research and activities (Bansal 2018).

AERB, as it is officially not a policy-advising body and does not fall into the direct chain of command, fits into the administrative conception of a regulatory body. The other criteria of arm’s length oversight, however, becomes fuzzy, given the participation of nuclear operators in various committees of the regulatory body, subservient positioning of AERB within the DAE and so on. These angles have been explored thoroughly in the third chapter.

The AERB has been criticized for being secretive and opaque, thus, constraining a fair review of its efficiency and effectiveness (Chari 2014; The Nuclear Threat Initiative (NTI) Index 2014). The International Atomic Energy Agency (IAEA) also recommended that India must “ensure its atomic regulator’s independence in order to prevent an undue influence and must adopt a national policy for radioactive waste management” (PTI 2015).

The Department of Atomic Energy (DAE) tabled the Nuclear Safety Regulatory Authority (NSRA) bill in the union cabinet in 2011 citing the Mayapuri incident and the Fukushima crisis as urgent rationale for strengthening nuclear security and safety mechanisms in India (Jacob 2014). The NSRA bill was introduced in Parliament in 2011 but with the change in government in 2014, it lapsed. However, the anti-nuclear protests on installation sites, need for integration with global nuclear trade for fulfilling vast energy needs by securing fissile material and technology (Mishra 2010a; Nayan 2011; PTI 2014) and deteriorating regional security environment, continuously flag the need for effective and autonomous nuclear regulation.

The next section presents the rational, scope and structural organisation of the thesis along with schematic representation of linkages as discovered through the course of this research.

1.4. Structure of the Thesis

In any polity, nuclear affairs are dealt with by specific organisational units that cater to decision-making. This nuclear bureaucracy, often finds additional status and leverage given the ‘high-politics’ nature of nuclear science and technology. This thesis argues that the specific culture of nuclear organisations is a product of the esoteric nature of nuclear discourse and sociology of knowledge associated with them. This specific culture of nuclear organisations in turn, shapes the attitude and behavioural dispositions of their members about the appropriate degree and nature of autonomy that should be granted to a nuclear regulatory body.

Organisations and institutions, irrespective of the extent and nature of stability associated with them, undergo transformative moments, necessitating the need for change. Such changes may be induced by internal or external reasons or both simultaneously. At the same time, not all historical opportunities bring a change in the status quo through a reorientation of guiding principles and/or technical solutions at a practical level. The thesis, as much as it attempts to implore changes and its underlying causes while analysing the evolutionary stages of the AERB, also analyses the impediments to such changes and argues that the resistance from within the nuclear establishment is one of the most important reasons for the non-autonomous nature of the Indian nuclear regulatory body i.e. the AERB.

The thesis proposes following three hypotheses:

1) Nuclear regulatory structures in the Indian civilian nuclear programme evolved as a response to the various crises events experienced during the management of nuclear infrastructure worldwide.

2) Sub-optimal performance of the Indian civilian nuclear establishment has been a major reason for the lack of the independent civilian nuclear regulatory structures in India.

3) Non-separation of civilian and military nuclear facilities has significantly contributed to the absence of an independent civilian nuclear regulatory structure in India.

To understand the evolutionary growth of Indian civilian nuclear regulatory regime led by AERB (the dependent variable), this study has employed three analytical independent variables which were found to be indicative of and co-related to the nature, structure and direction of the institutional changes in nuclear regulation:

a) Global nuclear regulatory norms,

b) Crisis-learning in the event of nuclear accidents and nuclear terrorism, and

c) Strategic imperatives - dynamic interaction and linkages between the civilian and military nuclear programme.

The first variable has been chosen because of the knowledge intensive nature of nuclear technology which is still evolving. Given the limited number of countries that are engaged in nuclear research, international sharing of best and standard practices in civilian uses of technology is a prevalent phenomenon in nuclear field. This variable also allows a third level analysis of the regulatory discourse and offers useful insights, standards and organising principles, the relevance of which have been discussed in second chapter.

The second variable of crisis-learning is a standard and one of the most widely accepted causative rationale cited in organisational theories as an agent of change. As, shown in the diagram, crisis-learning as a variable also informs the development of international nuclear regulatory framework. This variable therefore, helps in consolidating a) independent responses of Indian nuclear regulatory body to crisis-events, b) independent responses of international nuclear regulatory regime to crisis-events and c) synergetic linkages between international and Indian regulatory regime in response to crisis-events.

The third variable relates to the dual-use nature of nuclear power and corresponding strategic implications of the weapon program on the nature and mandate of civilian nuclear regulatory regimes. This variable was chosen because it represents the underlying tension within the nuclear regulatory discourse characterized by the dual use nature of nuclear technology.

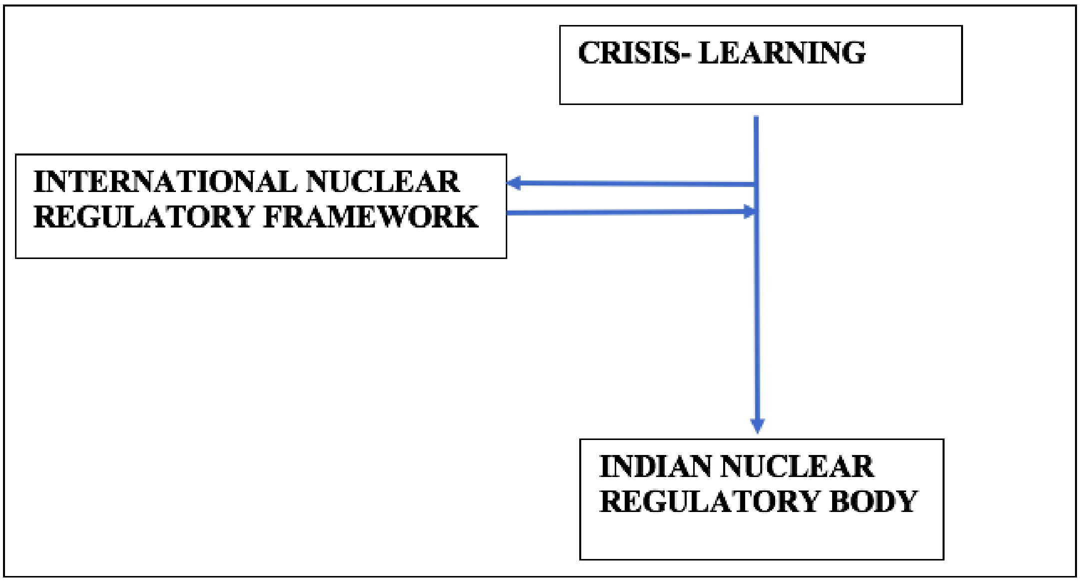

Figure- 1.4. Schematic representation of inter-relation between the variables

Source: Author

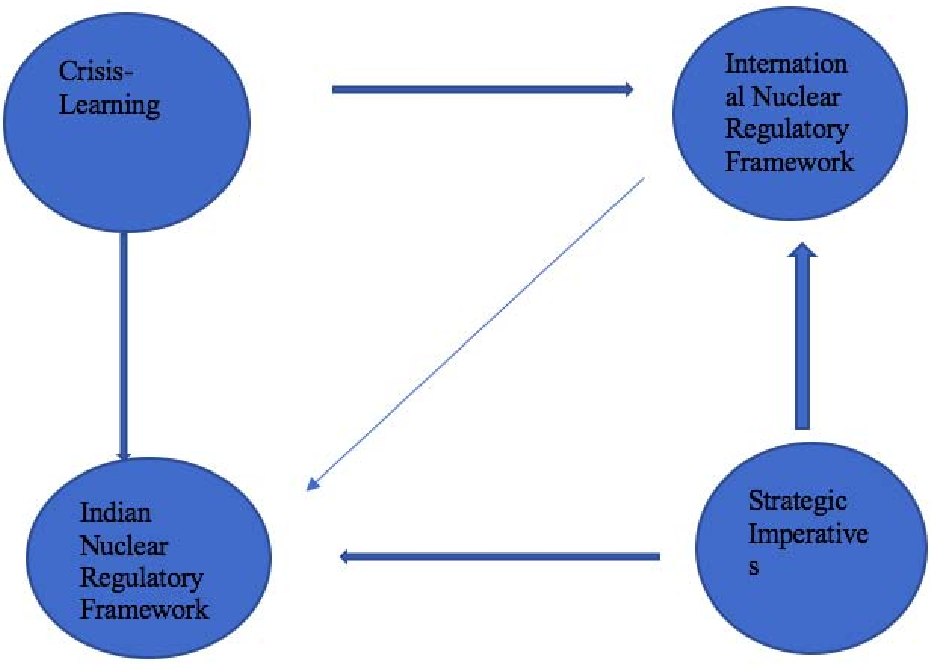

Figure- 1.5. Schematic representation of inter-relation between dependent and independent variables

Source: Author

As the figure shows, the three independent variables of international nuclear regulatory regime, crisis learning and strategic factors influence the nature of Indian nuclear regulatory framework which is the dependent variable here. Crisis learning and Strategic factors- these two variables also affect the third variable which is international nuclear regulatory framework, the evolution and adaptation of which have been in a response to major crisis events and national strategic considerations.

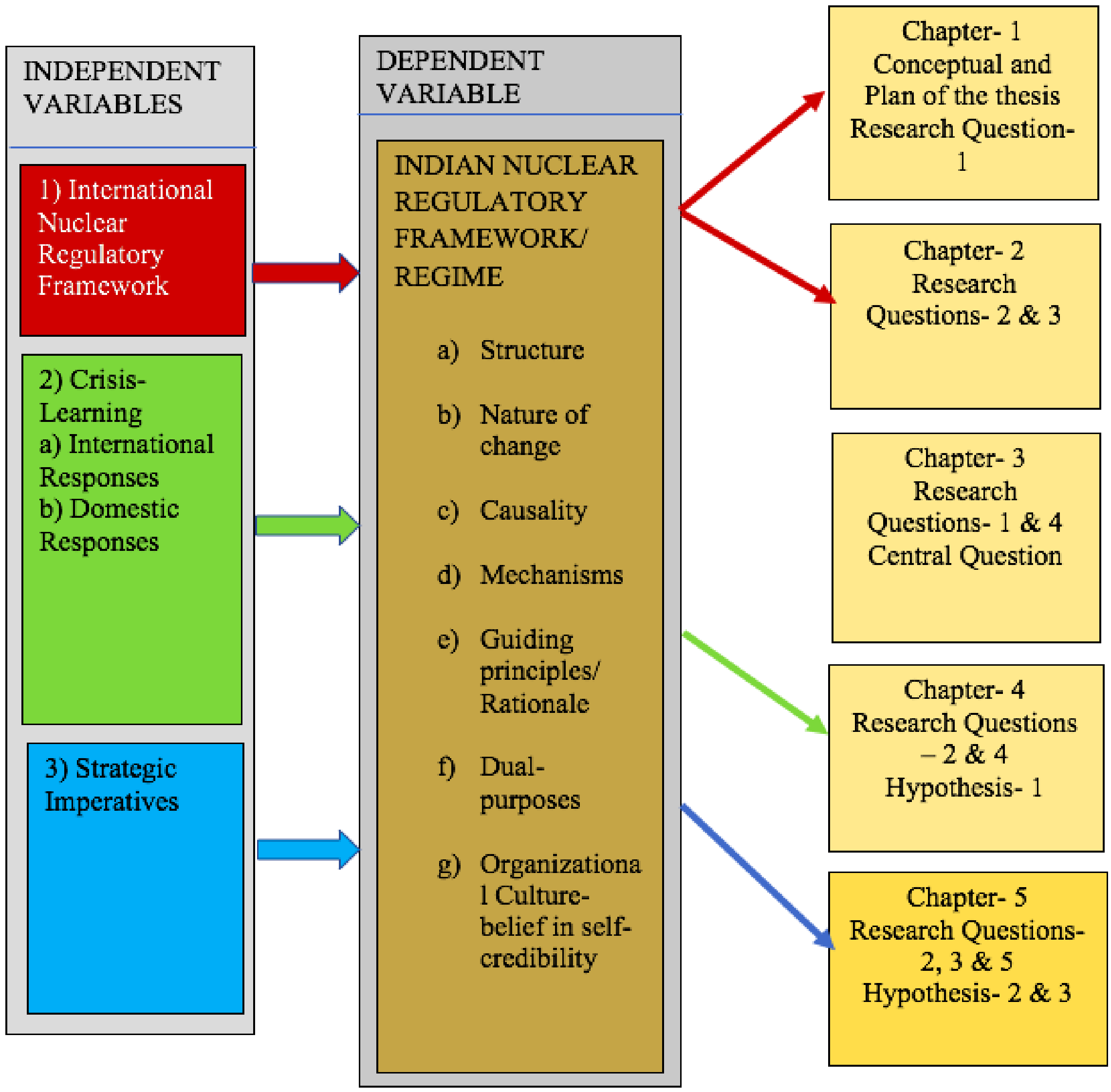

Figure- 1.6. Schematic representation of the thesis plan

Source: Author

Chapterisation

This first chapter has discussed the contextual background of regulation, and civilian nuclear regulation specifically, to situate AERB in the broader concept of regulation. It also reflects upon some of the basic regulatory provisions. It has explored the concepts and debates on ‘regulation’ in order to nuance the discussion on nuclear regulation.

The second chapter primarily argues that: a) the nature of the cooperative regime established in the nuclear domain, is a product of international power politics and b) India’s partaking in it is a product of its own national strategic considerations on the one hand, and its self-perception of being a responsible member of international nuclear order.

The third chapter essentially presents a historical narration of evolution of AERB and other institutional mechanisms related to the aspects of nuclear safety and nuclear security. It will also present a critical analysis of the same.

The fourth chapter details how a crisis event and subsequent crisis learning act as motivations for change in nuclear regulatory regimes. Even when ‘the stage transition theory’ (discussed in detail in fourth chapter) falls short in terms of major transitions in AERB, some sort of learning, limited even if not extensive, can be deciphered post-crisis events. The chapter situates crisis learning in organisational theories of change and resistance to change.

The fifth chapter presents a specific analysis of Indian nuclear weapon programme on Indian nuclear regulation, if any.

The concluding chapter will bring together the findings of the thesis and reflect upon the hypotheses.

Research Methods

This study is a descriptive and historical account of nuclear regulation in India. There are three sets of primary sources that were considered:

1) Official reports, memos, official websites and annual reports of the DAE, AERB, IAEA and other such institutions involved in Nuclear regulation in India and on an international level.

2) Personal field interviews with resource persons from India and abroad. Resource persons include current AERB officials (chairperson plus two non-DAE board members, employees in AERB divisions), former AERB officials, former DAE employees (non-AERB), independent nuclear analysts, an ambassador, and a member of Canadian nuclear regulatory commission.

3) A survey of AERB employees conducted by the author (with official permission from AERB management) to gather data on perceptions and attitudes of AERB employees towards nuclear regulation. Questionnaire proposed by the author were vetted (some were removed and some modified too) by the AERB and then sent to the AERB officers through their respective departments. The survey allowed anonymous responses too. Questions were made optional at the request of the AERB. While the total population of AERB is 250, around 69 employees responded, which is The data (both a summary as well as individual response sheet has been shared with the AERB).

4) Information obtained through RTI by the author and other RTI documents available online.

5) Questions raised in Indian parliament and responses from the DAE

The study has also made use of several secondary data sets in the realm of newspaper articles, internet sources, books and articles written by esteemed analysts on the topic and so on.

Apart from a historical analysis of regulatory phenomenon in the Indian context, this study has also undertaken an effort to engage in theory-testing in the fourth chapter. This particular theory pertains to development of risk regulatory regime. Insights from concepts of regulation as developed in an administrative sense have been extrapolated to provide the over-arching theoretical umbrella and tools to understand this specific phenomenon in terms of regimes, nature, composition, status of legality and autonomy etc. These have been discussed in this introductory chapter.

This thesis is rooted in positivist methodology and privileges existing behavioural and historical evidences and patterns to asserts its claims.

Rationale and Scope

Interest in this research topic has been a result of its relevance in the contemporary world, given the dual-use nature and practice of nuclear technology. Risks and dangers associated with its weapon uses initiated and continues to affect the global politics through the disarmament, non-proliferation and counter-proliferation discourses. Civilian deployment of nuclear technology in electricity generation, medical uses and so on, while becoming progressively integral to modernization drive, is also fraught with threats of nuclear terrorism, nuclear accidents and such, thereby spurring demands for effective nuclear regulation, more transparency and accountability of the management and operating units. The nuclear discourse has been primarily centred on strategic debates and has affected military thinking in significant ways. Its impact on the civilian nuclear regulation, however, has been under-researched.

This study is relevant because the regulatory aspects of India's nuclear programme have been under-researched. Though there is some work on regulatory mechanisms in the civilian domain, a holistic understanding of factors that affect regulatory mechanisms is missing. As India is at the footsteps of a nuclear energy renaissance with planned upcoming investments in this sector, it is important to reflect on the adequacy and effectiveness of its nuclear regulatory institutional framework and mechanisms. It is also important in the wake of the need for stringent regulatory measures to establish India's credibility in the international market of nuclear trade, as India wants to establish itself as a significant player and power holder in the same.

The Scope of this project is limited to understanding the evolution of nuclear regulatory regime in India and does not extend to generalize the analysis and results to the regulatory regimes in other countries or to other risk prone technologies in general. It only looks at the multiple variables that contribute to the evolution of civilian nuclear regulatory mechanisms in the domain of policy making in India. The study acknowledges the vibrant and important role played by nuclear activists in India and abroad but refrains from studying the (if they can be called so) 'anti-nuclear' and 'nuclear reformists' movements.[4]

[4]Nuclear accidents have supplied increased momentum to the various strands of 'anti-nuclear movements' (if they can be called so) whose oppositions span over a number of normative and practical concerns (Bhadra 2013) ranging from a principled critique of nuclear energy (Perrow 2011; Ramachandran 1991), disarmament policies (Bidwai and Vanaik 1997; Mian 2008), emphasis on environment- friendly energy options (Ghosh 1988; Udayakumar 2012; Dietrich 2011)), emphasis on a drive towards more transparency and accountability with institutions carrying out effective separation of power and a system of checks and

At the same time, the study refrains from pitching the debate on pros and cons of nuclear energy per se or the economic feasibility and viability considerations and concerns. This study of regulatory framework therefore is limited to the considerations of safety, security and safeguards.

The scope of regulation for the purposes of this study has been broadened to include safeguards related aspects too. In a more conservative sense, the national nuclear regulatory bodies all over the world primarily have safety and some security related mandates. However, in countries, like Canada, which does not have a nuclear weapon programme, even the safeguards related functions are performed by the same national regulatory agency. The international nuclear regulatory conventions and codes too, focus on safety in a much more organised and focussed manner. Focus on nuclear security regulations emerged comparatively recently. This study, while analysing Indian regulatory structure also encompasses safeguards regimes as one of the relevant aspects because of their implications for the nuclear commerce guidelines and dual-use considerations. Also, the safeguards compliance, or to be precise, non-compliance on the part of India had a few implications for the regulations pertaining to safety in an indirect manner. To understand Indian response to international nuclear commerce regulations, the study has analysed the process and substance of Indian undertakings with respect to the safeguards systems.

Definitions

For this study, 'Nuclear Regulation' would mean the promulgation of an authoritative set of rules by the government (preferably by a non-partisan parliament) accompanied by some mechanisms for monitoring and promoting compliance with those rules in the operations of civilian nuclear and radioactive facilities. It has been derived from the narrow definition of the term 'regulation' in an administrative sense and the 'nuclear' component is meant to signal the associated risks and dangers involved with the use, storage, transport and disposal of fissile material and the corresponding need to devise effective regulation for the safety and security of life forms.

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balances especially in the civilian energy domain (Ramana and Kumar 2014), protection against occupational hazards and health risks (Ramana and Shimray 2007; Karlsson 2009; Ganesh 1987) etc.

The term 'Independent Nuclear Regulatory Body' may be conceptualized as the institution of an autonomous and effective public body placed in charge of regulating the individuals and agencies involved in dealings with the nuclear material. The autonomy is to be asserted vis-à-vis the regulated clientele and associated pressure lobbies directly and indirectly. Specifications and parameters outlines in this chapter will be used to qualify AERB in subsequent chapters.

Summarising the Major Findings of the Thesis

While the first and second variable, namely international nuclear regulatory framework and crisis-learning were found more relevant in driving and accounting for the changes associated with the Indian nuclear regulatory regime, the third variable, namely strategic imperatives, primarily reflected a rationale for resistance to change and preservation of the status quo pertaining to regulatory structure. All the three variables, however, are informed and affected by the dilemmas associated with the dual use nature of nuclear technology, and the 'high-politics' attitude associated with nuclear discourse.

The study found that while these three independent variables significantly shaped the discourse of civilian nuclear regulation in India, their comparative strengths in influencing the same vary. While the first two prompted a more positive and steering effect on the regulatory regime towards an autonomous structuring and functioning, the latter's impact present a complicated picture. Strategic imperatives though do not directly inform the questions of autonomy of national regulatory body and play a shaping/conditioning role in the overall regulation discourse. The study found that the subject matter of 'regulation' itself has been defined in terms of limitations drawn normatively in response to the strategic discourse (elaborated in chapter 5). The utility of atoms for the weapon purposes shaped not only the Indian but also the international debates and discussions on the nature, instruments and modalities of nuclear regulation (discussed in detail in chapter 2).

International nuclear regulatory framework was found to exert higher motivational force and moral pressure if not political, upon national entities to create and maintain higher standards of civilian nuclear regulation. It also acted as a filter through which the lessons of crisis events were analysed. These then to a great degree percolated to national nuclear regulatory regime through technical guidelines. The second chapter provides insights into the basic operating principles, politics and implications of the international order or the third level variable on the regulatory regime.

With a rise in crisis-learning, there has been a higher demand for more autonomous regime. Such autonomy is sought in terms of regulatory organisation vis-à-vis the institutional forces involved in promotion of nuclear energy projects.

Conclusion

In sum, this chapter highlighted the specifics associated with a nuclear regulatory body within the concept of regulation in general. Debates covering the question of autonomy, range of practices, structural modelling and so on provided a context for the overall theme of the thesis relating to Indian civilian nuclear regulation. These offer several objective and subjective criteria that the thesis will adhere to while analysing the Indian nuclear regulatory body in subsequent chapters.

It also discusses a background of Indian civilian nuclear regulation in brief to introduce the empirical domain which the thesis seeks to engage with in subsequent chapters. The last section of the chapter discusses the structure, rational, scope, definitions, chapterization and a brief summative finding of thesis.

The chapter offers following conclusion and arguments:

First, 'Regulation' appears as an ambiguous concept and therefore, takes on many administrative forms, the robustness and effectiveness of which are judged in accordance with the broader disciplinary understanding and specific field where regulation is carried out. Nuclear regulation, being a specialized technical discipline, demonstrates a degree of conservativeness in its structuring as far as autonomy of a nuclear regulatory body is concerned, more so, autonomy from the government.

Second, functional criteria of regulation as discussed in the international domain are more prescriptive in nature and broadly outlined. The broad and somewhat ambiguous prescription therefore permits a broad spectrum of models that can serve as templates for the modelling of a national nuclear regulatory body. Though autonomy of regulatory bodies has been accepted as a novel principle by national and international bodies, its exact manifestation and enabling structural landscape remain a subject of immense debates and fragmented opinions. The guidelines which offer more details are non-binding in nature while the binding ones are very broadly defined.

Third, while the concept of IRAs came to be debated in national contexts most prominently in relation to economic regulation, such debates have been missing from international debates and discussions on structuring nuclear regulatory authorities in a way so as a to accord credible autonomy and effectiveness to them. This reflects a limited institutionalization of the concept of IRAs in civilian nuclear regulation internationally.

Fourth, in the case of nuclear regulation, an emphasis on autonomy from the government is limited. Given a specialized and mammoth importance of nuclear weapons in national security domain, civilian nuclear operations too have remained under the predominant authority of the government. Most of the countries emphasize on autonomy of the regulator from the regulated entity rather than autonomy of the regulator from the government itself in a major way. Countries with private nuclear installations, however, remain very cautious, and rightly so, not to promote delegated self-regulation or deregulation in this field.

While the concept of independent regulatory body evolved as a novelty in American administration, it has not been a very popular model in general, and even less so in nuclear. The international framework does not go far enough in devising criteria of a nuclear regulatory body in terms of its autonomous functioning. Reasons for such a restricted mandate will be discussed in the next chapter.

Chapter: 2

International Nuclear Regulatory Framework

Introduction

This chapter presents a historical narrative of the evolution of the international nuclear regulatory framework and identifies the major factors that have influenced this evolutionary process, leading to its current nature and structure. It also evaluates the international nuclear regulatory framework through an analysis of regulatory mechanisms, institutions and practices that pertain to safety, security and safeguards associated with nuclear energy. Though there is no explicitly designated international body for nuclear regulation, there has been an evolving consensus on the need for strengthening international oversight, at present most vibrantly advocated by the International Atomic Energy Agency (IAEA), over national regulatory mechanisms.

The chapter is divided into five sections. The first section will focus on the historical context of the post-second world war world and considerations that led to the establishment of the IAEA as an international organisation to deal with matters of nuclear technology and shaped its subsequent evolution significantly. The second, third and fourth sections will individually and respectively analyse the safety, security and safeguards related regulatory aspects of global nuclear regulatory framework. The fourth section also includes a sub-section dealing with export control regimes that significantly supplement the safeguards related instruments. The last section will detail India's observance and compliance, with respect to its commitments toward the global regulatory framework.

While the previous chapter analysed the concept of regulation as understood by the IAEA in its published documents, this chapter will narrate and analyse the political discourse through which the understanding and concept of nuclear regulation evolved in the IAEA. The chapter argues that the shaping of the regime itself in terms of its authority and mechanisms reflects the underlying tension between a need for standardization in nuclear operations and management internationally and a jealous preservation of sovereignty claims by the state units. The international order, which itself is predominantly, if not singularly, a product of international nuclear hierarchy, plays a role in shaping the nuclear regulatory governance. States have historically shown caution, if not disdain, to international regulation in general as it undermines their national sovereign rights to a certain extent. A penchant for security of nuclear operations against the threat of terrorism, adversarial attacks and so on add to the securitization of nuclear power and corresponding need for secrecy enforced by a sovereign jurisdiction.

Nuclear power as an emerging and relatively less explored realm of science and technology distinguishes itself from the more widespread technologies like thermal power and others in terms of its limited expansion, relatively risky operations, costs and stability quotient. While several countries are involved with on-going researches in developing safer, more cost-effective and large capacity reactors with distinct technologies, no one country seems to have mastered all of these at once. The nature of nuclear technology, in terms of its dual-use potential, high-risk nature and long gestation periods, prompts a more collaborative approach, requiring bilateral as well as international consultation and discussion. An international nuclear regulatory regime (although evolving and limited in nature), therefore, is a natural corollary for the prospects of peaceful uses of nuclear energy at a worldwide level. This regime comprises of designated bodies, institutions and mechanisms, norms, standard practices etc. and involves an overall consensus on the need for standardization of different parameters which constitutes the sine qua non in nuclear operations. Standardization, by its very epistemological nature, requires wide acceptance and compliance, the feasibility of which depends on the nature and extent of commitment offered by national entities to the widely acclaimed technical institutions.

This chapter employs the definition of 'global nuclear governance' proposed by Findlay (2010):

> [nuclear governance is a] web of international treaties, agreements, regulatory regimes, organisations and agencies, monitoring and verification mechanisms and supplementary arrangements at the international, regional, sub-regional and bilateral levels that help determine the way that nuclear energy, in both its peaceful and military applications, is governed. (Findlay 2010: 9).

This chapter, however, will primarily analyse the existing international instruments and mechanisms along with the ones specifically undertaken by India. Given the India-specific, bilateral and regional commitments are being kept out. An analysis of international nuclear regulatory framework in this chapter, therefore, will be concerned only with the legally binding obligations through treaties and conventions and non-binding standardized codes and guidelines that states have adhered to in a multilateral setting, primarily under the aegis of the IAEA, but not restricted to it.

2.1. Historical Background

To understand the ideational evolution of the concept of nuclear regulation right after the twin nuclear explosions in Japan, this section will outline the dynamic political considerations especially on the part of 'superpowers' namely the United States of America (U.S.A.) and the Union of Soviet Socialist Republic (USSR), that led to the establishment of the IAEA in 1957. With changes in power differential and status between the two, the whole process and rationale given for IAEA's existence underwent a series of changes, eventually leading to its current form.

The Post-Second World War period was characterized by a series of unresolved dilemmas. The emergence of nuclear weapons as the ultimate tool of destruction and its solo possession by the US (up till 1949) led to anxiety and a compelling desire on the part of the Soviet Union to correct the nuclear imbalance - a typical case of security paradox. The other dilemma pertained to the nature of the atom itself. Atomic power could not only unleash horrific destruction but also held the key to a promising future with ever-expanding possibilities of creating huge amounts of energy and useful medical and industrial products.

The US had spent a lot of political will, material and manpower in nuclear research and was convinced that the atom could be harnessed for peaceful purposes to harbor huge economic potential. The US also realized that the nuclear monopoly was hard to retain for long. The wheels of innovation could not be turned back and it was imprudent to assume that the USSR and other countries would not try to muster the great technology that had become the hallmark of super power status. Canada and United Kingdom (UK), US' war-time allies, were requesting nuclear knowledge and technology for peaceful uses in recognition of their contribution to the war-time nuclear project. They had already committed not to divulge nuclear technology, information and secrets to a third party without mutual consent under the secret Quebec agreement (August 1943) (atomicarchive.com 1998).

One of the prominent earliest efforts at regulation of the nuclear energy can be traced to this period characterized by uncertainty and confusion among the policy-making circles in the US. Scientists like Neils Bohr and Oppenheimer believed that the nuclear secrecy and monopoly would not last long as both the technology and the material exhibited wide geographical distribution and so proposed that the establishment of an international body to control the atomic energy venture was a less risky idea than engaging in an arms race (Lavoy 2003). It was, therefore, of utmost importance to devise a regime that could enable sharing of nuclear technology without risking the proliferation of nuclear weapons. The power politics of those days informed by super-power rivalry in a cold war context and risks of nuclear proliferation shaped the nature and mandate of this agency (IAEA) when it was finally established in 1957. These series of events will be discussed in the next three sub-sections.

Baruch Plan: A Prelude to the Establishment of the IAEA

Two initiatives led by US tried to envisage an international agency to manage civilian nuclear activities – The Baruch Plan and the Atoms for Peace programme. On 15 November 1945, the US Great Britain and Canada jointly declared that they were prepared to share the knowledge pertaining to peaceful industrial uses of atomic energy on a reciprocal basis with the member states of the United Nations (UN), “just as soon as effective enforceable safeguards against its use for destructive purposes [could] be devised” (Szasz 1970: 12). Since the UN Charter had already been drafted and inadequate to accommodate this new dynamic of a nuclear world, they proposed the establishment of a specialized commission within the UN in order to control atomic energy in a way as to enable its use only for peaceful purposes, elimination of nuclear weapons from national armaments and devising a system of effective safeguards equipped with power of inspection and other means to protect complying states against the hazards of violations and evasions (UNGA 1946).

Any efficient regime for promotion of nuclear energy while not risking proliferation, could not be established without the support of Soviet Union, which by this time was ardently pursuing its nuclear research. With the Soviet consent for the proposal, the four nations issued a joint communiqué on 27 December 1945 that called for the establishment of the United Nations Atomic Energy Commission (UNAEC) to recommend on the issues of control of peaceful uses of atomic energy; elimination of nuclear weapons; application of verification and compliance measures simultaneously and reporting to the Security Council. The commission was unanimously endorsed by the General Assembly in its very first resolution (United Nations 1970). This was the first ‘international’ attempt at regulating the control and dissemination of nuclear technology.

Reflecting upon the mandate to be accorded to the UNAEC, the Acheson- Lilienthal report formulated by the US state department in March 1946 concluded that as no country could be trusted on its own not to attempt nuclear weaponization through the diversion of fissile material from energy production, an international agency should be entrusted with the job of undertaking all the 'intrinsically dangerous operations in the nuclear field, with individual nations and their citizens free to conduct, under license and a minimum of inspection, all non-dangerous, or safe, operations' (US Department of State 1946). An agency with mere inspection powers would lack in the technical and operational skills required to detect the changes in scientific technology and procedures that could be adopted by states to produce nuclear weapons illegally. So, the only effective method, it advised plausible, was through the creation of an international agency with the political and technical capabilities to monopolize the dangerous nuclear operations and research, including the field of nuclear explosives. It would own, operate and develop nuclear science and technology on behalf of all nations and be the owner of nuclear ores and fuels. International inspectors, could be then entrusted the task of discovering clandestine nuclear activities within a state. (Goldschmidt 2006).

The Baruch plan, presented to the United Nation Atomic Energy Commission (UNAEC) in 1946, borrowed heavily from the Acheson-Lilienthal report, but put more stress on the safeguards aspect to be comprising of more than inspection rights. It proposed the formation of an International Atomic Development Authority, which was to conduct surveys and possess all the uranium, thorium and other fissionable material. All other nuclear activities were to be permitted by its authority that could be leased to the states only under safeguards. This proposal desired a supra-national international agency whose primary responsibility would be verification through inspection. This meant agency was to be given adequate freedom of access to the member states and also a right to punish the violations. The inspectors were to be recruited for their proven competence on an international basis (Baruch 1946). It also proposed that the members should not be allowed the veto power to avoid penalties against atomic energy violations and till the time such an international agency was effectively operational, the US shall have the monopoly over nuclear weapons, after which existing nuclear weapons could be destroyed and weaponization could be banned altogether (Kearn 2010, Goldschmidt 1986).

This shift from national to international management of nuclear activities was to be done in stages and the last stage envisaged surrender of nuclear weapons (till this time only with US) to the commission. Not surprisingly, the Soviet Union rejected this proposal and the underlying agenda of maintaining the atomic disparity that accrued great coercive powers to the US. It also opposed intrusive inspections as a threat to its sovereignty (Lavoy 2003). A voting on this plan on 30 December 1946 saw 10 in favour while Poland and USSR abstained (Goldschmidt 2006). For the next two years and over 200 meetings, even within the US camp, disagreements were abounded on several issues like possession of ground ores of uranium and thorium.[5] The UNAEC informed the Security Council of its impasse and the proposal fell through.

With a failure to institute the international agency, international attention shifted to traditional disarmament. Throughout 1946, the US. continued increasing its nuclear stockpiles but forbade the export of nuclear materials and associated technical information under its atomic energy act. As the proposal for 'supra-national' atomic agency did not take off, the UN focused on international arms control and the US government enacted the Atomic Energy Act in 1946. An independent atomic energy commission (civilian) to monitor nuclear research and progress with a "rigid system of security classification and export licensing", came into being (Lavoy 2003).

The USSR detonated its first nuclear device in 1949 and the UK in 1952. The UNAEC was finally merged into the commission for disarmament and the only ever initiative of entrusting the entire control of dangerous nuclear activities to an international agency was cast aside.

The idea of a supra-national agency over and above the national entities, handling nuclear operations, although seeming a great stride, fell short of adequate regulatory credentials. To Though nuclear energy and nuclear weapons both were considered as important agendas, the strategic imperatives undermined the establishment of a robust and credible civilian international agency. The contents of official texts produced during these formative years emphasized on 'management' and lacked an emphasis on 'regulation' as a concept or a strategy. Tremendous emphasis on nuclear weapons therefore led to a

[5]Belgium and brazil insisted that ground ores of uranium and thorium be owned by the respective states themselves. After extraction, however, they could be owned by the international agency (Goldschmidt).

sidelining of nuclear energy management concerns which could later be revived only with the ‘atoms for peace’ programme.

‘Atoms for Peace’ Programme

The next effort at international ‘regulation’ of atomic energy came through the momentum generated after the ‘Atoms for Peace’ speech of the US president Eisenhower. Originally intended to focus on the destructive potential of nuclear technology, Eisenhower insisted on the inclusion of ‘peaceful uses of nuclear energy’ as one of the objectives in the Presidential address of 8 December 1953 (Bechhoefer 1959). He invited ‘principally involved’ governments “to make joint contributions from their stockpiles of normal uranium and fissionable materials to an international atomic energy agency” under the aegis of the United Nations (Eisenhower 1953).

Eisenhower’s speech was motivated by interests in gains from nuclear commerce. The US was developing technologies to harness the power of atoms on an increasing scale but required a larger skilled manpower from across the world in a spirit of positive international cooperation in the field of new technology. A wide application of nuclear energy across the world could prove beneficial for finding new markets for the American industry. Under its domestic act, the US had placed an embargo on export of nuclear material and technology; while internal nuclear commerce was allowed, trading with outside world was not. The US wanted to make sure that a system of effective and enforceable international safeguards against destructive use of atomic energy had been established before a wide application of nuclear energy could be promoted (Hall 1965). But by mid-1950s, more countries were carrying out research in this field. Also, other nuclear powers like Soviet Union were not observing the same degree of restraints as the US. Therefore, the idea of embargo was not as effective in curtailing proliferation as much as it was costing to the American nuclear industry by limiting their growth potential. American stringent export laws were proving ineffective in maintaining secrecy and it feared that international nuclear commerce and cooperation would be developed without Anglo-Saxon participation, and above all, the US desired to “initiate a process of détente and disarmament” (Goldschmidt 2006).

The Atoms for Peace programme offered multiple benefits to the US. It could divert public attention from a huge defence budget committed to the improvisation of the lethality of nuclear weapons; serve as a “direct challenge to the Soviets’ near monopoly of ‘peace’ propaganda” (Jackson cited in Weart 1988); arrest the nuclear weapon programme of the Soviet Union and other countries by encouraging a diversion of limited nuclear material for the civilian uses; help boost the American dominance and prestige in the field of science and technology (psychological warfare); and as a propaganda tool, present a humanist and benevolent image of America which despite its mastery over the destructive power of the atom was spending in the peaceful uses of nuclear energy (Krige 2006). Keeping these benefits in mind, the US revised its domestic act for nuclear trade in 1954. Initially, the revised amendment of the US Atomic Energy Act did not make verification and safeguards as the pre-requisites for international cooperation but provided that in case of agreement of cooperation, the parties needed to mention the terms, conditions, duration, nature and scope of cooperation and to ensure that no material transacted therewith could be used for atomic weapons or transferred to unauthorized entities (Patterson 1955). The new act allowed the transfer of fissile material to other countries governed by specific terms and agreements for each. The bilateral trade between the US and other countries led to the creation of a set of safeguards and verification system which was later incorporated by the IAEA constitution in its draft. On the other hand, eventually, bilateral nuclear agreements ended up curtailing the mandate of the IAEA which neither became the sole repository of fissile material nor the sole agency to devise universal guidelines for such exchanges. The provisions that were borrowed from the US Atomic Energy Act had already been considered inadequate in the Acheson- Lilienthal report (Hall 1965). The bilateral trading arrangement also boosted regional nuclear trade regimes like EURATOM which constrained the usefulness of the proposed agency. The technological and economic assistance offered through the programme, contributed significantly to the Indian and Pakistani nuclear weapon programmes (Lavoy 2003: 27).

This attempt at the creation of an international agency as the ‘watchdog’ in the matters of peaceful uses of nuclear energy could become feasible only with the huge dilution in the mandate it was envisioned for. The IAEA came to adopt a weak and ineffective mandate with respect to the expectations it was supposed to live up to. The context of the Cold War on the one hand, impeded an expanded mandate of regulation that could be assigned to the IAEA and on the other hand, persuaded the super powers to adopt a mutually cooperative attitude keeping in mind the reputational costs associated with the opinions of the newly emerging third world countries. At the same time, the mutual aim of limiting proliferation of nuclear weapons brought the two superpowers to negotiating table once again. In the words of Lavoy, the Atoms for Peace programme helped in producing “many of the most important elements of today’s nuclear nonproliferation regime: International Atomic Energy Agency (IAEA), the concept of nuclear safeguards, and most importantly, the norm of nuclear nonproliferation” (Lavoy 2003: 26). The atoms for peace programme was welcomed by many developing and developed countries which expressed their support for establishing an international body under the United Nation’s aegis to promote peaceful uses of nuclear energy.

Establishment of the International Atomic Energy agency (IAEA)

The emerging consensus on the establishment of an international body to manage the peaceful uses of nuclear energy led to the extensive negotiations among some 80 countries in 6 stages for the establishment of the IAEA from January to September 1954 through 13 documents (Bechhoefer 1959). For the USSR, the disarmament question was one of the fundamental ones and needed to be resolved before considering the distribution of fissionable material for civilian purposes. The US insisted on separating the mandate of the IAEA from that of disarmament, which was later agreed upon by the Soviet Union. This change in Soviet attitude was partly due to the unilateral insistence of US to speed up its program of harnessing peaceful potentials of nuclear energy with or without the help of Soviet Union. In order to allay the Soviet suspicions regarding the impartiality of the IAEA, the US representative in the UN General Assembly clarified that the agency would not have its authority over all the transactions of the member-states but will approve only those projects and material over which the agency would secure the right to mandate approval by the member-states.

> The Agency would concern itself only with the materials specifically earmarked for Agency projects by the contributing states. It would have no control over the use of any other fissionable material. Any contributing state would remain free to transfer fissionable materials to another state without securing the consent of the Agency (Skogmer 2004: 27).

However, over a period of time, the US also shifted its position and was not willing to empower the supra-national agency so much that it could control all the peaceful uses of nuclear energy and be the supreme authority to decide in such matters over and above the sovereignty of the member states.

Gordon Dean (1954), a former chairman of the United States Atomic Energy Commission (1950-53), argues that the Atoms for Peace programme eventually helped in proliferation.

As the technology for energy and weapon generation is similar to some extent, the IAEA-assisted nuclear commerce helped proliferation in a more effective manner than the then prevalent technology denial regimes created by the US. The energy deficient countries were keen to exploit atomic power and some started clandestine research causing higher risks of proliferation; India being a case in point.

Bechhoefer (1959) argues that the establishment of the IAEA was cumbersome with regard to the third umbrella objective (indirectly but clearly) that concerned with non-proliferation and to an extent disarmament. This implied consultation with Soviet Union and other stakeholders at every stage and for every minute detail. Because of the emphasis on the 'negative' aspects pertaining to safeguards and non- diversion to military uses, the peaceful aspects suffered a consequential delay. Thus, the civilian and military uses of nuclear power and correspondingly 'regulation', ran in tandem with each other since the very beginning.

The IAEA became more pressing importance in the following years with a universal realization that atomic energy operations could have trans-boundary effects and the control and management of such activities was required also for saving populations from the harmful impact of radioactivity (Hall 1965); this required a collaborative and piecemeal approach which could only be garnered by an international agency equipped with technological, political and normative mandate to regulate.

Against this background, once the IAEA was established in 1957, it was entrusted with the mixed responsibilities of managing proliferation concerns along with promotion of safe uses of nuclear energy for peaceful purposes. However, the criteria of ownership of nuclear ores and material was separated and finally discarded in favour of control of atomic energy because of uncontrolled traffic in atomic minerals (Hall 1965). Despite being the apex and most widely appreciated body of international technical expertise in the matters of nuclear energy, the IAEA has not been designated as a regulatory body. In fact, the regulatory mandate is indirectly premised in its official role as promotor of 'safe and peaceful uses' of nuclear energy. In order to promote safe and peaceful uses, countries carrying out nuclear energy programs should abide by certain standard technical practices and organising principles.

On the other hand, the non-proliferation-related mandates, observable in the IAEA safeguards regime, are more pronounced, both in letter and spirit, reflecting a preponderance of nuclear weapon discourse over the civilian one. This aspect will be discussed in detail in the following sections dealing specifically with safety and safeguards regulation.

In general, security, safety and safeguards aspects are not mutually exclusive and their boundaries overlap in technical and conceptual terms (Higinbotham 1979). Various technical specifications simultaneously function for two or all the domains. For example, the construction of physical barriers of steel and concrete helps enhance both the safety and security by blocking the radioactivity release and intrusions respectively. Similarly, the practice of nuclear material accounting can help the concerns of security and safeguards both. A closed fuel cycle, by its nature is more proliferation-resistant and leads to reprocessing of nuclear waste, making the residue less harmful in terms of safety. The over-lap is disadvantageous too in certain respects. For example, the concerns of nuclear safety require a more transparent system, which may prove risky in terms of security, which requires more confidentiality. In general, security consciousness gained prominence in relatively recent decades than nuclear safety (Alger and Findlay 2010). These also explain why the nuclear safety regime is much more stable, robust and extensive as compared to the nuclear security regime which evokes the dangers of information leakage, industrial espionage and sovereignty violation in more complex ways.

In terms of historical evolution, one can find a graded approach with respect to safety, security and safeguards. Till 1950s, the safety and safeguards were the main concerns for nuclear community. Concerns about proliferation shifted priority toward safeguards. In the 1960s and 1970s civilian nuclear commerce led to vast transportation of these materials and associated tools from supplier countries to the recipient ones; therefore, new concerns towards physical protection of nuclear material emerged. 1990s onwards and especially after 9/11, the threat perception focused on nuclear terrorism. With rising instances of accidents and advances in global communication systems, the motivation and ease of knowledge sharing (Addison 2009) have gained prominence. To understand the international regulatory framework, this chapter deliberates on the three aspects i.e. nuclear safety, security and safeguards. Though their boundaries are not often clear, there is a dominant perception that the three aspects should be assessed distinctly in their own rights. The structure of this chapter follows this line of reasoning and outlines the three aspects separately. The next section deals with the safety-related mechanisms of international nuclear regulatory framework.

Table- 2.1. Major mechanisms pertaining to international nuclear regulatory framework

S. No.	Safety	Security	Safeguards
1.	Convention on Early Notification of a Nuclear Accident, 1986[6]	Convention on the Physical Protection of Nuclear Material, 1980[7]	Classic Safeguards or Item-Specific Safeguards (1965, 1966 and 1968) INFCIRC/66/Rev.2
2.	Convention on Assistance in The Case of a Nuclear Accident or Radiological Emergency, 1986[8]	Code of Conduct on The Safety and Security of Radioactive Sources, 2003	Comprehensive or Full Scope Safeguards (1972) INFCIRC/153/Corrected
3.	Convention on Nuclear Safety (1994)[9]	Un Security Council Resolution 1540 (2004)	Strengthened Safeguards or Additional Protocol (1997) INFCIRC/540/Corr.1
4.	Code of Conduct on The Safety and Security of Radioactive Sources, 2004	International Convention for The Suppression of Acts of Nuclear Terrorism (2005)[10]	Integrated Safeguards System (1999)
5.	IAEA Safety Fundamentals, Requirements, Practices and Guides (over several years)	Amendment to the Convention on the Physical Protection of Nuclear Material, 2005[11] (yet to enter into force)	Export Control Regimes: a) Nuclear Suppliers Group (NSG) (1974) b) Australia Group (1985)[12]

6 India signed it on 29th September 1986 and ratified on 28th January 1988.

7 India deposited the instrument on 12th March 2002. (IAEA 2017b)

8 India signed it on 29th September 1986 and ratified on 28th January 1988.

9 India signed it on 20 September 1994 and ratified on 31st March 2005.

10 India signed and ratified it in 2006 (Rajagopalan 2015: 46).

11 India deposit the instrument on 19th September 2007 (IAEA 2017b).

12 India became a member on 19th January 2018 (Bhattacherjee 2018).

			c) MTCR (1987)[13] d) Wassenaar (1996)[14]

Source: Author

2.2. International Nuclear Safety Regulations

This section will discuss safety related regulatory mechanisms, institutions and processes and analyse their nature in terms of their effectiveness, authority and mandate. It also analyses the reasons for the shift in the safety mandate of the IAEA over the years.

The IAEA Nuclear safety standards programme defined nuclear safety as the "protection of *all persons* from undue radiological hazard" (Hurst n.d.: 51)). The IAEA Fundamental Safety principles 2006 modified it as "protection of '*people and the environment* from harmful effects of ionizing radiation" (IAEA 2006: 2).

The IAEA safety glossary (2007: 116) defines it as "the achievement of proper operating conditions, prevention of accidents or mitigation of accident consequences, resulting in protection of workers, the public and the environment from undue hazards." The approach therefore aims at prevention of accidents in the first place and if they do occur, to adopt adequate and proportionate mitigation measures to protect the humans and environment alike. The safety preparedness requires the capacity to handle and mitigate the varied nature of accidents, be they man-made, naturally induced or a combination of both. The goal of environment protection however does not find explicit mention in the IAEA statute (Pelzer 2013). The 2009 EU directive on nuclear safety is almost the same as that adopted by the IAEA, except that it does not explicitly mention protection of environment. These definitions, therefore evolved with time and took a lot of diplomatic effort to be framed subsequently. The next sub-section analyses the underlying tension in the IAEA mandate between promoting nuclear energy operations and safety regulation.

Initial mandate of the IAEA

Article II of the IAEA statute (1956) states its objectives as

[13] India became a member of Missiles Technology Control Regime (MTCR) on 27th June 2016.

[14] India became a member on 7th December 2017 (Panda 2017).

> to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world. It shall ensure, so far as it is able, that assistance provided by it or at its request or under its supervision or control is not used in such a way as to further any military purposes (IAEA, 1956: 5).

These objectives clearly reflected an innate agenda towards promotion of nuclear energy, conditional to the concerns of nuclear non-proliferation. The safety concerns do not figure out in the IAEA's objectives at least initially. Also, since the agency's primary mandate has been to promote the peaceful uses of nuclear energy, its role as regulator of nuclear activities to ensure safety and security, appeared restricted and relatively less prioritized. In fact, the IAEA has nowhere been designated officially as an international nuclear regulator. At the same time, the twin agendas of promotion of peaceful uses along with non-proliferation are somewhat contradictory as a "spread of peaceful nuclear energy equates to the spread of knowledge about the fundamentals of nuclear weapons technology" (Persbo et al. 2005: 1).

The initial negligence for safety concerns emanating from the radioactive nature of the fissile material are partially accounted for by the fact that the IAEA's statute was highly borrowed from the American Atomic Energy Commission (AEC) which under the leadership of Lewis Strauss was in denial of severe effects of radioactive fallout on human lives. The tasks of promotion of nuclear energy necessitated that the public concerns on safety be mitigated or reduced to a minimum. It was necessary to alter the malevolent image of nuclear power. A recurring concern about nuclear safety could jeopardize the future of nuclear energy.[15]

Even as 'safety' was not identified among the stated objectives, it was listed as one of the functions of the IAEA. Article III of the IAEA statute (III.A.6) identifies one of the functions as

> to establish or adopt, in consultation and, where appropriate, in collaboration with the competent organs of the United Nations and with the specialized agencies concerned, standards of safety for protection of health and minimization of danger to life and property (including such standards for labour conditions), and to provide for the application of these standards to its own operation as well as to the operations making use of material, services, equipment, facilities and information made available by the Agency or at its request or under its control or supervision; and to provide for the application of these standards, at the request of the parties, to operations under any bilateral or

multilateral arrangements, or, at the request of a state, to any of that State's activities in the field of atomic energy (IAEA 1956- III.A.6: 6-7).

This stands in contrast to the mandate covering safeguards, which has been emphasized recurrently throughout the statute. The IAEA was set up with the agenda of supplying nuclear material and technology to needy countries, conditional on the recipient states' strict adherence to the international safeguards regime comprising of inspections and verification. This international control and supervision were not proposed with the same rigour when it came to the protection of health and environment against the risks of radioactivity and hazards in the operation of nuclear energy. The IAEA has developed several reports and guidelines concerning the safety aspect, but none of these were made binding international obligations upon the states to comply with. The inspection rights which hold so much prominence in the non-proliferation domain were not extended to the safety concerns with equal rigour. As a supra-national authority, the IAEA holds many overwhelming rights and privileges in the matters of non-proliferation, lending it a unique status. However, the corresponding safety regime is comparatively backward (Kaminga, M. T. 1995).

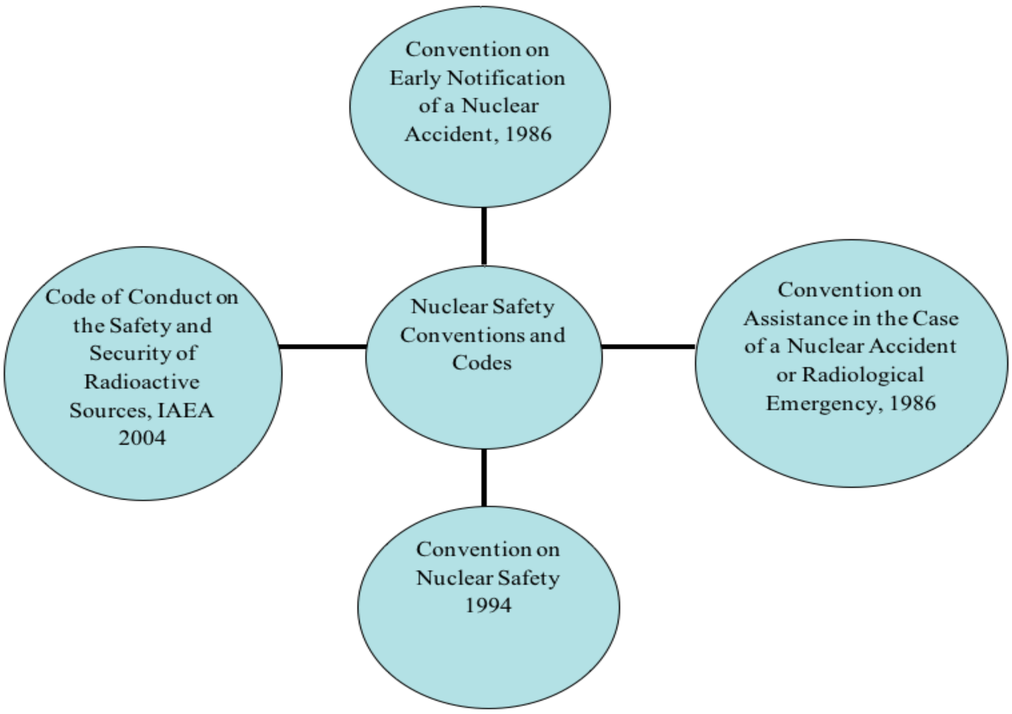


Figure- 2.1. International Safety Conventions

Source: Author

The IAEA's statute does not designate it as a regulatory agency in letter but there is a tacit assumption that the agency can fulfil the mandate of setting safety standards and observe compliance under conventions, if authorized to do so. For example, IAEA codified a set of non-binding practices for the Basel Convention on international trans-boundary movement of radioactive waste. However, the agency's role was limited to promulgation and codification of standards and it cannot observe compliance in its own right. The IAEA can impose safety standards only on the projects in which it has aided the member-states.

The IAEA statute had authorized safeguards inspectors to also observe the health and safety standards in the facilities where it is mandated to apply nuclear safeguards. However, with the adoption of NPT, where all the Non-Nuclear Weapon States (NNWS) are obligated to comply with the safeguards, the safety aspects, do not find a place in the NPT induced obligations and have therefore been marginalized.

The Codes of Conduct essentially propose a mid-point between binding conventions (of limited value given the sovereign reluctance of states) and non-binding recommendations of the IAEA. These are applicable if the states incorporate them into national legislation and then implement or by adopting them as self-executing (Wetherall 2005). These codes, therefore, have little legal relevance. However, if these codes are adopted as obligations under multilateral or regional agreements, then mutually agreed mechanisms of reporting, peer review mechanisms and such can be instituted to ensure their compliance by the member states. This depends on political will and commitment towards safety. For instance, Code of Conduct on the safety of research reactors, proposed at the insistence of INSAG at the IAEA General Conference in 2004, has provisions for periodic meetings and regional meetings of members to share experiences, lessons learnt and best practices gathered through self-assessment.

Codes of Conduct as instruments of regulation, however, remain more free-standing as compared to the treaties to that effect and are more amenable to political scrutiny than legal one. IAEA's safety codes and guidelines, even when non-enforceable mostly, serve as important benchmarks which national governments adopt to maintain safe nuclear operation. This normative aspect of IAEA's role in safety regulation is discussed in the next section.

Normative, Infrastructural and Technical Role of the IAEA

The agency's role in nuclear safety, Fabrizio Nocera (2005: 13) argues, is as "norm entrepreneur as it provides the 'common technical matrix' which is used by the national regulators to base their rules on, often guided by the agency itself. Post Chernobyl the IAEA revises and upgraded its guides; it issued a hierarchical ranking of its various safety documents in 1989. There are more than 200 such documents till date. IAEA has clubbed these documents under three categories:

- Safety Fundamentals- lay down the basic objectives, concepts and principles. These are to be complied with without exception.

- Safety Standards- lay down the basic requirements to be fulfiled in case of particular applications and activities. These should be followed by new facilities while the previously existing ones should apply them within a reasonable time of adjustment

- Safety Guides- lay down the recommendations derived from international experience over the years and 'should be followed to ensure safety'. These are practical suggestions and should be followed unless viable alternatives to these are available (Gonzales 2002).

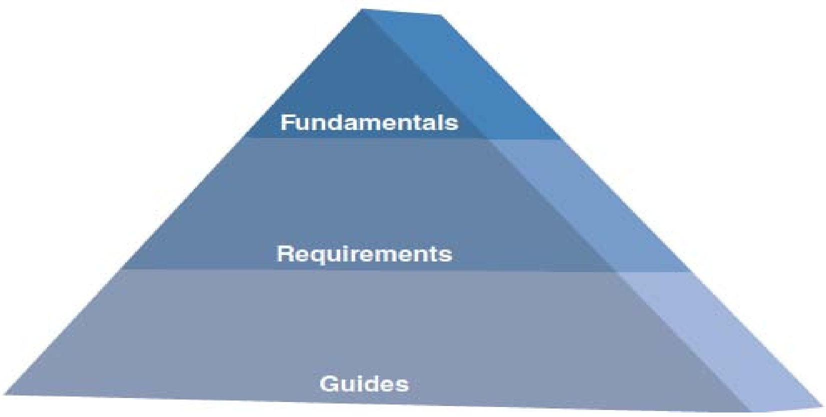


Figure- 2.2. IAEA Safety Fundamentals

Source: Findlay, T. (2012), "Unleashing the Nuclear Watchdog: Strengthening and Reform of the IAEA"

However, the safety fundamentals are very general in nature and not binding on the member –states. These are binding on the IAEA though in its dealing with the nuclear facilities of the member states.

<u>Table- 2.2.</u> <u>IAEA Fundamental Safety Principles</u>

Responsibility for Safety	The prime responsibility for safety must rest with the person or organisation responsible for facilities and activities that give rise to radiation risks.
Role of Government	An effective legal and governmental framework for safety, including an independent regulatory body, must be established and sustained.
Leadership and management for safety	Effective leadership and management for safety must be established and sustained in organisations concerned with, and facilities and activities that give rise to, radiation risks.
Justification of facilities and activities	Facilities and activities that give rise to radiation risks must yield an overall benefit.
Optimization of protection	Protection must be optimized to provide the highest level of safety that can reasonably be achieved.
Protection of present and future generations	Measures for controlling radiation risks must ensure that no individual bears an unacceptable risk of harm.
Protection of present and future generations	People and the environment, present and future, must be protected against radiation risks.
Prevention of accidents	All practical efforts must be made to prevent and mitigate nuclear or radiation accidents
Emergency preparedness and response	Arrangements must be made for emergency preparedness and response for nuclear or radiation incidents.
Protective actions to reduce existing or unregulated radiation risks	Protective actions to reduce existing or unregulated radiation risks must be justified and optimized.

Source: IAEA (2006). "Fundamental Safety Principles." *IAEA Safety Standards Series No. SF-1*. Vienna: IAEA: 5–16.

A series of multi-lateral and bilateral technical programmes are being run to strengthen the safety standards of operating reactors worldwide. However, the IAEA does not hold a right to review the national facilities on its own. It requires requests from the member states to conduct such reviews. Also, these can only be conducted in the facilities that the member states specify. Therefore, these reviews may not be considered comprehensive for all purposes. Also, their recommendations are not binding but advisory in nature and mostly confidential.

An international regulatory framework comprising of binding commitments especially in the safety domain has not been a popular idea. Even after the Three Mile and Chernobyl incidents, a pro-active convention on nuclear safety with binding commitments was opposed by the states like Britain and France, who believed that the non-binding codes and guides along with convention related to accidents would be sufficient (Ahearne 1987). However, the growing realization that the Chernobyl was not an isolated incident and certain facilities especially in eastern and central Europe were vulnerable to safety failure prompted the formulation of the first legally binding nuclear safety convention in 1994 i.e. Convention on Nuclear Safety.

The IAEA also offers Integrated Nuclear Infrastructure Review Services for states installing nuclear power plants for the first time. To assist its member states in safe operations, the IAEA offers various review services related to different aspects of safety regulations. Its Nuclear Safety Review Services include:

- Operational Safety Advisory Review Teams (OSART) – reviews operational safety standards of countries.
- Peer Review of Operational Safety Performance Experience (PROSPER)- reviews the credentials of reactor operators and assesses the availability of comprehensive information, reliability and capability of plant personnel, management practices etc. and offers recommendations in case of inadequate compliance with the international standards. It thus partially fulfils the obligations of states under the CNS.
- Integrated Regulatory Review Service (IRRS) - started in 2005 integrated all the earlier existing aspects of regulatory bodies in the realm of nuclear safety and radiological protection. It is not an audit or inspection kind mechanism but more of a peer review mechanism which suggests scopes for improvement. The national regulator carries out self-assessment against the IAEA Fundamental Safety Standards and these reports along with the new findings during the review are deliberated upon by the expert team. Safety Culture Assessment Review Team-conducts a thorough review of the safety culture at particular nuclear facilities and offers recommendations to improve the overall safety culture.
- Engineering Safety Review Services
- International Probabilistic Safety Assessment Review Teams

- Review of Accident Management Programmes
- Transport Safety Appraisal Service
- Education and training review service- self-assessment reports of states are internationally peer-reviewed and plan for implementation of recommendations.
- Emergency preparedness reviews
- Radiation safety appraisals
- Safety Aspects of Long Term Operation of Water Moderated Reactors Peer Review Service (IAEA 2008)
- Research reactor and Fuel cycle facility (FCF) safety review services- RR reviews cover the design, safety analysis, operational limits, regulatory credentials, reactor operation and maintenance, radiation protection and waste management etc. The FCF reviews cover conversion and enrichment facilities, fuel fabrication facilities, spent fuel storage facilities, reprocessing facilities, fuel cycle research and development facilities and waste conditioning facilities (IAEA 2014a).
- Safety Assessment Reviews
- Transport Safety Appraisals
- ARTEMIS- Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation- covers integrated review services for waste and spent fuel management, nuclear discharges into the environment, decommissioning of nuclear plants and environmental remediation of radiologically contaminated sites (IAEA 2017c).

In fact, states themselves carry out periodic safety reviews (by plant operators) and national nuclear regulatory bodies report these to the IAEA. On the other hand, special reviews are conducted by states after major safety related events. The IAEA may be invited to participate in these review processes. These reviews focus on plant specifications and their adaptability and propose modifications in plant designs, if any. However, such reviews are not mandatory for all the member states and many states, even when they carry out such reviews, may have their own criteria for national safety review mechanisms. For instance, the OECD countries have a “Joint IAEA-OECD/NEA International Reporting System for Operating Experience” (IAEA/NEA 2010). Even though external international agencies are involved in such inspections, they are not carried out in the spirit of audit but rather mutual learning and support group kind of mechanism based on a consultative approach.

The utility of the IAEA inspections for a cautious regulator, however, is no less pertinent. While the states have been forthcoming in allowing these peer reviews on a voluntary basis, there has not been a consensus on making them mandatory. Information generated through these reviews like identification of best practices and problems found within the existing review systems, help build the repository of knowledge that can be utilized by others not directly undertaking these review services (Addison 2009). Apart from these non-binding normative, technical standards, the IAEA has come to adopt a few binding conventions in the realm of safety as well, especially because of crisis events. These conventions will be discussed in the next few sections.

Binding Safety Regulations

This section will discuss the conventions and other crisis-related mechanisms that were instituted after the Chernobyl disaster when need for more than national safety regulations was realized by member-states of the IAEA.

The first globally binding international instrument for making it obligatory on the member states to apply the radiation protection norms was the International Labour Organisation No. 115 pertaining to Convention Concerning the Protection of Workers Against Ionizing Radiation, adopted on 22 June 1960 (Pelzer 2013). Recommendation No. 114, “Radiation Protection Recommendation, 1960”, was added later. These established a fundamental framework for radiation protection and applied to all activities causing exposure of workers to radiation. It required its members states to implement the convention through incorporation into laws, regulations, codes of practice or other such appropriate means. It also directed consultation with representatives of workers and employers (Pelzer 2013). It, however, was negotiated outside the IAEA. Low number of signatories (around 50) with the exception of major states like Canada, China, Pakistan, North Korea, US and so on, the global nature of the convention was lost (International Labour Organisation 2017). At the regional level, however, binding international radiation protection norms were enforced in the Organisation for European Economic Co-operation (now OECD) and in EURATOM in 1959.

The next wave of support for binding safety conventions came after the Chernobyl incident in 1986. The disaster shook the public confidence in nuclear energy installations and to manage the damage, the IAEA moved quickly to propose two conventions which were widely agreed upon- 1) the Convention on Early Notification of a Nuclear Accident, 1986 (122 parties, 69 signatories) (IAEA 2018a) and 2) the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, 1986 (117 parties, 68 signatories) (IAEA 2018b) (as of November 2018). Apart from the transport related laws, this was the first time when an attempt to internationalize the nuclear safety concerns through a binding agreement was mutually agreed by such a large number of states. Both these conventions, however, have a reactive approach to safety and covered the aftermath of a nuclear incident or accident. These conventions do not cover the preventive aspects. The first convention requires that the state party, in case of a nuclear accident within its jurisdiction, shall inform other states either directly or through the IAEA, which are or may be physically affected by the incident of the nuclear accident. Information such as nature of incident or accident, the time and exact location of its occurrence and such other information which can be of help in minimizing the radiological consequences in those states. It authorizes the agency to inform all the member and non-member state parties which are or may be physically affected by the accident about the receipt of such notification and provide them with the information received to this effect (IAEA 1986a). It covers accidents at *all* (emphasis added) kinds of nuclear facilities. Each state party is obliged to provide the 'full details' of the accident, to the IAEA and the affected or likely to be affected state parties and to ensure the identification of a 'competent authority' and 'point of contact' to ensure the coordination of information exchange in such times.

The latter convention emphasizes on cooperation between state parties and requires the IAEA to facilitate prompt assistance in case of nuclear accident or radiological emergency so that a damage to life, property and environment from the radioactive releases can be minimized. It obligates the agency (IAEA) to respond to the requesting state party's or a member state's request for assistance in case such a nuclear accident or radiological emergency happens by:

> a) making available appropriate resources allocated for this purpose;
>
> b) transmitting promptly the request to other states and international organisations which, according to the Agency's information, may process the necessary resources; and

c) if so requested by the requesting State, co-coordinating the assistance at the International level which may thus become available (IAEA 1986b).

The conventions do not specify the finer details that could be implemented and leave it to the states to do it through complimentary agreements at bilateral or regional levels, for instance - 'Whether an incident may or has consequences for other states through transboundary release of radioactivity.' This reluctance on the part of member-states highlights the rather cautious attitude of signatories towards binding international obligations in the domain of nuclear safety which till then was managed primarily through the domestic set ups (Pelzer 2013).

Both the conventions require the IAEA to keep a database of the 'competent authorities' and 'point of contact' at all times to enable coordination between the state parties and relevant international organisations. The IAEA and the Nuclear Energy Agency (NEA) together devised the International Nuclear and Radiological Event Scale (INES) in 1989 to assess the severity of nuclear and radiological events for the public purpose. Originally meant only for nuclear reactor accidents, in 2009, the INES was extended to cover other events too involving transport, storage and use of radioactive material and sources.

To deal with nuclear emergencies, the IAEA also established the mechanism of Emergency Preparedness Review Teams in 2004 to review the emergency preparedness of states and offer recommendations for improvement. However, these can be dispatched only at the request of the state.

Crisis-events challenged the inertia and unwillingness of member states to coordinate their efforts at nuclear regulation, though in a very limited and reactionary manner. There have been demands for binding international regulatory control in the field of nuclear safety since 1960s, however, the states with major nuclear programmes often resisted these and argued that the safety was primarily a national concern and any attempt at stringent international regulation would infringe the sovereign rights of the states in managing their nuclear activities. Such attempts were also justified in the name of varying regulatory need and standard specifications associated with different nuclear technologies. With the growing reactor technologies, it was considered prudent that even when the states observed safety standards of the IAEA, specific demands of their respective nuclear technology program were taken into account. It was argued that any standardization may miss the safety issues specific to different reactors (Kaminga 1995). After Chernobyl, these considerations were nuanced and more effort was directed at instituting mechanisms that could ease the handling of a post-crisis situation. This effort at internationalization of nuclear crisis management later extended to management of reactor safety during peace times as well. Culmination of it was the convention on nuclear safety which was proposed in 1994.

The Convention on Nuclear Safety (CNS)

This section will analyse the convention on nuclear safety which is one of the most exhaustive binding safety convention as a part of international civilian nuclear regulatory framework.

Drawing upon the enthusiasm and caution among member states in the field of safety regulations, the ‘Convention on Nuclear Safety’ was proposed to ensure standardization of safe practices in nuclear reactor operations. As of November 2018, there have been 85 contracting parties, and 65 signatories (IAEA 2018c). It borrows the technical parts mostly from the IAEA Safety Fundamentals which were published by the IAEA Board of Governors (BoG) in 1993 and is widely consented to by the states. The acknowledgement is not explicit though. As these technical aspects are already consented under the IAEA auspices, the convention has essentially made them binding. However, while the safety fundamental accords nuclear safety the “highest priority”, the convention talks about giving safety its “due” priority (IAEA 1994).

The CNS applies to all the *land based* (emphasis added) nuclear power reactors; existing, decommissioned and future; and covers radioactive waste and spent fuel if stored or treated at those sites. It however, does not cover the entire fuel cycle and so fuel fabrication, enrichment facilities etc. lie outside its purview. The convention covers the siting, design, construction and operation of nuclear reactor facilities, provisions for availability of adequate financial and human resources, quality assurance, assessment and verification of safety, radiation protection and emergency preparedness.

The treaty aims at creating a nuclear safety regime through national measures and international cooperation in order to protect the population and environment from the potential effects of radioactivity and to prevent and/or mitigate the consequences in cases of radiological emergency. Its obligations on states are primarily divided into four parts: general provisions, legislation and regulation, general safety considerations and safety of installations. This convention is the most explicit legally binding convention pertaining to the affairs of regulation. Article 2 of the convention defines ‘regulatory body’ for each contracting Party as:

> …anybody or bodies given the legal authority by that Contracting Party to grant licenses and to regulate the siting, design, construction, commissioning, operation or decommissioning of nuclear installations” (International Atomic Energy Agency 1994: 2).

Article 7 lays down the Legislative and Regulatory Framework for the contracting parties and obligates the states “to establish and maintain a legislative and regulatory framework to govern the safety of nuclear installations” (IAEA 1994, article 7). This framework shall provide for:

- The establishment of applicable national safety requirements and regulations;
- A system of licensing with regard to nuclear installations and the prohibition of the operation of a nuclear installation without a license;
- A system of regulatory inspection and assessment of nuclear installations to ascertain compliance with applicable regulations and the terms of licenses; and
- The enforcement of applicable regulations and of the terms of licenses, including suspension, modification or revocation (IAEA 1994: 4).

Under Article 8, it also mandates that the “regulatory body be provided with *adequate authority, competence and financial and human resources* to fulfil its assigned responsibilities and an *effective separation* between the functions of the regulatory body and those of any other body or organisation concerned with the promotion or utilization of nuclear energy” is ensured (IAEA 1994: 4). It entrusts the primary responsibility of nuclear safety to the operators and proposes the need for a licensing system to ensure regulatory control over them. In accordance with other liability conventions, it too provides for routing of all the liabilities to the operators, in case of a nuclear accident or incident. Indian domestic civil nuclear liability law channelling a certain liability to suppliers under certain conditions, therefore, is a deviation from this norm.

The convention, however, neither accords to itself a decisive and binding regulatory power nor does it authorize the IAEA in that capacity. It explicitly mentions in its preamble that the “responsibility for nuclear safety rests with the state having jurisdiction over a nuclear installation” (IAEA 1994: 1). It describes itself as an ‘incentive convention’ and commits to the application of fundamental safety principles for nuclear installations. It does not credit the safety standards to the IAEA. In fact, the convention maintains an arms’ length distance from the IAEA. The Expert group that met to consider the outline of a convention on nuclear safety specifically argued that the IAEA should not be ‘given any new institutional role in the safety of nuclear installations’ (Unnumbered report cited in Szasz 1994). The state parties are not legally binding to adopt all the safety standards laid down by the Agency, but in case of non-compliance they would have to specify in the periodic peer- review meetings which are to be held with intervals not exceeding 3 years, as to demonstrate how their alternative arrangement ensures the same or better safety performance than the agency standards. It, nevertheless obligates the IAEA to provide a secretariat for the contracting parties and the Director-General of the IAEA is designated as the Depositor of the Convention.

Articles of the Conventions are addressed primarily to the Contracting Parties and not to the ‘Agency’ (IAEA). These lay down the broad framework to be followed by the member states in ensuring nuclear safety. As it does not take upon itself the regulatory role, there are no punishments mentioned in cases of violations. The member states are supposed to implement the safety standards and conduct national reviews and present the report at the meetings. Essentially, the convention does not provide for a verification and inspection regime on an international level but legally obligates the states to prepare their own safety review reports and therefore, runs on a mutual peer review system (of the submitted national reports) to ensure compliance. Inadequacies of national efforts could be highlighted at these meetings and the subsequent meetings could follow on the implementation of previous recommendations by the member states. It adopts the ‘naming and shaming’ technique to observe compliance form the member states. This is considered acceptable enough to account for the adequate international regulatory control in maintaining the nuclear safety standards. There is no provision for an outside assessment of such declaration. CNS, however, initiated the drive towards standardization of safety regulatory practices through binding commitments. This later culminated into another binding convention which is the subject matter of next section.

Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (1997)

A proposal for including safety management of radioactive wastes came to be discussed during the negotiation of CNS itself but it could not be included in the CNS because of a lack of consensus (Tonhauser and Prevor 2006). It was later adopted and opened for signature in 1997 and then entered into force in 2001. This convention has (as of November 2018) 80 state parties plus EURATOM (subject to entry into force) and 42 signatories (IAEA 2018d). India, Mexico, Pakistan and many countries with ambitious nuclear energy plans like Egypt, Bangladesh have not signed this convention. This convention aims to ensure a high level of safety in all the stages of spent fuel and radioactive waste management through national measures and international cooperation (IAEA 1997a). It closely follows the CNS model of national reports, periodic review meetings and peer review. The mandatory national reports require the details on state's safety practices in spent fuel and waste management, a list of the spent fuel management facilities, radioactive waste facilities, their location, essential features and inventory. Countries like India, Britain, France and Japan have not signed this convention on accounts of disagreements on the definition of spent fuel. The convention treats spent fuel within the category of radioactive wastes. India claims that spent fuel cannot be categorized as radioactive waste because it can be re-used to generate power (BSCAL 2013). India argued that initial understanding around 1994 was to have a convention on radioactive wastes but 1996 onward, it is being pushed to convert the radioactive waste convention as joint convention on spent fuel and radioactive waste (BSCAL 2013). France has proposed including 'spent fuel' as a separate category within the radioactive waste convention.

At the same time, India urges that if human safety is the prime concern, then wastes generated from the military facilities/installations too should be included in the convention. All five nuclear weapon states have opposed this. After several rounds of discussion, the draft included an understanding of spent fuel in two stages: 1) spent fuel as generated from civilian nuclear operations and 2) spent fuel at reprocessing facilities to not be covered except with the declared consent of the contracting party (Tonhouser and Prevor 2006).

Apart from these binding conventions, codes and review services, there are experts' forums like the INSAG, appointed by the IAEA Director General, which includes professional experts in the field of nuclear safety. Its reports are published as the IAEA safety documents. The Nuclear Energy Agency (within the Organisation for Economic Cooperation and Development) started the International Reporting System for Operational Experience (IRS) in 1983 and extended to include the members of the IAEA in 1996. It reports unusual incidents that can have safety implications, for example, unplanned shutdowns of nuclear power plant. It coordinates with national regulators and points out flaws, precursor events, and design flaws etc. which are then passed to the operators. Like other international safety regimes, reporting to IRS is voluntary on the part of the states. A similar reporting system is practiced by the World Association of Nuclear Operators (WANO) which comprises of states and private nuclear operators. Sharing of these experiences is vital to ensure learning in this field and could be useful in strengthening the safety credentials of nuclear industry. The Post- Fukushima Action plan envisioned closer cooperation between the IAEA and the WANO.

Multiple other expert groups operate under the IAEA/NEA, and work on different stages of nuclear fuel cycle toward preventive safety steps. The International Seismic Safety Centre, established post-Fukushima, has expedited its efforts on devising safety practices to prevent or mitigate the impacts of natural disaster like earthquakes, floods, volcanoes etc. All these institutions are knowledge-based centers which review best practices across the world, standardize them into codes and guides for wider implementation, offer training services to enable internalization of this knowledge and coordinate the safety related research across the world under its Technical Assistance Programme, mostly directed at developing countries.

In sum, the international nuclear safety framework is primarily normative and prescriptive in nature with no binding obligations. While there is an increasing amount of research, and understanding of radioactive impact of nuclear activities, there is a parallel discourse of de-securitization of the safety issue in order to avoid public paranoid. This subdued international framework apart from a few binding legal obligations, therefore, can hardly be characterized as comprehensive and adequate regulation. Also, the international nuclear regulatory system presupposes the safety and security responsibility of radioactive sources with the national authorities and therefore provides an appendage to self-regulation in that sense. At the same time, the regulatory oversight is more prominent in the safety of operating nuclear power plants and the same has been lacking for other aspects of nuclear fuel cycle pertaining to enrichment plants, reprocessing plants, fuel fabrication plants and so on.

Overall, one can observe a greater reluctance by sovereign member states to accept binding conventions and treaties. While the nuclear industrial economic concerns and the quest for preserving the national sovereignty overshadowed the emergence of an international regulatory control of civilian facilities pertaining to safety, similar apathy has not been witnessed in the 'safeguards' concerning non-proliferation. At the same time, as the IAEA is responsible for promotion of peaceful uses of nuclear energy, there is an inherent tension in its role as a regulatory agency. These concerns are not restricted to safety regulation alone. Security related regulatory mechanisms too, highlight the tussle between need for internationalization of regulatory standards and efforts and sovereignty concerns of member states. These dynamics will be discussed in detail in the next section.

2.3. International Nuclear Security Regulations

This section deals with nuclear security-related regulatory mechanism and institutions that constitute international nuclear regulatory framework, both within and outside the aegis of the IAEA.

The term 'Nuclear Security' has been defined as "the Prevention and detection of, and response to, theft, sabotage, unauthorized access, illegal transfer or other malicious acts involving nuclear or other radioactive substances or their associated facilities" (IAEA 2008: 12).[16] So, it includes the nuclear and radioactive sources both and is concerned with preventive as well as curative measures. The concern for security is unique in case of nuclear energy because of the dual use nature of the atoms and the strategic nature of nuclear energy facilities and processes. Such facilities are lucrative for terrorists to seize nuclear weapon-related material, technology or parts or even simply to create terror by disrupting these facilities. A malfunction or disruption in the civilian nuclear facilities too, can cause radioactive release and disrupt the daily lives, making them high-priority targets

[16]Working Definition established by the Advisory Group on Nuclear Security in 2002, December 1-5, 2003

of terrorists. Threats of nuclear terrorism may relate to an attack on such facilities, diversion and unauthorized use of such material, making of 'dirty bombs' etc.[17]

Radioactive sources emanating from industrial, medical uses, if left untreated or land in wrong hands, can also be highly risky and harmful. The agenda of security of radioactive sources gained global attention when a certain unaccounted medical material (Caesium-137) in Brazil in 1988 accidently killed several people, led to a contamination of thousands more and caused damage to the immediate environment. But it was only a decade later upon French insistence, at the International Convention on the Safety of Radiation Sources and Security of Radioactive Materials held in Dijon, that an action plan was formulated on safety and security of radioactive sources too (Findlay 2012). The IAEA had earlier published the International Basic Safety Standards for Protection against Ionizing Radiation and Safety of Radiation Sources in 1996, binding on those states that adopted these or were taking assistance from the IAEA.

The IAEA statute formulated at the time of its establishment lacked emphasis on nuclear security concerns. Its insistence on ensuring the non-military application of nuclear energy under its supervision or control was mainly derived from the objective of non-proliferation. Member states have been very cautious of sharing the security credentials of their nuclear facilities and material, hindering the kind of inspection envisaged under safety and safeguards regulations through international collaboration. The quest for ensuring nuclear security, therefore, has been a comparatively recent phenomenon. Against the background of the 9/11 attacks followed by a pro-active US war on terror, the UN resolution 1540, against nuclear terrorism was proposed. The next few sub-sections will analyse the specific instruments and mechanisms that have been evolved to guide states in their security preparedness.

Convention on the Physical Protection of Nuclear Material, 1980 (CPPNM)

The Convention on the physical protection of nuclear material is the only legally binding instrument on nuclear security that has been provisioned under the IAEA. It emphasizes on the protection of nuclear material during international transport and provisions for a

[17]Bertrand Goldschmidt (2006: 8) recounts that the idea of nuclear terrorism which is so relevant today was first talked about at the time of atoms for peace speech. The new agency that was initially proposed was conceived of as a 'bank' responsible for "receiving, storing and redistributing" (nuclear) material and "would have to be absolutely secure against theft". However, nuclear security as a separate issue focus emerged later in international domain.

framework for the protection, recovery and return of the stolen nuclear material. It was opened for signature in 1980 and entered into force in 1987 (155 parties and 44 signatories) (IAEA 2017b). It applies to nuclear material used for peaceful purposes during international transport and domestic use, storage and transport without affecting the sovereign rights of the states within their territorial jurisdiction. It requires the states to inform the contracting party in advance and ensure the adoption of security practices during international transport as prescribed by the convention in Annex I before undertaking the export or import of nuclear material or passage of nuclear consignment of a non-contracting party state (IAEA 1979). The contracting parties are also obligated to ensure the physical protection of nuclear material by incorporating the convention's guidelines with their national laws and observe those during use, transport or import and export of such material. The annex lists three categories of protection according to the nature of nuclear material. It requires the states to criminalize the theft of nuclear material within their national laws and provides for inter-state cooperation in case of breach or offences to nuclear security. All the state parties are obliged to notify a national point of contact to handle the affairs related to the physical protection of nuclear material and assist the other states in recovery and protection of such material to the maximum extent possible. Although the role of the IAEA has not been mentioned specifically in this convention, it is presumed that it serves as the treaty depository and would offer assistance when required.

In the wake of renewed interest in nuclear security, an amendment in 2005, pursuant to the efforts since 1999, altered the title of the convention to "Convention on the Physical Protection of Nuclear Material and Nuclear Facilities" (IAEA 1999). It created a legally binding mechanism which requires the contracting states *to establish and maintain a national regulatory regime, which would ensure 'appropriate physical protection regime' (emphasis added).* Such framework includes designs to prevent theft and other unlawful taking of nuclear material, ensure a rapid and comprehensive measure to locate and if possible recover the stolen material, prevent the sabotaging of nuclear material and facilities and mitigate or minimize the radiological damage in case of sabotage. This amendment, therefore, requires greater cooperation between and among the states to locate and recover stolen or smuggled nuclear material, prevent and combat such offences and mitigate the radiological consequences of such acts.

It also obligates the states to create a legislative and regulatory framework and designate competent authority or authorities to implement the framework requirements including evaluation and licensing to ensure the physical protection of nuclear material and facilities (IAEA 2016a). However, to generate consensus, many physical protection measures were dropped from the text draft, resulting into weak obligatory standards. Also, the lack of funding is a major obstacle in the fulfilment of international obligations (UN News Centre 2008). Most of the IAEA’s funding is voluntary which at times comes with conditions of usage to which it could be applied, thereby limiting the scope of its involvement.

The convention rests the authority of implementation with the state. It does not propose any international institutional regulation to provide oversight but urges to strengthen the national regulatory institutions and processes. There is no verification or compliance mechanism or even peer review mechanism under the aforesaid convention. There is a provision of review conference every five years but it assesses the overall progress of the convention and not the individual state parties. There is no reporting of national reviews and therefore non-compliance or loopholes are not verifiable. Also, there are no consequences to non-compliance (Boureston & White 2010). There is a dispute resolution mechanism involving the International Court of Justice but not for non-compliance cases, but in the cases requiring the interpretation of statutes. This convention thus has very limited authority in the matters of international regulation of nuclear security requirements. Steinhausler (2009) argues that the language of the convention is unclear and ambiguous allowing the states to scapegoat if they do not want to prioritize nuclear security. As the convention provisions self-evaluation by the state, no agency can regulate the states to comply with these obligations.

This amendment is not in force yet; it requires two-third ratification of the original contracting parties. As of 2012, out of the 140 state parties to the CPPNM, only 60 have ratified the amendment (Department of Atomic Energy 2012), excluding some significant states like the U.S.A., Canada, France and Pakistan. The International Physical Protection Advisory Service (IPPAS) conducts the reviews of the legal and regulatory infrastructure of the state that requests its assistance and determines the extent of the state’s compliance with the CPPNM. Its reports are confidential. The IAEA has its own International Nuclear Security Advisory Service (INSServ) which performs a similar job at the state’s request and offers technical assistance and advice to improve the security credentials of the state.

Code of Conduct on the Safety and Security of Radioactive Sources, 2003

This sub-section deals with code of conduct on the safety and security of radioactive sources which apart from being a non-binding guideline is also one of the most detailed IAEA documents on nuclear regulation.

The Action plan formulated by the IAEA Secretariat in March 1999 and supported by the International Conference of National Regulatory Authorities competent in dealing with the safety and security of radioactive materials in 2000, resulted into a non-binding international agreement- the Code of Conduct on the Safety and Security of Radioactive Sources. First published in 2001 and finalized in 2003, it incorporated more security effective provisions in the light of 9/11 events and the consequent threat of nuclear terrorism. After much deliberation, it was successful in the inclusion of import and export of radioactive substances too within its purview in the Supplementary Guidance on the Import and Export of Radioactive Sources released in 2003. The radioactive materials are used in various applications all over the world and have been very beneficial to the mankind. However, they come with added safety and security concerns. So, this code offers the most detailed guidelines on the framework of national regulatory control for effective and secure management of radioactive material. However, it does not apply to radioactive sources within military or defence programmes. Nuclear material as defined in the CPPNM, except for sources incorporating plutonium- 239, also is excluded from its purview. It provides three categories of radioactive material and sources in the descending order of their harm potential. Though a review meeting isn't provisioned in the mandate, de facto meeting practice has been established (Stoiber 2009).

Being a code, it is not binding on the member states and therefore though its guidelines on shaping of a regulatory authority presents a desirable standard, states do not follow it in verbatim and national variations in shaping of regulatory bodies are a common thing. Also, though the document deals with regulatory authority and functions, these have been crafted in broad terms, leaving a lot of specifics to be decided by the concerned state governments.

Nuclear security regulations are also a product of the international nuclear order in general. Increased emphasis on nuclear security and nuclear terrorism are also a product of American pressures behind it. Having witnessed 9/11, international system has become more alert to concerns of nuclear security. Though this has not translated into IAEA led binding conventions, there has been a larger emphasis on the nuclear security agenda in United Nations and nuclear security dedicated forums like Nuclear Security Summits. These extra-IAEA mechanisms and instruments will be discussed in the next few sub-sections.

The UN Security Council Resolution (UNSCR) 1540 (2004)

This section deals with one of the important binding instruments proposed under the United Nation's aegis to deal with the concern of nuclear security. After 9/11, US' diplomatic energies bore efforts through the UN Security Council Resolution, 1540 in 2004 which proposed specific national measures to strengthen nuclear security preparedness of involved countries. Its importance lies in internationalization of export control regimes which was earlier restricted to a limited number of countries (Nayan 2014).

It affirms that "the proliferation of nuclear, chemical and biological weapons as well as their means of delivery,[18] constitutes a threat to international peace and security" (UNSCR 2004: 1). It obligates the states not to provide, support and/or cooperate in any way with the "non-state actors who attempt to develop, acquire, manufacture, possess, transport, transfer or use nuclear, chemical or biological weapons and their means of delivery" (UNSCR 2004: 2). The states are also supposed to adopt and enforce adequate and effective provisions to curtail nuclear terrorism by establishing appropriate control over related material, effective border controls and law enforcement efforts, effective national import, export, trans-shipment, re-export and control on funds and services to this end and to cooperate with the IAEA's efforts under various multilateral obligations. It therefore mandates an obligation on the capable states to provide other states with capacity building in the field of nuclear security. It calls upon states to present a first report to the committee (constituted under the resolution to oversee its implementation initially for a period of two years but extended later) regarding their undertakings of the step to fulfil their commitments. It can also ask for further reports from time to time. The Committee can offer technical assistance (subject to the availability of resources) on state's request to help capacity building for compliance or in preparation of national

[18]It defines 'Means of delivery' for the purpose of this convention alone as: missiles, rockets and other unmanned systems capable of delivering nuclear, chemical or biological weapons that are specially designed for such use (UNSCR 2004: 1).

reports etc. It conducts annual reviews on implementation along with a comprehensive review every five year (Davenport 2017a). However, it does not have a sanction committee and does not investigate or prosecute alleged non-compliance of obligations by the states. However, it being a UNSC resolution, is binding on member-state under article VII of the UN charter (Nayan 2014).

International Convention for the Suppression of Acts of Nuclear Terrorism, 2005

Another important multilateral initiative dealing with the threat of nuclear terrorism is the International Convention for the Suppression of Acts of Nuclear Terrorism, 2005 [mandated by a UNGA resolution in 1996 (Rajagopalan 2015)]. Under this convention, it is considered as an offence if someone unlawfully and intentionally, possesses or makes radioactive material or device or uses or damages a nuclear facility with the intention to cause death or injury or substantial damage to property and environment. Also, if someone compels a natural or legal person, an international organisation or a state to do or refrain from an act, or threatens credibly or demands a radioactive material, device or nuclear facility by threat or force. Acting as an accomplice in such acts or attempting to commit these things or directing or organising such activities shall be liable to be considered as offender. However, if only a single state's sub-entities are involved in such acts, this convention does not apply unconditionally. Also, activities of armed forces during armed conflicts and of military under their official duties are precluded from this convention. It, thus, cannot be interpreted to discuss the use or threat of use of nuclear weapons by the state.

The member states are obliged to declare these offences as punishable and accord appropriate penalties under their respective national laws. They are supposed to take all the measures to prevent and counter such offences in their territories, on vessels or aircraft under their flag or registered in their names and inform relevant states and international organisations of such offences in their territories. They shall exchange and verify information pursuant to this cause but are not required by the convention to go beyond the confidentiality of any information permitted under their national laws. The convention requires the state parties to prosecute and/or extradite an offender. It also directs them to offer significant mutual legal assistance to each other in the matters of criminal proceedings. It applies to all nuclear facilities. There is no provision for review meetings of member states though. Implementation of activities under this are conducted by the

United Nations Office of Drugs and Crime through its branch for terrorism prevention in Vienna (Stoiber 2009) but ultimate responsibility for implementation lies with nation states.

This convention's depository is with the UN. It, therefore, does not lie in the IAEA's 'family' of treaties,[19] although it has been granted certain duties under the convention. For example, in cases of seizure of nuclear or radioactive material, device or facility, these are to be held under the IAEA safeguards and physical protection, safety and health standards prescribed by the IAEA. States 'may' call on the assistance of IAEA in such cases and are obliged to inform the IAEA DG as to how they wish to retain or dispose the material, device or facility they seized thereof.

Despite a limited mandate, the IAEA's influence and services in nuclear security regulation cannot be undermined. The IAEA offers International Teams of Experts which promote and facilitate the state's adherence to the legal instruments on nuclear terrorism. Some of these services include the INSServ, the IPPAS and the Nuclear Security Advisory Services. Such missions are prepared on the request of the state parties (IAEA 2012a). Based on an integrated analysis of the reports of these missions, the IAEA has instituted the Integrated Nuclear Security Support Plan (INSSP), which offers a more 'holistic' approach to nuclear security capacity building by devising country-specific security plans. The IAEA has also established Nuclear Security Support Centre in 2008 which cooperates with the states in setting up their own National Security Support Centres. They act as the training centres for knowledge and skills dissemination required for improving nuclear security preparedness. The information sharing function is further carried out through the International Nuclear Security Education Network established by the IAEA in 2010. It organizes joint research programmes, student-faculty exchange programmes and develops organisational technical tools to spread the awareness about safety needs and standards.

The IAEA's Illicit Trafficking Database (ITDB) facilitates exchange of information between the states on reported incidents of illicit trafficking of nuclear or radioactive materials. It acts as database for all kinds of illegal activities related to nuclear or radioactive material, including scams, done or attempted at and thwarted, with or without

[19]It implies that international security regime is not comprised of IAEA as the sole legitimate authority and through this convention, UN directly involved itself with nuclear security concerns.

crossing international borders, intentionally or not. Although, state participation in reality, is very voluntary and limited. The role of the IAEA in Nuclear security is more restricted because nuclear security, technically is not an original statutory function of the IAEA and developing countries have objected to inclusion of nuclear security agenda in regular budget (Findlay 2013). Budgeting for nuclear security programmes, therefore, is a concern and mostly reliant on voluntary funding by the states (Findlay 2016). Also, exchange of such sensitive information could be a risky act. Verification is problematic as states are reluctant to provide complete information on their nuclear security arrangement and it would be thus difficult to evaluate them with respect to the international standards.

At the same time, nuclear security regulation of the IAEA is supplemented by a larger involvement of United Nations as a multilateral institution. However, even at the UN level, the commitment of member states is less than optimal. Over the years, UN involvement has shifted to ‘more relevant issues of the day’ and nuclear security regulations are being discussed in dedicated multilateral groupings. One such platform is Nuclear Security Summit which will be discussed in the next sub-section.

Nuclear Security Summits (NSS)

In the light of clandestine nuclear activities and discovery of A. Q. Khan network of nuclear smuggling, the American president Obama launched a dedicated initiative of ‘Nuclear Security Summits’ in 2009 to counter nuclear and radiological terrorism. These are a biennial conference of world leaders to evaluate the robustness of national plans in ensuring national security through international cooperation. It is an international platform shared by around 50 countries that agreed to strengthen their nuclear security credentials. It invites regular, voluntary and progressive commitments on the part of these countries to improve the international nuclear security regime. In a bottom-up approach, the states decide their respective political commitments called ‘house-gifts; and ‘gift-baskets’ and measures to achieve them and share it with other leaders and the media (Davenport 2017b). While the states agreed to make national commitments in the 2010 conference, many of them have progressed to offer multilateral commitments at the subsequent summits. Though not legally binding, these commitments are political pledges and therefore the member states are driven to demonstrate credible performance against their commitments. Unites States championing the cause of nuclear security with special emphasis on challenge of nuclear terrorism has added political weight to the initiative. But at the same time, U. S. patronage has evoked Russian non-endorsement which has favoured IAEA as the arbiter in commitment obligations on nuclear security (Shinkman and Welsh 2016)

The Nuclear Security Summit also publishes the national nuclear security index and rank the national programmes in order of the robustness of their security credentials. The summit initially aimed at securing 'all vulnerable nuclear material in 4 years' but it gradually broadened to include radioactive sources, safety-security interface related issues, nuclear forensics etc. (Banerjee 2014). In 2014, a gift basket from The Hague summit was introduced in the IAEA as an Information Circular (INFCIRC/869), making it possible for non-participants also to join the initiative. This circular includes recommendations for the observance of the IAEA's nuclear security fundamentals. Otherwise, these practices are not binding but through the NSS, they are being incorporated into the national laws and therefore become operational. However, even the NSS with all its spotlight too, has not been able to produce binding international commitments to strengthen nuclear security (Findlay 2014). All the pledges offered are based on voluntary political commitments and without a standing organisational structure or adequate financial and other such support to IAEA, monitoring of such compliance remains unilateral in nature.

To sum up, the Nuclear Security regime under the IAEA comprises mostly of non-binding obligations. The provisions are loosely premised and offer vast latitude of implications including minimal to no action. There is no external oversight for most of the measures proposed. Therefore, the robustness of the regime relies primarily on the emphasis and efforts states put in managing nuclear security with respect to the possibility of a threat. If a state does not sincerely and imaginatively look at the nuclear security threats, the corresponding compliance with the non-binding regimes is bound to be inadequate. Also, because most of these provisions are technical in nature, its implementation gets stuck at the national political level, which is mostly wary and even skeptical of external oversight and information sharing. Being broadly designed, it is difficult to measure specific compliance and most of the initiatives have no enforcement mechanism, sanctions or dispute resolution mechanisms (Stoiber 2009). C. M. Ten, however, argues that the conventions are the most standard and effective approach as they are "motivating rather than penalising in their approach" (Ten 2009: 202).

2.4. International Nuclear Safeguards Regulations

An overview of national nuclear regulatory bodies all over the world reveals that in NNWS, the national nuclear regulatory authority monitors compliance with safeguards obligations as well, like in case of Canada (Jammal 2018). Those with a nuclear weapon program, however, safeguards are not considered as a part of regulation, and regulatory aspects pertain primarily to safety and sometimes security concerns. This section will analyse the evolution in the nature and types of safeguards that are being administered in multilateral settings since the establishment of the IAEA.

A safeguard system is a regime of verification and inspection measures to ensure that the states are duly fulfiling their legal obligations under international trade arrangements and that any diversion of significant quantities of nuclear material or technology from the peaceful nuclear activities to the production of nuclear weapons or other nuclear explosives or unknown purposes is timely detected and avoided/ deterred through the risk of early detection (IAEA 1972: 9). Everton argues that "the fundamental and indeed foundational purpose of IAEA safeguards is maintaining international confidence that states remain compliant with their non-proliferation commitments" (Everton (2015: 46). The system of safeguards predates the formation of the IAEA and was instituted through the bilateral technical programmes undertaken by the U.S.A. as the supplier for the purposes of nuclear trade. These safeguards were instituted under the IAEA regime when it took up the task of non-proliferation. These were, however, less powerful than what was originally conceived in the Baruch plan but this dilution enabled the compromise between the superpowers during the cold war.

Originally conceived with the objective of nuclear disarmament, the term 'safeguard' came to mean the inspection, accounting and other measures that intended to contain proliferation of nuclear weapons. Arrangements for stringent safeguards measures were resisted by the states fearing an "impingement on state sovereignty; intrusiveness in terms of both state security and commercial confidentiality; cost; and relative prominence of safeguards within the Agency's overall mandate" (Findlay 2012: 58). As the verification might not be rolled back, the developing countries have demanded higher technical assistance to compensate for verification provisions in order to comply with safeguards obligations. A few countries like India and Pakistan have shown reluctance to implement these safeguards because of their advance nuclear weapon programme.

Safeguards are the most intrusive and comprehensive instruments of international regulatory governance in the nuclear field and the Non-compliance related to safeguards are reported to the (BoG) at the UNSC while those related to security follow the UNSCR 1540 guidelines (Jammal 2013). The nature and kinds of safeguards, however, have undergone changes over the years, in response to power politics of the time. As a result, there are different kinds of safeguards and different nuclear cooperation agreements explicitly qualify the nature of safeguards a country needs to abide by in order to ensure non-proliferation. There are broadly four kinds of safeguards applicable in multilateral settings which will be discussed individually in the next few sections.

Classic Safeguards or Item-Specific Safeguards (1965) (INFCIRC/26 and INFCIRC/66)

Nuclear safeguards were first publicly put forward in November 1945, in the joint declaration by the US, UK and Canada, that made the scientific exchange for nuclear energy conditional on the acceptance of a safeguard regime by the recipient state to the effect of constraining the destructive use of nuclear technology. The US made these safeguards mandatory in all its bilateral cooperation with other countries. However, safeguards were institutionalized regionally in 1957 with the creation of the European Atomic Energy Community (Euratom). Internationally, it was institutionalized through the establishment of the IAEA in 1961. Argentina and Brazil have their own bilateral safeguards system which independently verifies compliance with their joint safeguards but they all work closely with the IAEA. The initial safeguards covered small reactors of less than 100 MWt capacity and the material transferred from one state to another. Later, large reactors too came under its mandate (IAEA 1961).

The birth of IAEA's safeguard regime has a Cold War context. Its safeguards could be applied to only those projects where concerned states required agency's assistance. This implied that the states with technological capabilities and resources of fissionable material like USA, USSR and France would not be required to implement those safeguards as they would not require agency's assistance. The US refusal to treat France at par with Britain prompted France to not participate in the regime. States engaged in bilateral nuclear trade with the US also refused to comply with the IAEA safeguards obligations (Greenberg 1965).

The first safeguards agreement was signed between the IAEA and Canada in 1959 but the first safeguards document (INFCIRC/26) containing principles and procedures for safeguards application was approved by the IAEA BoG in 1961 (IAEA 2015) and was not accepted widely in the beginning. The Western Europe had its own regional safeguard arrangement in the form of the EURATOM. These covered 'ores' too which are explicitly excluded from the IAEA safeguards regime (Office of Nuclear Regulation 2017). The

EURATOM's safeguards were developed mainly in keeping with the American policy demands as it as the exporter of nuclear technology and helped to reduce the Europe's dependence on Gulf for oil and bring in a new energy renaissance. Certain countries opposed the co-existence of EURATOM's safeguards along with the IAEA as the right of self- inspection to a regional bloc could be fraught with risks and could undermine the international safeguards regime under the IAEA. Promotion of the regional safeguards arrangement was seen as undermining the international authority of the IAEA. It also gave an excuse to the eastern bloc under Soviet Union to refuse international inspection on its territory (Fischer 1997).

The IAEA's attempt at covering research reactors under verification regime was opposed by India and Soviet Union which were averse to the proposal of inspectors from hostile states visiting the facilities of huge national security and economic importance. It nevertheless formulated the complex procedures and guidelines for verification. The inspectors were mandated to cover only those locations and routes that would be designated by the states (IAEA 1961).

The IAEA was mainly an American creation and thus was initially unacceptable to countries that wanted to preserve Euratom's authority (as a legitimate forum vis-à-vis the IAEA), by the Soviet bloc (apprehensive of American predominance in IAEA) and by certain developing countries (facing controls being the recipients of advanced nuclear technology, material and equipment from the west). Initially, the USSR compared the IAEA safeguards to a 'spider's web' designed to "ensnare developing countries and stifle their scientific and technical progress" (Fischer 2007: 9.).

Although the US decided to transfer the safeguarding responsibility to the IAEA in case of its dealings with the non-European Economic community states and the Soviet Union declared its support for the IAEA safeguards in 1963, even by 1979, the Soviet Union was not entirely confident of the IAEA's capabilities in handling the proliferation concerns and considered its own safeguards system as more efficient (Mendelsohn 1979).

The IAEA statute authorizes it to establish and administer safeguards in order to ensure that the nuclear material, technology, equipment etc. are not used for military purposes. It would be responsible for the safety, security and safeguards of the nuclear material and facilities under its tutelage. It was also mandated, upon the request of the state party, to monitor the application of safeguards in the pre-designated facilities. The statute envisaged a non-intrusive nature of the international regulation and provided that the sovereign rights of member states are duly respected. So, the agency could examine equipment and facilities, call upon the maintenance and operation records and the progress report. It also had rights to verify the implementation, albeit with restrictions. The choice of inspectors was to be made with the consultation of states and the representatives were to be escorted by the state delegates if the state urged so. Also, certain restrictions on the movement of international inspectors within the state being investigated were proposed. The states were to declare their holdings to the IAEA which were then verified by it.

These safeguards could be applied in cases where the agency provided support, or under bilateral or multi-lateral treaty obligations or if a state unilaterally requested so (IAEA 1968), to the ‘principal nuclear facilities’ as designated by the BoG. Also, these applied only to the “nuclear material” (IAEA 2001) which has been defined under the IAEA regime as to include “special fissile material”[20] and “source material”.[21]

In 1965, the safeguards coverage was extended to reprocessing plants, conversion and fabrication facilities and storage sites if they operated on safeguarded nuclear material. Uranium, or thorium mines and mills, however, remained excluded (IAEA 1968). However, these applied to specific plants and fuel and not the entire nuclear fuel cycle of NNWS.

Prior to the NPT, the Euratom and the IAEA were the two dominant safeguards regimes. Domestic opinion in US was divided over the question of co-existence of Euratom and IAEA safeguards but eventually, the US permitted the Euratom safeguards to be upheld while exporting technology and fuel to the Western Europe. This was problematic for Soviet Union which apprehended that under Euratom’s safeguards, Western Germany could initiate a weapons programme which could be a grave security threat for Soviet Union given the strategic and parabolic significance of East and West Germany in the

[20]Special fissile material is something that can be readily used for nuclear weapon production like plutonium-239, Uranium- 233 and enriched uranium in the isotope of uranium 233 or 235 and other material as such determined by the IAEA BoG from time to time (IAEA 1989: 37).

[21]Source material is something that needs to be processed to be usable like uranium containing naturally occurring mixture of isotopes, uranium depleted in the isotope of 235 or thorium contained in the metal, alloy, chemical compound or concentrate or such material as determined by the Boards of Governors from time to time (IAEA 1989: 37).

Cold-War period. This led to the demand for amalgamation of the safeguards systems under the IAEA and the Euratom regimes. The process of integration was boosted by the 'new partnership approach' advanced by the secretaries of the two organisations in 1992, enabling joint inspections. Euratom's safeguards were very comprehensive but covered only the civilian facilities of the two nuclear states in Europe (France and England). The IAEA safeguards covered these lacunae. Next sub-section will discuss the changes that were introduced in the safeguard regime once a non-proliferation treaty was proposed.

Comprehensive or Full-scope Safeguards Agreements (CSA)

This section discusses the changes in safeguard regimes and subsequent compulsory obligations that were to be undertaken by the NNWS within the NPT to avail the benefits of nuclear cooperation and commerce.

The safeguard system was further strengthened in a major way by the coming into force of Non-proliferation treaty (NPT) and the treaty of Tlatelalco (IAEA 2015). It allowed the non-nuclear western European countries to have an access to this sensitive technology while forfeiting their right to develop a nuclear weapon programme.

The IAEA is not a party to the NPT but it has been designated as International Safeguards Inspectorate under the NPT (IAEA 2015). With the enhanced mandate under the NPT, the IAEA devised a safeguard regime covering the entire fuel cycle. By 1968, the IAEA had laid down a safeguard regime for almost all the types of nuclear power plants (Fischer 2007).

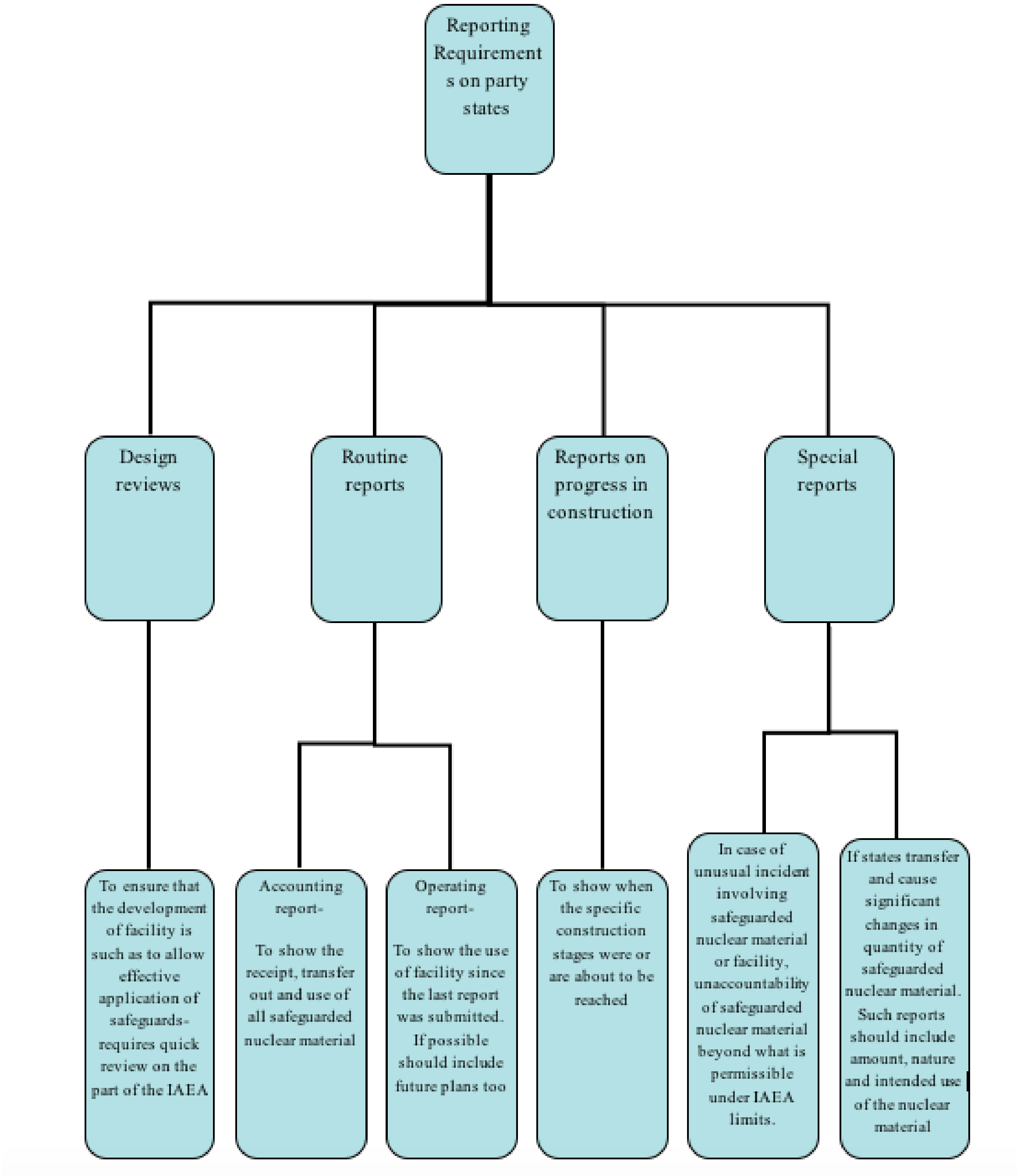


Figure- 2.3. Reporting Requirements under INFCIRC/66/Rev/2

Source: Adapted on the basis of INFCIRC/66/Rev/2 (1968)

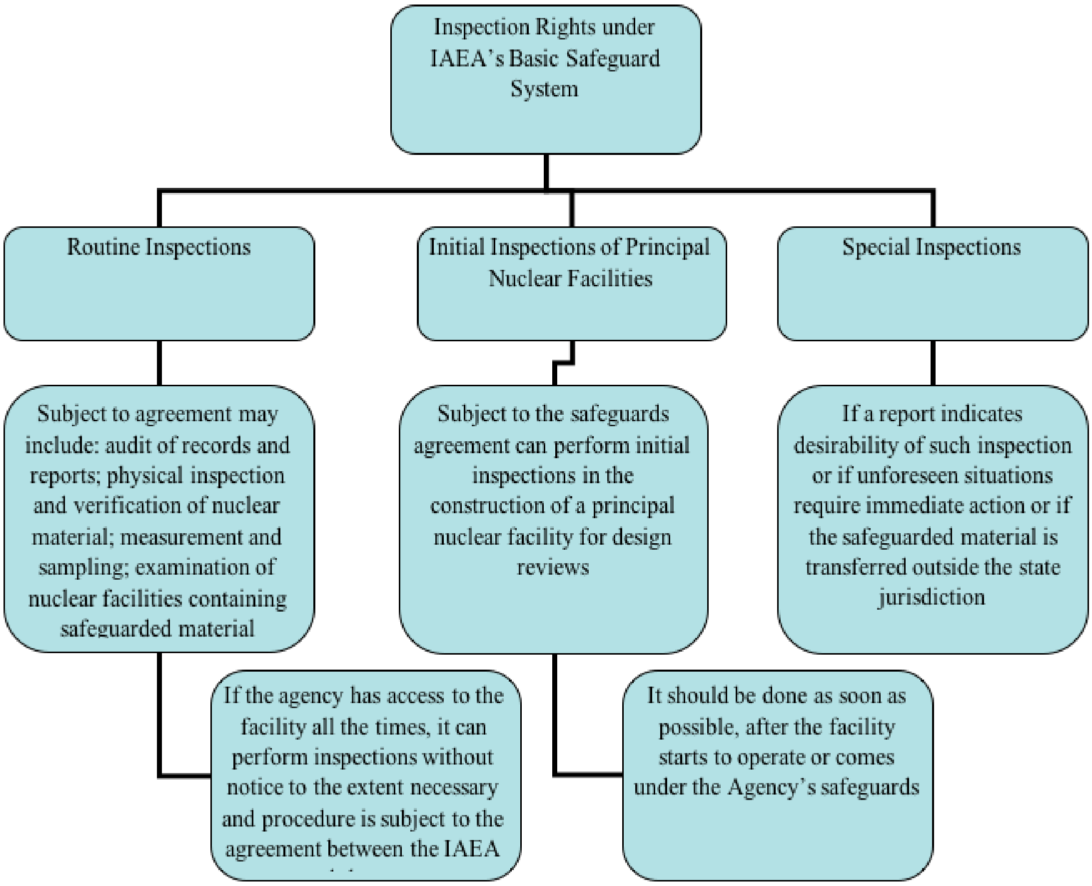


Figure- 2.4. Inspections Rights Under Basic Safeguards System

Source: Created on the basis of INFCIRC/66/Rev/2- Articles-49-54 (1968)

The NPT made it legally binding for the NNWS under it to place all of their nuclear activities under safeguards, as by definition they would be 'peaceful' being undertaken by the NPT signatories. It covered all the source material and the special fissionable material and all the peaceful activities (IAEA 1972). The member states were obligated to negotiate a comprehensive safeguard agreement with the IAEA. As per a 2015 report of the IAEA, out of 182 states that have safeguards agreements in force, 174 are under comprehensive safeguards agreements, 5 nuclear weapon states have voluntary safeguards agreements and 3 states have item-specific safeguards agreements. Parties complying with additional protocol are 126 in number (125 states and EURATOM) while another 21 had signed it but were yet to bring it into force (IAEA 2015).

The NPT negotiations tried to meet a mid-point between the stringent requirements proposed by the nuclear weapon states to control proliferation (as they were outside the purview of it being declared nuclear weapon states); and non-intrusive measures proposed by the NNWS which did not want to give upon the right to engage in any of non-military uses of nuclear energy including the right to reprocessing the spent fuel without a parallel provision of safeguards for nuclear capable states. To muster the support of major NNWS like Germany and Japan, the safeguard regime was diluted to have the least minimum human inspections to avoid industrial espionage.

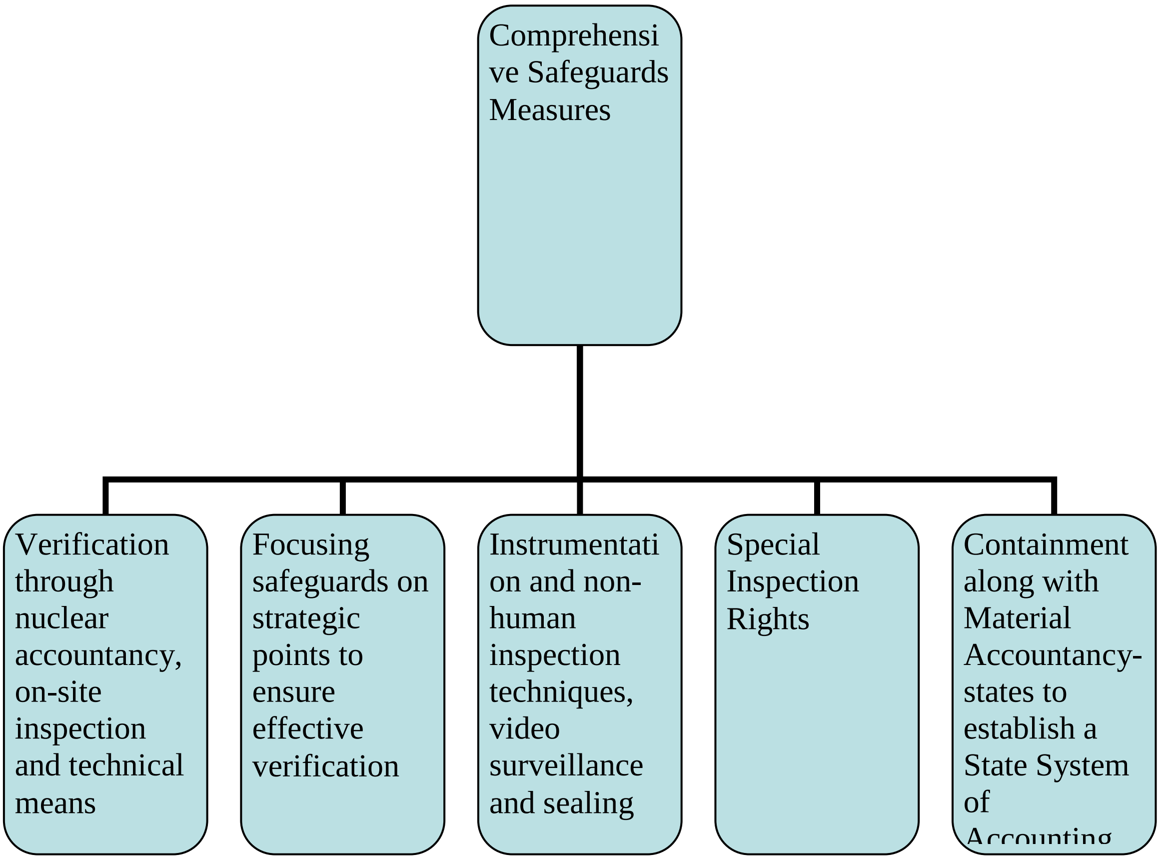
The IAEA safeguards under INFCIRC/66 were to be applicable to only the specific items (material and facilities). Also, they covered only those facilities which the government had declared to the IAEA. The IAEA inspectors were not to have authority over undeclared facilities. The inspectors would have the rights to visit only previously agreed 'strategic points' in facilities declared to the IAEA. The NPT provided a remedy to this effect. It provided for application of IAEA safeguards on all nuclear material used in all nuclear activities within the territory of a state (which accepted CSAs), or under its jurisdiction or control anywhere else to ensure their uses for peaceful nuclear activities alone.[22]

In the spirit of cooperation for nuclear commerce, the process for laying down a comprehensive 'full scope' safeguard regime was approved by the BoG in 1971. It came to be adopted in 1975-76, without the participation of nuclear capable France and China and a few conflict-ridden states like Pakistan, India, Brazil etc. The purpose of these safeguards was to enable a 'timely detection' of diversion of 'significant quantities' (which was defined as '8 kg of Plutonium, or 25 kg of U-235 contained in HEU') of nuclear material from peaceful activities for use in explosion. It proposed material accountancy and surveillance as the basic tools for such early detection and deterrence. At the same time, it was not to be very intrusive, or hamper technological development, or interfere unduly in the civilian nuclear energy programme. It would require only that minimum data which would be necessary to carry out its responsibility and cause minimum possible inconvenience and disturbance to the member states. Also, the states were given rights to reject the choice of inspectors proposed by the agency and a dispute resolution mechanism was instituted.

Article 36, however, makes an exemption in the form of small quantities protocol concerned with states that operate with small quantities of nuclear material. Very little

[22]It also lays down the IAEA's responsibility to "not impede the economic and technological development of states or cause undue interference in their peaceful nuclear activities and to protect their commercial and industrial secrets and other confidential information during implementation of safeguards" (IAEA 1972:2).

reporting is obligated on states and the IAEA generally precludes inspections. The protocol still requires states to implement safeguards on relevant material and facilities and report on imports and exports related to those (Alger 2008).



<u>**Figure- 2.5.** Measures Under Comprehensive Safeguards</u>

Source: Based on Scheinman, L. (1987), The International Atomic Energy Agency and World Nuclear Order

The design report requirement under NPT safeguards provisioned that member-states were to report any design changes to be carried out in existing or new facilities as soon as the state authorities decided to construct, authorized construction or modified a facility. The IAEA holds the right to demand design reports throughout the life cycle of the nuclear plant including decommissioning (IAEA 2014a). Additionally, the Special Inspection rights grant unlimited access to the agency inspectors if the state suspects that an undeclared facility or unusual activity exists. The IAEA needs permission from the state concerned. If not granted, the BoG could direct the state to permit the access. If refused even then, the BoG could report to the Security Council that the agency "was not able to verify that there has been no diversion" (Fischer 1997: 283).[23]

Each state is also obligated to tailor a subsidiary arrangement with the IAEA setting out the timing, mode and extent of inspection activities. These are confidential and not submitted to even the BoG.

One of the major institutions created under the CSAs is the State System of Accounting and Control (SSAC), which is a national body responsible for ensuring nuclear material accountability and coordinating with the Regional Systems of Accounting and Control. These two serve as the point of contact for operational issues between the state and the IAEA. The SSAC ensures submission of design information to the IAEA and maintenance of correct records by the operators, provides physical access to the designated facilities, and ensures the accuracy and precision of various measurements undertaken by the plant operators regarding the quantities and types of nuclear material (Murakami 2012). It was designed to have effective inventories and national procedures for evaluating discrepancies. Its reports are then sent to the IAEA for evaluation.

Table- 2.3. Inspection Rights under Comprehensive Safeguard Agreement

Routine Inspections	-Purpose is to verify the consistency of records and location, identity, quantity and composition of safeguarded material -Number of inspections depends on the facility type and stock of nuclear material or throughput in effective kgs. -Length of notice period- 24 hours' notice if material contains plutonium or uranium enriched to more than 5%. One week's notice in all other cases. -the inspected state has right to receive advance notice of place and time of inspection and state representatives can accompany them. There can be unannounced inspections but a general period must be specified.
Ad-hoc Inspections (IAEA1972)	-Purpose is to verify the initial material inventory report and identify changes since the submission of first report -Also, to verify that the exported nuclear material is not diverted during transport, a 24-hour prior notice to the state is sufficient. -States to be notified at least a week before the arrival of inspectors.

[23]Special inspections are rare. It has only been carried out in Romania on the request of its government. North Korea, on the other hand, declined to allow it (Mozley 1998: 167).

Special Inspections[24]	-if the agency concludes that even after information and subsequent explanation offered by a country is not adequate to determine on compliance -Must be preceded by a consultation with the state concerned -During inspection, the IAEA can request access to any location within or outside the designated buildings. However, the inspections of outside locations depend on the consent of the state. In the case of refusal, the IAEA can only call upon the state to take the required action without any delay. -Greatly depend on the cooperation of the state. Therefore, they are mostly non-practical in case of non-compliance.

Source: Based on INFCIRC/153/ Corrected, art. 83a (1972)

The NPT safeguard system is not without loopholes though. The arrangement allows the member-states to withdraw from the treaty with a 6 months' notice in advance on grounds of national security. The non-nuclear weapon members are entitled to access nuclear material and know-how as long as they keep them under safeguards. The expertise gained during the membership then can be advanced for weapons generation after the withdrawal from the treaty as was done by North Korea.

The 1974 'peaceful explosion' by India drew further attention to the loopholes in the safeguard arrangement. India was not a signatory to the NPT, so could not be accused of violating it. But it did violate the 'Gentleman's Agreement' with the Canada and the U.S.A. This situation was rectified by the BoG in 1975 by making this agreement contingent on an undertaking that no safeguarded items would be used for making nuclear weapons or explosive device or any other military use. This unexpected move on the part of India also led to the formation of the NSG (originally London Club) which comprises of non- IAEA countries too. It agreed to lay down certain restrictions on the export of nuclear technology, equipment, material etc. (discussed in a later section)

The safeguard system has worked more or less to the satisfaction of international community. Outliers like India and Pakistan were not the members of NPT and thus could not be constrained by the safeguards. The agency's inspection rights were violated a few times and there were a few deviations on the part of countries like Egypt, Taiwan, South Korea but they were not discovered then and thus the safeguards system remained unchallenged (Findlay 2012). Not trusting the IAEA safeguards system, Israel bombed Iraq's research reactor 'Tammuz' in 1981 and was criticized by the UNSC as "a serious

[24]These were evoked only once to verify the extent of the North Korean nuclear programme in early 1990s.

threat to the entire safeguards system" (Blix (2005) quoted in Findlay 2012: 59).[25] The IAEA's safeguards system came to be challenged in 1990s upon the discovery of an undetected Iraqi nuclear programme running parallel with its peaceful program under the IAEA safeguards systems (IAEA 1998). The limitation of the safeguards mandate was grossly visible and as Hans blix argued, catered to the detection in industrialized countries and not so effectively in the closed societies (Blix 2005).

The IAEA safeguards verified the official declaration of the states and ensured that the declared nuclear material was accounted for. But, there was no mechanism to account for undeclared nuclear material or facility. Weak political will for intrusive inspection rights undermined the provisions of strong regulatory regime (Findlay 2012). The clandestine nuclear programme, smuggling, illicit trafficking etc. thus lied outside the effective watch of the safeguards. The inadequacies of the safeguard regime glared through the discovery of illicit nuclear activities in Iran and Libya and remained undetected for quite some time. Later, these were brought to the limelight primarily because of the efforts of the USA and the UK. These incidents forced reconsideration for more effective safeguards leading to the mechanism of strengthened safeguards or additional protocol which will be discussed in the next sub-section.

Strengthened Safeguards or Additional Protocol

In the light of new reports claiming clandestine nuclear operations in Iraq around Gulf war in 1991, the IAEA undertook measures to strengthen the safeguard regime. Earlier safeguards systems pertained to a verification only of declared nuclear programmes and activities. As a result, Iraq could carry out certain clandestine activities related to nuclear weapons alongside its declared activities through the assistance offered to the civilian program under safeguards. When the DG brought the matter to the Board in August 1991, an intensive review of CSAs was carried out and new and improvised safeguard system in the form of additional protocol was proposed. Additional protocol is based on a 'cradle to grave' (Alger 2008: 3) approach and covers undeclared facilities too. The emphasis is on 'completeness' of information along with the 'correctness'. Additional protocol, therefore, expanded its scope to cover undeclared activity along with ensuring

[25]The IAEA also said that Israel undermined the frequency and effectiveness of IAEA safeguards that would have come into place when the reactor came into operation (IAEA 1998).

non-diversion of nuclear material for weapon or other explosive purposes. It is a legal document reinforcing the safeguards agreement.

One set of provisions focused on enhancing the scope of agency in the areas where it was already entitled to access information. It included demands of additional information from states on their existing and future nuclear plans, environmental sampling at sites where the agency has access to, stringent monitoring measures imagery that would transmit data to the IAEA Headquarters directly, short notices and unannounced inspections and expansion of the IAEA's open source information through techniques like satellite. The other set of provisions focused on negotiating a supplementary agreement with the member states for additional safeguards. The additional protocol was agreed upon by the BoG in 1997. It expanded the agency's mandate by proposing among other measures (Persbo et al. 2005, IAEA 2015):

- States to report on every aspect related to nuclear fuel cycle including nuclear mines and waste facilities, research and development activities, manufacture and export of sensitive nuclear-related technologies.

- Agency's rights of inspection and verification for manufacturing, export and import locations in the state, research related facilities and all the buildings at the nuclear facilities at short notices

- Complementary access to undeclared locations on the request of inspectors to resolve a question or inconsistency or if they doubt that the state is involved in 'cleaning up'. States are obliged to make reasonable efforts to provide such access.

- Right of environmental sampling at locations beyond those provided under safeguards agreement. Wide area environmental sampling after Boards procedural approval and consultation with the states.

- States to accept the designation of inspectors accorded by the IAEA and issuance of multiple entry visas for safeguard inspectors (valid for at least one year).

- Agency to have a right to use the internationally established communication system including satellite systems

The Model Additional Protocols (INFCIRC/540 corrected) were negotiated under the '93+2 exercise' in 1997.[26] It is a model protocol based on which, the states (who have already accepted CSAs) could tailor their safeguards regimes with the IAEA (IAEA 2015). Also, each safeguard agreement based on this protocol would require approval from BoG and signature and ratification by the concerned state (Findlay 2012). An additional protocol is a voluntary mechanism and is not a mandatory provision included under the NPT treaty obligations but the Nuclear Suppliers Group (NSG) has made the protocol a pre-condition for export of items on its list though (Horner 2011). These safeguards are applicable only to the NPT parties and the states importing items under the tutelage of the NSG.[27] Countries with facility specific safeguard (INFCIRC/66) like India and Pakistan had tailored model protocols to comply with (Rosenthal 2013, IAEA 2015).

To streamline the safeguard system, the IAEA has devised strategic plan for the period 2012 to 2023 and much emphasis is placed on 'information driven' inspection and evaluation of country's nuclear activities. Each state under safeguard is now subject to a continuous, collaborative evaluation by a multi-disciplinary team forming state evaluation groups, which is a group of agency personnel and compiles reports based on the CSA and AP safeguards, the IAEA's in-site evaluation and open sources.

Another major innovation in ensuring effective implementation of safeguards pertains to an on-going work on devising a 'safeguard culture' which would be based on previous experiences of international inspectors and would provide secure and immediate access to the relevant information online for their users under a new IAEA Safeguards Information System. Also, there is an increasing focus on delegating more autonomy and decision-making power in the hands of human inspectors to solve the on-site problems. Many western states, however, have shown reluctance towards greater reliance on human resources for such activities. Additionally, a new more intensive system of safeguards, 'Integrated Safeguards System' was proposed to supplement non-proliferation efforts of 'willing' members, which will be discussed in the next sub-section.

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[26]Named so because it was drafted in 1993 with an intention to be implemented in the next two years (Davenport 2018).

[27]As of June 2018, 132 countries and Euratom had concluded additional protocol agreements (Davenport 2018).

Integrated Safeguards System

With higher access of information about safeguards implementation in states complying with CSAs and additional protocol, the IAEA felt confidence to issue 'broader conclusion' for a state as a whole that "all nuclear material remained in peaceful activities" (IAEA 2015: 11). The first such declaration was made by IAEA in 1999.

These apply to the states that comply with the Comprehensive Safeguards Agreement and the Additional Protocol, thereby releasing the finances and personnel for areas where they are needed more (Persbo et al. 2005). These aim at ensuring more effective safeguards by decreasing reliance on traditional routine inspections, focusing on more remote sensing and automated reporting systems and by refining verification modalities and techniques. The redundancies are identified and rational measures are followed to reduce the verification burden on the parts of both the state and the IAEA (IAEA 1997b). Given the intensity of such inspection and verification mechanisms, not all states even within the NPT are enthusiastic about it. Since 2001, the IAEA has been drawing State Level Safeguards for states with 'broader conclusion'. In 2014, the Integrated safeguards were implemented with respect to 53 states (IAEA 2015) and by the June 2017, it had extended up to 69 states (Davenport 2018). The first state with a 'broader conclusion' was Australia in 1999 (Davenport 2018).

Overall, the civilian nuclear program in both NPT or non-NPT countries, when carried out with any help from the IAEA or other NPT countries (most of the suppliers are NPT members) for fuel or equipment and so on, comply with the IAEA safeguards system based on mutual agreements. Most of the cooperation is dependent on compliance with full scope safeguards. The IAEA safeguard regime though deriving substantially from NPT safeguards system, offers a more universal way to countries to engage in nuclear commerce than that mandated by the NPT regime. But at the same time, as it upholds the safeguards regime as propounded by the NPT, its own legitimacy in this respect is dented for upholding the unjust nuclear hierarchy in some ways. This normative and political association with nuclear hierarchical arrangement has contributed to the legitimacy crisis that the IAEA faces today. in the wake of clandestine programmes in North Korea and Iran. Factors like "inadequate application of nuclear safeguards where needed, limited authority for the IAEA to investigate possible clandestine nuclear programs, personnel rules that limit access to the best-qualified. Inspectors, and lack of technical resources and funding" (Ferguson 2008) have further contributed to a less than optimum implementation of safeguards regime.

At the same time, IAEA's. authority is being circumvented by the so-called 'willing cartels or coalitions' proliferating in the realm of export control groups and counter-proliferation initiatives. Johnson argues that a small group led by the US "uses the 'war on terror' to shift international support from regime-based non-proliferation to counter-proliferation under the auspices of willing cartels or coalitions of the self-proclaimed 'good guys'" (Johnson 2006: 76). While these adhoc initiatives like NSG, UNSC Resolution 1540 (formulated as a 'legislative' resolution of UNSC), Proliferation Security Initiative (PSI), Container Security initiative and such have been hailed by US as a viable strategy of working through "effective multilateralism" (Samii 2006: 430), these have also led to a dilution in the agenda of genuine non-proliferation (and disarmament) which require NWSs to make compromises on advantages gained by their nuclear weapon status. While these initiatives share a similar goal with IAEA in the form of non-proliferation, they have brought the discourse of 'counter-proliferation' to a limelight and being 'coalition of willing', encompassing mostly the nuclear supplier states, undermined IAEA's multilateralism in some sense.

The international non-proliferation discourse though most importantly informed by the NPT, is not restricted to it. NPT reflects the power based international order, permitting amassing of nuclear weapons by the five states namely US, UK, France, China and Russia while justifying their security driven need for nuclear weapons. But at the same time, it refuses to acknowledge the similar needs of other countries to the same extent. The extended nuclear umbrella offered by these nuclear-weapon states are informed by their own geo-political interests. This arrangement, therefore is primarily based on political order informed by great power rivalries and balance of power logic rather than any moralistic, impartial or order-based distribution of security gains. Resonating these concerns, some of the countries like India and Pakistan did not sign the NPT and developed nuclear weapon capability in a secret manner. They however, had to face the consequences in terms of international sanctions on nuclear and economy related aspects. Additionally, these were forced to sustain their civilian nuclear energy programme without much help from nuclear community. Not only that, in response to such proliferation, nuclear supplier countries created export control regimes to restrict nuclear commerce to those countries that accepted safeguards regime under NPT, even for civilian purposes. These will be the subject matter of next section.

Export Control Regimes

The international system of states, ever since cold war period, laid a great emphasis on containing the horizontal proliferation of nuclear weapons. At the same time, states also recognized the huge economic potential of nuclear commerce while promoting peaceful uses of nuclear energy. The dual-use nature of atoms, however, required a carefully crafted regime that could effectively dissuade weapon program while boosting the nuclear electricity generation. In order to achieve these objectives, the NPT safeguards regime was created but it suffered from the lack of clear definitions about source material, sensitive technologies etc. To deal with such problems, the Zangger Committee was formed in 1971, named after its chairman, Professor Claude Zangger of Switzerland. It produced a list called the 'Trigger list' which contained the required definitions; items for processing, use and production; and terms and conditions regarding the export of these items to NNWS that are not parties to the NPT. Export of such items required adherence to the safeguards as these pertained to nuclear material and technology that could directly help develop nuclear weapons.

However, India's peaceful explosion in 1974 and reports about certain clandestine programmes related to nuclear fuel cycle in a few other countries forced the non-proliferation lobby to devise effective methods of guaranteeing a more risk proof nuclear export regime. Also, France, a major supplier in nuclear commerce had not signed the NPT, causing concerns about potential shortcomings in the existing export regime. France had not joined the NPT and consequentially was not a member of Zangger committee.

These considerations led to the formation of a new suppliers group (originally called London Club) known as the Nuclear Suppliers Group in 1974.[28] France joining this group was a major achievement on the part of non-proliferation lobby. However, commercial interests dominated this forum resulting into an overall inactivity from mid 70s to mid

[28]The Zangger Committee's 'trigger list' pertains to nuclear material related exports that trigger the requirement of IAEA safeguards when supplied by a NPT member to any NNWS not party to the NPT and essentially established three supply conditions as mentioned in table (NTI 2018a). The NSG, additionally covers material of dual-use, non-nuclear material for reactors, nuclear related plant and equipment and technology associated with all of these (NTI 2018b)

80s. As a result, the proposals to make the nuclear export contingent upon the acceptance of full-scope safeguards failed.

With the end of the cold war and disintegration of the Soviet Union, the concerns for non-proliferation enhanced as new states came to possess sensitive nuclear material and technology. The Gulf war and the Iraqi clandestine nuclear programme revealed the 'dual-use gap' and forced a renewed emphasis on closing the loopholes in the nuclear exports regime.

The NSG formulated two sets of guidelines after the Indian weapon test and Iraq's diversion of dual use items to the weapon programme. They list the items, technologies, and equipment etc. that require export control. These items are continuously reviewed for their inclusion on the list.

Table -2.4. NSG Evolution Phases

Provisions	**Trigger**	**Requirements**	**Features**
Zangger Committee	Non-Proliferation Regime	Assurance of non-explosive use, IAEA safeguards requirement, re-transfer or re-export to require the same criteria too (NTI 2018).	'Trigger List'- provides definitions and list of items that can be processed, used and produced, and terms of conditions for export to the non-NPT countries.
Nuclear Suppliers Group (NSG)	1974 'Peaceful Nuclear Explosion' by India	Adherence to one or more international or regional non-proliferation treaty, supplier as per NSG guidelines, enforcement of legally based domestic export control system in accordance with NSG guidelines, commitments towards non-proliferation weapons and delivery mechanisms (Nuclear Suppliers Group 2017)	
Part- I in 1978	1974 'Peaceful Nuclear Explosion' by India	Adherence to the Comprehensive Safeguards by the recipient state in all its nuclear facilities (India was granted a waiver to this rule in 2008)	Deals with material, technology and equipment explicitly used for nuclear use
Part- II 1992	Clandestine nuclear programme of Iraq	Adoption of safeguards for specific nuclear activity or facility where the import is destined to.	lists the dual-use items which are legitimately used in civilian nuclear programme but can be diverted for the weapon purposes

2004	Nuclear programme of DPRK and Iran	'Catch all' provision (King 2009)	Provides for the blocking of an export if the member suspects that it might be diverted to a nuclear weapon programme even if the object does not appear on the trigger lists (King 2009).

Source: Author

However, this cartel's membership is voluntary, consensus- based and there have been violations. For example, Russia supplied nuclear fuel to India in 2001 in violation of NSG provisions in spirit. The member states are however, obligated to inform the other members of export denials so that there is no export to potential proliferators. Despite the close-knit nature of these groups, policy differences are abundant leading to problems with universalization of standards and criteria.

Over the years, especially since the concerns of clandestine nuclear weapons became more prominent in 1990s, the export control regimes witnessed an expansion in number, kinds and mandates. Apart from NSG as discussed above, there are three other such regimes, namely (MTCR), Wassenaar Arrangement (WA) and Australia Group (AG). MTCR pertains to controlling export of missiles capable of delivering weapons of mass destruction (WMD) i.e. capabilities of 500 kg payload and a range of 300 km and above in category 1 and category 2 including rocket systems, components and technology. While WA pertains to control of export of conventional ammunitions and items of dual-use, the AG (established in 1985) caters to export control of chemical substances and biological agents. While these four are the major components of export control regimes, AG isn't related to nuclear proliferation particularly. These three too, like the NSG, function on consensus basis and around 30 countries are members of all the four. These groups lie outside the IAEA and their rules, norms and standards are framed by the member countries alone which also are often the supplier states of these goods and technology. These agencies mainly serve as discussion forums for technology transfer conditions, proliferation risks and such. There are no compliance and verification measures and broad agendas set in these forums are implemented only at the national discretion of the individual member states.

For the proponents, these regimes are indispensable instruments, over and above the safeguards systems, to ensure non-diffusion of sensitive military and dual-use technology to potential proliferators or rogue states by making such acquisition tough, politically and economically costly, easier to detect by enforcement agencies, and partly verifiable through end-use control systems. Given the close-knit characteristic of these groups, many of the states formally and informally abide by the denial lists of one another so as to ensure non-supply to risky or dubious entities. Predominantly membered by northern advanced countries, these regimes have been often criticized by southern developing countries as unjust and 'discriminatory' (Moodie 2010). To them, such regimes are based on unjust principles and lead to denial of advanced and useful military and commercial technologies to the developing countries. Aiming at 'technology containment' (Mistry 2002) or 'techno-imperialism' (Muller cited in Latham and Bow 1998), these regimes have been additionally criticized for maintaining their relative economic advantage over the target countries (Chellaney 1994: 443) in accordance with the geo-politic and geo-economic interests of advanced countries (Vishwanathan 2016). Some critics also find them not only unnecessary, given the existence of safeguards regime, but also incompatible with the promises of promotion of scientific capabilities and knowledge for peaceful uses enshrined in various conventions.

As many of these concerns are genuine to varying degrees, these regimes have limited membership. Also, with the changing nature of nuclear threat emanating especially from non-state actors, questions of new-entrants to the regimes like India and Pakistan and issues of facilitation of non-risky dual-use technologies through monitoring rather than exclusive supply denial to non-member countries (Latham and Bow 1998) are some of the issues forcing these forums to revisit some of the norms and rules of their operations.

Having discussed the international nuclear regulatory framework, the last section enumerates and analyses India's position, and nature and degree of compliance with international nuclear regulatory instruments and mechanisms.

India's Compliance with International Nuclear Regulatory Mechanisms

This section will analyse Indian compliance, and also non-compliance, with some of the instruments and mechanisms of international nuclear regulation in the matters of safety, security and safeguards (also export control). It will also reflect upon the rationale and considerations governing Indian behaviour in the above-mentioned aspects.

Indian engagements with the IAEA date back to its early foundation days as India played an active role in its establishment. It was a founding member of the IAEA in 1957 and participated in initial discussions regarding the mandate that could be accrued to the new body. With India joining the ‘Washington Group’ in February 1956 along with USSR, Czechoslovakia and Brazil, the group became more representative as the agency extended its presence in developing countries. ‘Indian formula’ for the position of quasi-permanent seats on the BoG still remains the organising principle for the same. India substantially participated in the debates on issues like those of extensive safeguards (which it opposed), the ‘prompter-regulator’ dichotomy in the mandate to be covered by the IAEA, North-South debate on the issue of position of Director General, Chinese representation, technical assistance program, role of inspectors while conducting investigations in host countries, additional protocol on safeguards, dual-use items, nuclear fuel cycle etc.

Safety-related Compliance

India has, time and again, emphasized its support and commitment to the IAEA and very often adopted the IAEA technical standards and norms as they evolved, for different stages of nuclear operations and management. Such adherence has been carried out through a) adoption and ratification of IAEA instruments and conventions in the field of safety, security and safeguards and then b) incorporation of those in the national guidelines (Thakur 2018, Bhardwaj: 2018). India, ever since the beginning of its nuclear programme, registered its belief in the need for international cooperation and information-sharing in order to ensure safe and economic uses of nuclear energy on a worldwide scale. India, historically, has been more receptive, forthcoming and participatory in carrying out changes in technical standards and safety and security-related programmes proposed by the IAEA, unless there were grounds for undermining or compromising its nuclear weapon programme.

The IAEA commands wide legitimacy and respect in India’s nuclear establishment. It is held as an authoritative body when it comes to nuclear standards and codes. It, however, as reflected in its own official mandate, is not considered as international nuclear regulatory body in letter at least. Despite that, its role, as a watchdog agency of the United Nation, is recognized in spirit, if not letter. This belief emanates from the fundamental point that it’s body of *experts*, trained in nuclear science and technology, is drawn from different countries and the best of minds in nuclear field are consulted before developing standards and guidelines. Indian experts, too, being members of such esteemed and esoteric conferences and discussion groups, attest to its credibility. As Indian scientists and engineers are a part of the teams framing the guidelines, it facilitates their adoption at national level. The rules, standards, technical guidelines and such therefore, when proposed by the IAEA, are adopted in toto except in specific cases where local tailoring is believed to be more productive and safe in terms of their scientific application (Sundararajan 2017).

India's compliance with the IAEA conventions in the realms of safety, security and safeguards, however, has not been unconditional or prompt always. As far as inventory is concerned, India signed the Convention on Nuclear safety when proposed in 1994 but ratified only on 31st March 2005. It seems the delay was more due to bureaucratic lethargy than any intention to not abide by it (Sood 2018).

In the wake of Chernobyl, India also signed and ratified the twin conventions- convention on the Early Notification of Nuclear Accidents and Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency when they were proposed in 1986. India has been compliant with most of safety related conventions of the IAEA and accepted obligations under those. Indian regulatory compliance, therefore also resonates the overall consensus on need for international cooperation to deal with and develop robust mechanisms to deal with crisis events. This aspect has been dealt with in more detail in chapter 4.

Some, however, like the Code of conduct on safety of research reactors (and Code of Practice on the International Transboundary Movement of Radioactive Waste and Code of Conduct on the Safety and Security of Radioactive Sources) have not been signed by India. As Indian research reactors are utilized for dual purposes, India has avoided any international obligation requiring reporting of their operations. Indian promptness with regard to safety conventions emanate mostly from its respect and acceptance of rule and order proposed by the IAEA regime. Additionally, under the CNS, all the declared civilian facilities placed under safeguards are open to inspections while in case of WANO review, the country chooses as to which reactors would undergo inspections. All the operating nuclear power plants in India have undergone two rounds of WANO review while the third is in process (Government of India 2006). WANO conducted evaluations of KAPS-1 & 2 in 1998 and of NAPS-1 & 2 in 2000 (Government of India 2006).[29] NPCIL has sent its senior engineers to be a part of WANO review of other countries' power stations and of jointly conducted training programs with WANO and the IAEA (Gopalakrishnan 2002, Government of India 2006). Indian nuclear regulatory authority, the AERB maintains close contacts with other national nuclear regulatory agencies like the Network of Regulators of Countries with Small Nuclear Programmes, CANDU Senior Regulators, Cooperation Forum of State Nuclear Safety Authorities of Countries which operate WWER Reactors and European Nuclear Safety Regulatory Group.

Overall, one can observe that Indian compliance with the international 'regulatory' regime in the safety domain, has been a response of four prominent and distinct concerns, which have shown varying degree of flexibility over the years:

1) Respect for norms and order in international politics
2) Respect for and acceptance of IAEA's technical and regulatory expertise and guidelines
3) Over-arching principle of maintenance of national sovereignty, security and interest
4) Progressive need to participate in international nuclear commerce.
5) Safety-related accidents and incidents

This compliance, however, has not been without contingent qualifications. The Operational Safety Review Team of the IAEA reviewed the Rajasthan Atomic Power Station (RAPS) in 2012 and then conducted a 'follow up mission' to the same in February 2014. The Integrated Regulatory Review Service of the IAEA reviewed the Indian regulatory agency, the AERB in 2015 and suggested improvement potentials while applauding some of the features of the national nuclear regulatory agency. These external inspection regimes were allowed only as part of the bargain secured through Indo-U.S. nuclear deal and subsequent NSG waiver for limited nuclear trade with India. In fact, as the last chapter shows, India has been reluctant in accepting such inspection and verification regime, unless it had something concrete to gain in terms of material interests. Indian need for more flexible access to the nuclear supplier countries, arising because of

[29]NPCIL also was the first member at the WANO Tokyo Centre to invite WANO Pre-Startup review team for its construction plant in 2006 (Government of India 2006)

poor quality of its own domestic fissile material, therefore compelled India to abide by more intrusive safety mechanisms. In conclusion, Indian respect for the international nuclear norms and rules in peaceful uses of nuclear energy significantly affects its compliance with the same but at the same time is conditioned by the overarching principles of national sovereignty and ‘national interests’.

Security- related Compliance

Indian compliance with IAEA security related mechanisms and programmes, reflect an alignment of its ‘national interests’ [given Pakistan’s history of contributing to nuclear proliferation and terrorism (Rajagopalan 2015: 46)] with that of the international cause of defence against the threats of nuclear terrorism. India, therefore has shown much enthusiasm in this particular area. India is a party to all the 13 international instruments in place for combating international terrorism including nuclear threat (Ministry of External Affairs 2016).[30] India signed the CPPNM in 2002 and ratified its 2005 amendment on 19th September 2007 (IAEA 2017b). It also enacted the Weapons of Mass Destruction and their Delivery Systems Act in 2005 to carry out its obligations under the UNSC 1540 resolution (Ministry of External Affairs 2014).[31] At the same time, it has participated in several exercises of PSI as an observer despite not being a full member (Rajagopalan 2015).

The National Investigative Agency created under the National Investigation Agency act 2008, in order to curb the threats of terrorism including nuclear threats, has been designated as the central counter terrorism law enforcement agency. This act has a mandated reference to the above two terrorism related acts along with the Atomic Energy Act. To ensure India’s compliance with international commitments already undertaken relating to nuclear safety, security, safeguards and export controls, the Nuclear Controls and Planning Wing was set up in the Department of Atomic Energy in 2013 to collaborate with the MEA on international cooperation in such fields. Even when non-binding, the provisions of code of conduct on the safety and security of radioactive source has been adopted and enshrined in national guidelines. Also, to contribute in preventing illicit and

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[30] At present, there are around 19 conventions related to international terrorism. All, however, do not pertain to nuclear threat. Also, India is not a party to all of these instruments.

[31] Initially, India, siding with other NAM countries, opposed the resolution being legislated through UNSC in the matters of international law but later with the wide adoption of the resolution and glaring menace of nuclear terrorism, accepted it (Nayan 2014).

unauthorized use of nuclear and radioactive material, India cooperates with IAEA's ITDB database (Rajagopalan 2015). The study observes that Indian compliance with these instruments are a product of basically three factors:

1) Its belief in the credibility and efficacy of these instruments in curbing the threat of nuclear terrorism and smuggling

2) Apprehending responsible compliance on its part to further an acceptance of its nuclear weapon state status internationally

3) Such compliance furthering Indian objective of becoming a member of nuclear export control regimes progressively.

The Foreign Trade (Development and Regulation) act came into existence in 1992 but was quite general in nature and restricted foreign trade to a small list of items. Its amendment act in 2010 included the 'enabling provisions of the WMD act of 2005 and now includes licensing of services and technology with military or dual-use implications along with financial services (Nayan & Stewart 2013). In 2005, India rather adopted a rule prohibiting supply of enrichment and reprocessing (E&R) technology and goods to countries that do not already have them,

India also revised its Special Materials, Equipment and Technology (MSET) list originally issued in 1995. It came to be replaced by a new list known as Special Chemicals, Organisms, Materials, Equipment and Technologies (SCOMET) list in 2001. It was further revised in 2017 in compliance with the non-proliferation commitment enshrined in certain laws like the Weapons of Mass Destruction and their Delivery Systems, Prohibition of Unlawful Activities Act 2005 (Ramachandran 2005). To fulfil its commitment under treaties like the CPPNM and the UN resolution 154 (Ministry of External Affairs 2014), India amended the domestic Unlawful Activities (Prevention) Act 1967 and included some more offenses under it. India participates in the IAEA' Incident & Trafficking Database and has agreed voluntarily to comply with the provisions of the IAEA Code of Conduct on the Safety and Security of Radioactive Sources.

India has also been cooperating with the Interpol's radiological and nuclear Terrorism Prevention unit and the World Custom Organisation on nuclear trafficking issues (Ministry of External Affairs 2014). India has been an enthusiastic participant in the conferences on nuclear safety and security. It participated in the Ministerial level international conference on Nuclear Safety organised by the IAEA in 2013 and 2016. It contributed 1 million dollars to the IAEA's Nuclear Security Fund, both in 2013 and 2016. It also contributed $100,000 for the up gradation of the Seibersdorf laboratory of the IAEA (Nayan and Anand 2016). It also pledged to support the joint agreement, the INFCIRC/869 on strengthening nuclear security architecture in Nuclear Security Summit (2016). India has been supportive of the Global Initiative to Combat Nuclear Terrorism (GICNT) and participated in the three working groups of the same in the fields of Nuclear Detection, Nuclear Forensics and Response and Mitigation. A dedicated counter nuclear smuggling team was constituted in India as announced in the NSS 2016 summit (Ministry of External Affairs 2016). India not only attended all the nuclear security summits but also the preparatory meeting for the first conference, called 'sherpa meetings'. Though initially reluctant when the idea of 'gift basket' came up in 2012, India pledged to participate in gift baskets for 2016 summit concerning nuclear smuggling, nuclear security contact group and sharing of best practices (Nayan and Anand 2016). It also pledged to support the joint agreement, the INFCIRC/869 on strengthening nuclear security architecture in 2016 NSS.

The development of proliferation-resistant technology is a considerably new emphasis area requiring international collaboration to assess the technological advances at present. To further this objective, India proposed setting up a Global Centre for Nuclear Energy Partnership (GCNEP) in 2010 Nuclear Security Summit (NSS) held at Washington. Apart from the voluntary contribution to the Nuclear Security Fund, India also offered the services of its cost-free expertise in information security to the Division of Nuclear Security of the IAEA (Sinha 2015). The facility has even started conducting off-campus courses as the infrastructure construction is ongoing in Haryana near Delhi and aims to be a viable platform for international exchange of ideas related to peaceful uses of nuclear energy including the safety and security aspects. The center also hosts a training school for scientific professionals. There are five such schools: a) Advanced Nuclear Energy System Studies; b) Nuclear Security Studies; c) Nuclear Material Characterization Studies; d) Radiological Safety studies and e) Studies on Applications of Radioisotopes and Radiation Technologies (Government of India 2017b). Formal agreements with the OAEA and many other countries like Russia, France and others to this platform have already been signed.

However, the method of devising the ranking system has come under cross-fires, also in Indian quarters. Certain countries argue that the transparency and information-sharing required to demonstrate the security robustness may become risky for the states and therefore the objective criteria may not be an adequate and apt marker of national nuclear security credibility.

India like many other countries has argued against intrusive inspections and data-gathering through inspections for security related mechanisms for the fear of information-leakage and malicious uses of information by vested political interests of enemy countries.

In conclusion, Indian undertakings with respect to security regulations follow the evolution of the same internationally to a great extent. Accompanied with enhanced access to export control regime itself, Indian compliance in this domain has been influenced by its co-aligned interests with international security regulations. The 'war on terror' initiative enforced through UNSC Resolution 1540, PSI and such have in fact, allowed a broader acceptance of India as a partner in the 'coalition of willing' (but officially kept out of some of these forums like NSG), even when India has not signed NPT. This is in recognition of the fact that even as India has refused to abandon its nuclear weapon programme, its participation and compliance with multilateral initiatives in nuclear security domain would aid the cause of non-proliferation and counter-proliferation.

Safeguards and Export Control- related Compliance

On the issue of safeguards, however, Indian stand had been confronting since the beginning. In the initial phases, the Indian delegation sought to defer discussion of safeguards and wanted to enter into agreements with individual governments where it could be treated on a case-by-case basis. India also opposed safeguards application on the source material, particularly, the natural uranium (Goldschmidt 2006). The USA, supported by the majority of group members, particularly, the UK and the Canada, could successfully resist most of the attempts to weaken IAEA safeguards. India, however, was able to introduce a phrase limiting the IAEA's safeguards rights and responsibilities solely to those projects or arrangement where its help was sought. It also expressed its reservations on the clauses on deposition of uranium and plutonium generated from reprocessing with the IAEA supplied material. Such debates were instrumental in the evolution of the IAEA's mandate. This trend however, has undergone limited flexibility in recent years, due primarily to economic concerns and lack of enough uranium domestically.

Safeguards regime and regulations are characterized by the norms of non-proliferation regime operative under NPT. India, though initially enthusiastic about it in early 1960s, refused to sign it when it was proposed. Indian portrayal of NPT as 'nuclear apartheid', reflect its animosity with the non-proliferation norms that privilege the security and power status of a selected few at the cost of vast majority of states. To term it as 'normative' opposition alone, however, would be naivety. Indian opposition to NPT and the corresponding safeguard regimes is also a response to its security concerns that remained unaddressed with the same. Chinese acquisition of nuclear weapons in 1964 and non-availability of guaranteed 'nuclear umbrella' or extended nuclear deterrence through any of the superpowers affected Indian decision of not endorsing NPT in a major way (Kennedy 2011). India's own nuclear weapon programme, corresponding international sanctions and consequent adversity faced by its nuclear energy programme, therefore, became the cost and effect of its normative and security-based opposition to the NPT regime.

After a long resistance, India agreed to put its civilian facilities under IAEA safeguards after the India-U.S. nuclear deal post 9/11 and the subsequent NSG waiver to facilitate the same. India was not a member of non-proliferation regime so its conduct of nuclear tests cannot be technically seen as a violation of non-proliferation regime per se. However, it went against the normative consideration of non-proliferation which it has championed for though with demand for universality. Other than India's own undertaking of nuclear tests and possession of nuclear weapons, its record in non-proliferation has been impeccable and demonstrates self-restraints on the lines advocated by IAEA. It has observed self-restraint in export of sensitive items under the national export control regime. It has been furthering the cause of global disarmament since its early participation in international nuclear politics.

India has been critical of international export control regimes in the past and considered them as technology denial regimes that hamper the peaceful programmes in nuclear energy, space, pharmaceuticals and such of developing countries. Non-transfer of supercomputers to India by America in 1983 (Saran 2016) and sanctions on import of cryogenic engines from Russia by Indian Space Research Organisation in early 1990s (Vishwanathan 2016; Balachandran 2016) being cases in point. This position also reverberated the normative understanding of the non-aligned states, which India deeply identified with (Nayan & Stewart 2013).

This national position stands altered with India’s new-found status as a ‘de facto responsible nuclear power’ and special NSG waiver on nuclear commerce in late 2000s. India’s formal membership of the NSG has been blocked by China which has been evoking the condition of developing specific criteria for non-NPT countries to be admitted as NSG member and advocating Pakistan’s membership for the same too if India is admitted. NPT membership, however per se is not a mandatory criterion for NSG membership (Balachandran 2016). Due to ‘consensus’ practice of decision-making in NSG and huge clout of China in nuclear market being the biggest buyer, US efforts at lobbying for India’s membership have not been successful yet (Sethi 2016). Power-politics, and not India’s merit, therefore remains the guiding principle for membership in these regimes (Rajagopalan 2016).

Indian participation in the rule-based mechanism and regimes, accompanied with qualified strategic tilt of US in favour of India facilitated its admission into the MTCR in 2016, Wassenaar in 2017 and AG in January 2018. Membership to these regimes does not automatically facilitate collaborations with supplier countries which still are within the sovereign jurisdiction of the member countries. India’s increasing interest in export control regimes emanate from its requirement for fissile and nuclear-related material, technology and know-how and a possibility of being a prospective supplier especially in the field of special steels, forgings, control instruments (Khanijo 2016), heavy-water reactors, plant construction, repair and maintenance (Mishra 2016). Additionally, their membership status signifies the achievement of significant scientific and technological capabilities and a seat at the high-table ensuring its participation in rule-making endeavours.

In conclusion, India's interactions with the IAEA reveal the importance of international politics in systemic terms (in terms of polarity), ‘perceived national interest’ with considerable flexibility, fear of nuclear terrorism, utility of nuclear power for weapons and energy programmes, principles and policies on non-proliferation and disarmament and a keen Indian interest in shaping the global order.

Conclusion

In sum, this chapter dealt with the evolution and nature of international nuclear regulatory regime. It discussed the underlying power-politics accompanying important landmarks while establishing the operating principles for the three domains of safety, security and safeguards (also export control). It also discussed the mechanisms, instruments and norms associated with these three domains. The last section dealt with Indian compliance with international nuclear regulatory regime and provided explanation and rationale for the nature of Indian engagement with the same. The chapter made the following arguments.

One, the international nuclear regulatory framework falls much short of the criteria (separation of the promotory and regulatory functions, effective capabilities, licensing criteria and availability of financial and human resources) that it envisages for a regulatory authority in its codes and conventions. Though not formally designated as a regulatory authority, the IAEA has been the most important single multilateral agency in this regard. However, it suffers from a basic contradiction in its very statute which authorizes it to seek promotion of the peaceful uses of nuclear energy while ensuring the safe operations of nuclear energy. Therefore, its responsibility, accountability and vigilance in this matter are undermined, both in theory and practice. This lacuna has primarily been a result of limited political commitment on the part of states to authorize regulatory powers to a supra-national agency in matters of this sensitive and dual-purpose technology. A robust international regulatory regime would require comprehensive transparency to be offered by national nuclear programmes but this is not a popular idea among sovereign member states.

Two, there is no specific definition of ‘nuclear regulation’ in the international arena. The concept has been defined in general terms with little specificity. International guidelines primarily characterize a regulatory authority through the range of functions it performs or is supposed to perform. Even there, international documents prepared at the insistence of member states have charted out broad functions like licensing, inspection and others. General and broad nature of mandate, therefore has resulted into variability in the structures of nuclear regulatory authorities created in several countries. This undermining of regulatory function, more importantly in the domain of safety can be attributed to the objective of promotion of nuclear energy which is as one of the foundational rational of IAEA.

Three, the IAEA has evolved and expanded its reach to national programmes through certain conventions enabling a limited international regulatory control. However, most of these conventions are not binding and even when they are, the recommendations are very broad in nature and most of them lack any compliance or verification mechanism. Its reports are not mandatory to be complied with by the states. The IAEA's authority in the field of nuclear safety and security regime is also rigged by the fact that it serves as the international watchdog in pursuant to its responsibilities in ensuring nuclear safeguards under the Non- proliferation treaty. Therefore, its role as an international regulator is undermined owing to its corresponding obligation under NPT to protect the nuclear hierarchy in the international order. However, this regulation is more evident in specific cases where the member parties opt for the IAEA assistance and therefore are bound to comply with the international standards.

Four, the international regulatory framework lacks teeth and is highly inadequate. However, it does provide a standard to be complied with if the states are ever vigilant on their part. The success of international regulation in the safety and security domain is heavily dependent on the state's compliance and less so in case of nuclear safeguards. The international regulation is more vibrant in safeguards while safety and security have primarily been left to the domestic regulation in the spirit of international cooperation.

Five, the international civilian nuclear regulation is primarily normative in nature and emphasizes on self-regulation by states in ensuring nuclear safety and security. Its role is most vibrant in compilation of standards. But the implementation part is severely ineffective. The limited co-regulatory functions are restricted to the moral obligations to comply rather than a techno-political obligation on the member parties. Over the years, this normative obligation is transforming into political obligation. In fact, the value of the IAEA regulation lies not so much in its legal standing but more so in the normative and political sense. This can be accounted for by the end of cold war and thus better east-west coordination and the reasons of major nuclear security and safety related incidents and accidents. However, the conscious and jealous preservation of sovereignty has often hampered delegation of supra-national authority in the hands of international organisations. The facilitating mandate further impedes international regulatory control.

Six, International Nuclear Regulatory Regime adopts a more 'soft-law' based approach where the most prevalent kind of arrangements are non-binding ones (Boyle 1999: 902).

The binding obligations are much more general in nature than the specific guidelines proposed in codes, rules and recommendations. The former being more amenable to sovereign acceptance given a general reluctance in the international realm to allow supra-national or even intrusive peer reviews of nuclear facilities. This is neither the best nor the most uncontested approach to establish the international nuclear regulatory framework especially in the safety domain but the most preferred one, at least for the time being as many states prefer lowest common denominator in terms of international binding commitments. One of the most important tools adopted by the international institutions in this domain are the review meetings, of both the binding and non-binding commitments. These involve at least some sort of self-assessment, if not peer-review and opportunity for cross-comparisons and learning. Their periodic nature is an incentive for regular revisiting of safety and security credentials of national nuclear bodies in varying fields.

Seven, the international nuclear regulatory framework devised by the IAEA since its pre-establishment phase and through the gradual progressive evolution, has been greatly affected by the strategic aspects and inter-twined discourse of civilian and military programmes of nuclear power. It explains the limited mandate of the IAEA, its coverage mostly of explicitly specified civilian programme and more specifically to the land-based installations. The non-proliferation and disarmament discourses limited the idea and nature of the IAEA as a regulatory agency and widely shaped its powers and functions.

Eight, among the three aspects of civilian regulation, safety has been most widely accepted as the undisputed function of national regulatory bodies. All the national regulatory bodies observe the maintenance of safe nuclear operations. Safeguards on the other hand, especially in countries with nuclear weapon programme have not been under designated national regulatory body.

Nine, a relatively stronger regulatory regime in the realm of safeguards as compared to both safety and security reflects the operative power hierarchy supported by more powerful nations which favour non-proliferation as one of the most important rational of an international nuclear regulatory agency.

Finally, Indian approach towards international standards has mostly been compliant when it comes to safety and security regulations. India has included many of the IAEA's technical standards and best practices in its domestic legislation and incorporates the new ones incrementally. It, however, does not strictly view the IAEA as a regulatory or promotory agency per se. It highly values the IAEA's scientific research and contributes to their progress because of highly esoteric nature of the nuclear discipline and IAEA's credibility as an 'expert' body. As far as safeguards regime is concerned, for a long period of time up until 2008, India remained an outlier to it, even opposed it. Its own interest in nuclear trade and desire to be a part of global regulatory framework without signing the NPT, has engineered limited softening of its stand towards the safeguard regime, albeit in a limited manner. Compliance in this area, however, is greatly affected by national strategic considerations.

Chapter: 3

Evolution of the Indian Nuclear Regulatory Mechanisms

With the aim of deciphering incremental transformations in the nature, mandate and practices of the Indian nuclear regulatory body, this chapter presents a historical account of the same. The first section entails a brief context of evolution of the Indian nuclear energy programme at the time of independence and attempts to situate the regulatory concept within the energy development programme as and when it developed. It argues that the nature of nuclear regulatory regime in India is greatly influenced by the 'high-science' attitude associated with nuclear energy in general. Elitist and secretive ways of nuclear energy establishment precluded popular assessment of regulatory performance, a characteristic more pronounced in the formative years. The second section is divided into various sub-sections that separately and critically analyse the institutional structure, functioning, nature of the establishment and the need for reforms in the existing system. The third section specifically discusses nuclear security regulations in India, for which the AERB is only partially responsible. The evolution and progress of safeguards related regulatory obligations are discussed separately in the fifth chapter.

Fluidity in the conception of regulatory regimes in general and non-standardization of specific attributes of a nuclear regulatory agency in particular, make an objective assessment of its regulatory credentials and credibility particularly difficult. However, a qualitative assessment of the same remains a viable proposition which has been undertaken in this chapter. This chapter especially relies on two sets of primary data. The first pertains to individual interviews from within the DAE and a few others related to/working in the field of nuclear policies. The second is the survey of AERB officials conducted by this researcher with official permission of the AERB.

This survey was conducted through google forms consisting of 30 multiple-choice questions measured on Likert scale pertaining to regulatory aspect and organisational features of the AERB offered five sets of options: strongly agree, agree, neutral, disagree and strongly disagree. Results have been enumerated in terms of agreement, disagreement and neutrality by clubbing the first two together and the last two together for simplification. The original questionnaire proposed by the researcher was vetted and modified by the authorities. The questions selected by the authorities only were included in the final questionnaire sent to the officials. All the questions were optional as requested by the authorities. The number of respondents, therefore, differ in different questions ranging from 65 to 69. The total number of officials in AERB is 250 and so the sample size accounts for around 25-27% of the population. Conducted over a duration of around 15 days, the responses were collected and shared with the AERB at the request of the authorities. The questionnaire link was shared by the AERB authority to its officials. Respondents were allowed to respond anonymously and 53 out of 69, responded anonymously. Majority of respondents (62.3%) chose not to mention their department within the AERB.

This chapter compares and contrasts these results with the findings ones collected through analytical secondary literature on the subject along with the interview responses. Through a qualitative assessment of the regulatory credentials of the AERB as per the parameters laid down in the first chapter, this chapter argues that AERB's credibility as an independent nuclear regulator falls short of its claims.

The first section now discusses the beginning phases of nuclear energy programme in India and focuses on the scientific-political collaboration that shaped the nuclear organisations' structural contours which remain more or less the same even now.

Brief Overview of the Evolution of the Indian Nuclear Energy Programme

This section will discuss the reception of nuclear science in the Indian political establishment as one of the tools for proving India's mantle in world politics and bring in economic gains and prestige. It argues that these perceptions about the role of nuclear energy in the country's development shaped the fundamental organisation of nuclear establishment.

Both Homi Jahangir Bhabha, a brilliant nuclear scientist, and the first PM of India, Jawaharlal Nehru, shared a vision about the importance of science in pursuit of development for the nascent independent state of India. Both believed that it was the only way to break free from the miseries of poverty and under-development caused by the British rule. Both believed in nuclear power as "a vital energy source and marker of India's scientific modernity" (Arnold 2013: 365).

They, however, also shared a vision of India where it would no more play a subversive role to the interests of greater powers in the international order and to carve out a niche for itself. Science, especially nuclear science, therein appeared as a major instrument of power (Abraham 2006). In no uncertain terms, the decision for relying on nuclear energy to power the future India was taken, primarily at the top-level, without generating a broader consensus about the pros and cons of nuclear energy. Similarities of their visions also found characteristic resemblance in the personalities of both the leaders and the centralized nature of their functioning. Bhabha became the most authoritative scientific person while holding important positions of the scientific institutions and a recognized Indian scientist of international stature. Nehru relied on him and entrusted him with the responsibility to take control of the entire nuclear programme both at the policy and operational levels.

This centralization of authority draws its rationale from the then prevailing colonial practice of instituting scientific or research establishment within the realm of state rather than in public institutions like universities. Nehruvian science believed in state directed science to be conducted for the welfare of people (Arnold 2013). Modern science and technology required strategic directions and huge financial support that could only be provided by a centralized union government. Nehru's "Scientific Policy Resolution" presented to the parliament in 1958 also echoed the need for state control of major industries for India's development and freedom. Centered on such ideological and normative presumptions, the central government, in exercise of powers delegated to it by section 13 of the Atomic Energy Act (AEA) of 15 April 1948, provided for the establishment of the AEC in August 1948.

Created as the policy making body in charge of nuclear programme, it was attached to the Ministry of Natural Resources and Scientific Research, which was entrusted with the responsibility to implement its policies. Besides Bhabha as the chairman, other eminent members of the AEC were S. Bhatnagar, who was the then Director General of the CSIR and L. V. Krishnan, the Director, National Physical Research Laboratory. The agency initially envisaged developing and training scientific personnel for the promotion of nuclear energy on a commercial scale. Given the dynamic advances in nuclear technology in western countries specifically, Bhabha realized the need to seek international cooperation at least in the initial stages to kick-start the Indian nuclear programme. The initial years of nuclear programme naturally, focused exclusively on building foundations by developing technological capabilities & manpower, building infrastructure and an administrative system of management. He, at the same time, was also concerned about developing an indigenous pool of scientists trained in the nuclear field. Reasons were numerous. He was sceptical of relying on foreign assistance for the import of reactors and associated tools and technology. Reliance on imports in nuclear field could be risky and disastrous because of unknown variables, badly engineered plants or technical mistakes, cost factors and so on. An expansion of nuclear energy programme in India would not work without the availability of Indian scientists trained in the reactor technology in order to handle and experiment with new methods.[32]

Indian nuclear energy programme was highly dependent on international technological collaboration, foreign aid, and exchange like so many other national nuclear programs of different countries at that time (Abraham: 2004). Indigenisation could help lowering the costs of production and maintenance along with developing the technical knowledge and skills of scientists through real-time experiences with the reactors. This idea of indigenisation, albeit not fully achieved became one of the most important operating principles over the years. At the same time the overall emphasis for the same also reflected a desire for recognition among the Indian scientists at the international high table (Abraham 1999; Anderson 2010; Chengappa 2000). The colonial experiences of humiliation and subservience prompted an urge for proving one's merit and talent with the support of national government. Fortunately, for them the political leadership shared the similar vision for the country.

Bhabha, in his capacity as the pioneer of Indian nuclear energy programme formulated a three-stage proposal which primarily aimed at indigenous development of complete fuel cycle. He outlined this plan in his presidential address at the United Nations Conference on Peaceful Uses of Atomic Energy in 1954 (Gopalakrishnan 2002). India lacked good quality fissile uranium for use in the nuclear reactors, while possessing potentially fissile thorium in abundance. Along with these, argues Gopalakrishnan (2002) that a relatively weaker base in mechanical engineering sciences and production technology as compared

[32]He recalled that though the steel industry in India was an old one, being in place almost since 1920s, non-reliance on foreign collaboration could still not be achieved by his time. India involved a German consortium for the Rourkela steel plant and then a British consortium for the Durgapur plant. Handling and maintaining the plants alone could not automatically lead to the inculcation of ability to design and build new and efficient plants. He, therefore, proposed that powerful scientists and engineering groups be involved in the construction and operation phases so that the acquired knowledge can be fine-tuned to lead to self-reliance. This, he also, proposed for the nuclear power plants. A few scientists were funded and sent to the US and other countries to get training in nuclear engineering (Chowdhry 1970).

to chemistry and chemical engineering might have favoured heavy water production and plutonium extraction rather than resorting to centrifuge process for uranium enrichment required for light-water reactors. Bhabha therefore proposed that the first stage be based on heavy water reactors using natural uranium derived from local resources and international imports, generating plutonium as a by-product. The irradiated plutonium would be recovered through the reprocessing of the spent fuel. This recovered plutonium stockpile along with depleted uranium from the first stage could be utilized as core for the second stage involving, what are called 'the breeder reactors' as it breeds more fuel than it consumes. This additional plutonium and/or uranium-233 thus produced, could then be used as the core for the third stage thorium cycle, where the thorium blanket would undergo fissile reaction because of the core activity. This would ensure that more fissile material is generated in the process than the amount consumed leading to a self-sustaining closed reactor cycle. The adaptability of this programme for the weapon programme will be discussed in the fifth chapter.

Way back in the 1950s, Bhabha hoped that India would develop around 20,000- 25,000 MWe of installed electricity generation capacity by 1987. The next DAE head, Vikram Sarabhai too predicted that India would produce around 43,000 MWe of nuclear energy by the year 2000. Not only these predictions have not come true, as of 2018, the overall achievement in terms of total installed capacity remains abysmally sort of the targets envisaged. At present, it stands at a total of 5700 MWe installed capacity and contributes around 3% to the India's energy basket. The projected target is to reach 20,000 MWe by 2020 through the construction of 8 GWe of LWRs and the 2.5 GWe of the Prototype Fast Breeder Reactor (PFBR) along with the operating pressurized heavy water reactors (PHWRs), fast breeder reactors (FBRs) and the boiling water reactors (BWRs) (Grover and Chandra 2005). Medium term target is tapping 60,000 MWe by 2030 (Grover 2014). The DAE has also proposed to produce around 63,000 MWe by 2032 through a mix of PHWRs, FBRs and imported or foreign collaborated light water reactors. Given India's past records of delays, huge local opposition to nuclear energy projects at the proposed sites, problems of land acquisition in today's times and the under-development of infrastructural capacity to absorb so much energy into its existing distribution system, these projections appear too magnanimous to achieve. Such targets therefore seem incredulous. Despite these, the political offices have outlined a continuance of state support to the nuclear energy programme.[33]

This kind of political patronage to the nuclear establishment has also affected the degree of autonomy that the latter has enjoyed in national policies and programmes. Structural organisation of DAE institutions and concentration of authority in DAE secretary and AEC trace their origin to the initial leadership of Bhabha.

Bhabha believed that different tasks and institutions required different kinds of administrative mechanisms and practices. Scientific institutions, for that matter, are very different from other government departments. The transfer of government practices, either to industrial enterprises or research and development produces inefficiencies and lack of morale. Believing this, he introduced a different set of administrative practices in the Tata Institute of Fundamental Research (TIFR), of which he was the director and later extended those to the Department of Atomic Energy (DAE) when it came into being. His management of the AEC reflected his desire and belief to assert as much autonomy and non-interference for the institution as it could from the institutionalized political authority.

Kamla Chowdhry (1970), a close friend of Sarabhai, Bhabha's successor to the DAE, states in her book that Bhabha managed the conflicts of the two opposite systems i.e. one of decentralization, delegation, reporting and control, evaluation and motivation and the other where there is more scope for research innovation, learning, insights etc. by superimposing his own personalized system of management enabling the environment for scientific research. Scientists and engineers were paid according to their merit and maturity, rather than in terms of organisational position and status (Chowdhry 1970). He built the institution around individuals, which could provide incentives for merit and research. As novel the idea is, it does not escape from the criticism that such centrality of individual scientists at times over powers the policy requirements. The nature of scientific pursuit, given its experimental and often long gestation period, when allowed to operate without constraints may turn policy-blind. Indian experimentation with a variety of reactors is a case in point. Over the period this became one of the criticisms of the Indian

[33]Nuclear energy programmes all over the world slowed down and even halted in various parts of the world. But there is also a recognition that developing countries, if lacking in other major sources of energy like oil and natural gas, might need to focus on developing nuclear energy (discussed in detail in chapter 4).

nuclear energy programme. Also, such kind of autonomy was not envisaged for the academic institutions in general but only for the DAE institutions subsequently.

Sharma (1986) alleges that the nuclear policy making in India, like its counterpart in the political field at least initially, was shaped by feudal dynastic equations. Personal and family (dynastic) considerations were frequently opted as the raison d'tere of the major policy decisions. Negotiations with foreign countries for nuclear technological knowhow and components imports were carried out by Bhabha, thus influencing major policy decisions pertaining to the feasibility and possession of nuclear weapons, Tarapur negotiations with U.S.A. and so on. Personalization in policy making in the initial years extended to the civilian domain in terms of Bhabha's three-stage vision for India's civilian nuclear programme. With the centralization of authority in the DAE, the funds and mandates for nuclear research in other scientific institutions and universities also were centralized. Influence of personalization was reflected in the Atomic Energy Conferences dealing with atomic energy policy, dismissal of Meghnad Saha's scathing criticisms on secrecy and lack of transparency in the India ACA act, side-lining of universities and other scientific institutions in the field of nuclear research, shifting of Secretariat to Bombay making administrators available to the services of scientists and so on.

The 1948 act creating the AEC, like many other institutions, was modelled after the British Atomic Energy Act and brought the atomic energy under the exclusive purview of the state (Abraham 1999). Perkovich (1999) argues that the secrecy imposed under the act over research and development exceeded the ones maintained in either the British or the American atomic energy legislation. Such staunch mandate for secrecy raised questions about the intentions of nuclear programme as it was excessive given the declaration of intent as civilian and peaceful uses of nuclear energy alone. Objective of a nuclear weapon program was categorically declined by the leadership in the initial phases.

While introducing the atomic energy bill Nehru gave two reasons for imposing a strong ambit of security (Ramana 2003: 216):

> The advantage of our research would go to others before we even reaped it, and secondly, it would become impossible for us to cooperate with any country which is prepared to cooperate with us in this matter, because it will not be prepared for the results of researches to become public (Nehru quoted in Bhatia 1979: 85).

Nehru's responses on the question of pursuing the nuclear weapon programme remained ambiguous for a long time. Even in the beginning, when Nehru's views were more supportive of the peaceful uses of nuclear energy alone, he shielded the nuclear establishment from ministerial or bureaucratic scrutiny. When the finance minister questioned the unexplained costly endeavours of the AEC, Nehru warded him off by saying that the AEC merited secrecy and he himself had been getting reports from it from time to time (Abraham 2009: 46). This patronage of the AEC with the Prime Minister's office (PMO) continues even now.

Meghnad Saha, another leading scientist, questioned the extensively secret nature of the AEA 1948 and suggested a more open and transparent nuclear energy program as done in France. He pointed out that even in countries like the U.S.A., the AEC's exclusive powers comprised of procuring minerals, producing fissile materials and the weapon programme. The industrial firms collaborated in the nuclear energy programme and other peaceful uses of atomic energy was carried out with the participation of universities and research institutes. During a debate on peaceful uses of atomic energy in the Lok Sabha on May 10, 1954, Saha stated:

> First of all, there should be no secrecy. If you read out the Atomic Energy Act, you find that it does not tell us what to do but it simply tells us what is not to be done…I would ask our honourable friends on the Treasury Bench to read the Atomic Energy Acts of England and America and see how broad- based they are…(Saha M. quoted in C. V. Sundaram et al., 1999: 1548).

He believed that the veil of secrecy would only scuttle the huge energies and collective efforts of the scientists. Despite such critical remarks, however, the government did not amend the draft of the act and it was passed. This centralization of powers within the AEC accompanied by higher emphasis on secrecy, at the cost of democratic accountability, was further aggravated with the passage of the Atomic Energy Act 1962. It was granted exclusive powers to carry out all the activities and research related to atomic energy and related hardware. Neither the AEC nor the DAE report to the cabinet despite such powers and are answerable to only the PM. The AEC itself being a policy-making body for nuclear programme parallels the mandate of cabinet over most of the policy matters. Evasion of provisions for institutional accountability therefore makes it difficult even for other ministers or bureaucrats to challenge the policies of these bodies. People's participation becomes all the more difficult then.

Overall, one can observe that nuclear establishment as an institution occupied a high prestige in political echelons, resulting into a higher degree of autonomy for nuclear organisations vis-à-vis the government. This institution thrived on minimal oversight of political government and/or administrative bureaucracy. Its comparatively higher status among institutions of national development and security also accorded it a higher degree of organising autonomy within. The next section situates the evolution of regulatory mechanisms and institutions within this broader idea of need to expand nuclear energy projects.

3.2. Regulatory Evolution of the Indian Nuclear Energy Establishment

This section will discuss the evolution and growth of nuclear regulatory practices, mechanisms in general and the establishment of AERB in particular. It will also identify important junctures in this evolutionary progress, characterized by a change in regulatory principles or degree of institutionalization.

In 1954, through a presidential order under article 77 of the Indian constitution, the DAE was formed as the overall body in-charge of research, technology development and commercial reactor operation and the AEC was brought under it on August 3, 1954., Bhabha was made its first secretary. The DAE was to report directly to the Prime minister, in a way, over-coming the political authority of the ministry to which it was attached. The AEC was re-constituted in 1956 through a (cabinet) resolution, with substantial financial and administrative powers on the lines of the Railway Board in India, as the highest policy making body for the atomic energy programme (Sankaran 2015). A March 1, 1958 official resolution also provided for the chairman of the AEC to act as the ex-officio Secretary to the DAE. Significance of this resolution was not only in asserting Bhabha's unparalleled position in the nuclear establishment but also that the secretary DAE became the most powerful position in the nuclear policy matters for all the subsequent period as it was the highest bureaucratic office in the system. Other members of the commission were to be appointed by the PM on the recommendation of the AEC chairman (i.e. DAE secretary) and he could overrule all other members except the member for Finance and Administration, who, only in a financial matter, could ask for the matter to be referred to the Prime Minister (Sharma 1983). The commission had the authority to frame its own procedural rules. The resolution further equipped the AEC with full executive and financial powers. This move in a way dissociated the nuclear domain from the supervision of other ministry heads.

In the beginning, there was no concurrent proprietary audit performed on a regular basis as Bhabha opposed this and even when the membership of the AEC was increased from 3 to 5, he did not allow inclusion of a full-time member of the Finance and Administration at Bombay who was to be under the reporting requirements to Finance department outside the DAE (Singh 1973). His emphasis on a single modality of control led to non-inclusion of finance member in the administration at DAE Bombay.

In the original atomic energy act, only the government was entitled to operate nuclear power plants. An amendment to the Act in 1987 enabled a government company to own and operate nuclear power plants. This led to the establishment of the NPCIL, as a government utility to handle the PHWRs and the BWRs power plants and the BHAVINI to set up the fast (breeder) reactors. The power planning and engineering projects division of the AEC was reincarnated into the NPCIL (Menon 1988). Later, in December 2015, the act was again amended to allow joint ventures of the two public sector companies to own and operate the nuclear power plants. As of now, the core nuclear industry is inaccessible to private companies. The reasons of safety, insurance pool in case of disasters, regulatory difficulties relating to the monitoring of safety, evolution of organisational safety culture in private organisations, security and safeguards, compliance with international safety, security and safeguards obligations and other such reasons have made the nuclear establishment skeptical of private participation in the core area of nuclear power plant ownership and operations (Grover 2017, Sundararajan 2017). Private manufacturing of prescribed equipment and tools is allowed though.

The Indian nuclear energy programme began with the designing and construction of the first research reactor named Apsara in 1955 with British assistance (Ramana 2003: 218). Even before the Atomic Energy establishment, Trombay (AEET) was formally set up, this reactor became critical (operational). It was the first reactor in Asia outside the Soviet Union and used enriched uranium supplied by the UK. While Bhabha’s three-stage vision program became the foundation of the official nuclear energy programme since the beginning, the safety concerns took some time in becoming an institutional concern in the nuclear establishment. There was no formal clearance for the Apsara reactor, for instance for the first criticality (Sundararajan et al.” 2008). The onus of introducing safety mechanisms was with the designers, based on available published research on the topic. Bhabha informally sought a second opinion from some of his foreign friends on the design front. While the term ‘regulation’ lacked a conceptual understanding in those formative years, any practical and limited manifestations were entirely upto Bhabha’s predicaments.

The second reactor too was a research reactor named CIRUS with 40 MWe capacity natural uranium heavy water reactor. Built with Canadian assistance, it attained criticality in 1960. For the CIRUS- (Canadian Indian US) reactor, the Canadian authorities insisted on a design and safety report. The three chapters on safety- 1) administrative controls including emergency procedures, 2) safety analysis on postulated accidents and 3) waste management were prepared by the eminent members from the country’s Reactor Operations Division (namely V. Surya Rao and S. L. Kati) and Health Physics Division (namely A. K. Ganguly, S. D. Soman and V. V. Shirvaikar). C. N. G. Stewart, the head, Heath Physics Division at Dounreay reviewed the report at the insistence of Bhabha) (Sundararajan et al. 2008).

Later Ganguly went to Canada to get the formal approval on safety mechanisms. So, this was the first formal design and safety report prepared for an Indian nuclear power reactor. For all practical purposes, Bhabha’s directives were the most important source of the safety regulations. His directive issued on February 27, 1960 read,

> Radioactive material and sources of radiation should be handled in the Atomic Energy Establishment in a manner, which not only ensures that no harm can come to workers in the Establishment or anyone else, but also in an exemplary manner so as to set a standard which other organisations in the country may be asked to emulate (Bhabha quoted in S. K. Garai 2015: i).

The zero-energy experimental reactor, Zerlina was indigenously built but used US supplied heavy water as the coolant and moderator (NTI 2017). Unsafeguarded, it was set up for studying the natural heavy water uranium systems and attained criticality in 1961 (decommissioned in 1983). For this third reactor, the AEET (BARC) prepared a safety analysis report with the focus on heavy water storage, ramp reactivity addition and withdrawal of control rods. V. Surya Rao, presented this report in the IAEA symposium in 1962, the first ever by an Indian scientist.

Later in 1962, a formal reactor safety committee was set up by Bhabah with A. S. Rao as chairman and V. Surya Rao, V.N. Meckoni and Ganguly as members (Sundararajan et al.

2008). This high-level committee had three working groups, one each for Apsara, Cirus and Zerlina reactors. The working groups first reviewed the safety mechanisms and sent the report to the main committee. A program committee was set up to review proposals for reactor utilization and irradiations in these reactors. However, the final approval was to be given by the safety review committee (Sundararajan et al. 2008). A special committee on reactor control system was also constituted to monitor any related proposed changes and the final change was to be carried out once the reactor safety committee approved them. So, there was a multi-tier arrangement devised for the safety review of the reactors in 1962.

The first commercial power reactor then was installed at the Tarapur Atomic Power station (TAPS) where the two boiling water reactors were set up on a turn-key basis by the General Electric Company USA. This plant had limited Indian participation and covered site selection, tender preparation and evaluation, design reviews, operation and maintenance, contracting services in certain systems and local services in civil construction works (Sankaran 2015). Its site was selected without a formal review. Soon after that, however, an apex committee under M.N. Chakravarti, (earlier was in the Railway Board) was constituted for selection of sites for future nuclear plants (Sundararajan et al. 2008). Grounds for this choice are not clear though. Later the Health Physics Division (HPD) of BARC developed a set of safety criteria for siting purposes, which included “designation of 1-mile (1.6 km) exclusion zone and 3 miles (4.8 km) sterilization or low population zone” (Sundararajan et al. 2008: 4-5). These criteria for containment and siting of the reactors were discussed at the IAEA sponsored international conferences.

The first approach to the criticality of this reactor could not be approved as there was no formal regulatory authority at that time (Sundararajan et al. 2008). The then DAE president Sarabhai ordered an ‘independent’ committee under the chairmanship of A. K. Ganguly along with members form Reactor Engineering Division (RED), BARC to review the commissioning practices on achievement of criticality, and later operations too. This committee also reviewed the commissioning practices for the TAPS II that happened within the same month. This committee was later renamed as the DAE Safety Review Committee (DAE-SRC) on 3rd February 1972 by the Secretary DAE vide office memorandum no. 2/16/ (29)/79-PP, prompted with the near commissioning of the

Rajasthan Atomic Power Station Unit -1 (RAPS-1). Further, in 1975, its mandate for safety policies was enlarged to cover all the DAE constituent units including the power and research reactors and the fuel cycle facilities like the UCIL, NFC and others. So, the committee performed certain regulatory functions though the mandates were not essentially carved into regulatory terms.

In the case of the Rajasthan Atomic Power Station (RAPS), which housed the first PHWR, site selection, design reviews, indigenous development of certain components etc. was taken up by the Indian side. It was a CANDU Pressurized Heavy Water reactor built with the Canadian assistance and began producing electricity in 1973. The second unit of the RAPS plant saw more of indigenisation. Its operation, however, was delayed because of the withdrawal of the Canadian assistance after India's nuclear tests in 1974. Indigenisation efforts were stepped up all the more in Madras atomic power station (MAPS) where the Indian side took up the design and engineering responsibilities. The RAPS units 3 and 4 which became operational in 2000 also were indigenously developed in the wake of the international sanctions. With the accumulated experiences over the years, this plant saw site and safety related improvements for example use of containment structure.

The desire for energy self- sufficiency greatly contributed to Bhabha's fascination with the fast breeder reactors. These reactors were seen as a promising source of larger amounts of energy while taking care of the wastes generated by the heavy water reactors. At the same time, advanced breeders were supposed to be utilizing the vast resources of thorium that India had in abundance vis-à-vis uranium which is required in water reactors but occur in very limited quantities in India. Idea of a closed fuel cycle was persuasive for more than one reason and was being pursued enthusiastically in different parts of the world. Being an upcoming technology, the costs of experimentation were bound to run high but because of close synergy between Bhabha and Nehru on nuclear policy, it was adopted as part of India's official vision on nuclear programme. To materialize this plan, the first plutonium reprocessing plant to recover the irradiated plutonium from spent fuel of earlier reactors was commissioned in mid 1964. A formal safety review committee under the chairmanship of Ganguly was established in 1966 but owing to a dearth of published research on the topic, information was quite limited. This committee thus prepared the report and subsequent guidelines, based on experiences from the first plant.

Another committee, led by Soman to evaluate the next Power Reactor Fuel Reprocessing Plant at Tarapur and a radiological laboratory complex used these standards (Sundararajan et al. 2008). So, during this period, there was no formal regulatory authority to review the different kinds of undertakings in reactor technology and fuel cycle. The arrangement of the in-house committee structure, however, provided, some sort of safety regulation, which tantamount at best to self-regulation. The approach was adhoc and incremental and catered to specific reactors.

Technology for the first fast-breeder reactor, a test reactor, was developed in collaboration with France. The reactor type being quite different from the thermal reactors took a lot of time and discussions between the designers and the regulators. Under Sarabhai's order, the fast reactor programme was assigned to a separate Reactor Research Centre (RRC) along with other facilities like Reactor Engineering Laboratory for sodium technology. This RRC was later renamed as the IGCAR. As there was no AERB at that time so no formal safety clearance for nuclear project was acquired. The DAE-site selection committee cleared the Kalpakkam site which already housed the MAPP reactors. The newness of the design was a serious concern and therefore an 'independent review' of the design and safety aspects of the reactor was assigned to a Safety Evaluation & Working Group (SEWG) led by D. V. Gopinath (Sundararajan et al. 2008). He also led the safety committee constituted in 1982 for the commissioning. The safety report of FBTR was submitted for review to both the Reactor Research Centre Safety Committee and the DAE-SRC.

The French partners withdrew their support from the test breeder reactor after the Indian 1974 nuclear test. With the hampering of fuel supply from France, Mark-I carbide was developed as indigenous fuel. Due to constraints of limited availability of enriched uranium, this previously untested fuel was cleared by the DAE-SRC as the driver fuel (Sundararajan et al. 2008). An addendum for safety report of the small carbide fuel was issued then. The FBTR therefore saw the safety review by a number of in-house research wings. The regulation, though by the AERB, of a nascent technology being developed in relative isolation from the international community was primarily experimental and collaborative with the research wings of the DAE.

Slow and continuous evolution of nuclear energy projects led to a realization of need for regulatory mechanisms over and above the assumption of responsible operators and designers. The AERB silver jubilee publication claims that even in the absence of a formal regulatory body, the safety credentials even during the initial phase were solid. It credits the meticulous leadership of Bhabha in cultivating a resilient safety culture, which was carried forward by the subsequent chair of the commission. It prompted the HPD and the DRP to maintain a robust safety in the design and operation of such facilities. The document asserts that with the eminent scientists like Rao, Ganguly and Soman leading the safety departments, there was an obedient compliance to their directions. As respected as they were for their knowledge and wisdom, their courage and resilience to resolve the issues at higher-level discussions even at the AEC chairman level, ensured the autonomy of these departments (Sundararajan et al. 2008.

As novel as it seems, in principle, a reliance on personalities (of leading heads of safety departments) for regulatory credibility during initial days can be characterized as problematic. A close-knit group of scientists comprising of members from within the DAE alone ensuring the safety compliance measures during those days also highlights the significance of inter-personal relations in these departments. But from a regulatory point of view, such inter-personal relations undermine the need for arms' length regulator. Some Interviewees from within the department,[34] however, did not see this as a weakness but rather a strength of regulatory credibility (Sundararajan 2017, Sundararajan et al. 2008). Later, these agencies started including non-DAE members as well. These recruitments can hardly be called independent in principle though as critical entities would most likely not be called for such reviews (Ramana 2017).

In 1970s, Ashok Parthasarthy (2007: 131-132), a senior bureaucrat and science advisor to the prime minister suggested that an appropriate body located in the department of science and technology should inspect all the nuclear facilities to ensure health and environmental safety. The science and technology department, at that time, had the national responsibility to ensure the preservation of environmental quality and therefore could be authorized to maintain the same with respect to the nuclear facilities. But the idea of an external agency monitoring its external record was not acceptable to the AEC and the proposal was discarded (Ramana 2012a).

[34]The term 'Interviewees', unless, otherwise specified in this study, refers to the resource persons whose opinions were sought by this researcher as a part of this study.

Though India did not agree to undertake compliance with the IAEA safeguards, it was an enthusiastic founding member of the IAEA and kept updated with technological and regulatory standards and practices that it evolved to ensure safe management of nuclear energy. There was no internal domestic pressure as there was no audit of the institution and it remained shielded from more democratic accountability. The expansion in the areas needing regulation, however, were also expanding with increasing number of nuclear and radiological facilities. A number of steps were taken to establish the needed expertise starting from the scratch. Many scientists combined R&D efforts with participation in regulatory activities. One instance of which is that the team that was developing advanced dosimeter systems for measuring worker radiation dose was also engaged in monitoring countrywide radiation facilities in industrial and medical institutions (Krishnan 2017). As the programme expanded, there was a need to find staff wholly devoted to regulatory activities in respect of the nuclear facilities as well as the far more numerous radiation facilities in industries and hospitals in the country.

On July 23, 1979, after the TMI, the DAE secretary constituted a committee to review "the existing terms of reference of SRC, its functions, the modalities of reporting by the Units as well as the impediments faced by the committee" (Sundararajan et al., 2008: 13). The rationale offered was "to ensure that along with the safety consciousness, safe practices prevail in the DAE units" (Sundararajan et al. 2008: 13-14) So, essentially, it meant that even though the committee was confident about the safety consciousness and responsibility on the part of associated individuals, the recommendations were to institutionalize this consciousness in the form of standard practices that could be followed by future generations too. The need for a vibrant regulatory institution with a definite mandate was partly a response to the uproar caused by the Three Mile Island incident that happened on March 28, 1979 in the USA. It was the most alarming accident in a civilian nuclear facility of the time and safety credentials of the nuclear energy programme came under a sharp criticism worldwide. Most of the respondents from within the DAE, however, located the rationale not in the TMI but in the desire to keep updated with the international focus on regulatory practices (Chetal 2018; Raj 2018; Chetal 2018).

The committee was earlier presided by M. D. Karkhanawala who was the chairperson DAE-SRC then. But due to his sudden death, V. N. Meckoni, the then Director Chemical Group, took over the chairmanship of the committee. This body reviewed the existing mandate and challenges faced by SRC and proposed the creation of a regulatory body "to effectively fulfil the responsibilities of DAE for regulatory and safety functions envisaged under Sections 16, 17 and 23 of the Atomic Energy Act, 1962" (Sundararajan et al. 2008: 14, CAG 2012).

However, all the seven members were serving members of nuclear establishment and on the question of ensuring independence of the regulatory body, they proposed the AERB to be constituted by and reporting to the AEC while drawing the members from senior DAE positions as well as external members (i.e., non-DAE members).

The Meckoni committee did not cite any lacunae in the functioning of DAE- SRC but suggested that "since the activities of DAE and use of radiation sources in the country have increased, it is considered necessary to establish a separate body with the responsibility to carry out the regulatory and safety functions in an effective manner" (Department of Atomic Energy 1981: 14). It was to assist the DAE in framing rules and regulations for enforcing safety and regulatory requirements envisaged under the AEA 1962.

This Meckoni committee report titled, "Reorganisation of Regulatory and Safety Functions" in 1981 made several recommendations and became the foundation for establishment of AERB in 1983. It recommended status of a statutory body for the proposed institution of the AERB. While the AERB was supposed to lay down the standards for safe operations, SRC was to enforce them, conduct surveillance and carry out review of proposed changes in installations. SRC (with members derived from DAE) was made accountable to the AERB. Periodic safety reports of DAE installations were to be submitted to the AERB by the SRC. In case the enforcement was not found adequate, the AERB could take up the matter with AEC. Furthermore, the Division of Radiological Protection, BARC was made an executive agency of AERB for non- DAE installations for radiological safety.

In the final stance, the recommendation about statutory status was ignored and AERB was created by the DAE through an Executive Order of the President. Executive orders, however, can be altered by the issuing authority itself under the seal of the government without needing parliamentary approval for the same. It happened in year 2000 when DAE excluded BARC, India's principal strategic facility, from the AERB's purview

(Reddy 2012). Since then, safety credentials of BARC installations are rather reviewed by its own internal three-tier mechanism with BARC Safety Committee (BSC) as the apex body. These have not been without problems though (discussed in detail in chapter-5).

The SARCOP head who is an ex-officio member of the AERB is also on the board of the BSC (Sinha 2017). Although, the AERB has taken to itself the job of developing safety documents for radioactive waste management and spent fuel processing, BARC facilities are managed under BARC's authorities and implement the rules laid down by AEEB. Nuclear Material Accounting is carried out by the DAE, predominantly the BARC and AERB has no role there.

The report (1981) also suggested the "need for the participation of experts from other regulatory agencies such as the Central Electricity Authority, Central Pollution Control Board, Ministry of Labour and academic institutions to gain from their expertise and experience" (Sundararajan et al. 2008: 15). The members of safety related departments till then mostly belonged to the different DAE facilities making it more or less an in-house affair. Over the years, the number of non-DAE experts on the board has increased though there is no specific provision specifying the qualification or number of such experts in such committee. Therefore, while there is an increasing inclusion of the non-DAE experts, they are selected by the AEC, thereby potentially undermining the autonomy and authority of these members in presenting dissenting viewpoints. Also, the nature and qualification of such expertise is not specified. Such inclusive attempts are therefore at the will of the establishment itself. Pakistani counter-part i.e. Pakistan's nuclear regulatory authority (PNRA), to that extent, broadly defines the qualification of all - the chairman, the two full-time as well as the seven part-time members (Salik 2017).[35] In countries like U.S. and France, the regulatory authority reports to the parliament while in Pakistan, it reports directly to the prime minister. In case of India, this report is presented to the AEC.

The AERB was set up on November 15, 1983 under the enabling provisions of section 27 of the atomic energy act 1962 by a presidential order. Later, the DAE-SRC's functional responsibilities were clarified through a separate notification. Appeals against decisions of

[35] The chairman is required to have a 'postgraduate degree, preferably a PhD in physical or nuclear sciences or engineering and technology from an internationally recognized university, a work experience of at least 25 years in the relevant fields and should be a citizen of Pakistan'; the two full-time members are supposed to have a similar qualification but with a work experience of at least 20 years in the field of radiation protection, nuclear or reactor safety.

the AERB were to be filed before the AEC. Under Factories Act 1948, DAE was vested with authority to frame and enforce rules in all DAE installations and by this executive order, AERB was authorized to deal with all industrial and radiological safety issues of DAE installations. It draws its mandates from its constitution order i.e. SO 4472 and certain Rules framed under Atomic Energy Act 1962 like the Radiation Protection Rules (RPR), 2004 (Bansal 2017). Apart from the office order establishing the AERB and specifying its responsibilities, there are few other provisions as well. For example, Safety Mining and Processing rules and Safe Disposal of Radioactive Waste rules (1987) and Atomic Energy (Radiation Processing of Food and Allied Products) Rules, 2012. Some mandate is also drawn from the environment protection act 1986, carried out by AERB in DEA installations. The Industrial Safety Act 1948 which has been tailored through the Atomic Energy Act 1962 in form of Atomic Energy Factories Rules 1996, for application of industrial safety in units of DAE, are enforced by AERB to ensure the implementation of industrial safety rules. Under the National Disaster Management Act, AERB is mandated to coordinate with the disaster management force and devise effective ways to prevent and mitigate radioactivity related crisis events if they happen. Though the AERB is not the governing authority for the purposes of the Civil Nuclear Liability for Nuclear Damage Act 2010 and the Civil Liability for Nuclear Damages Rules, 2011, it is supposed to notify occurrences of all nuclear incidents.

The AERB was mandated to enforce sections 16, 17 and 23 of the Atomic Energy Act 1962 covering control of radioactive substances, administration of Factories Act, 1962 in the DAE installations and enforcement of safety related provisions. The mandate of the AERB, in India therefore is primarily restricted to the safety aspects of nuclear regulation while the security mandate was a later addition, albeit to a limited extent (discussed in a later section in detail). The board consists of a chairman, chairman SARCOP (Safety Review Committee for Operating Plants) (ex-officio), four external members and a secretary. The secretary earlier used to be a voting member but then the practice was abandoned as it was felt that the secretary should match with the professional capabilities of other experts (Bhardwaj 2018). The external members are distinguished professionals/academicians related with nuclear and radiological safety.

Further, the S.O 2865 dated October 26, 2004 provided that regulatory and safety functions of all projects/facilities/plants based on technologies developed by BARC, which would be eventually operated by organisations other than BARC, shall be carried out by AERB from design stage onwards on the basis of specific requests from Director, BARC from time to time (Sinha 2017). Regulation of other research centres like IGCAR, VECC, RRCAT etc. is with the AERB.

As far as AERB's regulatory control over nuclear industry is concerned, it does not have economic regulation as its mandate. The nuclear corporations, at the same time, are government owned. The overall fiscal audit of the nuclear operators i.e. the NPCIL and Bhavini are undertaken by the CAG. The Financial audit of NPCIL is done annually while the transaction audit is done at regular intervals to cover all the units and corporate office of NPCIL within a period of 2-3 years by the West/South zone branches of the O/o Principal Director of Commercial Audit and ex-officio MAB-IV, New Delhi.

Currently, the AERB has 8 technical divisions.: two safety review committees- the Safety Review Committee for Operating Plants (SARCOP) and Safety Review Committee for Applications of Radiations - SARCAR) and an advisory committee (for Project Safety Review – ACPSR – comprising of field experts).

Recognizing the need for an in-house R&D facility for dedicated research on issues of regulatory interest, the AERB, under the chairmanship of Rama Rao, commissioned its own Safety Research Institute (SRI) at Kalpakkam in 1999 (Sundararajan et al. 2008). The institute, however, does not harbour the entire R&D available at the AERB. This facility has limited expertise and performs functions like computational modelling and others without offering the entire set of expertise required for the regulatory purposes (Krishnan 2017).

A.K. De, a former director, IIT Bombay and a mechanical engineer by training, was appointed as the first chairman of AERB with P.N. Krishnamoorthy, former deputy director (DRP) as member secretary. The choice of a non-DAE chairperson was a deliberate move with a commitment towards autonomy of the board. The first Board meeting was held on March 10, 1984 and a formal organisational structure was approved by the Board on September 5, 1985 and then it came into existence on September 30, 1985 (Sundararajan et al. 2008).

De recalled that when he was approached by Raja Ramanna, the then AEC chairman, to take up the regulatory responsibility in AERB, he had no experience in the field as he was into research and had spent some time in industry as well. There were overlapping mandates between the AERB and the DAE-SRC and a sort of unwillingness to curb the responsibility of existing DAE-SRC (De cited in Sundararajan et al. 2008: 2004). So, in the beginning, functions and responsibilities were not clearly defined. Ramanna insisted that AERB should focus only on radiation safety related aspects in medical and industrial applications. K. S. Parthasarthy, the then Secretary, AERB mollified the doubts and advocated that similar power and mandate overlap initially happened with the USNRC as well (Sundararajan et al. 2008: 205). Ultimately, the SRC, that was acting as an independent unit till then, was brought under AERB and DAE- SRC was disbanded. As initially the members were drawn primarily from the BARC and the NPC, instilling a regulatory sense in AERB personnel with special emphasis on public safety, different from research and operation was required. Devolution of functions and power took time. De also recalled that initially he was prohibited from talking to press on nuclear issues. It was only during his second chairmanship in 1987 that he could talk to press and tell them what AERB was doing. He cautioned against too much of secrecy in nuclear establishment and citing French practice of "Public Hearing", advocated practices that would enhance public trust in safety of nuclear plants (Sundararajan et al. 2008: 206).

Rama Rao, the next AERB chairperson, also was picked like De. He was placed in DRDO earlier. Ramanna in his capacity as member of Search and Selection Committee, asked him to be the AERB chairman despite former's reservations against an administrative job (Sundararajan et al. 2008). However, Rao still had some ideas about DAE activities involving primarily metallurgy but apart from this, he did not have much idea about DAE or AERB. He acknowledged that he was not informed about operation of reactors and his first tutorial on it was on a train journey to Rawatbhatta by Ch. Surendar, especially on OPRD (over pressure relief device) system (Sundararajan et al. 2008: 212). These instances reveal that AEC's discretion and authority in the appointment of the AERB chairpersons, therefore, has been absolute since the beginning.

In sum, one can observe that due to an expansion in nuclear energy programme and facilities and activities associated with radioactivity, the DAE felt the need to establish a separate body that could be entrusted with the task of regulation alone. Before the AERB was established, 'regulation' was not treated as an administrative domain in itself. Safety precautions were considered as essential for promotion of peaceful uses of nuclear energy.

Therefore, starting with no concept of regulation per se, the DAE moved to a committee structure under the SRC which monitored execution of different stages of nuclear energy generation. However, it was only with the establishment of the AERB that the 'regulatory' control took a concrete manifestation. However, having located within the institutional structure of the DAE, and having drawn its operating principles, codes, modalities, personnel etc. from the DAE itself, the AERB continues to be shaped by the larger institutional culture of the DAE as a whole. Also, the initial years saw close cooperation and synergy between various wings of the DAE including those related to the safety mandate. Over the years, it emerged as one of the most characteristic attribute of the organisational culture in the DAE wings including the AERB.

3.3. Critical Analysis of the Indian Civilian Nuclear Regulatory Framework

This section now will critically analyse the institutional structure, mechanisms and practices adopted by the AERB along the lines of qualitative parameters as specified in chapter one. These relate to the administrative structure, staffing principles, financial provisions, nature of accountability, regulatory mandate and more. These parameters while underlining the operating mechanisms in detail will also reflect upon the autonomy and efficiency of civilian regulatory body.

Administrative Arrangement

This sub-section will critically analyse administrative structure of the AERB and examine the arguments on both sides of the debate. The regulatory body, AERB, is heavily dependent upon the DAE for funds, manpower, technical expertise and material resources. It reports to the AEC whose chairperson is the overall head of all the departmental units that it is supposed to regulate. The establishment has often claimed that the AEC is the highest-level policy-making body for nuclear program and it includes the cabinet secretary, the principal secretary, the national security advisors and independent scientists, apart from the NPCIL chairman and DAE secretary. These independent scientists mostly are the retired members of the DAE institutions. It is unlikely that these independents would be selected to serve on the commission if they raised too many questions on government policy. There is no explicit or written specification of qualifications or characteristics that the independent AEC members need to possess (Grover 2018). The close synergy between the government and the DAE, however, make it unlikely that matters of regulatory body would invoke major opposition from non-scientific members to what the scientific members already agree to especially if the matter pertains to appointment of regulatory staff, which in essence is about scientific competence and expertise. Even if the AEC has government representatives, in terms of regulatory autonomy, it means little because the government also has an interest in expanding nuclear energy.

Suvrat Raju (2018) argues, “Functional independence and autonomy would mean independence from both the DAE *and* the government” (Raju 2018). This, line of reasoning does not indicate that such decisions are necessarily made with a bias towards promotion while compromising regulation. The logic of the arrangement, however, indicates that such eventualities are rather quite probable. Such a non-transparent way of regulatory staff selection, therefore undermines confidence in regulatory appointments.

Major decisions like shutting down the plants, come up to AERB board, which consults the relevant advisory committee (Bhardwaj 2017). The board is presented with reports every three-months, which may review the decisions taken earlier. It can also meet additionally to discuss important issues. Rath (2018) and Khakhar, two of the external member of the AERB board pointed out that they did not come across any instance of dissent in these meetings till then and while the decisions of the meetings are recorded, no record of the dissent as such is kept. In case of a tie in decision making, the Chairman has the second casting vote. However, decisions are mostly taken by consensus and there has never been any instance when the Chairman was required to exercise the second casting vote. Such minutes, even when kept, are not for outside circulation and therefore cannot be reviewed by external agencies.

Gopalakrishnan attributed the poor safety record of Indian nuclear establishment to the reasons of “lack of a truly independent nuclear regulatory mechanism and the unprecedented powers and influence of the DAE, coupled with the widespread use of the Official Secrets Act to cover up the realities” (Gopalakrishnan 1996). Aggravating the anomalous organisational structure subordinating the AERB to the agencies that it needs to regulate in public interests, the lack of enough technical staff outside DAE has been another major issue undermining the autonomy of the AERB. Around 95 per cent members of the AERB’s evaluation committees are scientists and engineers on the pay rolls of the DAE. With so much dependency on the DAE, the autonomy of the AERB’s decisions are bound to be affected either directly or indirectly. He informed that the DAE's interference manifests itself in various ways, for instance, the AERB itself toning down the seriousness of the safety concerns or agreeing to postpone the essential repairs to suit the DAE's time schedule and allowing the nuclear installations to continue to operate even when the safety credentials warranted an immediate shutdown or repair.

Most of the interviewees, while not having worked directly with Gopalakrishnan, have argued that over the years, his suggestions have been complied with (Bhardwaj 2018; Bansal 2018; Raj 2017). Some also argued that certain recommendation measures, for example, procurement of a part say turbine, requires to be imported and so takes time. They argued that this delay on the part of the NPCIL, though it appears so, is not disobedience or indifference, but just a practical constraint (Bhardwaj 2018; Bansal 2018). Most of them undermined the possibility that the NPCIL would dare to not comply with the AERB directives as the regulator is highly respected in the entire establishment. Some also argued that Gopalakrishnan's criticisms were more of personal vendetta with the establishment (apparently for not being promoted) than genuine lacunae on part of AERB or NPCIL (Thakur 2018). Veracity of such claims remain unverified.

INSAG-17 recommends that finances for a regulatory body

> should not be decided by or subject to the approval of those parts of the government which are responsible for exploiting or promoting nuclear technologies…the budgetary process should be designed in such a way that the legitimate financial needs of the regulatory body and the consequences of inadequate funding are brought to the attentions of the political decision makers at the highest level (INSAG-17, 2003:7).

The AERB draws its budget and administrative support from the DAE institutions. There is no separate budgetary head allotted to the AERB and is clubbed with that of the DAE. It means the financial allocation including salary, expenses on undertakings and others are born by the DAE in its budget. Interview respondents from within the AERB attested to being adequately funded and attended to at the time of budgetary allocations. Once the budget is approved, the AERB chairperson can make independent adjustment to internal resource allocation (IRRS Report 2015, Sundarajan 2017). Sundararajan (2017), having worked on AERB's budget for four years attested that AERB's budget is never cut down by the DAE, even if other DAE wings like IGCAR etc. might see budget cuts.

In sum, in terms of a) the administrative structure; b) institutional separation of promotory and regulatory bodies; c) constitutional mandate; d) staffing principles; e) qualification criteria for AERB membership; and f) funding provisions, the Indian regulatory body is greatly undermined by its sub-department position within the DAE. Accompanied with secrecy permitted under Official Secrets Act and AEA 1962, such arrangements evade an objective assessment of their on-ground impacts on regulatory body. It also has been one of the strongest criticism of the current regulatory structure, thereby providing a reasonable justification for calls for reforms in the present structure.

Functioning

This section will analyse the functioning of AERB with a focus on adequacy of staff in terms of mandate (licensing), number and expertise, institutional mechanisms, committee structures, regulatory oversight on utilities and so on to evaluate its functional effectiveness.

The prime responsibility for nuclear safety, as defined in the IAEA SF-1, lies with the plant/facility operator, which is also the internationally followed norm. The functions of the AERB can be summarized as follows (Government of India 2017b):

1. Develop safety policies in nuclear, radiological and industrial safety areas.
2. Develop Safety Codes, Guides and Standards for siting, design, construction, commissioning, operation and decommissioning of different types of nuclear and radiation facilities.
3. Grant consents for siting, construction commissioning, operation and decommissioning, after an appropriate safety review and assessment, for establishment of nuclear and radiation facilities.
4. Ensure compliance of the regulatory requirements prescribed by AERB during all stages of consenting through a system of review and assessment, regulatory inspection and enforcement.
5. Prescribe the acceptance limits of radiation exposure to occupational workers and members of the public and approve acceptable limits of environmental releases of radioactive substances.
6. Review the emergency preparedness plans for nuclear and radiation facilities and during transport of radioactive sources, irradiated fuel and fissile material.

7. Review the training program, qualifications and licensing policies for personnel of nuclear and radiation facilities and prescribe the syllabi for training of personnel in safety aspects at all levels. Assessment of competence of key personnel for operation of NPP.
8. Take such steps as necessary to keep the public informed on major issues of radiological safety significance.
9. Promote research and development efforts in the areas of safety.
10. Maintain liaison with statutory bodies in the country as well as abroad regarding safety matters.
11. Review of "Nuclear Security affecting Safety" at Nuclear installations
12. Notify Nuclear incident under Civil Liability for Nuclear Damage Act, 2010 (AERB 2016).

The regulatory process consists of three major tier-review of the power plants (NPCIL 2015) (based on the need more tiers may be assigned):

1) the Unit Level Safety Committees
2) the Safety Review Committee for Operating Plants and
3) the Atomic Energy Regulatory Board.

The AERB carries out inspections of these facilities every 6 months for each NPP. Other statutory authorities like the Pollution Control Board, Central Electricity Authority, Department of Explosives, Inspectorate of Boilers, Ministry of Environment and Forests too have certain mandate for oversight at different stages of lifetime of the facility. In accordance with international conventions and guidelines, as well as national statutes, one of the most definite responsibility of the national regulator is to undertake licensing of different stages involved in nuclear power generation in accordance with the nationally prescribed criteria. AERB along with various other entities involved in licensing procedures have enumerated several qualifying criteria and steps to be followed for starting a nuclear power plant.

a) Licensing

There are six major stages concerning nuclear power plants that require AERB's licensing:

1) Siting; 2) Designing;[36] 3) Construction; 4) Commission; 5) Operation; and 6) Decommission.

At each stage a comprehensive review in a multi-tier structure of safety committees is carried out before issue of consent based on requirements specified in AERB Safety Codes and associated Guides. Apart from the laid down regulations, regulatory decisions are also based on operating experience feedback and engineering judgment. Kaiga project in 1991 became the first site for nuclear power projects that was formally assessed by the AERB's advisory Committee for Site Evaluation (Sundararajan et al. 2008). The committee existing before the AERB, finalized the sites for earlier projects. The site selection procedure has two main stages:

a) site selection and b) site evaluation.

The *site selection committee* is a DAE committee and includes the members from the Central Electricity Authority, Ministry of Environment & Forests, Atomic Energy Regulatory Board (in individual capacity, consent from this body does not imply AERBs consent), NPCIL, BARC, IGCAR, Atomic Minerals Division and other experts as it deems fit, presided by the NPCIL CMD. The site rejection and evaluation criteria are mentioned in AERB's Code on Site The site is selected first in which there is no involvement of AERB as regulator. Once site is selected then it is put for evaluation. Only after evaluation licence is granted by AERB for siting stage. Evaluation for Nuclear Facilities including seismicity, distance from airports/air corridors/ availability of land and cooling water and so on. It assesses the sites in terms of criteria fulfilment as specified by the siting related specific guides of the AERB. The overall evaluation and ranking is then sent to the AEC and the DAE. The final selection for any nuclear power plant is made by the central government. At this stage, the AERB is not involved but any member of it in his/her individual committee may be a member of the SSC (Bansal 2018; Sinha 2017)).

The *site evaluation committee* (SEC), on the other hand is an AERB committee and may consist of members from BARC, NPCIL, and other academic institutes as well as members from other industries like ONGC etc. (Bansal 2018). The Site Evaluation Committee carries out the evaluation of the site for its suitability for housing proposed

[36]In India, designing is treated as an integral part of construction stage, therefore, it has not been not really written separately. That's why there is no licence for design (Bansal 2018).

reactor with respect to its effect on site, effect of site on plant as well as ease of implementation of emergency measures. There are many design related information which are evaluated by AERB at the siting stage to ensure that radioactive releases from the plant are within acceptable limits both during normal operation and during accident conditions. At this stage, several detailed studies related to geo-technical, seismo-tectonic, hydrological investigations etc. are to be conducted for assessment of the design features. These are progressively evaluated.

Generally, the SSC members are not part of the SEC. The interviewees also argued that even if there is some overlap in membership, it does not affect the SEC decision because at the end, a site cannot be permitted without meeting all the mandatory criteria laid down in the siting requirements (Bansal 2018)

The site for the Narora power plant, however, was alleged to be motivated by the political electoral concerns during Indira Gandhi's prime minister ship (Sharma 1996). This is also to mention that the Narora plant is situated in the seismic zone 4, which implies its vulnerability to seismic conditions more than other Indian reactors which are mostly located in seismic zone 2 or 3. The AERB was non-existent at the time but the existing DAE-SRC's site evaluation committee approved the project (Sundararajan 2017). Also, the AERB requirements does not forbid locating an NPP in zone 4 per se if engineering solution are available, but lower seismic rated zones have been preferred in general (Bansal 2018). Constitution of these committee also highlight the permissive ecosystem in licensing procedure as members of NPCIL and other DAE agencies can also sit on these committee.

Apart from the SEC's licensing consent, the *expert appraisal committee* (EAC) of the Ministry of Environment, Forest & Climate Change (MoEFCC) reviews the terms of references of Environment Impact Assessment (EIA) report including the responses to public consultation. Based on the recommendations of EAC, the MoEFCC decides on grant of environmental clearance to a project. However, the clearance from MOEF is subjected to meeting the dose limits by AERB which are independent of the project as well as number of units at a site. Further, it also mentions about waste management as per AERB requirements. For nuclear sector, when there is an EAC which has AERB representative as one of its members, it is an independent Committee under MoEF. Its primary clearance, however, relates to the non-radiological environmental concerns. For radioactivity related concerns, the DAE remains the primary go-to body- be it AERB or ESLs of BARC and so on. Bidwai, in a public hearing panel submission noted that the ESL of BARC is not an independent body and so is the case with AERB. It is therefore difficult to say if the Environmental Impact Assessments presented at the public hearings that involve different entities of DAE, are truly independent (Menon 2011).

The MoEF and the AERB siting clearances, however, are independent from each other's jurisdiction and grant separate clearances, both of which must be obtained to clear the site for construction works (Bansal 2018). This is verified and assessed by AERB prior to grant of siting consent. As several detailed studies related to geo-technical, seismo-tectonic and hydrological investigations etc. are to be conducted for assessment of the design features, these are progressively evaluated and therefore, the process of site evaluation and grant of siting consent by AERB spans over a long period of time. AERB's Advisory Committee for Project Safety Review (ACPSR) which reviews the project proposals of a nuclear facility for siting, construction, commissioning and operations has a membership from MoEFCC.

b) Safety-reviews

AERB carries out safety review of proposals through a multi-tier structure of safety committees. Initially the proposals / applications are reviewed by the in-house staff of the AERB. The review findings are then put up to first tier unit level safety committees and then to second tier safety committees and finally to the Board of AERB. For, nuclear projects, the first-tier review is done by project design safety committee (PDSC) followed by Advisory Committee for Project Safety Review (ACPSR) and then Board of AERB. The Advisory Committee reviews the proposals right from siting, construction, commissioning up to operation stage. Once the plant becomes operational, the safety review is taken over by SARCOP. So, for operating plants, the review is first by the respective unit level safety committee and then by Safety Review Committee for Operating Plants (SARCOP). These are reported to the board, which also is the highest level of decision-making body in such cases.

In addition to these, the organisation which is responsible for the design of fast reactors, the IGCAR, or NPCIL in case of the thermal reactors, have internal safety committees also including plant level safety committee which is mandatory as per AERB requirements. So, before they put up any document to the PDSC, the internal safety committees would discuss the topic and give the recommendation to the PDSC. Regulatory board discussions do not take place until the subject has been discussed in the internal safety committee. And invariably the internal safety committee will have members who are not part of the design committee. They may have some members who were not directly involved in the design of that particular facility so as to give a wider coverage of the experts (Chetal 2018). An internal safety committee is constituted by that particular unit. It will have members who have knowledge in that type of activity but all members need not be from that very facility. For example, the reactor operation and the engineering facility operation are of the same nature so a person in the reactor operation could become in charge for the safety committee of that facility of engineering nature also. It is not necessary that all the members of the internal safety committee will be staffed from the unit which is to be licensed by the regulatory board (Chetal 2018).

A project design safety committee is never headed by a person of the organisation whose reactor is under review. Today it has become a convention that all the member secretaries of safety committees will be from the AERB itself.

i) Regulation of BWRs

A peculiar time was the VVER project at Kudankulam. The boiling water reactors, as they required enriched uranium, were not a part of Bhabha's three vision programme and India had till then relied on PHWRs. Light-water reactors have an advantage that they can be constructed for quite larger capacities than the PHWRs (Bhardwaj 2018). When the establishment decided to import the 1000 MWe VVER reactors from the Russian federation in 1987, the AERB was presented with considerable challenge as all its guidelines were designed keeping in mind the PHWRs. As a result, it relied on the IAEA and USNRC standards and cooperation from the Russian regulatory authority, the GAN. On the insistence of the GAN, a cooperation agreement was formulated between the former and the AERB in 1999 and a team of AERB officials led by S. K. Mehta, visited Russia to interact with the designers and observe the prototype plant there.

The agreement was finalized in 2003 when the then GAN chairman Yuri G. Vishnevsky visited India. The construction for the plant had already began though even before the agreement was finalized. A 2001 workshop organised by the AERB on 'Consenting

Process for NPPs' deliberated on consenting processes and it was decided to carry out the review simultaneously with the construction activities. The clearances therefore were issued in three sub-stages: Excavation, First Pour of concrete and Erection of Major Equipment (Sundararajan et al. 2008). While the construction license can be issued at one go, over the years, it is being done in the above mentioned three stages.

ii) Regulations of breeder reactors

The experience of regulating the FBTR enriched the AERB's capacities. To strengthen this potential, some of the skilled personnel from the IGCAR, involved with breeder reactor, were transferred to the AERB to help with the regulatory aspects for the PFBR project. In practice, some of the senior experts from IGCAR or BARC move to AERB when either the AERB demands a particular expertise for regulatory competence or if for some reasons, the person wants to move to the regulatory body. In rare cases, these employees move back to the parent organisation. This is not forbidden on paper though (Bhardwaj 2018; Chetal 2018). According to Sundararajan (2017), as nuclear science is in a state of flux, it is indispensable for the regulatory staff to keep updating their scientific knowledge and credentials and that can happen only with the circulation of such experts among the different wings of the DAE. People involved in operations or research would be more likely to understand the practical safety integrities than the personnel limited solely to the regulatory body.

There is a continuous indo-French agreement on the R&D of the fast reactors which is between the IGCAR and the CEA. That relates to the R&D portion and not on the commercial fast reactors- design or construction. It is confined to the R &D alone (Chetal 2018). Nevertheless, atomic energy regulatory board from time to time is in interaction with the regulatory boards of other countries, where they discuss many issues. So, for the fast reactor system of the FBTR operation or the PFBR licensing, other than the AERB, no foreign body is involved (Chetal 2018).

In response to the question on delay of commissioning of the commercial breeder in an interview with this researcher, Chetal located the cause in the newness of technology for both the operator and the regulator. He argued,

> First of a kind reactor anywhere in the world takes longer than usual to construct because the components of that reactor are different compared to what has been

> done by the Indian industry. First of a kind reactor takes more time for licensing because the licensing process, people in the regulatory system are also in learning mode. They are evolving with the system so obviously they are going to very fine details. They like to know about all the incidents that have taken place in the reactor and be convinced that the events have low probability of nuclear accident. In addition to that, they also like to see that the regulatory requirements of thermal reactors are also respected in case of fast reactors. Though in some cases it is not applicable, nevertheless it takes time to converge that this requirement is not effective (Chetal 2018).

The task of a regulator is to make sure that the design as presented for review contains adequate provisions to meet safety objectives. The regulatory, therefore, generally does not propose solutions as ownership of solution would conflict with responsibility for regulation. It is up to the designer to satisfy the regulator.

The operating license of a NPP is renewed every five years through a license renewal process. Planned inspections are announced to the utility while the surprise ones, obviously are not. The AERB can have external experts as inspection team members as well but they cannot lead the team. Also, externals are rarely included in inspection teams, unless their expertise is required in a specific area of inspection. The IRRS report mentions that no external expert was deployed as inspection team member in 2014, while one such member was deployed in 2013.

Nuclear regulation as a field, given its highly technical nature, must choose the regulatory staff from the same professional-institutional background as the regulated entities. This, however, is no constraint in including certain non-DAE experts in the regulatory agency. The AERB has certain non-DAE expertise at its board but the random and unspecified procedure of their selection raises serious questions on the nature of their participation in the AERB proceedings.

AERB is the social regulator of the nuclear energy programme as it concerns itself with safety and health related matters alone. It has no economic regulatory mandate relating to costs, price and other such factors pertaining to the economic aspects of nuclear operations. Its mandate is limited to the civilian facilities alone. In addition, various rules under the atomic energy act and RPR 2004, result in limited authority of the AERB as regulator. At the same time, the AERB lacks any competence in regulation related policy-matters. There is no policy-advising power with the AERB. While it has limited mandate with respect to security, the safeguards related functions remain entirely out of its mandate. This limited mandate of the AERB with respect to civilian facilities reflect the higher importance given to promotion of nuclear energy as compared to regulation.

c) *System of the RSOs*

Atomic Energy (Radiation Protection) Rules, 2004 require that employer of a facility should designate a Radiological Safety Officer (RSO) for carrying out periodic radiation monitoring of the facility. For non-DAE facilities, the employees of the facilities with required qualifications and experiences, after having undergone the specified training course, were designated as RSOs. These RSOs are certified by the AERB. The Station Operation Review Committee (SORC) has to meet every week or at every time an event/ violation takes place. And that periodicity, whether they meet or not, whether registers are being maintained or not, etc. is monitored by the AERB. The RSOs are supposed to ensure that workers take adequate safety measures while working and if there is undue radioactive exposure to the workers, actions can be taken against the RSOs, including revoking of their licenses.

Initially, for the Nuclear facilities within the DAE, the Health, Safety & Environment Group, BARC had been providing necessary support with respect to surveillance and advice on health physics aspects, in order to ensure compliance with the radiation protection requirements. The Officer–In-Charge(s) of the Health Physics Units (HPU) were designated as RSOs for these facilities. In Nuclear Power plants, the HPU had staff from BARC as well as trained NPCIL staff. Over the years, the health physics expertise was gradually and progressively passed on to NPCIL staff. NPCIL had its own training school where lectures from BARC imparted training on health physics aspects. 2009 onwards, the HPU in nuclear power plants became a part of NPCIL organisation. This was done with the rationale that the NPCIL having demonstrated its maturity and capabilities in discharging the responsibilities of radiation monitoring, was capable of handling this on its own. This is similar to the monitoring of industrial safety aspects by Safety Officers to be designated under the Factories Act (Sinha 2017). The AERB during its regulatory inspection, inspects the Health Physics Units to verify compliance with the established procedures.

The AERB does not have resident inspectors as RSOs. Though these RSOs report to the AERB, they are not its employees. Critics contend that placement of the RSO with the utility runs counter-intuitive to regulation as while these persons are in charge of monitoring radiological exposures, they as part of the NPCIL staff, receive production incentives if higher output of electricity is produced (Ramana 2009). This would mean that they have incentives to under-report safety violations. Legally, the practice stands on its merit as the RPR requires the utility to maintain the RSOs. There is a strong faith in the establishment that both the utility and regulator have unflinching commitment towards nuclear safety. It, however, would appear more logical if RSOs were AERB resident inspectors on its roll, rather than being utility's employees.

The IRRS report of 2015 observed that "the AERB places a large burden of their inspection activities upon the information received from the NPP" (IRRS 2015: 56) as it reviews performance report, radiological safety report, event reports and so on, provided by the unit itself. The AERB does not carry out all these investigations by itself in the first place (Bhardwaj 2018). The IRRS report suggested that the AERB "should consider increasing the frequency of routine on-site inspections at NPPs commensurate with the size of India's nuclear programme" (IRRS 2015: 2). On the positive side, it maintained that the AERB takes "full benefit from operating and safety review experience with the aim of continuously enhancing its regulatory framework and processes" (IRRS 2015: 2).

For other non-AERB mandated units, the Health Physics Units continue to be a part of BARC. Even the Environmental Survey Laboratories (ESLs) stationed at Nuclear Power Plants and other Nuclear facilities are under Health, Safety & Environment Group of BARC.

d) Safety Codes, Guidelines and Rules of the AERB

Safety codes, guidelines and rules are formulated by the AERB under the radiation protection rules. The CAG audit of 2011 claimed that this rule-making power of the AERB is rather limited and that the body is non-autonomous. Over the years, the practices followed are one of deliberative consultation and multi-tier reviews. The content of codes is prepared by AERB in consultation with other units like BARC, IGCAR and even the utility. Retired members of these organisations too, at times, are included as members of the code formulating committees or advisory committees at several levels (Chetal 2018). Despite the participation of members from other wings, the regulatory committees are often headed by the AERB personnel in general. The IAEA guidelines on specifics are consulted too. AERB formulates guidelines for precautions to be taken, say how to ensure safety and security while transporting nuclear material from one place to another or spent fuel management and so on. It does not monitor the actual process but provides guidelines which the relevant bodies should follow (Bhardwaj 2018). These guidelines are periodically reviewed and revised if necessary. Such revision involves insights collected through regulatory experience and feedback from users. New developments in the field also are considered during such revisions. Also, interviewees from within the establishment argue that many of the AERB committees employ external expertise in different fields (Khakhar 2017; Bansal 2018).

These guides tell the acceptable/desired methodology for ensuring compliance with the requirements outlined in the safety codes. It does not mean that they must be followed in letter precisely. If the utility can convince the regulator that the same requirement can be achieved through a different route, through some other means or process, it is accepted if it is technically convincing. The utility is not compelled to comply with the exact technical guidance always. One can follow alternatives as long as they fulfil the safety requirement. But it has to be demonstrated that requirements of safety codes are met (Bansal 2017). Shutting down a reactor for some time is rare and is done in cases of gross safety violations. Most of the violations do not call for on the spot enforcement action. The recommendations are drafted at site during inspections and are finalized in AERB by the concerned division and then formally sent to the concerned utility for their responses.

The AERB has adopted a philosophy of graded approach to regulation under the RPR 2004, whereby the regulatory attention is prioritized to commensurate with the risks involved. Further, apart from its own staff, AERB utilizes the expertise of retired experts from nuclear community and also gets technical support from premiere organisations like BARC, IITs etc. In addition, the launch of ELORA i.e. web-based licensing programme for radiation facilities has helped in multi-fold increase in registration of wide spread medical diagnostic x-ray units in the country. AERB has also entered into Memorandum of Understanding with various State Governments for establishment of Directorate of radiation Safety for inspection of medical x-ray installations. S. K. Sharma, a former AERB chairperson, emphasized on developing scientific expertise of regulators through engagement in research activities related to safety and regulatory practices. The emphasis was to be on developing in-house competence. While the CAG report cited the dearth of adequate staff as a lacuna in regulatory body, the interviewees from within the system denied it as a problem (Bansal 2017; Sinha 2017; Bhardwaj 2018; Chetal 2018; Raj 2017; Sundararajan 2017). Many of them argued that regulatory oversight for NPP is quite adequate and it is rather the non-NPP radioactive industrial and medicinal sectors that require more manpower for extensive regulation (Bansal 2017; Bhardwaj 2018). It was also emphasized in CAG's report on AERB in 2012. Critics, however, urge otherwise (Ramana 2017; Raju 2018). The sheer scale of radioactive facilities in India ranging from nuclear power plants to radio-diagnostics and medicines and so on is huge and a small number of 280-300 regulatory personnel, where not all are involved in inspections, to be effective, is a herculean task if not impossible.

The regulation of nuclear industry (supplying components, machines, parts and so on), however, is not carried out by the AERB. It is the responsibility of the utility to give a confidence to the regulatory body that a purchased component is safe which is being put in the reactor. The atomic energy regulatory board does not come into picture with any of the companies. Deviations from the prescribed specifications related to component and equipment need to be discussed with the regulatory body depending on its significance in terms of safety importance.

Though the AERB's safety regulation credential on record has been fairly straight, there are also reports of lacunae, ineffectiveness and limited autonomy, reported mostly by sources from outside the establishment. One example, being the Tarapur plant, which has been permitted to operate beyond the normal life-time of reactors. A. Gopalakrishnan, a former AERB chairperson recommended closure/decommissioning of the plant owing to various safety related issues. The plant is similar in design to the Fukushima plants and quite older than those units. He mentioned that the boiling water reactors at Tarapur vintage design supplied by the US in 1969 experienced numerous safety issues and such reactors have been shut down all over the world. India has been doing continuous modifications to keep them operational. The steam generators, the pats of which became unavailable with the stoppage of American assistance since 1974, became disabled with extensive tube failures causing a de-rating of the plant from 200 MWe to 160MWe. In 2007, upon the reporting of serious seismic shortfalls at the units 1 and 2, the NPCIL installed seismic sensors. This plant, procured on a turn-key basis from America had engineering and technical faults since the beginning. One of the reactors remained off-line for 8 months while the other was shut down for nine months, 'trippings' and outages were common during monsoon. Zirconium alloy cladding of the fuel developed perforations, resulting in radioactivity build up in reactors.

Officials, however, have justified this extension owing to 'several extensive upgrades over the years' (Bansal 2017), increasing its longevity. It underwent an early upgradation in the year 2000 resulting in many improvements. Inspection of life limiting welds in the reactor were found to be fine through various inspection campaigns.

The AERB as the national regulator formulated the safety manual on decommissioning requirement in 1998, compliance with which, is one of the pre-requisites of operator licensing. None of the plants before or after this period, however, had a decommissioning plan in place (Ramana 2012a). This reflects either a lack of commitment or effectiveness on the part of the AERB which did not compel the utilities to formulate a plan in the first place. Interviewees defended it on the ground that non-submission of decommissioning plan is basically because it is supposed to be a prior assessment and contingency plan but on-ground specifications might change by the time the plants are decommissioned say in 40 or 60 years or so. One would need to formulate the decommissioning plan anyway then. World over however, standard practice is to propose a decommissioning plan beforehand.

In a fair assessment, there is a lack of adequate expertise outside the DAE. Having a small pool of expertise therefore undermines the objective of separating the regulatory personnel from the non-regulatory scientific personnel involved in other DAE units. This problem is more structural, given its roots in a faulty education system and job market which do not promote and support such expertise beyond DAE-installations adequately. Lack of a strong and robust university system in India has resulted into the absence of a knowledge pool in the academic circles, leading to the inward-looking nature of the scientific establishment. This is a matter of serious concern that even after so many years of reactors operation, there has not been enough promotion and avenues for development of such skills outside a very few elite institutions like the IITs. Even not all the IITs have courses in nuclear engineering or other branches of nuclear expertise as required. While there are non-DAE members on the AERB board, they are mostly handpicked by the establishment and while being distinguished in their own professional field, may not be the kind of critics required for thorough and objective assessment of the safety preparedness. Rajaraman (2017) suggests that it would be more credible if foreign experts can be invited from time to time to oversee the regulatory performance without compromising national sovereignty. Resorting to the earlier practice of appointing a non-DAE expert as the AERB chairperson too could help in assuaging concerns about non-autonomous nature of the regulatory body (Krishnan 2017).

The DAE, however has become too accustomed to function in an unchecked and uninterrupted manner to go beyond the explicit international commitments it has taken with respect to the IAEA in form of the IRRS mission, CNS peer review and such. The establishment, however, has defended such alliance on various occasions.

Another important problem lies with the huge dependence of the AERB on the technical support organisations (TSOs) for the expertise. The TSOs like the BARC, Raja Ramanna Centre for Advanced Technology, TIFR and such are dedicated research centres associated with the DAE in the field of nuclear and non-nuclear applications. The AERB has its own technical staff but for many issues, they bond with the TSOs to help in the regulatory mandate. The advisory committee or the special committee, site evaluation committee, task force after crisis events and such others employ members from TSOs to supplement the expertise available at the AERB. The TSOs are, obligated also to advise the utility, evoking concerns of conflict of interest in its role. However, given a 'fraternal' working environment within the DAE, these roles are often accommodated and even accepted as a non-challenge to separation (between promotory and regulatory) principle. This is reflected in organisational cultural characteristics of self-objectivity, expertise-based impartial evaluations and fraternal connections having been trained similarly within the DAE units including AERB. Sundararajan, a former AERB personnel justified such congruence between AERB and TSOs on the ground that research-oriented nature of the latter might benefit the former as nuclear science is a knowledge intensive field and the regulatory body will only benefit from such collaboration.

The downside, however, is no less pertinent. There is a huge congruence between the industry and the TSOs as Indian nuclear energy programme is run by the state corporations, the NPC and the Bhavini. India being deeply involved with continuous research in the field of reactor technology has seen great synergies between the personnel employed with operations and those who as part of TSOs, help develop the design and safety features for these reactors. Being the guiding agency for nature and kind of equipment, designs, and modalities of operations, the TSOs at least in theory would be less likely to pursue the regulatory activities in a more objective manner. It is a little puzzling that many of the interviewees undervalued the NSRA bill for the fear that it would obstruct the support of the TSOs to the regulatory if reformed (Bhardwaj 2018). The bill, however, clearly stated that such support will be facilitated through clear cut agreements.

Many of the AERB committees including SARCOP also have members from the other institutions of the DAE like the NPCIL, BARC and so on but the terms of reference for consulting the non-AERB members are not clear. Though these committees are often presided over by an AERB member, the IRRS team suggested that terms of reference could be updated to specify that the non-AERB members can only provide information input.

The IRRS mission to India in 2015 applauded the professionalism and integrity of the atomic energy institutions and did not find any de facto compromise of the regulatory body. Also, the regulatory body is dedicated to a single mandate it has been entrusted to: regulation. It, however, also noted that the "governance framework of atomic energy has both the nuclear industry (utility) and regulatory body reporting to the AEC, there isn't clear separation of regulation with the potential to compromise the independence of the AERB" (IRRS 2015: 9). It, therefore suggested establishing a de-jure independence of the regulatory body through a legal process. On the other hand, a 12-days assessment of the PNRA by the IRRS team in 2014 found it as "an independent and competent regulatory body" (IRRS 2014: 1).

Apart from the structural issues, one of the serious lacuna on the part of AERB pertains to the extent of its public outreach. In the recent times, it has tried to inform the public about the safety measures installed and in-built in the design and structure of the power plants but it falls short in numerous ways. The public does not have access to the details of even the routine releases from nuclear power plants (Raina 2011). Public hearings for siting often are conducted in a high-handed manner and peoples' concerns remain unassuaged.

Overall, one can observe that the AERB has been entrusted with the functional mandate comprising of licensing of different stages of nuclear operations befitting a nuclear regulatory body as discussed in IAEA documents. However, some of the mechanism like over-reliance on utility for safety reviews, less than optimal transparency in the regulatory functioning, limited involvement of non-DAE experts in major regulatory reviews and so on undermine its effectiveness in a functional sense.

Involvement of the NPCIL in the AERB Committees

In order to assess the autonomy and effectiveness of AERB, this section focusses not on regulator but the utility i.e. the NPCIL. It analyses the powers and perception associated with the NPCIL both formally and informally and places regulatory body in a comparative domain with the NPCIL.

The activities relating to design and construction of nuclear power plants originally were entrusted to the Power Projects Engineering Division (PPED) of the DAE in 1967. This division was merged with a newly created Nuclear Power Board in 1984 and operated for next three years with more responsibilities. With the proliferation of power sector activities and projects, a need was felt to consolidate all those activities. Therefore, a new public-sector company, the NPCIL, was constituted within the DAE in 1987.

In terms of regulatory credentials, another major anomaly is that the AEC, among other members, also includes managing director NPCIL, director BARC but not chairman AERB. Such institutional structure of the AEC tantamount to a weakening of the AERB which, already crippled by its huge dependence on the DAE for operational purposes, remains outside the policy making body. Khakhar (2017), the current Director IIT, Mumbai, who is also on the regulatory Board for a consecutive second term reasoned that the AEC being policy- making body does not need to include the AERB chairperson. Policy-making and regulation are different jobs entrusted to different units and therefore, the AERB chairperson's exclusion from the board follows logically. While the logic sounds fair, it becomes problematic when the NPCIL's representation in the AEC is considered as then it becomes a part of the agency to which the AERB reports. Being a government-owned corporation, its presence in the highest decision-making body, with an exclusion of regulatory body, is structurally inimical to regulatory interests and power relations. Also, NPCIL practically is a reincarnation of the previously existing power sector structure of the DAE itself. This institutional linkage developed through past associations coupled with the fact that it holds the exclusive responsibility over nuclear power plants (thermal) indicate its heavy weight.

The DAE's huge confidence in NPCIL's organisational safety culture is also evident in the radioactivity exposure data collection mechanism. Data of radioactive exposure of the personnel is collected by the NPCIL machines and is sent to the BARC through National Occupational Dose Registry System (NODRS) which keeps exposure data of all. Mostly, the AERB reviews data reports of the NPCIL units. This record is not public but the people working in the plants can get it (Sinha 2017, Bansal 2017, Bhardwaj 2018). This arrangement works on the assumption that safe operation is in the best interests of NPCIL, therefore, it would undertake all necessary precautions to not allow excessive exposure of radiation to workers. NPCIL, on account of being a government sector unit, also transpires confidence in safe operations (Bhardwaj 2018, Grover 2017).

While there are several problems associated with govt. owned and profit-based enterprises like reasons of profitability, inadequate emphasis on safety, apathy associated with public-owned enterprises, insufficient standardization of job conditions of contractual workers and/or deliberate neglect that also informs decision-making in a profit-making corporation, interviewees from within the establishment undermined an association of such motives with NPCIL or BHAVINI. Studies on radioactive impacts on health of contractual workers, for example, have shown contradictory evidences, making an objective assessment difficult. But having received similar training in safety requirements and close-knit and inter-dependent nature of nuclear establishment, nuclear corporations are deemed above such petty considerations and follies.

Another contention lies with the committee structure of the AERB. SARCOP (which is one of the most important body which takes important decisions regarding utility, for example, modification in existing plants), for example, also has NPCIL members. Decisions are primarily taken on a consensus basis and pending/more important decisions go to the board. Such arrangement, therefore, allows an unusual and avoidable involvement of the utility itself in the regulatory functions/decisions. As per international conventions, a regulatory body is supposed to maintain an 'arms-length' distance from utilities in order to avoid any undue influence in its working. This is not the case with Indian regulatory system. The system puts much faith in the fact that both the utility and regulatory personnel undergo similar and common training at the beginning, primarily at the Homi Bhabha Training Institute (HBNI) and assumes that the utility demonstrates a safety consciousness almost at par with the regulator. But at the same time, it should also be noted that Indian nuclear operators and other personnel are comparatively quite well qualified (relative to their counter-part in other countries reference). Every regular staff has a B. Tech degree (or equivalent) so the level of training and expertise is quite high (Balachandran 2018).[37] This aspect was also appreciated by the IRRS mission 2015. There is no denying the fact that highly trained nature of nuclear operators and other staff contribute to the self-belief and credibility that the nuclear establishment has resonated as one of the attributes of its organisational culture.

This, however, runs counter-intuitive to the idea of autonomous regulation. While the professional competence of the utility personnel is a laudable and confidence-building in terms of safety preparedness, it does not compensate for the over- involvement of utility in the regulatory committees, raising questions on autonomy of regulatory units. The fraternal affiliations between the regulator and industry within the DAE therefore, undermine autonomy structurally.

Secrecy and Transparency in AERB's Functioning

Transparency has been cited as one of the major attributes of an independent regulatory body (INSAG-17: 2003). This section will present a critical analysis of the AERB's credentials with respect to this parameter.

India remains the only country to experiment with so many different kinds of reactor designs on a commercial scale. Most of the countries have preferred to master the technology of one or two major types of reactors. India, on the other hand, harnesses electricity from BWR, PWR, PHWR and FBR design types. All these design types are different from each other. A multiplicity in the types of reactors technology, fuel composition, players, architects, designs, vendors and so on complicate the standardization of units, rectification of faults, efficiency of plant management, differing licensing requirements and ease of operational learning across different types of reactors (Sethi 2010). The nuclear establishment, however, claims to have mastered these technologies successfully. If true, the sheer magnitude of expertise is worth applauding. Such choices, however, are also fraught with the risks of financial overruns and safety mishap potential but the limited political control over the scientific nuclear establishment,

[37]In U.S., for example, all the technicians do not have a B. Tech degree (or equivalent) unlike their Indian counterparts (Balachnadran 2018).

an informed public debate and ‘elite’ nature of technology has largely kept it unhindered in its pursuits.

Critics point out that the veil of the secrecy, covering the entire range of DAE’s operations including both the civilian and military responsibilities, effectively shield the shortcomings of the civilian sector in the broader ambit of national security, resulting in less than transparent functioning and lack of effective accountability. For instance, at times, access to the financial accounts were restricted citing ‘strategic concerns’. Such rationale was cited even when the CAG questioned the costs of producing heavy water in the DAE facilities. Even the reprimand of the Public Accounts Committee for disregarding the cannons of accountability, could not force it to open up financial accounts for appraisal (Ramana 2009: 6). The DAE simply maintained that “Heavy water being strategic material, it is not advisable to divulge information relating to its production and cost to functionaries at all levels" (Public Accounts Committee 1992-93 mentioned in Ramana 2012b). DAE similarly ward off the CAG’s question on cost overruns by 133% at the Manuguru heavy water plant by saying that the plant catered to strategic and not commercial purposes. In view of the poor performance of the nuclear energy, the NPCIL was established in 1987 to make it competitive with other energy corporations. The CAG audit of the NPCIL for the financial year 1987-88 revealed serious irregularities with the DAE and also mentioned the shortcomings related with NAPS project in terms of its approval without an appropriate deign for equipment and buildings; unrealistic cost estimates and time schedules, time delays and cost overruns (Buddhi Kota 2012). Dr. Grover, an AEC member, in response to such predicament regarding heavy water clarified,

> Certain materials have been categorized as prescribed material as per the Atomic Energy Act. A notification issued by the Department of Atomic Energy lists prescribed substances, prescribed equipment and technology. Heavy water is listed as a prescribed substance. So, the word is prescribed and not strategic. DAE maintains a record of heavy water inventory (Grover 2018).

The implication, however, remains more or less. Even for a prescribed substance, external investigative access remains limited.

A. Gopalakrishnan, in an interview to the *Indian Express* on 18 June 1996 mentioned,

> During my six-year-old association with the AERB (3 years as a member and the remaining period as chairman), I was able to study the nuclear regulatory process thoroughly. I discovered that it was a total farce. I was of the opinion that the

> government and the public should know this because ultimately, they finance the nuclear establishment. My straightforward attitude was not liked by the top bosses of the establishment. The DAE wants the government and the people to believe that all is well within our nuclear installations. I have documentary evidence to prove that this is not so. A national debate is needed. My only concern was to ensure the safety of the employees and the people at large (Gopalakrishnan 1996).

S. D. Soman, former AERB chairperson (he was associated with HPD, BARC) also emphasized a need for more transparency and stringent training programmes for activities ranging from mining to waste disposal. He was credited with starting the practice of holding press conferences annually when annual reports came up and the entire AERB Board was supposed to be present at such conferences to answer the questions from public on safety issues. However, he remarked that in later years, the practice took a back seat and interaction with media became lesser, which was not good for public confidence (Sundararajan et al.).

S. P. Sukhatme, another former AERB chairperson too cited transparency as a major challenge facing AERB, apart from the need to attract talented and skilled human resources for the establishment.

Such secrecy also shrouds the reporting of nuclear related incidents in the public domain. For instance, after the Narora plant fire, two enquiry committees were set up, one by the NPCIL and the other by the AERB. The reports have not been made public though. Similarly, two investigation committees, one by the NPCIL and the other by the AERB, were formed after the Kaiga containment dome collapsed during construction. The AERB investigation team had non-DAE experts while the NPCIL committee comprised of internal members without any external expert participation. The reports of both the investigations again, remain confidential (Buddhi 2012).

The TSOs collect a lot of data on the radioactive levels at nuclear plants, in vicinity, radioactive installations etc. but these are not in public domain. It seems more cautious of the fact that people might get al.armed by even the low doses of radiation without understanding that some of it is natural and not harmful. This approach, however, compromises its potential for transparency which requires wider public campaigns and consultations. Public outreach and disclosure of relevant information is fraught with risks of evoking panic but it is an essential element of regulatory activities and help maintain a check on over-ambitious drive or safety cautiousness of operators.

Most of interviewees from within the establishment (both acting and retired) agreed that enough transparency in AERB's functioning exists while others emphasized on the need for greater transparency for public purposes. Those interviewed from outside the establishment invariably highlighted the opaque functioning of the regulatory body and the DAE in general. Survey respondents, however, most of them (71%) supported the argument that enough public transparency exists in the AERB's functioning while 18.8% disputed the same. 10.1% did not choose either side.[38]

"Enough public transparency exists in the AERB's functioning"

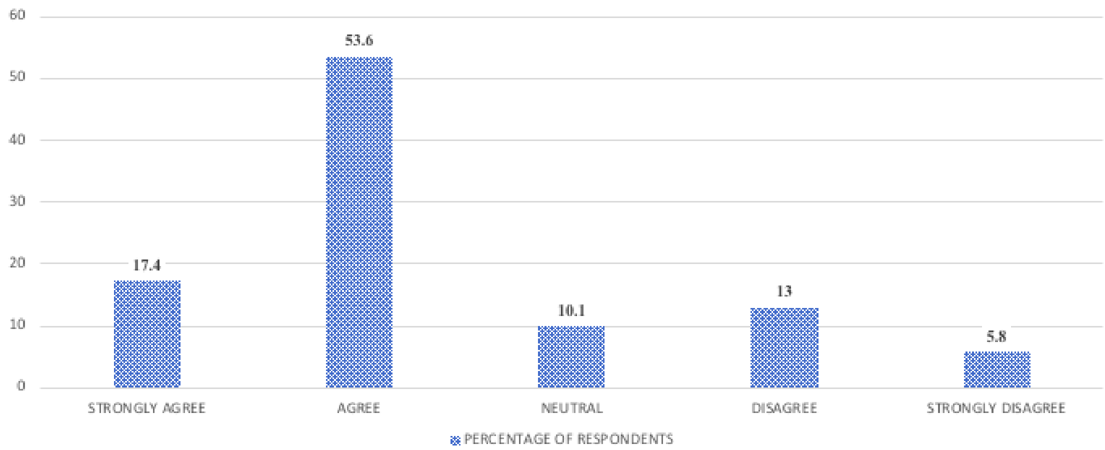

Figure- 3.1. (**Sourc**e: Author)

Findings therefore are disputed as far as primary data is concerned. The AERB comes up with annual reports detailing its regulatory activities on a yearly basis. However, there have been news reports of under-performance or subdued performance of the AERB in response to certain safety failures in nuclear plants. At the same time, several radioactive facilities remain under-regulated in India, a concern reiterated both in the CAG report as well as interview responses across the spectrum.

Additionally, the original questions pertaining (separately) to lack of transparency (for those who agreed that there is a lack of transparency) being attributed to factors like a) weapon program, b) technical nature of nuclear information and c) nuclear organisational culture were removed by the authorities. While no data on these could be generated

[38]This thesis will refer to the following representation of survey data through bar graphs where the quoted text represents the exact statements on which survey responses were sought. The bars represent the percentage of respondents in each category.

through the survey, outright removal of such questions can be interpreted as a reluctance on the part of the authorities to flag these questions fearing a negative perception towards AERB's transparency credentials. In light of such ground evidences, and sources, transparency record as one of the regulatory parameter remains less than optimal.

Functionally, though the mandate of the regulatory is quite limited by the virtue of existing rules in the first place, the AERB has worked hard over the years to fulfil its responsibilities properly. There are, however, severe constraints in terms of its structure, huge reliance on TSOs, limited outside expertise pool, huge regulatory expanse in the non-DAE radioactive installations and so on mandating a need for regulatory reforms.

Need for Reforms

Especially since the harsh audit of the CAG in 2011 (other major reason being crisis-events, which will be dealt separately in the next chapter), there has been a focus in nuclear establishment on better coordination and opening of regional centres is an effort in that direction. Along with Mumbai, which is the main office, other centres are being established in Delhi, Kolkata and Chennai to facilitate prompt responses (Bhardwaj 2018).

Critics (Ramana 2017, Raju 2018, Gopalakrishnan 1999 and so on) over the years have flagged the non-autonomous nature of regulatory body as a severe problem in the management of nuclear energy programme. The prevailing perception is that being placed under the AEC, AERB's hands are tied through control of its budget and thereby its authority to take strong action against the DAE facilities if required in the interests of safety, is undermined. Also, the present arrangement provides a lower level of parliamentary oversight over AERB performance as the AERB's report is presented to the AEC.

Interviewees, however, cautioned against the modalities of autonomy that could be envisaged. A regulator, independent from government, especially given the parliamentary nature of Indian polity, for nuclear establishment (govt. owned) which carries out the twin programmes of energy and weapon production, is therefore risky and practically difficult to achieve. The 'autonomous agencies' like the CAG and so on too get appointed by the Cabinet committee on appointments, which essentially means government appointment (Rath 2018). Even provisioning AERB appointment outside the AEC will/shall still require some sort of consultation with the scientific body (as Supreme Court judges are appointed by a collegium of judges) given the technical nature of nuclear science. Nuclear operators, till, now are government corporations alone and dual-operations being conducted in the DAE, there is an apprehension towards instituting outside regulators. With the separation of civilian and military facilities this imperative has been addressed to quite some extent, however, there does not seem to be an enthusiastic support for the same. Also, in order to ensure more autonomy, even nuclear regulators can be provisioned to be instituted outside the DAE and may be attached to another ministry, even if DAE or AEC is granted some powers in selection of experts. A chain or hierarchy of command without AEC or DAE's involvement might envisage more confidence in regulatory structure in general.

A. Gopalakrishnana, former AERB chairperson, in his tenure, appointed an AERB committee to prepare a document to model the nuclear regulatory authority on (Gopalakrishnan quoted in Newsclick 2011). He analyzed the structure of some of the independent regulatory bodies in India. For example, the department of Labour hosts the office of the chief inspector responsible for mine safety. Similarly, the Chief Commissioner responsible for railway safety reports to the civil aviation department and not the Railway board. This report called as the "Code for Governmental Organisation for Regulation of Nuclear and Radiation Facilities" submitted in 1996, spelt out the desirable role, responsibilities, structure and organisation for the AERB. The idea was to have a 'functionally autonomous regulatory body'. It is not clear as to what happened to the report eventually. Post-Chernobyl, Rajiv Gandhi also issued a directive on file that the AERB be made an autonomous body, even be reporting directly to the prime minister if need be. The nuclear bureaucracy however, scuttled this directive. In 1996, the then Cabinet secretary tried to revive the directive and framed his own recommendations to provide autonomy to the AERB but even that report did not see the light of the day (Gopalakrishnan 1999).

The 1997 Raja Ramana committee constituted by the DAE in the wake of major safety recommendations proposed by Gopalakrishnan, also recommended that the AE act be amended so as to make the nuclear regulatory authority more effective. Despite the union government's directive in 2000 to suggest amendments in the 1962 act, no concrete measure was taken to act upon it until public perceptions started turning adversely with the Fukushima accident in Japan and radioactive exposure in Mayapuri, Delhi (Jacob 2014).

Most of the present and former employees of different wings of DAE (who were interviewed) however, have claimed otherwise (Sundararajan 2017; Bhardwaj 2018; Sinha 2017; Grover 2017; Grover 2018; Raj: 2017). According to them, AERB has an independent and autonomous existence. Former chairperson S. S. Bajaj said, "We have never compromised on the safety of the plants and the workers and even went to the extent of shutting down the operating plants till the required safety measures were implemented by the operators on several occasions" (PTI 2011). At times, it has ordered penalties, sometimes ordered a reduction in the power levels of reactors and at times even ordered them to shut down for carrying out the required safety arrangements, appropriate tests and evaluations (Parthasarthy 2011).

Gopalakrishnan himself, in a 2005 article, expressed more confidence in the safety culture and management of the DAE and the AERB. In the wake of Indo-US nuclear deal and its need for India, he wrote,

> As a nuclear engineer and former chairman of AERB, I am well aware of the Indian and international status in this field. In 1995, when I submitted a comprehensive report to the government on the 'Safety Status in DAE installations', most of the critical safety deficiencies documented by the AERB had been identified prior to that by the DAE management themselves. The failing was that, having understood the defects, the DAE never took steps to rectify them over the decades. Subsequent to the acceptance of the 1995 AERB report by the government, both the parliament and the government put continued pressure on the DAE to make urgent rectifications. To the credit of the subsequent managements of the DAE, I am reasonable assured now that most of the safety issues pointed out in 1995 have been resolved within the last decade. The Indian nuclear engineers and scientists, along with the national industries, worked in achieving this, without any foreign assistance and often through the development and implementation of indigenous technological solutions (Gopalakrishnan 2005).

Reflecting upon comprehensive AERB review undertaken in 1995, Gopalakrishnan, writing in 2002, also concurred that most of the deficiencies were found in the 4 reactors originally built with varying levels of foreign collaboration and the later indigenous reactors with more safety features (at kakrapar and Kaiga) had very few or no serious defects at all (Gopalakrishnan 2002). But, he also mentions that the 1996 review of the AERB report by the AEC while directing prompt actions in compliance saw a more active influence of the non-DAE members of the AEC.

At the same time, while he informs that 119 out of 134 safety issues reported in the AERB report were completely resolved (communicated to him by former AERB secretary, K. S. Parthasarathy) and expressed more faith in the overall safety improvement of the DEA and NPCIL's facilities, he also mentioned that no detail regarding which of the high-priority issues remained unresolved or how the issues were resolved was provided (Gopalakrishnan 2002)[39].

In 2012, quite so because of the Fukushima crisis in an advanced state like Japan, the Comptroller and Auditor General of India undertook a review assessment of the AERB. Greatly dissatisfied with its working, while undertaking the performance audit on activities of the Atomic Energy Regulatory Board, it pointed out a number of problems with the institutional structuring, functioning and legal status of the AERB. It concluded that legally the AERB remained "subordinate to the central government, with powers delegated to it by the latter" (CAG 2012: vi.). It lacked the necessary authority to devise and revise the rules relating to nuclear and radiation safety. Among others, it pointed out following problems (CAG 2012).

1) the penalty fines for violations in nuclear and radiological facilities were too low to serve as deterrent. Even that was not under the AERB's authority to impose and observe compliance.
2) A comprehensive national policy on nuclear and radiation safety was still not in place.
3) Despite the mandate under the Meckoni committee (1981) and Raja Ramanna committee (1997) recommendations, the 27 safety documents remained unavailable.[40]

[39]His optimism derived from some of the information available through the NPCIL relating to notable modifications and safety enhancements, for example, "the en masse coolant channel replacement and the retrofitting of a high-pressure emergency core cooling system of RAPS-2 were completed" (Gopalakrishnan 2002: 387) and the same were being planned for MAPS-1 and RAPS-1 units too. Over pressure relief device of RAPS-1 was repaired in 1997. This brought the reactor to a higher power rating of 150 MWe (Chaturvedi, V. K. (1997), "OPRD Repair at Rajasthan Atomic Power Station", *Nu-Power* 11(1-3). For more details, pls see Gopalakrishnan (2002), "Evolution of the Indian Nuclear Power Programme".

[40]S. S. Bajaj, a former AERB chairperson, in response mentioned that the AERB had developed around 140 safety codes related to the construction and operations of nuclear facilities, storage of nuclear material and others. But he also acknowledged that around 26 more codes had to be created. For more, refer, Pandey, K. (2015), "New Bill, Old Problems", *Down to Earth*, [Online: web] Accessed 20 January 2016 URL: http://www.downtoearth.org.in/coverage/new-bill-old-problems-48038. Also, interviewees argued that required no. of safety documents depend on various factors like change in technology, or availability of alternate technology and so on which sometimes make earlier assessment redundant (Bansal: 2017; Bhardwaj 2018).

4) Inspection of radiation facilities, their monitoring and renewal consenting processes remained weak. Many un-licensed radiation units were operating all over the country. Even the existing consenting files were not maintained with adequate data. Around 91 per cent of the medical x-ray facilities therefore remained outside the purview of the AERB.
5) AERB only reviewed the on-site emergency preparedness reports prepared by the NPCIL and fuel cycle facility. It did not participate in those itself, not even as observers.
6) The off-site emergency preparedness showed inadequacies but the AERB lacked the capabilities to ensure compliance. Also. The emergency preparedness guidelines and codes for the radiation facilities like industrial radiography and others are not in place despite the fact that some of them are high-risk centres.
7) Absence of a legislative framework for decommissioning of NPPs. The AERB lacked mandate to ensure it except through prescribed codes, guides and safety manuals. None of the NPP, in operation or the ones already decommissioned have a decommission plan.
8) Despite liaisons with international nuclear bodies, the AERB was slow to adapt the international standards, codes and good practices in domestic practices.
9) In the absence of fee structures, the AERB ends up paying the costs of the consenting processes.
10) Frequencies for inspection of radiation facilities were not prescribed. But compared even with the lowest frequency periodicity prescribed by the IAEA-TECDOC, the AERB did not conduct around 85 per cent of such inspections of industrial radiography and radiotherapy units.
11) AERB failed to ensure compliance even when deficiencies in such units were pointed out in Kerala.

Apart from these, Ram Mohan and Els Reynayers Kini (2016) observed that one of the problems among many, as with the current mandate of the AERB pertains to grievance redress system or appeal procedure against decisions of the AERB. The AERB's constitution provisions that appeal against its decisions shall lie with the AEC whose decision shall be final in such matters. The appeals can lie with the courts also as in the case of Kudankulam nuclear power plant. The IRRS mission in 2015, too mentioned it in a reference but did not suggest a more neutral and coherent appeal procedure.

Since 2011, the AERB has undergone three CAG audits: 2011-12; 2015-16 and 2017-18 (Bansal 2017). As a major step in commitment to transparency, the AERB put up the report of the IRRS review of 2015 on its website. In an unprecedented manner, the reports were put on the AERB website boosting its commitment for transparency.

With the uproar caused by the Fukushima disaster, the long-talked reforms were being raised on the public platforms once again. The CAG audit of AERB highlighted numerous lacunae, which needed to be addressed. Due to negative public perception especially since the disaster, govt. proposed regulatory reforms and drafted the NSRA Bill (Raj 2017). At the same time, after the Indo-U.S. nuclear deal, euphoria about huge nuclear energy expansion in India also led to speculations about liberalizing the atomic energy sector and enable some sort of private sector investment to enhance capital capability along with new enthusiasm. This idea, however, faced a lot of resistance too especially from within the nuclear establishment as several guidelines and regulatory requirements would have required adjustments to cope with new challenges emanating from private participation pertaining to safety, security and safeguards related aspects of production of nuclear energy. This aspect will be discussed in detail in the fifth chapter.

To address the criticism of its legal status, the bill proposed replacing AERB with a statutory nuclear safety regulatory authority (NSRA). A council for nuclear safety with chairman AEC as its member was also proposed. The NSRA chairman was to be one of the members of the search committee that was to select the members of the NSRA. The Council for Nuclear Safety would act as the appellate authority, which would be constituted ‘as and when required’. To accord more disciplinary power to the new authority, all the violations were to be penalized by imprisonment up to five years.

While the bill was hailed in certain quarters as quite some improvement in the authority of regulatory body, many feared that the bill did not go far enough in ensuring the autonomy of the Board (Jacob 2014, Ramana 2017). The chairman AEC was to be a member of the top body i.e. the Council for Nuclear Safety and hence was to exercise influence over the appointment of the chairperson of the regulatory body. This in effect implied a certain subordination of the regulatory body to the promotory body. The Council for Nuclear Safety was to be a political body chaired by the Prime minister. Chairman AEC as the only scientific expert on the panel could then garner more informal authority in appointment. The bill also said explicitly ‘the Central Government may, by notification, supersede the authority for such period, not exceeding six months, as may be specified in the notification' (Kalra 2012).

As per the proposal, the chairman NSRA was to be on the search committee for other members. It implied that autonomy and independence of the rest of the members would be subordinate to the chairman. Also, these members could be removed without a judicial enquiry. This in effect implied the body was highly susceptible to the influence of the CNS, which was primarily a central government body. The appellate authority was not a permanent body and it was confusing as to how an appeal could be filed in the first place. Penalty was specified but it is difficult to imagine same punishment for all degrees of violations (PRS Legislative Research 2011).

The Parliament Standing Committee on Science and Technology, Environment and Forests (2012) while analysing the provisions of the bill agreed that the NSRA lacked authority in the form proposed. The Public Accounts Committee (2013) criticized both the current and the proposed structure of the regulatory body in the document titled 'Activities of Atomic Energy Regulatory Board'. It suggested the "DAE should seriously re-examine the provisions of the bill and take necessary steps urgently so as to ensure that the nuclear regulator becomes an independent and credible body at par with similar regulators in other countries" (PAC 2013 quoted in Jacob 2014)). Another worrying provision was exclusion of the NSRA from the purview of the RTI Act, undermining the need for transparency (Jacob 2014).

The DAE's half-hearted support to the NSRA stems from other institutional concerns as well. The AERB employees are on the DAE payroll and are government services. With the restructuring, there is a fear that once the NSRA becomes autonomous as proposed in the 2011 bill, the AERB staff will cease to be government employee. This may result in employees of the present AERB wanting to shift to other institutions of DAE like IGCAR, BARC and so on, as many people prefer government jobs (Balachandran 2018). This could be very harmful for the regulatory body in terms of availability of expertise. Also, at present, the TSOs help provide research data and other services both to the regulatory body and the utility. So, there is a conflict of interest even at present which is worked out through informal discussions, MoU indicating that an expert reviewer working with utility/licensee cannot undertake AERB's responsibilities and a culture of mutual faith. Once the NSRA becomes autonomous and moves outside the DAE, this work culture would be compromised and conflict of interest then may cause time-consuming impediments to smooth and swift functioning of the establishment (Bansal 2018).

Suvrat Raju and M V Ramana, leading scholars in the field of nuclear regulation, argue that the secret mode of functioning in the atomic energy establishment does not augur well in instilling public confidence in them. The establishment often forms 'experts committees', the members of which are hand-picked and mostly from within the establishment. These committees then investigate and discuss in secret. These reports, after the review, often declare that the safety standards are very high in DAE facilities and operations. Raju and Ramana (2014) suggest that a transparent working of the regulatory body can be ensured in the NSRA if it could envision the role of independent experts, perhaps nominated by the civil society in the vicinity, in the assessment of any nuclear project. This will also be good for public confidence. The suggestion while laudable, may run into the risk of failure given an ignorant or apathetic civil society though. But more than anything, there does not seem to be a discussion on any such modality in official quarters.

At the same time, the draft "allowed the central government to direct the authority on matters of "policy" and the government could also decide whether an issue was one of "policy" or not. So, in principle, if the NSRA were to raise objections about a reactor, the government could simply say that establishing the reactor is a matter of policy and so the NSRA cannot stop it." (Raju 2018).

The new body, if created by an act of parliament could enhance its legal stature. Making it accountable to the parliament through submission of annual reports and such measures could strengthen and diversify the over-sight that the DAE witnesses currently. If created by the parliamentary legislation, any change in the structure and/or function of the regulatory would require parliamentary approval. In effect, the NSRA would have gained more authority even if not become a truly autonomous body in a more nuanced sense. Also, unlike the present arrangement where the DAE or the scientific establishment ensures AERB's accountability, with the NSRA, there would have been a higher political and non-DAE bureaucratic control, one of the reasons precisely why some personnel from within the nuclear administration did not view the bill favourably (Sundararajan 2017; Grover 2017).

Many interviewees evoked the concern that the regulatory body being accountable to a non-technical or political body may not be a better idea as the latter would not understand the job in a real sense. This argument, however, dilutes the accountability concern. In fact, political accountability may not be a bad thing because the current arrangement facilitates more sensitivity towards compulsions of the utility like need to keep the plant operational or defer a safety over-haul for some time and so on. Such sensibilities to the fraternal organisations, however, rather run the risk of undermining the regulatory oversight (Raju 2018).

The bill was introduced in the lower House on 7 September 2011, but it lapsed with the change of government and dissolution of the 15th Lok Sabha. Some official momentum for reforms generated after the IAEA-IRRS's 12-day review from March 16-27, 2015 (the first review) of the AERB which recommended that the regulator and the rest of the nuclear establishment be de-linked and independent statutory status be granted to the body. The IAEA categorically asserted that as India is strongly committed to security, the AERB needed to be independent of and separated from the government and the promotory body (Sasi 2017). It also suggested that the Indian government should allow more on-site inspections at the nuclear power plants that have been put under the international safeguards.

The status quo group, hailing mostly from within the nuclear establishment (both retired and acting), however, considers Indian nuclear safety record as exemplary and adequate. This group has mostly been resistant to the idea of stringent regulatory reforms for two main arguments: first, the present system works perfectly fine so no need to bring changes and secondly, because the kinds of reforms proposed would not make much of a difference in terms of enhancing regulatory effectiveness or autonomy. Some even suggested that reforms may even curtail the current level of effectiveness. A. R. Sundararajan, former AERB personnel and Baldev Raj, former DAE personnel argued that with the so-called more autonomy of the AERB, it would become difficult for it as a body to call upon the expertise from TSOs like BARC, IGCAR. Also, it would suffer in terms of its scientific credentials, which remain dynamic given the continuous on-going research in the nuclear field. A. R. Sundararajan, a former AERB scientist said that even if the newly constituted body under the NSRA was constituted, it would not make much of a difference as the scientific expertise still would remain with the DAE. Also, it would just mean that the AERB would become answerable to political bureaucracy than the scientific establishment, which would not make any value addition. Instead of that, it would be better to have the accountability of the AERB with the scientific body, which can contribute to its expertise in real sense. Regulatory organisation benefits if its personnel have wide experience and expertise base. An isolated regulatory body as proposed through the NSRA bill may compromise this quality (Bhardwaj 2018; Sundararajan 2017).

In response to the question of MP Sashi Tharoor in the parliament about the current status of the NSRA bill, on 12 April 2017, the Minister of State for Personnel, Public Grievances & Pensions Prime Minister's Office, Jitendra Singh replied that the bill proposal for converting the de facto functional independence of the AERB into a de jure status is under examination. He further mentioned that the

> Government is fully conscious of the importance of the role of regulator for promotion of safe use of nuclear and radiation technology. While the process of setting up of NSRA is underway, it may be noted that as the national nuclear regulator, AERB is fully competent and geared to meet the requirements of enforcing safety standards and regulations of the functioning of nuclear power plants in the country. AERB is functionally independent from the Government and the facilities it regulates and has adequate powers with respect to its mandate of enforcing safety regulation of nuclear and radiation facilities (Government of India 2017a).

This view resonates the dominant perception in the DAE that as a regulatory body, the AERB is functionally independent of the DAE, even if not legally so (Grover 2017; Rath 2018). The bill seems to be in pipeline and the draft is being re-worked to address the lacuna. The government has not given any public indication about its introduction in the parliament anytime soon, however.

The lapse of the bill in the wake of limited and qualified support from the DAE, also highlighted the centrality of the DAE in nuclear affairs even if it relates to regulation. Some critics argue that DAE did not oppose the bill explicitly but they did not push it hard enough to be prioritized in policy-making circles leading to its lapse. DAE's predominance in nuclear affairs is not only formally and legally ensured through the AE act but also informally through the huge policy clout of Secretary DAE. It is perplexing as to why a country with broad and exhaustive emphasis on democratic governance has an AEA which privileges power and authority centralization in one particular institution to the almost complete marginalization of broader stakeholders. Ambassador Rakesh Sood

(2018), one of India's leading experts on nuclear policy issues in India, with long years of experience in this field, in response to a question on non-passage of NSRA bill for instituting more autonomous regulatory body argues that

> If the Atomic Energy Regulatory Board (AERB) was set up under a separate act, then the chairman of the AERB will have full budgetary authority and when AERB conducted inspections, it would not have to look over the shoulder to see that it does not upset the head of the atomic energy establishment. Ultimately the nuclear establishment is controlled by the Secretary of DAE. Till the time this position changes, AERB cannot be fully autonomous but who is going to ask for it? Certainly not the Secretary of DAE because why should he diminish his authority voluntarily. This is human nature. In India, we consider our scientists to be gods and demigods anyway. This is not a question of institutional politics, it is in the nature of any institution to not want to share power (Sood 2018).

Having enjoyed unbridled power for quite a lot time since its establishment, DAE as an institution is resenting efforts at greater oversight and external accountability. It is in nature of institutions and authorities to not want to give up power easily. Non-transparent institutional processes, selective involvement of 'external' members and DAE's tacit resistance to NSRA's idea of non-technical chain of command along with an external regulator indicates a distrust of people from outside the 'technical' establishment and is actually a desire of the establishment to pack regulators with people who thin like them (Raju 2018). Gopalakrishnan (1999) in his critical assessment of regulatory body argued that the DAE itself does not favour shift in power position to its disadvantage. Suvrat Raju (2108) alleges, "a shortage of external pool of expertise is by design where the DAE has consciously stopped such expertise from being created outside its own hierarchy. Within the establishment. Everyone is invested in nuclear power and subscribes to a shared set of myths about nuclear energy and nuclear safety."

In organisational studies, an unfavourable change in power structure has often been hailed as a factor for non-willingness on the part of the authorities or management and therefore, their pessimistic attitude towards it. Admitting such rationale, however, can be self-incriminating and therefore, a lack of explicit evidence to that effect is only natural.

Lack of political interest in regulatory affairs also is responsible for preponderant status of DAE in such matters. A belief in the optimal functioning of regulatory body without undue interference and technical support of TSOs, the DAE seems more of a status quo institution which sees more harm in uncooked thoughts and experimental reform of AERB as adversarial for the regulatory itself.

Having discussed the safety regulation mandate of the AERB, the next section undertakes an analytical description of India's security regulation which is only partly managed by the AERB.

3.4. Nuclear Security Regulation in India

In tune with the global trend, an assessment of threats and corresponding need for nuclear security has evolved as a relatively later phenomenon compared to safety and safeguard regulations. Concerns for nuclear security initially focused more on material security and gradually assumed a comprehensive character, encompassing nuclear infrastructural facilities as a whole.

PM Nehru, in the beginning of nuclear energy programme itself cautioned that source material for nuclear energy was not an ordinary substance and needed to be handled with care (Perkovich 1999). The emphasis on security was not explicit though. Later a definition more or less similar to the internationally accepted definition of nuclear security was adopted by the AERB as well. Nuclear security is thus defined as "all preventive measures taken to minimize the residual risk of unauthorized transfer of nuclear material and/or sabotage, which could lead to release of radioactivity and/or adverse impact on the safety of the plant, plant personnel, public and environment" (AERB 2005: 93).

Unlike nuclear safety, the responsibility and obligations to ensure nuclear security remain fragmented in India. There is no singular or central authority to monitor the security credentials. Different dimensions of nuclear security including physical security of nuclear material and facilities, export controls, cyber security and development of proliferation-resistant technologies and such are handled by different entities in India like the AERB, BARC, BISF and even military in certain domains. India has resorted to the policy of pursuing closed fuel cycle option with the motto 'reprocess to re-use'. This way, the waste products generated in different stages of reactor operation are utilized as fuel for the next stage reactors, together with the help of reprocessing, fabrication facilities and such. This helps not only in reducing the stockpile of the wastes but also in strengthening non-proliferation credentials as radioactive and fissile material stock-pile is stored for shorter durations then. The closed cycle option is in operation for the PHWRs while the similar mechanisms and facilities are being developed to manage the FBR cycle as well. In such pursuit, the fast reactor fuel cycle facility, reprocessing facilities, waste management facilities and others are being developed at the Kalpakkam complex. The high-level waste generated even after reprocessing is vitrified after it is put in in stainless steel over-packs and stored as solid waste under surveillance. This material, however, requires cooling off before all these processes can be taken up (Wattal interviewed by Paliwal 2015).

Nuclear material accounting as one of the favoured methods of ensuring advertent and inadvertent diversion of nuclear material to illegal and illicit recipients, is conducted by BARC in India. AERB is concerned only with development of guidelines for storage, transportation and such concerns.

For ensuring physical security within the plants, the primary onus lies with the utility operator. The AERB while reviewing the design of the reactor and the plant, reviews the in-built security mechanisms. It is important to note that the security did not fall into the original mandate of the AERB unlike the safety aspect. It was done in the late 2000s. Also, the security mandate of the AERB is restricted in a sense that it regulates only those security aspects that relate to nuclear safety. There is a national Design Basis Threat document and each facility draws up its own specific plan for providing physical security measures to be deployed at the plants. Threats from thieves, terrorists, saboteurs, insider-collusion and others are considered in the national DBT. The AERB concerns itself mostly with the physical security aspects of the plant. It reviews the inherent designs of the equipment and assesses the in-built security potential. The AERB monitors requirements related to the exclusion zone, safety of workers, safety of people living close to a nuclear plant and so on (Bansal 2017).

The other security related aspects rests with Central Government and through it, with the DAE. For example, the requirement of access control to an NPP from safety point of view is provided by AERB but the overall perimeter security and concerns of entry and exit to the plant lies with DAE. The I. G. security monitors these aspects. Other such security related aspects like background checking of the personnel, entry and exit, such responsibilities lie with the IG security.

Every power plant is protected by the CISF, under the Ministry of Home Affairs. The personnel are periodically rotated and specifically trained. Some facilities like the heavy water plant in Baroda are protected by the police force of the Deputy Superintendent of

Police. After the 9/11 attack, anti-plane guns have been installed on the plant perimeter walls by the armed forces to avoid incidents like plane crashing with the reactor walls and causing damages. A senior IPS officer is always on the roll of the DAE to handle coordination with the security agencies (Grover 2014).

The lapsed NSRA bill specifically provisioned for entrusting the responsibilities with the regulatory body for "Measures for physical security within the area of main plant boundary, physical protection of nuclear and radioactive materials under storage and transport (within and outside India), and nuclear and radiation facilities" (Government of India 2011: 9). There was said to be a proposal to limit transfers of units of CISF personnel to within the nuclear facilities rather than posting new personnel on a rotational basis. The present status of the proposal is not known (Krishnan 2017).

Rajeshwari Rajagopalan in a comprehensive study of the Indian nuclear security arrangements and practices titled, "Nuclear Security in India" (2015), has argued that the actual performance is much more robust than what the NTI security index for India signifies. She attributes this mismatch to the methodological issues with the NTI comparative quantitative approach of ranking. At the same time, she cautions that Indian nuclear establishment needs to proactively engage in PR campaigns for highlighting its security achievements and credentials, which remain highly under-reported. Among various measures, she proposes enhancing the autonomy of the national regular, creating a separate police force for monitoring nuclear security, regular exercises at all levels and so on.

High-enriched uranium (HEU) being a proliferation concern, India decided to shut down its only HEU core in APSARA reactor and replace it with non-HEU core in 2010, as one of the concession under the nuclear deal.

The export controls for nuclear items, unlike for other commercial goods, are not with the commerce ministry but with the DAE. Indian nomenclature for nuclear and dual use items is somewhat different from the NSG guidelines but it has ensured different procedures for the export control rules implementation of the nuclear and the dual-use items (Grover 2014). The dual-use items are governed by the SCOMET notification under the Foreign Trade (Development and Regulations) Act 1992. This act was amended in 2010 to strengthen the safeguards potentials and avoid leakage. In 2017, the DGFT vide notification no.5 dated April 24, 2017, issued a revised SCOMET list enumerating items, whose export is either prohibited or permissible under an explicit authorization (Ramachandran 2005). The DAE decisions are in line with the NSG part-1 and Part- 2 export control guidelines. Because they are the experts so they do it. The DAE proposes directives which are then mulled over by the DISA in the MEA. Together they frame and carry out the nuclear export controls (Balachandran 2018).

Many Indian scientists have been attending the seminars and discussions related to ensuring nuclear security, export controls, fuel cycle related matters, standards for being responsible supplier and so on. Stringent background checks of the personnel, multiple layers of protective security checks and barriers, and advanced technology of surveillance, material detection and others have been deployed at the sea-ports, facilities etc. as parts of regular procedural regulatory requirements. According to a brochure of the MEA, there are five elements of the nuclear security architecture in India: Governance, Nuclear Security Practice and Culture, Institutions, Technology and International Cooperation (MEA 2014).

To punish the violations of the nuclear security arrangements, a few changes have been made in the criminal activities prevention laws. For instance, the Unlawful Activities (Prevention) Act 1967 was amended in 2012 to include the offences under the scope of and as defined in several treaties including CPPNM and the UN resolution 1540 (MEA 2014). This was also in compliance to these mechanisms that India has signed as a sovereign member state. The National Investigations Agency Act 2008 also has reference to the Atomic Energy Act, the Unlawful Activities (Prevention) Act and the WMD Act extending the jurisdiction of the NIA to handle the cases arising out of the violations of these acts. Other security related mechanisms include an Inter-Ministerial Counter Nuclear Smuggling Team set up in 2015, a Nuclear Control and Planning Wing (NCPW) within the DAE, a crisis management group (CMG), a Computer Information and Security Advisory Group (CISAG) and so on (Grover 2014).

Overall, the security mandate is fragmented and some sort of further clarity would be beneficial (Bansal 2017). As AERB is only partially responsible for ensuring nuclear security, many interviewees preferred not to comment on this or expressed the subject matter as out of their competence. Those who acknowledged the security related mandate of the AERB from within the establishment, expressed confidence that the present system is adequate and there is no confusion. 43.2%. of survey respondents favoured the need for centralization of nuclear security regulation as opposed to 10.4% who did not.

"Nuclear Security regulation in India needs to be centralized"

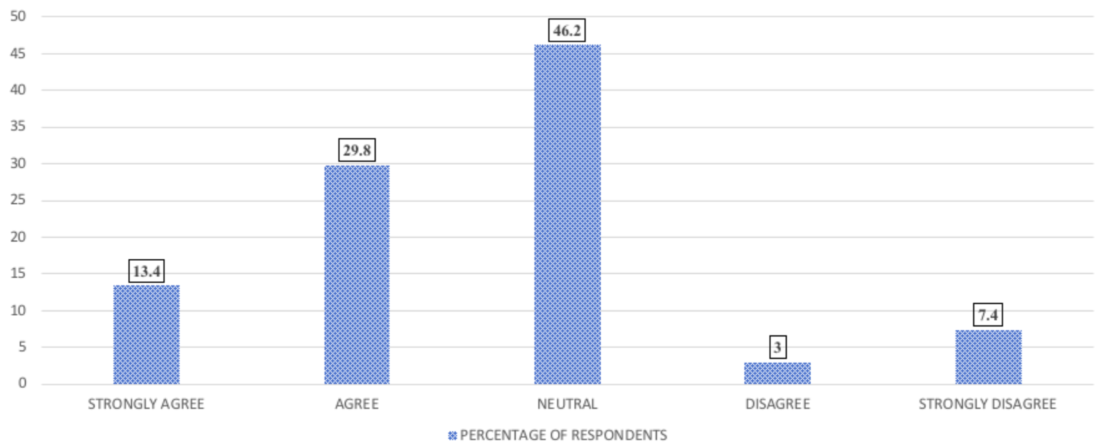

Figure- 3.2. (**Source**: Author)

Interaction between different security wings and the finer intricacies are not known to the regulatory body. The regulators deal with only those aspects of security as specifically assigned to it. Safeguards, on the other end are totally outside AERB's purview and will be dealt with separately in the fifth chapter.

Conclusion

In sum, this chapter has discussed the historical evolution of the structure of the AERB and analyses the questions of regulatory autonomy and effectiveness through the help of qualitative parameters like administrative structure, reporting obligations, nature of oversight, funding and staffing principles and so on. It also highlights the subjective opinions dominant within the nuclear establishment with respect to the need for regulatory reforms. In the course of description, the chapter identified various drivers of change and that of resistance to change in regulatory regime. Last section enumerates India's security regulation in brief. The chapter offers following summative findings and conclusion along the lines of parameters stated earlier:

1. Institutional separation between the twin functions of promotion and regulation: constitutional mandate and administrative structure.

The interviewees from within the department (both current and former) emphasized that there is an adequate separation between the bodies responsible for the functions of promotion/ development of nuclear energy and its regulation. Survey respondents from within the AERB agreed with this viewpoint. 65.2% agreed on this, 13% disagreed and 21.7% remained neutral. Those interviewed outside (DAE) of the establishment argued that AERB's placement within the DAE undermines this separation. Secondary analytical literature supports this view. Even when the IAEA documents do not provide an explicit model to be followed by regulatory bodies, they have pointed that a placing a regulatory body within the organisation responsible for promotion of nuclear energy undermines its autonomy.

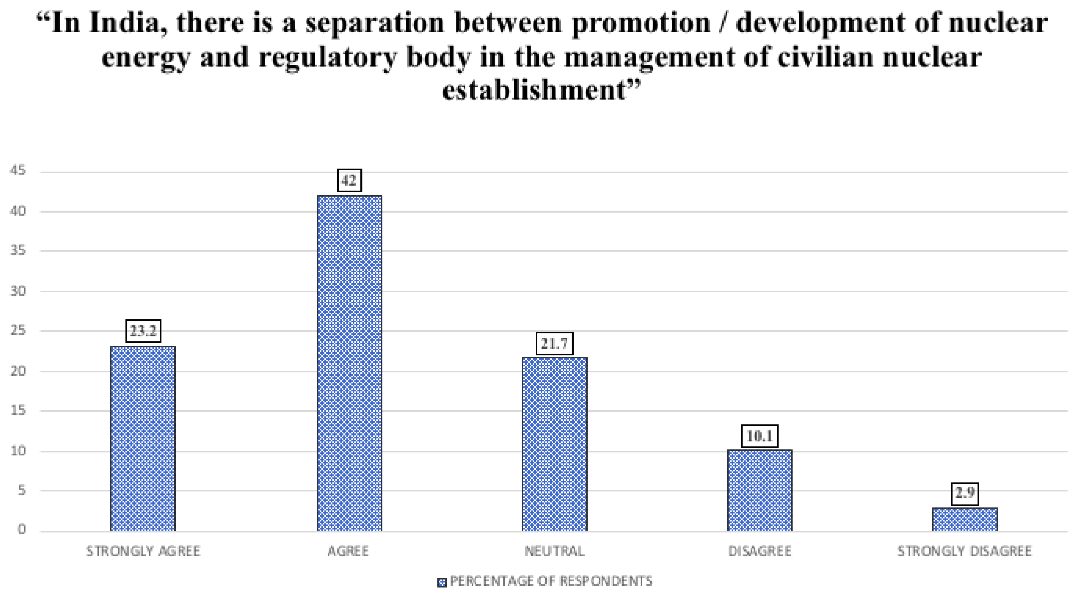

Figure- 3.3. (**Source**: Author)

This chapter finds that the primary data sets, despite problematic administrative structuring of the AERB, indicate a functional separation between the two kinds of job. This can be explained by the dominant thinking prevailing within the nuclear establishment that there is a functional separation between the twin functions. Though problematic in conceptual terms (as asserted in literature and by non-establishment respondents and asserted in this study), this organisational belief also explains the lack of a strong push from the establishment for regulatory reforms. Perceived adequacy in current modelling, therefore, offers resistance to the idea of a change brought through a formal institutional separation.

2. Autonomy of the Regulatory Body (statutory, administrative, functional)

The interviewees from within the department (both current and former) emphasized that despite AERB's placement within the DAE, it is administratively autonomous and there is no interference in the regulatory activities of the AERB from any other DAE wing. Those from outside the DAE opposed this assertion. As per the IAEA guideline, administrative structuring would tantamount to curtailment of autonomy. IRRS review mission too highlighted this and so did CAG reports. Survey Respondents supported the argument of AERB being autonomous but the response distribution varied across the twin criteria of administrative and functional autonomy.

In an administrative sense, 45.6% supported administrative autonomy while 35.3% disagreed with 19.1% being neutral. As one can see, the gap between the two contradictory opinions is small.

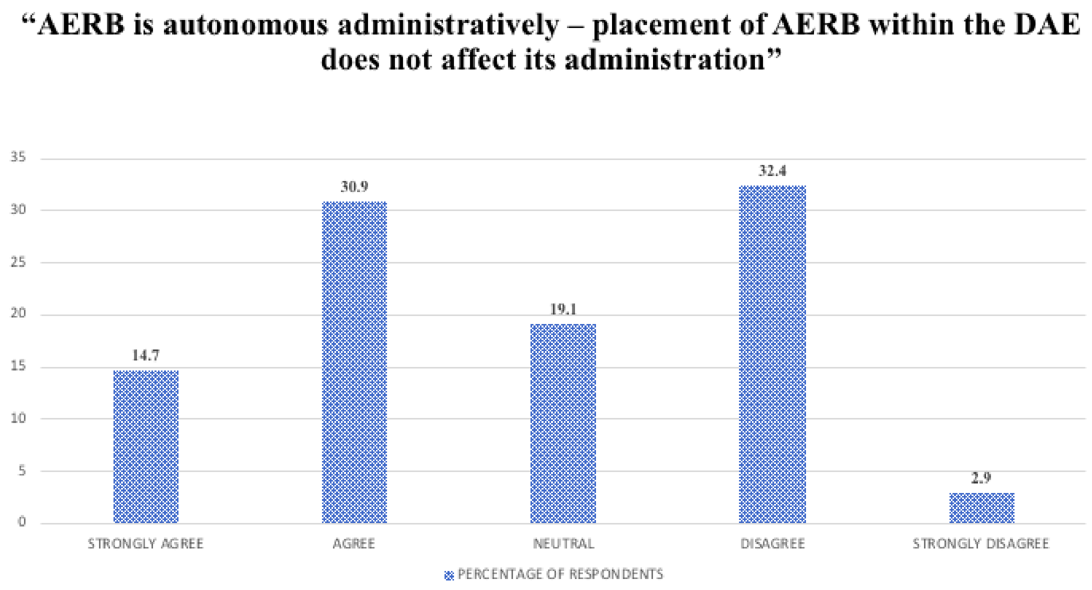

Figure- 3.4. (**Source**: Author)

This gap, however, is larger, when evaluated with respect to functional autonomy where as 60.8% responded favourably while 23.1% expressed dissatisfaction.

“AERB is autonomous functionally – there is no interference with safety and regulatory functions of the AERB from other wings of the DAE”

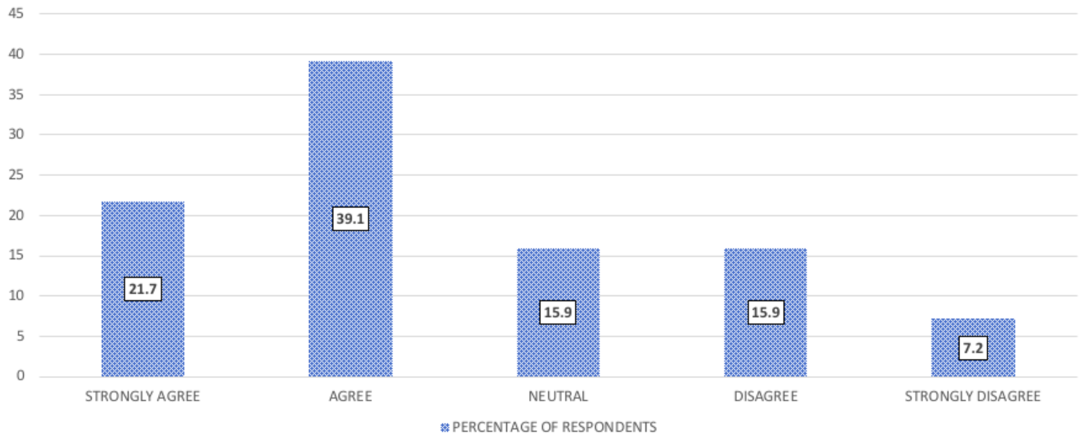

Figure-3.5. (**Source**: Author)

3. Staffing principles- number and expertise

a) Adequacy of staff

The interviewees from within the department (both current and former) emphasized that there is adequate staff at the AERB to handle its safety mandate related to nuclear and radioactive installations. Those from outside the establishment pointed to non-adequacy in view of huge radioactive installations in the country along with nuclear plants. The survey respondents from within the AERB however runs counter to the establishment’s view. In fact, on this parameter, more no. of respondents (48.5%) agreed that availability of human resources with the AERB is inadequate, while 39.7% considered the number to be adequate. The institutional appraisal of the CAG too concurred with this view point.

“Availability of human resources with the AERB is adequate”

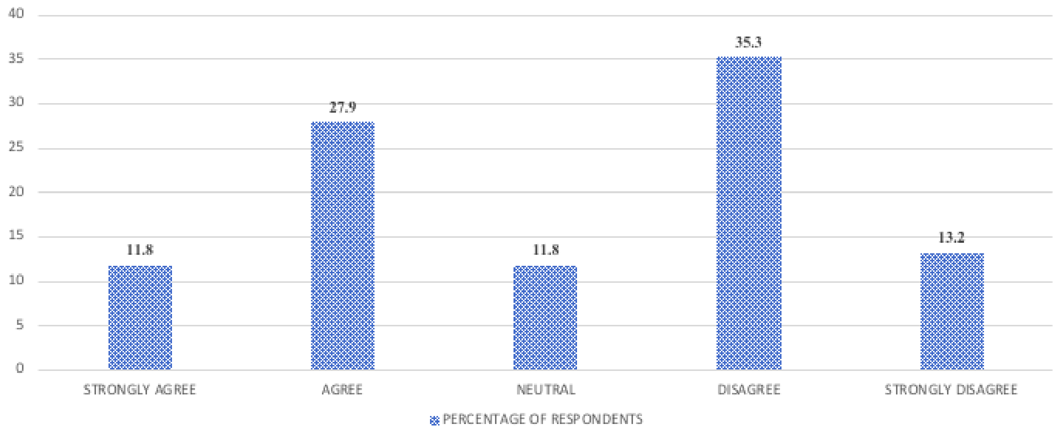

Figure- 3.6. (**Source**: Author)

As there are no universally agreed standard principles or IAEA guidelines available to determine adequacy of staff, this chapter finds that the huge range of regulatory operations (including both nuclear as well as radioactivity related regulation) should require more number of regulatory staff. This chapter finds survey result as an authoritative indicator of the same as the respondents themselves are engaged in regulatory operations and common sense-wise it makes more sense that they would be aware of regulatory burden and activities more than any other entity.

b) External inputs

The interviewees’ responses showed mixed results as while some attested that there is enough consultation from outside experts and cognition of ‘non-official’ reports as well, others argued that there is a lack of expertise available outside the DAE for consultation.

Survey respondents favoured the former view emphasizing on external consultation, though in varying degrees. 43.3% agreed that there is a good back up expertise for regulatory consultation while 25.4% disagreed and a good 31.3% remained neutral.

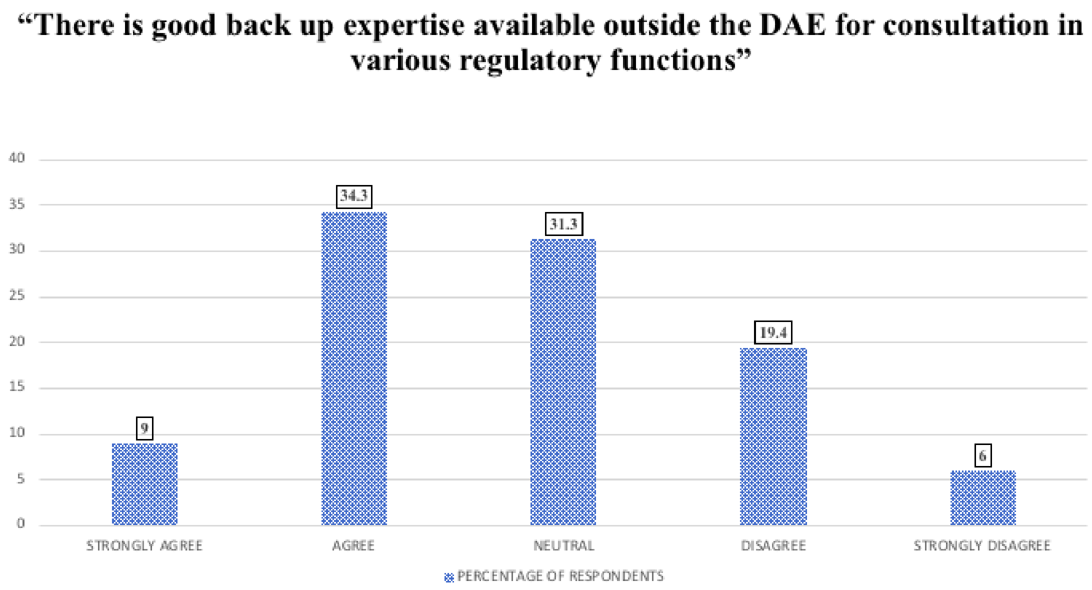

Figure- 3.7. (**Source**: Author)

46.3% respondents agreed that (at least some) AERB employees' job related to searching for external sources for operation feedback information, 26.8% disagreed and around 26.9% remained neutral.

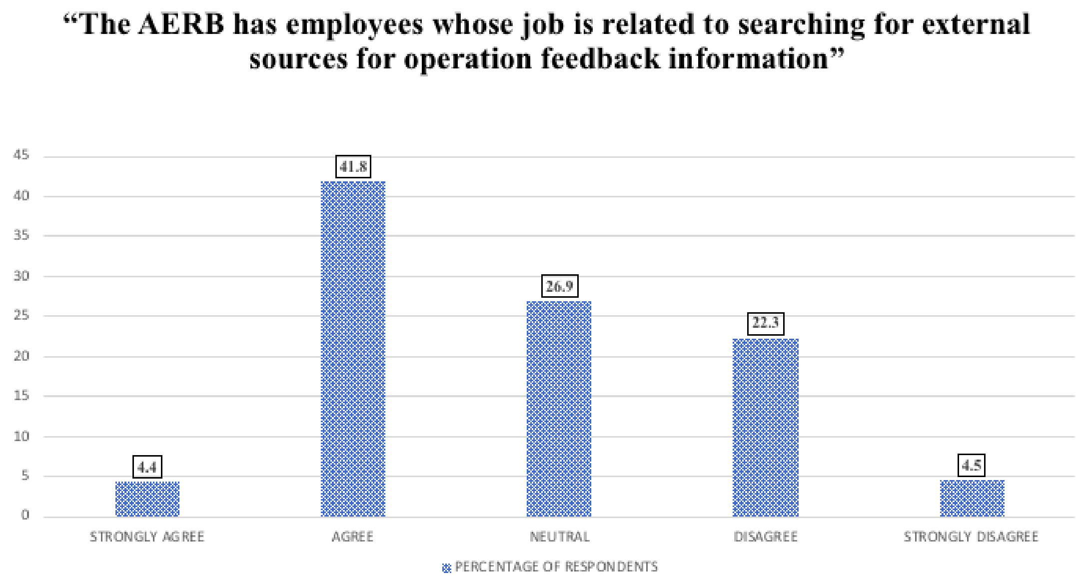

Figure- 3.8. (**Source**: Author)

In another related question on importance of external sources like reports, consultants, newsletter etc. for regulatory function, 60.8% responded in positive while 10.1% disagreed and 29% remained neutral.

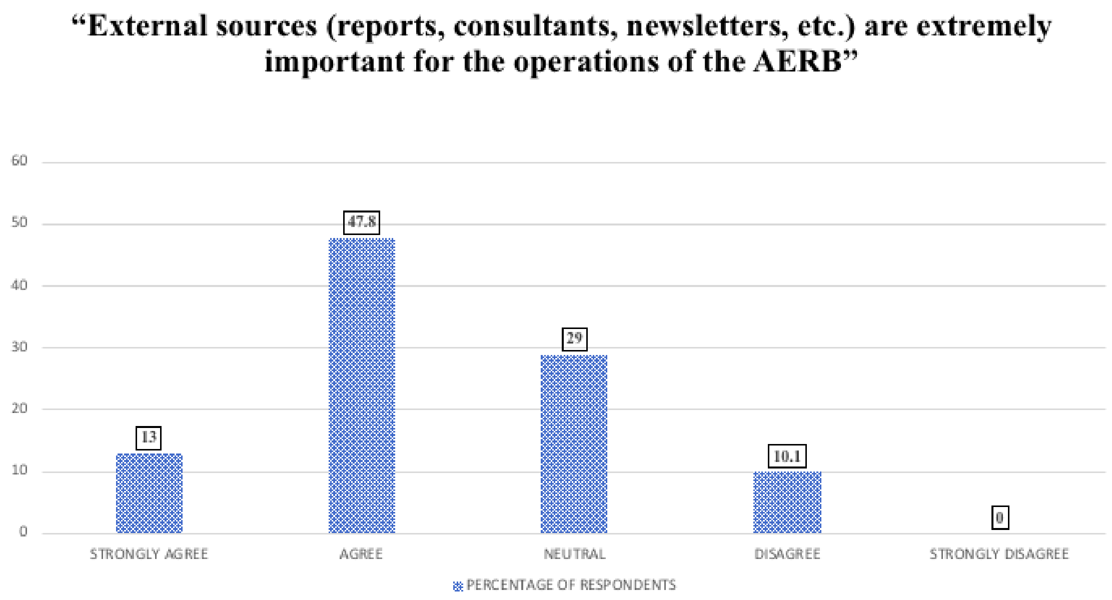

Figure- 3.9. (**Source**: Author)

4. Funding provisions.

The interviewees from within the department (both current and former) emphasized that even though AEC provides funds for AERB functioning, the latter is autonomous and enjoys financial autonomy. Those outside the establishment, did not comment, given the nature of question pertaining to official knowledge. Survey respondents favoured (50.2%) the argument of financial autonomy of the AERB where its budget is not constrained by partisan preferences of the AEC/ DAE. 17.9% disputed this argument.

“AERB is autonomous financially- AERB’s budget is not constrained by partisan preferences of the AEC/DAE”

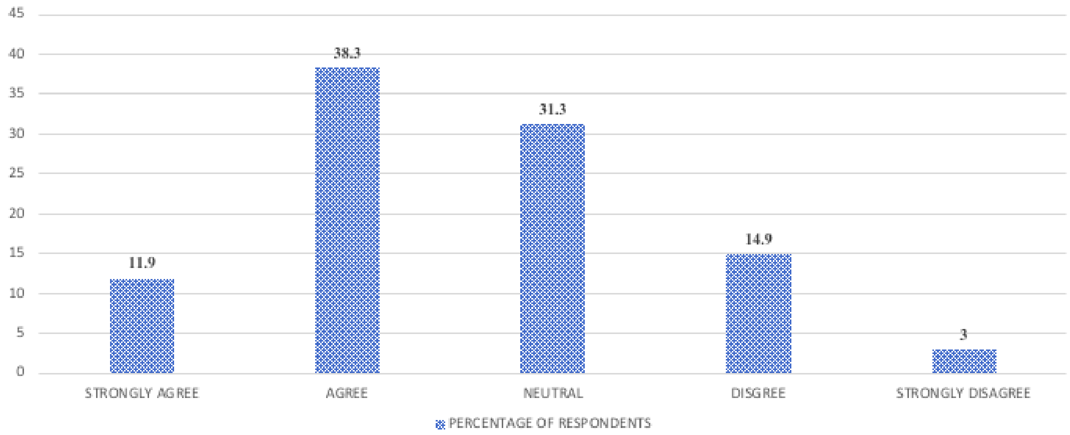

Figure- 3.9. (**Source**: Author)

5. Nature of enforcement, reporting and verification authority granted to it.

The interviewees from within the department (both current and former) emphasized that the AERB field officers have enough regulatory authority to ensure compliance. Majority of survey respondents (58%) agreed with this assessment while 23.2% did not.

“The AERB rules and mandate provide enough provisions for effective authority / powers with site observers/regulatory inspectors”

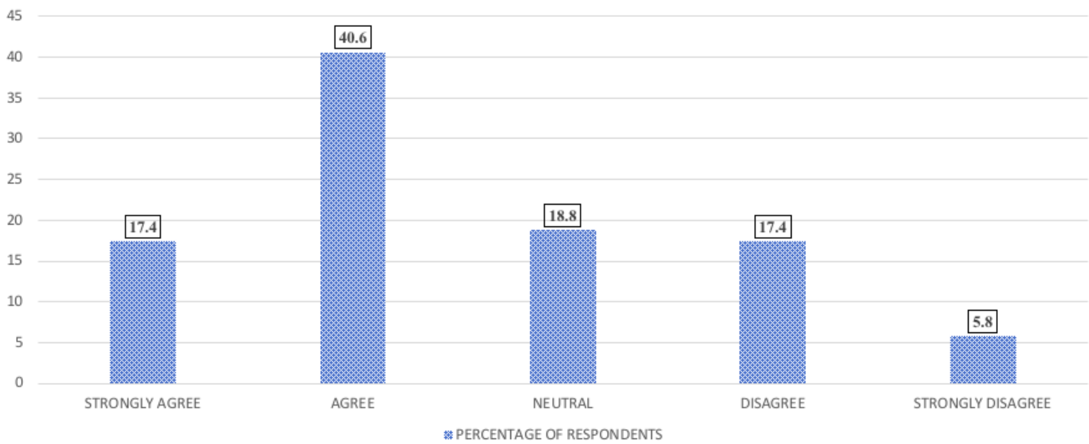

Figure- 3.10. (**Source**: Author)

Expressing a satisfaction with the utility, 71% respondents agreed that feedback mechanism on event reporting and compliance on the part of utility is robust. 10.1% did not agree with this assertion while 18.8% chose not to take sides.

"Feedback mechanism on event reporting and compliance on the part of utility is robust"

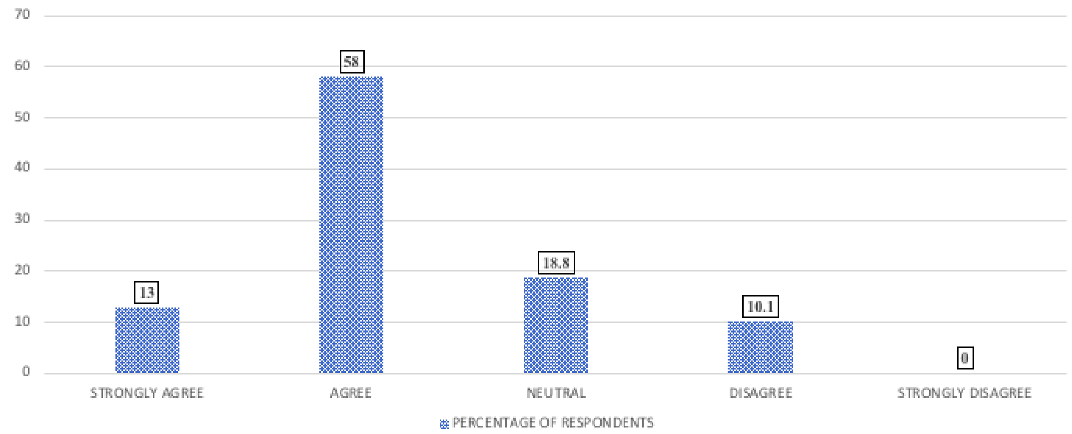

Figure- 3.11. (**Source**: Author)

Such confidence in NPCIL's credibility also reflects an organisational culture attribute of the DAE which despite the profit-making nature of the utility places more emphasis on the prevalence of a common nuclear safety culture in all wings of the DAE (which may be true but cannot be conclusively established in this chapter due to inaccessibility of on-ground external analysis). But the study also does not dismiss a probable inference that utility's compliance with regulatory requirement is robust.

The chapter concludes that the AERB does enjoy specific mandates as listed in CNS relating to licensing authority at different stages of nuclear energy production. AERB's regulatory mandate is most pronounced in the domain of safety. Safeguards, being seen as a factor associated with weapon program lie completely outside the scope of AERB and enjoy higher degree of secrecy and clout in policy circles. AERB despite being a non-statutory body itself has legally enforcing provisions. But the actual nature and deployment of these provisions remain contested by independent analysts and some of the survey respondents.

6. Provisions for its own technical research and development.

The interviewees from within the department (both current and former) expressed close synergies between the AERB and TSOs in performance of regulatory functions. Even those interviewed from outside the establishment concurred to this view. In case of survey responses, this question demonstrated maximum concurrence with 95.6% agreeing to it with zero disagreement.

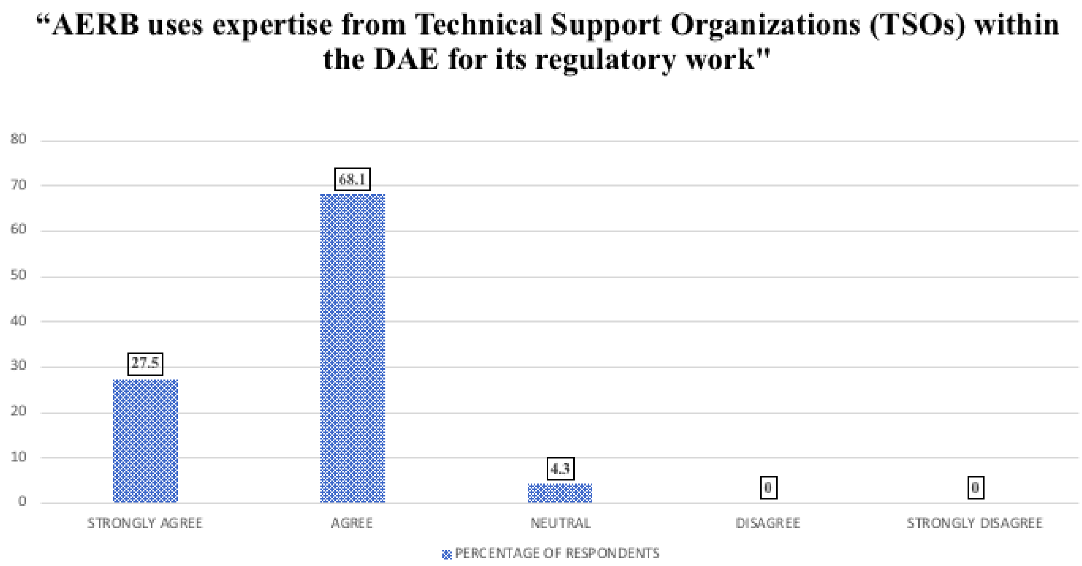

Figure- 3.12. (**Source**: Author)

However, while the results are fairly conclusive demonstrating involvement of TSOs in regulatory function, certain caveats need to be pointed. Firstly, the merit of such an arrangement has been widely debated. While those within the establishment have lauded it as a good practice bringing in more updated knowledge to the regulatory personnel through association with TSOs, it has been negatively viewed by the outside respondents for indicating inadequacy of technical competence of the AERB. Second, the original question was worded as – “AERB is *dependent* on expertise from Technical Support Organisations (TSOs) within the DAE”. But it was rephrased by the authorities as “AERB uses technical expertise from Technical Support Organisations (TSOs) within the DAE for its regulatory work”. Another question “A robust safety research laboratory of AERB, independent of TSOs will contribute to a more effective and autonomous regulatory body” was removed by the authorities. These modifications in questionnaire took away the analytical edge of this parameter in determining the AERB’s technical competence adequacy which has been identified as a crucial factor for regulatory effectiveness as outlined in the IAEA documents as well. The SRI, AERB's own research lab, has limited regulatory research potential as per the accounts of interviewees too.

The chapter concludes that though interaction with TSOs is conceptually beneficial for development of regulatory skills, expertise and updating of existing knowledge, the current practice of such an indispensable dependence on TSOs is not beneficial for regulatory autonomy and effectiveness. This dependence on TSOs becomes more worrisome in the light of the fact that TSOs not only are the DAE institutions but also are deeply associated with utilities as discussed in the chapter.

Based on these findings, this chapter makes following broad arguments:

One, the initial phase of Indian nuclear programme adopted an evolutionary approach to regulation and developed extensive cooperation within various wings of the DAE. This modus operandi has come to be internalized in the current regulatory regime as well. The AERB's institutional dependence and faith over such synergies between the DAE wings emanate from this evolutionary practice. A belief in the fool-proof safety culture of the organisation emanates from its own self-belief in the uniqueness of nuclear organisations being imbued with unparalleled sense of responsibility.

Two, strong fraternal affiliations within the various wings of the DAE and an arrangement where utility is involved in regulatory committees as members may compromise the robustness and discipline that should be garnered through an impartial and ever-vigilant regulatory body/regime. Even if the regulatory body is 'de facto' autonomous, as often claimed by the establishment, in the absence of a structural autonomy, it may degenerate into a timid body that obliges the authority hierarchy.

Three, on the basis of an evaluation of AERB's structural, administrative and functional attributes according to the parameters outlined in the introductory chapter and discussed in this chapter, this chapter concludes that AERB is not an autonomous regulator.

Four, there is no objective method to find if AERB is truly de facto independent as claimed by several respondents, interviewees and government responses. Access to the records and performance of regulatory processes during various stages, is highly restricted. Several newspaper reports claiming AERB's ineffective over-sight or of its authority being undermined have been discredited by various interviewees from within the establishment. Also, there is an over-all transparency issue with the DAE as a whole, and national audit agency too has limited mandate over it.

Five, the AERB and the DAE in general, presume a sense of rationality and safety-cautiousness on the part of the nuclear corporations. This reflects a cozy organisational culture that reifies nuclear standards and actors. Such beliefs, therefore present a normative and functional resistance to the idea of changes in regulatory arrangement through parliamentary act. They also denounce the 'arms-length' directive as it undermines and creates a sense of fragmentation within the establishment, counters the assumption of scientific wisdom and safety sensitivities and argues for an over the top hierarchical placing of regulator over the utilities, as opposed to the current system of an informal co-regulation and mutual consultation and formal.

Six, Nuclear security regulation in India remains fragmented and no concrete evidence of this being a major policy consideration could be found. However, this was the only question where percentage of neutral opinion (46.2) exceeded either of the extreme responses indicating lack of a vibrant debate on nuclear security regulation mandate of the AERB. However, because of the international focus on nuclear security especially since 9/11 terror act, India did undertake various nuclear security related commitments but these do not appear to have percolated to or related to AERB mandate specifically. On the other hand, there has been proliferation of authorities to deal with nuclear security regulation. Based on review of secondary literature alone on India's nuclear security regulation, this study asserts that nuclear security remains a fragmented and incoherent domain and some sort of centralized or even clearly demarcated spheres of security regulation could boost India's claims of the same.

The next chapter will discuss the impact of crisis-events on evolution of nuclear regulatory regime in India.

Chapter- 4- Crisis Learning and the Indian Nuclear Regulatory Regime

"It is not the strongest of the species that survive, nor the most intelligent, but the one most responsive to change".

—Charles Darwin

Organisations evolve. Need for organisational evolution and development is often generally rooted in learning that is a result of a realization that existing structures, techniques and mechanisms are perhaps not sufficient to carry out organisational goals. Some such learning can even lead to a shift in basic organisational goals. Learning as a rationale for change, therefore, can occur at both individual managerial level or organisational level as a whole through collective memory or shared experiences. This chapter situates nuclear regulatory changes (structures, mechanisms and standard practices) as a response to learning that has emanated through the experiences of crisis events in India and across the world. Though learning can occur at several levels, viz. individual, group, organisation, systemic and such, the chapter focusses on organisational learning, observed in AERB (given the institutional nature of the study).

To decipher the lessons that were envisaged in the civilian nuclear regulatory domain after certain nuclear crisis events, the chapter is divided into six major sections and corresponding sub-sections. The first section provides a conceptual background to the theme of crisis. The second section, which is theoretical, is divided into three sub-the first two sub-sections pertain to two sets of theories: one, organisational theories on probabilities of accidents; two, crisis as a factor affecting organisational change in regulatory regimes. These theories have been drawn upon to acquire analytical tools to reflect upon the organisational characteristics of nuclear establishment in India with respect to probability of accidents and safe-keeping. The third sub-section briefly discusses the specific methodological issues of this chapter. Rest of the chapter is more empirical in nature. The third section of the chapter elaborates the politico- technical context of the three major nuclear accidents worldwide, each one having been analysed in three different sub-sections. This section therefore analyses their impact on: a) international nuclear regulatory mechanisms and b) Indian nuclear regulatory mechanisms. The fourth section analyses the implications of safety related crisis events that occurred within India on national nuclear regulatory mechanisms. The fifth section critically analyses the cumulative impact of safety related crisis on the evolution of the AERB. The sixth section deals with security related events and their impact on Indian regulatory regime, if any. The last section before conclusion will discuss institutional mechanisms that have evolved in the Indian context to deal with nuclear related crisis events over the years as a concrete manifestation of learning. The concluding section enumerates the observations and tests the theoretical premises spelt out in the first section.

To decipher the inferences of ‘crisis learning’ in the safety domain, this chapter analyses the impact of the three-major global nuclear accidents i.e. the Three Mile Island, the Chernobyl and the Fukushima disasters which occurred in commercial nuclear plants. It would also look at nuclear accidents that occurred in India like Narora plant fire, Mayapuri incident and others (these had little or no radiological releases). The lessons for crisis learning would be sought in terms of technical details (of nuclear materials and equipment etc.) and organising principles (of regulatory structure) that have evolved as a response to such crisis events. The concept of nuclear learning has primarily evolved in the field of nuclear material management to prevent accidental use (Sagan 1993) and in the contexts of strategic stability induced by deterrence. This chapter, however, pertains to the specific of nuclear learning in the field of civilian nuclear operations and regulations alone.

This chapter, however, does not analyse every safety related incident that occurred in India and is limited to only those incidents which were rated on INES scale as a positive number. Also, it does not look at the specific regulatory changes that were brought about in the countries where major accidents took place but focusses only at the resultant multilateral regulatory mechanisms.

4.1. Background and Conceptual clarifications

This section will discuss the nature of ‘crisis’ as understood in civilian nuclear domain so as to provide a reference for understanding organisational nuclear learning which this chapter seeks to highlight.

There is no doubt about a possible devastation that could be caused by an intended or accidental use of nuclear weapons. Security studies in the recent decades have been deliberating on ways to prevent such usage. The dreadfulness of nuclear weapons is attributed not only to the huge numbers of immediate deaths it could cause, but also a severe radioactive contamination that can adversely affect the population for several more years. Such radioactive contamination is highly enduring and can easily affect the ecosystems in even distant places. The qualities of radioactivity to be air- and water- borne, therefore, hugely magnify its ill effects.

Such radioactive contamination, however, can also be generated through accidents in civilian facilities involving nuclear power generation or in nuclear research facilities. Transport, storage and waste disposal facilities too involve a danger of radioactive leakage and contamination. Threats of nuclear terrorism further assuage the alarming nature of a probable nuclear crisis. The un-neutralized or unattended radioactive materials generated through industrial usage, hospital products etc. too can have dire security and safety implications. In the background of these concerns, this chapter explores the nature and implications of nuclear learning from crisis events.

This study uses Seeger at al's definition of crisis as "a specific, unexpected, and non-routine event or series of events that create high levels of uncertainty and threat or perceived threat to an organisation's high priority goals" (Seeger et al. 1998: 233). To analyse organisational learning, this chapter employs Hillyard's definition of 'Crisis learning' as "learning together from the event to prevent, lessen the severity of, or improve upon responses to future crises" (Hillyard 2000: 9). This chapter suggests following procedural steps to decipher crisis-learning for the purpose of analysis as:

a) Recognition/Acceptance of the occurrence of the crisis event by the appropriate/ designated authority
b) Review studies/reports on causes and nature of nuclear/ radioactive mishap
c) Action taken report or guideline, if formulated or adopted after such events
d) Any reporting system on compliance
e) Institutions if any created to prevent such occurrences in future or/and to modify responses to such incidents

While the first three steps are necessary for establishing crisis learning, the last two are contingent in nature but when present, add to the robustness of the claims. Given the dearth of published or publicly available resources, classified event reports and data access limitations and expertise unavailability, the study has limited standard ways to gauge the effectiveness of the measures taken in response to crisis learning. Therefore, this chapter is making only a tentative assessment of crisis learning rather than arguing the case for 'effective' crisis-learning.

To assess the threat value of such occurrences and enable an effective communication and understanding among various stakeholders, the IAEA devised the **International Nuclear and Radiological Event Scale** (INES) in 1990. It classifies nuclear and radiological events based on three criteria: impacts on a) people and environment (direct exposure to radiation dose); b) Radiological barriers and control (unplanned radiation exposure within such facilities); and c) Defence- in- Depth (events with no direct impact on people but demonstrate inadequacy of established measures intended to prevent accidents).

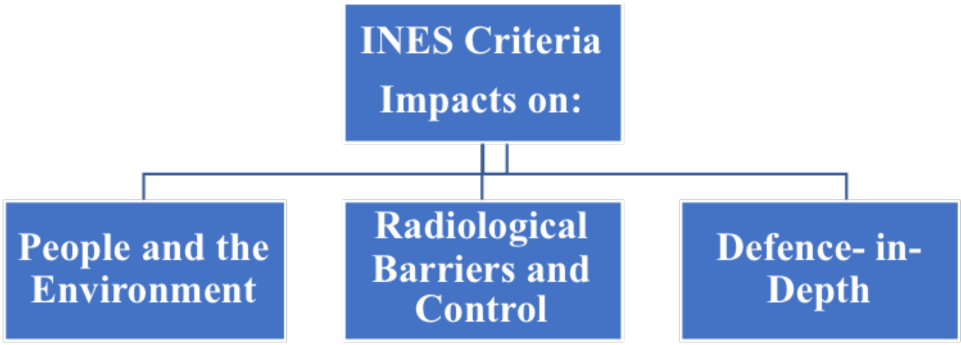

Figure- 4.1. INES Impact Criteria

Source: Based on INES: The International Nuclear and Radiological Event Scale documented by the IAEA, Available on http://www-ns.iaea.org/tech-areas/emergency/ines.asp. Accessed 17 September 2016.

This scale provides a seven-level classification of severity of events with radioactive impacts:

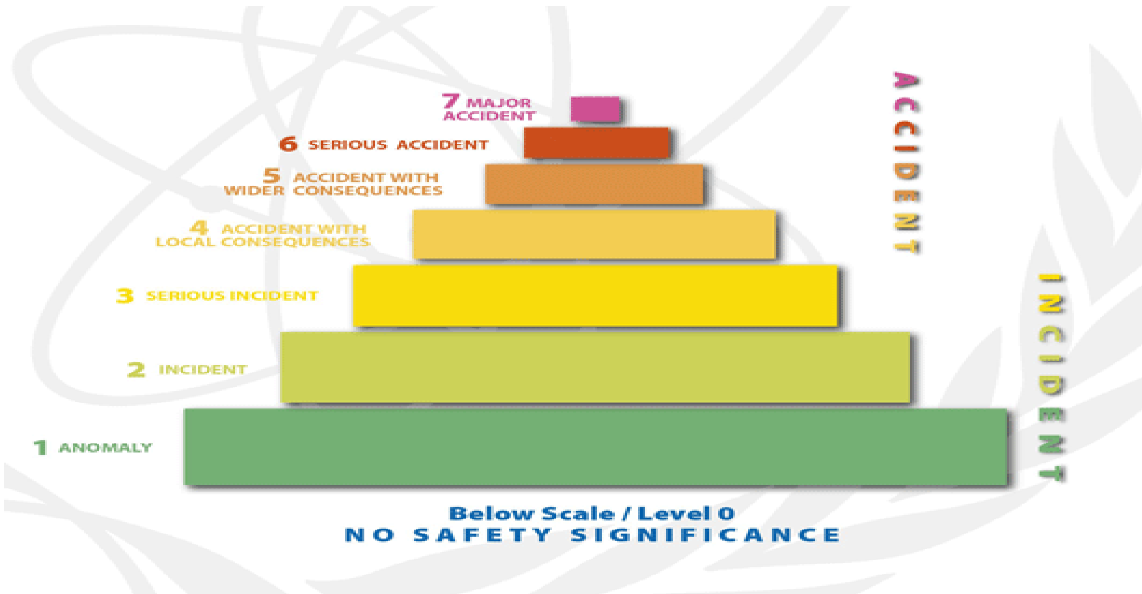

Figure- 4.2. International Nuclear and Radiological Event Scale

Source: http://www-ns.iaea.org/tech-areas/emergency/ines.asp, Accessed on 16 September 2016.

Below Scale/ Level 0 events are without safety significance. The scale is so designed as to represent ten times greater severity impact with the rise in each level (IAEA 2014d). Levels ‘1-3’ are termed as ‘incidents’ while ‘4-7’ are termed as ‘accidents’ (Koshy 2016).

Till date, only Chernobyl and Fukushima events have been categorized as the level ‘7’ accident. The Three Mile Island, 1979 event was categorized as a level ‘5’ event, same as the Windscale Pile, UK, 1957 where around 10 tons of radioactive fuel melted in the reactor core subsequent to a 16-hour fire (The Editors of Encyclopedia Britannica 2013). The Kyshtym disaster in Ukraine in 1957 was rated ‘6’ on the INES scale. The entire region remained highly contaminated as radioactive waste generated from nuclear weapon facility was recklessly dumped by the Soviet officials in the Techa river, some even dumped on-site with little concern for radioactive impacts on citizens or environment (Soran and Stillman 1982, Cellania 2015).

The Windscale Pile and the Kyshtym disasters, however, were dubbed as ‘military facilities’, according them somewhat immunity from public review and mass criticisms. Also, both these accidents occurred during the cold war period and nuclear arms race (national security discourse) came handy as a justification for shielding these accidents from mass scrutiny and criticisms for a long time (Gillis 2013; Leatherdale 2014). The highly secretive nuclear programme of USSR kept the accidents hidden from the eyes of western media and world community. The Kyshtym disaster even got revealed only because of an internal dissident in Soviet Union. Apparently, the USA also helped shielding the accident at that time fearing an adverse impact on domestic public about safety of its own nuclear reactors (Lewis 2018). This chapter deals with safety incidents and accidents in civilian nuclear plants alone.

India, in compliance with international nuclear regulatory framework has adopted the INES scale for assessing the severity of nuclear/radioactive incidents. It has appointed the national regulatory body (AERB) as national coordinator to communicate with the IAEA in crisis events. The national coordinator, i.e. the regulatory body gives a provisional rating to the incident/accident happening in the country based on the IAEA code criteria. If there is a nuclear accident in a power plant, the utility presents the root cause analysis, instrumentations, charts and other relevant data to the AERB. If needed, the AERB conducts its own investigation. All the relevant data and provisional rating are given to the IAEA which may or may not agree with the national regulator. Either way, the regulatory body may be called upon for discussion. Finally, the IAEA decides the INES ranking for incidents/accidents identified as crisis events (Bansal 2018). Before looking at specific crisis events, however, the next section will deal with theoretical and conceptual premises to enable a comprehensive understanding of nuclear crisis learning in civilian domain as a phenomenon. These theories relate to the nature of organisational culture and organisational change which relate to the possibilities of crisis-learning and subsequent modifications and adjustments once a crisis takes place.

4.2. Theoretical Approaches to Organisational Change

In order to make a more conceptual understanding of crisis learning in civilian nuclear domain, this section will deal with two set of theories concerning a) organisational cultures and probabilities of accidents and b) regulatory regimes transitions. The first set of theories link organisational cultures, their standard operating procedures and employees' beliefs of self-credibility as capable and responsible agents to the probabilities of accidents in an industrial organisational setting.

Organisational Cultures and Proneness to Accidents

There are two major approaches to analyse the probabilities/ likelihood of accidents in case of risky technologies depending upon the organisational culture and management practices followed by the concerned organisation (Sagan 1993): High- reliability theory and Normal Accident theory.

The first one is more optimistic about extremely safe operations of hazardous technologies, provided appropriate organisational design and management techniques are designed and implemented. So, according to this view organisations can be more effective and can compensate for human frailties like cognitive limits, biases, incentives etc. if they are properly designed and managed. Hazardous technological organisations create a formalized structure with very clear, consistent and mostly well-agreed upon operational goals like safe operations. This theory is rooted in 'closed rational systems' approach (Scott 1987) which believes that certain hazardous technological organisations become 'rational' in themselves and undertake great efforts to prevent the interference and influence of outside environment or agencies. Sagan (1993) pointed out four causal factors that could account for good safety records within the organisations:

- *The prioritization of safety and reliability as a goal by political elites and the organisation's leadership*- leaders' commitment is necessary for provision of huge expenses required to cover the high-costs of safety and to articulate clear operational goals.

- *High levels of redundancy in personnel and technical safety measures*- duplication and over-lapping enable quick replacement of one by the same or similar mechanism in case of failure or unavailability of the first component or personnel.

- *The development of a "high-reliability culture" in decentralized and continually practiced operations*- first, socialization in 'homogenous set of assumptions and decision premises' (Weick 1987), prioritizing operational goals and learning to take responsibilities etc., then decentralization to promote entrepreneurial skills and spontaneity. Overall, it promotes centralization and coordination in terms of operating principles and culture which is to be followed.

- *Commitment to organisational learning*- incremental learning through trial and error, willingness and ability to learn, developing imagination and preparedness through simulations (Wakeham 2013).

The normal accident theory, on the other hand, exhibits less optimism about the possibility of nuclear accidents. Charles Perrow, a major proponent of this theory argues that "given the system characteristics, multiple and unexpected interactions of failure are inevitable" (Perrow 1984: 5). Nuclear technology involves a complex interaction with various system components, making it accident-prone despite strict regulations. Effective regulation, therefore, can reduce the events of catastrophe but cannot altogether prevent it. Such interactively complex systems have an innate potential for tragedies and catastrophe. There can always be certain operator errors and unfavorable environmental conditions. Industry's motives for profit may compromise their investment on safety credentials. Quality regulation too cannot provide for all exigencies and almost anything can cause an accident given the complex interplay witnessed in nuclear technological operation (Perrow 2011:50). Perrow (1984) believes that modern technologies, by nature, are prone to create disasters.

The proponents of normal accidents theory, belonging mostly to academics, independent research institutions and anti-nuclear movements in India, have been wary of the safety records for multiple reasons: first, they believe that the nuclear technology inherently is unsafe and should not be pursued; secondly, the Indian safety record is not as exemplary as the establishment proclaims it to be. This group has often criticized the DAE for covering up or downplaying the safety failure incidents at various nuclear sites. Thirdly, an absence of a major radioactive crisis till now does not guarantee its non-occurrence in the future too and fourthly, the lack of sufficient autonomy of the regulatory agency and a culture of secrecy, isolation and arrogance would undermine the preventive capabilities that the establishment could achieve in order to run the nuclear operations in a fail-safe mode for most of the times. Scientists like M.V. Ramana, Subbaroa, Suvrat Raju, A. H. Nayyar and a few others have been writing critically on the sub-optimal management of nuclear facilities both in India and globally. Bidwai (2011) noted, “Nuclear Accidents happen because of the nature of nuclear technology. Natural calamities only make them more likely. All reactor designs are vulnerable to core meltdown accidents”.

The Indian nuclear establishment, on the other hand, seems to believe in the conceptual framework of high reliability theory, which posits that prevention and timely mitigation of crisis events arising out of complex nuclear technology is fairly possible. For this, it has preferred a relatively isolated existence from the wider society, intensive socialization within the nuclear scientific community together with the technological partners and an organisational culture infused with discipline and secrecy. To them, this kind of ideal military-kind organisational setting strengthens the reliability and safety in the nuclear facilities (Mishra 2017).

At the same time, while they do not negate the possibility of nuclear accident happening at all, the interviewee (mostly nuclear scientists and engineers) found it very unlikely (Raj 2017, Sundararajan 2017, Bhardwaj 2018, Sinha 2017). “Except for a very few accidents nothing happened major and internationally India is considered a very competent country not only with respect to technology but also its capacity to meet the highest safety standards” argued Baldev Raj (2017), a retired scientist of the DAE. As the study specifies in further sections, there have been institutional affirmation of robustness of Indian nuclear safety capabilities immediately after crisis events happened in India or in some other country.

As discussed in the previous chapter (on Indian nuclear regulatory regime), there is an inward resistance against any major changes in the organisational structures within Indian nuclear establishment. A belief in effective functioning and autonomy of the system is a major reason for resisting change. The public on the other hand, especially those not in the vicinity of the nuclear facilities, seems to be oblivious of the nature of the nuclear operations, their consequential effects and therefore of the adequate prevention and mitigation measures. The lack of information or misinformation and misperceptions about the nuclear operations at the level of masses then seem to be the only points that both the establishment and the external critics agree upon. At the sites proposed for nuclear power plants, the instances of resistance form public have been on rise with the involvement of activists with masses on ground.

The perception about a belief in the credibility of 'experts' and their capabilities and intelligence to quickly adapt to changing environment therefore, are some of the organisational attributes of Indian nuclear regulatory organisation, which have conditioned their responses to crisis events and affected the nature and degree of crisis learning over the years. This aspect will be empirically explored in detail later in the chapter. The next conceptual section will deal with 'crisis' as a factor for bringing in organisational change, especially in regulatory regimes/ organisations. Such changes can be observed in the forms of structural institutional changes, mechanisms and procedures followed, changes in working philosophy and principles, causality and direction or nature of transformation.

Crisis Learning in Organisations

Organisational change has been defined by Cummings and Huse (1985) as "a state of transition between the current state and a future one, towards which the organisation is directed". Emphasizing on change as essentially a linear progression, which might not be apt for analysing complex dynamics associated with organisations, it essentially characterizes a 'planned change'. Such planned changes are taken up by managerial or authority class. Organisational change, however, can be unintended as well, pushed by external environmental factors. A clear-cut demarcation, however, is not possible as some changes are planned by authorities in response to environmental factors. Nandler and Tushman (1989) propose a classification of reactionary (in response to an external event) and anticipatory (initiated in anticipation) changes. Distinctions between incremental, continuous, slow and small changes on the one hand and radical, intermittent, fast and large changes on the other are one of the most popular categories of change classifications. Gersick (1991) while discussing punctuated equilibrium argument of change talks about gradual (prime or current structure remains same) vs. revolutionary changes (current structure and order is replaced), Dunphy and Stace (1988) use the classification of incremental vs. transformational change, Miller and Friesen (1984) discuss evolutionary (incremental) vs. revolutionary (dramatic) change. These classifications essentially focus on process (duration and nature) and result of organisational change (superficial or fundamental). However, there are no scientific ways to characterize a change as evolutionary or revolutionary and qualifications like ‘long’ or ‘short’ change, are often a product of subjective assessment of time frame.

The concept of organisational change also involves a temporal element where the preceding and subsequent characteristics/parameters can be delineated at a juncture or over a fragment of time. Any major change would then include changes in many structural elements in the organisation or a single revolutionary change in any one structural element. These, therefore, relate to changes in ‘content ‘dimension. The other dimension of studies on organisational change focuses on the ‘process’ dimension of change: the pace, sequence of activities, decision-making and communication systems, the resistance encountered etc. (Barnett and Carroll 1995). Process considerations may be independent of content, or they may be interactive. The concept of structure is understood as patterned regularity. While some scholars look at the formal configuration of roles and procedures and prescribed organisational frameworks, others look at the interactive processes and dynamics (Ranson *et al.* 1980).

Many scholars, who study internal factors of change argue that organisational change is steered primarily by the managers. However, the outcome of the change can be unexpected and unintended (Merton 1936; March 1982). Among the causes for organisational change, there are various theoretical propositions:

1) Game theory (Shapiro 1989) - cost benefit analysis favoring a new organisational principle, mechanism or route

2) Life cycle or development theories- Certain scholars argue that as an organisation grows older, certain structural transformations should take place (Greiner 1972).

However, Barnett and Carroll (1995) dismiss these theories for being based on retrospective histories of a few and large organisations causing an element of suspicion over the neutrality and universality of this theory.

3) Internal Factors- “Structural inertia theory” of Freeman and Hannan (1984) - this theory in a way contradicts the life cycle theory. It argues that with time, the organisations become stable, processes get routinized and norms are more widely accepted, diminishing the need for change.

4) External Factors- theories focusing on environmental factors are counted here. The political environment, inter-organisational dynamics, technological innovation (Tushman and Anderson 1986), resource stability and competition etc. are some of the factors that affect organisational change.

However, the factors are not always exclusive and instances of organisational changes often demonstrate mixed factors. At the same time, these theories do not explain why certain organisations grab the chances for change while certain others need to be pushed for the change (Barnett and Carroll 1995).

Looking at regulatory regimes as a temporal manifestation (time as a contextual factor) of state-market relationship and interactions (nature of state’s control over the regulated market or industries), Newman and Howlett (2014) argue that “regulatory regimes [*situated in different spaces or countries (added for clarification)]* have similar development patterns, although the time spent at each stage in the process can vary significantly according to unique domestic factors” (Newman and Howlett 2014: 493).

Regulatory regime cycle has been compared to human life cycle. Bernstein (1955) posited a four-phase model involving ‘Gestation’ as recognition of problem and preliminary management, ‘Youth’ as institutionalization of IRAs by the government, ‘Maturity’ as ideological and functional stability (Newman and Howlett 2014) and ‘Old age’ as regulatory capture or ‘death’ as deregulation (Derthick and Quirk 1985). Newman and Howlett (2014) also argue that the rate of development and transition through regulatory stages occur at different speeds stimulated by periodic crises events. The pace and nature of crises, therefore, are instrumental to regulatory changes.

Newman and Howlett (2014), however, criticized the idea of a somewhat linear pattern of regulatory growth based on its attaining the functional prerequisites for effective command and control and for not accounting any agency to the actors within the regulatory regime.

Also, neither the characteristics of the stages nor the sequencing has remained controversy free. Stigler (1975) argues that the phenomenon of regulatory capture is often built into the system and that it can occur in the early phase also. Formation of IRAs (discussed in introduction chapter) also is not a universal phenomenon and its occurrence in the youth stage is further less prevalent.

Drawing from their research in contemporary biotechnology regulatory regimes, Howlett and Migone (2012) posit that in early phases, the existing regimes try to solve a new problem by adaptations in the existing institutional arrangement of rules and laws and exhorting regulatees for voluntary compliance. They further argued that only if this 'infant stage' (a stage added later by Howlett and Migone to imply mostly voluntary self-regulation) failed to address the issue, the process of 'standard seeking' identified by Leiss (2001) and Otway and Ravetz's (1984) phases- scientific, technical and administrative - would be resorted to. A progression of stage from gestation to infancy, however, would require scientific or statistical evidences (Howlett and Newman 2013).

However, it is widely acknowledged that this cycle is not automatically progressive and different stages may take different time to complete. For Newman and Howlett (2014), exogenous factors affect the timing and sequence of regulatory life cycle more than the agents in regulatory regime themselves. Especially the risk managing authorities are more reluctant at least initially in identifying the problem as hazard and categorizing it as a public emergency requiring more strict regulations (Howlett 2014). Newman and Howlett have also argued that for progression in risk regulatory regimes,

> …an important factor…is the presence or absence of repeated crisis which, when present, contribute to driving the regime to the next level or stage of development by undermining the belief or claim made by either or both public and private actors that existing standards and hazard definitions are adequate to deal with the hazard in question (Newman and Howlett 2014: 504).

External shocks, in the form of crises events, coming from the environment in which an organisation operates or is situated, therefore, acts as a strong driver of change in organisational attributes and procedures.

Wildavsky (1988) argues that without trials, there cannot be new errors but without them, there would be less new learning too. Therefore, the government should not excessively regulate hazardous technologies. However, as Marone and Woodhouse caution, nuclear consequences can be too severe to warrant the trial-and-error strategies or definitive controlled study of a nuclear accident, which would be impractical (Morone and Wooodhouse 1998).

Irrespective of differences in classification terminology and basis of change, there is a widespread consensus on organisational learning being a factor for strategic performance of the organisation. What all kinds of changes can be considered 'organisational learning', however, are a subject matter of intense debate. Herbert Simon said (1991), "all learning takes place inside individual heads; an organisation learns in only two ways: a) by the learning of its members or b) by ingesting new members who have knowledge the organisation didn't previously have" (Simon, 1991: 125). Unless the individual learning is not socialized and accessible and accepted by other individuals within an organisation, it cannot be called organisational learning. Apart from this, such learning needs to be institutionalized so that even when these individuals leave the organisation, practices and ideas are not abandoned. Institutional roles, norms, memories, mental maps and such therefore, become a repository of information and learning and need to be communicated to the newcomers. Simon (1969) characterized organisational learning as a) growth of insights and b) restructuring of structural elements and outcomes of organisation itself (output-oriented). Insights are not easily decipherable and change in output is not always feasible. These lead to a lot of confusion as to what can pass as organisational learning. Scholarly interpretations range from characterizing learning as "a) new insights or knowledge (Argyris & Schdn 1978; Hedberg, 1981), or b) new structures (Chandler, 1962): or c) new systems (Jelinek, 1979; Miles, 1982); or d) mere actions (Cyert & march, 1963; Miller & Friesen, 1980); or e) some combination of the above (Bartunek, 1984; Shrivastaba & Mitroff, 1982)" (Fiol and Lyles 1985: 803). Fiol and Lyles (1985) discuss low- level learning (behavioural changes within an organisation) and higher-level learning (cognitive change leading to adjustment in general rules and norms). Measuring learning or change, however, is not an easy task.

Drawing from IAEA guidelines on regulatory authority, this study assumes that a nuclear regulatory organisation *should* strive for autonomy and separation of power and functions vis-à-vis other organisations associated with promotion of nuclear energy. This autonomy is directed at ensuring safe and secure nuclear operations. Considering it as a desirable organisational goal in accordance with standardization of nuclear regulatory regimes, this study looks at directionality of organisational change as evident through data. This study concurs with the view that boundaries between internal and external drivers of change can be fussy and therefore no such judgment is made in the course of this study.

In order to decipher organisational learning, this chapter focusses upon institutionalized or regularized practices and mechanisms that have evolved over a period of time in the functioning of AERB. It especially looks at crisis events as a change inducer. A nuclear crisis event given the nature of radioactivity exposure, even when occurring in another part of the world may induce organisational learning in one's own organisation. Many of the important changes in AERB were 'planned' by the authorities in response to crisis incidents both in India as well as abroad. The chapter will look at both the process and content dimensions of regulatory change.

In terms of theoretical grounding on organisational change, this chapter will focus on life cycle or development theories as it offers specific insights on 'regulatory organisation's as base points. The research concurs with Newman and Howlett's (2104) assessment that time spent and development patterns followed by a regulatory regime, though similar across spaces or countries (because of IAEA's. standardization efforts) differ according to unique domestic and national factors.

This chapter adopts Herbert Simon's approach and deciphers organisational learning as those new standards, practices and mechanisms which have been routinization and institutionalization in AERB. Also, as a large scale of evidences, like new insights or knowledge, new structures, mere actions and so on can pass as organisational learning, this chapter privileges changes in behavioural patterns (standard operating principles and mechanisms) with or without an ideational/normative shift (in foundational principles) along with, as indicators of organisational learning. Therefore, changes in SOPs as well as foundational questions will be sought as objects of analysis in this chapter.

The conceptual aids, as discussed above will now be used in the next section to reflect upon the responses of Indian atomic energy establishment with respect to specific crises events related to safety and security. Following sections will try to charter the role of crisis events and crisis learning in the process.

Methodology for Data Collection

As the data pertains to the specific measures undertaken specifically by the regulatory body and nuclear establishment in general, the chapter runs the risk of positive confirmation which may present a biased picture. This data pertains to *what was done rather than what was not done.* There is no standard, precise, step-wise, detailed specification of actions formulated by the IAEA or any other international body that are to be taken by national regulatory bodies or state agencies in the wake of crises events. Given the nature of data and non-availability of standard measures to be followed after crisis events, the chapter analyses public speeches and press conferences addressed by nuclear establishment in India in response to crises events. Also, the steps outlined in the beginning of this chapter have been taken as standard for claiming the evidence of organisational learning. It may be noted that the inventory of disasters discussed here covers only commercial facilities related disasters and military or experimental reactors related accidents are precluded from this study.

Also, in deciphering crisis-learning, the study chose to highlight the behavioural or tactical adjustments in standard operating procedures along with fundamental changes in organisational philosophy. (even when they did not bring about a change in organising and regulatory principles or philosophies primarily. Fundamental changes in organisational philosophy are not common-place events. So, a study focussing on crisis-learning in just this domain would have limited contribution to offer.

4.3. Crisis- learning in the Civilian Nuclear Operations

Crisis events induce a propensity for critical thinking, often accompanied with remedial measures on the ground. Nuclear being one of the high-risk technologies, the caution on the part of the operators and regulators, generally, is an important part of the organisational culture. This, however, does not preclude the possibility of inadequacy or incompetence or inadvertent mistake on the part of the handlers, which sometimes transpire into real crisis events on the ground. This section would enumerate the major crisis events and the lessons that were later deliberated upon to a) help prevent the occurrence of such events in the future and b) to mitigate the disaster potential, if they ever occur. This section is divided into two sub-sections: a) major nuclear incidents that occurred outside India and b) the ones that happened within Indian territory in the civilian domain.

There have been a few major safety-related incidents in the course of civilian nuclear operations all over the world. This section would present a case-wise analysis of some of these incidents, specifically the ones that were marked among the highest on the INES scale. The section enumerates only those international incidents that had any impact upon the Indian nuclear regulation. In the domestic field, the incident-cases have been chosen as per the degree of alarm associated with them according to the events risk-standards measured by the INES scale and recognized so by the appropriate authorities nationally and internationally.

The Three Mile Island (TMI) Accident (1979)

The Three-Mile Island happened because of multiple system failures and operator errors causing core damage and little hydrogen explosions (outside the reactor though). The accident happened on 28 March 1979 around 4 a.m. Because of a small loss of coolant and faulty relief valve, enough de-pressurization could not take place and this prevented the activation of emergency core cooling until late. The operators diagnosed the problem wrongly while the engineered safety systems could not rescue the situation (Jain et al. 2013). This caused over-heating of the reactor and eventual core melt-down.[41] The President's Commission attributed the accident to the supplier, Babcock and Wilox, which did not provide timely information to the operator about the emergency cooling system (Ramana and Raju 2013).

The accident highlighted the problems with over-dependence on human intervention, designing faults and incorrect diagnosis of the crisis. The biggest technical take-away from it was a shift towards development of passive safety mechanisms to reduce the need for operator's intervention. The human aspects of nuclear operation, too, came under higher scrutiny.

The incident also triggered a *misplaced* concern of hydrogen explosions (due to zirconium-water reaction) and subsequent cracking of containment dome, among

[41]It is a very brief and simplistic presentation of events that ultimately transpired into TMI accident. For more details, please refer the USNRC report on TMI, IRSN 2015.

scientists (Corey, Jacquemain 2015, World Nuclear Association 2012, Biello 2011). Earlier this was brushed off as a possibility as this hydrogen concentration occurs outside the containment building. Though the hydrogen accumulation in the Three Mile incident was not much, so not much damage was caused because of it. But since then, the installation of vents in the nuclear reactor building to prevent the explosive accumulation of hydrogen has been included as a component of the designing. However, the vents failed in Fukushima and let to hydrogen explosions sending radioactive materials and gasses into the environment. Therefore, while there is a continuous learning about technological learning to ensure a better safety of nuclear energy operations, there can always be unforeseen eventualities.

Another major technical fix related to the popularity of a strong containment dome as a component of defence-in-depth concept since the TMI incident (Jacquemain 2015). Despite severe damage to the core, the containment structure functioned efficiently in TMI. The radioactivity remained trapped within the reactor building for several hours and slowly released depending upon the environmental conditions. While the containment domes had already been a part of design-basis safety mechanism, its robustness acquired renewed importance with this event.

Of the three major nuclear accidents, the Three-Mile Island was the least alarming as there were no casualty reported, little radioactive leakage and the accident was brought under control quickly. But it did highlight the possibility of a core melt down accident happening in real terms. Some of the technical issues were dealt with in the later designs but the US Nuclear Regulatory Commission (USNRC) did not propose substantive reforms and most of the existing nuclear plants were permitted to continue without any significant alterations (Lyman 2011, Jacquemain 2015).

The nuclear electric utility industry in US was quick to recognize that its future depended on non-occurrence of such disasters and established the Institute of Nuclear Power Operations (INPO) to ensure safety and reliability through "periodic on-site evaluations of each nuclear plant and corporate support organisations, training and accreditation, events analysis and information exchange, and assistance" (The Institute of Nuclear Power Corporation 2007).[42] While INPO self-regulates the nuclear industry in USA, it served as

[42]This institution has been established by the industry to oversee its own performance. This was to serve as an effective mechanism for self-regulation through peer review. Poor safety performance of any utility

precursor to the establishment of WANO post-Chernobyl. As an institution of nuclear operators worldwide, WANO can carry out inspection reviews, monitor the safety compliance of reactor units and suggest means and ways of improvements. Being an industry institution, its regulatory credentials attract skepticism. Nevertheless, it provides a level of limited, self- regulatory peer-review mechanism.[43]

The IAEA, in response to TMI, instituted the OSART missions in 1982, to assess the operational safety and performance of the personnel as expected under the IAEA regulatory guidelines, under an intensive three-week review (IAEA 2016b). This then becomes useful in terms of comparing and assessing the similarities between the IAEA and the national regulatory regime. At this stage, the proposal of the US to introduce a convention at the IAEA requiring member states to immediately report the nuclear accidents that could have radioactive implications across borders, was rejected by many European countries including France (Ahearne 1987).

Indian Establishment in Responses to the TMI

This section will discuss the response of Indian nuclear establishment in response to TMI which happened several thousand miles away from India. One of the major attention point for Indian establishment recognized officially was emergency preparedness (Krishnan 2017). Following the accident, lack of a well formulated emergency preparedness plan for evacuation of citizens in the path of the plume came in for criticism. That set the tone for the emergency plans for Indian facilities. This was before the AERB was even established in 1983). The IAEA, as it generally does, swung into action and in 1981 sponsored an international workshop on radiation emergency preparedness in Kalpakkam (Krishnan 2017).

At the time, the TMI accident happened, the two reactors at Tarapur and one at Rajasthan were in-operation. Five other NPPs were under different stages of construction. It was the most alarming accident in a civilian nuclear facility of the time and overall safety

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could jeopardize the future of entire industry. This idea enabled cooperation on the part of operators to establish the credibility of INPO and perform by it. The INPO, however, exists as a voluntary organisation of the industry and though complements some of the activities of National Regulatory Commission in the U.S.A., is not recognized as its sub-ordinate agency. The safe operation of a nuclear utility is the liability of the individual operator alone, both as a standard international practice and in India national regulatory set up as well.

[43]All the Indian power plants have undergone WANO peer-review inspections and their follow-up missions too (IRRS Report 2015).

credentials of nuclear energy programme per se came under a sharp criticism worldwide. Soon after TMI, under the chairmanship of M. R. Rao, the then Head, Reactor Operation Division, BARC, a task force was constituted to conduct a thorough safety audit of the operating plants and suggest recommendations for improvement (Sundararajan et al. 2008). The task force made several recommendations spanning also the under-construction plants as well as future plants. The report was discussed in the Safety Review Committee (SRC) meeting in 1979. It emphasized on aspects pertaining to the "reliability and availability of the engineered safety features, human engineering aspects and emergency preparedness" especially those concerned with public domain (Sudararajan et al. 2008: 89). Many of the recommendations, however, required quite some time as they required preparatory activities to enable proper integration with the existing models. Some of the options were long-term measures involving design reviews and analytical studies. To see that these get implemented in due course of time, it was thought desirable to have a strong and institutionalized follow-up. This was ensured by creating a computerized database of the recommendations that were suggested by the Task Force along with the implementation reports (Sundararajan et al. 2008).

Once established, this mechanism was later extended to cover subsequent SRC safety reviews as well. It was continued later with the establishment of the SARCOP as well (Sundararajan et al. 2008). After the establishment of the AERB too, the Operating Plants Safety Division (OPSD) maintains this database. Based on the feedbacks and reports from the utilities and periodic regulatory inspections, this database is periodically reviewed and updated. The unit safety committees, OPSD and the SARCOP then monitor the progress of the implementation of review recommendations. There is periodic reporting of this review implementation to the AERB board as well.

After TMI, there were specific committees too that were constituted to assess the probability of a TMI like accident in India, and if it occurred, what measures could be taken. Radiological implications were worked upon by a three-member committee of the DAE-SCR comprising of S. S. Bajaj, L V Krishnan and A. R. Sundararajan. The engineering committee comprising of Kakodkar and others reviewed the design engineering related aspects. However, no visit was made to the site of the TMI and the disaster was studied on the basis of information available through the government, IAEA and media sources (Sundararajan 2017).

On July 23, 1979, the DAE secretary constituted a committee to review "the existing terms of reference of SRC, its functions, the modalities of reporting by the units as well as the impediments faced by the committee" (Sundararajan et al. 2008: 13). The rationale offered was to ensure that along with the safety consciousness, safe practices prevail in the DAE units. Need for a vibrant regulatory institution with a definite mandate was partly a response to the uproar caused by the TMI that happened on March 28, 1979 in the USA. This rationale, however, has not been backed by the DAE officials who attribute the event to a mere continuation of the vibrant and conscious safety culture that the DAE SRC had managed to build over the years and have negated the idea that the TMI led to the establishment of the AERB as an independent body to review nuclear safety regulations in India (Sundararajan 2017; Raj 2017; Chetal 2018; Rajaraman 2017; Bhardwaj 2018). They have argued that the TMI was a different reactor design than the ones then operating in India. Also, it occurred too far away from India geographically and therefore no radioactive harms reached India anyway. Interviewees also argued that Indian reactor safety was robust as apart from other in-built safety mechanisms, the Tarapur reactors built on the American model and the Rajasthan ones built on the Canadian model already had the containment domes (Sunadararajan 2017).

However, the timeline of establishment of the AERB and the preliminary committee reports that proposed its establishment, found their way in policy circles post TMI, when robustness of regulatory authorities in general came to be emphasized. Safety question that came to be associated with nuclear accidents could be partly addressed by creation of an institutional regulatory body.

Overall, there are following take away of this section: one, though the establishment of AERB is officially not attributed to the TMI occurrence, the internal safety audit of the Indian plants right after TMI was the largest in its scale and depth till then, prompting the establishment of the AERB. Two, Post-TMI, the regulatory mechanisms saw a major streamlining and institutionalization as the system of committees was re-organised to create a centralized safety regulatory body with various sub-committees. Three, Creation of AERB can be seen as an important juncture in regulatory evolution as specific discussions on autonomy of regulatory body through structural measures and wider expertise consultation were taken up officially, though not all were followed in full measures.

The next major accident which raised questions on nuclear safety and on human potential to contain the radioactive mishaps was Chernobyl in the erstwhile USSR. It will be the subject matter of next section.

The Chernobyl Accident

Chernobyl disaster was one of the most alarming disaster related to the civilian nuclear programme. It has been the only nuclear accident in a commercial power facility where deaths were caused by radiation. Two plant workers died on the same day and 28 more died within a few weeks because of acute radiation poisoning and thermal burns. 19 more died by the end of 2004 (Nuclear Energy Institute 2011).[44]

The accident was not reported initially and doctors were asked not to mention 'cancer' on reports. It was only when the radioactive cloud expanded and was caught on Swedish radars that the Soviet government announced the occurrence of a nuclear accident and damage to the nuclear core. Initially, it was attributed to 'human-error' emanating from indiscipline among Chernobyl staff (INSAG 1986), but later in 1991, a revised report of the IAEA (INSAG-7: The Chernobyl Accident: Updating of INSAG-1), based on Soviet nuclear supervisory agency and an independent research of acclaimed Russian scientists, shifted the blame of Chernobyl to specific reactor features, especially the control rod design (Schmid 2011).[45] Designers' reluctance to share sensitive information with the operators emanated from a culture of secrecy woven around nuclear weapons in general and automatically covering nuclear energy programmes too, by extension. The cold war tensions of espionage characterized the nuclear establishment and contributed to the Chernobyl crisis (Schmid 2011).

The Chernobyl disaster was significant for many reasons. It fuelled the demands for certain transparency in nuclear programme at least to the extent that it affected the civilian population across the world. The disaster aggravated the realization that nuclear radioactive risks are de-territorialized in nature. Trans-boundary impacts of radiation

[44]As the Soviet reactors did not have a containment dome like that of the western reactors in the post-1980 phase, the radioactivity spilled in public surroundings and required public evacuation (World Nuclear Association (2018).

[45]Earlier, when the problems with the RBMK (nuclear reactor type at Chernobyl) design rods came to the light, the designers simply changed the operating manual for the control room staff. They did not communicate it to the operators as to why this alteration was required and how would this change the technological arrangement. No change was made in physical design specifications. While this move worked for a while, it failed when the operators tried to shut-down the reactors to conduct certain tests.

necessitate a coordinated approach to help prevent the occurrence of such crisis and support mitigation measures once a nuclear incident/accident occurs.

The INSAG (1986) report, also identified ‘nuclear safety culture’ as one of the important organisational attributes to be inculcated into civilian nuclear operations. The concept of nuclear safety culture thus became one of the most important dictum of nuclear organisational culture internationally and was later defined in 1991by the INSAG as

> Assembly of characteristics and attitudes in organisations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance (INSAG-4 1991: 1).

International nuclear safety regulation regimes remained non-binding except for transportation related rules during the initial decades of IAEA’s establishment as states relied on national laws and regulations alone to ensure safe management of nuclear installations. But such was the impact of fear induced by the Chernobyl crisis that it led to negotiations of two legally-binding international conventions under the aegis of the IAEA, surprisingly in a very small period of time. The two conventions- Convention on Early Notification of a Nuclear Accident and the 1986 Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency essentially focused on international communication and coordination immediately after a nuclear accident or radiological crisis occurred. The conventions made it obligatory on the part of the member states to report any such occurrence to all the directly and indirectly affected or yet to be affected states and the IAEA (discussed in second chapter). Also, after Chernobyl, the IAEA and OECD coordinated in developing the INES scale to standardize the reporting of nuclear crises events (discussed in the first section of the chapter).

The efforts at enhancing the scope of international regulation in the 1960s were resisted by the associated member states, which considered nuclear safety regulation as primarily a national responsibility. The initial international regulation, originated in the domain of nuclear liability through Paris and Vienna conventions because of preliminary realization of trans-boundary effects of radioactivity. Chernobyl brought forth the compelling argument of a global approach towards nuclear safety regulation as well (Savchenko 1995). This eventually led to the negotiations on need for conventions to prevent nuclear accidents in the first place. Though delayed but Convention on Nuclear Safety in 1994 and the Joint Convention on the Safety of Spent Fuel management and on the Safety of Radioactive Waste Management in 1997 were proposed. Chernobyl disaster also had an impact on liability regimes which were strengthened and linked in due course of time (IAEA 2003). The IAEA also instituted the mechanism of Assessment of Safety Significant Event Teams after the Chernobyl accident.

Both the TMI and Chernobyl accidents worsened because of the wrong assessment of the plant personnel about the best safety mechanism to be resorted to in face of spiralling crisis. A complacency on the part of the operator was evident in both the cases (Ahearne 1987). Also, both highlighted a lack of imagination and advanced preparedness to deal with emergency system failures. Both these accidents also indicated that human-machine interface is a crucial aspect of nuclear safety chain and over-redundancy too clouds operators' judgement. This directed efforts at simplification, and automation of control rooms (Carlsson 2003). Industries now focused on creating new designs that would incorporate more "Passive Safety" features. Such mechanisms rely less on engineered safety mechanisms and more on natural mechanisms to reduce dependence on operator's interventions. For the existing operational reactors, 'safety culture' became the doctrinal keyword.

The Chernobyl and Fukushima both were 'beyond the design basis', i.e. operators had not thought it credible that such a series of failures could occur and lead to a disaster of this sort. Scope of the Design-basis is determined by regulators who determine the necessary levels of safety to ensure plant's survival based on type, severity and likelihood of distressing events (Lyman 2011). The event, therefore, widened the ambit of imagination about what more 'design-basis' features could be included in new reactor designs. However, it is difficult to pronounce what that meant for different utilities in different parts of the world. Some experts in Western countries contended that Chernobyl was caused due to outdated designing of reactors and defence-in-depth was not adequately addressed in designing, a characteristic associated with soviet design reactors (World Nuclear Association 2018).

After these accidents, the IAEA over several rounds of discussion, recommended member states to pursue the concept of defence-in-depth. While earlier it consisted of three layers- "prevention of failures, mitigation of an accident sequence once it has begun, and features to reduce consequences", states were advised to include two more layers- "accident management for beyond design basis accidents and emergency preparedness" (Suzuki 2014: 1244).

Indian Establishment in Responses to the Chernobyl

The Chernobyl incident, like its predecessor TMI, also set into motion another major safety review of the nuclear plants in India. As the disaster was caused primarily because of the negligent and callous attitude of the operator, it was considered a fault more of the organisational culture of the Soviet nuclear establishment rigged with hierarchical rigidity than a reflection on the inherent safety credentials of nuclear industry in general (Sundararajan 2017). The incident, however, made the establishment cautious about the maintenance of a good safety culture in the nuclear institutions. The Task Force report emphasized the necessity of complying with the already established reactor safety principles in design and operation and promoting good safety culture. It also suggested improvements in the on-site and off-site emergency preparedness at all the utilities. These exercises became more rigorous in the wake of Chernobyl accident and L V Krishnan and A. R. Sundararajan, therefore, drafted the first manual on emergency regulation (Sundararajan 2017). The first public drill with renewed regulatory guidelines related to emergency preparedness was conducted at Kalpakkam. Rajiv Gandhi, the then PM, even sent his principal secretary to congratulate the associated people for conducting this (Sundararajan 2017).

When the news of radioactive contamination of food because of the Chernobyl fall-out was reported from other countries, the AERB took upon the task of prescription of permissible levels of radionuclides in imported food items. This was one of the first policy decisions of the AERB and after much discussion and debate, it decided to consult the non-DAE specialist institutions as well. Upon the insistence of its first chairman, Mr. A. K. De, representatives "from the ministries of agriculture, food and civil supplies, health and family welfare, commerce, environment and forests, Bureau of Indian Standards, Marine products export promotion authority, National Institute of Nutrition, Consumer Guidance Society of India, research institutes dealing with food technology, fisheries and toxicology" along with the ones from the labs of BARC, IGCAR, VECC and so on were invited to discuss and arrive at the decision (Parthasarathy 2016).

The AERB was in the initial years of its operation at the time of the Chernobyl, having been established in 1983. A second Meckoni committee was constituted on march 21, 1987 to review the functions and responsibilities of the AERB. An official mention or interviewees reference to Chernobyl about the timing of the committee has not been affirmed in letter. This report submitted in May recommended a re-structuring of the DAE-SRC as AERB-SRC (and later as SARCOP). The mandate of the regulatory body was further enhanced. The Board now comprised of four specialized divisions: Nuclear Safety Division; Industrial Safety Division; Operating Plants Safety Division and Radiation Safety Division (Sundararajan et al. 2008).

Chernobyl also delayed Indian official decision to buy Kudankulam reactor, a boiling water design from USSR. Rajiv Gandhi's visit to Moscow in 1985 brought a positive momentum on India's part to purchase the reactor but was stalled because of Chernobyl (Menon 1988). It was finally processed in 1987 when Soviet PM Nikolai Ryzhkov visited India. The AEC committees then vetted the design and favoured it. The then AEC chairman, M. R. Srivinasan led a team to USSR to a few 1000 MW nuclear power stations.

Next major accident was Fukushima disaster in Japan which is the subject matter of next section.

The Fukushima Accident, 2011

After the Chernobyl disaster, the western and Indian nuclear industry realized the horrors of nuclear accidents and the importance of nuclear safety for the future of industry. However, at a level, they also dismissed the possibility of a Chernobyl kind of disaster in the west primarily because of two reasons: one, they argued Soviet designs were outmoded and the western reactors were more modern and robust with adequate safety mechanisms (Thomas 2012) and two, they blamed Soviet nuclear organisational culture with inadequately trained personnel (World Nuclear Association 2016) which undermined the importance of nuclear safety. The Indian establishment also dismissed a possibility of Chernobyl type accident happening in India as they believe that its organisational safety culture is much more robust and also because Chernobyl was more of a 'man-made' disaster. The Indian nuclear establishment also dismissed Chernobyl type incident in India primarily in the belief that Indian safety culture is much more robust and Chernobyl was more of a 'man-made' disaster. Operators had inadequate information about reactor designs and thus were not fully aware of contingencies (Schmid 2011). This confidence, however, was seriously undermined with the occurrence of Fukushima disaster in 2011 in an advance country like Japan.

The Fukushima reactors were boiling light-water reactors (little different design than the TMI boiling light-water reactors). As per the design-basis, the plant walls were capable of resisting up to 5.7-meter-high waves (The IAEA Mission Report 2011). The Tsunami caused waves over 14-meter-high, something which belied the calculations of Fukushima reactors designs. The Earthquake caused an external power cut resulting into station black-out. Flooding damaged the emergency diesel generators. Without electricity, adequate water to cool down the reactors could not be provided and due to over-heating, the reactor core melted down and hydrogen explosions occurred. Fortunately, the plant maintained the structural integrity despite the earthquake and the reactor could be shutdown (Jain et al. 2013).

The Fukushima accident became a nightmare for several reasons. Though there was no death reported because of the radioactivity unlike Chernobyl, two workers died because of flooding in the power plant though. Several reports argued that the radioactive contamination did spread over long distances all the way to Europe and America. Also, Japan is widely acclaimed for its professionalism and technical advancement. A nuclear disaster of this scale has created an overall pessimism towards nuclear energy projects in general. A BBC survey conducted post- Fukushima among 23 countries between July and September 2011, involving a sample size of 23,231, demonstrated that 71% people were opposed to building new reactors. While 39% said that the government should harness energy from the existing ones, it should not build new reactors. 30% opined that the operating plants should be closed down as soon as possible. Around 22% respondents agreed that nuclear power was relatively safe and more nuclear power plants should be built. Among the countries with nuclear energy programmes, except in UK and USA, people are more opposed to it than they were in 2005 survey (Black 2011).

In India with a sample size of 1254 (third highest sample size, unweighted), opinion seemed divided. While 23% respondents (10-point drop from the previous survey in 2005) favoured building more nuclear infrastructure, 21% argued that nuclear energy is dangerous and nuclear plants should be closed. Nearly 40% of the respondents remained ambiguous in their opinion. India was the only country in the survey to have such a divided opinion among the range of countries with active nuclear power plants (BBC World Service 2011).

Growing demands for energy, however, especially in the newly emerging countries along with a focus on creating 'clean' sources of energy keeping in mind the threat of climate change has led to a positive momentum towards creation of safer and cheaper nuclear energy. The efforts to make nuclear energy competitive with other conventional sources of energy are rooted in the belief of a 'nuclear renaissance'. However, costs kept on increasing with the addition of more safety features and regulatory requirements.

The overall public opinion, however, does not reflect the policy position of respective governments. Some European countries like Germany, Switzerland and Italy have decided to not have new nuclear reactors; Germany and Switzerland are also phasing out the existing plants. Austria, Sweden, Belgium and Spain too are reconsidering to curtail their nuclear energy generation programme.[46] Many others are considering a phase out and evaluating their options. US has not build any nuclear reactor for power since 1979 but the existing ones run for 40 years, some being extended to even 60 years of operational life. Overall, the western countries are primarily curtailing their consumption of nuclear energy. There are, however, concerns in certain quarters to re-vitalize the nuclear energy expansion to reduce carbon foot-prints (Srinivasan, M.R. (2016) quoted in IANS (2016). However, Asian economies like India, China etc. have decided to carry out their nuclear energy programme and expand it in due course to meet their huge energy requirements (World Nuclear Association 2017). European countries are not as dependent on nuclear energy as many of the developing countries. They are connected to electrical grids of neighbouring countries enabling import unlike the Asian countries (Ghosal 2011).

Safety risks undermine the insurability of nuclear industry. Fukushima damage costs soared beyond 250 billion dollars, bankrupting the TEPCO, which was the fourth largest utility in nuclear industry (Cooper 2011). Also, in nuclear discourse, liability is mostly exclusively associated with the operator making him/her vulnerable to bankruptcy owing to a crisis.

The IAEA's role in nuclear safety regulation has mostly been of setting standards and aiding the states in improving their nuclear safety credentials. Despite the coming into force of the twin conventions in 1986, the agency's role remained primarily limited. The IAEA neither conducted any enquiry into the incident nor communicated with the

[46]Merkel initially declared phasing out nuclear energy plants, then suspended the decision and again oscillated to phasing out.

member states regarding the exact events that transpired on an immediate basis. The press conference was held 3-days later but most of the information was based on what the Japanese government provided, which was already undermining the situation and trying to downplay the ill-consequences of the accident. However, after IAEA Director's visit and meeting with Japanese prime minister, a senior agency official was deployed in Fukushima to coordinate assistance activities. Japanese authorities designated two IAEA liaison officers to work closely with NISA (Japanese national regulator) and agency's radiation monitoring team started sending several relevant information close to Fukushima site to Vienna (Amano 2011).

On March 15, it established a Fukushima Action Coordination Team to ensure inter-departmental coordination and organised two support teams for nuclear safety and radiological consequences (IAEA 2011b). Japan, in compliance with the CENNA, did notify the IAEA about Fukushima disaster within two hours of the accident. However, some of the initial inaccurate information that was conveyed, further tarnished the agency's image which looked ill-informed. The agency worked in a restrained manner and did not seek to release the independent information related to the crisis without first seeking approval from the Japanese government (Findlay 2012). IAEA DG Amano also admitted that IAEA's responsibility to provide authoritative and validated information quickly was limited in the then prevailing arrangement (Amano 2011).

Fukushima, therefore, also highlighted the inadequacy and ineffectiveness of the IAEA. It remains unclear if the IAEA can conduct independent investigation after a crisis (cross-check). IAEA's safety mandate is limited even by its own admission. The IAEA's Director General himself stated a few days later (March 21, 2011),

> ..we are not a "nuclear safety watchdog" and that responsibility for nuclear safety lies with our member states. The IAEA acts as a hub for international cooperation, heloing to establish safety standards and providing expert advice on best practice. But, in contrast to the Agency's role in nuclear non-proliferation, nuclear safety measures are applied voluntarily by each individual country and our role is supportive (Amano 2011).

Despite all the limitations, however, the IAEA sprang into action and provided a lot of help and expertise to Japanese government in dealing with the crisis. The Action Plan formulated by the Ministerial Conference on Nuclear Safety from 20th to 24th June 2011 convened by the IAEA deliberated on measures to improve the nuclear safety credentials of member states. Despite the IAEA's consistent efforts in the field, the agency's powers to command compliance from the member states were not increased. Most of the international gatherings organised around the theme of Fukushima disaster recognized the contributions of IAEA and its role in strengthening nuclear safety (Findlay 2012). The IAEA conducted over 30 peer review missions between March 2011 and March 2012 (IAEA 2012b).

Post- Fukushima, major intellectual inputs were offered to strengthen the international nuclear safety regulation. Following are some of the measures proposed and followed in due course of time (IAEA 2011c):

- Yukiya Amano, the Director General (DG) of IAEA announced that the standards would be revised and strengthened as the existing ones seemed inadequate.
- The post-Fukushima Action Plan directed the Integrated Nuclear Infrastructure Review Services to incorporate the lessons learned from Fukushima in revising the guidelines for national power national infrastructure evaluation methodology. However, it did not talk about strengthening the Review Services or making them mandatory for the member states.
- The member states were asked to "undertake a national assessment of the design of nuclear power plants against site specific extreme natural hazards and to implement the necessary corrective actions in a timely manner" (IAEA 2011c: 2). On the request of the member states, the IAEA Secretariat developed a Methodology for member states to assess the safety vulnerabilities of NPPs against site specific extreme natural hazards, which was released on November 16, 2011. The Agency also, offered to provide assistance and support and to organise peer reviews of national assessments if warranted by the states. European Commission asked the member states to conduct the "stress tests" to gauge the safety standards of their nuclear facilities.[47]
- The Action plan originally recommended random and regular hosting of the OSART missions spread over three years covering one-tenth of the reactors and voluntary peer-reviews. This, one of the most contentious provision, was toned

[47]There is no objective way to assess the safety preparedness especially for beyond-design threats. Stress tests, however, refer to making an assessment about national system's capability to remain 'stable under the most unfavourable NPP conditions and give an understanding of the potential vulnerabilities and the ways to resolve them (Kutkov and Kachenko 2017).

down and the action plan eventually recommended that all the states with nuclear power plants should host at least one OSART during the next 3 years, starting with the older plants. Therefore, even after the Fukushima disaster, support for effective international regulation was limited.

- It directed the IAEA Secretariat to strengthen cooperation with World Association of Nuclear Operator (WANO) through an amendment of the Memorandum of Understanding (MoU) to enhance information exchange related to operational experience and safety and engineering areas. The DG Amano invited WANO as an ‘observer’ in the meetings of Nuclear Safety Standards Committee and requested it to offer its inputs.
- The Secretariat was directed to carry out comprehensive assessments of national regulations in congruence with IAEA Safety Standards under the Integrated Regulatory Review Service. The member states with nuclear power were directed to ‘voluntarily host’ IRRS missions on a ‘regular basis’ and conduct a follow-up mission within three years.

The Post- Fukushima Action plan encourages and recommends the states to conduct national emergency preparedness reviews and ‘request’ the IAEA reviews thereafter through EPREV missions (IAEA 2011b).

Post-Fukushima, the WANO decided to conduct peer-reviews every four years, with a follow-up at the two-year point.[48] The INPO brought out a special report on the lessons learnt from Fukushima crisis including measures accounting for unexpected crisis, operational and accident response, design and equipment, knowledge and skills, operating experiences etc. (The Institute of nuclear Power Operation 2012).

The 2012 meeting of the CNS parties too decided to cover additional safety issues related to specific design, operational and organisational issues keeping in view the lessons from Fukushima. These were included as additional issue areas that future CNS reviews were mandated to cover. These pertained to design features to avoid long-term offsite contamination, emergency preparedness enhancement measures and others along with

[48]The WANO was established in the 1989, post-Chernobyl, and has conducted more than 500 peer reviews in 31 countries/ areas with at least one review in every member state. http://www.wano.info/en-gb/programmes/peerreviews.

ensuring an “effective independence of the regulatory body from undue influence” (World Nuclear Association 2018).

Many observers, including the Independent Commission constituted by the National Diet of Japan (2012), believed that Fukushima was partially a result of ‘revolving door’ phenomenon in Japan where the collusion between the utility and the regulatory authority compromised the safety preparedness. The commission criticized the utility TEPCO for arbitrary interpretation and faulty probabilistic approach to the probability of a Tsunami to avoid adopting counter-measures. This negligence proved to be a dire mistake in the course of time (Kurokawa 2012).

Fukushima like most of the other nuclear crises events resulted because of a few common factors like faulty design, insufficient backup system, human error, inadequate contingency plans and poor communications. Cooper points out the following similarities between the TMI and Fukushima crisis: “failure of voluntary, self-regulation; denial of the reality of risk; lack of safety culture; lack of a comprehensive; consistent regulatory framework; the challenge of continuous change and the failure to resolve outstanding safety issues; failure to require existing reactors to add safety measures because of cost and complexity and confusion and chaos in response to a severe accident” (Cooper 2011: 2).

Indian Establishment in Responses to Fukushima

Indian nuclear establishment, at first, was dismissive of Fukushima being a nuclear disaster in the first place. S.K. Jain, the chairman of the NPCIL said,

> There is no nuclear accident or incident in the Japan’s Fukushima plants. It is a well-planned emergency preparedness programme which the nuclear operators of the Tokyo Electric Power Company are carrying out to contain the residual heat after the plants had an automatic shutdown following a major earthquake (ITGD Bureau 2011).

Srikumar Banerjee (2011), the then chairman AEC too underestimated the seriousness of problem. He argued that quenching out residual heat once the power plant could shut down was the appropriate way out and Japanese were doing it. However, this proved much difficult to carry out as the core meltdown had already happened. He further opined that,

> .. [b]ecause of the unprecedented tsunami, the external power was unavailable for the emergency diesel generators to take over…during the process the pressure was building up in the reactor which had to be released in a phased manner which resulted in the exothermic reaction due to hydrogen generation… *It was purely a chemical reaction and not a nuclear emergency as described by some sections of media (emphasis added)* (Special Correspondent 2011).

He also dismissed the fear of increased level of radioactivity in the vicinity of the plant. Such an understanding of the disaster proved misleading and inaccurate subsequently. Steam generated during the vent off was rich with radioactive isotopes like Caesium-137, Iodine-131 and Strontium-90 (Bidwai 2011). The Japanese government itself distributed iodine tablets to mitigate the ill effects of iodine radiation and prevent the occurrence of thyroidism in the affected population subsequently.

Banerjee, agreed that the Himalayan region may be rigged with an earthquake as severe as experienced in Fukushima but also emphasized that geotectonic investigation and seismic study reports are considered before the construction work for plants start. Except Narora power plant in Uttar Pradesh, which is in zone 4, all other plants are in the seismic zone 2 or 3. So, the Indian plants are relatively safe unlike Fukushima, which fell in zone 5, making them vulnerable to severe earthquakes (Gupta et al. 2011).

In contrast to the boiling water technology deployed in Fukushima plants, most of the Indian plants are based on heavy water technology, which is apparently easier to manage as pointed out by P. Ravindra Reddy, chairman of MTAR technologies and supplier of certain components to the NPCIL (Gupta et al. 2011). Safety consideration in this technical sense, however has not constrained Indian purchase of several BWRs from abroad. It is easier to build high capacity reactors of larger magnitude in case of BWRs than the PHWRs.

In another interview to the NDTV (2011), the AEC chairperson informed that Indian reactors are equipped with passive means to ensure removal of decay heat. This would not require any thermal back-up failure of the kind which resulted in Fukushima disaster.[49] He expressed faith in the annual exercises that are being conducted as part of emergency

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[49]Even the reactor at Unit-1 at Fukushima plant was equipped with a passive thermal siphoning mechanism. It used an outmoded isolation condenser which is considered as the last resort for enabling natural circulation. However, with the power failure, the isolation condenser valves remained almost completely closed curtailing the flow of steam and water. This therefore proved a faulty mechanism to blow off the residual heat. Documentary 2016/ World’s Worst Nuclear Disaster. Available on https://www.youtube.com/watch?v=xFxVd2tO-II&t=1648s at 18:15 interval.

preparedness in case of crisis events involving coordination between various authorities like National Disaster Management Authority (NDMA), district administration, emergency management team and crisis management team etc. The disaster preparedness, in India, however, has been in question for being ineffective and formal (Gupta et al. 2011). Ramana, (2009) argued that many emergency preparedness exercises conducted as part of the regulatory requirement in India demonstrated several deficiencies and lack of infrastructure. A DAE personnel acknowledged on the condition of anonymity that infrastructural requirement at some of the sites for the purposes of emergency preparedness have not been adequate. The efforts to streamline all the sites are on-going though. One of the reasons for undermining confidence in such exercise is the poor state of public infrastructure like roads, in the first place. For example, the road between Kaiga and Karwar is so shallow and broken that the vehicles carrying spent fuel and radioactive wastes met with accident around thrice over the years, the latest being in January 2018 (TNN 2018). Fortunately, the truck was empty.

Banerjee argued that Fukushima was 'less of a quake problem, much more a Japanese problem'. Japan's failure to consider grid failure as an exigency was a serious fault in their emergency preparedness. In case of India, power failure is an ordinary problem and therefore, a situation thought and planned for. He also argued that Indian engineers and scientists have different external 'coupling' mechanisms to ensure the required cooling off of the fuel rods. He did not detail the specifics though (Bagchi 2012). Such an attitude has also been a constant response of the Indian nuclear establishment in response to the international crisis events. Having operated for several successful reactor years without an accident beyond the INES level 3, is often highlighted by the spokespersons and proponents of the establishment. In another interview with The Tribune's Editor-in-chief (2011), Banerjee waved off the possibility of a Fukushima like event by highlighting the fact that Indian programme have 335 reactor years of successful operation without any major accident ever.[50]

The official Indian response to Fukushima reflects that the initial assessment of the disaster was misconceived. Severity of accident was underestimated. Their public communication emphasized that there had not been any on-site death due to radioactivity.

[50]Even the fire in Narora power plant was in a non-nuclear turbine section and did not cause any radioactive release and contained successfully.

However, such a position is unnerving normatively and problematic factually. Impact of radioactivity cannot be deciphered immediately after the accident and results become visible over time. Also, assessment of radioactivity leakage immediately after accident would not be a sensible proposition as the radioactive core needs to cool down first to enable investigation. The Three Mile accident with comparatively lesser severity than Fukushima could be properly evaluated only when sufficient access to the core could be obtained after the core shutdown. Fukushima was worse off. Not only the four reactor cores were exposed, but also the spent fuel, making it more difficult to access the site and analyse it objectively.

While the public opinion is mixed about the safety of nuclear infrastructure and indispensability of nuclear energy for India, the official (political) response has been clearly in the favour of not only continuity but also expansion of nuclear energy projects.

In response to the Fukushima accident, Manmohan Singh government directed the nuclear establishment to conduct reviews of nuclear power plants and provide for any inadequacy in safety regulation and compliance. Responding to the question of a phasing out of nuclear energy owing to its risky nature, both Jain and Banerjee argued that Indian reactors were fail-safe and India will continue its civilian nuclear power programme without compromising on the safety parameters. The AEC and DAE had already declared the failsafe and robust nature of Indian civilian facilities warding off any scope for mishaps and accidents. However, following the top orders, the establishment conducted ‘thorough reviews of nuclear plants’.

The NPCIL, AERB and BARC, conducted separate investigations and the reports were analysed. 6 task-forces constituted by the NPCIL reviewed the safety status of Indian NPPs depending on the kind of reactors. The two boiling water reactors at Tarapur, of 160 MWe each, were analysed by a separate committee and specific recommendations were given, implementation of some of which required AERB’s approval. These reactors are the oldest operating power reactors and despite operating for around 40 years, are still being operated as several of its systems have been replaced by more modern components (Sinha 2017). The remaining 18 reactors were grouped into three categories as a) Pressurized Heavy Water Reactors (PHWRs) at RAPS 1 &2; b) PHWRs at MAPS 1 & 2; and c) Standard PHWRs from NAPS onwards. Later 2 more task forces were constituted (one for the VVER at Kudankulam plant, and the other for 700 MWe PHWRs at KAPP

3& 4 and RAPP 7 & 8) to assess the safety credentials of under construction power plants. The recommendations were complied with as it appears in the implementation report of the NPCIL. The NPCIL also constituted six task forces to review the safety credentials of the power plants depending on the kind of reactors.

These safety reviews covered the 20 civilian NPPs but the military and research reactors remained unaccounted for. One of the major take away of reviews was to assess the designs of existing plants for their robustness against site-specific extreme events of natural hazards and implementation of measures to do so. Another idea was to revise the design requirement and specifications in the initial stages to accommodate for in-built safety mechanisms against those hazards. In general, the Fukushima crisis, prompted the need for creating 'beyond design' measures while preparing for natural events threat management with greater margins than ever (Chetal 2018).

After Fukushima, AERB provisioned specific reviews to assure mechanisms for uninterrupted cooling of the core. All power plants were required to protect the emergency power supply system sufficiently well, to assure availability of electrical power for several days to maintain operation of safety systems. Besides, capability in DAE was developed and tested for immediate forecast of direction and level of dispersion of any released radioactive materials on the basis of meteorological observations at the site and nearby stations of IMD (Krishnan 2017).

An in-house cell was established by the AERB to regularly monitor the progress on events and maintain a close vigil on the radiological status. Data from IERMON stations of India were provided to AERB. Periodic updates were provided by AERB on its websites on a daily basis to keep the public informed on the radiological status. Subsequently, AERB established its own Nuclear and Radiological Emergency Monitoring Cell with monitoring and communication infrastructure to independently assess the situation during crisis time and inform public. It also constituted a high-level task force under the Chairmanship of Shri S.K. Sharma, former Chairman, AERB for safety assessment of Indian nuclear power plants under extreme external events (Sundararajan et al. 2008).

Overall, post-Fukushima, 47 regulatory inspections (25 scheduled and 22 special inspections) were carried out by the AERB in 2011-12 and pointed out numerous safety design and support systems shortcomings (Jog 2012). While the reports assessed that design basis safety features in Indian reactors were adequate, several measures pertaining to the same were proposed. Post crisis reports have often presented this paradox in Indian case.

The Indian establishment meticulously conducted several safety reviews of the operating reactors and carried out several short-term to long-term recommendations to strengthen the safety credentials including allocation of additional emergency diesel generators at higher elevation in case of a flood, additional air-compressors at higher elevation for supplying instrument air to critical valves and dampers, seismic strengthening of additional water storage tanks and so on (Sinha 2015).

India, in compliance with Post-Fukushima action plan of the IAEA, invited the OSART review at Rajasthan in November 2012 and a follow-up in February 2014. On the side-line, India asked for ‘enhanced security measures’ for the Kudankulam reactor that was being supplied by Russia. The latter on receipt of additional payments added the safety measures of the fourth-generation reactors to the third and fourth units of the Kudankulam plant. These measures included double containment and protection building, passive system for fast injection of high pressure boron, a molten core-catcher among others.[51]

Questions raised on the autonomy of nuclear regulatory agencies in wake of Fukushima, led to a renewed emphasis on bringing about legal reforms in the institutional structure of the Indian nuclear regulatory body. Replying to the question of autonomy of AERB, the then AEC chairperson, Srikumar Banerjee (2011) mentioned that although AERB is independent, there are further steps being taken to ensure its autonomy by making it a statutory body which would enable it to broaden its activity, extend its collaboration with technical expertise from different organisations and to revise the reporting structure to make AERB answerable to a body outside the AEC’s ambit. The NSRA was hailed as a major step in that direction. But over and above the shortcomings of the bill, it could not be passed by the then parliament and lapsed. These aspects had been discussed in detail in the previous chapter.

[51]It’s a unique Russian advance. It is a “container below the bottom of a reactor vessel. In case of hypothetical accident, the ‘core catcher’ will be able to contain liquid and hard fragments of nuclear reactor core and parts of materials of which the reactor has been constructed; this prevents damage to containment building and escape of radioactive materials” in case of a core meltdown. CAPS (2015), “Russia to Provide Safety Solutions for KKNPP 3& 4”, Nuclear Security, 9 (6).

Overall, though undermined initially, the AERB and DAE in general realized the seriousness of Fukushima disaster and carried out three safety preparedness reviews keeping in mind 'beyond-design basis' threats. These reports remain confidential but official reports have claimed compliance with proposed measures. One of the major response to Fukushima was intensified public debate demanding regulatory reforms which were initiated in the forms of NSRA bill but could not be converted into policy actions. Even when the disaster did not happen in India, it was cited by the DAE as one of the official rational for introduction of the NSRA bill.

Another international crisis event, of lesser intensity than the three mentioned above, and studied by Indian nuclear establishment was nuclear fuel processing facility at Toki-mura, Japan in 1999. It, however, was not a commercial facility but a fuel preparation plant for an experimental reactor. There the workers added "16 kg of enriched uranium containing 18.8% of uranium-235, in a single tank, instead of the 2.4 kg" which was the maximum permissible amount, in violation of the standard procedures (Sundararajan et al. 2008: 120). This led to severe radioactivity exposure and death of a worker. SARCOP analysed this incident and reviewed Indian nuclear facilities especially the fuel fabrication and spent fuel facilities. It concluded that Indian plants had conservative designs with respect to the achievement of criticality allowing adequate safety margins during operations. The personnel were duly trained and authorized as per standard procedures. As additional precautions, however, it directed those facilities to "carry out a formal review of the design, procedures, internal audits, documentation, training and administrative controls to ensure criticality safety of the plant" (Sundararajan et al. 2008: 121).

The emphasis on Indian nuclear establishment 'doing something' in the wake of a crisis abroad, also has been questioned at times. Mishra (2012) cautions that

> India must not fall into *over-concerned parallelism syndrome.* Each time a problem related to nuclear technology takes place anywhere, a section of the public draws baseless parallels to India's programme. They tend to forget that nuclear risks, to a great extent, are location-, and technology-specific (Mishra 2012: 110).

While a crisis situation anywhere may escalate general paranoia about safety associated with nuclear energy programme, there are always lessons to be learnt which can come handy in efforts at preventing such incidents from taking place in the first place. At the same time, complacency within nuclear establishment employees with respect to their professional competence and credibility can be risky too. A myth about 'absolute safety' of nuclear reactors (Funabashi and Kitazawa 2012) and over-simplistic understanding of 'nuclear safety culture' (Suzuki 2014) along with regulatory capture were later accepted as one of the important reasons for Fukushima. These lessons, irrespective of location of nuclear reactors, are useful reminders for nuclear regulators to continuously assess and review not only industry's performance but also their own credibility with respect to such assessment.

Despite the ill-consequences, crisis events serve as a useful reminder of the ever-inadequate preparedness to avert the disaster. They also create awareness about the complex interplay of technological systems which may result into a severe accident. Crisis learning in nuclear field can reflect both the divergent trends with respect to nuclear energy projects. As the BBC poll post-Fukushima suggested, public opinion has been more focused on the inevitability of accidents and therefore a reluctance to support any further expansion of nuclear energy programmes. However, even the public opinion is not uniform and varies both at the inter-state and intra-state levels.

Overall, the section observes that crisis-learning in Indian nuclear establishment with respect to major accidents has focussed more on the tactical and technological aspects of the crisis learning where focus is on developing safe, viable and quick solutions for the technological mishap that may create a crisis in the first place. This kind of learning is more about technological fixes and rigorous regulatory procedures to be adopted. India, also has kept pace with crisis-learning at the IAEA level in terms of adoption of new standard practices, technological innovations and reactor designing. It also complied with reviews and reporting systems recommended by the IAEA. However, such learning and improvisations have not altered basic organisational philosophy and/or structure of the regulatory body per se.

Having discussed major nuclear accidents around the world and response of Indian regulatory regime to these events, the next section is going to discuss some of the more aggressive crises situations that occurred in Indian nuclear reactors/plants.

4.4. Safety-related Incidents in India

In India, fortunately there has been no major crisis *accident* (as defined by the INES scale) relating to radioactive release. There have been few minor incidents over the years but radioactivity released remained limited in effect and spatial spread. The highest crisis magnitude reached was level 3 at the international nuclear event scale which was Narora plant fire. There have been a few incidents of limited consequences over the years, some of which remain unacknowledged by the AERB and the DAE (discussed later in the chapter). They acknowledged a few minor incidents and near-miss accidental cases and appropriate mechanisms were introduced to resolve the inadequacy. For instance, the establishment itself acknowledged that the TAPS had radioactive exposures exceeding the safe limits set up by the SRC. The 1977-79 period saw TAPS annual collective dose reaching 5000 man-rem while the prescribed dose was 1000 man-rem (Sundararajan et al. 2008).

Following are some of the relatively major crisis events that happened domestically along with the consequential action taken measures.

Fire at the Narora Power Plant

The fire in the turbine section caused station blackout for 17 hours in March 1993. Two blades in the turbine generator of the Unit-I broke down due to accumulated stress. They sliced through other 16 blades, leading to a destabilisation of the rotor system and causing excessive vibration. The pipes carrying hydrogen gas busted and caused fire (Sunadrarajan et al. 2008).

The cables of 4 power supply systems, being fire non-resistant were burnt causing the loss of back-ups in emergency and a station blackout within just 6 minutes of the fire. Fortunately, safety mechanisms worked properly and the two reactors automatically tripped. Crash cooling was initiated to cause rapid heat dissipation. In a brave and fortunate act, some men climbed to the top of the rector building to open valves so that boron could be released. Full power was restored 17 hours later. The nuclear establishment played down the criticality of the disaster and rejoiced the fact that there was no radioactive release and the reactor system shutdown automatically. The incident, however, was avoidable if the operator and the AERB had taken enough precautions. It was reported that the UK based General Electric (GE), which transferred the turbine blade technology to the BHEL, had informed of such possibilities in 1989. It also suggested design modifications for the blades that had operated for more than 10,000 cycles. Unit-I at Narora had completed 16,251 cycles (Subbarao 1998). The Indian manufacturer even prepared the detailed drawings for fabrication and supply of the new blades but the DAE ignored the suggestions (Subbarao 1998; Panneerselvan 1999). "It was a case of callous management. At other plants, the blades were cracking exactly at the same point as in. MAPS-1" (Gopalakrishnan quoted in Panneerselvan 1999).

As the defence-in-depth of the engineered safety features degraded in the event, it was rated at level-3 on the INES (Sundararajan et al. 2008). The accident could have been more disastrous had it not been for the courageous workers who climbed up the dome to release the valves manually.

This incident, however, acted as an eye opener for the establishment. Prior to this event, the plant inspections were conducted as per the need basis, especially after a complexity arose (Mishra 2017). NAPS investigation brought to the light the fact that certain design reviews, especially those related to cable routing, were carried out before the incident but were not fully implemented by the operator. A special group, the Directorate of Regulatory Inspection & Enforcement was created within the AERB to carry out regular and periodic regulatory inspections of nuclear facilities.

An investigation led by S. K. Mehta (the then director reactor group BARC), submitted the findings and recommendations which led to a review of all the NPPs in operation then. Immediate inspection of all the turbines in other plants too was taken up and indeed cracks were found in the blade roots of the MAPS units. The incidents also prompted the initiation of the practice of the Safety Assessment Report for Renewal of Authorization review for operating nuclear power plants. A multi-tier review mechanism too was started since this time. The committee cited various incompetence and offered technical suggestions: In terms of technical learning, some of the safety improvements were proposed (Sundararajan et al. 2008: 36-37):

a) Incorporation of the Gravity Addition of Boron System for meeting the requirement of sub-criticality margin during station black-out condition.
b) Provisions for reactor trip on 'low coolant flow in adjuster rods'; 'more than one rod of primary shutdown system not in parked position' and 'no primary coolant pump/shut down cooling pump running'.
c) Provision for reducing compressed air ingress into boxed up containment.
d) Incorporation of seismic monitors and seismic trips.
e) Programme for monitoring of garter springs position and their relocation in case of displacement.

f) A sequential loading scheme for emergency power supply was evolved.

g) Neutron shielding for the fuelling machine maintenance area was augmented through thermal neutron absorber materials on roll-on shields.

h) Design provision was formulated for purification of the moderator under reactor shutdown, using boron saturated ion exchange columns.

Many of these provisions were later incorporated as standard design features for the future reactors as well. The AERB realized the need for inspecting the roots of the turbine blades and allowed the NPCIL to shut down the reactors sequentially and not simultaneously for inspections (Parthasarthy 2013). The extensive review resulted in design modifications of several systems, cabling routes, ventilation systems etc in other reactor units as well – principally for ensuring that the control room remains habitable in any kind of fire accident and to prevent fire in turbine area from affecting cables leading to and from control room.

Narora plant fire, therefore, resulted into several novel practices and mechanisms to ensure advance detection of faulty technical systems. It also helped institutionalize routine inspections of NPPs by the AERB. This, however, has not made the system full-proof and other incidents happened post-Narora, though at different plant sites. One of such event relates to dome collapse at Kaiga power plant which will be discussed next.

Dome-Collapse at the Kaiga Power Plant

During the construction phase in 1994, the dome of the unit-I of Kaiga plant collapsed and about 130 tons of concrete fell from a height of nearly 30m. Official resources blame it on design faults (Sundararajan et al. 2008) while independent researchers hinted at other reasons like “poor design, substandard material, defective workmanship or a combination of all the three” (Havanur 1994a: 3). Since access to site remained restricted and review reports were not made public, it is difficult to identify exact cause of the incident.

Fortunately, this accident did not happen during an operational environment, else it could have been disastrous. The investigation reports of both the NPCIL and the AERB concluded that it was an industrial accident without any release of radioactivity. In this case, the AERB directive “to carry out an integrated ECCS testing in Kaiga- 1 and 2 and RAPS- 3 and 4 and proof and leakage tests on the reactor containment” before the start up were ignored (Panneerselvan 1999). The V.N. Gupchup (pro VC University of Bombay) committee was then constituted by the AERB. It recommended strict actions and the

NPCIL was directed to suspend "all civil construction activities related to the inner containment structures (wall and dome) of Kaiga Unit-2 and RAPP Units- 3&4". Unit-I construction work was also forbidden without acquiring the AERB clearance first for the same. Other construction however continued (Hanavur 1994b). Later, the committee proposed that the design be checked by independent peer consultants or in-house experts.

Flooding at the Kakrapar Power Plant

A heavy rain for about 15 hours flooded the Kakrapar plants in 1994. The unit-I was in the temporary shutdown state while the unit-II was under commissioning (pre-operational phase). This shut down was prompted by detection of faulty blades at Narora plant fire. Idea was to replace the faulty turbine blades at kakrapar too but the shut-down was stretched beyond schedule (Gadekar 1994). This fortunate delay proved a boon as flooding during operations could have been much more disastrous. The turbine building basement got flooded along with pump house and cable tunnels leading to a malfunctioning of many safety mechanisms. Fortunately, it did not lead to any loss of life. Bathymetric studies of near shore regions were undertaken to assess tsunami intensity and inundation maps.

The NPCIL investigated the incident and its report was reviewed by the AERB. The flooding was attributed to "clogging of discharge sluice gates of the nearby Moticher lake into the Tapti river" (Sundararajan et al. 2008: 38). The subsequent actions focused on evolving adequate draining from the lake by the local authorities. This incident prompted a subsequent re-assessment of the flooding potential of the power plants and embankments were made around the safety infrastructure where desired. For instance, in RAPP-1 and 2, a 'flood' DG was installed at a higher elevation. The review also highlighted the importance of "continuous recirculation flow than the periodic ones in the Annulus Gas Monitoring System" (Sundararajan et al. 2008: 38). Measures also included proper action plan in case of a leakage in the coolant or the Calandria tubes

This is also noticeable that these three incidents which are considered as the most alarming safety crisis events in commercial plant sites in India were all reported during the AERB chairpersonship of Gopalakrishnan, who expressed deep reservations regarding the autonomy and functioning of the AERB. Information regarding disaster management plans, which involve public, too are not being provided under the official secret acts and concerns of national security. Even the Supreme Court dismissed the Public Interest Litigation demanding disclosure of such reports, while endorsing the view that the AERB review report citing major safety lacuna would reveal sensitive data to the ‘enemy’ (Jishnu 2011).

While these incidents happened during 1990s, the establishment has claimed of subsequent emergency preparedness and efficiency of review mechanisms in pointing out faults in advance (Bansal 2018, Bhardwaj 2018). This confidence, however, was somewhat shaken with a more recent event that occurred in 2010 at Mayapuri, Delhi and contributed significantly to the limited debate on effectiveness of AERB.

Mayapuri Radioactive Over-Exposure

Certain radioactive Cobalt-60 (emits gamma radiation, more harmful and long-ranged than alpha or beta radiation) from Chemistry department at the Delhi University, got into the scrap market of Mayapuri leading to radioactive overexposure of its handlers causing the death of one person and illness in many others. The IAEA called it “the most serious global instance of radiation exposure since 2006” (IAEA quoted in Mishra 2010b: 10). This imported material is supplied by the Board of Radiation and Isotope Technology and requires AERB consent for replacement. It is the responsibility of the supplier to return the defunct radioisotopes as per the end-user agreement.

This material was imported from the Canada before the AERB was formed and because of unmaintained inventory of these material, the AERB was not aware of their status (Rath 2018). The Directorate of Radiation Protection (DRP) placed under BARC before the establishment of the AERB was mandated to keep a tab on it. The poor management and upgradation of records while the transformation in 1983 while the AERB was established, resulted into poor implementation of safety directives.

After this incident, a number of preventive mechanisms to avoid recurrence of such event were taken. A committee involving G K Rath, a non-DAE member of the AERB board, along with the AERB personnel brought out a report recommending measures for safe uses of radioactive materials in the educational institutions. The University Grants Commission (UGC) approved the ‘UGC Guideline for Universities, research Institutes and Colleges for Procurement, Storage, Usage and Disposal of Radioactive and Other Hazardous Materials/Chemicals’ in 2010 (Grover 2014). The DAE on the other hand geared itself to prepare an inventory of such material as imported in the earlier decades. The Radiological Safety division (RSD) of the AERB carries out regulatory inspections of all non-DAE radiation facilities.

In November 2011, a proposal to provide mobile radiation detection systems (MRDS) to 800 police stations covering 80 cities was reported by PTI. These MRDSs were to be fitted to police vehicles to "detect and get al.erted in case a van approaches any radioactive source or a radiologically contaminated area or detects any radioactive source being transported" (PIB 2011). Concerns for radioactive safety after Mayapuri incident prompted this measure and was re-emphasized in the wake of nuclear and radiological terrorism around 2016 again. The implementation, however, was at snail pace and from 2016 to 2017, 5 batches of trained personnel were reported, that too not from all states and UTs (NDMA).

The CAG audit of the AERB in 2011 highlighted the lopsided nature of national nuclear discourse as one of the factors contributing to the negligence of radiological safety and security. Most of the scholars, media, scientific community and public focus on nuclear weapons and nuclear power plants, drawing wider government attention often leading to a neglect of radiological concerns (Mishra 2012).

Apart from these, the AERB annual reports and the silver jubilee publication narrate other minor incidents related to safety norms violations or radioactivity releases and the corresponding actions taken by the AERB including suspension of plant operation that were resumed only when several safety related modifications were incorporated, re-training and re-authorization of entire plant personnel were conducted and a thorough assessment of facility for safe operations were undertaken. Some of these include over-exposure incident at RAPP Cobalt facility at Rawatbhata in 1999; stoppage of operations in the wet section of New Uranium Oxide Fuel Plant at NFC in 2002 and so on (Sundararajan et al. 2008).

4.5. Critical Analysis of the Safety-related Organisational Learning

Crisis-learning over the studied period is discernible in the precautionary attitude and technological adjustments that have been made in the nuclear operations, design and emergency preparedness over the years. For instance, when Tsunami hit the Indian east coast in 2004, the Kalpakkam reactor automatically shut down and remained un-operational for three days. The establishment has time and again refuted the possibility of a potent Tsunami destructive enough to cause damage to the reactors. Banerjee, chairman AEC from 2009-2012 argued in an interview that security precautions along the Kalpakkam plant were strengthened. Later, Tsunami wall barrier structures and min-wave breakers were constructed to prevent floods (Chengappa 2011). In a similar instance, the NPCIL task force report recalls that the December 2006 earthquake did not cause any radioactive release as the safety features enabled a safe shutting down of the reactor and provisions of reactor cooling and isolation of containment were already met. The review however, recommended that early warning system for Tsunmai, and additional cooling water sources for longer duration cooling should be provisioned, which were acted upon by the NPCIL. The corrective measures were not implemented just at those reactor sites where minor incidents took place but also at other plants like Tarapur and Tamil Nadu (Chetal 2018). After the event, an assessment of height barriers for coastal plants was revised.

Crisis-learning is also discernible in the in-built design modifications in the newer reactors. The experimental Advanced Heavy Water Reactor (AHWR) which is being developed has been installed with passive safety features incorporated from the previous experiences with the major accidents that renewed the importance of nuclear safety time and again. The test reactor was specifically tested keeping in mind the lessons of previous three crisis events: Three-Mile Island, Chernobyl and Fukushima.

The extent of such learning, however, remains disputed. Gopalakrishnan (1996) has pointed out that as there have been multiple instances of fire in different facilities over the years, an absence of learning is discernible. There was a fire in the RAPS-2 caused by an overheated cable joint, ultimately disabling 4 out of 8 pumps. The 1991 fire in the KAPS-led to a complete loss of emergency diesel power. Even the D.C. power supply was partially lost. Many incidents remain un-reported or un-acknowledged by the DAE. Also, it is puzzling that despite the claims of remarkable safety culture and preparedness of the NPCIL, the regulatory body's audit always offered several recommendations for improving the same. After the Fukushima review, for instance, it said that a "continuous monitoring of healthiness and availability of seismic trips circuits did not exist" at the Narora power station 1 & 2. (Jog 2012). Officials, however, justify it on the grounds of being extra cautious and so the need for additionalities (Bansal 2017). Also, as most of the post crisis review reports remain confidential, there is no authentic way to know the credibility of safety robustness claims made by NPCIL and AERB. Havanur writing in relation to the nuclear establishment's claim about advantages of a double containment structure for nuclear safety observed, "Our own nucleocrats, true to their style, have never disclosed any meaningful information on reactor safety except for banal assurances of 'highest degree of safety' and 'defence in depth' (Havanur (1994b: 2).

In another article written in 2002, while reflecting upon the safety in DAE installations, he on the one hand, applauded the better credentials of Indian designed reactors (as compared to the collaborated reactors) developed after 1974 sanction but also on the other hand, highlighted that many of the safety issued highlighted in AERB review report of 1995 were already identified by the DAE in its own evaluations of 1979 (post-TMI) and 1986 (post-Chernobyl) as urgent but were not taken up even by 1995 (Gopalakrishnan 2002). Overall, while there appears a more emphasis on ensuring safety through in-built technological mechanism, crisis-learning in civilian operations remains limited on account of a stagnant organisational culture,

Also, safety related events at strategic facilities like BARC, reprocessing facilities and such, remain outside the AERB's purview. Many of the interviewees refused to acknowledge the occurrence of events that were not reported by the AERB. At times, the ranking of events by the AERB get questioned by independent experts, for instance, the heavy water pipe leakage at Kakrapar reactor in 2016 (Koshy 2016).[52] In sum, learning reported is bound to be positive as negative or non-learning is not acknowledged.

In many instances, critics have pointed out that the AERB's autonomy is questionable as its review recommendations are not implemented swiftly by the utility (Gopalakrishnan 1999). In terms of regulatory reviews recommendations, sometimes delay is caused as utility may have genuine reasons. Sometimes, some of the recommendations being based on short and immediate policy measures, are reversed or re-modified by the AERB personnel over time depending on the need for their implementation as sometimes

[52]The event was rated as level -1 which basically implies an anomaly in the plant. This, was however, contested by Gopalakrishnan, a former AERB chairperson who argued that the reports on quantum of leak were contested and the given rating could be a downplaying of the seriousness of the issue.

dynamic environment makes those measures redundant or requires different set of regulatory commands (Bansal 2017).

One cannot assume that all units will have 'perfect' safety credentials and preparedness, as the standards keep varying depending on a number of issues. The problem, however, is a sense of complacency and doctrinal faith in the establishment which places its own safety consciousness at a paramount level, despite evidences to the contrary. And while these evidences having being pointed out from independent research analysts have been discredited by the establishment, the safety suggestions of AERB after crisis events are seen as 'additional precautions'. There rarely has been an acknowledgement of systemic and regulatory problems from the official policy circles.

Nuclear and radiological safety is one of the most prime mandate of AERB as the official national nuclear regulator.[53] This clear identification of authority as it stands in safety credentials of civilian infrastructure, gets fuzzed in case of nuclear security. Characterized by involvement of a multitude of actors, security mandate remains more fragmented. This will be the subject matter of next section dealing with nuclear security management and regulation.

4.6. Nuclear Security Regulation and Organisational Learning in India

As laws and regulations dealing with nuclear security in India have already been discussed in chapter 2, this section will specifically focus on role of regulatory body and associated institutions that play a role in the same in India.

Occurrence of 9/11 as an unanticipated event, created a security psyche among the countries with respect to nuclear terrorism. 'Un-thinkable' could not be a luxurious category anymore. To prevent any such future eventuality, the USNRC asked its nuclear designers to come with designs that could stand a collision with civilian aircrafts. In the field of nuclear security, there has been a discernible shift from security of fissile material alone to that of nuclear plants, know-how and technology (Mishra 2017). The terror attack of 9/11 stimulated the idea that such an aerial attack on nuclear installations and facilities are possible and the idea may be lucrative to terrorists intending to create chaos and destruction. Such attacks can cause both the radioactive and the non-radioactive damages

[53]The AERB is mandated to monitor safety regulation not only in the nuclear (civilian) but also the radiological units. Both entirely come under AERB's mandate.

to the population and property. In case of India, the 9/11 prompted a reinvigoration of security arrangements to deal with aerial and cyber-attacks. To avert aerial attacks, no fly zones and anti-aircraft guns have been installed at nuclear plant sites. India and Pakistan since 1988 have a Confidence Building Mechanism to ensure non-attack on each other's nuclear installations. Since the time it came into force in 1991, there has been a sharing of list specifying the precise location of the nuclear facilities every year in case of a change.

Nuclear security learning in India has mostly been through observational analysis on the basis of information available through the IAEA and other international platforms. There has not been any significant security related incident in India but there were report of malicious intent and planning by the Al-Qaeda terror group to sabotage one or many nuclear facilities at different times. In 2009, the safety of the BARC at Trombay in Mumbai was stepped up in wake of intelligence reports warning terrorist attack on the facility to commemorate 26/11 anniversary. BARC being located near sea, the navy and coast guards also were deployed in the surveillance of the area along with army and CISF which are already deployed to protect the facility with the most strategic significance in the country (ET bureau 2009). Earlier in 2006 on the eve of Independence Day, the National Security Guards, the elite security force was deployed at the BARC for the first time because of intelligent reports indicating a possible terrorist attack on the facility (PTI 2006).

Along with threats of nuclear terrorism, other incentives for strengthening nuclear security preparedness came from the threats of nuclear smuggling. The world-over newly found interest in ensuring nuclear security as counter-proliferation measure finds reverberations in the Indian establishment as well which has also chosen to be a part of global terrorism prevention regimes and mechanisms. Such efforts have been discussed in the first chapter. There has not been any terrorist breach of such facilities in a significant manner though. The reports of smuggling of nuclear material, however, have been in news occasionally (NDTV 2016, Maryum 2018). The state police in Meghalaya in 2008 reported that it found a packet of powdered uranium with a printed inscription of the DAE, stolen by 5 men (Bhaumik 2008). The eventual confirmation by the UCIL state unit was not reported however. Interviewees blamed media for reporting without clear information. There also have been a few mysterious deaths of the nuclear personnel in the last decade. For instance, a KAPS staff, Loknath Mahalingam was found dead mysteriously in 2009. In

2010, a mechanical engineer of BARC was found murdered. The DAE, however, has not issued any reports on whether the murders concerned nuclear security or not. Also, nuclear security remains a highly classified agenda in the nuclear establishment. There is very little information-sharing even with the international agencies for the fear of information leakage, state prompted espionage and terrorism threats.

The NDMSs conceived after 2011, primarily because of radiological safety concerns, received additional push from the government as instruments for thwarting nuclear and radiological terrorist attempts as well by detecting unusual and illicit depository of radioactive sources at any location or in transport (Choudhury 2016, Chauhan 2016, Jog 2013). Union Home Ministry accorded this classified project a top priority in 2016 and training of police personnel in handling these devices were initiated by the NDMA (Chauhan 2016).

The relative disjuncture between the safety and security regimes in terms of robustness and extensiveness can also be explained in terms of crisis learning. As a response to three major nuclear safety incidents, there has been a corresponding learning in terms of crisis management and prevention in the safety domain. Not only new systems are more disaster proof, there is also learning in the field of disaster management once it occurs. Though the corresponding learning cannot be measured in absolute empirical terms, the non-repetition of similar safety related technical failures convey a sense of learning from previous crisis events, even if in a limited manner. In the case of nuclear security related incidents, though there have been some activities of theft, smuggling and sabotage, there has not been any major issue as of now, especially in India. Steinhausler's research cites a total of 17 security related incidents over a duration from 1972 to 2007, none of these have resulted into any radioactive release (Steinhausler 2008). As there have been fewer incidents and that too of limited promiscuity, the institutionalization of crisis learning in terms of regime formation is limited. There, is however, a culture of sharing the knowledge about best practices in the nuclear security domain as well.

4.7. Crisis- Learning in the Indian Nuclear Regulatory Regime: Institutional Manifestations

As creation of a new institution or institutional mechanism is considered a concrete and definite evidence of organisational learning (discussed in first section), this section will discuss additional specific regulatory mechanisms and practices that were created and have been institutionalized over a period to add to regulatory effectiveness.

There have been four major safety audits in India, one after the TMI in 1979 ordered by the P. M. Morarji Desai, then in 1986-87 after Chernobyl, in 1995 with the chairmanship of Gopalakrishnan and finally after the Fukushima incident in 2011. India signed the two international conventions relating to early notification of nuclear accidents and convention on assistance in cases of nuclear accidents or radiological emergency in 1986, right when they were proposed in 1986 after the Chernobyl incident.

By 1978, the forerunner of the AERB, the DAE-SRC had already created a format for reporting unusual occurrences known as Safety Related Unusual Occurrence Reports (SROUR), later renamed as Significant Event Reports (SER). It formulated a set of criteria to be applied uniformly with respect to the events that need to be reported and the details thereof. It also intended to gain the operating feedback to enable technical and institutional learning. The idea was to create an inventory or record of such events and disseminate this information to different units to enable learning. It created a computerized data bank of unusual occurrences and consequent SRC recommendations. This mechanism helped India in compiling data for the IAEA incident reporting System in 1984.

Based on the severity of the potential consequences, the AERB classifies nuclear power plant related emergencies into following categories: Emergency alert, plant emergency, site emergency and off-site emergency. The first three are contained within the plant boundary and do not involve local administrative authorities. Plant emergency is limited to a section of the plant and is to be handled by the operator which is supposed to have comprehensive emergency preparedness and response plans (EPR). Simulation exercises are carried out every quarter by each NPP to streamline response to such eventualities if they ever occur. A prior information is given to the AERB and it is up to the latter then to decide if it wants to observe the exercise (Bhardwaj 2018). The off-site emergency classification, however, is not in sync with the IAEA classification (IRRS 2015).

An off-site emergency involves the local district administration under the district collector for providing necessary infrastructure. The AERB is oblized to observe the off-site emergency exercises (which happen every two years) while its presence for other emergency exercises is not mandatory (Bhardwaj 2018). The review report is shared with the utility and the DM. The regulatory team also reports it to the AERB. These are mentioned in the annual reports. It is however duty of the utility to ensure that the follow up action of the district authority is ensured. While the AERB may suggest measures in such cases, it does not involve itself with the coordination with the local authorities (Sinha 2017, Bansal 2018). It, however, has power to review the progress made by the utility.

The IRRS team (2015) suggested that the emergency preparedness response (EPR) management should be equipped with full-time specialists and the current arrangement (at the time of review in 2015) with a total of 8-12 personnel assigning 30% of their time to it is inadequate. Also, the role of AERB in crisis situation is rather limited. As per Civil Liability for Nuclear Damage Act, AERB has to notify a nuclear incident after assessing the gravity of risk involved and ensure its wide publicity. For facilities which are not under the purview of AERB, the information of the incident will be communicated to AERB by DAE for notification. The IRRS team suggested that the regulatory presence on site during emergency could help in better assessment. At present, the assessment is done by the CMG-DAE (it has one AERB member) and the AERB then analyses the assessment of this body. Direct verification by the AERB, therefore, is undermined.

To strengthen the response force in the events of radiological emergency, the National Disaster Management Force has been trained to adopt and enforce quick and effective measures, the training isn't given by the AERB though. Nuclear and radiological events are one of the functional responsibilities of such forces. The DAE has set up 23 Emergency Response Centres (ERC) at various DAE sites including the NPP sites and radiation facilities, with the nodal ERC at the BARC (Press Information Bureau 2017). These centres manage responses to radioactive crisis events and maintain trained emergency response teams and radiation detection instruments and systems. The Emergency Response Teams (ERT) comprise of several specialized teams like the Aerial Survey Team, Field Monitoring Team and so on, with BARC being the nodal agency. In case of an event, first of all, a Quick Impact Assessment is made through the help of an Impact Assessment Software developed by the BARC (Mishra 2010b). The nearest ERT is activated by the CMG of the DAE, on receipt of confirmation. The CMG investigates the damages and coordinates between state and central agencies to generate an effective response to the crisis.

To deal with safety and security aspects of radiological hazards, the NDMA started training police personnel with NRDSs since 2016 as discussed earlier. The NDMAs attempts at containing or preventing radiological hazards through NRDSs also get coordinated help from trained experts with specialized facilities of the DAE and national disaster response force stations (Choudhury 2016).

The IRRS 2015 mission suggested that the AERB “should consider including in its process on managing regulatory and operating experience the feedback on measures taken in response to internationally reported events” (IRRS Report 2015: 19). This would help in ensuring greater transparency and feedback learning among the regulators worldwide. The demand for autonomy of the regulatory body appears more pertinent in the sense that the AERB’s legal mandate is quite restricted in the first place (primarily safety) and on top of that, structural organisation and limited legal options further constrain its authority in nuclear security related matters.

The NSRA bill, the draft of which was prepared by the DAE in 2011, mentioned that the two incidents namely Fukushima disaster and Mayapuri radioactive exposure acted as the factors that acted as the precursors for the urgency to strengthen the AERB as national nuclear regulator. The DAE has always emphasized that the AERB is sufficiently autonomous to perform its functions independently and effectively. Even after the CAG and Public Accounts Committee criticized the subordinate status and ineffective functioning of the AERB as a body under the command of the DAE, the latter has always been defensive about its claim of AERB’s autonomy. These two events, however, forced it to work towards its public image, which could be reformed by the reform bill. These aspects were dealt with in the previous chapter in detail.

An unavoidable consequence of crisis-learning has been witnessed in the over-all shoot up in the costs of reactor production. The DAE and the AERB seem to follow a preventive approach in regulation. Each of the major nuclear crisis event led to a re-evaluation of the prevailing safety standards and technical innovation in ‘back-fitting’ or new designs subsequently. As a result of this re-designing after every crisis, costs of the new reactor designs have gone up time and again, because of heightened expenses on additional safety mechanisms and increased construction time.

Conclusion

In sum, this chapter attempted to understand the role of ‘crisis’ as a driver of organisational change particularly in the case of the Indian nuclear regulatory body, the AERB. In doing so, it outlined conceptual debates related to nature of an organisational change. It argues that while crisis learning as a factor of change can occur at both superficial and fundamental levels, in case of Indian nuclear regulatory progression, it has remained mostly at the procedural and technical levels. The chapter provided empirical evidence to this effect through the study of post-crisis responses of Indian nuclear establishment. It has also attempted to identify organisational learning through the creation of new institutions and institutionalized practices in the realm of regulation because of major crisis events.

As the study focussed on ‘what was done post-a-certain crisis event, what kind of reports came out, what mechanisms were created and so on’, the findings of the study were bound to indicate a positive organisational learning. More information is available on the ‘responses which did take place’, while the same for knowing ‘that which was desirable but not undertaken’ is limited. Recognizing this limitation of the nature of evidences, the chapter offers following conclusion:

One, changes in regulatory mechanisms and practices have followed a positive co-relation with crisis events in India or elsewhere. The chapter concurs with Newman and Howlett’s assessment on progression of regulatory cycle being not automatic and crisis events being one of the most important factors in driving a regulatory change. In case of AERB too, the exogenous factors like crisis events elsewhere affected timings of demands for regulatory reforms.

Two, in terms of stages in regulatory cycle, one can discern a clear link between the major incidents that happened world-wide and the corresponding alterations in the powers and/or functions of the Indian regulatory body. All incidents of significance have certainly been followed by an intensive review of the nuclear facilities. These reviews, however, have been mostly performed mostly by the internal members of the nuclear establishment, comprising of the AERB and the Technical Support Organisations (TSOs) like BARC and NPCIL. These, however, have not led to major changes in the primary structuration of the regulatory body which limits its autonomy statutorily. At the same time, while the on-ground evidence of a compromise in the AERB's regulatory competence remains unacknowledged by the establishment, institutional over-hauling too has not got much support from the establishment.

Three, the Indian nuclear regulatory body i.e. AERB has moved from 'infancy' to preliminary stages of 'youth' where the Independent regulatory body is supposed to form. By institutional standards, one may argue that formation of a 'deemed autonomous' body can be seen as the youth period. As AERB is not totally autonomous, one cannot convincingly declare it to be in 'youth' stage.

Four, despite problems with the AERB's structural organisation, the study did not find incriminating evidences of regulatory capture of the AERB. While reforms are necessary to ensure its autonomy, the AERB's safety regulation has received world-wide appreciation and most of the emergency situations could be handled without much loss to life and property.

Five, major revisions of nuclear regulatory and operational practices have followed a reactionary approach as evident in the establishment of AERB, proposal of the NSRA bill, India's acceptance of the IAEA's conventions and review mechanisms and so on after various crises events.

Six, crisis events have not been successful in pushing the need for effective and independent regulation beyond a point even internationally. The Fukushima disaster specifically pointed to the phenomenon of regulatory capture. It urged its member states to undertake efforts at national levels to ensure a separation between agencies responsible for regulation and promotion of nuclear energy. The Chernobyl disaster propelled the need for international coordination in the field of nuclear regulation more as a reactionary response. The Three Mile Island incident mostly reverberated technological solutions to avert a nuclear crisis. All these led to more institutionalization in the international regulatory mechanisms and practices and were incrementally adopted by the member states. But these could not bring states to officially designate IAEA as nuclear safety watchdog or even to take binding peer-reviews based on real time and routine and surprise inspections. Even when the need for effective international regulation was emphasized at multiple counts in the top-level conferences, there has been very little effort on the ground to strengthen the IAEA or any other body as an international regulatory body. However, the crisis events did cause a definite stepping up in the level of national regulations characterized by immediate safety and security reviews conducted worldwide.

Seven, while the three crisis events pushed for a more effective regulation, most of the energies were directed at finding technological solutions as witnessed in the introduction of more passive safety features at the design level. The new designs however, also warrant the need for specific regulatory practices and skills, the development of which is at a slow pace and fragmented in nature, depending mainly on commitment of individual states. Most of the regulatory organisational changes have been reactionary in nature as major changes were followed after crisis events in Indian plants or elsewhere. There are, however, nuances to this argument which will be discussed in detail in the conclusion chapter. Also, regulatory changes have mostly been incremental and slow. With the absence of a highly alarming incident or accident in Indian plants, need for radical or transformational reforms have been very limited. Establishment of AERB and proposal of NSRA, however, are two such junctures, where a change in organisational philosophy and structure were discussed at the management level.

Eight, the absence of a relatively major crisis within India has tacitly been heralded within the policy circles as an important rationale for continuing more or less with the same regulatory structure, along with a few technical and medium level modifications. Specific institutions like NDMA have been created to deal with nuclear accidents over the years but the efficacy of such bodies, remain unevaluated as there has not been any major nuclear emergency in India. Though the possibility of a nuclear accident is not categorically denied by the establishment, there appears to be a strong sentiment that India’s safety, security preparedness is advanced enough to not let an adverse event spiral into a crisis. In fact, absence of major crisis events beyond INES level 3 domestically has often been hailed as the success of current operating procedures of the regulatory body.

Nine, while a lack of major crisis in Indian nuclear power plants espouses confidence in the nuclear safety culture in NPCIL and other DAE wings, a complacency, can be risky. Some Interviewees from within the establishment too cautioned against a complacency around successful crisis management record. Most of the interviewees (from within the nuclear establishment), however, dismissed the possibility of a major incident on a real-time basis or of its spiralling to dangerous proportions. This tendency was also reflected in reflected in many of the articles written by former or current nuclear establishment personnel or statements issued by official nuclear policy circles. 59.4% of survey respondents too expressed confidence in safety preparedness while 18.8% disagreed. 21.7%, however, chose to remain neutral.

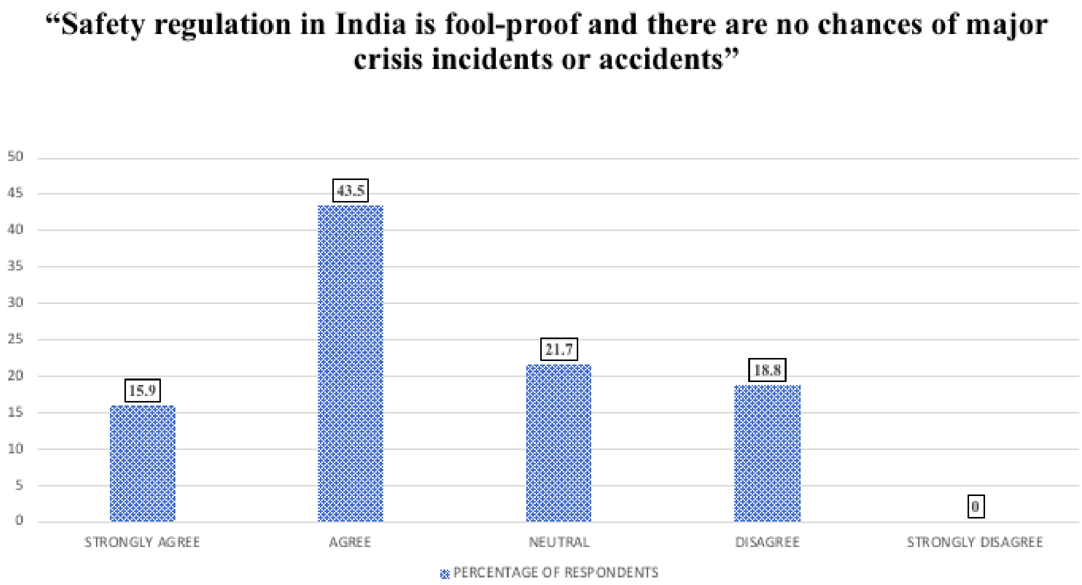

Figure- 4.3. (**Source**: Author)

While crisis events were characterized by more effective regulatory reforms, the establishment (DAE and AERB) did make efforts to assuage public perception. However, it is difficult to ascertain crisis as the most important factor for regulatory change in the case of AERB. This point will be discussed in detail in the conclusion chapter in tandem with a discussion on other variables as well.

Chapter: 5

Implications of the Nuclear Weapon Programme on the Civilian Nuclear Regulation in India

This chapter analyses the impact of India's nuclear weapons programme on its civilian nuclear energy programme in terms of structure, functions and guiding principles. The first section deals with the initial phases of nuclear energy programme in terms of a) explicitly projected public policy related to the peaceful uses of nuclear energy and, b) the covert undertaking of nuclear weapon programme and associated contextual rationale. The second section, sub-divided into seven sub-sections, would enumerate the consequences of Indian 'peaceful nuclear explosion' (PNE) of 1974 and nuclear weapon tests of 1998 on the nuclear energy programme. To assess the impact of these tests, the nature of initial foreign collaborations associated with Indian nuclear energy programme will be discussed. The third section would discuss the factors and considerations, especially those related to the strategic programme, that were instrumental in shaping the Indian side of the terms of the deal. The fourth section would specifically reflect upon the implications of safeguards on AERB evolution, if any. The conclusion would enumerate the findings keeping in mind the implications of weapon programme on the evolution of regulatory regime in India.

5.1.Indian Nuclear Energy and Nuclear Weapon Programme: Situating Convergences

This section will analyse the evolution and progress of nuclear energy and weapon programme, the latter within the garb of civilian programme. It will also look at the Indian nuclear weapon programme as a process that culminated into the PNE of 1974 through the lens of contextual factors that justified its adoption explicitly in 1974 and then again through the 1998 tests.

Indian nuclear energy program since its inception became intertwined with the weapon programme, though not explicitly. During the initial decades, the demonization of nuclear weapons in India drew its support from the Gandhian pacifists. The debacle caused by the twin explosions in Japan created both a desire to master these weapons as well as their condemnation as the downfall of humanity. As a prominent third world country leading the non-alignment block, India at least in public, denounced the desire of producing nuclear weapons. PM Nehru as a leader of NAM criticized the mad arms race between the two superpowers especially in the nuclear field. Nehru on multiple accounts claimed that Indian nuclear energy programme was being developed for peaceful purposes alone (Cohen 1998). While Nehru did not give explicit direction to the scientific establishment to develop of nuclear weapons (not officially at least) but he wanted them to develop the technology for the same (Cohen 1998). For him, atomic power could be utilized for huge energy demands of the country but at the same time, he was not unaware of importance of nuclear weapons in international politics and national security. This dilemma regarding India's options vis-à-vis the dual uses of atoms fundamentally shaped the centralized and secretive nature of nuclear establishment's functioning, supported by his political patronage

The AEA 1948 not only caricatured nuclear energy programme as a 'state-science', leading to monopolization of all nuclear related activities in the hands of the central government, but also provided a deep layer of secrecy around its operation. The latter, was questioned in the constituent assembly by Krishnamurthy Rao, on the grounds that, when compared with foreign precedents (AE acts of foreign countries), such secret ways of functioning in case of nuclear programme is accorded only with respect to defence programme in Britain (Perkovich 1999: 18). Nehru responded, "I do not know how you are to distinguish between the two." (Nehru quoted in Ramana and Reddy 2003: 217). On the question of military uses of nuclear energy, Nehru responded in constituent assembly in 1948,

> …[w]e must develop this atomic energy quite apart from war. Indeed, I think we must develop it for the purpose of using it for peaceful purposes….Of course if we are compelled as a nation to use it for other purposes, possibly no pious sentiments of any of us will stop the nation from using it that way.. (Nehru quoted in Abraham 1999: 51).

Nehru's responses were tailored by the consideration of keeping the nuclear option open in case the future eventualities required an alteration in India's stand on the nuclear question. Even during the Nehruvian regime, the idea of producing or procuring nuclear weapons lingered. While answering a question in the parliament, Nehru said he was not sure if the twin uses could be separated. Nehru's biographer S. Gopal, "It is not generally known that Nehru wrote to Bhabha that he was against outlawing atomic weapons. His policy was never to use it but to have it because we can't completely abjure from it." (Chengapppa 2014)

The high levels of secrecy that over-shadowed AEC's working right from its establishment proved conducive in the long run to keep the weapon program a secret, at least till the time the political leadership decided to declare it publicly. Nehru shielded the AEC from bureaucratic interferences and ministerial scrutiny (Gopalakrishnan 2002; Abraham 1999; Sharma 1983; Chakma 2005). It even "insulated the AEC and the DAE from all possible influences of independent scientists of the Universities" (Sharma 2005: 39). While for other departments, the cabinet ministry exercised the oversight powers, this was not the case with AEC, which remained outside the ministerial scrutiny. To the finance minister's remarks about AEC employing high costs without providing enough information about its programs in 1952, Nehru responded, "The work of the AEC is shrouded in secrecy. I try to keep in touch with it and get reports from time to time… I do not know how else we can proceed in this matter" (Anderson 2010: 200). He even asked the Finance Minister not to show the summary of the AEC's report to the others and also did not encourage making copies of those (Anderson 2010: 200). He, nevertheless, created and protected the institutions and political controls over the nuclear establishment to allow it the kind of flexibility and environment that could facilitate alterations in the nuclear programme in a secret manner. At the same time, this zealot protection also extended to the civilian programme as the separation of civilian and military programme explicitly was not conducive. India had pledged its support for non-proliferation and nuclear disarmament. Explicit separation of the civilian and military facilities could belie India's normative groundings which focused on the destructive nature of nuclear weapons more than its security-providing aspect. At the same time, it could mean informing the world of its weapon programme which would have led to non-cooperation and withdrawal of technical and financial support of the west to its nascent nuclear energy programme.

Affirmative evidence about the exact time around which political leadership permitted a production of nuclear weapons, is not conclusive but one of the earliest such evidences are traced to 1960 when during discussions over a Westinghouse project, Nehru asked Bhabha if he could make a nuclear bomb, in the presence of Kenneth Nichols, an engineer with significant role in the Manhattan project (Perkovich 1999: 36). To this Bhabha responded in affirmative and suggested it would take him around a year to do that. Nehru said, "Well, don't do it until I tell you to" (Nehru, quoted in Perkovich, 1999: 36).

Official policy during the decade of 1950s appears ambivalent at best. As early as in 1958, while the nuclear energy programme was in a nascent phase in terms of actual construction and operation of power reactors, Nehru ordered the construction of a plutonium reprocessing plant with a capacity to process 20 tons of fuel a year. This plant called ‘Phoenix’ was to use the PURIX method keeping in mind the quantity of spent fuel of the CIRUS. Officially, this plant, which had substantial utility from a nuclear weapon production point of view, was projected and justified as being crucial for materializing Bhabha’s three stage vision for a self-sustaining nuclear energy programme in a long term. This plant was supposed to process the spent fuel generated from reactors to help further the second stage of energy generation through breeder reactors. Construction began in 1961 and the plant was commissioned in 1965. By this time, however, an operational commercial reactor was not even in place. It is difficult to say if any one objective superseded the other in the minds of decision-makers. Critics argue that while the official rationale offered was to use the plant for producing the fuel required for the breeder program so as to use the domestically available thorium, one principal objective was to use it to separate and enrich plutonium for weapon production (nuclear weapon archive 2001).

Indian overtures during 1950s relied heavily on the rhetoric of its interests in peaceful uses of nuclear energy alone. A post-facto analysis of Bhabha’s lobbying with U.S., however, suggests evidence to the contrary. Bhabha rejected the American offer for supplying a standard research reactor in 1955 and instead asked for transferring a nuclear power reactor, “omitting essential safeguard features” (Lavoy 2003: 29.). Such conditions (safeguards) were termed as “more or less an insult to India’s peaceful intentions” (U.S. Department of State quoted in Lavoy 2003: 29). After much deliberation in US, acceptance of safeguards was proposed as a condition for the agreement. In 1955, Bhabha even asked an U.S. embassy official if the U.S. AEC could provide India with technical information on effects of nuclear explosion or if it could help in setting up a joint monitoring station in India to study the air borne fragments produced by nuclear explosions (Andrew Corry quoted in Lavoy 2003: 29.).

Similarly, the 1956 inter-state negotiations to decide on the mandate of the IAEA before its establishment, saw opposition from the Indian delegate on the question of safeguards. Bhabha (the official Indian delegate) was the only one to oppose the proposal for accepting safeguards on natural uranium. He argued that while safeguards on special fissionable material, i.e. enriched uranium or plutonium, was acceptable but those on natural uranium were not. He argued that these could undermine industrial development of the non-nuclear weapon countries because of constant controls while the nuclear weapon countries could use military nuclear programmes and non-military materials and information interchangeably. At the same time, he also opposed "perpetuation of safeguards applied to successive generations of nuclear materials" (Goldschmidt 2006: 10). India then had nuclear materials but required international assistance to establish its nuclear energy programme and this provision could have brought Indian programme under safeguards in perpetuity. His most ardent categorical opposition, however, was to article XI I.A.5 which provisioned that the agency would have a right to

> decide on the use of all special fissionable materials recovered or produced as a by-product and to require that such special fissionable materials be deposited with the Agency, except for those quantities which the Agency allows to be retained for specified non-military purposes under continuing Agency safeguard (Goldschmidt 2006: 10).

Essentially, it provided for agency's rights over spent fuel generated out of safeguarded programmes. Because of active lobbying by India along with mostly third world countries and at times Soviet Union ultimately led to a dismissal of such stringent safeguards power with the agency and watering down of the ones that were ultimately formulated. In conclusion, India invested a lot of diplomatic efforts in making sure that its nuclear assistance from bilateral or multi-lateral forums remained free or minimally affected by safeguards regulation internationally. This, in effect, also shielded its secret nuclear weapon programme because of limited and selective international inspection and verification.

Before entry into force of the NPT in 1970, the terms of international nuclear technology and material supply were comparatively liberal. For CIRUS reactor, therefore, India could acquire nuclear technology and material without safeguards or inspection obligations. The reactor design was modelled after the Canadian NRX reactor which produced plutonium efficiently because of its high-neutron economy (Ramana 2006) India, however, had agreed to utilize the heavy water procured from America only for peaceful purposes [no safeguard criteria mentioned in the cooperation agreement for this {Rosenthal 2013)]. A similar guarantee was given by India to the Canadians for the use of reactor as well. Despite proliferation concerns, Canada supplied the reactor technology speculating that India might be able to procure it from some other nuclear vendor anyway. India carefully declined the Canadian offer of fuel for the plant and proceeded to manufacture the natural fuel required for the reactor (Nuclear weapon archive 2001). This was done so as to have a complete control over the spent fuel generated from the plant. Later, it was utilized for producing weapon-grade plutonium. Also, its design served as a prototype for the later development of more capable Dhruva research reactor for producing nuclear weapon grade plutonium.

The deteriorating India- China relations near the end of 50s, made Nehru less skeptical of the weapon programme. Learning about the Chinese nuclear test, he directed Bhabha to speed up the process of developing such capabilities (Chengappa 2014, Chakma 2005). After Nehru's death, Lal Bahadur Shastri asked Bhabha in 1964 to reduce the critical time needed to make a nuclear explosive. Before his death in 1966, Bhabha in an unprecedented move declared that it would take India around 18 months to make a nuclear bomb.

For all the explicit purposes, up till 1974, India never expressed its intention of developing nuclear weapons.[54] It did try to seek the nuclear umbrella of superpowers so as to ensure its own security preservation in the view of deepening Sino-Indian rivalry especially since the 1962 war. With the Chinese acquisition of nuclear power, India desperately tried to seek the nuclear umbrella of U.S. With the failure of such diplomacy, India pulled out of the NPT negotiations, which it ardently supported initially and pursued the nuclear weapon programme discreetly. Andrew Kennedy in his paper, 'India's nuclear odyssey' (2011) argues that with the surge of realist thinking in top policy circles especially after India-China war, the Indian strategy shifted to resilient defence preparedness. Indian perception about discriminatory nature of NPT which privileged security considerations and power status of a few on account of possession of nuclear weapons, to the marginalization of similar interests of other countries also strengthened Indian resolve of a pursuit of nuclear weapon programme (Gopalakrishnan 2002, Sagan 1996).

Indian decision to carry out the 1974 n-test is also situated within a domestic political turmoil situation after the death of Nehru in 1964. The incumbent Morarji Desai

[54]The U.S., however, was aware of discussions on the PNE in the Indian official circles around 1970 (Perkovich 1999: 159).

challenged the successorship of Nehru’s daughter for the post of prime minister. Upon a declaration of majority support with Indira Gandhi, the Desai faction split off the congress and contested against the Congress-I faction led by Indira Gandhi. This political instability and uncertainty had similar resonance in the nuclear energy establishment with the sudden demise of Bhabha in 1966. His successor to the DAE, Vikram Sarabhai, prioritized the space programme over the nuclear programme to strengthen the satellite communication and technology in India. This, however, does not mean that the nuclear programme came to a halt. There was a slow but steady ongoing research in the nuclear field (Perkovich 1999).[55]

When all the Indian efforts to secure a defence against Chinese nuclear weapons failed, the scientific establishment excited to test its caliber, found a natural ally in the political establishment which was disappointed with the international security environment. The deteriorating security environment compounded by a discriminatory NPT convinced the policy makers that it could not rely on the help of others and must develop robust defensive capabilities. The step-by-step knowledge and expertise culminated in 1974 nuclear weapon tests. This, however, does not mean that Indian nuclear weapon program was a product of India’s security apprehensions alone.

The Indian desire for nuclear weapons did not emanate from the strategic factors alone. A very major role was played by the will and aspirations of the nuclear bureaucracy and the nuclear scientific community in India which saw nuclear weapons as the ultimate way for establishing their credibility world-wide. Nuclear establishment since the very beginning remained under the protective sanctuary of the prime minister and communicated directly with the prime minister office. Very few people had authority to discuss nuclear matters and so it remained shielded from the scrutiny of other ministers or public at large. One of the factor ensuring continuity in pursuit of nuclear programme can be attributed to the ability of nuclear scientists to “pursue programmes that diverge in subtle ways from

[55]The AEC approved the Purnima reactor in 1969 to study neutron behaviour in fission and use of U-233 as a fuel. In the same year, the NPT was finalized. Purnima-I reactor attained criticality in 1972. This tank-type reactor employed 21.6 kg of plutonium-239 and worked on the same principles as a rudimentary fission bomb. These reactors helped the BARC scientists in assessing the chain-reacting plutonium system. These calculations were later employed in determining explosive power and neutron trigger of India’s nuclear bombs (NTI 2017b). This reactor was decommissioned and renovated as Purnima-II, which after attaining criticality in 1984, essentially produced 10 watts energy by using uranium-233 nitrate solution as a fuel.

proclaimed policy" (Ramana 2003: 212) because of the unique authority structure of the AEC, shielding even cabinet scrutiny significantly.

For nuclear scientific community, mastery in the technology and production of nuclear weapons meant not only huge intellectual recognition but also extensive provisions of funding and experimental liberty (Anderson 2010: 16; Perkovich 1999). Perkovich (1999) also argues that as the nuclear establishment was unable to fulfil the grand promises of producing cheap nuclear energy and attain self-sufficiency, the weapon program was rather to justify its increasing demands for funds. The esoteric nature of the discipline, further compounded the elite status of its practitioners. This acute interest and determination in the pursuit of nuclear weapon technology was ingrained in the India's nuclear programme since the beginning. Stating the intellectual significance of the atomic bomb, Raja Ramanna of the DAE said,

> There was never a discussion among us over whether we should not make the bomb. How to do it was more important. For us it was a matter of prestige that would justify our ancient past. The question of deterrence came much later. Also, as Indian scientists we were keen to show our Western counterparts, who thought little of us those days, that we too could do it (Ramanna quoted in Chengappa 2000).

None of this, however, would be possible if the political regime did not allow it. Indira Gandhi, decided on the nuclear test in 1974 for no definite or conclusive reason. Scholars contend that she agreed to the tests in order to enhance the popularity of her regime which was struggling to keep up with its development commitment given the poor state of economy (Kennedy 2011; Sagan 1996). Such demonstration of strength and power internationally was thought to reap domestic dividends in terms of electoral politics.

The nuclear tests of 1974 confirmed the pursuit of nuclear weapon programme in India contrary to its public posturing and diplomatic signaling over the years. Roberta Wohlstetter argued in 1978,

> The rhetorical separation, as if in a dichotomy, of peaceful and military uses of nuclear energy, as well as the rhetorical identification of investments in civilian nuclear energy with economic development and catching up with the advanced countries, form a substantial part of the background of cumulative changes that made India's nuclear explosive program easier (Wohlstetter 1978: 341).

Explicit nuclear energy programme coupled with non-separation of civilian and military programme therefore acted as a shield and tool for confidence-building by the Indian negotiators, who in their avowed dedication to the unhampered national sovereignty resisted subjecting its facilities to the IAEA inspections.

5.2. Implications of the 1974 and 1998 Nuclear Tests

Implications of sanctions were quite unnerving initially. India started its nuclear programme through foreign collaboration and assistance, a stoppage of which put the Indian scientists and engineers in a difficult bind. This section will briefly enumerate the collaborative aspects of Indian nuclear energy programme so as to provide a context for analysing the implications of sanctions and withdrawal of foreign assistance post-1974 in the later section.

During the initial phases, India was heavily dependent on foreign imports for expertise development, technology and material. Foreign assistance was available more readily for the heavy water reactors though, which used natural uranium as fuel and heavy water. Nehru’s political patronage to the nuclear energy project was coupled with an arduous leadership of Bhabha who harped on his personal international scientific reputation to gather requisite technological and material support from foreign suppliers. Bhabha’s role in grooming nuclear scientists for providing a lifeline to his vision of self-sustaining Indian nuclear energy programme has been brilliantly documented in existing literature on India’s nuclear histories (Anderson 2010, Phalkey 2013, Lavoy 2003, Perkovich 1999). Bhabha successfully made use of the American interest in the promotion of nuclear technology in South Asia outlined in two major resolutions of Eisenhower’s administration: 1) NSC 5409 [U.S. policy towards South Asia, which focused on supporting “strong, stable and responsible governments in a region that is a ‘major battle ground in cold war’” (Office of the Historian 1954:1)] and 2) NSC 5507/2 (Peaceful uses of Atomic Energy) to promote its national interests. He carefully exploited the cold war competition between USA and USSR to India’s advantage. American interest in wooing India, apart from the gains of nuclear commerce also appears to have emanated from its apprehension that USSR and communist China would try to convince India to at least continue its neutralism, if not refuse to join the communist bloc, after Stalin’s death in 1953 (Office of the Historian 1954).

Confident of India’s peaceful intent, U.S. was ready to offer a heavy water reactor, also to promote its own nuclear exports. Its 1963 agreement with India provided for an “exclusive use of the U.S. fuel in Tarapur reactors, in exchange for a U.S. guarantee of its supply” (Bradford and Gilinsky 1977 cited in Noorani 1981: 401). This provision also convinced India to agree to an initial acceptance of safeguards at Tarapur which it otherwise was reluctant to undertake. The Indian government also refused to accept the IAEA inspections on the reactors themselves despite generous financial terms as they considered it to be an affront to the ‘national sovereignty’ (Gilinsky 2007). Victor Gilinsky, a former commissioner of the U.S.NRC argues that given the American eagerness to conclude the deal in the wake of the U.S.-Soviet competition for the dominions of influence in the countries of the third world, it was accepted as ‘functional equivalence’ of reactor inspection (Gilinsky 2007).

India, in fact, became one of the first countries to receive American aid and assistance for nuclear energy generation under the ‘Atoms for Peace programme’. American assistance initially included training Indian scientists and engineers and later extended to the supply of U.S. power reactors to India. The first two such reactors were constructed at Tarapur which also marked the beginning of the Indian nuclear energy programme. These were boiling water reactor-types using imported enriched uranium with a capacity of 210 MWe. Construction started in 1964 and commercial operations began in 1969. The General Electric Company of the US supplied this plant on a turn-key basis (Sethna 1979). Under a Loan agreement for this project in 1963, the US International Development Agency provided a loan of 80 million dollars. The US atomic energy commission supplied the 10 tons of heavy water in 1955 for the CIRUS research reactor supplied by Canada and around 93 million dollars were granted by US to India as Atoms for Peace loans and grants between 1954 and 1974 (Lavoy 2003).

Around the same time, India was also negotiating with Canada for the supply of a heavy-water reactor and in 1964 both decided to set up a PHWR of 200 MWe capacity power station at Rajasthan. It was a replica of an existing Canadian reactor design but an operational feedback from the reference reactor was not available to the designers at that time. This posed problems for Indian operators later as several issues arose with the functioning of these reactors (Gopalakrishnan 2002: 375). RAPS-1 came into commercial operation in November 1972. Another reactor at the same site (RAPS-2) was also agreed upon in 1966.

Gary Milhollin (1987) argues that almost every essential facility in South Asia was either imported directly or copied from the imported designs or built with foreign assistance. By 1974, the U.S. alone had provided training to around 1100 Indian nuclear physicists and engineers (Wohlstetter 1976). Around 263 personnel were trained at Canadian facilities before 1971 (Perkovich 1999 quoted in Ramana 2006). Such reliance on foreign collaboration coming to an impasse, had serious implications for the Indian nuclear energy program, leading to its slowdown considerably (Milhollin 1987). The 1974 tests, however, did not lead to the stoppage of all international cooperation agreements immediately.

The second research reactor CIRUS [40 Megawatt-thermal (Mwt) heavy-water moderated reactor] was built with an Indo-Canadian collaboration using US supplied heavy water. BARC scientists at the same time were designing a plutonium extraction and recovery plant to process the spent fuel of CIRUS once it became operational. With construction beginning in 1961, the plant was commissioned in 1965.

This CIRUS design was mastered by Indian scientists who later designed and built (with some modifications), a 100 MWt heavy water moderated reactor called Dhruva. The latter was commissioned in BARC in 1985. The plutonium reprocessed and recovered from the spent fuel generated by the CIRUS reactor was used in the 1974 nuclear tests. To avoid international criticisms, the test was officially called as 'peaceful nuclear explosion'. Milhollin (1987) argues that it is unviable to assume that there would not be any fraction of US-origin heavy water being used at Tarpaur when the bomb was produced, given the fact that when the plant was started, it was only the US supplied heavy water that fed the plant. In the absence of a mechanism to trace the origin of the plutonium 'conclusively', the USA export control mechanism failed in this instant. While the response of the US executive to the Indian 'peaceful explosion' was mixed though definitely tilting towards condemnation, the Canadians not only rejected the Indian explanations but also terminated its nuclear cooperation with India when India refused to apply IAEA safeguards and freeze its nuclear weapon programme (Albert Wohlstetter dot com 2008).

India gave the nuclear material accounting report to the IAEA for this plant while Canada refused to undertake it. As a result of the sanctions, the RAPS-2 took a long time in construction and commissioning. Over a period, the costs also over-ran. There was certain leakage issue at some point of time but as the Canadians refused to provide any technical assistance at all, India was forced to manage on its own. Then India over-time developed its own expertise to deal with such safety-related things (Balachandran 2018).

Almost a 30-year period of sanctions starting post 1974, over civilian nuclear cooperation with India in terms of facilitation of nuclear commerce, compelled the Indian nuclear establishment to rely exclusively on indigenous capability development for some of the aspects of nuclear fuel cycle. These sanctions got reinforced with the sanctions imposed after the 1998 tests which included around 200 Indian entities along with the DAE, the DRDO, ordnance factories making conventional arms and equipment and even some private firms working for them (for instance, L&T, Walchand Nagar industries, Godrej & Boyce, BHEL and so on (Rekhi and Joshi 1998). The US firms were banned from exporting anything to these entities (Rekhi & Joshi 1998; India.com 2018). However, as the DAE and related agencies were already under the sanctions, it did not have substantial implications for the nuclear programme then (Balachandran 2018; Grover 2018). Some of the dissemination of technical knowledge to the Indian scientists was facilitated by various international conferences where such matters were discussed freely (Ramana 2006).

Overall, pursuit of a parallel nuclear weapon programme affected the civilian program in numerous ways. Mostly, it affected the civilian program adversely because of international backlash to the weapon program and forced the establishment to make sub-optimal choices when it continued with the program. The years since then witnessed India struggling to maintain its nuclear energy program without undertaking safeguard regulations. The next few sub-sections will look at the specific issue areas that arose in the wake of post-1974 sanctions.

Deliberate Avoidance of the Safeguard Regime by India

The Indian leadership perhaps did not anticipate rather quite stringent response of international community to the PNE. As India was not a signatory to the NPT, the foreign suppliers were not ready to transfer the light water reactor technology to India without safeguards as it required enriched uranium, the technology which they did not want to export to India as it had not signed the NPT. Rather than purchasing safeguarded light water reactors which can operate on higher capabilities, India preferred to go for PHWRs of lower capacity. Choice of PHWR was also a result of two other factors: 1) It fits into

Bhabha's first stage of nuclear vision program and 2) it did not require enriched uranium, the technology for which was not available domestically. Once mastered, a PHWR's spent fuel could be reprocessed to produce weapon-grade plutonium.

Indian exploitation of loopholes within legal obligations imposed upon recipient country prior to 1974 generated a need in US to strengthen the non-proliferation aspects of nuclear commerce. At that time, Zangger committee already maintained a 'trigger list' of items that required countries receiving such supplies to accept IAEA safeguards on those facilities which were to use such items. But with Indian tests, US took the initiative to form what is today known as the NSG. The number of items that could now be exported only with application of safeguards increased. Another impact of Indian test was US Congress enacting the Nuclear Non-Proliferation Act (NNPA) in 1978 (U.S. domestic act) which provided that it will not supply nuclear related items to countries that did not agree on IAEA safeguards on *all its nuclear activities (emphasis added).*[56] Later, this provision of the NNPA act was adopted by the NSG in 1992. Unwilling to accept these safeguards that could seriously jeopardize its weapon program, India suffered the supply cut-off from America. US also prompted other supplier states in the NSG to adopt full-scope safeguards. The American withdrawal affected the nuclear energy program in India substantially as before the tests, it was the largest nuclear supplier to India.

To mollify the international resentment, TAPS-1 &2 and RAPS- 1 & 2 were put under the safeguards. Also, as the imported heavy water was available under the conditionality of peaceful uses and application of safeguards, India kept its fully completed plant at Madras idle (CANDU design) for two years (Milhollin 1987).[57] The heavy water required for the

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[56]Some of the items before the NNPA 1978 were exported without safeguard obligations. This was recognized as a loophole in existing export provisions of the USA and therefore all such assistance was capped with safeguards application requirement Later, this provision was adopted by the NSG too, in 1992, when Gulf war brought home the realization of undetected diversion of nuclear assistance to the weapon program by some countries despite safeguards.

[57]Heavy water post-sanctions, at least the initial amount, however, might have been imported as India could not have produced that much heavy water indigenously in that short period of time. The source of this heavy water, however, is not known in public domain. Balachandran in an interview to the researcher argued that those were were procured from Romania but being unsafeguarded, India was under no obligation to report it (Balachandran 2018). Other speculations regarding its source, following possibilities have been indicated: 1) India imported it from China, the import from which was not conditional upon peaceful uses; 2) clandestine supply from any of the three suppliers either directly and covertly or through international black market; 3) India diverted that amount from safeguarded material by escaping the international inspections. Anonymous sources from within the atomic energy establishment conceded to the argument of such supply coming from the US itself either through secret agreements or indirectly through international black market. In general, certain nuclear trade with foreign companies continued even after the 1974 tests, without much publicity though.

plant was initially to be provided by US but after the tests, US refused to offer such assistance. Also, this plant (MAPS-1), even though was a 'replication' of Rajasthan plant (but replication was not forbidden under the original India-Canada agreement), could be kept outside the safeguards and plutonium recovered from its spent fuel could be used for the strategic programme.

Fuel crunch, Cost Over-Runs and Delays

The Tarapur reactors were commissioned by the US on a turn-key basis. Initially the reactors were fed 40 tons of enriched uranium fuel, which lasted for 2 years after which the reactors were provided with roughly 20 tons annually (India Today 1978). Indian tests were a great set-back to the non-proliferation regime and US-led non-proliferation regime sought to punish the Indian violation by stopping all the nuclear assistance to India. Some of the members of the American Congress opposed the compliance of the deal made between India and America, which promised the supply of enriched fuel to the plant under safeguards.

Agreements with India were concluded before the enactment of American NNPA act (1978) but the non-proliferation lobby in the US wanted the government to revise the terms of agreement with India so as to freeze its nuclear weapon program. When India refused to comply with post-facto condition of applying safeguards on all its facilities and citing it as breach of the contract, the US withdrew its commitment to supply enriched uranium fuel for the Tarapur plant as agreed upon in the agreement. Fuel shipments post 1974 and before stoppage were delayed leading to a lowering of Tarapur reactors' power rating, indicating a decline in electricity production. With prolonged delays, it became clear that India would need to develop the indigenous capability to find a way to fuel the reactors in order to keep it running or procure the same from some other friendly states. US went back on its agreement to supply fuel for TAPS but helped in its procurement by not objecting to other countries supplying the same to India. It also facilitated fuel supply for the same from France in 1982 (Grover 2017). The plant came under safeguards application. This too was stopped when the NSG guidelines in 1992 made such supply conditional on acceptance of safeguards on all nuclear activities of the recipient country. This implied that India was required to put all other plants too under the safeguards,

safeguards, irrespective of whether those plants utilized foreign assistance or not. India did not want to abide by this and France pulled out its fuel supply. At that time, China stepped in to supply fuel to TAPS as it was not a member of NSG then (Subramanian 2004). But after, 1998 tests, where Indian political leadership overtly identified China as hostile to its interests, China refrained from supplying any more fuel (Gopalakrishnan 2002). This situation could be resolved only in 2001 when Russia agreed to supply the enriched uranium for TAPS reactors.

Though the Indian nuclear science establishment managed to proceed substantially through coordinated national efforts at indigenisation, the constraints of fuel supply and enrichment technology undermined the achievement of India’s three-stage nuclear energy program. There were numerous cost over-runs and huge delays in the commissioning of almost every nuclear power plant at least since 1974. A sudden withdrawal of the fuel supply for Tarapur plant and other technical assistance delayed its commissioning. There were similar delays in other projects as the requisite skill was not still developed and it took some time to develop such capabilities indigenously. While Rajasthan unit-1 (built with Canadian assistance) was completed in 1972, the Kalpakkam units near Madras could be ready only in 1983 and 1985, after a 10-year slippage (Menon 1988).

When the tests happened, the RAPS-2 was still in construction. Outraged by the Indian test, Canada withdrew all its assistance to this reactor abruptly within four days and asked India to comply with IAEA safeguards on all its facilities. This affected RAPS-2 project significantly as most of the crucial equipment and components were being provided by Canada.

Therefore, because of the n-tests and corresponding sanctions on fuel supply, technological collaboration and such, the Indian nuclear energy program paced down considerably (Sethna 1979, Rekhi and Joshi 1998). Most immediately affected were the BWRs running on enriched uranium. International assistance became increasingly precarious with aggravating safeguards requirements. The PHWRs also were affected as many of the critical component and equipment in the design of such reactors became unavailable.

Tarapur fuel fiasco after the sanctions also saw India emphasizing on at least a 5-year stockpile of enriched uranium to be provided by Soviet Union during negotiation for

Kudankulam reactors in 1988 (Menon 1988). It was a boiling water reactor and therefore required enriched uranium which India did not have the indigenous capability to produce then. Indo-Russian nuclear cooperation is the subject matter of the next sub-section.

India-Russia Collaboration in the Indian Nuclear Energy Programme

During the sanction duration, one country which rather enhanced its nuclear cooperation with India was Russia. The VVER (water-cooled water-moderated light water power) reactors were initially proposed by USSR during Morarji Desai government in late 1970s and then Indira Gandhi government but the breakthrough could happen only during Rajiv Gnadhi's government in 1985-86. This was stalled for a while due to the Chernobyl disaster in 1986 but eventually finalized in 1988.

The VVER reactor offered by the Soviet Union implied an additional 2000 MWe energy which was of huge significance then. Russia also refused to comply with the trade sanctions that were levied on India in the wake of the 1998 nuclear explosions. It refused to comply with the sanctions despite being a nuclear weapon state under the NPT and continued to support its decision of selling two VVER (nuclear reactors to India negotiated under a 'grandfather-clause' as the deal was signed way back in 1988 (Moody 1997: 113). It argued that the agreement was reached even before the NSG was formed which prohibits nuclear trade to a country not complying with the full-scope safeguards under the NPT. The settlement not only provides for sale of nuclear reactors to India but also allows it to transfer the technological know-how and subsequent indigenisation of the design (Dubey 2012). As part of their non-proliferation commitments and obligations however, they asked India to transfer back the spent fuel generated out of these plants to Moscow.[58]

The Indo-Russian agreement of 2001, where Russia agreed to supply enriched uranium to TAPS reactors after Chinese unwillingness to supply the same in the wake of 1998 tests, came under sharp criticism and diplomatic pressure from US on Russia. But the later refused to alter the agreement with India. Russia exploited exceptional clause of the

[58]It did ask India and Pakistan both to observe a moratorium on nuclear testing, sign the Comprehensive Test Ban Treaty (CTBT) unconditionally and accede to the NPT. Moscow however, also recognized India's security and strategic imperatives. In the late 1980s, it leased a nuclear submarine to India, the experiences and learning from which were later utilized by India in the design and operations of such submarines. It also helped with the building of India's nuclear-powered submarine, the Arihant.

‘safety requirement’ to justify its fuel supply to India before acceding to NSG in 1995 (Kerr 2012). In the meanwhile, India also experimented with MOX (mixed oxides of uranium and plutonium) fuel subassemblies to partially offset the requirement of enriched fuel in Tarapur reactors (Gopalakrishnan 2002: 377). The realization of the need to push indigenisation as the only solution for saving nuclear energy programme led to such coordinated efforts for the next two decades which will be discussed in the next section.

The VVER type Russian reactors were to be set up at Kudankulam near Kanyakumari in Tamil Nadu in 1988. These actually posed a great challenge for the AERB as it was a different technology than PHWR. The AERB’s regulatory standardization corresponded mainly to the PHWRs as they were pursued indigenously. The plant design was already approved in Russia but the AERB needed to conduct a detailed safety review of the design before issuing consent for the construction. Due to a lack of its own safety guidelines and codes for the PWR types, the AERB had to rely on the IAEA and other international standards. The Russian nuclear regulatory body (GAN) insisted on a formal agreement for safety and regulatory cooperation, as a result of which, it was formulated during 1999 (Sundararajan et al. 2008). With reciprocal visits, the final agreement was signed on January 15, 2003. A. Gopalakrishnan, former AERB chairperson in an article in frontline discussed that as India remained isolated because of the nuclear tests in 1974, the international cooperation in the realm of safety was available through the aegis of the IAEA (Gopalakrishnan 1999).

Indigenisation Efforts

The sudden withdrawal of foreign assistance severely affected the then on-going projects namely, TAPS and RAPS in numerous ways. Not only fuel supply was curtailed but also certain crucial components and equipment like microprocessors, chips, supercomputers and so on too were denied (Rekhi and Joshi1998). The GE company was barred by the US government from exporting the contracted spare parts or from transferring technical assistance to India (Gopalakrishnan 2002). This affected the TAPS reactors adversely. The NSG regime also made it difficult for India to import the same or similar supplies from other countries.[59] So, the immediate need of the nuclear establishment was to design and produce the components for the operating reactors. These forced efforts at

[59]Problems aggravated as Russia and France too joined NSG after gulf war in 1992 (Rekhi and Joshi 1998). In 2001, Russia refused to supply fuel for TAPS, citing NSG rules (Subramanian 2004).

indigenisation occupied the focus of establishment for next two decades when these efforts were carried out without significant external technological assistance (Bhardwaj 2013).

Even before the tests, the PPED of the DAE (now, NPCIL) was designing twin reactors to be set up around Madras. Its design was very similar to Canadian designed RAPS heavy-water reactors. But when foreign technical assistance stopped coming in post-sanctions, the project was redesigned to include some improvements for instance, double containment and vapour suppression systems (Department of Atomic Energy 2000). Furthermore, the core in MAPS reactors were redesigned to provide a gross output of 220 MWe (gross) as compared to 200 MWe (gross) capacity of RAPS reactor core (thermal power increased by 15% as compared to RAPS core and subsequent modifications in generators etc. were carried out) (Department of Atomic Energy 2000). Also, the RAPS-1 reactor end shields started developing cracks due to irradiation embrittlement of inapt material used by Canada. To prevent the same in MAPS reactors, the Indian metallurgists developed a stainless-steel alloy that could fabricate the end shields (Gopalakrishnan 2002: 378). Due to stoppage of assistance and sudden need to indigenise, the MAPS-1 got delayed. Its commercial operation began only in January 1984. MAPS-2 started operating in March 1986. RAPS -2 entered into commercial operation in April 1981 with indigenous components like calandria, end shields etc. (Sethna 1979: 6).[60] In the early years, these efforts were quite nascent and not full-proof resulting in structural failures at MAPS reactors and leading to their down rating to a power level of 170 MWe (Gopalakrishnan 1999). NAPS -1 & 2, saw further improvements and inclusion of new equipment and subsystem designs over and above the Canadian design to add to the operational performance and safety of these reactors (Department of Atomic Energy 2000; Bhardwaj 2013).[61]

As the AERB was established only in 1983, and due to the limited nuclear engineering knowledge in the country, PPED engineers who were leading indigenisation efforts, also

[60]RAPS-2, though developed with indigenous efforts, how came under safeguards as it used heavy water imported from Russia

[61]These included additions of "two high-pressure stages to the emergency core cooling system, two independent and diverse active shut-down systems and a third passive system depending on gravity" to slow down reactor core activity through the use of a borated solution, U-tube steam generators and so on (Gopalakrishnan 2002: 379; Department of Atomic Energy 2000).

started conducting evaluation of equipment and systems of RAPS and MAPS heavy water reactors. This motivation for operational and safety evaluations resulted primarily from the “difficulties experienced in the early operation and maintenance of RAPS -1, the limitations in infrastructure and manufacturing capacity within the country, and the desire to incorporate some of the then openly available information on emerging concepts in nuclear plant design” (Gopalakrishnan 2002: 379).

A catastrophic rupture in the pressure tube using Canadian design zircaloy-2 in 1984 in their Pickering station highlighted the accident-prone nature of this alloy which produced creep deformation induced by irradiation leading to blister formation and ultimately, the tube rupture. Scientists proposed the niobium-stabilized zircaloy-2 as the construction material for pressure tubes but because of sanctions, neither the alloy nor its metallurgical and production processes could be received by India (Gopalakrishnan 2002). BARC and NFC engineers, therefore, tried developing these indigenously. But to avoid project delays while this new alloy could be mastered, the DAE took a deliberate decision to continue using the zircaloy-2 in tube material of the ongoing projects (Gopalakrishnan 2002: 380). Later, these were replaced with better quality zirconium-Niobium alloy pressure tubes (Bhardwaj 2013: 789). KAPS-2 reactor became the first unit to receive the improved tube material. After the successful indigenisation of 220 MWe PHWRs, the BARC and NPCIL engineers started designing a 540 MWe PHWR.

Design, development and manufacturing of some of such plant equipment was taken up by domestic industries that were producing similar components for thermal power plants in the country. Some of the secondary system components continued to avail foreign collaboration as they were not covered by export restrictions. Public and private corporations like BHEL, SAIL, Larsen & Toubro, Walchand and Godrej industries took on some of these major supplies (Gopalakrishnan 2002). These came under sanctions after the 1998 tests (Rekhi and Joshi 1998). While all these changes pertained to the thermal nuclear reactors, another victim of the sanctions was India’s breeder program which is discussed in the following sub-section.

Impact on the Breeder Programme: Constraints and Indigenisation

Another important and adverse implication of weapon test of 1999 was on the Indian breeder program. Using liquid sodium as coolant, the breeders formed the second stage of

Bhabha's energy vision. Breeder reactors were expected to utilize the vast thorium reserves in the country. Enriching uranium in large quantities and of nuclear quality was a severe technological constraint in the initial years. The FBRs are more attractive given their fuel economy and propensity to generate lesser radioactive waste through a close fuel cycle. In fact, the breeder reactor is a better source of fissile plutonium for weapons. It does not require operations at sub-optimal level as is the case with thermal reactors. Bhabha's ultimate aim was to use the plutonium generated from the first stage and naturally available thorium to fuel the FBRs. This could take care of the issue of radioactive waste disposal while bypassing the need for enriched uranium to fuel the power reactors. These, however, are fragile systems as the leak of the sodium coolant can lead to sodium fire. Though these are important stages of the closed fuel cycle, the production of fissile plutonium and uranium in the intermittent stages is conceptually prone to proliferation risks. Sodium instability became one of the reasons in the western countries for abandoning research on them as viable routes of nuclear energy generation.

The Indian breeder program started in the mid-fifties itself, along with the thermal reactor programme. A team of scientists and engineers led by S. R. Paranjpe were dedicated to it (Bhoje 2006: 1). Internationally, France had shown keen interest in breeder technology and was operating the RAPSODIE experimental reactor. It was also constructing the 250 MWe prototype fast reactor PHOENIX. In 1968, India and France started discussing the setting up of a FBTR at Kalpakkam in collaboration. It was decided to build a 40 MWt, 13.2 MWe loop-type sodium-cooled reactor modelled after the RAPSODIE reactor in France (Gopalakrishnan 2002; Srinivasan et al. 2006).

France agreed to provide India with transfer of design of its test reactor and also provide training to Indian operation and maintenance personnel. So, the technical assistance for the breeder programme came from France but the responsibility to build and commission the FBTR remained with India (Sundararajan et al. 2008). By the time, French assistance was withdrawn in 1974, as a response to the n-test, India's breeder plant was in its initial stages of construction only. IGCAR (established in 1969 dedicated to the breeder programme) and Indian industries came together to fabricate several components and equipment for the same. The Indian team made a few additions and modification in the reactor design. They also added a steam-generator through a steam-water circuit in FBTR (Chetal 2018).

Another setback of the Pokahran-1 was the non-availability of imported enriched uranium (up to 85%) for the oxide fuel to be used in the FBTR. Plutonium rich oxide fuel had another set of operational problems and therefore the DAE had to resort to a mixture of 70% plutonium carbide and 30% natural uranium carbide to achieve high neutron emission as required by a small core of the test reactor (Prasad 2002).

The FBTR reactor took longer than expected before getting commissioned because of the withdrawal of the French assistance.

> With the much higher operational temperatures involved in the FBTR, the complexity of equipment, and the critical choice of materials, the completion of this reactor, in the absence of any foreign technical assistance and import of materials and equipment, presented a formidable challenge to the nuclear establishment (Goplalakrishnan 2002: 383).

Because of the problems in getting enriched uranium for FBTR, the DAE-SRC cleared the 'untested (mixed-carbide) fuel as the driver fuel, based on out of pile studies and international experience with low plutonium carbide fuel' (Sundararajan et al. 2008: 59). The AERB silver jubilee publication acknowledges that there are quite some differences between the fast reactor and thermal reactor physics and therefore the designers of the FBTR made great efforts to convince the DAE-SRC, the members of which were trained mostly in thermal reactor physics, to get the clearance for first criticality (Sundararajan et al., 2008: 59). Different kinds of reactor technology being used in India also imply additional work for the regulators.

After around 11 years of pain-staking efforts, the FBTR reached first criticality on October 1985. Soon after, however, a fuel-handling mishap resulted into shut down. Even repair tools needed to be designed for this reactor and it could be brought into operations in 1989. Operating at small power levels of about 1 MWt in 1989, it was slowly enhanced to 10.5 MWt by 1993 (Gopalakrishnan 2002: 383).

Several stages of consenting took longer than what it takes for the PHWRs as the reactor design was quite different and convincing the regulatory committee took lot of time and heated discussions (Sundararajan et al. 2008). This FBTR used the plutonium generated out of the CIRUS reactor built with Canadian assistance. It produces fissile plutonium as end product, which again can be used for the weapon purposes. India argued that its commitment for peaceful uses with respect to the CIRUS was limited to its non-deployment for weapon purposes. But any subsequent production of plutonium through the breeder reactor, even if it is fed upon the plutonium recovered from the spent fuel of the CIRUS, could not qualify to be covered under the peaceful use obligation unless explicitly expressed (in the Indo-Canadian agreement), which was not the case. Experiences and lessons generated from the operation of this FBTR is being used in the construction and design of the PFBR to be used for commercial electricity generation. However, its commissioning has been delayed since several years on account of several operational challenges.

Refraining from the Plutonium Inventory Declarations and Regulations

With the nuclear tests, Indian pursuit of the weapon program became known to the international community. This has also led to explicit references to weapon program and national security in India's dealing with international bodies and other states related to nuclear activities. For strategic security reasons, however, India does not declare its civilian inventory of plutonium to the IAEA or to the public. With such knowledge, it would become easier to make a fair assessment about the nuclear weapons India has which it does not want so (Rajaraman 2017). It has not signed the INFCIRC/549 declarations and the convention on safety of spent fuel management and safety of radioactive waste management too. These declarations do not in any case prescribe a time-frame within which the countries have to declare their inventory. Also, they do not have verification and inspection measures to ensure the authenticity of the national information. It also does not cover highly enriched uranium which is similarly sensitive as plutonium. Despite such flexibility, India has not signed these. The primary reason being that India does not want the world to know of its exact plutonium reserves as that could have implications for national security. Indian civilian programme being tied to the military one limits the transparency in this field. Indian participation in control of international fissile material regulation regimes therefore remain limited. India also avoided signing the Fissile Material Cut-off treaty (FMCT) for this reason. India has argued that because of its closed fuel program, the spent fuel forms a useful resource material. It has cited problems with inclusion of spent fuel in the radioactive waste convention and has refused to sign the above-mentioned conventions (Sundararajan 2017, BSCAL 2013).

For nuclear related conventions, the authority is with the DAE and the DISA-MEA. However, for signing any convention, primary consideration has been the following: whether it will require independent monitoring by a third party or not; whether it involves outside inspectors or not; will such inspections involve in any manner the diversion of some strategic information; will it involve dissemination of information that can help deduce what India's strategic programmes are. As the DISA might not know what kind of information can be exploited over a period of time, the DAE's involvement is substantial in these matters (Balachandran 2018).

Non-Separation of the Civilian and Military Facilities

As the nuclear weapon program flourished within and in the garb of the civilian program, a separation of facilities was uncalled for. Any explicit declaration of weapon program could immediately lead to cessation of foreign assistance crucial for initial stages of Indian nuclear energy programme as well. The decades ensuing nuclear sanctions post 1974 in effect forced the scientific establishment to indigenously develop the skills, technology, material and equipment for both the civilian and the military program. This required a mobilization of all domestic resources and expertise. A separation of the two programs and facilities was not required and there was no imperative to do so. A strict compartmentalization of the two programs could generate unnecessary friction and fraction within the nuclear establishment (Mishra, 2017: 108). Having developed mostly in isolation, even the safety practices needed to be evolved domestically and the cooperation between various wings was adopted as a suitable strategy for the Indian nuclear program. Because of international isolation and sanction post-tests, India developed its civilian and nuclear program in a closely integrated manner and built reactors that could be operated without the imported fuel and the required fissile material domestically. The original charter of the AERB, therefore, included overseeing and enforcing safety regulations in all facilities within the DAE as well as the outside ones involved in industrial and medical uses of radiation. Post 1998 n-tests, however, this situation changed.

Before the 1998 tests, all the nuclear facilities were under the AERB's oversight. The 1998 test did not explicitly talk about separation of the two programs but the research reactors and reprocessing plants were brought under the regulatory oversight of BARC Safety Council through the gazette notification issued in June 2000 (Grover 2017). Idea was that the military programme would not be under the same civilian regulatory body as the level of regulatory oversight would be different for these two sets of facilities. Also, with time, there has been a rising demand for inclusion of more non-DAE expertise in regulatory committees, perhaps it was considered beneficial to remove the military program from the outsiders' oversight and maintain the secrecy warranted by the nuclear weapon programme. The back end of the nuclear fuel cycle relating to reprocessing of spent fuel, fuel fabrication involving mixed oxides (for PFBR) and mixed carbides (for FBTR), high-level waste management and few others have been placed with the BARC as direct control of the government because of their significance for the strategic purposes (Grover 2004).

Overall, one can observe that a prioritization of weapon programme at those specific junctures i.e. 1974 and 1998 n-tests (not necessarily for security reasons alone) led to a marginalization of the needs of the civilian energy programme, for example, that of enriched uranium fuel required in BWRs or the PFBR. It appears that the civilian side had to suffer because there is too much emphasis on the military programme (Ramana 2017). Despite certain claims to the contrary, Indian nuclear programme was quite dependent on foreign assistance in the initial phases. Mastering nuclear technology is no easy task by any measure anyway. As the previous sub-sections demonstrate, both the PHWRs, PWRs (TAPS units) and breeder programme were considerably affected both in the short (fuel and essential component requirement) as well as long run (repair and maintenance). Relative under-performance on the part of nuclear establishment owing to above mentioned factors coupled with low reserves of high quality fissile uranium led to a considerable slowdown of the nuclear programme.

As India has neither signed the NPT nor is likely to become a member of the NPT anytime soon, international collaborations with India have been limited. However, a vast number of changes occurred with the signing of the Indo-U.S. nuclear deal in 2008, which in a major way circumvented the sanctions imposed on nuclear export to India. The next section will deal with various aspects related to the Indo-U.S. deal and its impact on India’s civilian program.

5.3. The Indo-U.S. Nuclear Deal (2008): Rationale, Processes and Implications

This section outlines the thinking in policy-making circles in India which influenced its decision to sign the Indo-U.S. nuclear deal. To understand the implications of the deal on India’s nuclear regulatory regime, this section will analyse the nature of safeguards commitment that India agreed to commit to and impact on the AERB’s functioning, if any. It argues that even though the deal pertained to civilian nuclear energy programme, one of the most important consideration in the negotiation process and eventual content of the deal reflected a preponderance of concerns associated with strategic programme.

The 18 July 2005 Indo- US joint statement opened up the possibilities of an international nuclear cooperation, which had been precarious because of the sanctions. This deal was an implicit but the most vibrant recognition of India as a nuclear weapon state. The extensive and minute negotiations that led to the Indo-U.S. nuclear deal reflect the anxieties of both the sides along with rest of the world for its consequences for the non-proliferation regime and nuclear commerce as a whole.

A literature review highlighted following major reasons for Indian interest in nuclear deal (Ravi 2018; Bommakanti 2018; Rajagopalan 2009; Jain cited in Ramanathan 2007)

1) To end India's isolation in international nuclear commerce
2) Strategic alignment with US (in countering China) (not a subject matter of this thesis)
3) To meet India's growing energy requirement

MEA (2008) statement on Indo-U.S. deal read,

> The Agreement would end technology denial regimes against India that have been in place for three decades and end India's nuclear isolation. It will open the doors for India to have civil nuclear cooperation as an equal partner with the USA and the rest of the world. It will enable us to meet the twin challenges of energy security and environmental sustainability. It will also have major spin-offs for the development of our industries, both public and private. At the same time, it will bring India the recognition it deserves thanks to the outstanding achievements of our scientists (MEA 2008).

The need for entry into the nuclear commerce regime, was one of the major reason for Indian interests in the deal. With a substantial indigenous programme, the Indian nuclear establishment hoped to be able to emerge as a supplier itself in the medium to long-term, especially relating to nuclear fuel cycle and the breeder programme. There have been global efforts at restricting the transfer of fuel cycle related technologies and material so as to lessen the dangers of non-proliferation. This would result into a more close-knit group of suppliers in such technologies in a multilateral oversight mechanism. An entry into the nuclear commerce regimes, therefore, could be beneficial for India in long-terms as it can emerge as supplier of some of these technologies and materials (Grover 2015).

Deal's importance for growing needs of energy in India has been widely acknowledged in the official circles. Precise reason of such indispensability is, however, disputed. There are two sets of plausible reasons here:

a) Lack of domestic fissile uranium in adequate quantity and quality for a sustainable nuclear energy programme

b) Need for technological collaboration for increasing the scale of expansion and availing technologies which Indian scientists have not been able to master at commercial scale.

The Indo- U.S. nuclear deal was crucial for supply of uranium as fuel for Indian reactors. Though India had mastered the designing and construction of the PHWRs, there was a crunch of natural uranium to fuel the large number of reactors envisaged under the nuclear energy plan. Even the available uranium has not been in utility as environmental clearance for some uranium mines has been problematic, for example, Meghalaya uranium mining met with huge local protests and was closed (Chetal 2018).

Keeping in mind the growing requirement of nuclear energy, withdrawal of assistance from western countries (except in few specific cases like French supply of Tarapur fuel for a certain period) and slow pace of indigenous production, the DAE around mid 1980s decided to purchase large capacity boiling water (1000 MWe) from SU (Sundararajan et al. 2008). A slow pace of the breeder programme which is the second stage, compelled DAE to consider the PWRs even when they did not fall in tune with Bhabha's programme. Though nuclear energy cooperation with Soviet Union continued even in the wake of the sanctions, it was not enough to fulfil the huge needs of Indian nuclear energy program in the areas of procurement of fuel and associated technology. Russian help, though precious given the isolation, was limited partly by the concerns of non-proliferation and partly because of NSG conditionality with respect to dual use items and technologies.

Over the years, India has mastered the production of PHWRs with enhanced safety features. However, these reactors are of small capacity with a maximum of 540 MWe [700 MWe capacity one has been proposed though (Bhardwaj 2013; Mohan 2016). As far as indigenous capabilities to pursue BWR technology is concerned, though India has been operating BWRs at Tarapur, it has not designed or constructed one indigenously that could be deployed for commercial purposes. Building large size reactors is a challenge in itself. No indigenous plant of 1000 MWe capacity or higher has been developed in India. Russian-origin 1000 MWe VVER being operated in India (even those were not operational before the deal).

As far as breeder program is concerned, the FBTR has been operating for over 25 years with intermittent shut downs and the PFBR for commercial harnessing of nuclear energy has not entered into commissioning as yet. Experimental breeder programmes are being pursued in countries like China, Russia and others. Some of the scientists interviewed by this researcher argued that India itself being a pioneer in the field might not benefit by international cooperation (Raj 2017, Grover 2017). Whether breeder research in other countries can help solve some of the difficulties faced by Indian breeder programme is unknown to this researcher. But the DAE was not in favour of putting breeders under safeguards even at the prospect of technological collaboration.

In terms of uranium enrichment and reprocessing capabilities, the interviewees responded that India already had the technology even before the deal as there is a functioning enrichment unit in India in Rattehalli which provides fuel for the Indian nuclear submarine reactor (Balachandran 2018, Grover 2017, Sood 2018, Ramana 2004).

Countering the argument of technological collaboration as a rational for India pushing for Indo-U.S. nuclear deal, Indian scientists have argued that in fact, India’s nuclear technological advancements especially in the FBR program was a lucrative proposition for the US, along with the strategic interests of course and therefore a reason for US to push the deal harder (Raj 2017, Grover 2015). Recognizing the technical advancements of the Indian scientists, they were invited in Generation IV International Forum for Future Reactor Design and in discussions about establishing the International Thermonuclear Experimental Reactor (ITER) project (Squassoni 2005) to harness fusion process on a large enough scale and India was accepted as a full partner, along with China, EU, Japan, South Korea, Russia and the USA in 2005, even before the Indo-U.S. deal was formally signed. This view reflects the advance state of such nuclear technology in India and disputes the argument of technological collaboration as a major incentive for India in the Indo-U.S. nuclear deal.

Need for technological collaboration in developing and handling large capacity PWRs and/or breeder program have not been accepted as one of the official rational for the deal and a lack of fuel (uranium) has been cited as one of the most important reasons for Indian pursuit of the nuclear deal (Grover 2018, Sood 2018, Subrahmanyam 2005). Indian energy projections cited after the Indo-U.S. nuclear deal, however, referred to purchase as well as indigenous development of large capacity BWR to achieve energy targets set by the DAE. Interviewees disputed the argument that technological collaboration was one of the important reasons for Indian pursuit of the nuclear deal. The MEA did acknowledge that the agreement could "enable us to meet the twin challenges of energy security and environmental sustainability. It will also have major spin-offs for the development of our industries, both public and private" (MEA 2008). The technological collaboration therefore was seen as an incentive, though not absolutely indispensable.

In the broader context of the envisaged Indo-U.S. strategic cooperation, President Bush conveyed his intentions to assist the Indian civilian nuclear energy programme. Recognizing India as "a responsible state with advanced nuclear technology",[62] he proposed that "India should acquire the same benefits and advantages as other such states" (U.S. Department of State 2005). To help India achieve nuclear security through nuclear power, he committed himself to seek agreement from Congress to adjust U.S. laws and policies. Not only that, he offered to work with friends and allies to adjust the international regimes in a way so as to enable full civil nuclear energy cooperation and trade with India, including but not limited to expeditious fuel supplies for safeguarded nuclear reactors at Tarapur (U.S. Department of State 2005). On its part, the Indian PM Manmohan Singh reciprocally agreed to "assume the same responsibilities and practices and acquire the same benefits and advantages as other leading countries with advanced nuclear technology, such as the United States". This he clarified, implied (U.S. Department of State 2005)

> a) identification and separation of civilian and military nuclear facilities and programs in a phased manner and filing a declaration regarding its civilian facilities with the IAEA;
>
> b) *voluntarily (emphasis added)* placing its civilian nuclear facilities under IAEA safeguards;
>
> c) *signing and adhering to an Additional Protocol with respect to its civilian nuclear facilities (emphasis added)*;
>
> d) continuing India's unilateral moratorium on nuclear testing;
>
> e) working with the United States for the conclusion of a multilateral Fissile Material Cut Off Treaty;

[62] Responsible behaviour shown in an 'exceptional' record of non-proliferation (Burns 2005) in terms of export controls (Squassoni 2005).

f) Refraining from transfer of enrichment and reprocessing technologies to states that do not have them and supporting international efforts to limit their spread and

g) ensuring that nuclear materials and technology are secured through comprehensive export control legislation and through harmonization and adherence to MTCR and NSG.

Of these the first three were most consequential for the expansion of Indian civilian nuclear power programme.

The nuclear deal did not explicitly recognized India as a nuclear weapon state. The term used was ‘countries with advanced nuclear technology’. Being undefined as such, there was confusion among the policy makers as to which safeguards regimes could be applicable to India.

Soon after the Indo-U.S. joint statement was released in 2005, the Indian Foreign Secretary Shyam Saran told media that India will accept such conditions as are accepted by nuclear weapon states. As a NWS under the NPT, the safeguard agreement allows the US (and other NWSs) to redesignate a civilian facility as military subsequently. The NWS do not apply safeguards on their R&D reactors as well (Prasad 2006). Such propositions could hardly be sold to the US Congress, which raised concerns about continuation of India’s nuclear weapons programme as a threat to the non-proliferation regime. President Bush had to face a lot of opposition and criticism domestically and internationally for trying to secure compromises for India in terms of nuclear trade concessions without being a signatory to the NPT.

The NSG guidelines allow a more permissive environment for the nuclear weapon states under the NPT to engage in nuclear transfers without license. The NNWs, however, are supposed to abide by the full scope safeguards of the IAEA on *all the current and future peaceful nuclear activities (emphasis added)*. Under the Indo-U.S. nuclear deal, these terms of nuclear trade needed to be tailored to reach a compromise between the most favourable option for India, which was to avail US-IAEA kind of safeguard and exemption under the nuclear trade regimes like the NSG, Wassenaar arrangement, and the most favourable option for the USA which wanted to cap India’s nuclear weapon programme, bring it under the non-proliferation regime even if in a limited way without compromising much on the credentials of the regime itself by rewarding a violator of the regime (apart from its own interest in selling nuclear reactors to India) i.e. India. US

Under Secretary Joseph testified,

> We indicated at the recent G-8 and NSG meetings that we would not view a voluntary offer (of the type in place in the five internationally recognized nuclear weapon states) as defensible from a non-proliferation standpoint or consistent with the Joint statement and therefore do not believe that it would constitute an acceptable safeguard arrangement (Joseph 2015: 5).

Therefore, the decision-makers in the US categorically rejected such a liberal arrangement. While the joint statement allowed India for 'voluntary' placing of reactors under the civilian list, US was not ready to offer similar flexibility as applicable under the voluntary safeguard agreements, which implies that a facility can be put off the list later. Difference lies at the voluntary decision component that can be made regarding taking off a particular facility off the civilian list.

The Indian side was willing to accept the safeguards as long as it did not harm its strategic programme. At one-point Kakodkar, the then DAE secretary argued that the technical integrities of separation needed to be mutually agreed upon in a way that India's strategic interests were not hurt in any way. He said,

> Both, from the point of view of maintaining long-term security and for maintaining the 'minimum credible deterrent', the Fast Breeder Programme just cannot be put on the civilian list. This would amount to getting shackled and India certainly cannot compromise one (security) for the other. (Kakodkar interviewed by P. Bagla 2006).

He argued that as the weapon programme was pursued at a later time compared to the civilian programme and both are intimately intertwined along the end stages and the fuel cycle, the breeder reactors could never be put under the safeguards. He cautioned that not only the present but also even the future breeders could not be put under the safeguards. He agreed that putting the breeders under the safeguards would hurt both- *minimum credible deterrence and long-term energy security* (emphasis added). Breeder program therefore had utility for both- civilian as well as military program (later never explicitly declared in official circles but is a widely known fact). This statement, rather, reflects that breeder reactor has a utility for Indian weapon program.

Many Indian scientists, led by Anil Kakodkar, urged against placing the FBR under the safeguards, also because they feared that IAEA inspectors could impede the research work and intellectual property rights claimed by India could get diluted with close external monitoring (Kakodkar, A. interviewed by P. Bagla 2006). The possibility of certain exclusive technical competence in the breeder technology cannot be denied completely. The reactor design was borrowed from France but later many inputs were indigenised (Bhoje 2018). Kakodkar, in fact, raised a pertinent point with respect to research. The R&D with the breeder technology being a new novelty, would require multiple changes in the kind and design at different junctures. Putting those under the safeguards could curtail the ease of scientific undertakings and involve a lot of paper work, which could dampen the scientific spirit. Also, one would need to explain the rationale of changing the path of research to the safeguard inspectors. Being experimental technology, these occurrences could probably be numerous. Many scientists in the DAE were vary of the fact that if kept under the safeguards various innovative technological features and mechanisms that have been developed indigenously over the years would have to be shared with the IAEA inspectors and that information could be leaked to US or other countries with advance nuclear technology (Ramachandran 2006). At the same time, the breeder programme would be slowed down as any movement of safeguarded material even within the premises requires inspectors to be called (Jain quoted in Balachandran 2006). Resonating these concerns, PM Singh declared in the Indian parliament in 2006,

> The separation plan that is being outlined is not only consistent with the imperatives of national security, it also protects our vital research and development interests. We have ensured that our three-stage nuclear programme will not be undermined or hindered by external interference. We will offer to place under safeguards only those facilities that can be identified as civilian without damaging our deterrence potential or restricting our R&D effort, or in any way compromising our autonomy of developing our three-stage nuclear programme (Ministry of External Affairs 2006).

Apart from such patent issues, there were also apprehensions that placing FBRs under safeguards would undermine the deterrence as the credible number of such warheads has not been determined (Pakistan and China too have not declared the number of their warheads). Placing such facilities under safeguards would have undermined the long-cherished objective of Indian policy makers of pursuing nuclear weapon programme unhindered by external forces.

Malik and Kanwal (2006) contended that any move to this effect could be counter-productive too because the reactor grade plutonium is of low quality, rigged with inconsistent fission predictability and is more prone to accidents. Therefore, some of the PHWRs alone, even if kept out of the civilian list would need to be scaled down considerably to produce the weapon grade plutonium in a low burn-up mode. The normal operating fuel burn-ups in the 220 MWe PHWRs is around 7000-8000 MW-days/ton (MWd/t). To extract weapon-grade Pu from these, the burn-up should not exceed about 2000 MWd/t (Malik and Kanwal 2006). This could imply substantial loss of energy. At the same time, the reactor grade plutonium (at present about 10 tons) from the PHWRs is required for feeding the FBTR and the PFBR (each reactor requiring 3-4 tons) and therefore this route could be highly uneconomical as compared to weapon-grade plutonium generation through the unsafeguarded FBRs.

Also, the Pu-239 produced in the PHWRs is contaminated with other higher isotopes like Pu-240, 241 and 242 (up to 20%) and is difficult to be separated during reprocessing. A higher percentage of higher isotopes in spent fuel of power reactors is attributed to the high burn-ups of the fuel, which is responsible for higher electricity generation in PHWRs than research reactors (Ramachandran 2006). A nuclear weapon made from the reactor grade plutonium therefore is ‘dirty’. This, in effect, implies that though weapon grade plutonium can be recovered from processing spent fuel of PHWRs, these impose higher reprocessing cost, efforts, lowering of operational power rating of commercial PHWRs and so on as compared to use of plutonium generated through breeder. Keeping breeder programme, out of the list of civilian facilities and therefore, out of safeguards was staunchly pursued by the DAE (Bommakanti 2018).

Kakodkar, the then chairman AEC, in a public statement cautioned against putting the PFBR and the IGCAR R&D facility under safeguards citing strategic reasons. The civilian nomenclature could not be adopted without considering its costs and implications on the strategic programme, which needed to be evaluated before agreeing to such separation. The FBRs run on the plutonium recovered from the spent fuel generated by the heavy water reactors but in turn produce weapon-grade plutonium. In a breeder, unlike the thermal reactors, even the contaminants react with fast neutrons causing higher economy of plutonium generation (Ramachandran 2006).

Ramachandran (2006) clarified that the diversion of some of the plutonium generated out of the breeders for strategic programme would have made sense for the reasons of credible minimum deterrence especially since the Pakistan’s nuclear arsenal were on increase. In fact, the breeder and Dhruva alone (CIRUS got decommissioned in 2010), based on his calculations, could not offer parity with the Pakistani arsenal as quite some amount of the breeder generated plutonium is to be employed for feeding the breeder itself in what is called the 'doubling period', in effect reducing the quantity of weapon grade plutonium. Construction of another Dhruva like facility with higher capacity was not prohibited under the deal but it was considered a costlier option with a substantial gestation period. To ensure a continuous and significant number of nuclear weapons to be produced on an annual basis, DAE pushed for keeping the breeders out of safeguards. Also, U-233, a by-product generated in the FBRs is a suitable fuel for Indian nuclear-powered submarine under the R&D or the ATV project (Malik and Kanwal 2006). These calculations seem to be a justification of the separation plan proposed by the DAE.[63]

Though there are no official declarations to the effect, especially since the nuclear projects have run into difficulties mostly because of liability concerns and land related local protests (Mohan 2016), there is nothing in the deal to stop India from putting breeders on the civilian list. Doing this, in fact, would facilitate the supply of fuel for these reactors which could be solely employed for energy generation through the plutonium and probably thorium cycle in the future. However, the policy circles seemed to be favoring weapon security more than energy security.

The entire BARC complex at Trombay and Kalpakkam including the IGCAR and the twin PHWRs at the MAPP, the two breeders, the nuclear submarine project at Ratahelli and the associated fuel reprocessing facilities were proposed to be kept out of the civilian list. Till the time, the plutonium economy from the breeders was not sufficient enough to match with Pakistani weapon generation, the thermal reactors at the MAPP could be operated on low burn-up mode to produce the strategic weapons.

Research reactors became another bone of contention between India and US. The US wanted the research reactors to be put under the safeguards. The weapon grade plutonium i.e. Pu-239, comes mostly from these two research reactors- 100 MW Dhruva and 40 MW CIRUS. Their spent fuel contains less than 7 percent of higher isotopes unlike the power reactors. CIRUS used natural uranium as fuel, heavy water as moderator and light water as coolant. The Dhruva reactor is based on the Canadian NRX research reactor. These two

[63]According to him, the Indian weapon capacity in 1998 was nearly 35 weapons (as some of the plutonium available from CIRUS and Dhruva was consumed in Pokharan-I and around 65 kg used for the initial loading of the FBTR) while the Pakistan's was 10. In the following decades, however, the Pakistani arsenal grew at a rapid pace given the construction of 50 MWth research reactor at Khushab in 1998 so much so that it achieved parity with Indian arsenal around the 2006 period, amounting roughly to 50-55 weapons on both the sides. With only Dhruva producing the weapon grade plutonium, the Indian strategic community feared that Pakistani arsenal capacity could grow beyond India's soon.

reactors contributed to the generation of most of the weapon-grade plutonium in India. US wanted to bring the fissile material generating facilities too under the safeguards, which, for obvious strategic reasons had no takers in India, in either the political or the scientific establishment. The US was particularly interested in directing the Indian side to put the CIRUS facilities under the safeguards as it was a considered a violation of the initial agreement under which the CIRUS reactors were fueled by the heavy water provided by the US (discussed in second section of the chapter). The plutonium generated out if it was used for India's nuclear weapons. The Indian side on the other hand resisted the idea on various grounds. One of the arguments being that since the west stopped supplying the fuel which was also a guarantee under the initial agreement and was violated by the west, the reactor was refurbished through indigenous efforts. To work out the technical modalities of the civil nuclear cooperation, two expert groups comprising members of DAE, MEA, army and PMO office were constituted to negotiate the details while keeping in mind the objective of preservation of the strategic nuclear programme. The extensive negotiations focused on four main elements: "the broad contours of a separation plan; the list of facilities being classified as civilian; the nature of safeguards to be applied to facilities listed as civilian and the nature and scope of changes expected in US domestic laws and NSG guidelines to enable full civil nuclear cooperation" (MEA 2006). PM Singh declared to this effect,

> ..in deciding the contours of a separation plan, we have taken into account our current and future strategic needs and programs after careful deliberation of all relevant factors, consistent with our nuclear doctrine…there has been no erosion of the integrity of our nuclear doctrine, either in terms of current or future capabilities…we remain firm in that the decision of what facilities may be identified as civilian will be made by India alone and not by anyone else. (Ministry of External Affairs 2006).

One of the most important factors informing India's proposed separation plan, therefore, was preserving the autonomy of its strategic capabilities. Probabilities of Pakistan's higher annual enrichment centrifuge capacity and plutonium inventory were instrumental in Indian desire to push for keeping the breeder program out of the safeguarded civilian list. China, in any case has a higher nuclear potential quantitatively and qualitatively both. In order to not be caught off-guard for any such eventuality in the future where the robustness of India's nuclear weapon capacity could be questioned, an urge for keeping the strategic resources unsafeguarded was quite strong in Indian circles. The Indian breeder program being in infancy was already consuming some of the plutonium as part of the initial loading of the fuel in breeder reactor, resulting in an overall decline in potential fissile plutonium inventory.

Since the nature of safeguards were instrumental in India's acceptance of the deal, a lot of negotiation efforts focussed at deciding on the nature of safeguards. The nature of safeguards that were to be applied to the civilian reactors determined to a large extent, the number of such reactors that India could agree to put on the civilian list. Therefore, several negotiation efforts were made at the Indo-U.S. nuclear deal to work out a proposal to the mutual liking of both the parties. Following safeguards type were in operation in different multilateral safeguards arrangement administered by the IAEA:[64]

1) Facility-specific, the INFCIRC/66- adopted in 1965, these safeguards are item-specific, also known as 'islanded safeguards agreement' (Ramachandran 2005: 578). These were prevalent before the adoption of the NPT and most of the agreements involving NPT members have been replaced by more extensive ones. As India has not signed the NPT treaty, there were conjectures that India could declare a separation of its civilian and military facilities and declare the civilian ones under INFCIRC/66 safeguards for the purpose of procurement of fuel for these facilities.

2) Comprehensive Safeguards Agreement (CSA)- the INFCIRC/153 (corrected)- approved in 1970 with the coming into force of the NPT, this instrument applies to all the nuclear material in all nuclear activities of the non-nuclear weapon states signatory to the NPT. India was not ready to accept the same as it possessed and continue to possess nuclear weapons and therefore the safeguards could not be applied to its facilities. An acceptance of this safeguard mechanism would have required India to give up its nuclear weapons and then avail the civilian nuclear commerce benefits. In effect, it implied entering the NPT as a non-nuclear weapon state, a choice that is absolutely formidable in its policy circles.

3) Model Additional Protocol -INFCIRC/540 (corrected)- approved in 1997, this instrument too provides for extensive mandate of the IAEA to inspect all the

[64]Additionally, there also was 'Small quantities protocol'- approved in 1971 and modified in 2005. This mechanism is available to states with very small quantities of special fissionable material not exceeding 1 kg. India stands far advanced in terms of its nuclear programme to undertake such safeguard regime.

facilities associated with the nuclear fuel cycle to ensure non-diversion of nuclear material to the weapon programme. This too was unacceptable to India as giving up nuclear weapons was a not conceivable option for it.

4) Voluntary offer safeguards agreements- there is no specific format of these agreements but these have been concluded separately and individually by the nuclear weapon states of the NPT with the IAEA as confidence- building measures. There are five such templates specific to each of the NWS: UK (INFCIRC/263), USA (INFCIRC/288), France (INFCIRC/290), Russia (INFCIRC/327) and China (INFCIRC/369). As India had not signed the NPT, it could not be treated at the same level as other nuclear weapon states designated under the NPT. NWS can divert the material from safeguarded reactors and shift the safeguarded facility to the list of unsafeguarded facilities on the pretext of national security by giving a notice to the agency (Ramachandran 2006).

India was proposing different safeguards standards for different facilities and programmes depending on the nature of the safeguard, degree of indigenisation, nature of fuel and design and contribution to the strategic programme. Processes attached to the nuclear fuel cycle mainly comprise of several facilities and India proposed the following initially: (Balachandran 2005):

a) Uranium mining, milling and refining- taken up by the UCIL, it could not be put under the international safeguards.

b) Isotope separation- it is carried out at the Rare Materials Project at Mysore, placed under BARC. The enrichment facilities here are known to contribute to the strategic programme and nuclear-powered submarine program, making it imperative to keep it out of the safeguards.

c) Fuel and target fabrication- This is performed at the NFC, Hyderabad. Some of the units at the NFC were dedicated to fabricate imported enriched uranium fuel and so were already under the IAEA safeguards. India proposed keeping it that way. But declaring it a civil facility could undermine the weapon related units and activities like the production of materials such as tantalum oxide and nuclear-grade calcium used in the castings of weapon cores or the vacuum arc furnaces could be jeopardized (NTI 2003a). In the final agreement, certain units of the NFC viz. 1) Uranium Oxide Plant (Block A); 2) Ceramic fuel fabrication plant (block A); 3) Ceramic fuel fabrication plant (Block A); 4) Enriched Uranium Oxide Plant; 5) Enriched Fuel fabrication plant and 6) Gadolonia facility have been placed under the safeguards (IAEA 2012c).

d) Power reactors - US initially insisted that all the civilian Indian reactors be placed under the safeguards. It was a deal breaker demand so US insisted that at least a ‘great majority’ of 22 Indian reactors be placed under the safeguards to convince the world of India’s peaceful intentions (Muhammad 2006). Considering great majority to mean three quarters, it implied putting 17 reactors under the civilian list including the 6 reactors that already did since 1974 test.

The nature of safeguards- whether to be applied in perpetuity or not- largely determined the Indian choice of such reactors to be put under the safeguards. Out of the 21 operating nuclear power reactors in 2015 (including the 2 plants at Kudankulam) with an installed generating capacity of 5780 MWe, 13 with a total installed capacity of 3380 MW were put under the IAEA safeguards and therefore could be declared eligible for imported fuel (Department of Atomic Energy 2015). A few power reactors even when linked to the electric grid (civilian purposes) were kept out of the safeguards as the spent fuel generated out of these reactors in ‘low burn ups’ mode could be processed to produce the weapon grade plutonium, even though it would undermine the efficiency of these reactors in energy generation. Also, it would be cheaper than building a separate research reactor for generating weapon grade plutonium (Ramachandran 2006). At the same time, some PHWRs were to be kept out of the civilian list so that they could be utilized for tritium production to be used for weapon purposes (Srinivasan M. R. interviewed by R. Prasad 2006). These continue to be fuelled by the domestically produced uranium (Sasi 2018).

e) Component fabrication- the exact location of the facilities carrying out these activities is not a common public knowledge. Many of these are carried out at the NFC which has been discussed. Tritium extraction facility and such having values for weapon programme were to be classified as military.

f) Weapons operations- All the sites holding nuclear weapons temporarily or permanent were to be outside the safeguards. But as the deal did not require the inventory of such locations, no separate list for military facilities was to be given.

g) Research and development activities- The two research reactors- Dhruva and CIRUS were devoted primarily for recovering plutonium for weapon program. These were deemed to be classified as military. The CIRUS reactor however, had been a touchy issue for America. According to a news report, Kakodkar and R. Chidambaram supported the shutdown of the ageing reactor in view of its declining potentials and it was decided that it would be shut down (Gopal 2006).

h) The reprocessing facilities - India had started producing and separating plutonium in the phoenix reprocessing plant by 1965, even before operating any power reactor. Indian emphasis on breeder programme for generating large amount of energy perhaps prompted this step. But at the same time, these are instrumental in plutonium based Indian nuclear weapons.[65]

India did not want to put any of these reprocessing facilities under the safeguards for the purpose of the deal. First of all, these reprocessing facilities are greatly related to the production of plutonium for weapons. Secondly, the limited international cooperation in this field prompted great indigenous undertakings to develop the technology. Sanctions, subsequent to weapon testing made the indigenisation all the more necessary. Thirdly, it contributes to the breeder program. All the reprocessing facilities are under BARC, which handles India's strategic weapon production. The idea was to keep the plutonium related information under covers as part of the national security policy (Raj 2017).

The Tritium extraction plant directly related to weapon program also is located at Kalpakkam. These concerns related to weapon program therefore shaped India's choices in proposing the separation plan. The idea of having separate reprocessing plants for civil and military purposes did not make much sense as it would imply duplication of infrastructure, equipment, personnel etc. which would not only be costly but also

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[65]There are three such reprocessing facilities in India (all under BARC) (: 1) Trombay reprocessing plant – the 1st reprocessing plant with a capacity of 60 tons per year, commissioned in 1964, reprocesses irradiated fuel form Dhruva reactor for weapons production. 2) PREFER at Tarapur- This plant was commissioned in 1975 and began operations in 1979. Before the deal, it was under what was called the 'campaign safeguards' i.e. when it reprocesses the natural uranium from RAPS-I and RAPS-II, which are under safeguards, the reprocessing facility too works under the safeguards. India did not want to put this facility under the civilian list as the safeguards are for perpetuity. And the plant contributes to the strategic programme too. It supplies fuel for the FBTR and Tarapur mixed oxides fuel fabrication facilities (NTI 2003b). 3) Kalpakkam Atomic Reprocessing plant- this indigenously built facility commissioned in 1998 reprocesses fuel from 2 PHWRs- the MAPS in Kalpakkam and FBTR (NTI 2003c). It provides the plutonium supply for the upcoming PFBR being developed at the IGCAR through a separate line for mixed-carbide fuels (Global security). This plant also separates plutonium for strategic purposes (Albright and Kelleher 2015) and was not under any IAEA safeguards.

unproductive as the weapon facility would be largely un-operational (Ramachandran 2005). Resources were limited anyway.

The Indian side was extremely conscious about the separation to the effect that it should not affect the strategic nuclear program adversely. Because of the non-separation of civilian and military nuclear programs in the first place, some of the facilities contributing to strategic arsenals were also connected to the power grid and the Indian side was finding it difficult to demarcate these facilities as civilian.

The entire separation plan reflected the utmost importance accorded to the strategic programme by India. The language of the plan primarily implied that every civilian facility, if not declared 'civilian' explicitly, will be considered as a 'military facility' and was to remain unsafeguarded. It provided"

- India will include in the civilian list "only those facilities…that, after separation, will no longer be engaged in activities of strategic significance" (Squassoni 2006: 21);
- The overarching criterion would be a judgment whether "subjecting a facility to IAEA safeguards would impact adversely on India's national security" (Squassoni 2006: 17);
- However, "a facility will be excluded from the civilian list if it is located in a larger hub of strategic significance, even if they were not normally engaged in activities of strategic significance" (Squassoni 2006: 17);

This implies three set of facilities here: purely civilian ones (designated so), functionally civilian but of dual-use purposes, and facilities of purely military nature. Officially, the second type has been clubbed into the last category.

As the Indo-U.S. nuclear deal tacitly recognized India as a nuclear weapon state, it was widely understood that some of the facilities would be kept out of the safeguard for the reasons of national security. Having concluded the negotiations, an India-specific safeguard was approved by the IAEA Board of Governors on August 1, 2008 to come into effect when India could declare having met the constitutional or statutory requirements for the same. On March 15, 2009 India signed the Additional Protocol and ratified it on June 22, 2014. It was one of the obligations under the deal in order for it to fructify. This additional protocol, however, took a lot of diplomatic efforts in finalization. The Model additional protocol system was designed for the non-nuclear weapon state where military programs were out of question in the first place. Applying it with regard to India, therefore was not feasible.

To suit the Indian case specifically, an additional protocol was customized. First of all, it applies on the civilian facilities as declared by India while leaving untouched the undeclared facilities implying continuation of nuclear weapon programme. Secondly, India was obligated to provide a list of civilian facilities alone. Any facility or programme not put under the civil list was considered to be military. But not making a separate list for military installations gave India more leverage to modify the future management of such installations. Once put in the civilian list, the facilities could not be shifted to military use. The 'in perpetuity' provision would bar such an arrangement. However, the non-requirement of a military list enabled India to maintain ambiguity about the real nature of non-civilian installations and flexibility to change their nomenclature in future. Also, this protocol differs from the model protocol significantly. It, most importantly lays down an obligation on India to provide the information about nuclear-related exports to the IAEA so as to ensure that the material is not diverted for unauthorized use. It provides for reporting on exports by India but leaves aside the activities related to R&D or reporting on imports (Wikileaks 2009).

India was also obligated to grant long-term visas to the safeguard inspectors designated by the IAEA (Grover 2015). The AP now allows the IAEA personnel to make regular entry and exits through multi-entry visas and guarantees 'free communication' generated by the surveillance or measurement devices of the IAEA that are put in place at the safeguarded facilities (Aneja 2014). The final safeguards agreement covers a total of 20 facilities including the Nuclear Fuel Complex, Hyderabad, the erstwhile safeguarded reactors and a few more like RAPS, Kudankulan plants and Kakrapar plants. The more intrusive inspections by the IAEA have been compensated well enough. The deal does not provide a termination clause in case of a nuclear 'test' and no trigger event as such specifically has been mentioned, primarily on the insistence of Indian negotiators. The U.S. national executive, however, can terminate the cooperation agreement under its national laws. Another important concession, among others, relates to right to re-processing. Under the deal, India has been given the right to reprocess the safeguarded nuclear material if the corresponding national reprocessing facility is put under the IAEA safeguards. This permissive environment is, however, conditional upon the prior consent to re-process on the part of the suppliers. This implies that such cooperation between the nuclear suppliers and India is not prohibited officially. It, however, is left to the diplomatic skills and political will of the negotiating parties.

The unsafeguarded facilities too can use the safeguarded fuel under the ‘campaign mode’ as facilitated by clause 25 of the deal albeit with certain set criteria. In terms of non-proliferations gains, many of the spent fuel and plutonium produced by the civilian domestic reactors came under the safeguards. The Indian deal evokes the conditions of perpetuity and Pursuit. The latter means that wherever the safeguarded material goes, safeguard will go along with that. Also, anything produced using this safeguarded material, too will come under the safeguards. Under the perpetuity clause, even if the US (or any other country) withdraws fuel supply to India, whatever has been provided till then would still be under the safeguards of the IAEA and also the material generated out of that (Balachandran 2018).

The requirements under the Hyde Act, USA, for example, constrain the reprocessing of the spent fuel according to conditions “commensurate with operating requirements”. This limitation is surpassed in the Indo-Russian agreements though, where pursuance of a closed fuel cycle is no constraint. A reprocessing by India of spent fuel generated out of atomic power plants built with Russian acceptance is allowed if the associated reprocessing plant too is brought under safeguards for that operation (Kazi 2007, Gopalakrishnan 2002).

The issues of enrichment and reprocessing technologies have run into diplomatic troubles over a period. Obama, keeping in mind the concerns of non-proliferation, opposed the transfer of these technologies to India without being an NPT signatory. The near consensus view in the NSG too, seems to reflect ‘utmost restraint’ on the part of the members in transferring such technology to India (Sultan and Adil 2008).

At the end, the APSARA reactor was decommissioned in 2010, mostly because of the US insistence (Gopal 2006). This reactor could be classified as civilian without adversely affecting the strategic programme. It was the only planned reactor in India using HEU and has been shut down and the planned replacement reactor would not be employing HEU

(MEA 2014a). Its, core using HEU, however, was replaced with a core not using HEU because of proliferation concerns raised by the US.

The deal also includes fuel assurances for India in case of any disruption in fuel supply in future. The provisions commit the U.S. to help India in establishing 'strategic fuel reserves' for the lifetime of its nuclear reactors in case the foreign supplies are halted through other sources. The nature of 'disruptions', however, remains unspecified. Some interpretations argue that the disruptions as specified refer only to sources beyond Indian political control for example market failures and others. Later, the U.S. President Obama clarified that these were political commitments and not the binding legal ones subjecting such cooperation to the state of Indo-U.S. relations.

All the nuclear cooperation agreements (NCAs) that India signed after the NSG waiver with foreign countries have the consent for reprocessing of spent fuel. The NCA with Russia even includes technological collaboration and development of associated technological know-how in India (MEA 2014b). The Indo-Russian cooperation reflects more flexibility on the part of Russia to support Indian nuclear energy programme as it continues despite the G-8 resolution restricting the sale of reprocessing technologies to non-NPT countries and does not require a return of the fuel and equipment already supplied to India in case a nuclear agreement gets terminated in future, as is required under the American-Indian nuclear pact (Rudyuhin and Dixit 2009). All the NCAs, however, have these common main features (Grover 2010):

1) Cooperation entails respective obligations. India would not comply with provisions of mechanisms it has not formally adhered to like the NPT, CTBT and others;
2) The cooperation is based on the premise of India's special status on account of NSG waiver;
3) India's need of assured fuel supplies is taken into consideration;
4) While the cooperation is limited to peaceful purposes, it would not affect India's strategic programme and facilities, the Indian military nuclear programme though not accommodated in NPT is recognized for practical purposes;
5) Both the safeguarded and unsafeguarded facilities, nuclear material, non-nuclear material, equipment, components, information or technology which India produces

or develops independently of the transferred items, remain under the Indian right to use;

6) Implementation mechanisms to facilitate and regulate the transfer of such material, equipment and technology to India;
7) Safeguards implementation will be through the safeguards and not through bilateral arrangements;
8) Physical Protection measures would be based on standards set under the CPPNM by the IAEA than on bilateral understanding;
9) Consent for reprocessing of the spent fuel and
10) Protection for Indian IPR in nuclear field.

Overall, one can observe that though India needed the deal for revitalizing its nuclear energy programme, one of the most important consideration shaping Indian proposal was unobstructed functioning of its weapon programme. The entire separation plan was catered to preserve the autonomy of strategic facilities even if it meant compromising on civilian program. Not putting breeder program under civilian list, which could benefit with international collaboration and fuel supply is a case in point, putting as many reactors as civilian to get imported fuel, another (Subrahmanyam 2005). The need for the deal compelled India to undertake safeguards obligations that it shied away from in the past. The deal therefore integrated India with the international regulatory regime pertaining to safeguards. This integration, however, is limited in nature and degree because of continuation of India’s weapon program. The next section will try to situate the AERB within the realm of safeguards implications and analyse the implication of Indo-U.S. nuclear deal enabled safeguards application on the regulatory body specifically.

5.4. Safeguards Regulation and the Evolution of AERB

In terms of regulatory implications, more number of reactors than the pre-nuclear deal phase has been brought under safeguards regulation. At the same time, such regulatory oversight is to be channelized through the IAEA's multilateral safeguard arrangements and not the bilateral ones. Also, the utmost importance has been given to an unhindered pursuit of nuclear weapon program while devising the safeguards obligations.

The Indo-U.S. nuclear deal's insistence on separation of facilities does not extend to a separation of the personnel deployed (Balachnadran 2018, Rajaraman 2017). Given the short pool of the expertise available, it was not a feasible option for the Indian side. It is a contested assertion as some of the interviewees argued that there is very limited expertise outside the DAE for consultation while some others argued that a credible external pool of experts exists and is often consulted for specific projects and purposes.

Although safeguards are not the mandate of a national regulatory body in India, they form an important component of the international nuclear regulatory regime where it occupies the most prominence and affects inter-state relations significantly. Through a negotiated approach to safeguards commitment, India managed to gain access to some of the nuclear trade benefits, even if in limited domains. US lobbied for Indian participation in export control regimes like NSG, MTCR, Wassenar, and AG. Indian entry into the last three happened in 2016, 2017 and 2018 respectively while access to NSG has been not possible primarily because of China's objections.

In countries like Canada, where there is no nuclear weapon programme, the safeguard responsibilities are entrusted to the national regulatory body. In US, where there is an explicit nuclear program, safeguards are still handled by U.S.NRC as the nuclear industry there comprises of private firms as well. It handles both domestic and international safeguards policy and regulates fuel cycle facilities, material control and accountability as well (U.S.NRC 2018a).

As far as AERB's mandate is concerned, neither does it have any safeguard related responsibility nor has there been any demand for the same. Therefore, these remain outside the purview of AERB. In fact, most interviewees did not think that a separation of civilian and military program could have implications for regulatory regime (Raju 2018, Krishnan 2017, Bhardwaj 2018, Chetal 2018).

The AERB holds no relevance in the *nuclear policy (emphasis added)* related matters. As an institution, it is not called upon to discuss policy issues. For example, the Indo-U.S. nuclear deal, which was a widely debated issue within and outside the nuclear establishment, did not involve consultation with the AERB *as an institution* (*emphasis added, no conclusion on consultation in with AERB officials in individual capacities*), as policy matters are outside its mandate (Raj 2017; Sundararajan 2017; Grover 2017). At the same time, matters like choice of reactors to be imported are not decided in consultation with the AERB. There were concerns regarding the French EPR reactor being an untested technology, and also the Kudankulam reactors, given concerns about the Soviet safety practices and mechanisms after Chernobyl. As these matters are seen as policy choices by India, there is no obligation to consult AERB in these matters. In practice, such consultation is not forbidden but there is no official obligation on the part of the AEC/DAE to consult specifically about the choice of reactors per se. The question of reactor type, however, must go before AERB review at the time of licensing. And then the AERB can decide on giving licenses upon fulfillment of mandatory safety criteria. This happened in case of French EPR reactors where the AERB made a license conditional upon the results of a few tests that were to be conducted within a specified period (Bansal 2018).

A separation of civilian and military facilities was carried out as a requirement under Indo-U.S. nuclear deal which basically resulted into explicit categorization of facilities as civilian for the purposes of safeguards. In effect, this civilian classification does not alter the safety-security mandate of the AERB. Also, safety and security were no bone of contention at the time of the deal (Rajaraman 2017; Bhardwaj 2018). They were not even discussed as such (Sood 2018, Rajaraman 2017). Concerns related only to the application of safeguards.

Some of the power reactors which are not in the civilian list are still attached to the power grid and come under regulatory mandate of the AERB. This separation of facilities has implications only from the point of view of safeguards, thereby limiting its scope and implications. Responding to the implications of this separation, Ambassador Sood (2018) argued,

> We did separation in a very limited fashion. Certain facilities were declared civilian and therefore separate safeguards were included by the IAEA for those facilities. We did not spin out the civilian side completely, I mean, the ideal thing

> would have been to spin off the civilian side completely and put it in the public domain (Sood 2018).

This takes us to another question related to separation of the twin programmes. Is pursuit of Indian nuclear weapon programme a factor that affects an effective functioning of the regulatory body i.e. AERB?

As far as official terms are concerned, it does not. Safeguards are not AERB's mandate anyway and nuclear deal does not talk about safety regulations in any specifics. Research reactors and fuel facilities associated with military program were taken out of AERB's mandate and placed with BARC Safety Council through a 2000 directive, after the Pokhran tests of 1998. So, though weapon program in a way restricted the number and nature of facilities that could come under AERB's mandate, separation mandated by nuclear deal did not alter any existing arrangement.

There, however, is a more organisational implication of weapon program on regulatory functioning in India. Given the covert nature of Indian nuclear weapon program in the beginning, the nuclear establishment maintained deep layers of secrecy around its operations. This culture of organisational secrecy extended to cover even the civilian operations. Reports of major safety reviews of Indian nuclear plants done after TMI and Chernobyl were deemed as top secrets for instance (Gopalakrishnan 2002: 385) and are still not in public domain. Even if safety issues reporting can lead to nuclear security safety issues, given the time frame involved and DAE's own affirmations about its prompt remediation of those issues, it is confusing as to why the safety audits are still not in public domain.

Safety record in BARC facilities being of strategic nature, remain much opaquer than their civilian counterparts. In 2003, an issue of six workers being exposed to severe doses of radiation came up. BARC acknowledged the incident when scientific officer and scientific assistant got radioactive overdoses upon entering the waste tank area. BARC director acknowledged, "This is the worst accident in radiation exposure in the history of nuclear India" (Anand 2003) but with caution as India had no history of such incidents at all (Radhakrishnan 2003). He also ruled out any disciplinary actions against 'erring' employees as the actions were 'not intentional' (Radhakrishnan 2003).

But, even after BARC safety committee's recommendation to shut down the plant indefinitely, as per BARC Facilities Employees Association (BEFA), the facility continued to operate which led to workers' strike. The management blamed the incident on workers' negligence (not wearing dosimeter badges) (Anand 2003), "little bit error of judgment, miscalculation and over-enthusiasm on the part of the employees" and "failure of equipment" having gone unnoticed (Radhakrishnan 2003). BEFA demanded appointment of a "full-time safety officer" along with 10 safety related demands. Ramana and Kumar (2013: 54) enumerate how previous instances of high radioactivity exposure of workers were ignored by higher officials citing "urgency of operation as a reason for the Health Physics Department not following safety procedures", to which the management did not respond. This researcher could not gather any response from interviewees on the questions of safety record in facilities under BARC's jurisdiction on account of their 'strategic nature'.

Gopalakrishnan, a former AERB chairperson (writing in 1999), argued that the DAE has become very powerful over the years and increasingly impervious to the concerns of public safety and welfare. The nuclear tests of 1974 further boosted its self-confidence to the point of arrogance. This status quo has continued over the years because of the facts that the civilian and weapons programme remained under the same individuals, authorities and facilities and the Official Secrets Act was often used as the magic bullet for covering its own adequacies and incompetence. Over the years, it has not only blocked the efforts to create an independent nuclear regulatory authority but also curtailed its effectiveness and autonomy by shielding the availability of information under the RTI act. He suggested that the AEA 1962, which guides the powers and jurisdictions of the nuclear energy establishment, should be amended to accommodate the weapon program too as India's nuclear tests in spirit and actions violated the mandate by deviating from 'peaceful uses of nuclear energy' (Gopalakrishnan 1999). This would then require a new Atomic Energy (Safety and Regulation) Act, under which the AERB could have a more empowered and effective authority to carry out its responsibilities independently. It appears that the civilian side has to suffer because there is too much emphasis on the military programme (Ramana 2017).

When the question of separation of civilian and military facilities popped up because of civil nuclear deal, the DAE's response at least initially, was one of opposition. The MEA was clearer than the DAE that to be treated as a nuclear weapon state (even if not explicitly, for the purposes of nuclear commerce) entailed certain responsibilities to that effect reflected through the official separation of the twin programme and application of safeguards on the civilian ones (Sood 2018). Reflecting on the differences of opinion between the DAE and the MEA during the initial phases, Ambassador Sood informs,

> The key principle is that you need to separate because for your own security, you need to have a much higher level of security for your military facilities because additional elements come into place and then there is a civilian fuel cycle. In terms of safety and security measures, they are at par obviously. But whether it's a research reactor that produces plutonium or it is a nuclear power reactor, it has implications for security of nuclear material. So, in terms of safety procedures, it has to be equivalent. You can't have difference but in terms of security where the materials are being fashioned into nuclear bombs, obviously the level of security will be higher, simple as that (Sood 2018).

In general, the DAE has not been very forthcoming to the question of according more autonomy to the AERB through statutory reforms. This tendency emanates from the close-knit nature of functioning within the nuclear establishment and has been discussed in the previous two chapters as well. In the wake of public demands for an autonomous regulatory body, the NSRA bill 2011 mentioned that even if a new reformed regulatory body as the NSRA would be constituted, the national defence and security related facilities would lie outside its purview. The central government however, could create a regulatory body for the exempted facilities, it said. No modality for the same was proposed though in the bill (Jacob 2014). The extent of parliamentary insight was not clarified however. This, therefore, would not have affected the AERB's role vis-à-vis application of safeguards in India.

Looking at examples in other countries, Ram Mohan argues that many European countries having shut down their military program, moved to establish "credible, autonomous and competent regulatory mechanism with strong emphasis on public and stakeholder engagement for their civilian programmes" (Ram Mohan 2011). The separation of civilian and military facilities in India, post the Indo-U.S. nuclear deal, then presents the prospects for movement towards a more empowered and robust regulatory system (Ram Mohan 2011, Prabhu 2015). Prabhu (2015) also argued that 'national security' or 'public interest' is often evoked as excuses on the part of the DAE to cloak even the quotidian operations. As an exemplary, he cites the response of Minister of State for DAE, Jitendra Singh's response to a Lok Sabha question on the average annual production from uranium mines as "it is not in the public interest to disclose the quantity of production of uranium" (Department of Atomic Energy 2018: 3).

Therefore, while the weapon program did not have tangible impacts on structure or functioning of the AERB, there is an underlying institutionalized organisational way of operations that privileges a culture of secrecy and opacity within the establishment's functioning. The AERB, however, fares better in terms of transparency compared to other wings of the DAE but it still lacks an effective authority. The organisational cocoon of the DAE, within which the AERB is placed, therefore, undermines the mandate, autonomy and expertise available to the regulatory body.

The option to stick to a single reactor type has some advantages. The cost of building new reactors is reduced. The Regulator's task is simpler. But, avenues to learn from experience and new knowledge and to seek more efficient and safer designs cannot be over-looked as well. The Regulator has to become acquainted with the new designs sufficiently well to carry out the task effectively. If the new design is indigenous, expertise is locally available and can be tapped. If it is an imported design, the experience of the regulators in other countries where the design has been accepted becomes useful. The Regulators in many countries publish their safety analyses and these are easily accessible. In their own interest in sales, the designers are also keen to get their design vetted and approved by various countries (Krishnan 2017).With the deal and import of different designs of reactors, the regulatory burden certainly has increased. At the same time, marginalization of AERB in such policy matters, even if legally sustainable undermines a more robust and responsible role that AERB could play as national safety regulator.

While the weapon program did not have tangible impacts on structure or functioning of the AERB, there is an underlying institutionalized organisational way of operations that privileges a culture of secrecy within the establishment's functioning. For example, there is "no practical way of independently verifying stated exposure data" (Ramana and Gadekar 2003: 418) even in civilian facilities. The AERB, overall, fares comparatively better in terms of transparency compared to other wings of the DAE but it still lacks an effective authority. The organisational cocoon of the DAE, within which the AERB is placed, therefore, undermines the mandate, autonomy and expertise available to the regulatory body.

Conclusion

In sum, this chapter has looked at the inter-twined discourses of nuclear energy and nuclear weapon programme in India. It organises the analysis as per two specific time-frames: 1) from inception of Indian nuclear energy program (and weapon program) till 2005 and 2) post-2005 changes in Indian nuclear energy program. The former period has been dealt with in the first section enumerating the implications of covert weapon program on the civilian program. This has been discussed in terms of organisational rational of secrecy as attached to nuclear energy program and political support to it on account of importance attached to mega science projects like nuclear technology in nation-building and national prestige. The pre-2005 period as discussed in second section deals with implications of nuclear weapon program on civilian nuclear energy program in terms of deliberate avoidance of international safeguards regime, limited availability of enriched uranium, technical collaboration, cost over-runs and delays, indigenisation efforts, impact on breeder program and so on. The last section has discussed how Indian strategic considerations predominantly shaped the terms and conditions of Indo-U.S. civil nuclear collaboration 2005 onwards. It also discusses the impact of the deal on the regulatory body i.e. the AERB.

The chapter makes following conclusion.

One, Indian civilian nuclear programme witnessed several compromises made by the political and nuclear establishment on account of a pursuit of nuclear weapon programme since the initial phases. In fact, energy program became the face of national nuclear policy which helped it in acquiring technical and material assistance, direct or indigenised employment of which played an instrumental role in India’s nuclear weapon programme. Non-separation of the twin programmes and explicit denial of pursuit of a nuclear weapon programme before nuclear tests rather became an effective diplomatic shield while handling negotiations for nuclear trade in the beginning of India’s nuclear programme. It helped India gather liberal international support for its energy programme and expertise amassed through these collaborations helped profusely in the development of India’s nuclear weapon capability.

Two, Indian regulatory body has no safeguards related functions or even a policy relevance role in matters of national nuclear policies. In response to the assertion that safeguards related regulatory responsibilities should lie with the AERB, all interviewees irrespective of their professional association with the AERB at present or as former employees expressed discomfort. There appeared a consensus that safeguards pertained to nuclear weapon programme and therefore should be dealt by a different body other than the AERB whose function primarily is restricted to civilian programme. Even when required safety preparedness of both the facilities would be quite similar, a difference in security and safeguards adequacy (more of quality than degree) has been perceived (Sood 2018), even though not explicitly stated many of the times. The NSRA bill too talked about creating a separate authority to monitor safety and security credentials of military installations, other than the one responsible for civilian facilities. Survey however, shows that 53.8% of the respondents favoured safeguards responsibilities to lie with the AERB while 10.8 disagreed with the idea. A good 35.4% chose neutrality of opinion. As the survey had limited questions related to safeguards on account of official vetting, the study cannot account for the rationale behind a majority survey respondent favouring placement of safeguards responsibilities with the AERB.

"Safeguards related regulatory responsibilities should lie with the AERB"

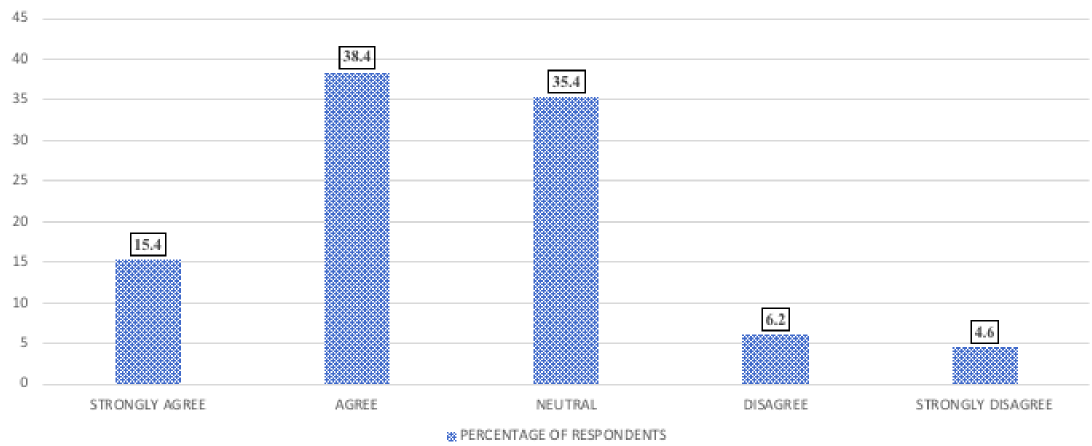

Figure- 5.1. (**Source**: Author)

Two, several choices made by the political establishment in the domain of civilian programme closely followed the needs of Indian weapon program, for instance setting up of reprocessing plant even before a commercial reactor started operating, breeder program, emphasis on keeping the breeder out of safeguards during Indo-U.S. nuclear deal and so on. Contours of international collaboration and cooperation therefore are constrained by the contingencies and requirement of nuclear weapon programme.

Three, a desire for boosting civilian nuclear energy programme to meet an ever-increasing demand for energy was one of the most important reasons for the pursuit of nuclear deal in Indian policy-making circles. However, the terms of the Indo-U.S. nuclear deal, especially the ones proposed and defended by India reveal that the Indian cooperation was foremost concerned with protecting its nuclear weapon programme from any adverse implications. It accepted the international safeguards regulation on its civilian facilities while making sure that the weapon program had a large leeway in terms of its programming and operations. The nuclear establishment, in particular, showed a keen interest in keeping the breeder programme out of the safeguards. While the civilian programme had valuable cooperation to be sought from the international community, it was treated only secondary to strategic programmes.

Four, most of the respondents denied the argument that separation of civilian-military facilities has affected the regulatory body in any way (Bhardwaj 2018; Krishnan 2017; Chetal 2018). The BARC facilities continue to remain with it. Civilian reactors, even if not explicitly declared so through the civilian list continue to be overseen by the AERB. Some of these power reactors, are now under the IAEA safeguards but the AERB's oversight on them remains more or less the same.

Five, in matters of safety mandate of the regulatory body (which is its primary mandate), there has been no institutional or administrative change post the separation undertaken in compliance with Indo-U.S. nuclear deal. At the same time, even after separation, no change has been observed in modus operandi of the AERB leading to the continuation of practices existing before the Indo-U.S. nuclear deal.

Six, India's acceptance of the international safeguards under the Indo-U.S. nuclear deal emanated most importantly because of a lack of enough uranium domestically. Equipment and technological considerations played a secondary role because of successful indigenisation efforts over the post-sanction decades. At the same time, any Indian compromise on safeguard front entailed two important considerations: 1) reciprocal benefits in terms of nuclear supplies and permissible nuclear commerce and 2) preserving the autonomy of India's strategic program. The latter deeply influenced the nature of safeguards commitment that India ultimately agreed to undertake with respect to its civilian facilities.

Finally, the Indo-U.S. nuclear deal also marked a watershed in terms of Indian integration with the international nuclear regulatory regime. Impacts were most glaring for safeguard and export control regimes related commitments affecting nuclear security and safeguards regulation in India. Therefore, even when the deal did not affect the AERB's mandate any significantly, it did lead to alterations in Indian nuclear regulatory regime in the form of higher Indian integration with international regulations pertaining to safeguards and export control regimes with implications for nuclear security as well (discussed in chapter two).

CHAPTER: 6

Conclusion

The objective of this thesis has been to conduct an enquiry into the nature of civilian nuclear regulation in India. In order to understand this evolutionary process in a comprehensive manner, three independent variables were proposed in the beginning of this study: First, international nuclear regulatory framework (norms, conventions, guidelines and institutions), second, crisis learning (technical and institutional learning which has evolved through major nuclear accidents and incidents in India and across the world) and third, the factor of Indian strategic imperatives. These three variables were studied independently of each other to account for their impact on the nature of evolution of civilian nuclear regulation in India, which was the dependent variable and the primary subject matter of this thesis.

Situated in an organizational conceptual domain, the thesis attempted to point out specific factors that have either offered a rationale for regulatory change or offered resistance to the idea of any change in status quo at different junctures of regulatory evolution. While focussing primarily on the administrative concepts of regulation, this thesis also attempted to reflect on the nature of mechanisms, tools and mandate that affect the AERB's regulatory performance.

This final chapter will briefly lay out a chapter-wise summary of the thesis. Thereafter, it will revisit the hypotheses as proposed in the beginning of the study in order to assess whether they stand falsified, verified or modified in the light of the evidence discussed in the thesis. The third section will bring out the overall findings of the thesis in the light of the evidence generated through the primary and secondary material. The last section will highlight the scope for further research, as well as the implications of this study for the theory and policy of civilian nuclear regulation.

6.1. Chapter-wise Analysis

The first chapter provided an overall conceptual context within which the study situates the practices of civilian nuclear regulation in India. This chapter surveyed the broader debates about the conception of regulation, regulatory practices, kinds of regulatory modalities and so on. As a specific definition of nuclear regulation in standard IAEA documents has not been postulated, the chapter analysed the guidelines and codes that relate to the conception of a regulatory body as discussed in the IAEA documents. The study found that these specifications have been shaped in rather general terms, and specifics were left to the national authorities to determine. The guidelines that dealt with the more specific characteristics were non-binding. The binding conventions only referred to broad and sometimes even ambiguous guidelines on the desired characteristics of a regulatory body. As there is no standard template postulated by the IAEA to guide states, therefore, modelling of a nuclear regulatory body varies across countries.

The second chapter presented an analytical narrative of the evolution and progress of international nuclear regulatory framework through an assessment of conventions, codes and guidelines in the realm of safety, security and safeguards. This chapter underlines that the dual-use nature of the nuclear science, national sovereignty considerations and power hierarchy. Within the international system of states have shaped the evolution of the international nuclear regulatory framework. The chapter also analysed and assessed the nature of Indian compliance with the international regulatory framework.

This chapter concluded that India has mostly complied with the international nuclear safety regulation mechanisms except in cases concerning spent fuel and radioactive waste. This exception is explained by different terminological understanding of spent fuel on the part of India vis-à-vis that of the dominant opinion within the IAEA. Security regulation has seen Indian compliance with enthusiasm. International safeguards regulation, however, has seen maximum Indian resistance on account of its weapon programme.

The chapter also concluded that India’s rationale of compliance, rejection or a partial sync with the international nuclear regulatory framework has been based on an interplay of following factors: first, wide legitimacy and acceptability of IAEA’s expertise and normative principles; second, national security and sovereignty considerations and third, a need to integrate with international export control regime for nuclear commerce.

The third chapter presented a historical and analytical account of the civilian nuclear regulatory evolution in India and evaluated this progression based on the parameters outlined in the introductory chapter to reflect upon the question of AERB’s regulatory autonomy and effectiveness. Drawing heavily from the primary data, this chapter analyses aspects pertaining to its structure, staffing, finances and such and argues that the AERB’s regulatory autonomy is sub-optimal. Interaction with regulatory staff through personal interviews and survey responses, however, lead to an inference that a sense of functional autonomy is quite vibrant within the AERB as well as other wings of the DAE. However, in absence of credible ways to investigate into the claims of actual effectiveness given a little and limited declassification of records, lack of avenues for external independent analysis and investigation through an actual review of on-ground implementation or a review of administrative papers, this study refrains from providing a definite conclusion on this account. This chapter also undertook an assessment of nuclear security regulation in India which is highly-fragmented but evolving in response to international nuclear security guidelines.

The fourth chapter focussed specifically on crisis-learning as a significant factor driving the evolution of the AERB. It discussed the major safety and security related events that happened in India or elsewhere and analyzed their implication for both-international nuclear regulatory framework as well as the AERB. This chapter situated crisis learning in the conceptual domain of organizational change and analyzed the reception of crisis event within the nuclear energy establishment in general and the AERB in particular. Some of the findings of the fourth chapter have been corroborated in the third section of the concluding chapter to make broad arguments pertaining to the factors responsible for regulatory changes in India.

The fifth chapter had two focal points: broadly, an analysis of the implications of the Indian nuclear weapon programme on the civilian nuclear energy programme and in a narrow sense, implication of the weapon program on the Indian nuclear regulatory evolution. The chapter highlighted the terms and conditions, negotiation process and dynamics associated with the conclusion of the Indo-US nuclear deal which marked a major juncture in the Indian nuclear history in terms of its relative integration with the international nuclear regime, most importantly in the realm of safeguards and export-control.

6.2. Revisiting the Hypotheses of the Study

Hypothesis 1- Nuclear regulatory structures in the Indian civilian nuclear programme evolved as a response to the various crisis events experienced during the management of nuclear infrastructure worldwide.

The findings of this thesis verify this hypothesis. The Indian Nuclear Regulatory Authority, once established, has been responsive to crisis learning both domestically and internationally. Every major/substantial crisis event was followed by thorough safety reviews of the Indian nuclear power plants and though there have been minor recurrent failures, similar kind of safety failures were mostly avoided. This study also asserts that even when crises related to nuclear safety and security have been limited, they have contributed to a progressive evolution of nuclear regulatory regime in India. Such progression might not have led to changes in fundamental regulatory principles, but they always led to addition of regulatory requirements or induction of new and improved component sub-systems that became a regulatory requirement for future set of reactors as well. The establishment has shown an interest in learning from crisis events and provisioned for additional safety features and mechanisms accordingly.

This verification of the hypothesis however, does not mean that crisis events have been the most important factor for bringing in regulatory change in AERB or in the Indian regulatory regime in general. Looking at the responses of the AERB and the DAE to crisis-events in terms of immediate safety reviews, one is inclined to infer that crisis events led to higher organizational learning vis-à-vis the periods when crisis did not occur. However, as the study focussed on deciphering the response of the establishment to a crisis event (as in concrete manifestation of what actions were taken), there is a positive bias in reporting. Relative importance of crisis learning as a factor vis-à-vis other factors driving regulatory change will be discussed in the next section.

Hypothesis 2- Sub-optimal performance of the Indian civilian nuclear establishment has been a major reason for the lack of the independent civilian nuclear regulatory structures in India.

The findings of this thesis neither falsify nor verify the hypothesis and it remains inconclusive. India's nuclear energy establishment remains a great deal short of its own expectations on proposed nuclear energy output and therefore it has been criticized for inefficient economy of operations and sub-optimal performance despite much government investment into it. This study could not find concrete evidence to argue that the sub-optimal performance of the Indian civilian nuclear establishment has been a major reason for the lack of the independent civilian nuclear regulatory structures in India. Also, as the AERB does not have economic regulation as its mandate and economic regulation or rather auditing specifically has been entrusted to the CAG (in a limited way), the study has refrained from an analysis of economic viability and efficiency of the DAE's nuclear energy programme. There are, however, indirect reflections to be noted. One can argue that DAE's projections related to the achievement of specified targets as well as Bhabha's three stage program remain too unrealistic and unachievable even after more than 60 years of nuclear programme. Even then there is no apparent accountability or answerability of the DAE with respect to such misleading projections, let alone the achievement of those projections.

It seems likely that in the face of sub-optimal performance with respect to energy production claims, the DAE would require the clout of secrecy and high-science status to ward off public criticism against its sub-optimal performance and misleading claims.

Another point relates to the larger organizational culture of ‘high-science’ and secrecy associated with the modus operandi of the DAE institutions, of which the AERB too is a part. Public transparency, a major attribute of regulatory autonomy (also specified under IAEA guidelines), has witnesses a sub-optimal level in the functioning of the AERB. The study found evidence to the effect that AERB and rather DAE in general, function with minimal ministerial and bureaucratic (one outside the DAE) oversight. Proposals of regulatory reforms, however, have not found much resonance and support within the DAE. As the chapter 3 discusses, even within the AERB, majority of the respondents (71%) believed that enough transparency exists in the functioning of the AERB.

Also, an acknowledgement to this end by the scientists themselves makes them culpable so it is not a surprise that the interviewees associated with the nuclear energy establishment (former and current), dismissed sub-optimal performance as a reason for the non-autonomous nature of the AERB. A belief in self-credibility, institutional socialization about organization’s role and/or a genuine belief in organizational functioning can explain interviewees’ dismissal. However, this study could not find ways to circumvent this interpretive dilemma. Specific fundamental questions relating to the need of the NSRA bill and qualifiers of public transparency were not included in the survey questionnaire by the screening authority. This too indicates excessive caution on the part of the authorities in ensuring that the overall tone of the survey responses remains positive towards AERB’s functioning.

In the face of such contradictory evidence, this study can neither falsify nor validate this hypothesis. In effect, therefore, it remains inconclusive.

Hypothesis 3- Non-separation of civilian and military nuclear facilities has significantly contributed to the absence of an independent civilian nuclear regulatory structure in India.

The findings of this thesis neither falsify nor verify the hypothesis. As discussed in chapter 4, the study reiterates that with the separation of civilian and military facilities, any tangible impact on the AERB's regulatory mandate has been very little and limited. The separation plan under the Indo-US deal has added another layer of regulation pertaining to safeguards. More number of civilian reactors have been brought under safeguards now but even with or without the deal, the safeguard regulation has not been the mandate of the AERB. So, in a sense, it indicates a rejection of the hypothesis.

However, if the regulatory evolution can be conceived of as a spectrum ranging from 'no-regulation to limited regulation, leading to the creation of an independent nuclear regulatory body', the study shows that the weapon program had significant impact in limiting the nature of the civilian nuclear regulation in India. Pursuit of a weapon program led to sanctions which adversely affected the regulatory requirement of safety which could be strengthened through the international and bilateral assistance otherwise.

Another significant evidence accounting for partial verification stems from an analysis of the NSRA bill. After the Indo-US nuclear deal, a separation of civilian and military facilities was undertaken. The NSRA bill proposed in the year 2011, talked about this separation. The NSRA bill to ensure a higher regulatory autonomy and effectiveness revised the terms of its administrative arrangement. It also provided that a separation of facilities would correspond to separate regulatory authorities as well. While the new authority subsuming the AERB was supposed to be more autonomous, it was to cater to the civilian program and facilities alone. An explicit separation of the civilian and the military facilities made it possible to envisage a more autonomous and transparent civilian nuclear regulatory body.

Also, the 2000 separation of civilian and military facilities rather undermined the overall safety regulation as the functioning of the BARC Safety Committee is more secretive than the AERB (discussed in chapter 4). This secrecy associated with weapon programme also shaped

Therefore, even when there is no concrete evidence to show that a non-separation of the civilian and military facilities constrained the independence of the regulatory body, there is a case for an inference that the separation of facilities, post-the Indo-U.S. nuclear deal, provides a permissive environment for devising higher autonomy conditions for the regulatory body. But as the separation of the facilities by itself was not the trigger for the introduction of the NSRA bill, it's causative role in undermining the regulatory autonomy remains inconclusive.

In the face of these contradictory evidence and arguments, this study assesses this hypothesis as inconclusive.

6.3. Overall Findings of the Study

The Indian civilian nuclear regulation is most prominently characterized by the institution of the AERB but goes beyond it and entails the larger organizational culture of the DAE within which the AERB is situated. In the broader context of this argument, this thesis presents following concluding remarks:

First, the study observes that civilian nuclear regulatory evolution in India through AERB has been progressive and incremental. When nuclear energy programme began, focus was on acquiring technology and expertise for the promotion of the same. Idea of regulation evolved with expansion of energy programme. With expansion, initial modes of regulation, up till 1981, can at best be characterized as self-regulation. In 1981, the AERB’s establishment signified an organizational separation (even if limited) of promotion and regulation functions. The committee structure has over a period diversified and evolved so as to offer specialized regulatory advice in the field of construction, operations and so on (discussed in chapter 3 in detail). The progression has mostly been linear moving towards independent regulation, something that has not yet been achieved. For instance, co-opting of the DAE-SRC within the AERB for regulatory purposes, establishment of SRI, inclusion of outside experts in AERB committees (though limited in several senses) reflect a growing institutionalization of regulatory mechanisms.

However, there have been regressive tendencies as well. Deputing NPCIL employees as RSOs at power stations is an example. Also, as the study has pointed out in chapter three, the first chairperson of the AERB was appointed from outside the DAE to demonstrate its impartiality and credibility. The later period, however, has seen this position being held by personnel coming from different wings of the DAE itself, including the NPCIL. While not questioning their scientific credibility, expertise and/or motivation of such personnel, in terms of regulatory principles, there appears an inward-looking nature of such appointments which undermines the general confidence in the autonomy and effectiveness of the regulatory body. Therefore, evolution of Indian nuclear regulatory body cannot be termed as a linear progression towards the attainment of an independent status and role.

Second, the study observes that Indian nuclear regulatory framework has evolved progressively in response to following factors:

1) Institutionalization and acceptance of IAEA's regulatory principles and technical standards.

2) Expansion of nuclear energy programme and nuclear related research in applied sciences causing organizational focus on multiple range of regulatory practices.

3) Floating ideas about the participation of private industry actors in nuclear reactors productions

4) Management of negative public perceptions generated especially after crisis events specially and alarmist attitude associated with nuclear energy projects in general (pressure from civil society movements for regulatory reforms).

5) Occasional nuclear crisis events questioning the assumption of nuclear energy being inevitably and inherently safe

6) In response to obligations (mostly in the field of safeguards but also safety) demanded by the supplier countries to adherence to certain standard design and operation requirements as demanded by supplier countries especially in the initial decades.

7) Need for foreign collaboration in procuring fuel, equipment and technology for nuclear energy program, more prominent in safeguards related international regulatory obligations.

8) A need to project India's good records in terms of safety, security and safeguard, to strengthen its image of a 'responsible nuclear power' even when it has not signed the NPT.

However, all these factors do not envisage the same degree of urgency in regulatory reforms and have been conditioned by contextual factors. For example, as India suffered through relative isolation in nuclear commerce after the 1974 tests, domestic factors became the more important drivers of regulatory changes vis-à-vis say a desire to participate in nuclear commerce as a supplier country. Also, the immediate after-math of the crisis events in India or elsewhere in the world always prompted extensive reviews in the Indian nuclear facilities.

Third, the survey asked the respondents to account for changes in the Indian regulatory norms, standards, structures and practices as a response to following factors in declining order of preferences:

a) Crisis-learning (Indian and international incidents and accidents)

b) Periodic Operational Feedbacks

c) International Nuclear Regulatory Regime (IAEA, WANO and others)

d) Indian Pursuit of Nuclear Weapon programme and

e) Concern for Public Perception

In terms of ranking preference, the international nuclear regulatory regime emerged as the most important factor (37.3%) (accorded rank 5) while pursuit of nuclear weapon program was ranked as the least important factor by 58.7% of respondents[66] (accorded rank 1). So, the hierarchy of factors according to the survey presents this order:

1) International Nuclear Regulatory Regime
2) Periodic Operational Feedbacks
3) crisis-learning
4) concern for public perception
5) pursuit of nuclear weapon program

Three of these variables directly or indirectly gathered respondents' opinion through another set of questions. These related to a) feedback mechanism on event reporting (periodic operational feedback) and b) AERB's regulatory standards sync with international technical standards (international nuclear regulatory regime) and c) crisis-learning.[67]

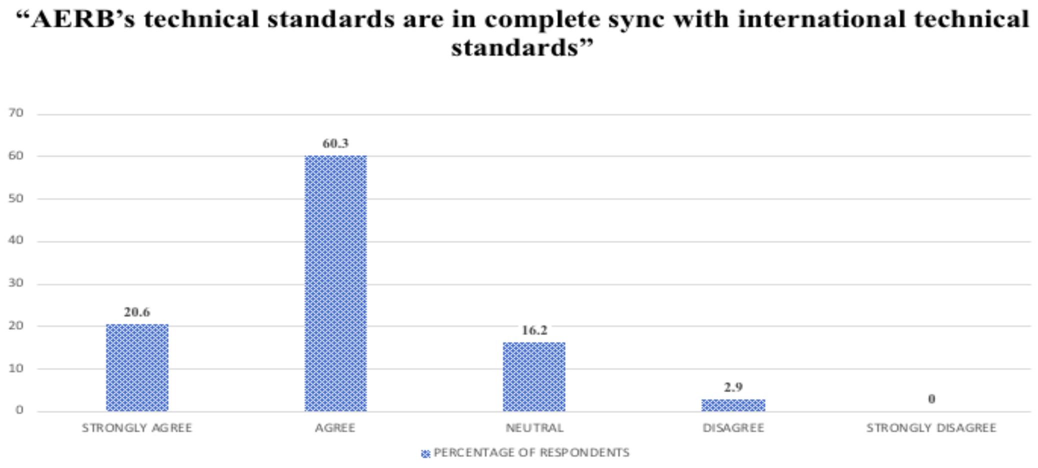

Figure- 6.1. **Source**: Author

[66]Sample size for this option i.e. pursuit of weapon program was lower than that for other factors.
[67] Factor 'a' discussed in chapter 3 and factor 'c' discussed in chapter 4 independently.

Comparing the responses within these categories, one can observe that confidence of employees with respect to these two factors presented this ordering:

1) International nuclear regulatory regime and
2) Periodic operational feedback

Therefore, this finding of ordering of these two variables inspire a high level of confidence. This indicates that most of the regulatory changes especially technical standards, norms and principles in the AERB have followed IAEA’s guidelines indicating a high level of acceptance of IAEA’s principles, a finding supported by an in-depth analysis of this particular variable in chapter two as well.

Four, high confidence levels in the feedback and reporting mechanism reflects a good amount of confidence in safety preparedness of utility, a point also corroborated through interviewees’ responses. This indicates that organizational learning corresponds to the ‘doing’ aspect and that regulatory changes have been in the nature of evolutionary or piecemeal reforms.

Five, survey data reveals that the ranking preference in terms of relevance for regulatory change finds crisis-learning as a factor at the third place (31.3% respondents accorded it a value of (5), i.e. below the options of international regulatory requirements and periodic feedbacks. This is also to be noticed here that though there have been a few potentially disastrous incidents in India, they could be contained well by the personnel. This factor alone has inspired a lot of confidence in regulatory effectiveness and safety preparedness, a factor reverberated by a majority of interviewees too (especially those from within the establishment). This inference is reinforced by responses to the question on safety preparedness in India. 59.4% of survey respondents expressed confidence in safety preparedness while 18.8% disagreed. 21.7%, however, chose to remain neutral. If the number and frequency of high-impact crisis is low, it means crisis learning too, will be limited. In that sense then one can explain as to why operational routine feedback was accorded a higher-ranking preference as compared to crisis-learning.

Six, occurrence of crisis itself can be sporadic and unpredictable, and that alone cannot be taken as an indicator of regulatory failure but repetitive and recurrent safety failures reflect poorly on regulatory credentials. Also, accidents can be for a number of reasons, natural, personnel mistake, advertent disturbance and so on. It is not a reflection of the robust regulation alone. At the same time, while crisis may not have occurred or remained limited in the past, its possibility cannot be precluded. A careful examination of interviewees (both the content and the process of the interviews) and secondary literature related to responses of people from within the nuclear establishment on the questions relating to past safety-related events, however, bring out following:

1) some accounts while not dismissing the *remote possibility* of a safety related incident or accident in nuclear plants, focussed on continuously evolving and adapting the nature of AERB's regulation which has enhanced its capability of continuous learning from mistakes and unintended events. This, while may or may not be true, hindered an enquiry relating to past occurrences. The study, however, does not dismiss the argument of organizational learning in AERB in response to crisis which has also been asserted in chapter 3.

2) some accounts questioned the 'mala fide intentions' of reporters and analysts while dismissing such reports as exaggerated or inaccurate or superficial.

3) Some accounts kept referring to the broader questions of unavoidability of nuclear technology, even if radioactivity is a risk factor. While there is nothing wrong with a discussion on the need for nuclear energy per se or on disputed and varying nature and degree of radioactive implications on lives and environment but resorting to such debates convey a sense that need for regulatory reforms, especially when coming from outside the establishment is seen as essentially an "anti-nuclear" stance favouring abolition of nuclear energy programme itself. This, however, is factually incorrect. Many of the critics of nuclear establishment have expressed more confidence in nuclear energy as a viable/ unavoidable energy source, provided enough safety and caution is built into its operations.

Seven, as per the survey respondents, public perception ranked fourth (22.3%) as far as its weight behind regulatory change was sought. Interviewees from within the establishment identified negative public perception with respect to nuclear energy as a major factor driving regulatory reforms (i.e., the proposal of for NSRA). The argument of negative public opinion post-TMI being a precursor to the establishment of AERB, however, was dismissed by such interviewees, but the timing and measures undertaken in the wake of the TMI leading to the establishment of the AERB, only seem too logical to be ignored (elaborated in chapter four). Interviewees, who have not been associated with AERB in any former or present capacity, along with the dominant opinion in secondary literature attributed public perception as a major factor pushing for the need of regulatory reforms. Based on these contradictory set of evidence, the study argues that public perception is a significant factor pushing for regulatory demand. However, its causative strength is undermined by the fact that the nuclear establishment, which plays a very significant role in nuclear policy matters, believes in adequacy of existing safety and regulatory preparedness of its nuclear installations.

Eight, the lack of an institutionally autonomous regulatory body is attributable to the lack of support from within the nuclear establishment which has mostly rebuffed the criticism against the non-autonomous nature of the AERB. Nuclear establishment believing in the robustness of regulatory system that is already in place, exhibits an institutional resistance against reforms so as to maintain status quo and equilibrium which might get upset by bringing in reforms of unfamiliar nature causing uncertain or adverse consequences for safe operations of nuclear power reactors (discussed in detail in chapter 3). A tacit resistance on its part, therefore, has been the most dominant factor causing a delay in structural reforms of the AERB. A snail-paced momentum within the policy circles to establish an institutionally autonomous regulatory body can be explained by following factors:

1) Nuclear Bureaucracy's organizational belief in the 'functional independence' of the present regulatory body
2) The organizational and institutional culture within the DAE favours synergetic cooperation and fraternal sensitivities between the wings than to have an arms' length away regulator.
3) DAE's has traditionally enjoyed huge prestige and power in Indian policy circles on matters of nuclear policy, supplemented by the huge enabling power of AEA 1962.
4) Successful demonstration of crisis-management capabilities and relative absence of major nuclear or radioactive incident in India
5) Constrained availability of expert pool outside the DAE
6) Lack of political opinion on nuclear regulatory concerns independent of nuclear bureaucracy's policy prescriptions.

Finally, The IAEA guidelines even when they do not posit a specific structure of a regulatory body have argued that though autonomy in a structural sense is an essential attribute of a regulatory body. The lacuna on that account alone, however, cannot be taken as a conclusive proof of the actual autonomy status. This leads to analytical ambiguity about what set of administrative and functional parameters can lead to optimum regulation. The DAE has often reiterated its argument of AERB's functional autonomy as a claim about its de facto independence. Due to a lack of robust research evidence to address the claim of de facto independence of the AERB by DAE officials, this study, following a positivist methodology, neither upholds nor rejects it. The on-ground functional autonomy of the agency remains inconclusive more so because of a lack of measurable standards/indicators of autonomy and less than transparent mode of functioning of the nuclear establishment. However, an evaluation based on administrative, structural, financial and such attributes (detailed in chapter three) together with the findings in the domain of organizational culture lead this study to conclude that the AERB is a non-autonomous regulatory body.

6.4. Implications for Theory and Policy Research

The study acknowledges that despite the best of the efforts and intention, there are inherent limitations to this endeavour in terms of time and focus of the thesis. With this understanding, this section presents certain themes that can be developed along the lines of this research and contribute to the realm of theory and praxis of civilian nuclear regulation.

Cross-national analysis is a prominent scope in this kind of work. A cross-country comparative analysis, can help in filling the gaps in existing guidelines outlined by the IAEA and help in devising common parameters that can be taken as indicators of regulatory performance effectiveness. This study has specified a few parameters in the introductory chapter to reflect upon the AERB's regulatory credentials. However, given the India-specific nature of the thesis, the study cannot claim to have provided an exhaustive and comprehensive set of parameters that could be applicable across the spatial (national) differences in regulatory organization, which demonstrates specificities of broader national political systems, nature of nuclear establishment and so on. Such empirical grounding can then be utilized to postulate theoretical premises. This can be taken up as an independent project in itself

In terms of relevance and scope for future policy research, the study has highlighted the problems that raise questions on the non-autonomous nature of the AERB. The debates, as outlined most prominently in chapter three but also in other chapters, lay out the viewpoints coming from different vantage points and offer a scope for re-thinking fundamental questions associated with regulatory autonomy. However, this requires first of all, an attitude and willingness to change if required. Only when the managerial or administrative class realizes the need for regulatory reforms, can these be undertaken in an effective way. Otherwise, something like the draft NSRA as proposed in 2011, while remedying some of the problems, would create new ones. One major step in this direction, to begin with, may be to carry out a departmental survey within the different wings of the DAE with anonymous response provision, as undertaken in this study. Starting a debate within the DAE itself would offer significant policy avenues.

This study was specifically centred around administrative approaches in studying regulatory regimes. This approach to regulation has its own challenges too. It is a technical field requiring some basic understanding of nuclear reactor terminology. Figuring out the committee structure of the AERB, kind of membership entailed in regulatory committees, mechanisms and instruments available to regulatory agencies and so on appeared mechanical initially but provided important conceptual tools and empirical evidence that could be utilized for an in-depth study of civilian nuclear regulation in India. Such administrative approach can be infused with a more sociological organizational approach as offered by STS to offer a more in-depth and critical analysis of the nuclear civilian regulatory evolution. This can be taken up in a future project.

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