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Nuclear Energy as a Tool of Sustainable Development: Myth or Reality?

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ABSTRACT

Nuclear is often left out of the "clean energy" conversation despite it being the second largest sources of low-carbon electricity in the world. Nuclear power energy resource gives us many reasons for a switch in energy pattern if we desire a sustainable development and climate change mitigation at a faster rate. Some of them are observed in the first leg of the research i.e. safety, constant supply, carbon free output and reliability in achieving our Sustainable Development Goals. The IEA projects that, even with continued subsidy and research support, the rest renewable sources can only provide around 6% of world electricity by 2030. This is the reason why governments are trying hard to have nuclear technology so that they can generate more amount of electricity within a specified timeframe.

Although, this resource has greater utility but the limitations associated with Nuclear Energy need earnest attention in respect of its impact on environment. It is established with the help of case law analysis of Chernobyl Accident, Three Miles Island etc. narrating the havoc occurred due to radioactive substances mishandling. Efficiency of nuclear laws can be analyzed from this very point that no major nuclear aversion has ever happened in India and it is possible only with the effective functioning of the nuclear laws of the country. Its compatibility with the international mechanisms set out by the IAEA and other nuclear export regimes. The sustainability to Nuclear Power is observed in respect of Indian scenario with the help of relevant data and statistics.

Long term sustainability of nuclear power is primarily a matter of the fuel cycle. From a resource conservation and waste management perspective, the environmentally-rooted 3R hierarchy of reduce, reuse and recycle should become its cornerstone.

Keywords: *clean energy, sustainable development, climate change, waste management*

I. INTRODUCTION

"*Sustainable Development meets the needs of the present without compromising the ability of future generations to meet their own needs.*" Sustainable development accommodates

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environmental protection, economic growth and social welfare. Presently, as due to combustions of fossil fuels and CO_2 emissions, Greenhouse effect is taking place which can rose the global temperature by two degree Celsius by 2050 which is considered to be an effective rise to melt the northern and southern ice caps of the world and wipe out all the glaciers being in existence. It becomes very important to shift towards clean and renewable energy resources because fossil fuels based power generation is a vital source of emissions globally. Nuclear energy is considered to be one of the most durable and affordable power which can provide the energy to ultimately achieve high living standards, good health, a clean environment and a sustainable economy. Nuclear energy provides large amounts of virtually carbon-free baseload power at stable variable cost, contributing significantly to both the economic and the environmental dimension of sustainable development. Nuclear energy in a sense contributes to all the proposed Sustainable Development Goals (SDGs)[2] enshrined by the United Nations in 2015. Nuclear power supports the realization of the SDG7 which states 'to ensure universal access to affordable, reliable and modern energy services (by 2030)'.

The inclusion of nuclear energy into a nation's energy mix increases technical and fuel assortment and creates potential competition with alternative sources in electricity markets. This has the potential to increase the overall effectiveness and efficiency of energy systems to the benefit of consumers. Nuclear energy generates power through fission, which is the process of splitting uranium atoms to produce energy. The heat released by fission is used to create steam that spins a turbine to generate electricity without the harmful by-products emitted by fossil fuels. As to meet the commitments of Paris Agreement of 2015, the scenario requires a significant scaling up of all clean, low carbon technologies such as nuclear power, with electricity demand expected to rise sharply in the coming years as countries need more power for development. Nuclear power currently generated almost 11% of the world's electricity, which amounts to one-third of the world's low-carbon power. However, according to the IAEA[3] report, global electricity demand is expected to almost double by 2050. As with the advancing of the nuclear energy its related challenges also pop in which can't be tune out and will be dealt in the later part of the research work. Presently, as the world is crippling with the complications of the climate change and the global regimes vigorously fighting for its mitigation and in that scenario nuclear power can play a vital role in the overall mitigation of climate change due to certain reasons: a) renewable energy sources such as solar and wind

[2] Sustainable Development Goals (SDGs) are a set of 17 universal goals passed by the resolution of the United Nations General Assembly (UNGA) in 2015, for the fifteen year from 2015-2030.
[3] International Atomic Energy Agency is a global body under the aegis of United Nations and is working to promote the safe, secure and peaceful use of nuclear technology.

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haven't yet proven themselves as viable solutions to meet the population's wide-scale energy needs, b) in nuclear power plants, atoms are continuously split, creating chain reactions that provide high amounts of sustainable energy for a long period of time.

Nuclear is often left out of the "clean energy" conversation despite it being the second largest sources of low-carbon electricity[4] in the world. Despite producing massive amounts of carbon-free power, nuclear energy produces more electricity on less land than any other clean-air source. Also the waste generated from nuclear power plants in the form of radioactive wastes, spent fuel such as hot water can also be reprocessed and recycled although countries lack technical capabilities for reprocessing of the waste generated by the plants but world is progressing on a great pace as countries are moving towards research and development and the technological exchange is helping countries to further reprocess the spent fuel to recover uranium and plutonium which avoids the wastage of a valuable resource.[5]

Clean energy from renewables like solar, wind, hydro, tidal, biomass, etc. need to be taken into wider consideration and deserves strong support. But the collective capacity of these technologies to produce electricity in the decades ahead is limited. The IEA projects that, even with continued subsidy and research support, these renewable can only provide around 6% of world electricity by 2030. This is the reason why governments are trying hard to have nuclear technology so that they can generate more amount of electricity within a specified timeframe. That is why nuclear energy is important to countries that do not use nuclear energy themselves. We all share the same planet and we should encourage large industrialised countries to use clean energy such as nuclear energy in a safe manner to curb emissions and prevent climate change consequences. Nuclear power like wind, hydro, tidal and solar energy can generate electricity with no CO2 emissions other GHG gases emissions which are harmful for the atmosphere. The vital difference is that Nuclear Energy is the only option to produce vastly expanded supplies of clean electricity on a global scale.

II. NUCLEAR ENERGY AND CLIMATE CHANGE MITIGATION

The global economy has been dominated by fossil energy resources since the rise of the industrial society because of the wide availability of fossil fuels, initially coal and later oil, their high energy density and easy transportability. The possibility to supply energy to emerging industrial centres made fossil fuels an invaluable driver of economic growth. They did not have any viable large scale alternatives until the 1920s-1930s. A direct outcome of this

[4] Hydropower is considered to be largest source of low-carbon electricity in the world.
[5] *Processing of Used Nuclear Fuel,* WORLD NUCLEAR ASSOCIATION (June, 2018), http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/fuel-recycling/processing-of-used-nuclear-fuel.aspx

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energy development was the gradual rise of CO_2 emissions and the resulting impacts on the earth's climate. The only significant low carbon alternative to fossil fuels until the 1950s was hydropower but its use was limited by the availability of suitable sites, i.e. sites with suitable water resources and topography, and their geographical location. This situation started changing in the second half of the 20th century as new energy technologies became more widely available primarily solar and wind energy. But as capacity factor is the problem for all intermittent energy sources. The sun doesn't always shine, nor the wind always blow, nor water always fall through the turbines of a dam. As nuclear power plants operate at much higher capacity factors than renewable energy sources or fossil fuels.

As the fuel required for harnessing energy in nuclear power plants is mainly uranium which is a mineral, so it is not a renewable energy source instead it is considered to be a clean energy source. The amount of uranium in the accessible part of earth's crust are immense and the export of uranium is covered by the multilateral export control regimes such as the elite group NSG, Australia Group and the Wassenaar Arrangement.[6]

As nuclear power releases less radiation into the environment or particularly with no output of carbon, the nefarious element of global warming than any other major energy source. An important question why nuclear energy becomes important is the energy gap as already the growing needs of the world economies to harness energy and most importantly in developing economies which are in transition phase like India, China, Brazil, Argentina, South Africa, etc. are getting increased on a huge scale and to address the energy gap nuclear power plays a vital role which cannot be addressed by any other energy source in the very short duration available. Also nuclear power is considered to be reliable and cost effective considering its potential to generate electricity.[7]

Global climate change mitigation is possible without nuclear power but exclusion of it will make mitigation more costly. Yet, how much nuclear power can contribute will depend on the development on the development of other technologies associated with the harnessing of nuclear energy generation.

III. IMPACT OF NUCLEAR ENERGY ON ENVIRONMENT

The biggest concern of using nuclear energy comes from the potential for radiation poisoning

[6] Jan Willem Storm Van Leeuwen, *Climate Change and nuclear power: An analysis of nuclear greenhouse gas emissions*, WORLD INFORMATION SERVICE ON ENERGY (WISE) (2017), http://www.dont-nuke-the-climate.org/wp-content/uploads/2018/11/vanLeeuwen-2017.pdf

[7] Marta Moses, *What are the advantages of nuclear energy?*, ENERGYWISE (Sept 19, 2018), https://www.edfenergy.com/for-home/energywise/what-are-advantages-nuclear-energy

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and pollution. Nuclear technology produces radioactive waste that comes into contact with humans and the environment during reactor accidents and waste storage leaks. The Chernobyl disaster, Fukushima disaster and Three Mile Island disaster are some of the cases cited below:

Chernobyl Accident:

Chernobyl is the worst nuclear disaster in the world to date. It occurred on April 26, 1986 when, during a reactor system test, a sudden surge in power resulted in an explosion and fire that destroyed Unit 4. Massive quantities of radiation fled and spread throughout the Western Soviet Union and Europe. Around 220,000 people had to be relocated from their homes as a result of the disaster.

For routine maintenance, Unit 4 was to be shut down. A test was conducted to determine the ability of the plant equipment to provide sufficient electrical power to operate the reactor core cooling system and emergency equipment during the transition period between a loss of power supply from the main station and the start-up of the emergency power supply. Workers have not implemented adequate precautions for safety or alert operators to the risks of the electrical test. This lack of awareness led operators to take action that differed from security procedures. As a result, a sudden surge in power resulted in reactor explosions and almost complete destruction. The fires that broke out in the building contributed to the extensive radioactive releases.

Three Mile Island

The partial meltdown at Three Mile Island Unit 2 is considered to be the most serious nuclear accident in the history of the U.S., although only small radioactive releases have resulted.

The accident started with non-nuclear secondary system failures, followed by a human-operated relief valve in the primary system that stuck open, allowing large amounts of coolant to escape. It was compounded by the initial failure of plant operators to correctly identify the problem. In particular, a hidden indicator light caused an operator to override the automatic emergency cooling system manually because he mistakenly believed that excessive coolant water in the reactor had caused the release of the steam pressure. The reactor was eventually brought under control, though only later the full extent of the accident was understood.[8]

Fukushima Daiichi

The earthquake and tsunami that struck eastern Japan on March 11, 2011 caused a severe

[8] Jennie Cohen, *History's Worst Nuclear Disasters,* HISTORY (Mar 18, 2011), https://www.history.com/news/historys-worst-nuclear-disasters

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accident on the northeastern coast of Japan at the Fukushima Daiichi nuclear power plant.

The earthquake cut off the reactors ' external power. Tsunami, which reached levels more than twice as high as the plant was designed to withstand, disabled reactor cooling system diesel generators. Battery power was quickly exhausted, and overheating fuel in the operating reactor cores of the plant resulted in hydrogen explosions that severely damaged three of the buildings in the reactor. Fuel melted in three of the reactor cores, and radiation releases from the damaged reactors contaminated a wide area around the plant, forcing almost half a million residents to evacuate.

The International Atomic Energy Agency (IAEA) concerns itself with all things related to nuclear facilities, including nuclear safety and security. In recent years, the nuclear power industry has improved reactor designs and performance. The IAEA activated the Convention on Nuclear Safety in 1996 and since then it was amended in 2015. The amendments include such protection measures as nuclear power plants are to be designed with accident prevention in mind, periodic safety assessments are to be implemented and national regulation agencies must take into account the IAEA Safety Standards. IAEA has put into place an effective mechanism in place where all the states are required to provide access to IAEA for inspection and regular safety checks to avert any mishap in future.

IV. SUSTAINABILITY OF NUCLEAR ENERGY

On balance, nuclear power compares well with alternatives in the considered dimensions of sustainable development. Today, the benefits of nuclear power in terms of sustainable development include low life-cycle GHG emissions, energy security during price volatility periods, stable and predictable generation costs, prior internalization of most externalities, small and managed waste volumes, productive use of a non-competitive resource, firm basic electricity supply and synergies. Lastly, nuclear power is consistent with "weak sustainability," as man-made assets such as reprocessing, advanced reactor and fuel cycles and other related knowledge make up for resource consumption.[9]

Aspects of nuclear power that need further attention include the permanent disposal of High Level Waste (HLW), proliferation of nuclear weapons and the cycle of nuclear fuel, achieving the highest level of safety in the design and operation of technology facilities, lower construction costs and public acceptance. Without further advances in technological innovation and international institutional arrangements for a participatory civil society in nuclear-related

[9] Holger Rogner, *Nuclear Power and Sustainable Development*, 64 JOURNAL OF INTERNATIONAL AFFAIRS 137, 159-160 (2010).

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issues, the current benefits of nuclear power can fade.

Long term sustainability of nuclear power is primarily a matter of the fuel cycle. From a resource conservation and waste management perspective, the environmentally-rooted 3R hierarchy of reduce, reuse and recycle should become its cornerstone. Closing the fuel cycle, reprocessing of spent fuel and recycling of fissile and fertile materials would drastically reduce the needs for fresh uranium mining and the associated environmental burdens, while at the same time reducing the volumes of HLW per unit of electricity generated. Proliferation of nuclear weapons can probably only be resolved satisfactorily by ultimately bringing "the whole fuel cycle, including waste disposal, under multinational control, so that no country has the exclusive capacity to produce nuclear weapons material."

Discussing the long-term sustainability of nuclear power can be an exclusively academic exercise for many people in the short run, given the imminent challenges of meeting rising energy demand, providing energy security and fighting climate change. Needed decisions now cannot wait for solutions that will only be available in the coming decades. In all situations, nuclear power is not necessarily the ideal technology or the all-in-all device for any purpose. In addition, one size doesn't fit all.

All countries differ in terms of their projected energy use growth, their national natural resource endowment, their existing energy system and infrastructure, their funding capacity, and their preferences and perceptions of risk. A mix of energy sources and technologies that may or may not include nuclear power will be used by all countries. On balance, however, in the considered dimensions of sustainable development, nuclear power compares well with alternatives. Nuclear power is readily available and it cannot be ignored if societies are serious about climate change and energy security.

V. NUCLEAR ENERGY SCENARIO IN CASE OF INDIA

The increasing threat of global warming means that developing countries such as India are under pressure to commit to carbon emission reduction targets and lessen their reliance on fossil fuels. India has declared that nuclear energy is vital for meeting the challenge of climate change and suggested supporting efforts to promote its public acceptance amid growing opposition to nuclear power and plans by some countries to phase out their atomic generation plants. While India is the world's fourth largest consumer of energy, behind the US, China, and Russia alone, it largely remains energy poor. Nuclear power remains an important option for meeting the challenges of higher energy demand, addressing climate change concerns, reducing volatile fossil fuel prices and ensuring energy security. According to the Department of Atomic

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Energy, India is planning to more than treble its nuclear electricity generation from the current 6,780 megawatts to 22,480 megawatts by 2031.[10]

India is a resource rich country of the world and that is the reason India has huge deposits of thorium on its south western coast in Kerala unlike uranium. As due to unavailability of uranium in the country, it has to largely rely on imports for the generation of nuclear energy in the country. The recent discovery of the Tummalapale uranium mine in Andhra Pradesh, which has the potential to be among the world's largest uranium mines, has boosted India's uranium reserves. India has uranium supply agreements to import most of its uranium needs with various countries such as Russia, France and Kazakhstan. India has huge thorium reserves that for hundreds of years could potentially power its thorium reactors. For the third stage, the large-scale deployment of thorium reactors, this is the basis of its plans. Thorium technology, however, as discussed earlier, remains a long-term goal rather than an immediate option for the country. There's also the security and security issue. No country in the world has yet shown a viable, commercial thorium reactor program.

Nuclear power can help India attain the goal of energy security sooner than other generation methods. Even though there are alternative routes, the increasing demand and population put a clock on the options we have. In a timed scenario, nuclear power is the best chance India has to reach close to energy security, if not attain it. While there are many anti-nuclear elements in the country, it is important to understand that nuclear energy is far more than just bombs.

As all the member-states ahead of the COP 21 which was held in Paris under the aegis of United Nations Framework Convention on Climate Change (UNFCCC) submitted voluntary pledges to take action against increasing carbon emissions and to reduce them and adapt to climate change agreement, which was signed during the COP 21 in 2015, in the form of Nationally Determined Contributions (NDCs).[11] India's NDC has outlined goals to reduce the carbon emissions intensity of its economy by 33-35 percent by 2030 as well as increase the clean energy electricity capacity to 40 percent of the total installed capacity in the same period.

Perhaps India's most important energy source in the coming decades will be nuclear power, given its enormous growth potential, emission-free nature, and consistent production nature. A substantial expansion of nuclear power can both enable the connectivity of millions of Indians who currently lack access to the power grid and contribute to global efforts to tackle climate

[10] *Nuclear power important to meet energy, climate challenges*, HINDUSTAN TIMES (Nov 10, 2018), https://www.hindustantimes.com/india-news/nuclear-power-important-to-meet-energy-climate-challenges-india-at-united-nations/story-7DWGTd3minYxrStgeOkgbN.html

[11] Aniruddh Mohan, *The Future of Nuclear Energy in India*, OBSERVER RESEARCH FOUNDATION (Aug 09, 2016), https://www.orfonline.org/research/the-future-of-nuclear-energy-in-india/

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change by curbing their total carbon emissions.

Spent fuel is a crucial resource in the Indian context and not waste for disposal. In order to separate uranium and plutonium for reuse, the closed fuel cycle requires reprocessing of the spent fuel. The first reprocessing plant in India was set up in Trombay in 1964. India currently has three operating reprocessing plants in Trombay, Tarapur and Kalpakkam based on Plutonium Uranium Redox Extraction (PUREX) technology. While the Trombay plant reprocesses spent fuel from research reactors, PHWRs process oxide fuels from the plants at Tarapur and Kalpakkam. The Bhabha Atomic Research Center (BARC) operates all reprocessing plants. India also started building an Integrated Nuclear Recycle Plant that could deliver a triple increase in reprocessing capacity by 2020. This Tarapur plant will be designed to allow nuclear waste to be separated into two components—one where 99% of radioactivity has been dissipated within 300 years and the other where waste will remain radioactive for a longer period of time. The Indian nuclear establishment reiterates its plans to strengthen the capacity for reprocessing in line with the expanding civilian nuclear program, in which task it is unlikely to face any major hurdle.

The below figure states the energy mix of the country where India is thriving to increase its nuclear energy share in the overall energy mix of the country considering the potential of the same.

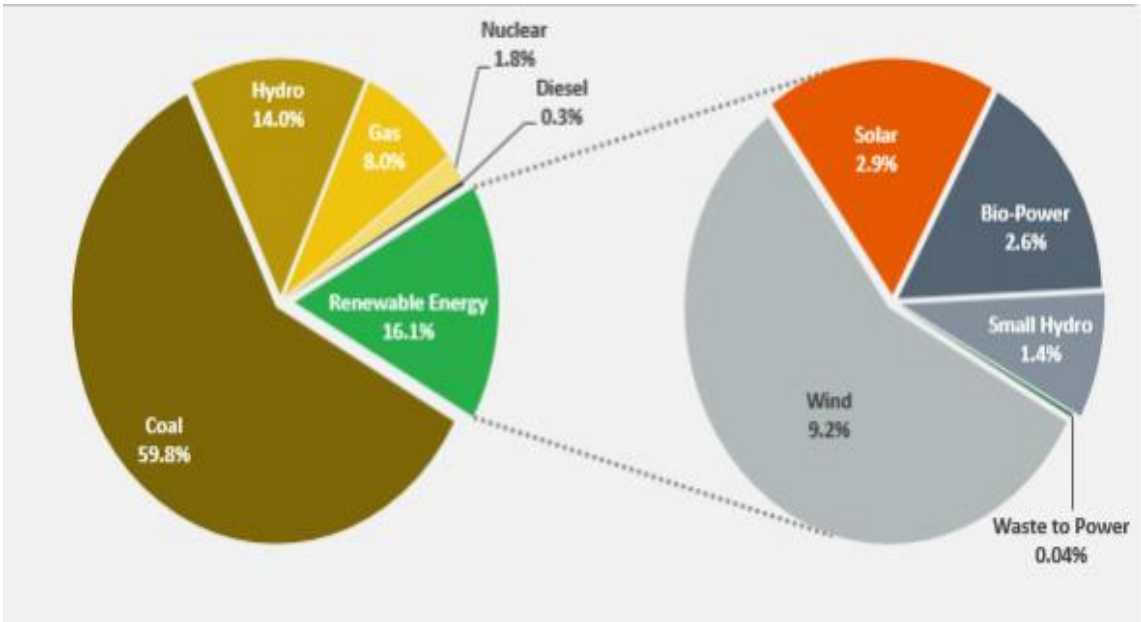

Figure 1: India's energy mix scenario.[12]

[12] Estimates provided by Central Electricity Authority, Ministry of New and Renewable Energy.

VI. CHALLENGES TO NUCLEAR POWER

- Worldwide, nuclear power provides hardly 2% of total energy consumption. This amounts to only 10.8% of world electricity production, in sharp decline since the record 17.6% reached in 1996. Nuclear energy will continue to decline, as the reactors currently under construction are too few to replace the many ageing reactors that will close within the next decades.

- Investors are turning their backs on nuclear power. According to International Energy Agency, from 2000 to 2015, 57% of investments in new electricity generation capabilities have been in renewables, and only 3% in nuclear. The point is the cost of nuclear energy keeps increasing.

- Radioactiviy and Nuclear waste from uranium mines to nuclear waste, including radioactive and chemical pollution from nuclear reactors, every phase of the nuclear cycle brings about pollution. The highly radioactive nuclear wastes will remain dangerous for over hundreds of thousands of years. Nuclear countries plan on burying the waste, but the only existing burial sites have turned into incredible fiascos that already contaminate the environment, although they store less radioactive wastes.

VII. EFFICIENCY OF NUCLEAR LAWS

Efficiency of nuclear laws can be analysed from the very point that no major nuclear aversion has ever happened in India and it is possible only with the effective functioning of the nuclear laws of the country. Also India is a responsible country on a global platform and given its impeccable record in case of non-proliferation NSG granted its exemption in 2008 to indulge into nuclear trade with the countries for bolstering its overall nuclear energy generation. India has also ratified an Additional Protocol[13] with the IAEA to enhance transparency of its nuclear infrastructure, a step considered to boost energy security and lift international confidence.[14]

Efficiency of Nuclear regulatory mechanisms can be constructed on the basis of the recent IAEA inspection of nuclear power plants of India on the request of the Government of India. IAEA undertook an Integrated Regulatory Review Services (IRRS) Mission which was the first of its kind for India and it is viewed as one of the most significant transparency efforts initiated by the AERB in recent times.

[13] The Additional Protocol is a legala document granting the IAEA complementary inspection authority to that provided in underlying safeguards agreements.

[14] Atul Aneja, *India more open to n-inspections*, The Hindu (Nov 18, 2016, 03:50 PM), https://www.thehindu.com/news/national/India-more-open-to-n-inspections/article11639106.ece

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Also Government of India, introduced a new bill in India named as Nuclear Regulatory Safety Authority Bill, 2011 to establish an autonomous and independent nuclear regulator for the faster pace of the nuclear generation and its related aspects but till date it has not been passed by the Indian Parliament. This particular bill has been considered by the experts as a welcome step to strengthen nuclear regulatory mechanism in the country.

Even the IRRS in its report recommended and clearly indicated that there should be a legal firewall between the AERB[15] and the other nuclear departments and entities it regulates, to ensure it protects itself from any undue pressures. Another important aspect that would need to be addressed is the grievance redress system or appeal procedure against decisions by the AERB. Currently, "the constitution of the AERB states that appeals against decisions of the AERB shall be with the Atomic Energy Commission (AEC) whose decision shall be final. Here, the IRRS mission remained rather timid by merely referring to and not fully suggesting a more coherent appeal procedure which would be more in tune with a fully independent mechanism."[16]

As Department of Atomic Energy is considered to be the apex authority in case of nuclear energy related aspects. It is under the direct control of Prime Minister's Office, considering its significance in the nation's development. The regulatory and safety systems ensure that equipment at DAE's nuclear facilities are designed to operate safely and even in the unlikely event of any failure or accident, mechanisms like plant and site emergency response plans are in place to ensure that the public is not affected in any manner. In addition, detailed plans which involve the local public authorities are also in pace to respond if the consequences were to spill into the public domain. The emergency response system is also in a position to handle any other radiation emergency in the public domain that may occur at locations which do not even have any DAE facility. As stated above the regulatory and safety functions of nuclear energy in Idnia are carried out by an independent body, the Atomic Energy Regulatory Board (AERB).

VIII. INDIA'S NUCLEAR SAFETY AND SECURITY MECHANISMS

As the Indian regulatory and safety mechanisms are considered to be competent enough to handle any situation arising out of the nuclear power plants due to its compatibility with the international mechanisms set out by the IAEA and other nuclear export regimes. As government of India ratified the Convention on Nuclear Safety in 2005. The Objectives of the Convention are to achieve and maintain a high level of nuclear safety worldwide, to establish

[15] AERB was constituted in 1983 by the Presidential order under Atomic Energy Act, 1962.
[16] MP Ram Mohan, *India's nuclear regulators have been audited,* THE HINDU BUSINESS LINE (Jan 03, 2016), https://www.thehindubusinessline.com/opinion/indias-nuclear-regulators-have-been-audited/article8061473.ece

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and maintain effective defenses in nuclear installations against potential radiological hazards, in order to protect individuals, society and the environment from harmful effects of ionizing radiation from such installations; and to prevent accidents with radiological consequences and to mitigate such consequences, should they occur.[17]

India also supports the international initiative to enhance Nuclear Safety as Indian delegation in 2015 supported the consensus on the Vienna Declaration on Nuclear Safety.[18]

The real evidence of effectiveness of a nuclear regulator lies in the safety record of the NPPs under its regulatory control. The safety performance of Indian NPPs has over the years remained satisfactory and in tune with the international benchmarks. There has not been any nuclear accident in any of the NPPs in India. The radioactivity discharges from the Indian NPPs have also been kept very low and is on par with the international averages. The radiation exposures to the public due to discharges from the operating NPPs have remained a very low fraction of the limits specified. The average radiation exposures to the occupational workers also have remained on par with the international benchmarks.[19]

India is currently seeking a major expansion of its nuclear power programme. With international civil nuclear trade easing, we are expected to have many new plants from foreign design vendors. In addition, the recent nuclear accident at the nuclear power plant in Fukushima has resulted in nuclear safety issues being re-examined worldwide with increased security expectations. There is a growing demand today for increased transparency on nuclear safety and regulatory issues. There are also increasing demands that safety standards / practices be harmonized internationally. All of these pose additional requirements for AERB with regard to increased regulatory resources and increased competence.

The IAEA has developed Nuclear Safety Standards (NUSS) for nuclear power plants developed by its Member States ' experts. They cover the following five areas: regulatory governance of nuclear power plants; safety in the design of nuclear power plants; safety in the operation of nuclear power plants; and quality assurance of nuclear power plants.' It was considered that formalized safety criteria, in the form of codes of practice and guidelines covering these areas, would greatly assist in ensuring that basic requirements are met. India fully comply with the guidelines and safety mechanisms of IAEA to ensure safety and security

[17] *Convention on Nuclear Safety*, Atomic Energy Regulatory Board (Feb 02, 2018), https://www.aerb.gov.in/english/convention-on-nuclear-safety

[18] The Vienna Declaration is part of an ongoing international effort to strengthen nuclear safety, subsequent to the accident at the Fukushima nuclear power plant in Japan.

[19] S S Bajaj, *Regulatory practices for nuclear power plants in India*, 38 Sadhana 1027, 1040-1041 (2013).

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of establishments.

India has vital reasons to ensure that its nuclear infrastructure is strictly safe and secure. The deteriorating regional security environment, the proliferation of clandestine and prosperous terrorist networks and neighborhood smuggling, and in particular the unique nature of its nuclear program, make nuclear safety a priority in India. India is aware of credible threats to the nuclear infrastructure. As a result, in coordination with international agencies and stakeholders, he has taken a number of security measures to strengthen his nuclear safety system. India has over the years developed a comprehensive security agreement in and around its nuclear infrastructure. However, much remains to be done to enhance all aspects of the nuclear safety governance of the country.

IX. SAFETY UNDER ATOMIC ENERGY ACT

Control of radioactive substances or plants generating radiation has been given to the central government to prevent radiation hazards; to ensure the safety of the public and people handling radioactive substances or radiation-generating plants; and to ensure the safe disposal of radioactive waste. That's really important. The monopoly over the atom of the central government is linked to the responsibility of ensuring safety and security. The Act contains, in addition to this obligation, only one section dedicated exclusively to the security issue. This places the central government under a duty to regulate certain circumstances where safety may be compromised.

X. CIVIL LIABILITY FOR NUCLEAR DAMAGE ACT, 2010

As after the signing of the certain nuclear safety conventions mentioned above, exigency emerges for India to enact its own civil nuclear liability laws to fix liability in case of any major nuclear mishap. Already India has safety mechanisms in place under various legislations but India didn't have any legislation to fix the civil liability for Nuclear Damage. To fill the vacuum India enancted it's Civil Liability for Nuclear Damage Act in 2010 which fulfilled its commitment towards Convention on Supplementary Compensation for Nuclear Damage (CSC). Until India adopted the Civil Liability for Nuclear Damage Act, 2010 and then Civil Liability for Nuclear Damage Rules, 2011, no specific legislation was in place to govern nuclear liability or to compensate victims for damages due to a nuclear incident in India. The Indian Civil Nuclear Liability Law holds equipment suppliers responsible for a nuclear accident, but Russia, France, and the USA often contended with this provision, although India reiterated that it had no intention to change it in the near future. By introducing supplier liability, we encourage security... Basically, this would achieve the illusive balance between

capitalism's profit motives and the principles of human rights.

With the comprehensive and organised framework with respect to nuclear energy in place it is expected that it will play an important role in enhancing India's efficiency in nuclear energy generation in future. Although there are some concerns with related to India's regulatory board and the demand was raised conferring statutory status on AERB so until and unless NSRA bill is not passed by Parliament there will definitely some concerns as independent regulator can better check the efficiency of the sector free from government and bureaucratic control.

Some of the challenges are also faced by the sector highlighted in the CAG report of 2012 as well are:

- One of the most important issues in nuclear safety is the legal status of the AERB, since the AERB remained a subordinate authority to the central government, with the latter delegating powers to it.
- As inadequacy on the part of the government to bring Nuclear Safety Regulatory Authority Bill of 2011 in the present regime is also an important area to be looked into as it would basically create independent and autonomous regulatory regime in case of nuclear energy.
- The 2012 CAG report highlighted the inadequate readiness for emergencies to address situations involving radiological effects from a nuclear power plant that may extend to public areas.[20]
- Also sometimes location and site clearances create a major issue and poses danger to the establishment of the Nuclear Power Plants as agitations against Jaitapur[21] and Kudankulam[22] Nuclear Power Plants in recent past have shown people's reluctance against establishment of nuclear power plants. Given the issues of land acquisition and environmental clearances the location of NPP sometimes poses danger.
- The controversy over "supplier's liability" has raised doubts over the compensation in case of an occurrence of a nuclear disaster, given the poor record of India in post Industrial disaster management.

As all the regulatory mechanisms kept in place, India can surely double its nuclear energy

[20] Karan Malik, *CAG Report Summary on Audit on Activities of the Atomic Energy Regulatory Board*, PRS LEGISLATIVE RESEARCH (Aug 23, 2012) https://www.prsindia.org/administrator/uploads/general/1345806440_CAG%20Report%20on%20AERB.pdf

[21] India and France are collaborating on Jaitapur Nuclear Power Plant.

[22] It has already been inaugurated by the Prime Minister of India in 2018 and it is in collaboration with Russian government.

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generation by 2030. Already India has set an ambitious goals for itself to increase the share of nuclear energy in the overall energy mix. Already India has put its Nuclear Power Plants under IAEA safeguards agreement which means open to inspection by IAEA which will surely increase its nuclear collaboration with other countries for the supply of uranium fuel needed for generation. The progress of nuclear energy is the result of the US-India civil nuclear energy deal of 2008. Alter that India has entered into various civil nuclear deals with the major nuclear exporting countries.

XI. CONCLUSION

The organizational weaknesses of the DAE are a reminder of how hard it is to establish a strong safety culture. AERB as we are aware that it not an autonomous body as it depends on the Department of Atomic Energy (DAE) for all practical purposes. It has, as a result, been unable to perform its regulatory functions effectively. The demand for establishing a truly autonomous nuclear regulatory authority has been a long standing one. The lapses in the Indian nuclear regulatory structure can be well addressed with the enactment of the new regulatory law which can provide the needed independence in the sector to the regulator free from interference. CAG report tabled in 2012, stated that "the legal status of AERB continues to be that of an authority subordinate to the Central Government, with power delegated to it by the latter," and recommended to the government to "ensure that the nuclear regulator is empowered and independent."

If India's plans to drastically expand its nuclear energy sector have to be effective, and acceptable to the people at large, it should bring the country's civilian nuclear establishment out of the thick layers of secrecy and opaqueness within which it has traditionally operated. The first step in that direction will be to establish a genuinely autonomous, transparent and accountable institution that is capable of regulating the country's "nuclear estate."

Also there is another imminent threat faced by nuclear establishments if efficiency of laws is not managed, the threat of nuclear terrorism which cannot be ignored when there is geopolitical risk faced by the country on its northern frontiers. To address all the shortcomings it becomes necessary for the nation like India to bolster its regulatory mechanism to keep in place all required checks and balances to ultimately increase its nuclear energy generation so that it can achieve the commitments to COP 21 of Paris. It is also necessary to achieve its Nationally Determined Contributions (NDCs) so that its carbon emissions can be reduced given the fact that more than 60% of its electricity generation takes place from fossil fuel sources.

Also another important aspect regarding disposal of radioactive waste, high up-front

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construction costs, and public safety are key factors that need to be evaluated.

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