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NUCLEAR ENERGY AND TECHNOLOGY

Ecological-Sociological Impacts with Special Reference to Koodankulam, India

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Abstract: The greenhouse effect has awakened the world to look for an alternative energy security, and 2011 Fukushima has threatened the world on the danger of the Nuclear Energy. In recent times, the developed countries concentrate on Renewable Energy Resources, while developing countries continue to invest in the nuclear plants and African countries have the desire to invest in Nuclear Energy. This research tackles the question of Nuclear Energy Security and the future of the Universe from philosophical and ecological perspectives. The study is based on the ecological and sociological impact of the Nuclear Project at Koodankulam in India.

Keywords: Alternative Sources of Energy, Ecological Concerns, Environmental Degradation, Future of Humanity, Nuclear Technology, Nuclear Threat, Philosophical Impacts, Radioactive Waste, Sociological Concerns.

1. Introduction

The discovery of nuclear fission by bombarding uranium atoms presented the world with the alternative energy hailed with euphoria as safe and clean. The fission of a single uranium atom has approximately 10 million times the energy produced by the combustion of a single coal atom. The fundamental point about

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nuclear energy is that the energy content of 1 gram of Uranium is equivalent to approximately 3 tons of coal. Consequently, Nuclear reactors began sprouting up in the 1950s and 1960s. Today, many countries have been driven to the use of nuclear energy in solving energy and electricity crises and reducing carbon dioxide emissions. Recent researches by the International Atomic Energy Association (IAEA) show that there are about 439 nuclear power reactors in operation in the world, operating in 31 countries,[1] and there are more than 150 naval vessels using nuclear propulsion.

As a result of the series of nuclear disasters from Three Mile Island to Fukushima, geopolitical concerns concentrated on the link between nuclear proliferation and the public health and provoked global debates about the future use of nuclear energy. The proponents, such as World Nuclear Association and International Atomic Energy Agency (IAEA), contend that nuclear power is a sustainable energy source that reduces carbon emissions.[2] The opponents, such as Greenpeace International accuse that nuclear power poses many threats to people and the environment. The Fukushima disaster sent shock waves all over the world, causing significant impact, and many countries including Germany, France, America and Japan look for renewable energy sources. This research paper analyzes the prospects of nuclear energy and its ecological and sociological impacts for the future especially in the Indian context.

2. Background of the Study

In the present day situation, demand for energy is huge and it keeps on growing. Some believe that the growing demand of the energy could be resolved only through the nuclear technology and sufficient number of nuclear plants must be constructed. In India, the nuclear reactor at Koodankulam has become the focus of debate between the proponents and opponents of the nuclear energy these days. As part of my research I visited

[1]S. K. Rajput, *Nuclear Energy*, Kindle Location 1009.

[2]Rajput, *Nuclear Energy*, Kindle Location 1263.

Koodankulam and Kalpakkam to study the situation and the views of opponents and proponents on nuclear reactors.

Recently, IAEA has come out with a proposal to build nuclear reactors in all the African countries, offering financial support and the required scientific equipment. The Fukushima disaster in 2011 raised serious concerns to reassess the need of the nuclear energy. The debate is still strong on both sides, which has divided scientists, environmentalists, doctors and the people of good will. As I now live and work in Tanzania, I wish to make a critical analysis of the nuclear energy and technology and its impacts on human life and the future of the universe.

3. The Understanding of the Nuclear Technology and Energy

Nuclear energy "is the energy released during the splitting or fusing of atomic nuclei, to extract usable energy from atomic nuclei via controlled nuclear reactions."[3] The most common method today is through nuclear fission, though other methods include nuclear fusion and radioactive decay. All utility-scale reactors heat water to produce steam, which is then converted into mechanical work for the purpose of generating electricity or propulsion. Nuclear energy traces its development from fission, fusion, and radioactive decay. Nuclear fission occurs "when certain types of heavy atoms become unstable and split into two medium mass parts," and nuclear fusion occurs "when light atoms are forced together to make heavier atoms." Radioactive decay happens when "unstable atoms emit energy in order to become more stable."[4] All the three processes involve interactions among powerful forces and changes of mass into energy.

4. The History of Nuclear Energy

The history of nuclear energy is a story of an old dream becoming a reality in the 20th century. The history of nuclear energy dates from about 2,400 years ago in ancient Greece, when

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[3]Rajput, *Nuclear Energy*, Kindle Locations 1002-1005.

[4]Charles D. Ferguson, *Nuclear Energy: What Everyone Needs to Know*, Kindle Location 290.

Democritus, a Greek thinker, first developed the idea that all matter is composed of indivisible particles called atoms.[5] Though in 1938 Otto Hahn (1879–1968) managed to split the atom, it was Lise Meitner (1878–1968) who first recognized that the uranium atom, when bombarded by neutrons actually splits. Physicists discovered that the atom contained large quantities of energy and the British physicist Ernest Rutherford, provided the theory of atomic structure. He wrote: "If it were ever possible to control at will the rate of disintegration of the radioactive elements, an enormous amount of energy could be obtained from a small amount of matter."[6] The first controlled self-sustaining nuclear reaction was made by Enrico Fermi[7] in 1934 and 1942 respectively.

Although many people may believe that Albert Einstein discovered nuclear energy, the records show that he did not involve directly in the area of nuclear energy research. Einstein's crucial insight is "energy and mass are equivalent."[8] Atomic disintegration was one manifestation of Einstein's mass-energy equivalence, as evidenced by the release of energy from the uranium mass through radiation provided clues to the understanding of energy.[9]

Electricity from nuclear reactors was generated for the first time on December 20, 1951 at the Experimental Breeder

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[5]Samuel E. Stumpf, *Socrates to Sartre: a History of Philosophy*, New York: McGraw Hill, 2007, 26.

[6]J. Kvasnicka, ed., *The History of Nuclear Energy*, Kindle Locations 31-33.

[7]Enrico Fermi was an Italian-born American physicist who was one of the chief architects of the nuclear age. He developed the mathematical statistics required to clarify a large class of subatomic phenomena. He discovered neutron-induced radioactivity and directed the first controlled chain reaction involving nuclear fission. He was awarded the 1938 Nobel Prize for Physics, and the Enrico Fermi Award of the US Department of Energy is given in his honour.

[8]Charles D. Ferguson, *Nuclear Energy: What Everyone Needs to Know*, Kindle Location 473.

[9]Amir D. Aczel, *Uranium Wars: The Scientific Rivalry that Created the Nuclear Age*, New York: Palgrave Macmillan Trade, 2009, 47.

Reactor (EBR-I) experimental station near Arco, Idaho, which initially produced about 100 KW. The Arco Reactor was the first to experience partial meltdown, in 1955. In 1952, however, "a report by the Paley Commission for President Harry Truman made a relatively pessimistic assessment of nuclear power, and called for aggressive research in the whole field of sustainable-solar energy."[10]

The Second Nuclear Age calls for nuclear technology with the expectations of producing energy as an answer to the global warming, which is becoming unmistakably dangerous.[11] The proponents claim that the demand for energy is huge, especially as economies in developing nations have surged at unprecedented rates. It is clear then that oil or gas could not meet these demands. Solar and wind energy have been expanding swiftly, but they have been still too costly and small-scale to power civilization.[12] There remained only two realistic options for generating energy – nuclear and coal.[13] Coal option met with hurdles as Scientists had uncovered more and more health hazards of coal effluents. In the early 2000s research confirmed the worst paranoids that burning of coal was causing at least 100,000 premature deaths every year around the world.[14]

In 1965 a commission of climate experts warned regarding future global warming due to the greenhouse effect of carbon-dioxide gas emitted enormously to produce energy. The scientists declared global warming, as a major threat to international security and health hazard for human beings and for the existence of the Universe.[15] By 2010 it was clear that the globe was warming as the scientists had been predicting for

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[10]Rajput, *Nuclear Energy*, Kindle Locations 1034-1036.

[11]Spencer R. Weart, *The Rise of Nuclear Fear*, Harvard: University Press, 2012, 247.

[12]Spencer R. Weart, *The Discovery of Global Warming*, 2nd ed., Harvard: University Press, 2008, 107.

[13]Weart, *The Rise of Nuclear Fear*, 244.

[14]National Academy of Sciences, *Hidden Costs of Energy*, <http://www.nap.edu/catalog.php?record_id = 12794> (12 June 2013).

[15]Weart, *The Discovery of Global Warming*, 207.

decades. Environmental activists began to divert their attention to nuclear reactors as a solution to the demands of energy security.[16] However, the nuclear disaster at Japan's Fukushima nuclear reactor raised questions on safety and reliability. Such worries, scepticisms, and conflicting views about nuclear power have led to serious global debate on the future use of nuclear power. This fierce debate has resulted in diversity of views between the proponents and opponents of nuclear power.

5. Genesis of Nuclear Energy Security Plans in India

In India, the Atomic Energy Commission was set up in 1948 for framing policies on development of atomic energy in the country. The Department of Atomic Energy (DAE) was established in 1954 with Dr. Homi Jehangir Bhabha as Secretary, and Sir J. R. D. Tata played a significant role in shaping the policies related to atomic energy program in the country. In India, nuclear energy development began with the objectives of peaceful uses of atomic energy in improving the quality of life of the people and to achieve self-reliance in meeting the energy needs.[17]

The Indian nuclear program was conceived based on unique sequential three-stages and associated technologies essentially to aim at optimum utilization of the indigenous nuclear resource profile of modest Uranium and abundant Thorium resources. India's energy demand is huge because of huge population and intensifying demands of energy supply for the multinational companies and factories. But the availability of fossil fuel is scarce to meet the escalating demands.

At present in India, there are 20 reactors with a capacity of 4120 MW in operation, which supplies three per cent energy need of the country and six reactors with a capacity of 3160 MW are under construction. Further, two Light Water Reactors (LWRs) of 1000 MW each are under construction at

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[16]Weart, *The Rise of Nuclear Fear*, 244.

[17]S. K. Jain, "Nuclear Power – An alternative,"<http://www.academia.edu/7288487/Nuclear_Power_-_An_Alternative> (26 August 2013).

Koodankulam in technical cooperation with the Russian Federation. The government officials and scientists claim that the country has developed comprehensive capabilities in all aspects of nuclear power from siting, design, construction, operation of nuclear power plants. Comprehensive multidimensional facilities have been set up. Capabilities have also been developed in front and back ends of the fuel cycle, from mining, fuel fabrication, storage of spent fuel, reprocessing and waste management. Infrastructure for other inputs – heavy water, zirconium components, control and instrumentation, etc. – has been established. Further, there are experts and training infrastructure has been developed for the specialized skills needed for nuclear power.

Manmohan Singh, the then Prime Minister of India on 11th March 2006, during the parliament debate on the nuclear energy, insisted that nuclear reactors are need of the time for the future and progress of India.[18] He claimed that nuclear reactors alone could meet the challenge of energy security. Siegfried Hecker one of the noted nuclear scientist affirmed that India is far ahead with regard to the nuclear energy and technology. He agreed that the Indian program of nuclear energy is innovative, ambitious, and the Indian technicians are world class;[19] yet there are safety challenges in spite of able human resources.

6. Arguments for Nuclear Technology

Proponents of nuclear energy led by the IAEA argue that nuclear power is a sustainable energy source; for its output is controlled and increases energy security by decreasing dependence on fossil fuel.[20] One of the major issues in support of the nuclear reactor is its ecological concerns, for it does not contribute to

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[18]Manmohan Singh, *Prime Minister in Parliament*, "Prime Minister's Reply in the Lok Sabha to the Debate on Civil Nuclear Energy Cooperation with the United States," New Delhi: 11 March 2006.

[19]Pallava Bagla, "Interview with Siegfried Hecker: What India Can Learn from Fukushima," *The Hindu,* Bangalore: 30 July 2013.

[20]Rajput, *Nuclear Energy*, Kindle Locations 1263-1264.

carbon emissions and greenhouse gases, thus it does not cause environmental pollutions and global warming. Hence, nuclear reactors and the energy produced from it are considered to be safe, clean and environmental friendly. Nuclear reactors require only a small space to provide large quantity of energy. The volume of waste is also small and could be stored easily and the risk factors would be solved by advanced technology. The operational safety record is better, comparing with the other major kinds of power plants.

Nuclear Technology is used in medical sciences. Cesium 137 is an isotope useful in medical and industrial radiology especially in laser operations. Nuclear reactors can be manufactured small enough to power ships and submarines; thus usage of fuel could be stopped. Just like the submarines which are using nuclear energy, aircrafts could be built with nuclear energy, which then does not require fuel refilling and keep on operating for 30 years.

7. The Drawbacks of Nuclear Technology

Nuclear technology, ever since it became a living reality, has provoked global debate with regard to its safety and reliability. Nuclear reactors have high capital costs for building the plant, very risky business and there is an increased scepticism about the use of nuclear power. They oppose saying that the nuclear reactors produce radioactive waste, and the use of depleted uranium in warfare to produce nuclear weapons and the nuclear reactors are a target of terrorist attacks.[21] They hold that nuclear power is potentially dangerous; Chernobyl and Fukushima disaster proved the involved risk. Reduction through new technology is under suspicion. The nuclear reactors are neither cheap nor economical, for considering the cost of construction, operating and maintenance (including the price of fuel), and

[21]Roger Gaikwad, "Nuclear Energy Debate," *National Council of Church Review* 132, 2012, 449-450.

decommissioning, disposal and maintenance of waste for several hundred years.[22]

In recent years, oppositions against Nuclear energy have increased. Analysis of the economics of nuclear power must take into account the risks of future uncertainties. To date all operating nuclear reactors were developed by state-owned or regulated utility monopolies in which accident liability and other factors were borne by consumers rather than suppliers.[23] The largest inevitable energy cost associated with nuclear reactors relates to the processes of mining and milling uranium fuel. According to nuclear scientists most of these ores would be extremely expensive to mine and process is very complex. Before uranium can be enriched, it must be converted to uranium hexafluoride gas, because it is in this form that the fissionable uranium 235 can be separated from the non-fissionable uranium 238. Moreover, most of the high-grade uranium ores are limited and the records show that the global high-grade reserves amount to 3.5 million tons.[24] More energy may be spent if the concentration of uranium becomes so low that the energy required to extract and refine would be greater than the amount of electricity generated by the nuclear reactor.[25] Thus, it is argued that nuclear energy is neither cheap nor safe, and so it calls to look for an alternative energy.

8. Nuclear Accidents and Safety

Ever since Nuclear Technology was introduced some serious accidents have occurred. There were several small accidents and the notable nuclear accidents are Three Mile Island, United

[22]Ferguson, *Nuclear Energy: What Everyone Needs to Know*, Kindle Locations 1036-1040.

[23]M. V. Ramana, *The Power of Promise, Examining the Nuclear Energy in India,* Kindle Location, 12.

[24]Helen Caldicott, *Nuclear Power Is not the Answer to Global Warming or Anything Else*, 8.

[25]Weart, *The Rise of Nuclear Fear*, 198.

States of America on 28th March 1979,[26] Chernobyl disaster in Russia on 26th April 1986,[27] and Fukushima Diiachi Nuclear disaster in Japan on 11th March 2011.[28] Nuclear-powered submarine mishaps like K-19 reactor accident (1961), K-27 reactor accident (1968), and K-431 reactor accident (1985),[29] and the latest Sindhurakshak submarine on 14th August 2013, which blasted and killing nearly 20 people and causing environmental disasters.[30] The nuclear accidents have terminated thousands of lives and let survivors traumatized and handicapped.

The Three Mile Island disaster was a combination of equipment malfunctions, design-related problems and worker errors, which led to partial meltdown and very small off-site releases of radioactivity.[31] In response to nuclear accidents, the

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[26]Donald Janson, "Radiation is Released in Accident at Nuclear Plant in Pennsylvania," the New York Times 29, March 1979, <http://www.nytimes.com/learning/general/onthisday/big/0328.html#article> (24 June 2013).

[27]David Fairhall, "Russia Admits Blast as Death Fears Rise," *The Guardian*, 30 April 1986, <http://www.theguardian.com/theguardian/2011/may/02/archive-russia-admits-blast-as-death-fears-rise-1986> (25 June 2013).

[28]Danielle Demetriou, "Japan Earthquake, Tsunami and Fukushima Nuclear Disaster," *The Telegraph* 2011, <http://www.telegraph.co.uk/news/ worldnews/asia/japan/8953574/Japan-earthquake-tsunami-and-Fukushima-nuclear-disaster-2011-review.html> (24 June 2013).

[29]United Nations Scientific Committee on the Effects of Atomic Radiation, "Sources and Effects of Ionizing Radiation," Report to the General Assembly with Scientific Annexes, <http://www.unscear.org/docs/reports/2008/11-80076_Report_2008_Annex_C.pdf> (22 June 2013).

[30]The Hindu Reporter, "Sindhurakshak," *The Hindu*, 22 August, 2013,<http://www.bluebird-lectric.net/submarines/INS_ Sindhurakshak_Indian_Navy_Scorpene_DCNS_France_nuclear_submarine_explosion.htm> (22 August 2013).

[31]United States' Nuclear Regulatory Commission, protecting People and Environment report on *The Three Mile Island* <http://www.nrc.gov/

International Nuclear Event Scale (INES) is used to measure the severity of nuclear accidents on a scale of 0 to 7.[32] The Chernobyl disaster received an INES score of 7 in the scale. According to the UN Report, *Chernobyl: The True Scale of the Accident*,

> Approximately 1,000 onsite reactor staff and emergency workers were heavily exposed to high-level radiation on the first day of the accident; among the more than 200,000 emergency and recovery operation workers exposed during the period from 1986 to 1987, an estimated 2,200 radiation-caused deaths […] An estimated 5 million people currently live in areas of Belarus, Russia and Ukraine that are contaminated with radio nuclides due to the accident […] about 4,000 cases of thyroid cancer.[33]

Thus the disaster continues to have effect on the people and environment. In addition to that the Fukushima Daiichi nuclear accident of 11th March 2011 was rated 7 on the INES due to the major release of radioactive material and widespread environmental effects,[34] and creating unanswerable fears among the people regarding the future of humanity.

9. Nuclear Health Threats

Nuclear power has raised many concerns regarding health, even when nuclear reactors are operating normally. Miners, workers, and residents in the neighbourhood of the mining and milling functions, and workers involved in the enrichment processes to create nuclear fuel are at risk for exposure of radiation and have increased incidences of cancer and related diseases.[35] Routine and accidental radioactive releases of nuclear reactors would contaminate water and food chains causing deficiencies for

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reading-rm/doc-collections/fact-sheets/3mile-isle.html> (13 June 2014).

[32]Rajput, *Nuclear Energy*, Kindle Locations 1305-1306.

[33]United Nation, <http://www.un.org/News/Press/docs/2005/dev2539.doc.htm> (14 August 2012).

[34]Nuclear Energy Agency, "Fukushima Press Kit,"<http://www.oecd-nea.org/press/press-kits/fukushima.html> (14 August 2012).

[35]Caldicott, *Nuclear Power is Not the Answer*, 36.

human beings and environments. Radioactive materials entering the soil and to the roots of plants, its substances may be adulterated thus mutilating the environment and human being.[36]

Although the radioactive particles are used in medical field today, radiation could affect negatively the systems of reproduction of human beings. Practically, all radiation-induced mutations are dangerous, and their harmful effects persist in successive generations.[37] Dr Mukesh Gupta, a quality assurance officer at Koodankulam, confirmed that "Radiation doses of about 200 milli-rems cause radiation sickness, but only if this large amount of radiation is received all at once."[38] Dr Muller (a Nobel Prize winner) affirmed that the cumulative amount of radiation received by the reproductive organs, be it a single large dose or many smaller doses,[39] each dose of radiation received adds to the risk of developing cancer or mutating genes in the reproductive cells. Radiation induces mutations that determine some genetic characteristics triggering diabetes, cystic fibrosis, muscular dystrophy, and certain forms of mental retardation are recessive diseases.[40] Uranium ore emits gamma radiation and uranium miners suffer a similar fate.[41]

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[36]Tony Salvitti, *Nuclear Power*, Kindle Locations 42-49.

[37]Everett L. Redmond, "Radioactive Fallout," DVD, *Microsoft Student 2009.*

[38]Mukesh Gupta and Suresh Babu, "An Overview on Power Scenario and the Need of Nuclear Power in India," Quality Assurance Department, Kudankulam Nuclear Power Project Report, < https://www.google.co.tz/search?q=Mukesh+Gupta+%E2%80%93+Suresh+Babu,+%E2%80%9CAn+Overview+On+Power+Scenario+And+The+Need+Of+Nuclear+Power+In+India%E2%80%9D&ie=utf-8&oe=utf-8&rls=org.mozilla:enUS:official&client=firefox-a&channel=fflb&gws_rd=cr,ssl&ei=cjB4VL7LO5HhuQSL3ICQDw> (14 July 2013).

[39]Hermann J. Muller, <http://en.wikipedia.org/wiki/Hermann_Joseph_Muller> (14 August 2012).

[40]Caldicott, *Nuclear Power Is Not the Answer*, 43-44.

[41]Keith Schneider, "A Valley of Death for Navajo Uranium Miners," *New York Times*, May 3, 1993.

10. Radioactive Waste and Waste Management

The biggest concern of S. P. Udayakumar and the People Movement against Nuclear Energy is the disposal of nuclear waste.[42] There is still no widely-accepted effective method and place for storage of the long-life radioactive residue.[43] As the facts stand, each regular 1,000 megawatt nuclear power plant generates 30 tons of extremely potent radioactive waste annually. Though nuclear power would be in operation for almost fifty years, the nuclear industry has yet to determine how to dispose safely of these deadly nuclear residues, which remain radioactive for thousands of years. Most nuclear waste is confined in huge cooling pools, appropriately called swimming pools at reactor sites, or in dry storage casks beside the reactor.[44]

Nuclear wastes emit Plutonium, which is a typical alpha emitter named after Pluto, the Greek god of hell. Plutonium is a radiological poison because of its high rate of alpha emission and its specific absorption in bone marrow. According to Glen Seaborg, Plutonium is said to be the most dangerous substance on earth, it is so toxic and carcinogenic that less than one-million of a gram if inhaled will cause lung cancer. Radioactive Iodine 131 is a very volatile isotope, which is usually released from nuclear reactors as a gas, either from routine or accidental emissions. "It is both a beta and a high-energy gamma emitter, and as such it is very carcinogenic."[45] Iodine 131 at high concentration is poisonous and may cause serious damage to skin and tissues. The Fukushima disaster reported that drinking water was briefly contaminated with radioactive iodine 131.[46] Strontium 90 is a beta and gamma emitter in which "an isotope released from reactors in small amounts on a

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[42]S. P. Udayakumar, *Puyalukku Pinne Poonthentral*, 9-31.

[43]Mark Denekamp, *Global Warming Carbon Taxes and Nuclear Fusion as the Answer*, Kindle Locations 582.

[44]Caldicott, *Nuclear Power Is Not the Answer*, 60.

[45]Caldicott, *Nuclear Power Is Not the Answer*, 62-63.

[46]Maxwell Irvine, *Nuclear Power: A Very Short Introduction*, Kindle Locations 1262-1265.

daily basis, mostly in the waste water but sometimes in air,"[47] affects the health and environment. Additionally, nuclear waste is extremely hazardous and the disposal thereof is one of the greatest global concerns of which even the highly developed countries have failed to treat it properly.

11. Environmental Issues

It is indeed true that the nuclear power does not produce greenhouse gas emissions (CO_2, NO_2) directly, but the nuclear fuel cycle produces them indirectly.[48] Nuclear power does not directly produce sulphur dioxide, nitrogen oxides, mercury or other pollutants associated with the combustion of fossil fuels but disposal of nuclear waste could lead to radioactive effects. A nuclear reactor is said to discharge significant amounts of radioactivity into the environment, even when operating normally.[49] Empirical evidences point to seriously adverse health effects of these routine releases. The radioactive wastes of uranium mining are dumped into the environment but the risks posed by dust and groundwater contaminated with the radioactive decay affect vast areas. Furthermore, reprocessing plants are extremely polluting. All gaseous radionuclides from spent fuel are released into the air.[50]

Nuclear power cannot provide a solution to the climate change crisis. Concerns about global warming and climate change have been exploited by the nuclear industry to promote atomic energy by dubbing it "clean", "carbon-free" and "environment-friendly." However, a number of studies have revealed that nuclear power is not a solution to climate change; rather, it will create more dangerous problems and aggravate them for the coming generations.

[47]Caldicott, *Nuclear Power Is Not the Answer*, 63-64.

[48]Rajput, *Nuclear Energy*, Kindle Locations 1288-1289.

[49]Dianuke Organization, <http://www.dianuke.org/nuclear-power-myths-about-low-cost-safety-and-emission/> (2 November 2012).

[50]Dianuke Organization, <http://www.dianuke.org/nuclear-waste-theperfect-plague/> (2 November 2012).

12. Plant Decommissioning

The price of energy inputs and the environmental costs of every nuclear reactor continue long after the facility has finished generating its last useful electricity. Both nuclear reactors and uranium enrichment facilities must be decommissioned after 50-60 years, returning the facility and its parts to a safe enough level then reactors must be dismantled. The process is very expensive, time-consuming, hazardous to the natural environment and dangerous for human beings who are involved in this process.

The total energy required for decommissioning can be as much as 50% more than the energy needed for the original construction. In most cases in nuclear reactor, the decommissioning process costs between US $300 million to US$5.6 billion.[51] Decommissioning at nuclear sites which have experienced a serious accident is the most expensive and time-consuming. The earthquake and tsunami in 2011 wrecked the Fukushima Dai-Ichi plant on Japan's coast, leaving Japanese taxpayers with an estimated $75 billion clean-up bill.[52]

13. Situation of Koodankulam

The Koodankulam nuclear reactor was signed by the Soviet leader Mikhail Gorbachev and the then Indian Prime Minister Rajiv Gandhi in Delhi on 20 November 1988, barely two years after the nightmarish Chernobyl accident on 26 April, 1986. The proposed foundation laying ceremony on 19 December 1988 was indefinitely postponed due to widespread opposition from the local people joining hand with other anti-nuke organization. Further, on 1 May 1989, there was a Coastal March to "Protect Waters, Protect Life" held at Kanyakumari, in which six fishermen were badly injured in police firing. In spite of all these opposition, the government wished to execute

[51]"Nuclear Energy," <http://www.fleurcom.org/Nuclear_Energy.htm> (24 August 2013).

[52]David McNeill,<http://www.independent.co.uk/news/world/asia/with-fukushima-nuclear-plant-still-leaking-japan-clean up-bill-soars-to-50bn-8730832.html> (25 August 2013).

the project. The project was shelved when Soviet Union collapsed and Rajiv Gandhi was killed. Again on 25th March 1997, the Indian Prime Minister H. D. Deve Gowda and the Russian President Boris Yeltsin signed an agreement, a supplement to the 1988 agreement. According to the deal Russia would deliver two Russian designed standard pressure VVER-1000 water-cooled and water-moderated reactors that would produce 1000 MW power per unit. Subsequently, Russia would extend a $2.6 billion (Rs. 6000 Crores) credit to India at 4% annual interest to be paid back over 12 years after the projected commissioning of the first reactor. At present the start estimate has become nearly $7 billion (Rs. 17000 Crores).[53]

As for now, the government has planned for a 'Nuclear Park' at Koodankulam. Demographically, the place has a higher population (approximately 50,000, excluding the reactor workers) than the regulation given by the Atomic Energy Regulation Board, which states that it should be less than 20,000 people. And within the 30 KM radius the population shall not exceed 1, 00, 000[54] but there are more than 4, 00, 000 people more than 100 villages consisting of two districts (Trinelveli, and Kanyakumari).

Corruption in nuclear industry and the Zio-Podolsk scandal has raised serious concerns on the safety of the nuclear reactor at Koodankulam.[55] Furthermore, Dr A. Gopalakrishnan, notable of India's nuclear establishment and former Chairman, Atomic Energy Regulatory Board (AERB) affirmed that there are flaws in the Koodankulam because of sub-standard materials and laxity of quality.[56] Admiral Ramdas, who served

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[53]S. P. Udayakumar, *The Kudankulam Handbook*, 24-43.

[54]Government of India Department of Atomic Energy <http://dae.nic.in/writereaddata/rsus1094_011211.pdf,> (25 August 2013).

[55]Dianuke Organization <http://www.dianuke.org/the-zio-podolsk -scandal-and-koodankulam-urgent-and-must-read-articles/> (14 April 2013).

[56]Dianuke Organization, <http://www.dianuke.org/serious-flaws-in -koodankulam-plant-dr-a-gopalakrishnan/> (19 June 2013).

as the chief Naval Staff of Indian Navy confirmed that there is huge scam in the whole process and the construction of Koodankulam nuclear reactor, therefore it is necessary to set up an independent enquiry on the whole issue.[57]

After hearing the issues raised concerning Koodankulam, the people who are working in the nuclear reactors for several years at Kalpakkam,[58] commented that at a normal situation the nuclear energy is safe and green but not cheap and would not cause radioactive waves. The scientist who work at the nuclear plants at Kalpakkam admitted that the Russian safety standards are poor but the Indian government is seriously concerned with safety measures. They affirmed that the running of the nuclear reactor in Koodankulam would be for the progress and development of the country; yet the safety challenges are to be considered seriously.

14. Renewable Energy as the Answer to the Energy Crisis

Renewable energy is usable energy derived from replenishing sources such as the Sun (solar energy), wind (wind power), rivers (hydroelectric power), hot springs (geothermal energy), and tides (tidal power).[59] Renewable energy provides 19% of the electricity generation worldwide.[60] India neither needs nuclear power, which is very dangerous, nor coal and bio-fuel, which could lead to greenhouse effect and global warming; rather India's energy security could be satisfied with energy from wind, water and solar power. According to the World

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[57]Dianuke Organization <http://www.dianuke.org/set-up-enquiryinto-koodankulam-scam-letter-to-the-pm-from-admiral-ram das/> (23 April 2013).

[58]The persons interviewed on 03 September 2013 at Kalpakkam Nuclear Plants requested not to reveal their personal identity for reasons of their job and security; hence their names and positions are not mentioned.

[59]"Renewable Energy," *Encyclopedia Britannica 2012 Ultimate Reference Suite*, 2012.

[60]Dianuke Organization, <http://www.dianuke.org/world-nuclear-industry-status-report-2012> (2 November 2012).

Nuclear Industry Status Report of July 6, 2012, renewable energy development has continued with rapid growth figures. Global investment in renewable energy totalled US$ 260 billion in 2011, almost five times the 2004 amount. Installed worldwide nuclear capacity decreased again in 2011, while the annual installed wind power capacity increased by 41 GW in 2011 alone. Since 2000, within the European Union nuclear capacity decreased by 14 GW, while 142 GW of renewable capacity was installed, 18 percent more than natural gas with 116 GW.[61] Renewable energy is quick to build, abundant, and cheap to harvest, and it is safe, flexible, secure, and friendly to climate. Investing in renewable energy then provides cheaper, cleaner, greener options that would ultimately serve consumers and the environment infinitely better.[62] Projections vary; but scientists have advanced plans to power 100% of the world's energy with wind, hydroelectric and solar power by the year 2030.

The following table makes it clear that the major attention of the world is on the renewable energy for it is viable.

Table: the Global Growth of Renewable Energy from 2008 - 2013[63]

Selected renewable energy global indicators	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Investment in new renewable capacity (annual) (10^9 USD)	130	160	211	257	244	214
Renewables power capacity (existing) (GWe)	1,140	1,230	1,320	1,360	1,470	1,560
Hydropower capacity (existing) (GWe)	885	915	945	970	990	1,000

[61]Dianuke Organization, <http://www.dianuke.org/world-nuclear-industry-status-report-2012> (2 November 2012).

[62]Caldicott, *Nuclear Power is Not the Answer*, 161-165.

[63]Arthouros Zervos, "Renewable 2013: Global Status Report," <http://www.ren21.net/Portals/0/documents/Resources/GSR/2013/GSR2013_lowres.pdf> (15 March 2014).

Selected renewable energy global indicators	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Wind power capacity (existing) (GWe)	121	159	198	238	283	318
Solar PV capacity (grid-connected) (GWe)	16	23	40	70	100	139
Solar hot water capacity (existing) (GWth)	130	160	185	232	255	326
Ethanol production (annual) (10^9 litres)	67	76	86	86	83	87
Biodiesel production (annual) (10^9 litres)	12	17.8	18.5	21.4	22.5	26
Countries with policy targets for renewable energy use	79	89	98	118	138	144

Wind energy is a form of energy in which turbines convert the kinetic energy of wind into mechanical or electrical energy that can be used for power. Wind resources are calculated based on the average wind speed and the distribution of wind speed values occurring within a particular area.[64] In spite of its challenges to the large-scale implementation of wind energy include siting requirements such as wind availability and environmental concerns, and land availability. It is cheap, fast to produce and could be pragmatic. Wind power is very attractive because it is benign; its development has short lead times; its mass production is economically very efficient; its technological development is rapid; and it is easy to site windmills on available land.

Solar energy is the energy derived from the Sun through the form of solar radiation. Solar powered electrical generation relies on photovoltaic and heat engines. The sunlight that reaches the ground consists of nearly 50 percent visible light, 45 percent infrared radiation, and smaller amounts of ultraviolet

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[64]"Wind Power," *Encyclopedia Britannica 2009 Ultimate Reference Suite*, 2009.

and other forms of electromagnetic radiation.[65] This radiation can be converted either into thermal energy (heat) or into electrical energy, though the former is easier to accomplish. Two main types of devices are used to capture solar energy and convert it to thermal energy: flat-plate collectors and concentrating collectors. Solar radiation may be converted directly into electricity by solar cells (photovoltaic cells). The power generated by a single photovoltaic cell is typically only about two watts but by connecting large numbers of individual cells together, as in solar-panel arrays, hundreds or even thousands of kilowatts of electric power can be generated in a solar electric plant.[66]

Hypothetically, 10 trillion to 20 trillion watts of solar power provided by photovoltaic could take the place of all conventional energy sources currently in use. Consequently, it has been estimated that a rather inefficient photovoltaic array covering half a sunny area measuring 100 square miles could meet all the annual electricity needs of India.[67] India could benefit a lot from solar power as it has almost 9 months of full sun to supply enough solar energy, though India requires additional equipped technology and facilities to harness this energy.

15. Conclusion

It is impossible to return to a naive simplicity. Nuclear technology is with us and cannot be wished away from it completely for it is necessary. One has to be a realist and face the dilemmas of decision and the risks involved.[68] The energy demand and security is the quest of all. But the nuclear option is neither desirable nor viable. Other options exist, and it is up to

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[65]"Solar Energy," *Encyclopedia Britannica 2009Ultimate Reference Suite*, 2009.

[66]"Solar Energy," *Encyclopedia Britannica 2012 Ultimate Reference Suite*, 2012.

[67]Caldicott, *Nuclear Power is Not the Answer*, 171.

[68]Ballard, "Reacting to Nuclear Power," 35 <http//:search. ebscohost.com> (25 August, 2013).

governments and citizens to implement them with urgency. The urgency of the global warming situation, to comprehend the extraordinary dangers of nuclear power, and to develop the motivation and altruism demand a personal and individual responsibility to protect universe for the future generations. Global resources are limited and the misapplication of science and industry has seriously damaged the ecosystems of this unique planet, threatening the ongoing existence of many millions of species, including human beings.

R. K. Gupta, former Scientific Engineer, Nuclear Fuel Processing Division, spoke: "Over 35 years I worked in plutonium plant of Nuclear Fuel Processing division of BARC Trombay. I became permanently physically handicapped, incapacitated during my service prior to retirement due to 'work environment', 'improper safety procedures', 'medical negligence', exposure to nuclear radiation', and 'nuclear contamination', etc."[69] He confirmed that the nuclear energy is not safe; it is dangerous both for humanity and environment. eco and people friendly energy resources and technologies are available and could be further improved. The crisis of nuclear war threatens the existence of our planet, and as Pope John Paul II said at Hiroshima, "From now on it is only through conscious choice and through deliberate policy that humanity can survive."[70] Nuclear energy and technology would lead to major negative impacts upon the world in general and to the Indian society in particular, especially with regard to ecology and environment and for the future of the humanity.

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[69]R. K. Gupta, <http://www.dianuke.org/nuclear-engineer-comes out -against-dae-calls-for-abandoning-nuclear-energy/#sthash. do OHPT xX. dpuf> (14 August 2013).

[70]Hunthausen Raymond, "Nuclear Deterrence and the Challenge of Peace Today," *CNS Documentary Service* 17 (1987) 11, 177-179. The U.S. Bishops' Pastoral Letter on War and Peace, "The Challenge of Peace: God's Promise and Our Response," <http://www.americancatholic.org/News letters/CU/ac0883.asp.> (26 August 2013).