The government of India is embarking on a massive nuclear power expansion program. However, its plans to set up nuclear plants and uranium mines across the country have met with fierce people's protests everywhere...
from Kudankulam, Jaitapur, Kovvada, Mithivirdi, Gorakhpur... to Meghalaya.

The PM and India's top atomic scientists are claiming that nuclear energy is a cheap, green, clean and safe solution to our future energy needs; that it is our gateway to a prosperous future.
They are dubbing the protestors as foreign agents, as being anti-development...

In reality, it is these protestors who are the real patriots, it is our rulers who have become foreign agents...

Nuclear power is about disease, it is about death, it has already produced the greatest health hazards the world has ever seen, which will last for the rest of time.

It is a technology that can destroy a nation.

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Unite, to fight Nuclear Madness

Lokayat

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Abbreviations Used in the Text

AEC	Atomic Energy Commission (India)
AERB	Atomic Energy Regulatory Board (India)
BARC	Bhabha Atomic Research Centre
BWR	Boiling Water Reactor
DAE	Department of Atomic Energy (India)
DOE	Department of Energy (USA)
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency (USA)
EPR	European Pressurised Reactor
FBR	Fast Breeder Reactor
FDA	Food and Drug Administration (USA)
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
IEP	Integrated Energy Policy (India)
LWR	Light Water Reactor
MAPS	Madras Atomic Power Station (Kalpakkam)
MoEF	Ministry of Environment and Forests (India)
MOX	Mixed Oxide Fuel
NPCIL	Nuclear Power Corporation of India Limited
NRC	Nuclear Regulatory Commission (USA)
PHWR	Pressurised Heavy Water Reactor
UCIL	Uranium Corporation of India Limited
WHO	World Health Organisation

For Units of Radiation: See Page No. 17

Important Note regarding References to this Booklet

For reasons of economy, we are not giving the references to the facts given in this booklet, as they run into nearly 16 pages. They are available on our website: http://www.lokayat.org.in/nuclear.

This book is an edited version of the main book, *Nuclear Energy: Technology From Hell*, written by us and published by Aakar Books, New Delhi. (You can also order the book from us.) A soft copy of the book is also available on the Lokayat Website.

INTRODUCTION

The government of India is promoting nuclear energy as a solution to the country's future energy needs and is embarking on a massive nuclear energy expansion program. It expects to have 20,000 MW nuclear power capacity online by 2020 and 63,000 MW by 2032. The Department of Atomic Energy (DAE) has projected that India would have an astounding 275 GW (1 GW = 1000 MW) of nuclear power capacity by 2050, which is expected to be 20 percent of India's total projected electricity generation capacity by then. With the signing of the Indo-US Nuclear Deal opening up the possibility of uranium and nuclear reactor imports, the Prime Minister stated in September 2009 that India could have an even more amazing 470 GW of nuclear capacity by 2050.[1]

This would be a quantum leap from the present scenario. As of September 30, 2011, the total installed power generation capacity in the country was 211,766 MW. Of this, the contribution of nuclear power—more than sixty years after India's atomic energy program was established—was just 4780 MW, or 2.26% of the total. Thus, the projected capacity in 2050 would represent an increase by a factor of over a hundred.

The government is seriously trying to implement this plan. It is planning to set up a string of giant size 'nuclear parks' all along India's coastline, each having 6-8 reactors of between 1000 to 1650 MW—Mithivirdi in Gujarat, Jaitapur in Maharashtra, Kudankulam in Tamil Nadu and Kovvada in Andhra Pradesh. It is also proposing to set up 4 indigenous reactors of 700 MW each at Gorakhpur in Haryana, and another 2 similar reactors at Chutka in Madhya Pradesh. To meet the fuel needs of these plants, it is proposing to set up several new uranium mining projects in Andhra Pradesh, Karnataka and Meghalaya.

Justifying this huge push for nuclear energy, India's politicians, nuclear scientists and other leading intellectuals are claiming that nuclear energy is safe, green and cheap. This propaganda campaign is being led from the front by the Prime Minister himself. Some of his most recent quotes:

- Tarapur, August 31, 2007: "(Since) our proven reserves of coal, oil, gas and hydro-power are totally insufficient to meet our requirements (and) the energy we generate has to be affordable, not only in terms of its financial cost, but in terms of the cost to our environment", this was the reason why "we place so much importance on nuclear energy."2
- At the Nuclear Security Summit, Washington, DC, April 13, 2010: "Today, nuclear energy has emerged as a viable source of energy to meet the growing needs of the world in a manner that is environmentally sustainable. There is a real prospect for nuclear technology to address the developmental challenges of our times ... The nuclear industry's safety record over the last few years has been encouraging. It has helped to restore public faith in nuclear power."[3]

Following the Fukushima accident, several countries put a pause or began phasing out their nuclear energy programs. However, the Indian Prime Minister has repeatedly asserted that India's nuclear expansion program will not be affected by the Fukushima accident. According to him, India's nuclear plants are world-class, our safety standards are unmatched, and that a Fukushima-type accident cannot happen in India (speech at the Nuclear Security Summit, Seoul, March 27, 2012).[4]

We examine these claims in this booklet. But before that, let us first discuss the basics of nuclear energy.

1. WHAT IS NUCLEAR ENERGY?

PART I: THE BASICS OF NUCLEAR POWER

The basic operation of a nuclear power plant is no different from that of a conventional power plant that burns coal or gas. Both heat water to convert it into pressurised steam, which drives a turbine to generate electricity. The key difference between the two plants lies in the method of heating the water. Conventional power plants burn fossil fuels to heat the water. In a nuclear power plant, this heat is produced by a nuclear fission reaction, wherein energy in the nucleus of an atom is released by splitting the atom.

The Atom

Everything is made of atoms. Any atom found in nature will be one of 92 types of atoms, also known as elements. (Actually, an element is a pure substance made up of only one type of atoms.) Atoms bind together to form molecules. So, a water molecule is made up of two atoms of hydrogen and one atom of oxygen. Every substance on Earth—metal, plastics, hair, clothing, leaves, glass—is made up of combinations of the 92 atoms that are found in nature.

Atoms are made up of three subatomic particles: the positively charged protons, the neutral neutrons and the negatively charged electrons. Protons and neutrons bind together to form the nucleus of the atom, while the electrons surround and orbit the nucleus.

Every element is characterised by its mass number and atomic number. The mass number is the number of protons and neutrons in its nucleus, while the atomic number is the number of protons. The chemical properties of an atom depend upon the number of protons in it, that is, its atomic number. There are atoms whose nuclei have the same number of protons, but different number of neutrons. The chemical properties of these atoms are identical, since they have the same number of protons. Such atoms are called *isotopes*. An isotope is designated by its element symbol followed by its mass number. For instance, the three isotopes of uranium are designated as U-234, U-235 and U-238.

Nuclear Fission

Fission means splitting. When a nucleus fissions, it splits into several lighter fragments. Nuclear fission can take place in one of two ways: either when a nucleus of a heavy atom captures a neutron, or spontaneously. Two or three neutrons are also emitted. The sum of the masses of these fragments (and emitted neutrons) is less than the original mass. This 'missing' mass has been converted into energy, which can be determined by Einstein's famous equation $E=mc^2$ (where E is the energy, m is the mass, c is the speed of light).

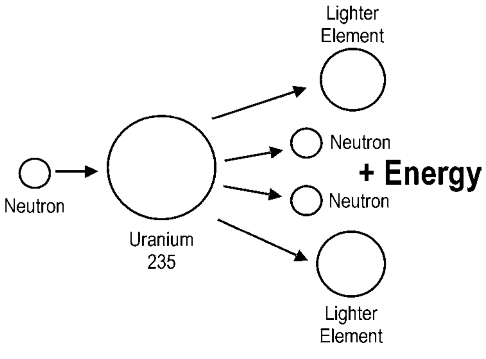


Figure: Nuclear Fission

Typical fission events release about 200 million eV (electron volts) for each fission event, that is, for the splitting of each atom. In contrast, when a fossil fuel like coal is burnt, it releases only a few eV as energy for each event (that is, for each carbon atom). This is why nuclear fuel contains so much more, millions of times more, energy than fossil fuel: the energy found in one kilogram of uranium is equivalent to the burning of 2000 tons of high-grade coal.

It is this energy released in a nuclear fission reaction that is harnessed to convert water to steam and drive a turbine and generate electricity in a nuclear power plant.

Nuclear Chain Reaction

The nuclear fission reaction is accompanied by the emission of several neutrons. Under suitable conditions, the neutrons released in a fission reaction fission at least one more nucleus. This nucleus in turn emits neutrons, and the process repeats. The fission reaction thus becomes self-sustaining, enabling the energy to be released continuously. This self-sustaining fission reaction is known as nuclear chain reaction.

The average number of neutrons from one fission that cause another fission is known as the *multiplication factor*, k. Nuclear power plants operate at k=1. If k is greater than 1, then the number of fission reactions increases exponentially, which is what happens in an atomic bomb.

Nuclear Fuel

The isotopes that can sustain a fission chain reaction are called nuclear fuels. The only isotope that can be used as nuclear fuel and also occurs naturally in significant quantity is Uranium-235. Other isotopes used as nuclear fuels are artificially produced, plutonium-239 and uranium-233. (Pu-239 occurs naturally only in traces, while U-233 does not occur naturally.)

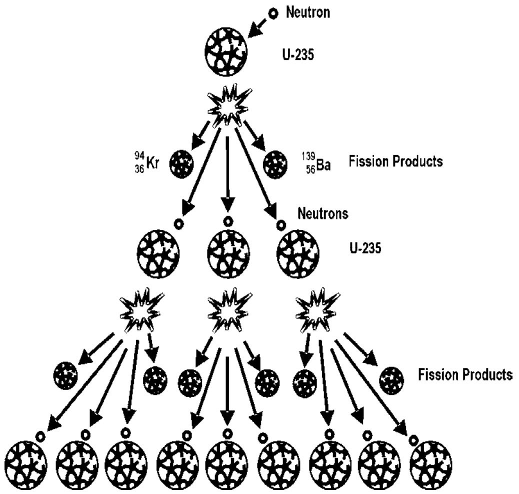


Figure: Nuclear Chain Reaction

We discuss the use of U-235 as nuclear fuel here. Uranium has many isotopes. Two, U-238 primarily, and to a lesser extent, U-235, are commonly found in nature. Both U-235 and U-238 undergo spontaneous radioactive decay, but this takes place over periods of millennia: the half-life of U-238 (half-life is the amount of time taken by half the atoms to decay) is about 4.47 billion years and that of U-235 is 704 million years. (For more on radioactivity and half-life, see

Chapter 3, Part I.)

While both U-235 and U-238 are *fissionable*, that is, both undergo fission on capturing a neutron, there is an important difference in their fission properties. U-238 can only be fissioned by fast moving neutrons, it cannot be fissioned by slow moving neutrons; therefore, it cannot sustain a nuclear chain reaction as the neutrons released during its fission inevitably inelastically scatter to lose their energy. However, U-235 has the property that it can be fissioned by slow moving neutrons too. This is what makes it *fissile*; in other words, it can sustain a nuclear chain reaction and can be used as nuclear fuel.

The concentration of U-235 in naturally occurring uranium ore is just around 0.71%, the remainder being mostly the non-fissile isotope U-238. For most types of reactors, this concentration is insufficient for sustaining a chain reaction and needs to be increased to about 3-5% in order that it can be used as nuclear fuel. This can be done by separating out some U-238 from the uranium mass. This process is called *enrichment*, and the resulting uranium is called *enriched uranium*. [Note that not all nuclear reactors need enriched uranium; for example, Heavy Water Reactors use natural (unenriched) uranium.]

As mentioned above, U-235 also undergoes a small amount of spontaneous fission, which releases a few free neutrons into any sample of nuclear fuel. These neutrons collide with other U-235 nuclei in the vicinity, inducing further fissions, releasing yet more neutrons, thus starting a chain reaction.

If exactly one out of the average of roughly 2.5 neutrons released in the fission reaction is captured by another U-235 nucleus to cause another fission, then the chain reaction proceeds in a *controlled* manner and a steady flow of energy results. However, if on the average, less than one neutron is captured by another U-235 atom, then the chain reaction gradually dies away. And if more than one neutrons are captured, then an *uncontrolled* chain reaction results, which can cause the nuclear reactor to meltdown; this is also what happens in an atomic bomb. To control the fission reaction in a nuclear reactor, most reactors use *control rods* that are made of a strongly neutron-absorbent material such as boron or cadmium.

The neutrons released in a fission reaction travel extremely fast, and therefore the possibility of their being captured by another U-235 nucleus is very low. Therefore they need to be slowed down, or *moderated*. In a nuclear reactor, the fast neutrons are slowed down using a *moderator* such as heavy water or ordinary water.

PART II: THE NUCLEAR FUEL CYCLE

The nuclear fission reaction that we have discussed above is only a small part of the entire complex process of generating electricity from uranium. The entire process is known as the nuclear fuel cycle. We now take a brief look at the various stages of this process (including the phase of uranium enrichment).

Mining: The nuclear fuel cycle starts with mining of uranium. Since 90% of the worldwide uranium ores have uranium content of less than 1%, and more than two-thirds have less than 0.1%, large amounts of ore have to be mined to obtain the amounts of uranium required.

Milling: The mined ore is then trucked to the mill to be processed to extract the uranium. Here, the ore is first ground into fine powder, and then treated with several chemicals to extract the uranium. The coarse powder thus obtained is called *yellowcake*. It contains 70-90% uranium oxide (U_3O_8).

Enrichment (not for Heavy Water Reactors)**:** The uranium oxide in the yellowcake contains both the fissile U-235 and non-fissile U-238. The yellow cake is now taken to a processing facility. Here, the uranium oxide is converted to uranium hexafluoride (UF_6), as this compound is gaseous at low temperatures and so is easier to work with. The UF_6 is now enriched either through diffusion or centrifugation, meaning the proportion of fissile U-235 in it is increased from 0.7 percent to 3-5 percent. The process yields two types of UF_6: one is enriched, and the other, which contains primarily U-238, is called *depleted*, so-called because most of the U-235 has been extracted from it.

Fuel element fabrication: The enriched uranium hexafluoride gas is now converted into solid uranium oxide fuel pellets, each the size of a cigarette filter. These pellets are packed into very thin tubes of an alloy of zirconium, and the tubes are then sealed. These tubes are called *fuel rods*. Each fuel rod is normally twelve feet long and half-an-inch thick. The finished fuel rods are bundled together to form the fuel assembly (or fuel bundle), which may have as many as 200 fuel rods. Several fuel assemblies are now placed in the reactor core of the nuclear power reactor—the number may go up to several dozen, depending upon the reactor design.

Nuclear reactor: The nuclear reactor is where the nuclear fuel is fissioned and the resulting chain reactions are controlled and sustained at a steady rate.

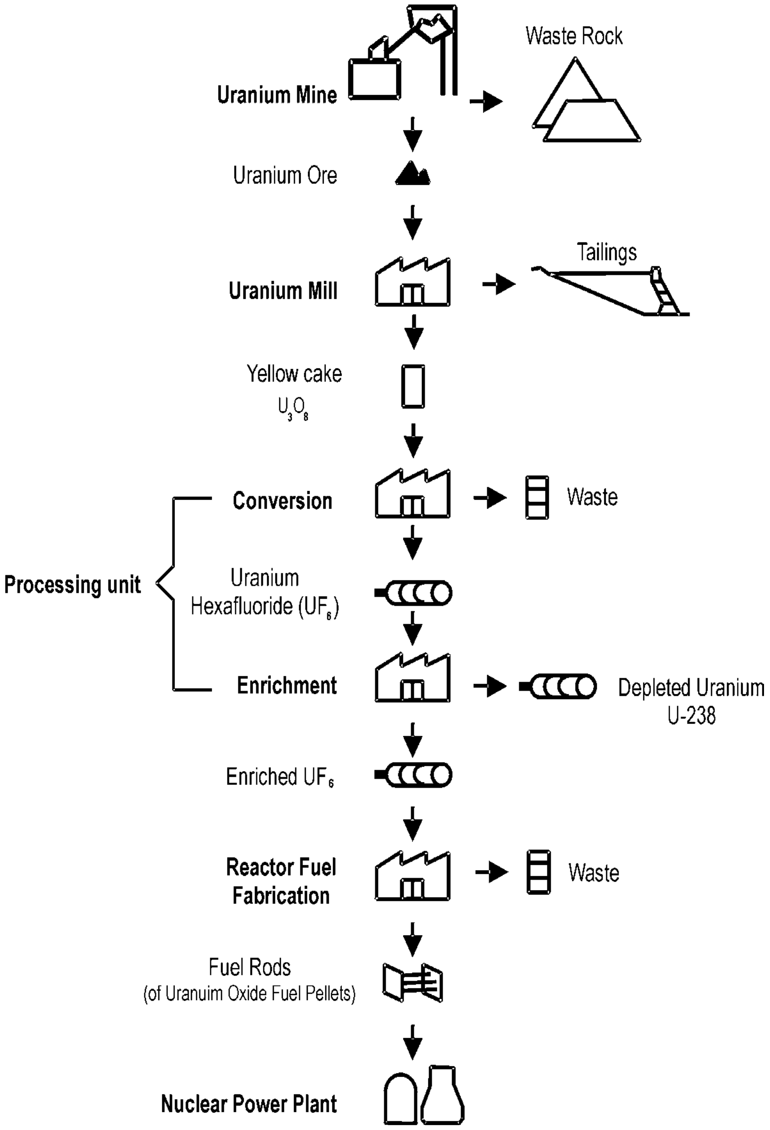


Figure: Nuclear Fuel Cycle

Decommissioning: Nuclear power plants are designed for an operating life of 30-60 years. When the reactor completes its working life, it is dismantled. Unlike conventional coal and gas power plants, the dismantling of a nuclear power plant is a very long-term, complicated and costly operation, because the entire nuclear power plant, including all its parts, has become radioactively contaminated.

The long-term management and clean up of these closed reactors is known as *decommissioning*, which can take anywhere between 5 to 100 years, depending upon the type of decommissioning plan.

Disposal of radioactive nuclear fuel waste: Every year, one-third of the nuclear fuel rods must be removed from the reactor, because they are so contaminated with fission products that they hinder the efficiency of electricity production. The uranium fuel after being subjected to the fission reaction in the reactor core becomes one billion times more radioactive; a person standing near a single spent fuel rod can acquire a lethal dose within seconds. This spent nuclear fuel is going to be radioactive for tens of thousands of years. Therefore, it needs to be safely stored for centuries to come.

Generally, the spent fuel is first stored for many years in on-site storage ponds and continually cooled by air or water. If it is not continually cooled, the zirconium cladding of the rod could become so hot that it would spontaneously burn, releasing its radioactive inventory. The cooling period can be from a few years to decades. After cooling, there are two options for the waste—either it is reprocessed, or it is moved to dry cask storage.

In the latter case, the spent fuel rods are packed by remote control into highly specialised containers made of metal or concrete designed to shield the radiation. These casks must be stored for centuries to come; however, no country having nuclear plants has succeeded in building such a long-term nuclear waste dump site. Presently, in most countries having nuclear plants, these casks are 'temporarily' stored near the spent fuel cooling ponds.

Reprocessing spent fuel: Reprocessing is a chemical process to separate out the uranium and plutonium contained in the spent fuel, which can then be used as fuel for what are known as Fast Breeder Reactors. Reprocessing also segregates the waste into high-level, intermediate-level and low-level wastes.

PART III: THE NUCLEAR REACTOR

Most nuclear reactors work on the same basic principles. The basic components common to most types of nuclear reactors are as below:

Reactor core: The part of the nuclear reactor where the nuclear fuel assembly is located.

Moderator: The material in the core which slows down the neutrons released during fission, so that they cause more fission. It is usually ordinary water (used in Light Water Reactors) or heavy water (used in Heavy Water Reactors).

Control rods: These are made with neutron-absorbing material such as cadmium, hafnium or boron, and are inserted or withdrawn from the core to control the rate of reaction, or halt it.

Coolant: A liquid or gas circulating through the core so as to transfer the heat from it. This primary coolant passes through a steam generator (except in Boiling Water Reactors or BWRs), where the heat is transferred to another loop of water (in the so-called secondary circuit) to convert it into steam. This steam drives the turbine. The advantage of this design is that the primary coolant, which has become radioactive, does not come into contact with the turbine.

Pressure vessel: Usually a robust steel vessel containing the reactor core and moderator/coolant.

Steam generator (not in BWRs)**:** Here, the primary coolant bringing heat from the reactor transfers its heat to water in the secondary circuit to convert it into steam.

Containment: This is typically a metre-thick concrete and steel structure around the reactor core. After the zirconium fuel cladding and the reactor pressure vessel, this is the last barrier against a catastrophic release of radioactivity into the atmosphere. Apart from a primary containment, many reactors have a secondary containment too, which is normally a concrete dome enveloping the primary containment as well as the steam systems. This is very common in BWRs, as here most of the steam systems, including the turbine, contain radioactive materials.

Types of Nuclear Reactors

At a basic level, reactors may be classified into two classes: Light Water Reactors (LWRs) and Heavy Water Reactors (HWRs). LWRs are largely of two types, Pressurised Water Reactors (PWRs) and Boiling Water Reactors (BWRs). LWRs, and of them, the PWRs, are the most widespread reactors in operation today. Heavy Water Reactors can also be of different types, one of the most well known being the CANDU reactors developed by Canada, which are a type of Pressurised Heavy Water Reactors (PHWRs). Most of India's indigenous reactors are CANDU reactors.

Below, we discuss the most well-known type of nuclear power reactor—the PWR, and also the reactor design of most of India's reactors—the PHWR or CANDU reactor.

Pressurised Water Reactor

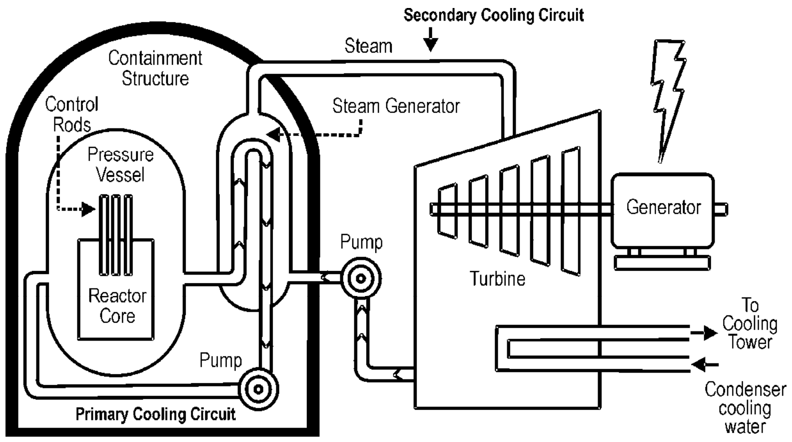


Figure: Pressurised Water Reactor

A PWR uses ordinary water as both coolant and moderator. It has three water circuits. Water in the primary circuit which flows through the core of the reactor reaches about 325°C; hence it must be kept under about 150 times atmospheric pressure to prevent it from boiling. Water in the primary circuit is also the moderator, and if it starts turning into steam, the fission reaction would slow down. This negative feedback effect is one of the safety features of this type of reactors.

The hot water from the primary cooling circuit heats the water in the secondary circuit, which is under less pressure and therefore gets converted into steam. The steam drives the turbine to produce electricity. The steam is then condensed by water flowing in the tertiary circuit and returned to the steam generator.

Pressurised Heavy Water Reactor (PHWR or CANDU)

A PHWR uses heavy water as the coolant and moderator, instead of ordinary water. Heavy water is a more efficient moderator than ordinary water as it absorbs 600 times fewer neutrons than the latter, implying that the PHWR is more efficient in fissioning U-235 nuclei. Hence, it can sustain a chain reaction with lesser number of U-235 nuclei in uranium as compared to PWRs. Therefore, PHWR uses unenriched uranium, that is, natural uranium (0.7% U-235) oxide, as nuclear fuel, thus saving on enrichment costs. On the other hand, the disadvantage with using heavy water is that it is very costly, costing hundreds of dollars per kilogram.

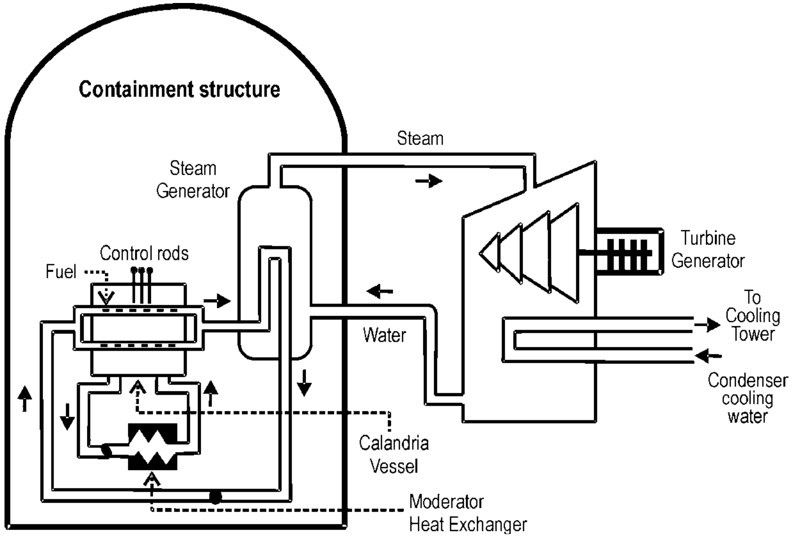


Figure: Pressurised Heavy Water Reactor

Conceptually, this reactor is similar to PWRs discussed above. Fission reactions in the reactor core heat the heavy water. This coolant is kept under high pressure to raise its boiling point and avoid significant steam formation in the primary circuit. The hot heavy water generated in this primary circuit is passed through a heat exchanger to heat the ordinary water flowing in the less-pressurised secondary circuit. This water turns to steam and powers the turbine to generate electricity.

The difference in design with PWRs is that the heavy water being used as moderator is kept in a large tank called Calandria and is under low pressure. The heavy water under high pressure that serves as the coolant is kept in small tubes, each 10 cms in diameter, which also contain the fuel bundles. These tubes are then immersed in the moderator tank, the Calandria.

2. IS NUCLEAR ENERGY GREEN?

Prime Minister Manmohan Singh (Aug 21, 2011): "I am convinced that nuclear energy will play an important role in our quest for a clean and environmentally friendly energy mix as a major locomotive to fuel our development process."[5]

Taking advantage of the growing crisis of global warming, political leaders, administrators and the global nuclear industry have launched

a huge propaganda campaign to promote nuclear energy as the panacea for reduction of greenhouse gas emissions.

While it is true that nuclear reactors do not emit greenhouse gases in the same quantity as coal or oil powered generating stations, but to conclude that nuclear energy is "an environment friendly source of power" is a far stretch. Nuclear reactors do not stand alone; the production of nuclear electricity depends upon a vast and complex infrastructure known as the nuclear fuel cycle. And the fact is, the nuclear fuel cycle utilises large quantities of fossil fuel during all its stages, as discussed below.

Carbon Emission and the 'Nuclear Fuel Cycle'

Uranium mining and milling are very energy intensive processes. The rock is excavated by bulldozers and shovels and then transported in trucks to the milling plant, and all these machines use diesel oil. The ore is ground to powder in electrically powered mills, and fuel is also consumed during conversion of the uranium powder to yellow cake. In fact, mining and milling are so energy intensive that if the concentration of uranium in the ore falls to below 0.01%, then the energy required to extract it from this ore becomes greater than the amount of electricity generated by the nuclear reactor. And most uranium ores are low grade; the high-grade ores are very limited.

The uranium enrichment process is also very energy intensive. For instance, the Paducah enrichment facility in the USA uses the electrical output of two 1,000 MW coal-fired plants for its operation, which emit large quantities of CO_2.

The construction of a nuclear reactor is a very high-tech process, requiring an extensive industrial and economic infrastructure. Constructing the reactor also requires a huge amount of concrete and steel. All this consumes huge quantities of fossil fuel. After the reactor's life is over, its decommissioning is also a very energetic process.[6]

Finally, constructing the highly specialized containers to store the intensely radioactive waste from the nuclear reactor also consumes huge amounts of energy. This waste has to be stored for a period of time which is beyond our comprehension—hundreds of thousands of years! Its energy costs are unknown.

Energy Balance

A study done for the Green parties of the European Parliament by senior scientists Jan Willem Storm van Leeuwen and Philip Smith in

2004 estimated that under the most favourable conditions, the nuclear fuel cycle emits one-third of the carbon dioxide emissions of modern natural gas power stations. They excluded the energy costs of transportation and storage of radioactive waste in their calculations, and also assumed high grade uranium ore is used to make the nuclear fuel. But these high grade ores are finite. Use of the remaining poorer ores in nuclear reactors would produce more CO_2 emissions and nuclear energy's green choga will no longer remain green.[7]

The concentration of uranium in India's uranium ores is very low. From the total uranium mined in Jaduguda over the last 40 years, Dr. Surendra Gadekar has estimated that the ore quality at Jaduguda hasn't been better than 0.03% for many years.[8] At such meagre concentrations, it is obvious that the total CO_2 emissions from the nuclear fuel cycle in India must be fairly high.

Actual Potential: Even Less

However, this represents only half the argument. Burning of fossil fuels is not the only factor responsible for greenhouse gas (GHG) emissions, though it is the largest (see Table 2.1). Obviously, nuclear power cannot help in reducing these other causes of GHG emissions, like use of fertilisers in chemical agriculture, industrial processes that emit GHGs, etc. Then again, fossil fuels are burnt for various uses, and nuclear power can replace fossil fuels only in large scale electricity generation, and not in its other uses, like in the transportation sector.

Table 2.1: Contribution of Various Sectors to Global Warming[9]

Fossil fuel burning	**66.5%**
of which	
Transportation	14.3%
Electricity and heat	24.9%
Other fuel combustion	8.6%
Industry	14.7%
Fugitive emissions	4%
Industrial processes	**4.3%**
Land use change	**12.2%**
Agriculture	**13.8%**
Waste	**3.2%**
Total	**100%**

Worldwide, use of fossil fuels for electricity and heating contributes to only 25% of the total GHG emissions. Therefore, replacing burning of fossil fuels with nuclear energy can only bring about some reduction in this part of the total global GHG emissions. (And that too, assuming that high grade uranium ore is used.)

How much reduction is possible? The International Energy Agency has estimated that even if nuclear energy contribution were to quadruple by 2050, it would reduce global CO_2 emissions by only 4%![10] The crisis of global warming is very acute, and to tackle it, what the world needs is not a marginal reduction in GHG emissions, but deep cuts—40% by 2020 and 95% by 2050. Obviously, nuclear power cannot significantly contribute to bringing about these reductions.

On the other hand, implementation of this scenario would require construction of 32 new 1000 MW nuclear reactors every year from now until 2050. Investment costs for these 1,400 new reactors would exceed $10 trillion at current prices. That is huge! Given the enormous subsidies needed to build just one reactor (discussed in Chapter 5), that would bankrupt even the richest countries!!

What about Renewable Sources of Energy?

The above discussion compared CO_2 emissions from the nuclear fuel cycle with that from gas- and coal-fired power plants. The nuclear lobby focuses on this comparison to make an argument for building nuclear power plants. But there is another facet to the whole issue, which the nuclear lobby very conveniently forgets: renewable energy sources emit less greenhouse gases than nuclear plants! In comparison to renewable energy sources, power generated from nuclear reactors releases four to five times more CO_2 per unit of energy produced, when taking into account the entire nuclear fuel cycle.[11]

If the growing crisis of global warming is an argument in support of promoting nuclear energy as compared to electricity from burning fossil fuels, then, by an extension of this same logic, shouldn't renewable energy be promoted as compared to nuclear energy?

3. IS NUCLEAR ENERGY CLEAN?

During President Obama's visit to India in November 2010, he and Prime Minister Manmohan Singh committed themselves to spurring the "development of clean and safe nuclear energy in India."[12]

From US to India, politicians and leading intellectuals are repeatedly asserting that nuclear energy is a safe and clean form of energy. They are all blithely lying. They believe that if you lie frequently and with conviction, people will believe you.

Even if nuclear power plants are operating normally, the entire nuclear cycle from uranium mining to nuclear reactors routinely emits huge quantities of extremely toxic radioactive elements into the atmosphere every year. The environmental costs of the deadly radiation emitted by these elements and its impact on human health are simply horrendous. What is infinitely more worse, since these radioactive elements will continue to emit radiation for tens of thousands of years, therefore, its effects will continue to plague the human race not just for the present, but for thousands of generations to come. And if there is a major accident, and nuclear reactors are inherently prone to accidents, the consequences will be cataclysmic! In the words of Dr. Helen Caldicott, the renowned Australian physician turned anti-nuclear activist who has worked tirelessly to expose the threat this technology from hell poses to human survival:

> As a physician, I contend that nuclear technology threatens life on our planet with extinction. If present trends continue, the air we breathe, the food we eat, and the water we drink will soon be contaminated with enough radioactive pollutants to pose a potential health hazard far greater than any plague humanity has ever experienced.[13]

In this chapter, we discuss the radiation emitted during each stage of the nuclear fuel cycle and its consequences for the human race. In the next chapter, we discuss the possibility of a major accident occurring in nuclear reactors and its probable impact, in the light of Chernobyl and the very recent Fukushima nuclear accident.

PART I: WHAT IS RADIATION?

Radioactive decay: Stable and unstable atoms

Most atoms found in nature are stable, that is, they do not undergo changes on their own. For instance, if we put an atom of aluminium in a bottle, seal it, and open it after a million years, it would still be an atom of aluminium. Aluminium is therefore called a stable atom.

Many stable atoms also have unstable isotopes. An unstable atom is one whose nucleus undergoes some internal change spontaneously. In this change, the nucleus emits *radiation* in the form of subatomic particles, or a burst of energy, or both. This emission of radiation is called *radioactivity*, and the nucleus is said to have undergone *radioactive decay*. In this process, the nucleus changes its composition and may actually become an entirely different nucleus. The process continues till the nucleus achieves stability.

To give an example: most carbon (C-12) atoms are stable, with the nucleus having six protons and six neutrons. Carbon has an unstable isotope, C-14, whose nucleus consists of six protons and eight neutrons. In its attempt to achieve stability, its nucleus gives off a beta particle (an electron). After emitting the beta particle, the C-14 nucleus now consists of seven protons and seven neutrons (one neutron has decayed into an electron and a proton, and the electron has been emitted as a beta particle). But a nucleus consisting of seven protons and seven neutrons is no longer a carbon nucleus, it is the nucleus of a nitrogen atom. By emitting a beta particle, the C-14 atom has changed into a N-14 atom.

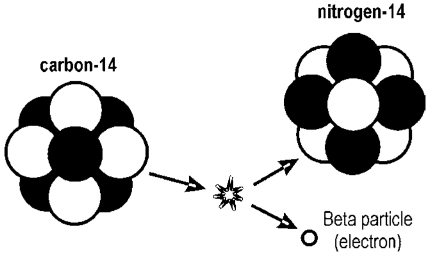


Figure: Unstable Atom

Types of Radiation

Radioactive isotopes emit three types of radiation:

i) **Alpha radiation:** Alpha particles are composed of two protons and two neutrons. Being heavy (as compared to beta particles), these particles do not travel very far. Therefore, they are not able to penetrate dead cells in the skin to damage the underlying living cells. However, when inhaled into the lungs or ingested into the gastrointestinal tract, they come into contact with living cells and severely damage them. The consequences for human health can be serious, including the possibility of causing cancer. For instance, plutonium is an alpha emitter, and no quantity inhaled has been found to be too small to induce lung cancer in animals.

ii) **Beta radiation:** This is composed of electrons. How does a nucleus emit an electron? The answer: a neutron breaks up into a proton and an electron, and the latter is emitted. Beta particles are lighter than alpha particles, and so while they travel farther than alpha particles in body tissues, the biological damage caused by them is less—like a bullet compared to a cannon ball. They can penetrate the outer layer of dead skin and damage the underlying living cells. If inhaled or ingested to enter into the blood stream, they can damage tissues and cause cancer. Thus, iodine-131 is a beta emitter. It concentrates heavily in the thyroid gland, increasing the risk of thyroid cancer and other disorders.

iii) Gamma radiation: This is akin to X-rays. It has great penetrating power and can travel large distances. Gamma radiation goes straight through human bodies. As gamma rays pass through the body, they can damage the body cells.

When people are exposed to radiation, it may or may not lead to disease—it depends upon whether the body's cellular repair mechanisms are able to repair the damage or not. But, as we see below, what is definite is that there is no minimum safe dose of radiation.

Units of Radiation

Becquerel and Curie: This unit applies to the strength of the source, that is, the radioactive isotope. In the International System of units (SI), it is measured in becquerel (Bq). One Bq is defined as one disintegration per second. Becquerel is a very small unit. An older, non-SI, and much larger unit of radioactivity is curie (Ci), defined as: 1 curie of radiation = 3.7×10^{10} disintegrations per second.

Rad and Gray: The radiation emitted by a radioactive element is not the same as the radiation absorbed by the body. The difference between the two is like a boxer who hits at his opponent, but he may or may not strike him. The radiation dose absorbed by the body is measured in a unit called rad. In the SI system of units, the unit is gray. A dose of 1 gray means the absorption of 1 joule of radiation energy per kilogram of absorbing material. The conversion factor is: 1 gray = 100 rad.

Rem and Sievert: Even for the same amount of absorbed radiation, different types of radiation have different biological effects. Thus, the same rad of alpha particles when absorbed cause much more damage than beta particles. This difference is measured by a unit called rem. To determine rem, the absorbed dose in rad is multiplied by a quality factor (Q) that is unique to the type of incident radiation. For gamma rays and beta particles, 1 rad of exposure results in 1 rem of dose, while for alpha particles, 1 rad of exposure is equivalent to 20 rems of dose. Another unit for measuring biological impact of absorbed radiation is sievert or Sv: 1 sievert = 100 rem.

Some examples of radiation doses:

Radiation Dose	Source
0.1 mSv	X-ray (chest)
0.4 mSv	Mammography
1.5 mSv	X-ray (spine)
2 mSv	CT scan (head)
15 mSv	CT scan (abdomen and pelvis)

Radiation is often measured in dose rates, such as millisievert per hour. Dose rates are important because faster delivery of radiation can have a relatively stronger impact; getting the same dose in 1 hour is usually worse than getting the same dose stretched out over the course of a year. Some important dose rates are:

- In the US (and several other countries), maximum radiation exposure limit for members of the public is 1 mSv/year.
- The maximum exposure limit for employees of nuclear facilities in most countries, including India, is 20 mSv/year; this limit is 50 mSv/yr in the US.

Half-life

Each radioactive isotope has a specific half-life. Half-life of an isotope is the amount of time it takes for the half the number of atoms of that isotope to decay. For example, radioactive iodine-131 has a half-life of eight days. This means that in eight days it loses half its radioactive energy, in another eight days it decays again to one quarter of the original radiation, ad infinitum. The amount of time taken by a radioactive isotope to decay to a harmless level can be obtained by a simple thumb rule: multiply the half-life by 20. (There is of course no unanimity on this; many experts say that radiation becomes harmless in 10 half-lives.) Thus, in the case of iodine-131, its radioactive life is 8 x 20 = 160 days. Some isotopes created during the fission reaction in a nuclear reactor have very short half-lives (less than a second), and some extremely long (millions of years).

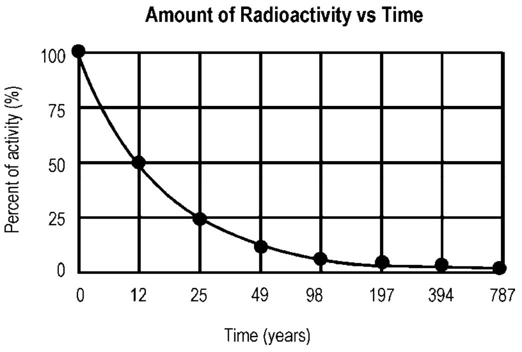


Figure: Decay Curve for Tritium

Part II: Radiation and Human Health

Impact of Low-level Radiation

Instructions providing all the information necessary for a living organism to grow and live reside in every cell of the body of the organism. These instructions are stored in a molecule called the DNA, or Deoxyribonucleic acid, whose shape is like a twisted ladder, called a “double-helix”. The DNA molecules are stranded together like letters in a sentence, and these strands are called genes.

Genes are packed into thread like structures, called chromosomes.

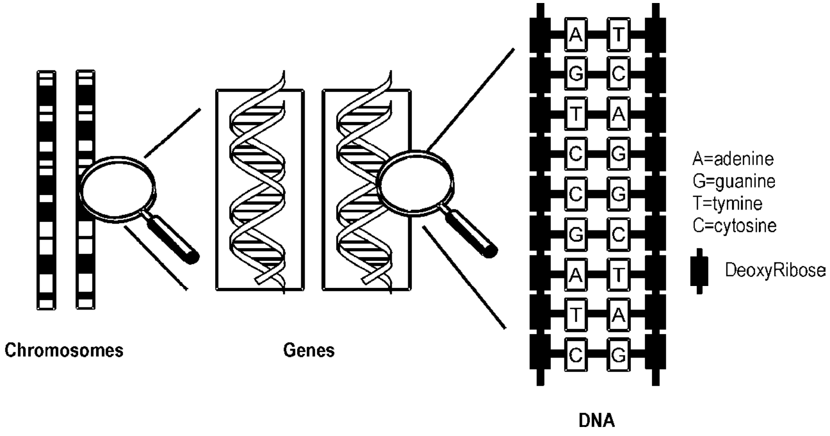


Figure: DNA, Genes and Chromosomes

Genes are the very building blocks of life, responsible for every inherited characteristic in all species—plants, animals and humans. Most genes are the same in all human beings, which is why all human beings are similar. A small number of genes are different, and it is these which are responsible for each human being’s unique features.

Even at low doses, radiation can have multiple effects.

i) The effects of radiation on the human body are the same like the biological mechanisms at work during the normal aging process. Therefore, radiation exposure causes illnesses among people 10-15 years earlier than would normally be expected due to the normal aging process. Examples include premature ageing of the eye and development of cataract at a younger age, neurophysiologic effects, increased likelihood of developing metabolic diseases like diabetes, arteriosclerosis (hardening of the arteries) and hypertension at a younger age, reduced ability to recover from diseases, decreased ability to cope physically with habitat variations, etc.

ii) Radiation can damage the foetus if a pregnant woman is exposed to radiation. It can cause death of the foetus, or it may so happen that radiation kills a particular group of cells that were going to become the left arm, or the septum of the heart. This results in congenital anomalies (birth defects).

iii) Radiation can induce mutation, that is, a chemical change, in the DNA molecule, thereby causing a change in the gene. If this mutation takes place in the reproductive gene, then it can cause the most unexpected changes in the offspring. This can be understood from the fact that radiation from the atmosphere and earth’s crust (called background radiation) is responsible for thousands of genetically inherited diseases, like cystic fibrosis.

Low-level Radiation and Cancer

All non-reproductive cells of the body have regulatory genes that control the rate of cell division. If a regulatory gene is exposed to radiation, and it mutates, then the cell may become carcinogenic. However, cancer does not develop right away; there is a long incubation period which can be from 2 to 40 years. Then one day, instead of the cell dividing into two daughter cells in a regulated fashion, it begins to divide in a random, uncontrolled fashion into millions and trillions of daughter cells, creating a cancer. All kinds of cancers can be caused by exposure to radiation, from cancer of the upper digestive tract and lungs to bone cancer and leukaemia.

Kakodkar and other conmen deputed by the DAE to hoodwink ordinary people have been arguing that since radiation is used to cure cancer, how can it cause cancer? It is true that in cancer therapy, a high dose of radiation is directed at cancerous cells to kill them. But while doing so, doctors are taking a risk. It is possible that the nearby normal cells may get damaged. As mentioned earlier, the body's cellular repair mechanism tries to repair the damaged cells, but it may or may not succeed. Even if it fails and the cells become cancerous, it is going to take many years for the secondary cancer to develop.

Impact of High Dose of Radiation

Exposure to a high dose of radiation, usually above 1 sievert, can result in what is called radiation sickness, whose symptoms include nausea, weakness, hair loss, skin burns, blood disorders and diminished organ function. If the dose is high enough, it can cause immediate death. It is estimated that 50% of the population would die in a month if exposed to a whole body dose of 5 sieverts over a period of a few hours.

No Safe Dose of Radiation

Over the past several decades, many official radiation protection groups have given recommendations regarding “acceptable” or "reasonable" levels of radiation exposure for the general public and nuclear workers. Many of these recommendations have been accepted by countries around the world and incorporated into their regulations. In the United States, Nuclear Regulatory Commission (NRC) guidelines state that nuclear plant operators cannot legally expose the general public to more than 100 millirems per person annually. Rules are more lenient for nuclear workers: they are allowed a yearly exposure of 5,000 millirems. In India, the standards set by the Atomic Energy Regulatory Board are that workers must not be exposed to more than 2000 millirems a year averaged over five consecutive years (and not more than 3000 millirems in any single year).

However, today there is a preponderance of scientific evidence to show that even very low doses of radiation pose a risk of cancer and other health problems and there is no threshold below which exposure can be viewed as harmless. In the words of Dr. John W. Gofman, Professor Emeritus of Molecular and Cell Biology at University of California, Berkeley, who received the 1992 Right Livelihood Award for his pioneering work on the health effects of low level radiation:

> (T)he evidence on radiation producing cancer is beyond doubt. I've worked fifteen years on it, and so have many others. It is not a question any more: radiation produces cancer, and the evidence is good all the way down to the lowest doses ... Scientists who support these nuclear plants—knowing the effects of radiation ... deserve trials for murder.[14]

Today, the evidence is so overwhelming that numerous scientific bodies have come to the same conclusion:[15]

- US National Council on Radiation Protection: "Every increment of radiation exposure produces an incremental increase in the risk of cancer."
- US Nuclear Regulatory Commission: "Any amount of radiation may pose some risk for causing cancer."
- The US Environmental Protection Agency: "… any exposure to radiation poses some risk, i.e. there is no level below which we can say an exposure poses no risk."

In short, there is no safe dose of radiation. To quote Dr. John William Gofman once again: "Any permitted radiation is a permit to commit murder."

Internal and External Radiation

Even though the above medical facts are well established for

decades now, many pro-nuclear intellectuals continue to claim that anti-nuclear activists are exaggerating the impact of low-level radiation on human health. One of their pet arguments is that there is nothing to fear from radiation releases from nuclear power plants, as they are much less than *background radiation* (naturally occurring radiation that is constantly present in the environment).

This is a strange argument. We obviously cannot do anything about background radiation, and therefore cannot prevent a certain number of people from getting cancers due to this. But should we not try and ensure that this number does not increase due to man-made radiation?

However, the most important mistake made in the above arguments is that these intellectuals confuse external radiation with internal radiation. Dr. Helen Caldicott explains the difference:

> The former is what populations were exposed to when the atomic bombs were detonated over Hiroshima and Nagasaki in 1945; their profound and on-going medical effects are well documented.
>
> Internal radiation, on the other hand, emanates from radioactive elements which enter the body by inhalation, ingestion, or skin absorption. Hazardous radionuclides such as iodine-131, caesium-137, and other isotopes currently being released in the sea and air around Fukushima ... (after) they enter the body, these elements—called internal emitters—migrate to specific organs such as the thyroid, liver, bone and brain, where they continuously irradiate small volumes of cells with high doses of alpha, beta and/or gamma radiation, and over many years, can induce uncontrolled cell replication—that is, cancer. Further, many of the nuclides remain radioactive in the environment for generations, and ultimately will cause increased incidences of cancer and genetic diseases over time.[16]

In other words, when you have internal contamination, it is like having a Fukushima nuclear reactor at the cellular level!

PART III: RADIATION EMISSION IN NUCLEAR FUEL CYCLE

Man-made radiation is released during all stages of the nuclear fuel cycle.

1. Uranium Mining

Uranium miners are exposed to radiation emitted by a number of lethal uranium daughters, the most dangerous being: (i) the radioactive gas radon-222—deposits in the lungs, to cause lung cancer; (ii) radium-226 (half-life 1,600 years)—deposits in the bones to cause bone cancer and leukaemia.

As a result, uranium miners suffer from a very high incidence of cancer. One-fifth to one-half of the uranium miners in North America have died and are continuing to die of lung cancer. Records reveal that uranium miners in other countries, including Germany, Namibia and Russia, suffer a similar fate.[17]

Waste Rock

The waste produced during mining, called waste rock or mine tailings, is in huge quantities—lakhs of tons. It is left lying in the open in huge heaps adjacent to the mine. This waste rock contains uranium ore of too low grade for processing in the mill. It also contains decay products of uranium. Being radioactive and toxic, they contaminate the environment, and will continue to do so even after the shutdown of the mines, to cause disease among people living near the mines for thousands of years: radon gas can escape into the air; radium-226 containing ore dust can be blown by the wind; and uranium and its decay products can seep into surface water bodies and groundwater.

The reason why the world is not bothered about these impacts is because 70% of the world's uranium lies on indigenous lands.[18] Thus, most uranium mines in the USA are situated near indigenous tribal lands of the Navajo nation, in the American Southwest. The radioactive wastes have contaminated the air, soil, groundwater and even the Colorado River. They are taking a terrible toll: thousands of Navajos are suffering and dying from uranium-induced cancers. No one knows how many exactly, because the authorities do not keep a track. Epidemiological studies reveal that Navajo children living near the mines and mills suffer 5 times the rate of bone cancer and 15 times the rate of testicular and ovarian cancers as other Americans.[19]

2. Uranium Milling and Mill Tailings[20]

Uranium mills are normally located near the mines to save transportation costs. The wastes generated from the milling process are in the form of sludge and are called uranium mill tailings. They are pumped to settling ponds, where they are abandoned.

Since uranium represents only a minor fraction of the ore (for example 0.1%), the amount of sludge or mill tailings is nearly identical to that of the ore mined. Since it is not possible to extract all of the uranium present in the ore, therefore, the sludge contains 5% to 10% of the uranium initially present in the ore; it also contains all the remaining radioactive constituents of the ore.

The sludge thus contains 85% of the initial radioactivity of the ore. One of its deadly radioactive constituents is thorium-230, a uranium decay product with a half-life of 80,000 years. This means that it emits radioactivity for lakhs of years! Th-230 is especially toxic to the liver and the spleen, and also causes leukaemia and other blood diseases. It decays to produce radon gas, a very powerful cancer-causing agent. Even though radon-222 has a comparatively short half-life of 3.8 days, its quantity will not diminish for a long time, because it is constantly being replenished by the decay of the very long-lived thorium-230.

Hence, the tailing ponds will continue to radioactively contaminate the environment and affect the health of the people living nearby for hundreds of thousands of years:

- Radon gas can travel many miles with a light breeze in just a few days.
- Seepage from the tailing ponds is inevitably going to contaminate the ground and surface water. This is happening at tailing ponds all over the world.
- Heavy rains can cause a spillover of the sludge into nearby areas. Has occurred at several tailing ponds.
- Or, the tailings dam may fail! The failure can be huge. For instance, on July 16, 1979, the Church Rock tailings dam in New Mexico collapsed, spilling 340 million litres of liquid radioactive waste and eleven hundred tons of solid mill waste into the Rio Puerco River. It is the largest release of radioactive waste ever in the US.

The tailings therefore need to be safeguarded for tens of thousands of years. In practice, the settling ponds are simply abandoned. Only when there is a major seepage from the pond, or the dam breaks, do governments move to take some damage control measures.

3. Routine Radiation Releases from Nuclear Plants

The process of splitting uranium in nuclear reactors creates more than 200 new, radioactive elements that didn't exist till uranium was fissioned by man. The resulting uranium fuel is a billion times more radioactive than its original radioactive inventory. A regular 1,000 megawatt nuclear power plant contains an amount of long-lived radiation equivalent to that released by the explosion of 1,000 Hiroshima-sized bombs.[21]

The diabolical elements created in the fission reaction leak out through cracks in the zirconium fuel rods. They now find their way into the environment through a number of ways. One way is that they mix with the primary coolant, that is, the water that cools the reactor core, making it radioactive. The primary coolant is piped through a steam generator to heat the water in the secondary cooling system. The primary coolant is not supposed to mix with the secondary coolant, but it routinely does (through cracks in the piping). Nuclear utilities in the US admit that about 45 litres of intensely radioactive primary coolant leaks into the secondary coolant every day.[22] The secondary coolant is converted to steam to drive the turbines. Being at very high pressure, some radioactive steam routinely escapes into the environment from the reactor.

Apart from mixing with the primary coolant, radioactive gases leaking from fuel rods are also routinely released into the atmosphere at every nuclear reactor. This is known as "venting". The nuclear industry claims that filters are used to remove the most radioactive isotopes, but in reality not all dangerous isotopes are removed and some escape into the environment.[23]

Finally, as we discuss in the next chapter, nuclear plants are inherently prone to accidents. Even if a major accident does not take place, accidental releases of large quantities of radioactive water or gases take place very frequently.

Radioactive Elements in Emissions

The radioactive steam and gases released into the atmosphere from nuclear reactors contain small amounts of the deadly radioactive elements created during the fission reaction. Some of these are:

- Cesium-137 (half-life 30 years): it mimics potassium and tends to concentrate in the muscle cells in the body, causing cancer.
- Strontium-90 (half-life 28 years): the body treats it like calcium and so it concentrates in breast milk and bones, to cause breast cancer and bone cancer years later.
- Iodine-131 (half-life 8 days): it is very carcinogenic; on entering the body, it concentrates in the thyroid, to cause the rare thyroid cancer.

An important toxic isotope that is routinely emitted in large quantities from nuclear power plants is tritium (H-3), a radioactive isotope of hydrogen. It has a half-life of 12.4 years and as such is radioactive for 248 years. H-3 combines readily with oxygen to form tritiated water (H_3O). Since this is chemically the same as water, it is

not trapped by filters, and so continuously finds its way into the atmosphere. In September 2010, the US NRC acknowledged that more than half of America's atomic reactors are leaking radioactive tritium. The "allowable" standard for radioactive tritium in drinking water in the US is 740 becquerels per litre of water; at 9 sites covering 18 reactors, the tritium levels were above 37,000 Bq/litre![24] In Canada, tritium levels in groundwater at the site of its Pickering "A" nuclear reactors were found to be as high as 700,000 Bq/litre.[25]

Tritium is readily absorbed through the skin, lungs and the GI tract into the human body. It causes tumours and cancer in the lungs and GI tract. In animal experiments, even at low doses, it has been shown to shrink the testicles and ovaries, and cause birth defects, ovarian tumours, mental retardation, brain tumours, decreased brain weight, and stunted, deformed foetuses.

Leakages due to Radioactive Corrosion

Apart from being created during the fission reaction, radioactive products are also created in another way in the nuclear reactor: due to bombardment of the metal piping and the reactor containment by neutrons. This is known as radioactive corrosion, or CRUD. The radioactive elements thus created include cobalt-60, iron-55, nickel-63, etc. During shutdowns of nuclear reactors for maintenance or refuelling, pipes, heat exchangers, etc. are routinely flushed to remove the highly radioactive CRUD build-up. This is now sent to radioactive waste dumps, from where the carcinogenic radioactive isotopes leak out to contaminate water and food supplies.[26]

To Sum-up

From the above analysis, it is obvious that though the nuclear industry claims it is "emission" free, it is in fact collectively releasing millions of curies into the environment annually.

Impact on Human Life

The routine emission and accidental leakages of radiation from nuclear plants obviously means that there must be increased incidence of cancer and other diseases in the people living around them. Very few studies have been done on this issue; these have come up with alarming findings. A study by researchers at the prestigious Medical University of South Carolina, USA found evidence of elevated leukaemia rates among children and young people living near nuclear facilities at 136 nuclear sites in the United Kingdom, Canada, France, United States, Germany, Japan and Spain. Elevated leukaemia rates among children were also found in a recent study that examined areas around all 16 major nuclear power plants in Germany.27 A Canadian federal government study found high rates of Down's Syndrome in communities living near the Pickering nuclear generating station.[28]

Impact on Marine Life

Many nuclear plants around the world rely on what are known as "once through cooling systems" to cool the steam after it has passed through the turbine. This steam is now made to flow over pipes containing cold water from the river/sea, the so-called third circuit (see Pressurised Water Reactor, Chapter 1, Part III). Here it gets condensed into water, after which it is pumped back to the steam generator, while the water in the third loop is dumped back into the river or sea from where it was taken.

Nuclear plant authorities claim that this intake and discharge of water from the sea does very little harm to marine life. This claim has been questioned in a report *Licensed to Kill: How the nuclear power industry destroys endangered marine wildlife and ocean habitat to save money*, released by the well-respected Nuclear Information and Resource Service (NIRS), USA, on February 22, 2001; its findings have since been confirmed by other environmental and marine authorities in the USA.[29] The report brings out in devastating detail the impact of these "once through cooling systems" on marine life. These cooling systems suck in and discharge as much as four million litres of water per minute. This huge amount of water is sucked in at such a high velocity that along with the water, marine life is also sucked in. The bigger marine animals impinge on "prevention devices" such as screens and barrier nets, and either drown or suffocate. While billions of smaller organisms, including small fish, fish larvae and spawn, pass through these screens and are drawn into the reactor cooling system where they get scalded and killed. US marine authorities are now claiming that it is these cooling systems that are responsible for the extensive depletion in fish stocks along the Atlantic coast.

With millions of litres of hot water being discharged into the waterway every minute, the total heat dumped into the waterway is tremendous. For instance, the nuclear power plants at Salem, New Jersey, USA, dump about 30 billion BTUs of heat hourly into Delaware Bay. That is the equivalent of exploding a nuclear bomb of the size that destroyed Hiroshima in the waters of Delaware Bay every two hours, all day, every day!

Such a huge hot water discharge leads to a temperature rise of the sea by 10-13 degrees Celsius and dramatically alters the immediate marine environment. It in fact creates a virtual marine desert.

4. Radioactive Waste: Leaking Everywhere

Probably the most monstrous problem created by nuclear power is that of spent fuel. Each 1,000 MW nuclear power plant generates 30 tons of radioactive waste annually. This is intensely radioactive, and is going to remain so for more than two lakh years! To get an idea of the deathly nature of this waste, let us discuss just one of its constituents, Plutonium-239.

Plutonium: Pu-239 is so toxic and carcinogenic that less than one-millionth of a gram if inhaled will cause lung cancer. It deposits in the liver to cause liver cancer, deposits in the bone marrow to cause bone cancer and leukaemia, and deposits in the testicles to cause mutations in reproductive genes and increase the incidence of genetic disease in future generations. The half-life of plutonium-239 is 24,400 years; so once created, it is going to cause cancers and genetic mutations for 5 lakh years!

Even though nuclear power plants have been in operation for more than fifty years now, mankind has not yet found a way of safely disposing of this lethal waste. Forget the long term, attempts to build even medium term storage sites for these wastes have failed. To give a few examples:

- As of 2008, more than 64,000 tons of deathly nuclear reactor waste had accumulated in the United States. It is currently stored at 121 locations in 39 states across the country. For the last 30 years, the US government had been trying to build a waste repository at Yucca Mountain in Nevada. After spending $13.5 billion on it, finally in 2010, President Obama cancelled the project and set up a panel of experts to find new ways to manage this waste.[30]
- The German government has invested several hundred million euros in research at the Asse nuclear storage facility in Lower Saxony in an attempt to solve the permanent waste storage problem of the nuclear energy industry. Recently, it was discovered that the site is in danger of collapsing, and authorities are now making an unprecedented attempt to retrieve and relocate hundreds of tons of waste from the site.[31]

That these attempts have failed should be no cause for surprise. Leave aside the problem of building a permanent storage system for this waste, considering its intensely radioactive and chemically corrosive nature, how do you guarantee that any storage system will not leak in say, a 100 years?

Since there is no way of removing the radioactive nature of these wastes, presently, in most countries, radioactive waste from nuclear power plants is stored in temporary storage sites near the reactors, either in huge cooling pools or in dry storage casks. Everywhere, this exceedingly toxic waste is leaking, leaching, seeping through the soil into aquifers, rivers, lakes and seas, to ultimately enter the bodies of plants, fish, animals and humans.[32] Its consequences are going to be with us for the rest of time.

5. Reprocessing: Worsening the Waste Problem

Currently, six countries with nuclear reactors, China, France, India, Japan, Russia and the United Kingdom, reprocess at least some of their spent fuel.

Supporters of reprocessing argue that it reduces the nuclear waste problem by segregating out the high-level radioactive waste—only this reduced volume now needs to be stored for thousands of years. Decades of experience from reprocessing plants the world over provides overwhelming evidence that not only is this not true, reprocessing actually worsens the problems created by nuclear energy:

i) As all the equipment used in reprocessing becomes radioactive, reprocessing increases the total volume of waste to be dealt with—by a factor of seven, according to the US Department of Energy (DOE)![33]

ii) Reprocessing as a waste management technique is far more expensive than direct disposal, primarily because of the enormous capital cost of the reprocessing facility.[34]

iii) Reprocessing plants discharge huge quantities of radioactive waste into the sea and air. For instance, the Sellafield reprocessing plant in the UK is one of the biggest sources of radioactive pollution in Europe. It discharges some 8 million litres of nuclear waste into the Irish Sea each day, making it one of the most radioactively contaminated seas in the world. Contamination levels in the vicinity of the Sellafield complex exceed the contamination levels inside the Chernobyl exclusion zone. The effects of this terrible contamination are visible in the local population. There has been a ten-fold increase of childhood leukaemia and non-Hodgkin's lymphoma around Sellafield, as compared to the British average.[35]

4. IS NUCLEAR ENERGY SAFE?

The fission reaction produces such a deadly concoction of radioactive elements that long-lived radiation contained within the reactor of a 1000 MW nuclear power plant is equivalent to that of a 1000 Hiroshima bombs! What if an accident in the nuclear reactor releases a significant part of these deadly radioactive elements into the environment in one go? It has happened before. Not once, but quite a few times. We discuss below the two biggest such accidents in recent times, the Chernobyl disaster of 1986 and the Fukushima accident of March 2011.

PART I: CHERNOBYL ACCIDENT, 1986

On April 26, 1986, Unit Four of the Chernobyl nuclear power plant exploded, spewing almost a quarter of the deadly radioactive fission products in its reactor core into the environment. This catastrophe will continue to plague much of Russia, Belarus, the Ukraine and Europe for the rest of time.

To this day, international institutions dealing with nuclear energy and the World Health Organisation (WHO), the public health arm of the United Nations, maintain a conspiracy of silence over the true effects of Chernobyl on human life. The WHO does not independently research the health consequences emanating from nuclear accidents. In 1959, it signed an agreement with the International Atomic Energy Agency (IAEA) whereby the WHO is precluded from publishing any research on radiation effects without consultation with the IAEA. Now, one of the explicit objectives of the IAEA is to promote nuclear power worldwide. Obviously then, the IAEA would seek to obfuscate the true magnitude of the Chernobyl disaster. Its pact with the IAEA has therefore muzzled the WHO, enabling the global nuclear industry to hide from the public any 'unwanted' information.

In September 2005, the IAEA and the WHO released the draft of a study by the UN Chernobyl Forum. The most important figures of this study were:

- just under 50 dead;
- 4,000 curable cases of thyroid cancer;
- no proof for an increase in miscarriages and sterility or leukaemia and other forms of cancer in relation to the reactor accident;
- total number of future deaths as a result of the disaster could possibly reach a maximum of 4000 people.

The IAEA declared: the Chernobyl case is closed.[36]

Let us compare these ‘official’ figures with some of the medical and ecological consequences of Chernobyl known today from several excellent studies. One of the most exhaustive of these studies was recently published by the New York Academy of Sciences, in 2009, and is titled *Chernobyl: Consequences of the Catastrophe for People and the Environment*. The book is authored by Dr. Alexey Yablokov of the Center for Russian Environmental Policy in Moscow and a former environmental advisor to the Russian president, late Prof. Vassily B. Nesterenko, who was the director of the Institute of Nuclear Energy of the National Academy of Sciences of Belarus at the time of the Chernobyl accident, and Dr. Alexey Nesterenko, a biologist and ecologist with the Institute of Radiation Safety, Belarus. The authors examined over 1,000 published scientific articles, which reflect more than 5,000 Internet and printed publications, mainly in Slavic languages, and never before available in English. According to this and other reputed studies:[37]

a) Radioactive emissions from Chernobyl accident may have been as great as 10 billion curies, or 200 times greater than the initial estimate, and hundreds of times larger than the fallout from the atomic bombs dropped on Hiroshima and Nagasaki.
b) The most extensive fall-out from Chernobyl occurred in regions closest to the plant—in the Ukraine, Belarus and Russia. According to one estimate, an area of 100,000 square miles—roughly the area of the state of Maharashtra—was heavily contaminated. It will remain so for thousands of years.
c) The accident caused noticeable radioactive contamination over practically the entire Northern Hemisphere. 40% of Europe was contaminated with dangerous radioactivity. Chernobyl fallout also significantly contaminated about 8% of Asia, 6% of Africa, and 0.6% of North America.
d) About 550 million Europeans (including European Russia) were affected by the contamination, of which an estimated 205 million live in significantly contaminated areas.
e) While 400,000 people living in a perimeter of 30 kms around the plant were evacuated and resettled elsewhere, more than 5 million people, including some 1 million children, continue to live in dangerously contaminated areas of Belarus, Ukraine and European Russia..
f) In all the territories contaminated by Chernobyl that have been studied, there is a significant increase in general morbidity, with diseases affecting practically all the body systems, apart from a high incidence of congenital malformations and cancers.
g) Children have been the worst affected, as they are the most vulnerable to radiation. In the Chernobyl territories of Belarus, Ukraine, and European Russia, less than than 20% children are well. In the heavily contaminated areas, it is difficult to find one healthy child.

Child Victims of Chernobyl

h) Yablokov et al., in their detailed study (cited above), estimate the total death toll worldwide from the Chernobyl catastrophe for the period 1986–2004 to be a mind-boggling 985,000 additional deaths. This estimate of the number of additional deaths is similar to those made by Prof. Gofman in 1994 and Rosalie Bertell in 2006, both world-renowned experts. These numbers will continue to increase for many future generations because of continued radiation from radionuclides like Pu-241, Am-241, Cl-36 and Tc-99 which have half-lives of between 20,000 and 300,000 years.
i) As a result of the Chernobyl catastrophe, millions of hectares of agricultural lands are dangerously contaminated with high concentrations of Cs-137 and Sr-90. Because these isotopes have such long half-lives, food in contaminated parts of Europe will be radioactive for hundreds of years. Thus, in Britain, 1,500 miles from the crippled reactor, 382 farms containing 226,500 sheep are severely restricted because the levels of cesium-137 in the meat are too high; while in south Germany, hunters are compensated for catching contaminated animals, and many mushrooms and wild berries are still too radioactive to eat.

j) The radioactive fallout from Chernobyl impacted fauna and flora over the entire Northern Hemisphere. It has resulted in morphologic, physiologic and genetic disorders in all living organisms: plants, mammals, birds, amphibians, fish, invertebrates and bacteria, as well as viruses. Dr. Janette D. Sherman-Nevinger, a toxicologist expert in the health impacts of radioactivity and the editor of the book by Yablokov et al., writes: “Every single system that was studied—whether human or wolves or livestock or fish or trees or mushrooms or bacteria—all were changed, some of them irreversibly. The scope of the damage is stunning.”

These are absolutely numbing statistics. Just one reactor accident is enough to contaminate half the globe, for tens of thousands of years! And yet the world wants to build new reactors!!

PART II: FUKUSHIMA CATASTROPHE, 2011

On March 11, 2011, a massive earthquake measuring 9.0 on the Richter scale, followed by a huge tsunami with waves as high as 14 metres, devastated the northeast coast of Honshu, Japan’s main island. The earthquake and tsunami hit 14 reactors in 4 nuclear power stations on the Pacific coast. 10 reactors in 3 of the nuclear plants—Onagawa, Fukushima Daini and Tokai Daini, suffered considerable damage, but fortuitously escaped meltdown. However, the Fukushima Daiichi Nuclear Plant was devastated, resulting in massive release of radioactivity into the environment.[38]

The Fukushima Daiichi Nuclear Plant has six Boiling Water Reactors, with a combined installed capacity of 4700 MW. The earthquake disrupted the cooling systems of the reactors, the tsunami worsened the accident, thereby initiating a complex series of events which ultimately lead to fuel meltdown in three of the reactors (Units 1, 2 & 3). The cores of all three reactors melted and fell to the bottom of their pressure vessels.

The accident badly affected the spent fuel pools of Reactors 1-4 too. The spent fuel pools need to be continuously cooled; the accident disrupted their cooling systems. The Fukushima reactors have their spent fuel pools located near the top of the reactor vessel. While the reactor core is encased in a steel vessel inside the primary containment, the spent fuel is outside this containment. All that shields the radioactivity from the spent fuel from getting dispersed into the environment are the thick outer walls of the reactor building—the so-called secondary containment. The spent fuel contains even more radioactivity than the reactor core, and so is far more harmful to the environment than the fuel in the reactor core.

A fast-moving chain of events led to the accumulation of hydrogen gas in the reactor buildings. The gas exploded, demolishing the roofs of the reactors buildings of Units 1-4, exposing their spent fuel pools to the atmosphere. It was followed by an explosion in the spent fuel pool of Reactor 3, which led to spent fuel rods being ejected from the pool into the atmosphere, scattering them for miles. At the time of the accident, Unit-4 was in shutdown state and all the fuel assemblies had been moved to the spent fuel pool. There was an explosion in this spent fuel pool too, and there is a possibility that radioactive materials were emitted into the atmosphere from this pool too.[39]

While all four reactor buildings are badly damaged due to the hydrogen explosions, the situation in Unit-4 is particularly dangerous as the spent fuel pool on its roof is brimming with used fuel rods, covered only with plastic. The fuel rods in this single pool roughly equal those in Units 1, 2 and 3 combined. What if the spent fuel pool cracks and loses its cooling water? What if the already fragile building collapses – either on its own, or due to another big earthquake, and the spent fuel pool crashes down? According to Arnie Gundersen, if that happens, the people in Tokyo should simply get on a plane and get out as fast as possible.[40]

Global Impact of Fukushima

Numerous independent scientists have given evidence to show that the Fukushima accident is at least as big, if not bigger, than Chernobyl. For instance, Arnie Gundersen, an eminent nuclear engineer and former nuclear industry senior vice president who has coordinated projects at 70 nuclear power plants around the United States, has pointed out that while the Chernobyl release was a single reactor, the Fukushima release is 10 reactor cores. That is because in addition to the 3 reactor cores that suffered meltdown in Fukushima, there were about 7 reactor cores in the spent fuel pools of Units 1-4. So 10 nuclear reactor cores could potentially release radioactivity into the environment. Chernobyl stopped releasing after about 2 weeks; while, we are now more than two and a half years into the Fukushima accident and it is still releasing radioactive material. Radiation readings inside the reactor buildings of Units 1–3 vary between 5 mSv/h and 73 Sv/h—levels at which a lethal dose would be reached within minutes—which makes human intervention almost impossible.[41]

Radiation from the Fukushima plant has spread to all across the globe. Not only countries near Japan, like South Korea, the Philippines, Vietnam, China and Russia, but also countries far away across the Pacific Ocean, from Canada to the USA and Mexico, and even Switzerland, Iceland and France, have detected traces of radioactivity from Japan's crippled plant in their soil, air and water.[42] Studies show high infant mortality rates in both Japan and the US west coast at almost precisely nine months after the disaster, a phenomenon also observed within nine months of the Chernobyl meltdown in 1986.[43] For the last two and a half years, hundreds of tons of radioactive water has been leaking from the plant into the Pacific Ocean every day; this leakage is going to continue for years, and threatens to contaminate the entire Ocean – an apocalyptic event.[44]

The multi-trillion dollar nuclear industry knows that if the full scale of the tragedy at Fukushima becomes known to the people of the world, it could lead to such an outcry that it could well sound the death-knell for the industry. And so from the beginning of the accident, the global nuclear industry and its accomplices—the governments of pro-nuclear countries from the USA to India—in collusion with the global media, have tried to downplay its potential impact. Not one country whose people are affected by the accident is carrying out comprehensive, Fukushima-related radiation testing.[45]

Impact on Japan

The amount of radiation released from the stricken plant during the first few weeks was so much that it could very well have brought Japan to its knees. Fortunately for the country, the winds were blowing out towards the sea most of the time during the accident, and so nearly 80% of the radiation wound up in the Pacific Ocean.[46]

[With the radiation blowing out to the sea, while the expected enormous number of cancers from this radiation will not be caused in Japan, that does not mean they have been eliminated: spreading out a given amount of radiation dose among more people, while it reduces each person's individual risk, does not reduce the total number of cancers that is going to be caused by that amount of radiation. Therefore, all that has happened is that these cancers have been spread out in a worldwide population.[47]]

The Japanese government declared a 20-km evacuation zone around the Fukushima plant; some other parts outside this region which have high levels of radiation have also been evacuated. In all, around 150,000 people have been forced to abandon their farms, homes, schools and jobs. Most of these people are never going to return to their homes.[48]

However, it is obvious that this evacuation zone is pathetic. Numerous radiation hotspots have been found at distances up to 200 kms and even 300 kms from Fukushima. Contamination levels in regions as far away as 100 kms from the plant have been found to be at many times the contamination levels in the Chernobyl exclusion zone, because of which several experts have called for Japan to expand its evacuation zone to between 60-100 kms from the plant.[49]

Samples taken from five different randomly selected locations in Tokyo in February 2012 were tested in a laboratory in the United States, which found that every one of them was contaminated enough to be classified as nuclear waste.[50] This means that people in Tokyo, 250 kms away from the Fukushima reactors, are essentially walking on radioactive waste every day.

If the Japanese government acknowledged the true extent of radiation contamination, compensating the millions of affected people and businesses would bankrupt Japan.[51] And so the government is trying to downplay the extent of the accident. For example, it has raised the allowable annual radiation exposure limit from 1 to 20 millisieverts. That is twenty times the internationally recognised annual allowable dose for adults. That's murderous! Arnie Gundersen has estimated that at least one out of every 20 young girls (5%) living for five years in an area where the radiological exposure is 20 millisieverts will develop cancer in their lifetime.[52]

Contamination of the Sea and Groundwater

In Reactors 1, 2 & 3, the fuel has melted through the reactor pressure vessel to the outer steel containment. The primary containments of these three reactors are also damaged.

With the cooling system disrupted, Tokyo Electric Power Company (TEPCO), the plant operator, has been pouring in hundreds of tons of seawater into the reactors every day in a desperate attempt to cool the reactor cores and the spent fuel pools. This water leaks out through cracks in the pressure vessels and secondary containments into the basement of the reactor buildings. This water is intensely radioactive, as it has flowed out after directly coming in contact with the molten fuel and all the deadly products of the fission reaction. Six percent of the fuel of Unit 3 is MOX, made from a mixture of uranium and plutonium oxides. Because it contains plutonium, a single milligram (mg) of MOX is as deadly as 2,000,000 mg of normal enriched uranium; if some of it leaks into the environment, it is going to remain radioactive for tens of thousands of years. With Unit 3 leaking water, this is obviously happening.[53]

While a certain amount of water that collects in the basements is partially decontaminated and then re-circulated back into the reactors, the amount of water that cannot be re-used is constantly increasing and reached 380,000 tons in May 2013, of which 290,000 is in storage tanks which are also leaking, and the rest is in the basements. The total amount of radioactivity contained in the water that has filled the reactor basement is more than 27 times the amount of cesium-137 released into the air in the first three weeks of the accident, or about 2.5 times the total amount released at the Chernobyl accident.[54]

The water that is in the basement and storage tanks is leaking into the underground aquifer. Towns near the Fukushima plant are reporting radioactive sewage sludge, which could be due to radioactive groundwater. The underground water is leaking into the sea. After covering up for more than two years, Japan admitted in August 2013 that 300 tons of contaminated groundwater may be seeping into the ocean every day![55]

TEPCO and the Japanese government simply do not know how to control this leakage. According to Arnie Gundersen, this leakage is going to continue for 20-30 years, there is no way in which it can be stopped.[56] Even if, eventually, the leakage is stopped, what has leaked into the Pacific is irretrievable.

Food Contamination

The hazardous radionuclides escaping from the damaged Fukushima plant are obviously being dispersed all over Japan with the winds and will come down with rain, to contaminate the soil and groundwater, vegetables, fruits, rice and other crops. As these toxins move up the food chain—like from soil to grass to cows to humans—their concentration increases, making them even more dangerous.

Cesium and radioactive iodine has been found in spinach and other green leafy vegetables in many prefectures. In Ibaraki and Fukushima prefectures, farmers are pouring out their milk on the farms as it has been found to be contaminated. High levels of cesium have been found in harvested tea leaves in Shizuoka prefecture 370 kms from the crippled plant. Small amounts of strontium have been detected in soil samples and plants 80 kms away from the Fukushima plant. High concentration of plutonium has been detected in a rice field 50 kms away from the stricken reactor.[57]

High levels of cesium have been discovered in plankton caught in coastal waters south of the Fukushima reactors, and also in small fish of the order of 4 to 5 inches as far away as 50 miles from the coast.[58] This radiation has started moving up the food chain to bioconcentrate in the bodies of larger fish, and finally, human beings. In January 2013, murasoi fish caught close to Fukushima's crippled nuclear plant was found to contain cesium at levels 2540 times the safe limit for human consumption; while in February, TEPCO admitted that rock trout was found to contain cesium at 5100 times the safe limit! The Japanese government has banned both the domestic sale and international export of most fish that are caught off the Fukushima coast.[59]

For ordinary people all over Japan, this contamination is terrifying, as it cannot be tasted, smelled or seen.

Estimating Future Health Impacts

In human terms, the impact of the Fukushima accident is going to be far more devastating than Chernobyl, as Japan is much more densely populated than Belarus, the country most affected by the Chernobyl accident: Belarus has a population density of 40 persons per square kilometer; Japan in contrast has an average of 800 persons per square kilometer.

This grim foreboding is coming true sooner than later. 42% of 52,000 tested children near Fukushima have thyroid nodules or cysts—an early indicator of an eventual increase in thyroid cancers. This is far more diagnosed cases than was seen after Chernobyl. These children must have received a very high dose of thyroid radiation from inhaled and ingested radioactive iodine. The hundreds of other radioactive elements that escaped and are now concentrating in food, fish and humans are also going to lead to the development of other types of cancers.[60]

European Committee on Radiation Risk (ECRR) scientific secretary and British scientist Christopher Busby has conservatively predicted, using the ECRR risk model and also the findings of cancer risk in Sweden after the Chernobyl accident, that:[61]

- If the 3 million people living in the 100 km radius of the Fukushima catastrophe remain living there for one year, approximately 200,000 will develop cancers in the next 50 years with 100,000 being diagnosed in the next 10 years.
- For those 7 million living between 100 kms and 200 kms from the site, the predicted number of cancers is 220,000 extra cancers in the

next 50 years, with about 100,000 being expressed in the next 10 years.

More recently, Arnie Gundersen has given an even grimmer warning: he estimates that there are going to be at least a million cancers in Japan over the next 30 years.[62] Even this may be an underestimate, as more than one million have died 25 years after Chernobyl. By choosing nuclear energy as an energy option, the Japanese political leadership has condemned the people of Japan to suffer epidemics of cancer, leukaemia and genetic disease for the rest of time.

A Nuclear Accident Never Ends...

More than a year after the accident, the reactors continue to leak radiation. There is no knowing when will TEPCO be able to bring the radiation leakages under control. (We're talking of radiation leakages into the air, not groundwater leakage, which may take decades.)

Even after that, the problem is, what do you do with the melted fuel? How do you remove it from the environment for hundreds of thousands of years? According to Arnie Gundersen, a US nuclear engineer with over 40 years of experience in the nuclear industry: "Somehow, robotically, they will have to go in there and manage to put it in a container and store it for infinity, and that technology doesn't exist. Nobody knows how to pick up the molten core from the floor, there is no solution available now for picking that up from the floor."[63] Many scientists are now of the opinion that the solution is to entomb the reactors like at Chernobyl.

However, that too is not going to be easy. Following the Chernobyl accident, a huge sarcophagus or coffin made from more than 400,000 cubic metres of concrete and 7,300 tons of metal framework was built over the destroyed reactor in order to prevent the release of radioactive materials from the melted fuel. Now, 25 years later, the sarcophagus is leaking and needs to be replaced. Work has begun on building a gigantic new shell to cover Chernobyl's exploded reactor and the existing sarcophagus. The new structure, an arch more than 105 metres high, 260 metres wide and 150 metres long, and expected to weigh 20,000 tons—the largest such structure in the world—is being assembled close to the Chernobyl site and will then be slid on rails over the existing sarcophagus, before the ends are blocked up. It is expected to cost $2 billion and take five years to build. This new structure is expected to last for at the most 100 years.[64] After that... ??

Entombing the Fukushima reactors is going to be an even more difficult task than Chernobyl—as there are four reactors here which would need to be encased. Moreover, it cannot be done immediately, as the cores are still hot. It is going to take at least a year, or even two years, for the reactors to cool sufficiently for it to become possible to fill them up with concrete and let them lie there, like a giant mausoleum. But again, this is possible only for Reactors 1, 2 and 3. This cannot be done so simply for Unit 4, as this building is in a bad shape. Concrete can't be poured into this reactor from the top because it may collapse the building, and with the spent fuel pond located at the top of the building, it will also then come crashing down. The Japanese will need to use massive cranes, cranes that lift a hundred and fifty tons, and put the nuclear fuel into canisters, which can then be removed. But this cannot be done in air, as the fuel is highly radioactive. It will have to be done under water. So a building will have to be built around the reactor building to provide enough shielding and water, and then the cranes can be sent in to put the fuel into canisters. The whole process is going to take decades.[65]

Even if the Japanese do manage to encase the reactors, the danger from the destroyed reactors will not be over. In the three reactors where the blob of melted nuclear fuel is lying at the bottom of the reactor vessel, the fuel could fission its way through the containment vessel, melt through the basement of the power plant and enter the soil and water table, causing huge contamination of the crops and groundwater around the power plant. What is the present location of the melted fuel a year after the accident? No one knows. According to independent experts, the only solution to this problem is to build a huge trench underneath the plant to contain the radiation—a giant diaper.[66] This will take many years and cost a fortune.

Will the Japanese government really attempt this solution? Considering its present behaviour wherein it is trying to downplay the accident and save as much money as possible, it appears doubtful that it will even address this problem. What have they done about this problem at Chernobyl? The numbing answer: nothing![67] There is an eerie conspiracy of silence the world over about this terrifying spectre.

PART III: NUCLEAR ACCIDENTS ARE INEVITABLE

Till before Fukushima happened, in the intervening 25 years after the Chernobyl accident, the global nuclear industry and its apologists were arguing that lessons had been learnt from Chernobyl, the necessary design modifications had been made in nuclear reactors, and no major nuclear accident will occur in the future. Now after Fukushima, they are arguing that this was a one-in-a-million chance occurrence, as the accident was caused by a huge earthquake followed by a massive tsunami. Such a double natural calamity will not occur again, so there is no need to worry. (Now of course it is well established that the meltdown in Reactor 1 had begun before the tsunami stuck, that is, it was caused by the earthquake.) Other 'official scientists' are putting the blame for the accident on the Japanese, that their regulatory systems were faulty, that the reactor was of an old design and should have been scrapped long ago, and so on. On the whole, the essence of the argument of these nuclear cheerleaders is that the Fukushima accident occurred due to some reasons particular to Japan, and that the other nuclear reactors worldwide are safe.

The inherent assumption in these arguments is that nuclear technology is inherently safe, and that if an accident has occurred, its reasons can be identified, lessons drawn and design modifications made to make the technology safer for the future. This argument is fundamentally flawed. M.V. Ramana, a noted nuclear safety expert, explains:

> It is a complex technology, involving large quantities of radioactive materials, and relatively high temperatures and pressures ... it is in the very nature of such systems that serious accidents are inevitable. In other words, that *accidents are a "normal" part of the operation of nuclear reactors, and no amount of safety devices can prevent them*.[68] (emphasis ours)

After the Fukushima accident, the Indian government set up a number of committees to review the safety of India's existing nuclear reactors as well as the Russian reactors being built in Kudankulam and the French EPR reactors proposed to be set up in Jaitapur, and suggest additional safety measures. The US and the European Union too set up committees to review the safety features of their reactors. However, nuclear technology does not become safer by adding some additional safety features. M. V. Ramana writes:[69]

> Accidents are inevitable ... no two major accidents are alike. Historically, severe accidents at nuclear plants have had varied origins, progressions, and impacts. These have occurred in multiple reactor designs in different countries. This means, unfortunately, that while it may be possible to guard against an exact repeat of the Fukushima disaster, the next nuclear accident will probably be caused by a different combination of initiating factors and failures.

> There are no reliable tools to predict what that combination will be, and therefore one cannot be confident of being protected against such an accident ... The lesson from the Fukushima, Chernobyl, and Three Mile Island accidents is simply that *nuclear power comes with the inevitability of catastrophic accidents*. (emphasis ours)

To sum up, in Ramana's own words:

> Catastrophic nuclear accidents are inevitable, because designers and risk modelers cannot envision all possible ways in which complex systems can fail.

Numerous independent nuclear scientists from around the world have come to the same conclusion. Following a near-miss in the Forsmark nuclear reactor in 2006, some of the world's most distinguished nuclear scientists examined the safety records of nuclear plants in several countries. Their report, presented to the European Parliament in 2007, concluded:[70]

> Many nuclear safety related events occur year after year, all over the world, in all types of nuclear plants and in all reactor designs ... Therefore, the widespread belief that lessons learnt from the past have enhanced nuclear safety turns out ill-conceived.

Mycle Schneider, a well-known nuclear consultant and the coordinator of this study, writes:[71]

> In the course of the last twenty years, the world has lived with the illusion that it is possible to make nuclear reactors safe. In reality, every day, countless incidents occur in nuclear reactors, and, since Chernobyl, catastrophe has, on several occasions, only narrowly been avoided.

Five years before the Fukushima accident, Dr. Helen Caldicott, the pioneering Australian anti-nuclear activist, had prophetically warned in 2006:[72]

> Statistically speaking, an accidental meltdown is almost a certainty sooner or later in one of the 438 nuclear power plants located in thirty-three countries around the world.

It happened in Fukushima. An accident needs a reason. The earthquake happened to be it.

After Fukushima, if we still don't learn the lesson and do not shut down each and every nuclear reactor in the world, sooner or later, another catastrophic accident is bound to happen again, in one of the world's 410 operating reactors.

5. IS NUCLEAR ENERGY CHEAP?

PM Manmohan Singh (August 31, 2007): One of the reasons why India is placing "so much importance on nuclear energy" is because it is financially "affordable".[73]

At one time, the nuclear industry and governmental authorities the world over were claiming that nuclear energy would soon be "too cheap to meter." That claim went through the roof way back in the 1970s. Then, in the first decade of this century, the nuclear industry began claiming that it has developed new designs, the so-called Generation-III, with low construction cost estimates (of $1000/kw) whose power would be competitive with fossil fuel based electricity. Ten years later, it is clear that it had deliberately understated costs to somehow bring about a "nuclear renaissance": the present construction cost estimates of these new reactors are of the order of $7000/kw.[74] Nuclear electricity has become so uneconomical that even John Rowe, former chairman and CEO of Exelon Corporation, the largest nuclear operator in the US with 22 nuclear power plants, recently admitted: "Let me state unequivocally that I've never met a nuclear plant I didn't like. Having said that, let me also state unequivocally that new ones don't make any sense right now." In fact, nuclear electricity is becoming so expensive that even operating plants are closing down in the USA (see Chapter 6). In an interview given last year, the former CEO of Constellation, Michael Wallace stated: "It is now not possible for merchant generating companies to move forward with new nuclear projects... The economic pressures are threatening even operating units. It is quite likely—more than that, highly probable—that there will be existing plants prematurely shut down for economic reasons."[75]

Despite these ground realities, India's leaders and nucleocrats are still insisting that nuclear power is cheaper than coal- or gas-based power!

That nuclear electricity generation is one of the most expensive ways to produce electricity has also been brought out in several studies of nuclear plant costs done over the past decade by many independent institutions. Probably the most sophisticated and widely cited of these studies is a 2003 study by the Massachusetts Institute of Technology titled *Future of Nuclear Power*, which was updated in 2009. This study concluded that cost of electricity generated by a new nuclear power plant is about 30-35% higher than that from coal- or gas- fired plants: 8.8 cents a kilowatt for nuclear versus 6.2 cents for coal and 6.5 cents for gas. This, even when the study had grossly underestimated the construction costs of nuclear reactors by as much as 30-50%.[76]

Further, these calculations do not take into consideration the huge subsidies given out by governments to the nuclear industry, which run into billions of dollars (see below).

No wonder that even the World Bank, which has been willing to finance the most environmentally destructive projects so long as corporations can make handsome profits, is not willing to give loans for nuclear plants![77] A statement signed by six of Wall Street's largest investment banks is even more revealing. In 2007, Citigroup, Credit Suisse, Goldman Sachs, Lehman Brothers, Merrill Lynch and Morgan Stanley informed the US DOE that they were unwilling to extend loans for new nuclear power plants unless taxpayers shouldered 100% of the risks! In justifying this demand, the banks stated:

> We believe these risks, combined with the higher capital costs and longer construction schedules of nuclear plants as compared to other generation facilities, will make lenders unwilling at present to extend long-term credit…[78]

Nuclear Subsidies Worldwide

Because nuclear energy is uneconomical, all governments worldwide which have a nuclear energy program subsidise nuclear energy. These subsidies include:

Capital Subsidies

For the past decade and more, as the poor economics of nuclear energy has become very evident, new reactor construction is mostly taking place in those countries where the nuclear electricity sector is in the public sector. Therefore the high costs and huge risks associated with nuclear energy are guaranteed by the government. This is the case with China, Russia and India, the three countries which account for 60% of the reactors under construction worldwide.

In the US, where the electricity industry has mostly been in private hands, the only reason why its present nuclear reactor fleet was built was because till the 1990s, distribution costs were regulated by the states, and regulators allowed nuclear electric utilities to pass on their high costs to consumers. This subsidy, which included cost overruns of nuclear plants, cost of abandoned nuclear plants, and high generation cost of nuclear electricity, totalled more than half a trillion dollars![79]

In 2002, when George Bush launched an ambitious program to restart nuclear reactor construction in the United States, the key component of his plan was granting huge dollops of subsidies to the nuclear industry. According to one estimate, the total subsidies being offered to new build projects in the USA exceed actual power generation prices![80]

Capping Operator Liabilities in Case of Accidents

A nuclear accident has the potential of rendering a very large area uninhabitable for thousands of years (discussed in Chapter 4)! And so, the insurance industry has not been willing to underwrite nuclear accident risks. Obligingly, governments have stepped in and provided the necessary guarantees. In the US, the Price Anderson Act limits the maximum liability of nuclear operators in case of a nuclear accident to at most $11.6 billion (as of 2008); the remaining expenses would be borne by the government. All nuclear plant operators contribute to this $11.6 billion fund, thereby further limiting the liability of an individual operator. This amount represents less than two percent of the potential costs of a nuclear accident, which can go up to as much as $560 billion, according to estimates made by the US NRC. The remaining 98% would have to be borne by taxpayers. This subsidy is provided in the European Union too. In France, if Electricite de France, France's nuclear power operator, had to insure for the full cost of a meltdown, the price of electricity would go up by about 300%.[81]

Without this liability shelter, nuclear reactors would never have split the first atom. This was in fact frankly admitted by Peter Mason, CEO of GE-Hitachi Nuclear Energy Canada, “If there was not a cap and if there was no suitable legislation insurance in place, then we wouldn’t be in the nuclear industry.”[82]

Nationalisation of Waste Management and Decommissioning Costs

The cost of storing the highly radioactive waste generated by nuclear power plants for thousands of years is simply mind-boggling. Add to it the costs of securing it against terrorist attacks, and it is obvious that no private firm, howsoever big it may be, has the financial capacity to bear these costs. Again, governments have helped out by effectively nationalising both these costs. Just like the insurance subsidy discussed above, without this subsidy too, it is doubtful if nuclear power industry would have developed at all.

Then, there are decommissioning costs, which too are huge.

Nuclear plant operators are required to set aside a certain part of their income during the working lifetime of the reactor to meet future decommissioning expenses. However, almost everywhere, they have not done so, and taxpayers will have to pay the deficit, running into billions of dollars—in another subsidy to the industry.

The French government has in fact gone ahead and nationalised both the decommissioning and waste management costs: the waste management costs are estimated at between $21 billion and $90 billion;[83] the decommissioning cost estimates keep rising, and were estimated to be 52 billion dollars in 2004.[84] The same is the situation in the UK, where the decommissioning costs are expected to cost future taxpayers 90 billion euros.[85]

India: Economic Costs of Nuclear Energy

Apart from all the above subsidies, the Indian government (through the DAE) gives several additional subsidies to the Nuclear Power Corporation of India or NPCIL (the public sector corporation that runs all of India’s nuclear reactors). The NPCIL is provided nuclear fuel at subsidised rates. Heavy water is supplied to it from DAE's heavy water plants at much less than the cost of production—according to one estimate, a subsidy of over Rs.12,000 per kg is being given.[86] For the Kaiga 1&2 reactors (220 MW each), the total heavy water subsidy alone works out to around Rs.1450 crores per reactor, which is around 17% of the capital cost! Then, the DAE reprocesses its spent fuel; this reprocessing is very expensive, but is not included in the cost of power. And these are just some of the known subsidies, we don’t know their full extent.

Even after availing these massive subsidies, the official cost of nuclear electricity from NPCIL's reactors is much more than electricity from conventional sources: between Rs.2.70 and 2.90 a unit (for reactors built since the 1990s), a price which is far higher than the cost of electricity from coal-fired plants.[87]

That is with regards to electricity from indigenous reactors. The cost of electricity from imported reactors is going to be simply extortionate!

Imported Reactors: Even More Subsidies

In an amazing sell-out, the government is providing even more subsidies to the reactors it is proposing to import!

There has been no competitive bidding for any of these reactors. The government has one-sidedly announced that it is reserving one

'Nuclear Park' for each of its favoured foreign vendors: Jaitapur for Areva (France), Mithivirdi and Kovvada for Westinghouse / GE-Hitachi (USA), and Kudankulam for Atomstroyexport (Russia). It is an unparalleled giveaway—the government has announced these reservations even before the terms of the reactor contracts have been negotiated! The foreign suppliers have been assured that they will be given the contract irrespective of the price they quote!!

To add to the pampering, the foreign firms don't have to acquire land for these projects; the government of India is doing so, under British-era undemocratic laws, wherein land can be compulsorily acquired from the people at a cost determined arbitrarily by it.

Irrespective of the cost of electricity that would be produced by these imported reactors, the government will be buying it, because the plants are going to be run by the government-owned NPCIL. Let us take a look at the estimated cost of electricity from the Jaitapur Nuclear Plant.

Jaitapur Nuclear Plant Costs

On December 6, 2010, the NPCIL signed an agreement with France's state-run nuclear group Areva for the purchase of the first two EPR reactors for the Jaitapur Nuclear Park. The cost of the deal? While announcing the agreement at a press conference, the Prime Minister stated that pricing issues are still "subject matters of negotiations". Meaning, that the government has agreed to buy the reactors, without finalising the price! Clearly, the government is hiding something.

We can get an idea about the cost of the Jaitapur EPRs from the cost of the EPR reactor being built in Finland by Areva, which is of 1600 MW. The contract price of this reactor was 3.2 billion euros when the agreement was signed in December 2003; by July 2013, its cost had escalated to around 8.5 billion euros, and the reactor is still years away from completion.[88] Obviously, the final cost is going to be much more. Even assuming that each Jaitapur reactor is going to cost 8.5 billion euros, this means each reactor is going to cost at the minimum Rs.68800 crores! That works out to Rs.41.7 crores per MW, more than eight times the cost for coal-fired plants (Rs.5 crores per MW)!!

The total installed capacity of the Jaitapur plant after all six reactors are constructed is going to be 9900 MW. At Rs.41.7 cr/MW, this means the plant is going to cost an astronomical Rs.4 lakh crores!!!

Given this huge capital cost, what will be the unit cost of electricity from the plant? Independent experts estimate it to be at least Rs.14 per unit, excluding transmission and distribution costs.[89] And this estimate does not take into account the huge subsidies to nuclear power discussed above.

Nuclear Liability Bill: Protecting Foreign Suppliers

The costs of nuclear electricity are so prohibitive, that the foreign vendors are still not satisfied with these subsidies. Through their governments, they mounted pressure on India to free them of all liabilities in case of a nuclear accident—they are aware that it could bankrupt them. Obligingly, the government has got the *Civil Liability for Nuclear Damage Bill 2010* passed by a pliant Parliament. The Act indemnifies the supplier from all liabilities in case of an accident. The only exception is in case the accident has taken place due to design defects; in that case, the operator can sue the foreign vendor in courts.

These provisions go against the Principle of Absolute Liability as laid down by the Supreme Court of India. There, the Court held that if an enterprise engages in an inherently dangerous and hazardous activity and if an accident takes place in the enterprise, then the industry should bear the cost of the accident irrespective of what the cause of the accident was. Since a nuclear reactor is inherently hazardous, by an extension of this principle, at the very least the foreign supplier of the reactor should be held equally responsible for an accident along with the operator, irrespective of whether there was a design fault or not.

The Act also limits the liability of the operator to a laughable Rs.1500 crores. Beyond this cap, if necessary, the government would pay the damages, but subject to a maximum cap of Rs.2100 crores, or $460 million. This is less than the compensation of $470 million approved by the Supreme Court of India for the victims of the Bhopal gas disaster way back in 1989, and which is universally considered shamefully inadequate. This, when a nuclear accident can be many hundreds of times bigger than the Bhopal gas tragedy!

However, the foreign suppliers are not happy with this Law. They want their nuclear corporations to be completely absolved of all liabilities even if an accident occurs due to design defects in the equipment supplied by them. Once again bowing to the wishes of the imperialists, the Indian government is looking for ways to implement their demand. Amending the Nuclear Liability Law is not politically feasible at present; so it is seeking to circumvent this mild Law by framing Rules which will protect foreign suppliers by further limiting their liability.[90]

The Liability Test

The Nuclear Liability Law raises a very important question regarding nuclear safety. Following the massive agitation by tens of thousands of people against the Kudankulam Nuclear Plant, the government deployed 'Top Gun' APJ Abdul Kalam (former President of India) to answer questions raised by the movement. He has been going around the country claiming that the plant is “100% safe”. There is a very simple indirect test by means of which even a non-expert can evaluate the question of nuclear safety. If there was really a “0% chance” of an accident, why are nuclear vendors working so hard to indemnify themselves?

6. GLOBAL NUCLEAR ENERGY SCENARIO

Prime Minister Manmohan Singh (August 31, 2007): A “nuclear renaissance” is taking place in the world, “and we cannot afford to miss the bus or lag behind these global developments.”[91]

The use of nuclear energy has been limited to a small number of countries, with only 31 countries operating 427 nuclear power plants as on 1 July, 2013. (This figure of 427 assumes that only the 10 Fukushima reactors are permanently shut down, and that the rest will all eventually restart.) This includes nine in Western Europe, nine in Eastern Europe (including Russia and Ukraine), seven in Asia (including China and Taiwan), two in North America, three in Latin America and one in Africa (South Africa). The current world reactor fleet has a nominal combined installed capacity of 364 GW. (But there is a huge uncertainty in these figures, as the future is undefined for the 50 Japanese reactors that are officially still operating but except for 2 units, all are shut down as of 1 July, 2013).[92]

The Initial Years: Boom and then Slowdown

On June 27, 1954, the USSR’s Obninsk Nuclear Power Plant (5 MW) became the world’s first nuclear power plant to generate electricity for a power grid. With nuclear energy from fission appearing to be very cheap and safe, installed nuclear power capacity rose quickly: rising from less than 1000 MW or 1 GW (gigawatt) in 1960 to 100 GW in the late 1970s, and 300 GW in the late 1980s. The IAEA euphorically forecast that global installed nuclear capacity would reach 4,450 GW by the year 2000.[93]

By the 1970s, the problems started becoming evident. Nuclear construction and operating costs were going through the roof. No solution was in sight to safely dispose of the rising mountains of nuclear waste. Several scientists started challenging the prevailing view that radiation released by nuclear power plants during normal operation was not a problem. And then, there occurred the Three Mile Island (1979) and Chernobyl (1986) disasters. They sent the nuclear industry into a tailspin. Worldwide, more than two-thirds of all nuclear plants ordered after January 1970 were eventually cancelled. By 2002, 253 reactor orders had been cancelled in 31 countries, many of them at an advanced stage of construction.[94]

'Renaissance' in the 21st Century?

By the beginning of this century, it was apparent that the nuclear power industry had entered into a long period of stagnation, and nuclear power was becoming a technology without a future. In a desperate attempt to revive its sagging fortunes, the global nuclear industry launched a massive propaganda drive (one of its claims being that new designs have been developed which are safer and cheaper—both of which have now been proved to be false) as well as bribed politicians all over the world.[95] It achieved some success, and some countries which had banned or halted nuclear construction began rethinking their policies. And so the nuclear industry began claiming that a nuclear “renaissance” was underway in the world.

But then the Fukushima accident happened. The catastrophe in Japan has virtually led to a 'meltdown' of the global nuclear industry. Many countries that had begun thinking of building new nuclear plants have abandoned their plans, and some have even decided to phase out their existing nuclear plants.

However, nuclear industry propagandists are claiming that this is only a temporary phenomenon, and that on the whole, the future remains bright like as before the Fukushima accident. Their intense propaganda has made many people, especially in India, believe that a nuclear revival is indeed taking place in the world.

Let us therefore take a look at the state of the global nuclear industry, with a special focus on whether a “renaissance” was indeed taking place before the Fukushima accident.

ASSESSING THE GLOBAL NUCLEAR 'RENAISSANCE'

The truth is, despite all the claims of the nuclear industry, it had begun slowing down even before the Fukushima accident. Since then, the decline has only accelerated, as the following statistics attest:

- Global nuclear electricity generation dropped by a historic 7 percent in 2012, adding to the record drop of 4 percent in 2011. The decline in 2012 is not just due to the shutdown of reactors in Japan; 16 other countries, including the world's top five nuclear generators (which generate 67% of all nuclear electricity in the world), decreased their production too.
- This decline had begun well before the Fukushima accident: world nuclear electricity generation has been steadily declining for the last 6 years now (except for a slight recovery in 2010). Nuclear plants generated 2346 TWh in 2012, 12% below the historic maximum of 2660 TWh reached in 2006.[96]
- The maximum share of nuclear power to commercial electricity generation worldwide was reached in 1993 with 17 percent; since then, it has fallen consistently, to 11 percent in 2011 and further to 10.4 percent in 2012, a level last seen in the 1980s.[97]
- Likewise, as compared to total global electricity generation capacity, the global nuclear power capacity has been consistently declining over the past few years, from 8.7% in 2006 to 7.4% in 2010 and 7.1% in 2011.[98]
- Ever since the first nuclear reactor came on-line in 1954, till the 1980s, the number of nuclear reactors and their total generating capacity had rapidly increased. Post-Chernobyl, the total number of reactors has more or less remained constant, hovering around 430-440, and the increase in total capacity has slowed down. At the end of 2010, there were a total of 441 nuclear reactors operating in the world. Their total installed capacity was 375.3 GW. Post-Fukushima, by 2013, the number of nuclear reactors that can be considered to be operating in the world had sharply come down to 407, and the installed capacity had declined to 349 GW. (At present, 52 of Japan's 54 reactors are shut down. In this calculation, we assume that Japan will eventually restart another 22 reactors—a very optimistic projection actually. That is, we are assuming that the 10 Fukushima reactors, the other 7 reactors on the Japanese East Coast affected by the Fukushima accident, and 13 of Japan's oldest reactors that are more than 30 years old will never restart.) This is 37 less than the historic maximum of 444 plants in 2002.[99]
- During the decade 1992-2001, there were twice as many startups as compared to reactor shutdowns (51/23), but in the past decade (2003-12), the trend has reversed (31/51). In the first half of 2013, four units were shut down (in the US), while only one started up (in China).[100]

That the world nuclear industry is stagnating is also obvious from an overview of the total number of nuclear reactors presently under construction in the world:

- As of July 2013, the IAEA had listed 66 reactors as "under construction" with a total capacity of 63 GW—a huge decline from the peak reached in 1979 when there were 233 units under construction totalling more than 200 GW. Even at the end of 1987, there were 120 units under construction. On top of it, most of these sites are accumulating substantial and costly delays.[101] Post Fukushima, it is very likely that many of them will never be completed.
- Two-third (44) of the units under construction are located in just three countries: China, Russia and India.[102] We discuss India in Chapters 7-8-9. China's pursuit of growth at all costs has pushed the country to the edge of a monumental environmental crisis, perhaps the worst in world history, with terrible consequences for its people. Chinese nuclear experts are warning that the country's aggressive nuclear power plans could lead to a major nuclear accident in the near future. It is therefore not at all surprising that such a dictatorship is making a huge push for setting up nuclear plants. Likewise, Russia has shown murderous apathy towards the victims of radiation leakages and nuclear accidents at its nuclear plants; it has also displayed criminal negligence in disposing of the radioactive waste from its nuclear plants. With such unconcern towards its people and the environment, it's pursuit of a huge nuclear-build program is also unsurprising.[103]
- Due to slowdown in new constructions, the world's nuclear reactor fleet is aging and 143 reactors are on their way to retirement by 2030.[104] Mycle Schneider and his colleagues (all very reputed nuclear energy consultants) in their World Nuclear Industry Status Report 2013 have calculated the minimum number of nuclear plants that would have to come online over the next few decades in order to maintain the present number of operating plants (as on 1 July 2013). They assume a general lifetime of 40 years for all reactors operating worldwide (a very optimistic assumption). They calculate that, even assuming that all the 66 units presently "under construction" come online by July 2020: (i) 55 additional reactors would have to be finished and started up prior to 2020 (that is, 8-9 grid connections every year); (ii) an additional 205 units would have to be constructed and brought online over the following 10-year period—one every 18 days.[105]

Both these are impossible targets, as reactor construction takes at least 10 years.

The conclusion's obvious: despite all the claims made by the IAEA and other nuclear propagandists, the the global nuclear industry is in decline, and the decline had begun well before the Fukushima accident.

Present Scenario: US, Canada, W. Europe

Let us now take a closer look at the present state of the nuclear industry and prospects for a "nuclear renaissance" in the United States, Canada and Western Europe (EU-15 + Switzerland) today. This is the region that was at the centre of the first boom in nuclear energy and where 55% of the world's operating reactors are located (as on July 1, 2013). This is also the region where public opinion is most informed and the debate most intense regarding nuclear energy.

USA and Canada

The United States has 100 operating nuclear power plants, more than any other country in the world. However, no new nuclear capacity has been added since the Watts Bar-2 reactor in Tennessee was commissioned in 1996; its construction took 23 years. It is now 38 years (since October 1973) since a new order has been placed that has not subsequently been cancelled.

Intense lobbying by the nuclear industry has enabled it to win billions of dollars in loan guarantees and other financial handouts from first the Bush and now the Obama administrations, a key subsidy being loan guarantees. Buoyed by these subsidies, in 2007, for the first time in three decades, utilities in the US applied for a license to build a nuclear plant. As of May 2013, the US NRC had received 18 licensing applications for a total of 28 reactors.

In 2009, four of the projects were shortlisted for loan guarantees: twin AP 1000s at Summer (South Carolina) and Vogtle (Georgia), a single EPR at Calvert Cliffs (Maryland) and a pair of ABWRs at South Texas Project (Texas). Four years later, the Calvert Cliffs project stands cancelled and the South Texas project is in deep trouble and unlikely to go ahead.

In the first half of 2012, for the first time in nearly 35 years, the US NRC granted a license for Vogtle and Summer projects. In an unprecedented move, Gregory B. Jaczko, then Chairman of the NRC, voted against the opinion of the four other Commissioners, stating that the decision was being taken "as if Fukushima never happened" and subsequently resigned from his NRC position. Construction of the first unit at both these sites began early this year.

The Vogtle and Summer projects are banking for their viability on unusual state laws that require customers to pay for the plant even during its construction period, irrespective of its final cost and irrespective of whether it ever runs or not. Despite this mindboggling subsidy, there is no certainty that the two plants will finally begin generation. Similar guarantees had been offered to nuclear plants in the USA in the 1970s-80s, but the plants suffered so many cost overruns and delays that finally the regulators were forced to step in and impose penalties, resulting in cancellation of many of the projects. Both the projects are already behind schedule; the Vogtle project is also already overbudget. Protests have begun in Georgia demanding that the billion dollar cost overruns should not be foisted onto customer's electricity bills.

Apart from this 'achievement', the US nuclear industry has also succeeded in winning plant life extensions: as of June 2013, 72 of the operating US nuclear reactors had been granted a life-extension license by the NRC, while another 18 applications were under review.

Despite these successes, the future of the US nuclear industry remains bleak. Beyond Vogtle and Summer, it is very doubtful if any new nuclear plants are going to take off in the near future. Of the 28 reactor applications received by the NRC, eight were subsequently suspended indefinitely or cancelled and at least 16 were delayed. Forget new plants, the booming renewable industry and the rising cost of nuclear electricity are threatening the viability of existing plants too. In the first half of 2013, nuclear operators in the USA announced the closure of 4 reactor units. While three of these reactors faced costly repairs, the Kewaunee plant in Wisconsin was running well and had received a license renewal just two years ago to operate for another 20 years, upto 2033; it simply became uneconomic to run. According to UBS Investment Research, these plant closures may be just the beginning of further closures for 'merchant plants' (those exposed to competitive electricity markets), due to rising operating costs of nuclear plants. Energy analyst Amory B. Lovins, after analyzing recent industry operating-cost data, has come to the conclusion: "For economic or other reasons, the gradual phase-out of unprofitable nuclear power plants, already quietly under way, may accelerate."[106]

Meanwhile, anti-nuclear groups in the US have petitioned the NRC demanding that the US shut down 31 of its reactors which are of the same General Electric Mark-I and Mark-II as the reactors of the

Fukushima Nuclear Plant.[107]

Let's now briefly go across to Canada, which was one of the first countries to invest in nuclear power and has 18 reactors in operation. No nuclear plants have been ordered there since 1978.[108] Over the past few years, there have been several proposals to build new nuclear plants; these would have been Canada's first nuclear reactors in 3 decades. However, all have come to naught, because of strong public opposition and high financial risks.[109]

Western Europe

In early 2011, nine West European countries—Belgium, Germany, Finland, France, Netherlands, Spain, Sweden, Switzerland and the United Kingdom—operated 129 nuclear power reactors with a total installed capacity of 125 GW. This was 33 units less than in 1988-89 when the number of operating units peaked.[110]

In the decade after the Three Mile Island and Chernobyl accidents, rising public consciousness about the terrible environmental consequences of nuclear energy pushed the governments of Belgium, Germany, Italy, the Netherlands, Spain and Sweden to impose a moratorium on construction of new nuclear plants. Some of these countries also decided to phase out their operating nuclear plants over the next two decades, with Italy actually shutting down its last nuclear reactor in 1990.

However, during the first decade of this century, powerful lobbying by the nuclear industry got all these countries to reconsider their decision to phase out their nuclear reactors; some of them even began considering building new plants. In Italy, a new right-wing government announced plans to build new power plants within five years. Finland and France ordered construction of two new reactors, the first new reactor orders in Western Europe (outside France) since 1980.[111]

Despite these apparent successes, a closer look makes it very evident that even in early 2011 (before the Fukushima accident), there was no nuclear 'renaissance' taking place in Western Europe. Public opposition to nuclear energy continued to be very strong in all these countries. While their operating plants were likely to get lifetime extensions, new reactor build in at least seven of the nine nuclear West European countries (Finland and France being the possible exceptions) appeared extremely unlikely in the near future.[112]

Simultaneously, many of these countries had also set ambitious targets for renewable energy and energy conservation. That left very little space for nuclear energy.

And then the Fukushima accident happened. With that, whatever little prospects that existed of a nuclear renaissance in Europe have evaporated. As recently as 2010, the German Bundestag (lower house) had approved plans to extend the working life of Germany's reactors by an average of 12 years. Post-Fukushima, powerful protests forced the German government to announce that all its 17 reactors would be shutdown by 2022; seven of the oldest reactors were taken offline in March itself, within days of the Fukushima accident. On June 8, 2011, the Swiss parliament approved a government plan to phase out the use of nuclear power and shut down the country's five nuclear power reactors in the medium term. A few days later, on June 12 and 13, a majority of Italians—54%—turned out to vote in a nuclear referendum and 94% of them voted in favour of putting a lid on nuclear power indefinitely. And in October, Belgium also announced that it is going to stick to its decision taken in 2003 to phase-out its 7 nuclear power plants, though it has not yet set a firm date for the same. (It had shelved this decision in 2009.)[113]

Even in France, supposed to be the most pro-nuclear country in the world, the nuclear industry has suffered a setback. France's nuclear reactors produce 75% of the country's electricity. For the first time since 1974, a French Government has announced plans for the closure of the oldest operating reactors (Fessenheim-1 and -2), the abandoning of a new-build project (Penly-3) and the systematic reduction of the share of nuclear generated electricity (from about 75 to 50 percent by 2025). Currently a major national energy debate is ongoing that will lead to framework legislation to be submitted to the National Assembly before the end of 2013.[114]

Finland and UK are the two exceptions as far as nuclear energy policy goes in Western Europe. Even though the Olkiluoto-3 reactor being constructed in Finland is in deep trouble (discussed below), in 2010, the Finnish Parliament approved a proposal to construct two new nuclear power plants in the country. Despite the Fukushima accident, the UK government in July 2011 announced plans for restarting construction of nuclear plants, and in April 2013 gave permission to EDF Energy to build two reactors at Hinkley Point. However, a lot of uncertainty surrounds the project: negotiations are still going on over electricity price, the key issue being how much of the economic risk associated with nuclear power should be passed on to consumers; there is no guarantee that finance can be secured for the project even with generous subsidies, as nuclear costs are very high and renewables are becoming very competitive; the agreement will also need the approval of the EU, as its regulations do not permit state subsidy to nuclear power.[115]

Flagships of the Nuclear Renaissance Holed...

The flagships of the so-called 'Nuclear Renaissance' are the two Generation-III+ EPR reactors being constructed in Finland and France, Olkiluoto-3 and Flamanville-3 (respectively).

From the beginning, the Olkiluoto-3 (OL3) project in Finland being executed by the French corporation Areva has been plagued with countless management and quality-control issues. Till November 2009, the Finnish nuclear safety authority STUK had detected about 3000 safety and quality problems in the OL3 project. STUK in fact has admitted that the number of problems is so large that it is possible it may not be able to detect all of them. Alarmingly, these include problems with several key components. A study done for Greenpeace by nuclear expert Dr. Helmut Hirsch has found that there are several instances where STUK has relaxed safety requirements and allowed installation of faulty components.[116]

These reactors also have worrying design problems. In an unprecedented move, on November 2, 2009, the nuclear safety regulators of Finland, France and the United Kingdom issued a joint statement raising concern about the EPR's Control and Instrumentation system, the nerve centre of the reactor; the US NRC has also expressed similar concerns. The Finnish regulator has still not validated the EPR's I&C system.[117]

These are scary facts! The EPR, being of 1600 MW capacity is the largest reactor ever built, and so its core contains more radioactive elements than any other reactor. In addition, for reasons of economy, it is designed to burn fuel longer, leading to increased radioactivity and greater production of dangerous nuclear isotopes. This will obviously mean greater thinning of the fuel cladding and more cracks resulting in higher radioactive releases from the reactor. All these make the EPR potentially more dangerous, both during routine operation and even more so in case of an accident.[118]

That is one part of the Olkiluoto-3 fiasco. The other part is that the project has turned into a financial disaster. The project was supposed to have been completed in 2009; as of today, it is seven years behind schedule and a whopping 280 percent over budget, reaching a total cost estimate of €8.5 billion ($11.36 billion). With three years of construction still left, there can be little confidence that there will be

no further cost and time overruns.[119]

The other European order for an EPR, Flamanville-3 in France, which is being built by EDF, is is going wrong just as badly as the Olkiluoto project and perhaps worse. This site too has encountered quality-control problems similar to those at the OL3 project, even though construction here began two and a half years later, in December 2007. This project too is years late and the price tag has doubled to €8.5 billion.[120]

Clearly, both the flagships of the nuclear renaissance have got holed below the water line...

Post-Fukushima Scenario: General Global Overview

Apart from Germany and other West European countries, many countries around the world have also begun reconsidering their nuclear energy programs. The Taiwanese government has suspended plans to build new reactors. Malaysia, Thailand and Venezuela have also announced a freeze on plans to build their first nuclear power plants. Brazil too has decided to scrap its ambitious nuclear build program wherein it had planned to launch up to 8 new nuclear reactors.[121] Even China has considerably slowed down its ambitious nuclear new build plans. Public protests against China's nuclear plants are also rising—in July this year, the government announced the cancellation of a proposed $6 billion uranium processing plant in Jiangmen after hundreds of people took to the streets to air their environmental concerns.[122]

In Eastern Europe, following Fukushima, Bulgaria has abandoned plans to build a new reactor at Belene; while in Lithuania, an overwhelming majority voted in a referendum in October 2012 against plans to build a new reactor, forcing the government to drop the project. In Poland, with public opinion opposed to government plans to re-enter the nuclear arena, the government has launched a $6 million publicity drive to drum up support.[123]

Bangladesh, Turkey and Vietnam have been considering building their first nuclear plants for years / decades; there is no certainty as to whether these plans will ever go ahead. Some East European countries with nuclear plants—the Czech Republic, Hungary, Romania and Slovenia—have also been debating starting new nuclear plants, but with escalating costs and growing public opposition, the future of all these plans is also unclear.[124]

In May 2012, Japan shut down the last of its 54 nuclear reactors. It restarted two reactors at the Ohi plant two months later, despite massive public opposition. The Japanese government is keen to restart at least some more reactors; officially, it has declared only the four Fukushima reactors as permanently shut down; the other 50 are still classified as "operational". While restarting all these reactors is virtually impossible, restarting even a few is not going to be easy as massive demonstrations of unprecedented scale have continued to flood the streets of Japan's cities. In fact, the future of the 2 Ohi reactors that have been restarted is also uncertain.[125]

On the other hand, the nuclear industry has been able to notch up some successes too. The UAE started construction of two reactors in 2012 / 2013 (being built by a South Korean consortium)—already, the costs have doubled. Ukraine and Belarus are the two countries worst affected by the Chernobyl disaster, with huge areas contaminated with radioactivity and very large number of people suffering from its health consequences. Yet, both countries recently signed agreements with Russia to build new nuclear plants.[126]

In the USA, the NRC granted licenses for four units and construction began on the first two in early 2013—the first new constructions in 35 years. All four are hopelessly uneconomic but proceed because of huge federal subsidies that rival their construction cost; and mindboggling guarantees by their state legislatures which have transferred all risks to taxpayers and customers. On the other hand, 4 operating reactors were closed down as uneconomic for the first time in 15 years.

It is thus obvious that globally, the overall future prospects for nuclear energy appear bleak. In the USA, after all the huffing and puffing by the nuclear industry and the US administration, at the most two to four reactors might come on line in the coming years—on the other hand, rising nuclear costs may lead to closures of many operating reactors. In Western Europe, the construction of two new reactors after nearly two decades has become such a fiasco that it is doubtful if any more reactors are going to be built there in the near future. All proposals for constructing new reactors in Canada, another country with a large nuclear power program, have been cancelled. At the most, Russia, China and India are likely to build a few reactors; UK, South Korea, UAE and Eastern Europe might also add a reactor or two. But considering that dozens of nuclear plants are scheduled to shutdown in the next two decades, it is obvious that the overall worldwide trend for nuclear power is going to be downwards. In all likelihood, the sun is setting for nuclear power globally.

The reasons for this dismal future are the colossal problems with nuclear energy. Apart from skyrocketing costs, construction delays and design problems, humanity has yet to find answers to the terrible safety issues with nuclear energy—the deathly radioactive pollution of the environment caused by leakage of radiation from nuclear reactors, the as yet intractable problem of safe storage of high level wastes, and the potential for catastrophic accidents. Because of these problems, public opposition to construction of nuclear plants in their neighbourhoods is intense, and so even if governments have been willing to support the construction of new nuclear plants, they have been forced to scuttle these plans due to powerful people's protests.

But what is probably going to deliver the knockout punch to nuclear energy is the falling costs of renewables. Capitalism is all about profits, it is deaf to pleas about environmental and health impacts. While costs of nuclear energy are soaring, renewable energy costs are continuously falling. Wind and solar electricity have not only become cheaper than nuclear electricity, wind is already cheaper than electricity from coal and solar is expected to become so in 2-3 years, as we discuss in Chapter 10. That should seal the fate of nuclear energy.

7. INDIA'S NUCLEAR ENERGY PROGRAM

Brief History

India's nuclear program was initiated just a few months after independence, with the passage of the Atomic Energy Act of 1948. Ignoring the claims of a galaxy of brilliant scientists like Meghnad Saha, Prime Minister Nehru handed over the reins of India's nuclear energy program to Dr. Homi Bhabha. The Atomic Energy Commission (AEC) was created in 1948 as the apex body in charge of nuclear policy in India. The Department of Atomic Energy (DAE) was set up in 1954 as the overall body responsible for research, technology development and commercial reactor operation. The Atomic Energy Establishment (AEE) was established as India's primary centre for nuclear research (later renamed Bhabha Atomic Research Centre or BARC after Bhabha's death in 1966). Bhabha was put in charge of all three establishments; he was thus virtually the dictator of India's nuclear program.

The Atomic Energy Act of 1948 allowed for a thick layer of secrecy over India's entire nuclear program. In 1962, the government passed the even more draconian Atomic Energy Act of 1962, which granted yet more powers to the AEC. No democratic country has given such authoritarian powers to its atomic energy establishment. The 1962 Act grants absolute powers to the AEC over exploration and manufacture of atomic material and related hardware. The AEC also has complete control over all nuclear research in the country. Additionally, the Act empowers the AEC to restrict disclosure of any information related to nuclear issues. Despite having such immense powers, the AEC does not report to the Cabinet, but directly to the Prime Minister.[127]

Bhabha initiated plans to develop the entire nuclear fuel cycle in India, including mining uranium, fabricating fuel, manufacturing heavy water, and also reprocessing spent fuel to extract plutonium. For executing these plans, the DAE set up a number of subsidiary organisations: the Nuclear Power Corporation of India Limited (NPCIL)—for designing, constructing, and operating nuclear power plants; the Uranium Corporation of India Limited (UCIL)—for mining and milling of uranium; the Heavy Water Board—to look after the plants that produce heavy water; and the Nuclear Fuel Complex—to manufacture fuel for the nuclear reactors.

Bhabha initiated discussions with a number of countries for assistance for setting up atomic power plants in the country. The AEC selected the Canadian CANDU type heavy water reactors for India's atomic power program. While all of India's initial reactors were to be of this type, Bhabha negotiated an agreement with the United States for setting up two Boiling Water Reactors at Tarapur; the US also agreed to supply the enriched uranium fuel for them.

Three Stage Program

Simultaneously, Bhabha announced a grand three stage program for the development of nuclear energy in the country. The logic behind this was that while India has very little uranium, it has plenty of the element thorium, about 32 percent of the world's deposits. Thorium is not fissile, but it can be converted to the fissile uranium-233 from which electricity can be generated. To make use of India's thorium reserves, Bhabha announced a three phase strategy for the development of this technology.

The first stage involved PHWRs, which use unenriched uranium as fuel. The spent fuel is reprocessed to extract plutonium. In the second stage, this Pu-239 is used in the core of FBRs, with the core surrounded by a "blanket" of U-238; the U-238 captures neutrons released during fission of Pu-239 to produce more plutonium, thus "breeding" its own fuel. Subsequently, the blanket would be of thorium, which would produce fissile U-233. Finally, in the third stage, the core of the FBR is replaced with U-233, to generate electricity. This reactor would also have a thorium blanket to breed more U-233.

Targets and Achievements

In 1954, Bhabha announced that there would be 8000 MW of nuclear power in the country by 1980; in 1962, he predicted 20-25,000 MW of nuclear power by 1987; and in 1969, the AEC predicted 43,500 MW of nuclear generating capacity by 2000.[128] The achievements have been mediocre. Even by 2013, the total nuclear generating capacity in the country was only 4780 MW, less than 11% of the target set for 2000.

INDIA'S PRESENT NUCLEAR FACILITIES

Uranium Mining and Milling

Mining and processing of uranium in India is carried out by the Uranium Corporation of India Ltd. (UCIL). Presently, it operates six underground mines and an open cast mine, as well as two processing plants, in the Jharkhand region. In April 2012, it commissioned its first mine outside Jharkhand, an underground mine at Tummalapalle in Kadapa district of Andhra Pradesh. Mining projects are also planned in the Lambapur-Peddagattu area in Nalgonda district (Andhra Pradesh) and at Gogi in Gulbarga area of Karnataka.

Meghalaya also has large reserves of uranium. Despite having the necessary clearances to begin mining in the West Khasi Hills district of the state, UCIL has been unable to begin mining in the area, due to strong people's opposition.

The yellow cake from UCIL's milling plants in Jharkhand is sent to DAE's Nuclear Fuel Complex at Hyderabad for refining and conversion into nuclear fuel.

India also operates seven heavy water plants to supply heavy water for India's PHWRs.

Nuclear Reactors

Presently (as on August 1, 2013), India has 18 small and two mid-sized nuclear power reactors in operation. These are mostly PHWRs, except for two units of BWRs in Tarapur. Another 6 reactors are under construction. Apart from these, a 500 MW prototype Fast Breeder Reactor (FBR) is under construction at Kalpakkam.

Reprocessing

Unlike most other countries, the DAE pursues reprocessing as a way of dealing with spent fuel—to extract plutonium for use in Fast

Breeder Reactors and for nuclear weapons. India has three full-scale reprocessing plants, at Trombay, Tarapur and Kalpakkam.

Table 7.1: India's Nuclear Reactors in Operation

Power station	State	Type	Units	Total capacity
Kaiga	Karnataka	PHWR	220 x 4	880
Kakrapar	Gujarat	PHWR	220 x 2	440
Kalpakkam	Tamil Nadu	PHWR	220 x 2	440
Narora	Uttar Pradesh	PHWR	220 x 2	440
Rawatbhata	Rajasthan	PHWR	100 x 1, 200 x 1, 220 x 4	1180
Tarapur	Maharashtra	BWR, PHWR	160 x 2, 540 x 2	1400
	Total		**20**	**4780**

Nuclear Waste Management

The DAE classifies the waste from its reprocessing plants into low-level waste (LLW), intermediate-level waste (ILW) and high-level waste (HLW).

Gaseous wastes produced during routine operations at nuclear reactors and reprocessing plants are released through stacks (75-100 metres tall) into the environment after filtration, while low-level liquid wastes are released into nearby water bodies, such as the sea in the case of coastal reactors. Data on such releases are scarce, but suggest that releases at Indian reactors are much higher as compared to similar reactors elsewhere. Intermediate-level liquid wastes generated in reprocessing plants are concentrated and fixed in cement.[129]

DAE temporarily deals with high-level waste by immobilising or vitrifying it—the waste is mixed with glass at a high temperature and allowed to cool, which slows down the diffusion of radionuclides from HLW. These blocks are presently stored at the Solid Storage & Surveillance Facility at Tarapur.

Indo-US Nuclear Deal and New Projects

Following India's nuclear tests in 1974, the developed western capitalist countries terminated all cooperation in the field of nuclear technology with India.

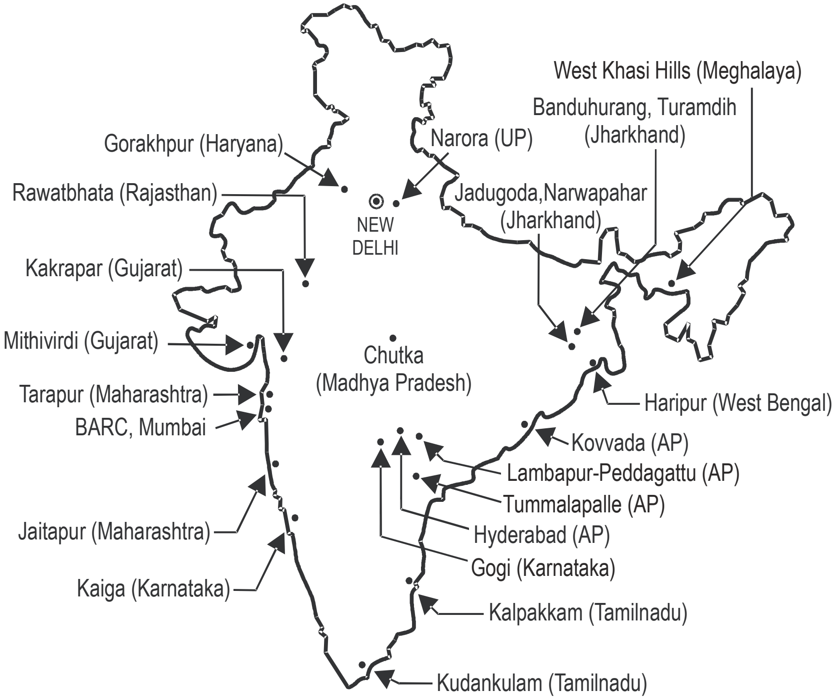


Figure: India's Uranium Mines and Reactors

However, by the turn of the 21st century, momentous changes had taken place in the world. In this changed scenario, India decided to open up its economy to unrestricted inflow of western goods and capital. It also abandoned its non-aligned foreign policy and independent defence policy, and aligned with the United States. As a reward, the US offered India an agreement on nuclear cooperation, which was greedily accepted by India's rulers.

The first steps towards this deal were taken in 2005, but it took more than three years to come to fruition as it had to go through several complex stages. The IAEA approved the Indo-US agreement in August 2008; the Nuclear Suppliers Group (a group of 46 nuclear supplier countries who coordinate their nuclear related exports) granted approval to India to access nuclear technology and equipment from other countries in September 2008; and US President Bush signed the agreement into law on October 8, 2008. With India now able to import uranium as well as reactors from other countries, the Indian government has signed agreements with a number of countries for uranium supplies and also announced plans to import big-size nuclear reactors and set up a string of 'Nuclear Parks' across the country, each of 6000-10,000 MW capacity. So far, the government has given in principle approval to the following 'Nuclear Parks':

- Kudankulam in Tamil Nadu: The initial agreement for setting up two Russian VVER-1000 reactors was signed much before the Indo-US Nuclear Deal, and construction began in 2001. Following the Nuclear Deal, plans have been drafted for building two more pairs of VVER-1000 units here, for a total of 6 reactors of total capacity of 6000 MW.
- Jaitapur in Maharashtra: A total of six EPR reactors from Areva of 1650 MW each, for a total capacity of 9900 MW.
- Mithivirdi in Gujarat and Kovvada in Andhra Pradesh: Six LWR reactors at each location, each of 1000 MW, to be set up by US-based corporations, either GE-Hitachi or Westinghouse.

The government had given approval for a nuclear park at Haripur in West Bengal too, but following a sustained agitation by the local people, the Trinamool Congress government led by Mamata Banerjee cancelled the project after it won the elections to the West Bengal state assembly in 2011.

The NPCIL has also got in-principle approval to build 4 indigenous PHWR reactors of 700 MW each at Gorakhpur village in Fatehabad district of Haryana, and another 2 similar reactors at Chutka in Madhya Pradesh.

8. RADIATION RELEASES AT INDIA'S NUCLEAR INSTALLATIONS

The nuclear industry is notorious all over the world for suppressing information. Even then, in the US and West European countries, at least some information is officially available on the release of radioactivity into the atmosphere from uranium mines and nuclear power plants. In India, however, no such information is available. That is because of the undemocratic Atomic Energy Act of 1962. The Act allows the nuclear establishment to deny all information about the state of India's nuclear installations and their safety situation to the public and even to the Parliament!

Taking refuge behind this draconian law, India's nuclear establishment has become a dictatorial entity lording over the people of the country. The DAE and its subsidiaries which run India's nuclear installations try to suppress all information about accidents and radiation releases occurring at these installations, and the impact of these radiation releases on people as well as on their own workers. Therefore, not much information is available about the state of India's nuclear facilities. The discussion below is based on the little information that has come out through unofficial and occasionally official sources.

PART I: SITUATION AT INDIA'S URANIUM MINES

The website of UCIL claims that "UCIL has a track record of adopting absolutely safe and environment friendly working practices in Uranium Mining and Processing activities"; it asserts that there is no radioactive contamination of the area due to uranium mining.

However, numerous surveys by independent doctors, nuclear physicists and public-spirited journalists have found the reality to be the exact opposite. UCIL's mining practices completely disregard the fact that the mine waste is radioactive. The waste is left carelessly dumped in the open; mounds of waste are also found scattered in the villages surrounding the mines. The company is so utterly callous that it has even supplied waste rock from the mines to the local people for construction of roads and houses![130]

There are three tailing ponds in the Jaduguda region spread over an area of 100 acres; they are estimated to contain crores of tons of radioactive waste. More than 30,000 people live within a 5 km radius from these tailing ponds. UCIL has not taken the slightest precaution to protect the health of these people from radiation releases from the ponds. The ponds are not even fenced off properly, and people freely walk across them!

Accidents Galore

As if this was not enough, there have been numerous accidents at the mines due to UCIL's faulty technical and management practices. Pipelines carrying uranium mill tailings from the Jaduguda uranium mill to the tailing ponds have repeatedly burst, causing spillage of the radioactive sludge into nearby homes and water bodies.

One of the worst such accidents took place on December 25, 2006—the burst pipeline continued to spew toxic waste into a creek for nine hours before it was finally shut off! Consequently, a thick layer of toxic sludge on the surface of the creek killed scores of fish, frogs and other riparian life. The waste from the leak also reached a creek that feeds into the Subarnarekha River, seriously contaminating the water resources of communities living along its banks for hundreds of kilometres.[131]

Terrible Health Costs

UCIL authorities refuse to acknowledge any health impact of uranium mining on mine workers. However, a survey by the well-known physicist Dr. Surendra Gadekar and medic Dr. Sanghamitra Gadekar in 2000 found extremely high levels of chronic lung diseases in the company's mine and mill workers. These were most likely to be silicosis or lung cancer. The UCIL termed these cases as tuberculosis, so as to avoid compensation payments.

The impact of radiation releases from the mines and tailing ponds on the health of the people of the nearby villages has also been colossal. One survey, in seven villages within a kilometre of the tailing dams, revealed that a shocking 47 percent of the women in the area suffered disruptions in their menstrual cycle, 18 percent said they had suffered miscarriages or given birth to stillborn babies in the last 5 years and 30 percent suffered from fertility problems. The Gadekars in their survey found a high incidence of congenital deformities and mental retardation among infants in the vicinity of Jaduguda. A more recent (2008) health survey by a team of doctors from the Indian chapter of 1985 Nobel Peace Prize recipient International Physicians for Prevention of Nuclear War also found clear evidence of increased incidence of sterility, birth defects and cancer deaths among people living in the nearby villages.[132]

Child Victims of Jadugoda Uranium Mines

PART II: NUCLEAR FUEL COMPLEX, HYDERABAD

UCIL processes the uranium ore in its mills in Jharkhand and sends the yellow cake to the Nuclear Fuel Complex (NFC) in Hyderabad. Here the uranium fuel rods are fabricated from the yellow cake, and supplied to all the nuclear plants in India.

The NFC churns out 50,000 tons of radioactively contaminated waste water every day. This is discharged into a waste storage pond located in the complex. Over the years, seepage from this pond has contaminated the groundwater. As a result, the situation in and around Hyderabad is becoming grave. Mysterious and painful diseases have already visited people living near the NFC. The DAE has prohibited residents of Ashok Nagar, a locality near NFC, from drinking water from underground wells in the area. Eleven villages near NFC also face the same problem. As the contamination spreads, it will affect the underground water supply to the entire city.[133]

PART III: INDIA'S NUCLEAR REACTORS

World's Most Unsafe Reactors

While release of small or large quantities of radioactivity from nuclear power plants (NPPs) occurs quite often at every nuclear reactor around the world, India's nuclear plants are amongst the most contaminated in the world. Some years ago, a survey in *Nuclear Engineering International* listed India's reactors in the lowest bracket in terms of efficiency and performance.[134] The US-based watchdog group—the Safe Energy Communication Council—has also described India's nuclear energy program, especially its reactors, to be the "least efficient" and the "most dangerous in the world".[135]

We discuss a few examples below.

Tarapur: Decrepit Reactors

The Tarapur-1 & 2 reactors are more than 40 years old. While the risk of accidents increases with age for all nuclear reactors, the Tarapur 1 & 2 reactors are particularly vulnerable as their design is even older than the Mark-1 design of the Fukushima reactors that exploded on March 11, 2011. All other reactors of this design have been shut down long ago!

These two reactors suffer from so many problems that they have earned the infamy of being amongst the 'dirtiest reactors in the world'. Many parts have become uninspectable, and the DAE lacks the technology to correct their problems. The radiation contamination of the reactor building and its environs is extremely high.[136] Yet the DAE continues to flog these two decrepit reactors—located just 100 kms from Mumbai. It is a form of Russian roulette with millions of lives at stake.

Kakrapar: Untested ECCS

DAE/NPCIL started up Kakrapar Unit-1 in 1991, without doing the full testing of its Emergency Core Cooling System (ECCS)![137] This is unheard of in the global nuclear industry. The ECCS is a vital safety system, the only backup system available in case the cooling system of the reactor fails, which can lead to a Fukushima type meltdown. Thus it is not known if it will function in case of an emergency! (Once the reactor begins operation, this testing can never be done.) All that we can do is pray that an accident does not happen to damage the cooling circuit of the reactor.

BARC: Leaking

This premier research institution in Mumbai is in an even poorer shape than India's nuclear reactors. The underground pipes carrying radioactive water as well as the storage tanks containing liquid nuclear waste are both leaking, due to aging and corrosion. The result is that caesium-137 has been found in the soil, water and vegetation at the BARC site and the Trombay coast, and that too, at high levels. Additionally, the research and reprocessing plants at BARC discharge their nuclear effluents into the Thane creek, which separates Navi Mumbai from old Mumbai.[138] The people of Mumbai are going to pay the price for this callousness of BARC for centuries.

Waste Management

The DAE pursues reprocessing as a way to manage spent fuel. However, as we have seen in Chapter 3, reprocessing plants are highly polluting. The reprocessing plants in France and England are the biggest sources of radioactive pollution in Europe, with radioactive releases from them polluting the North Sea as far away as the Arctic.[139] One wonders how far has the pollution from DAE's reprocessing facilities spread in the Bay of Bengal and Indian Ocean!

The DAE does not have enough reprocessing capacity to reprocess all the waste from its reactors. So, most of the remaining waste is accumulating in spent fuel pools near the reactors, and will inevitably leak to contaminate the environment.

So far, the DAE has made no effort to even find a temporary solution to the problem of safely storing this growing volume of spent fuel. The spent fuel pools contain an enormous amount of radiation, but are not stored in containments as secure as nuclear reactors.

Therefore, they are much more vulnerable to terrorist attacks or natural calamities like earthquakes. An accident at a spent fuel pool can be even more catastrophic than a nuclear reactor accident.

Accidents Aplenty

There have been hundreds of accidents, of varying degrees of severity, at DAE's nuclear reactors. Here is an extract from Molly Moore's report in the *Washington Post* in 1995: "Four decades after India launched a full-scale nuclear power program … it operates some of the world's most accident-prone and inefficient nuclear facilities. During 1992 and 1993, its most recent two-year monitoring period, the Indian government reported 271 dangerous or life-threatening incidents, including fires, radioactive leaks, major systems failures and accidents at nuclear power and research facilities. Eight workers died in that period."[140]

In what may appear to be astonishing, the same opinion has been expressed by Dr. A. Gopalakrishnan, a former chief of the AERB, the body responsible for overseeing safety at India's nuclear installations! In an interview to the media while remitting office in 1996, he stated that the current safety status of the nuclear installations under the DAE "is a matter of great concern."[141]

But then why didn't he do anything about it? It's because he had very little powers to do anything!

India's Nuclear Safety Watchdog: A Lapdog

In violation of all international nuclear safety norms, India's nuclear safety regulator, the Atomic Energy Regulatory Board (AERB), is subservient to the bodies it is supposed to oversee! The AERB is not only subordinate to the DAE, it is also subordinate to the NPCIL and Bhabha Atomic Research Centre (BARC), bodies it is supposed to regulate![142] This makes the regulatory process a complete sham. In the words of Dr. Gopalakrishnan:

> (India's nuclear regulatory process is) a total farce ... The DAE wants the government and the people to believe that all is well with our nuclear installations. I have documentary evidence to prove that this is not so.[143]

Probably the only time the AERB has attempted to function as an independent safety regulator was during the period 1993-96, when Dr. Gopalakrishnan was its Chairman. However, all his efforts to improve the safety situation of India's nuclear installations were stonewalled by the DAE. In 1995, the AERB undertook an overall safety assessment of

DAE's facilities. Its report to the DAE mentioned about 130 safety issues with regards to Indian nuclear installations, with 95 being top priority. According to Dr. Gopalakrishnan, to date nothing is known about whether any concrete action has been taken on any of its recommendations![144]

DAE Stories

That an accident of the scale of Chernobyl or Fukushima has not yet taken place in India should be no cause for comfort. The DAE/NPCIL have built and operated India's nuclear reactors so dangerously that it can only be the combined might of the 33 crore Gods in the heavens which has prevented a Chernobyl from occurring in India! We discuss below a few examples to illustrate this; they should give us all sleepless nights.

Fire, Narora, March 31, 1993

This accident has been NPCIL's closest approach to a catastrophic accident. That morning, two blades of the turbine at Narora-1 broke off due to fatigue, destabilising the turbine and making it vibrate excessively. The vibrations caused the pipes carrying hydrogen gas that cooled the turbine to break, releasing the hydrogen which soon caught fire. Within minutes, the fire spread through the entire turbine building. The control room soon filled with smoke, forcing the staff to vacate it. The electricity cables caught fire, leading to a general blackout in the plant. The power supply to the secondary cooling system too was affected, rendering it inoperable.

It took 17 hours for power to be restored to the reactor and its safety systems. A meltdown was averted due to brilliant thinking on the part of the operators. They heroically climbed onto the top of the building and manually opened the valves to release liquid boron into the core to slow down the reaction. Then, in another clever move, they utilised the diesel generator of the fire engine to keep the cooling system running.

What is most worrisome about this accident is that it was avoidable. In 1989, General Electric informed the turbine manufacturer, Bharat Heavy Electricals Limited (BHEL), about a design flaw which had led to cracks in similar turbines around the world and recommended design modifications. BHEL promptly informed the NPCIL, but the latter took no action till after the accident!

Secondly, even after the turbine blades had failed, the accident might have been averted if the backup safety systems had been operating, which was possible only if their power supply had been encased in separate and fire resistant ducts. Though this was established practice in the world nuclear design industry, this practice was not followed for this plant! Both the main supply cable and the backup power supply cable were laid in the same duct, with no fire resistant material enclosing or separating the cable systems. As a result, following the fire in the turbine building, along with the main supply cables, the backup power cables also caught fire and led to a complete blackout in the plant.[145]

Collapse of Dome, Kaiga, May 13, 1994

This accident at Kaiga is unprecedented in the annals of nuclear energy history. Just as construction of Unit-1 of the Kaiga Atomic Power Station located in Karnataka was nearing completion, on May 13, 1994, the concrete containment dome of the reactor collapsed under its own weight. Concrete slabs weighing hundreds of tons came crashing down from a height of about 40 metres. Had the dome collapsed after the reactor had commenced operations, it would in all probability have led to a reactor meltdown.[146]

The collapse of the containment in a reactor at any stage is unthinkable. It is designed to withstand not just natural calamities like earthquakes and hurricanes, but even the intense radiation from within in case of an accident in the reactor. But in India, we have a reactor containment that did not even withstand its own weight! It speaks volumes for the safety culture prevailing in our atomic energy establishment. It should have lead to a complete overhauling of the safety department overseeing the construction of the reactor. But the NPCIL/DAE did nothing, except setting up committees to whitewash the accident.

Flooding, Kakrapar, June 15, 1994

The numerous stories about the sloppiness and inefficiency of India's atomic energy establishment would make for hilarious reading, but for the fact that many of these have very nearly led to a 'Chernobyl-like' disaster. The flooding of Kakrapar Atomic Power Station (KAPS) on June 15, 1994 due to heavy rains is another such story. Fortunately for South Gujarat, the plant was in a shutdown state on that day, so nothing happened.

Just behind the turbine room of the KAPS is the Moticher Lake. Outlet ducts of the turbine building connect it to this lake. The lake has gates to control the water level. Following heavy rains on June 15, 1994, the water level in the lake began to rise. The outlet ducts became inlet pipes and water began entering the turbine building on the night of June 15 itself. But such is the level of 'emergency preparedness' of the DAE/NPCIL, that even as the flood waters were entering the turbine building to create havoc, the KAPS authorities were soundly sleeping! The flooding was discovered only on the morning of June 16, when the morning shift arrived for work. The authorities now frantically tried to get the gates of the Moticher Lake opened. But the gates had been neglected for years, and so were jammed! It was only two days later, on June 18, that a large pump arrived from Tarapur and work began to remove water from the turbine building.[147]

Forget big natural disasters, the NPCIL is so incompetent that after more than three decades of experience, it cannot even prevent flooding of its reactors in case of heavy rains!

India's Nuclear Reactors: Impact on People

From the above description, it is obvious that India's nuclear reactors must be leaking radiation. However, we only have scanty evidence on this as the NPCIL does not divulge any data. In 1993, at a meeting of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), India's nuclear officials gave figures of radioactive discharges from India's nuclear plants—they were higher than safe limits by about 100 times.[148] That India's reactors are emitting radiation at several times the international norm has also been admitted to by S. P. Sukhatme, then Chairman of the AERB, in 2002.[149]

Not much information is available about the impact of these radiation leakages on the health of people living around these reactors. The authorities simply don't do any studies. The only information we have is based on the following two surveys by independent scientists and doctors.

Rawatbhata Survey

Renowned scientist-activists Drs. Surendra and Sanghamitra Gadekar of Sampoorna Kranti Vidyalaya, Vedchhi, District Surat, Gujarat did a unique survey of the population living in five villages in the vicinity of the Rawatbhata nuclear power plant in 1991. The results of the study were published in the journal *International Perspectives in Public Health*. The survey found:[150]

- A huge increase in the rate of congenital deformities.
- A significantly higher rate of spontaneous abortions, still births and deaths of new born babies.
- A significant increase in chronic problems like long duration fevers, long lasting and frequently recurring skin problems, continual digestive tract problems, persistent feeling of lethargy and general debility. The young were more affected by these problems.
- Diseases of old age prevalent amongst the youth.
- A significantly higher rate of solid tumours.

Rawatbhata Nuclear Plant Health Costs

Kalpakkam's Forgotten People

Dr. V. Pugazhenthi and a team of doctors, under the guidance of Dr. Rosalie Bertell, the world renowned environmental epidemiologist, did a study in 2007 of the incidence of goiter and autoimmune thyroid disease (AITD) among the people living around the Madras Atomic Power Station (MAPS) at Kalpakkam near Chennai. They found a very high incidence of thyroid disorders among women above the age of 14 years living within a distance of 6 km from MAPS, with the incidence of goiter being an astonishing 23% amongst women in the age group of 20-40, and of AITD being as high as 7% amongst women in the age group of 30-39 years. This was obviously due to exposure to routine releases of radionuclides, especially radioactive iodine, from MAPS. In another worrying indication, the doctors found several cases of congenital defects and mental retardation in the coastal areas in a radius of 16 km from the nuclear complex, which must have been caused by exposure of the foetus to radiation.[151]

The radioactive effluents have badly affected the livelihood of fishermen in the coastal areas surrounding the plant. The area was once rich in many varieties of fish, but now due to the warm water released by the plant that keeps the fish away, the catch has drastically come down. Much of the fish caught by the fishermen is dead fish. They salt and dry it, and sell it in Chennai; the local people will not touch it because they know where it comes from.[152]

PART IV: INDIA'S FBR AND THREE STAGE PROGRAM

A Fast Breeder Reactor (FBR) uses a mix of oxides of plutonium-239 and uranium-238 as the fuel (also called MOX fuel). Pu-239 is the fissile material. The U-238 captures the neutrons released during fission of Pu-239 to transform to U-239, which then beta decays to form Pu-239. Thus, this reactor breeds fuel (Pu-239) as it operates, hence its name.

The worldwide experience with FBRs has proven that these reactors are extremely dangerous. Firstly, while all nuclear reactors are susceptible to catastrophic accidents, FBRs are even more so. That is because FBRs use liquid sodium as coolant, which is extremely reactive—it burns when exposed to air and reacts violently with water. This makes building, operating and repairing these reactors very difficult as even a minor leak can be dangerous. Most demonstration FBRs that have been built so far worldwide have been shut down for long periods due to fires caused by sodium leaks. The second problem that plagues breeder reactors arises from their use of MOX fuel, which contains plutonium. Because plutonium is about 30,000 times more radioactive than uranium-235, an accident in a FBR would be much more dangerous than in a uranium fuelled reactor.[153] Consequently, while during the initial decades of the nuclear era, many countries established FBR programs, nearly all of them have abandoned it today.

The DAE has been attempting to build a FBR since the 1960s, as the second stage of the so-called three stage nuclear program. Given the secrecy surrounding the activities of the DAE, not much is known about the progress of this program. It now claims that it is building a 500 MWe Prototype FBR. However, the reality is that after more than five decades, it has not even been able to build a properly functioning 10 MWe demonstration unit.[154] Clearly, for all its claims, DAE's three stage program is a complete failure.

[Even if the DAE does somehow manage to reach the third stage—breeders involving thorium-232 and uranium-233—sometime in the future, building these breeders is also very problematic. Thorium itself cannot be used as reactor fuel, but must be put through a nuclear reactor to first produce the fissile U-233. But along with U-233, another isotope of uranium is also produced, U-232, which emits energetic gamma rays. This makes fuel fabrication and reprocessing hazardous to the health of workers, and so has to be handled remotely, making it very expensive.[155] This explains why no country in the world has an active program to utilise thorium.]

Considering that FBRs are even more dangerous than uranium fuelled reactors, this failure of the DAE is actually a blessing in disguise!

PART IV: INDIA'S NUCLEOCRATS AND FUKUSHIMA

The Fukushima accident has made governments around the world pause and rethink their nuclear energy programs. The very pro-nuclear German government has decided to phase out the country's 17 nuclear reactors, while Italy has cancelled plans to construct new reactors. But the Indian government is unfazed. Cocking a snook at global concerns about nuclear safety, the Prime Minister chose the 25th anniversary of the Chernobyl disaster (April 26, 2011) to call a meeting and announce his government's resolve that it will go ahead with the Jaitapur atomic power project![156]

Here is a sampling of the statements made by some of India's leading nucleocrats after the Fukushima accident. NPCIL chairman S.K. Jain commented: "There is no nuclear accident or incident (at Fukushima). It is a well-planned emergency preparedness programme which the nuclear operators ... are carrying out to contain the residual heat after ... an automatic shutdown". Not to be left behind, his boss, Dr. Srikumar Banerjee, chairman of India's AEC, declared that the nuclear crisis "was purely a chemical reaction and not a nuclear emergency as described by some section(s) of media".[157]

Allaying fears about the Jaitapur nuclear plant, another 'atomic expert', Dr. Anil Kakodkar, a former chief of the AEC, declared that the Jaitapur plant is located in a less seismically active zone as compared to the Fukushima plant, and so is inherently safer; and that the reactor will be designed to withstand the worst earthquake recorded in the region. This is a very dumb argument. Obviously, the Japanese had planned their reactor designs to withstand the largest possible earthquakes they could visualise, and yet an earthquake bigger than the maximum they planned for did take place. The same can happen at Jaitapur too![158]

'Missile scientist' and former President APJ Abdul Kalam has been deployed by the government to defend the Kudankulam nuclear plant. He is claiming that the Fukushima accident is much smaller than Chernobyl, with no direct loss of life, and the reason is that there has been much improvement in management of nuclear accidents. He is also claiming that the radiation releases will not affect future generations.[159] Implying that we don't have to worry about nuclear accidents. In the words of Dr. Gofman, such scientists "should be tried for murder."

But what leaves one absolutely dumbfounded are the statements being dished out by the head of India's atomic energy program, Prime Minister Manmohan Singh. He is claiming that all our reactors have functioned without an incident, that our nuclear safety standards were unmatched, and that there is no possibility of a Fukushima accident happening in India.[160] A meeting of India's nuclear scientists and Cabinet ministers at the Prime Minister's residence a few months after the Fukushima accident expressed satisfaction "that there was no accident in any nuclear facility in the past in the country"![161] The arrogance, cockiness, ignorance and smugness of these nuclear czars takes one's breath away.

9. KUDANKULAM AND JAITAPUR NUCLEAR PARKS

On July 13, 2011, in a television address to the nation, Japanese Prime Minister Naoto Kan, accepted what scientists had been saying for years, that no amount of safety measures can guarantee that a catastrophic nuclear accident will not occur: "Through my experience of the March 11 accident, I came to realise the risk of nuclear energy is too high. It involves technology that cannot be controlled according to our conventional concept of safety."[162]

And if a major nuclear accident occurs, it can destroy a nation. Mikhail Gorbachev in his memoirs credits Chernobyl, and not Perestroika, for the downfall of the Soviet Union. The Fukushima accident very nearly led to the evacuation of Tokyo; even today, if there is a significant earthquake and one of the fuel pools collapses in Fukushima, Japan still could be cut in half.[163]

However, India's rulers are unfazed. Without even pausing to take a breath, they are pushing ahead with their plans to set up a string of giant nuclear parks all along India's coastline—with reactors many times as big as the ones we've installed at present!

The first of these is coming up at Kudankulam, in Tamil Nadu, for which Russia is to supply six VVER-1000 nuclear reactors. Construction of the first two reactors was started in 2001, and is now nearing completion. Preparations for starting construction work at the second nuclear park, in the Jaitapur region of Ratnagiri district (Maharashtra), have reached an advanced stage. This nuclear plant is going to be even bigger than the Kudankulam plant, with six EPR reactors of 1650 MW each, to be supplied by the French nuclear corporation Areva.

The government is simply not concerned with the environmental and health impact of these giant-sized reactors. This is obvious from the way the environmental clearance has been given to these reactors. For Kudankulam 1&2, this was given without any Environmental Impact Assessment (EIA) study. For Kudankulam 3 to 6, and for Jaitapur 1&2, the EIA study was done by the National Environmental Engineering Research Institute (NEERI), a body which, by its own admission, does not have the technical competence to assess radiation related hazards of nuclear reactors.[164] The reports prepared by NEERI are shoddy, to say the least. Thus, they do not take into consideration all the aspects of environmental contamination due to radiation releases from the reactors, nor do they deal with the known design problems of the VVER and EPR reactors.[165] The mandatory public hearings for receiving comments of the people on these EIA reports were a farcical exercise. And on the basis of this flawed process, the Ministry of Environment and Forests (MoEF) gave its environmental clearance to the reactors. That all this was a mere ritual, is obvious from the fact that for the Jaitapur reactors, the MoEF actually fast forwarded its approval so that the agreement with Areva for supply of the reactors could be signed during French President Sarkozy's visit to India in December 2010. In fact, Environment Minister Jairam Ramesh admitted that there were "strategic, economic and diplomatic concerns" that influenced his decision for clearing the project.[166]

Routine Impact

At least 5.7 lakh people live within a 20-km radius around the Kudankulam plant; while according to the 2001 census, the total population staying within a 20-km distance from the Jaitapur Nuclear Park is 2.6 lakhs. The routine releases of radioactivity from these plants, and the inevitable leakage from the radioactive waste generated by them, will cause the most terrible diseases in these populations for centuries to come.

Both these areas are unique in their ecology. Kudankulam lies at the edge of the Gulf of Mannar, one of the world's richest marine biodiversity areas. Likewise, the Madban area (the site for the Jaitapur Nuclear Plant) lies in the Western Ghats, which is among the world's ten top "Biodiversity Hotspots".[167] The ecology of both the regions is so precious, that only a diabolically destructive mind can make plans to wreck it by building a nuclear plant there.

The cooling systems of these plants will be sucking in and discharging billions of litres of seawater every day. Billions of fish, fish larvae, spawn, and a tremendous volume of other marine animals will be sucked in and killed by these cooling systems, leading to depletion of fish stocks along both these coastal areas. Additionally, water discharged into the ocean by their cooling systems will be carrying a terrific amount of heat—and this will dramatically alter the marine environment. All these effects are going to lead to a sharp decline in the fish catch in these very rich fishing areas, destroying the livelihoods of tens of thousands of local fisherfolk.[168]

Severe as these effects are, they pale before the most dangerous aspects of these Nuclear Parks.

VVER-1000: A Monster Reactor

There are numerous safety issues with these reactors. For instance, in the last couple of years, in the VVER-1000 reactors at Temelin in the Czech Republic and at Kozloduy in Bulgaria, numerous control rods did not move as designed. That can be catastrophic.

These issues are so serious that in 1997, the European Bank for Reconstruction and Development cancelled all loans for VVER reactors in Eastern Europe. Dr. Alexei Yablokov, chairman of the Russian Federation National Ecological Security Council, and one of Russia's best known experts on nuclear safety, has also admitted in a scientific study that these reactors are unsafe. The IAEA and the US DOE have in fact expressed the opinion that the VVER-1000 reactors cannot meet Western safety standards, even if improvements are made in them![169] (This is not to say that Western standards are very good.)

KKNPP—Nuclear Disaster in the Making

Even more dangerous than the above safety issues, it has now come to light that substandard parts and materials have been installed in the KKNPP reactors. In February 2012, the Russian Federal Security Service arrested the procurement director of ZiO-Podolsk, a Russian government-owned company, for supplying substandard systems and components to several Russian nuclear power plants. This included use of low quality steel in the fabrication of the reactor. After much dilly-dallying, the NPCIL has now admitted that crucial materials and reactor parts of the KKNPP reactors, including safety subsystems, equipment and components have been sourced from the ZiO-Podolsk. Dr Gopalakrishnan, former chief of India's nuclear safety body, has warned that these "deficiencies and defects are dormant today", but "may cause such parts to catastrophically fail when the reactor is operated for some time."

Despite these dangerous defects, the NPCIL and DAE have allowed the KKNPP to go critical in July 2013. Yet another instance of the extreme callousness of our nuclear authorities.[170]

EPR—Serious Design Problems

Messrs. Kakodkar and company are asserting that the European Pressurised Reactor (EPR) to be constructed at Madban in the Jaitapur region is safer, cheaper, more mature and more reliable than any other reactor in the world.

However, the fact is, this reactor is of an unproven design, as it is not yet in operation anywhere in the world: the first four reactors of this design are presently in construction in China, Finland and France. As discussed earlier (Chapter 6), not only are these reactors inherently more dangerous than present day reactors, they also have worrying design problems. A committee set up by the French government has raised serious questions about the design of the reactor; the safety regulators of the US and UK have also voiced similar concerns.[171]

On Areva—the EPR Supplier

Areva, the biggest atomic operator in the world, was voted in 2008 as one of "the world's most irresponsible companies". It has resisted cleaning up the radioactive waste from its abandoned mines in France; not only that, its negligence has led to this being used to pave school playgrounds and public parking lots. There have been numerous radioactive leaks from its nuclear plants. Its reprocessing plant at La Hague on the Normandy coast dumps more than 370 million litres of radioactive liquid waste into the English Channel every year.[172]

More significantly for India, Areva is failing to implement vital safety measures and has done very shoddy work in the construction of its EPR reactor in Olkiluoto, Finland. The safety and quality standards are so poor that the Finnish nuclear safety regulator has publicly admitted that it may not be able to detect all the problems![173]

Catastrophe in the Making

From the description given above about the VVER-1000 and EPR reactors and Areva corporation, it is obvious that these plants need much more stringent supervision during construction, they pose serious safety concerns and so need more exacting management standards during operation, and they are far more risky and so need much greater commitment to safety.

Which is the organisation that has been tasked with the responsibility of supervising the construction and subsequently of operating these reactors? The notoriously inefficient and completely untrustworthy DAE, and its subsidiary, the NPCIL:

- which lie every time an accident takes place at their installations;
- which have built and operated their much smaller 220 MW reactors so carelessly that they are supposed to be the "least efficient" and the "most dangerous in the world";
- which are so lackadaisical about the safety situation at their installations that they don't even have an independent nuclear safety regulator!

To make matters worse, the government of India, bowing to global nuclear industry pressure, has passed a Nuclear Liability Law, indemnifying foreign equipment suppliers of all liabilities in case of an accident in a reactor supplied by them!!

As we have discussed in Chapter 4, nuclear reactors are inherently prone to accidents; no amount of safety devices can prevent them. If there is a major accident at Jaitapur, in the minimum, Ratnagiri district will have to be permanently evacuated and Western Maharashtra will be radioactively contaminated. If there is a major accident at Kudankulam, in the minimum, Southern Karnataka, Southern Tamil Nadu and much of Kerala, along with neighbouring Sri Lanka, will be radioactively contaminated. For 20-30 thousand years. Its consequences will cripple the entire country for many decades.

Even if there was no alternative, how can we take this risk of damaging the health of our coming generations and rendering large tracts of land uninhabitable for thousands of years, how can we take the risk of destroying our country, just for meeting our present profligate energy needs?

What is even more stupefying is that we are taking this risk, when there is an alternative safe, green and cheap way of meeting our present and future energy needs!

10. THE SUSTAINABLE ALTERNATIVE TO NUCLEAR ENERGY

PART I: THE OFFICIAL ARGUMENT

According to the Integrated Energy Policy (IEP) of the Government of India, the country needs to sustain an 8-10% economic growth rate over the next 25 years if it is to eradicate poverty and meet its human development goals. To meet this growth rate, the IEP projects that the country will need to increase its installed electricity generation capacity to 778,000 MW by 2031-32, implying an increase of close to five times from the 2010 level of 160,000 MW. This huge future demand projection is the justification for the government's massive nuclear energy expansion program.[174]

False Assumptions

There are a number of problems with this entire set of propositions. Firstly, is the claim that the country needs 8-10% growth rate to eradicate poverty. The truth is that under the liberalisation-privatisation-globalisation development model being implemented in the country, GDP growth is no longer trickling down, that is, it is not anymore leading to eradication of poverty and better living standards for the common people. Rather, the opposite is the case—for the vast masses today, GDP growth rate has actually become a measure of the devastation of their lives.[175]

Secondly, even assuming that this growth is needed, the forecasts for power generation capacity needed to meet the country's growth needs are highly inflated. A number of experts have critiqued these forecasts.[176]

Thirdly, even assuming that the installed power generation capacity in the country does increase hugely, the belief that growth in electricity generation will lead to ending of load shedding in small towns and rural areas is also false. The total installed electricity generating capacity in the country has gone up by more than a hundred times since independence (Table 10.1). Despite this phenomenal increase, more than 44% of the country's households still have no access to electricity six decades after independence. In the rural areas, about 56% of the households have still not been electrified.[177] Further, the 44% villages that have been electrified have very inadequate supply of electricity, and even this meagre electricity supply is of poor quality. The government's drive to further add lakhs of MW of additional generation capacity will also go towards meeting the ever-growing electricity demand of the urban rich. It will not ensure quality power to the rural population and will therefore not lead to their development. That would need an entirely new orientation in our energy policy. We discuss this in the second half of this chapter.

Table 10.1: Power Generation Capacity in India (MW)

(on Jan 31, 2013)[178]

Thermal				Hydro	Nuclear	Renewable	TOTAL
Coal	Gas	Diesel	Total				
121,611	18,903	1,200	141,714	39,416	4,780	25,856	211,766

Unsustainable Projections

Even in the most renewable energy friendly scenario for 2031-32 drawn up by the IEP, it expects capacity addition of 63 GW from nuclear energy, 150 GW from large hydro-power (present capacity 39 GW), and 270 GW from coal based power plants (present capacity 121 GW). These are unsustainable projections.

i) We have already discussed extensively in this booklet the disastrous implications of nuclear energy generation.

ii) The social and environmental costs of setting up coal-based thermal power plants of a total capacity of around 150 GW capacity over the next two decades are also going to be huge. Each part of the coal cycle—from mining of coal, to burning it in power plants, to disposing of coal waste—causes irreparable damage to the environment and the health of people. Probably the gravest problem caused by coal based power plants is that they are the biggest source of greenhouse gas emissions in the world: according to one estimate, they account for one-third of overall global emissions.[179]

iii) Likewise, the proposal to set up large dam-based hydro-power plants of around 110 GW by 2032 will wreak havoc on the ecosystems and communities where they are located. Their social and environmental costs are so high that even the report of the World Commission on Dams, which was sponsored by the World Bank, concluded: "given the high capital cost, long term gestation period and the environmental and social costs, hydro-power is not the preferred option for power generation compared to other options."[180]

If we don't want nuclear plants, coal plants and large hydro-power plants, then what is the solution to the energy crisis? There does exist an alternative solution, and it is safe, green, clean and cheap too!

PART II: THE SUSTAINABLE ALTERNATIVE

It is possible to find a way out of this crisis, but that would call for a totally new approach to energy planning. This will have to include the following components:

1. Demand Side Management

Increasing end-use of electricity does not necessarily mean increasing electricity generation. It can also be achieved by improving the efficiency of the electricity generation and transmission system (through measures like improving the plant load factor, reducing transmission and distribution losses, etc.), and improving the efficiency of electrical devices like television sets, motors, heaters, bulbs, etc., i.e. improving end-use efficiency.

Table 10.2: Power Sector Efficiency in India

Power sector area	Prevailing level of efficiency in India	International best practice
Generating capacity utilization (Plant load factor)	Around 77%	More than 90%, to 100%
Aggregate Technical & Commercial losses (AT&C)	Around 32%	Less than 10%
End-use efficiency in agriculture	45-50%	More than 80%
End-use efficiency in industries and commerce	50-60%	More than 80%
End-use efficiency in other areas (domestic, street lights and others)	30-60%	More than 80%

The overall efficiency of the Indian power sector is very low as compared to international standards (Table 10.2).[181] If efforts are made to bring the efficiency levels up to even near international standards, the total savings that can be achieved add up to an astounding 50 GW of electricity generating capacity! This is out of the total present generation capacity of 210 GW in the country! In other words, just by improving the efficiency of the electricity network, the electricity demand can be reduced by at least 25%!

The power sector deficit in the country is around 10%, and the peak demand shortage is 17%. This means that the entire power sector deficit in the country can be wiped out just by implementing efficiency improvement measures! In fact, there would even be a surplus!!

The cost of implementing these efficiency improvement measures will also be much lower as compared to the cost of setting up new generating capacities—saving a unit of energy costs about one-fourth the cost of producing it with a new plant.[182] (And in this, we're not including the social and environmental costs of setting up new nuclear, coal or large hydro-power plants.)

2. Curbing Luxurious and Wasteful Consumption

However, in practice, a reduction in total energy consumption simply by improving energy efficiency will not occur. That is because of an inherent logic of the capitalist economic system, known as the Jevons Paradox, wherein improving energy efficiency actually leads to an increase in energy use. The resulting increase in demand may even exceed the savings due to improved energy efficiency.

For instance, even though the United States has managed to double its energy efficiency since 1975, its energy consumption has risen dramatically. Over the last thirty-five years, energy expended per dollar of GDP in the US has been cut in half. But rather than falling, energy demand has increased, by roughly 40 percent. Moreover, demand is rising fastest in those sectors that have had the biggest efficiency gains—transport and residential energy use.[183]

Therefore, in addition to promoting energy efficiency, steps will also have to be taken to curb demand—without this, total energy consumption will not reduce. Thus, steps will have to be taken to push high-end residential consumers into reducing their total consumption. Curbs will have to be imposed on electricity consumption in offices and institutions; many are so awfully designed that they need lighting even during daytime in summers, in a tropical country like ours! A particularly bad example is shopping malls and IT companies, which not only have 24-hour lighting, but also 24-hour air conditioning, 365 days a year. To curb such luxurious consumption of electricity, it will not be enough to raise electricity rates, as the rich can afford to consume costly electricity. Restrictions will have to be imposed on such luxurious use of electricity.

Apart from curbing luxurious consumption, wasteful consumption of electricity, like unnecessary illumination of commercial buildings and lighting of roadside hoardings, will also have to be curbed.

3. Emphasising Renewable Energy

The third component of the alternate energy paradigm is massively increasing the production of electricity from renewable sources like the sun, wind, flowing water (here, we are referring to small hydro-power plants and not large hydro-power plants) and biomass—for which there is a huge potential in the country.

Advantages over Nuclear and Fossil Fuel Energy

The advantages of renewable energy sources are incomparably huge, as compared to not just nuclear energy but also energy from fossil fuels:

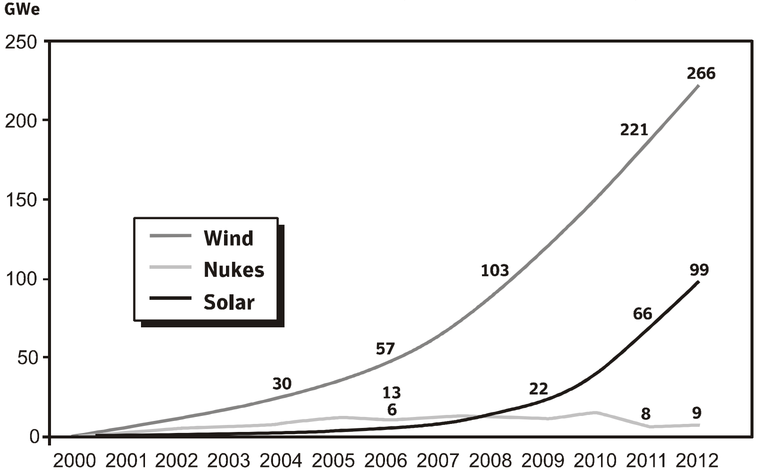
- They produce very little greenhouse gases, not only less than coal and gas but also much less than nuclear power plants (discussed in Chapter 2).
- They rely on virtually inexhaustible natural resources for their fuel.
- The costs of these technologies are rapidly coming down: since 2008, PV module prices have fallen by 80%, while prices for wind turbines, a more mature technology, have fallen 29%. In contrast, nuclear costs keep going up.[184]
- Consequently, wind energy not only beats nuclear electricity by two- or three-fold, it is also now cheaper than new coal electricity: for instance, the cost of new coal in South Africa is R O.99 whereas the cost of new wind is R 0.89 (per kilowatt hour), while the respective figures for Australia are A$143 per megawatts hour (for new coal) and A$80. And these figures are for countries with some of the best fossil fuel reserves in the world![185]
- Solar PV electricity costs have halved over the past 5 years.[186] Even without subsidies, solar PV electricity is already cheaper than nuclear electricity from new projects;[187] in fact, solar PV is expected to become cheaper than electricity from the grid in a few years, while according to some analysts, solar has already achieved grid parity in many markets around the world.[188] And these estimates do not take into account the health costs of conventional fossil fuel electricity.
- Finally, renewable energy is much more flexible. It takes only

months, often weeks, to install a PV facility or wind turbine; nuclear reactors can take anywhere from 10-13 years, and even up to 20 years in countries with no nuclear experience.[189]

Worldwide Boom in Renewables

Renewable energy has received only a fraction of government financial support as compared to nuclear energy, both in the US as well as in the European Union.[190] However, its advantages over both nuclear and coal energy are so overwhelming that despite these huge subsidies, nuclear and coal plant orders have withered over the last more than a decade, while there has been an explosive growth of renewable energy, especially wind and solar PV power, across the world. Figure 10.1 compares the net added capacity of nuclear (grid connections minus shutdowns), wind and solar since 2000. As the figure shows, while nuclear power capacity has remained largely constant over the past decade, even declining in some years, since 2000, global installed capacity of solar PV has grown at an astonishing average annual rate of 42%, and onshore wind power has grown at 27%.[191] This has resulted in 45 GW of wind and 32 GW of solar being installed in 2012, compared to a net addition of 1.2 GW of nuclear.[192]

Figure 10.1: Wind, Solar and Nuclear Grid Connections in the World 2000-12 (cumulated, in GWe)[193]



In 2010, for the first time, worldwide cumulative installed capacity of renewable energy sources [wind turbines (198 GW), small hydro-power (80 GW), biomass power (66 GW), solar PV & CSP power (41 GW), and geothermal power (11.1)] reached 396 GW, surpassing nuclear power's global installed capacity of 375 GW (prior to the Fukushima disaster).[194] In 2011, the gap further increased, with global renewable capacity increasing to 491 GW, while nuclear had declined to 370 GW.[195] Together, these renewables supplied more than 9% of total global power generating capacity (estimated at 5,360 GW by end-2011), up from 7.7% in end-2010.[196]

Renewables (excluding hydropower) made up more than 37% of total net additions to electric generating capacity from all sources in 2012. Global renewable power capacity (excluding hydropower) grew 21.5% over the previous year to exceed 480 GW by the end of 2012.[197] Including small hydropower, this would be around 570 GW.[198]

China – Europe – USA

Wind power in China has had a phenominal growth rate over the past decade, going from an installed capacity of less than 6 GW in 2007 to over 75 GW in 2012. Furthermore, it is not only in installed capacity that wind has achieved record increases; its corresponding electricity production is also impressive. In fact, in 2012, China achieved a historic crossover with wind overtaking nuclear power in the total amount of electricity produced. Even more remarkably, increase in wind electricity generation (26 TWh) in 2012 was more than double the growth in thermal power generation (12 TWh). Meanwhile, solar PV installed capacity in China doubled in just one year to reach 7 GW by end-2012.[199]

In the USA, of the 1,546 MWe newly connected to the US grid in the first quarter of 2013, 82 percent were renewables (more than half of this was solar), the rest natural gas plants—no coal, no nuclear.[200]

In the European Union, wind and solar PV accounted for 68% of new power capacity added in 2011, and 64% in 2012![201] Over the period 2000-12, while more than 166 GW of wind and solar were added to the EU power grid, nuclear installed capacity declined by 14.7 GW, and coal declined by 12.7 GW. As of end-2012, total wind and solar capacity in the EU (175 GW) was 18% of total installed power capacity in the region, and had exceeded total installed nuclear capacity (120 GW) by a wide margin.[202] The share of wind and solar in total electricity generated is also rising in parallel. In 2012, their share of total electricity consumption was 8.9%, up from 7.7% in 2011.[203]

In some European countries and regions, the share of renewables in the total power mix has grown so rapidly that it now provides more electricity than nuclear power. Thus, in Germany, all renewable sources (including small hydro-power) accounted for 35% of all installed power capacity and 17.9% of electricity consumption, generating more electricity than nuclear, hard coal, or gas-fired power plants (in 2011).[204] Four German states in fact met more than 46% of their electricity needs with wind![205] Denmark too has a high penetration of wind power. It had an installed wind power capacity of 4162 MW (in 2012) from which it met 27% of its total electricity consumption.[206]

According to a report by the European Wind Energy Association (EWEA), if renewable energy (including hydro-power) in the EU continues to grow at the same rate as it did from 2005 to 2010, it would meet more than one-third (36.4%) of EU's electricity consumption by 2020, and over half (51.6%) by 2030![207] Obviously, a major chunk of this would be from wind and solar PV energy.

Global Potential of Renewable Energy

Greenpeace in its *Greenpeace Global Energy [R]evolution* scenario shows that renewable energy sources could supply 38% of global power demand by 2020 and 95% by 2050.[208]

The Scientific American in 2009 reported a plan to power 100% of the planet by 2050 with only solar, wind, and water renewables.[209]

Note that all these proposals do not take into consideration the huge potential of conserving energy by imposing curbs on luxurious and wasteful consumption (discussed in the previous section). If that is done, it should be possible to achieve the above targets more easily and quickly.

India: Renewable Energy Potential

From India's present viewpoint, the most important renewable energy sources are:

- **Solar energy:** A variety of devices are in use to harness the energy from the sun falling on Earth's surface. The most common are solar heat collectors (like solar water heaters), concentrating solar power or CSP systems (these use mirrors and lenses to concentrate the rays of the sun and produce very high temperature heat, which is then converted to electricity), and photovoltaic (PV) panels, which convert sun energy directly to electricity.
- **Wind energy:** One of the cleanest and most sustainable ways of generating electricity.
- **Small hydro-power:** This does not have any of the disadvantages of large hydro-power plants; on the contrary, this is one of the most environmental friendly and cheap ways of providing electricity to remote villages, especially in hilly areas, where providing grid electricity is very uneconomical.
- **Biomass and biogas:** A large number of biomass materials have been used successfully for power generation, including bagasse, rice husk, straw, coconut shells, saw dust, etc. Plant and animal waste can also be used to produce biogas, which is an excellent way of meeting the energy needs of India's far-flung villages.

In India, grid-connected renewable energy deployment is barely a decade old, as compared to our nuclear energy program which began more than five decades ago. Furthermore, the budget of the DAE has always exceeded the budget of the Ministry of New and Renewable Energy by many times: for 2013-14, the allocations are Rs.98 billion and Rs.15 billion respectively.[210] Despite this late start and low government support, renewable energy capacity exceeded 24 GW by end-2012, more than five times the total capacity of our nuclear reactors (4.78 GW).[211] The corresponding electricity production was also much more: modern renewable energy sources (wind, solar, biomass) generated 51.2 TWh in 2011-12, while nuclear electricity generation was 32.3 TWh.[212] From this, it is obvious that if the government takes serious steps to promote non-grid decentralised energy like small hydro-power, windmills and biogas, we can definitely meet a very large portion of our energy and electricity needs from renewable energy sources in a very short period of time. Let us take a quick glance at the potential of solar and wind energy in India.

Solar Energy in India

Of all the renewable energy sources, solar energy has the highest potential. In most parts of India, clear sunny weather is experienced 300 to 320 days a year. The potential for solar energy has been estimated at around 30-50 MW per square kilometer of open, shadow free area. India's Thar desert, which is spread over 200,000 sq km, is one of the sunniest regions in the world; a piece of square land of 50 x 50 kilometers can generate more than 100 GW of solar electricity—more than double the total installed capacity of all the giant nuclear power plants being planned in the country.[213]

Solar prices are falling steeply in India too. They are already much cheaper than the price at which Jaitapur NPP is expected to supply electricity. During bidding held for the government's “Jawaharlal Nehru National Solar Mission”, in 2010, private solar power producers offered to set up solar power plants at a tariff of Rs. 10.90 a unit;

during the second round of bids in December 2011, prices had dropped to an astonishing Rs. 7.49 a unit. This means that solar prices would fall to the level of conventional electricity prices in just 3-4 years at the most.[214]

Wind Energy in India

The present installed wind power capacity in the country, of 17,353 MW as of end-March 2012, is already more than three times the installed nuclear power capacity.[215]

The government recently revised the official estimate of onshore wind potential in India to 102 GW. This is huge, more than one-half of India's total installed power capacity (180 GW). Even this is an underestimate, as it ignores recent technological advancements in wind turbines. More updated estimates, including one by US-based Indian researchers and published by Lawrence Berkeley National Laboratory, range from a staggering 750 GW to over 2,000 GW.[216]

4. Adopting Decentralised Energy Systems

The per unit cost of supplying electricity to India's far-flung villages from a centralised electricity generation system is very high. That is because while on the one hand it requires long transmission lines, implying transmission losses are also high, on the other hand, the total demand in the villages is low.

A very simple, efficient and cost-effective solution to this problem is making use of decentralised power generation systems (meaning electricity/energy generated at or near the point of use), based on renewable sources of energy. These can be a mix of wind (especially wind mills in preference to wind turbines), micro hydel, solar and biomass, depending on the location and availability of local resources. Due to low transmission losses, even if the cost of electricity from this decentralised system is more than the generation cost of conventional grid electricity, for the rural consumer decentralised electricity would be cheaper. It has other advantages too: since it is based on renewable energy sources, it does not have the environmental, social and health costs associated with large conventional power plants; furthermore, the technology being simple, local people can control and manage it, so they can get electricity when they want instead of having to wait for hours for grid electricity.

PART III: POTENTIAL OF THE ALTERNATE ENERGY PARADIGM

Given the huge scope for improving energy efficiency in the country, if the government indeed implements energy efficiency measures, imposes restrictions on luxurious and wasteful consumption of electricity, and promotes the use of decentralised energy systems to meet the energy needs of India's far-flung villages, then the additional grid electricity generation required for meeting our future growth needs is substantially reduced; in fact for a few years we may not require any new generation capacity, as there may be a surplus.

In that case, a major portion and possibly all our future electricity needs can be easily met from renewable energy sources, whose potential in the country is huge. To summarise the potential of grid connected renewable electricity generation in the country, as estimated by the government and other reliable sources:[217]

- 102 GW of wind energy;
- 15 GW of small hydro-power;
- 21 GW of biomass energy;
- At least 50-100 GW of solar energy; according to other estimates, actual potential can be as much as 400 GW.

Clearly then, it is possible to solve the energy crisis in the country with an Alternate Energy Paradigm. There is no need to set up the giant sized nuclear power plants being planned by the government; in fact the operating nuclear reactors can also gradually be phased out. There is also be no need to set up large centralised coal- and hydro-based power plants on the scale visualised by the government.

11. UNITE, TO FIGHT THIS MADNESS!

When such a cheap, clean, green and safe alternative energy paradigm is available, why are India's rulers indulging in this mindless spree of constructing costly giant foreign-supplied nuclear parks and indigenous nuclear plants? And not just nuclear power plants, but also ultra mega coal power plants and giant hydroelectric projects!

It's obviously not for meeting the energy crisis of the country; as we have seen above, there are safer, environment-friendly and cheaper options to mitigate the energy crisis. The real reason is: to provide US, French, Russian and other foreign corporations, and apart from them, the big Indian business houses, a fantastic investment opportunity, so that they can make huge profits. This was in fact the real 'deal' behind the Indo-US Nuclear Deal: the US signed the Nuclear Deal in return for India agreeing to buy $150 billion worth of US nuclear reactors, equipment and materials. Similarly, the 45 member countries of the Nuclear Suppliers Group (NSG) gave their approval to ending the embargo on nuclear trade with India on the promise of lucrative business opportunities. In a candid article in a leading Marathi daily on January 5, 2011, the former DAE head, Anil Kakodkar, explained why India is offering lucrative reactor deals to foreign suppliers: "We also have to keep in mind the commercial interests of foreign countries and … companies …America, Russia and France were … made mediators in [promoting the US-India nuclear agreement]… for nurturing their business interests, we made deals with them …".[218] India's big business houses were also keen on the deal, because they are expecting to get subcontracts from these foreign corporations worth thousands of crores of rupees.

Nuclear Madness: Part of Globalisation

Why is the Indian government mortgaging the interests of the people of the country to benefit big foreign and Indian corporations? It has actually been happening for the last two decades, since 1991 to be more precise, when under World Bank-IMF pressure, the government of India decided to restructure the Indian economy. The Indian economy was trapped in an external debt crisis. Taking advantage of this, India's foreign creditors, that is, the USA and other developed countries—also known as the imperialist countries—through the World Bank and the IMF (which are controlled by them), arm-twisted the Indian government into agreeing to this restructuring. The basic elements of this so-called 'Structural Adjustment Program' were:

- Opening up the economy to unrestricted inflows of foreign capital and imports and goods;
- Privatisation of the public sector, including welfare services;
- Removal of all controls placed on profiteering, even in essential services like drinking water, food, education and health.

This restructuring of the economy at the behest of India's foreign creditors has been given the high-sounding name of *globalisation*. Since then, governments at the Centre and the states have continued to change, but globalisation of the economy has continued unabated.

The essence of globalisation is that the Indian government is now running the economy solely for maximising the profits of giant foreign corporations and India's big business houses. These corporations are on a no-holds barred looting spree. They are plundering mountains, rivers and forests for their immense natural wealth. They are seizing control of public sector corporations, including public sector banks and insurance companies, created through the sweat and toil of the common people, at throwaway prices. Privatisation is also enabling them to enter essential services—including education, health, electricity, transport, even drinking water—and transform these into instruments of naked profiteering. Because these are essential services, the profits are huge.

The government of India has given up all concern for the future of the country, for conserving the environment for our future generations, for the livelihoods of the people of the country, for making available essentials like food, water, health and education to the people at affordable rates so that they can live like human beings and develop their abilities to the fullest extent. It is now only concerned with how to provide new and profitable investment opportunities for foreign multinational corporations and their Indian collaborators. *The invitation to foreign nuclear power corporations to set up giant nuclear parks in the country is just another of these policies, though it is undoubtedly amongst the most disastrous with consequences that will plague us for thousands of years.*

Unite — to Save India from Inevitable Destruction

Even for a technologically advanced and rich country like Japan, it is going to take years before it is able to bring the Fukushima disaster under control.

The public health care system in India is virtually non-existent. Our relief and rehabilitation systems are so abysmally inefficient and corrupt that even 26 years after the Bhopal gas tragedy, we have not been able to provide succour to the victims. Forget medical and economic rehabilitation, we have not been able to provide them even safe drinking water (the groundwater is poisoned)! A nuclear accident will be hundreds of times bigger than the Bhopal gas tragedy; if it occurs in a poor and technologically backward country like India, it will have apocalyptical consequences.

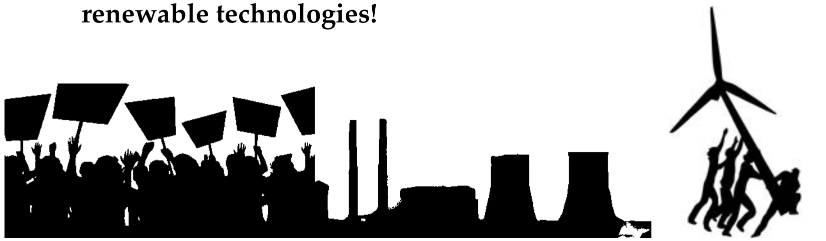
People are rising up in revolt at each and every place where the government is proposing to set up a new uranium mining project or a nuclear power plant. Powerful struggles by people of West Khasi Hills (Meghalaya) and Nalgonda (Andhra Pradesh) have forced the respective state governments to put on hold proposals to start uranium mining in these areas. Local people everywhere are waging heroic struggles against DAE/NPCIL plans to build nuclear power plants in Jaitapur (Maharashtra), Gorakhpur (Haryana), Kovvada

(Andhra Pradesh), and Mithivirdi (Gujarat). Tens of thousands of local people—with the support of people from all over Bengal—had been waging a resolute struggle against the proposal to build a giant nuclear park at Haripur. Finally, in August 2011, the West Bengal government, bowing to their pressure, decided to scrap the Haripur Nuclear Park.

Amongst the most heroic of all these struggles is the struggle of the people of Idinthikarai and other villages near the Kudankulam Nuclear Plant. Tens of thousands of people have been participating in protest marches, boat rallies, relay hunger strikes, in what is easily one of the most powerful non-violent people's movements in India in recent times. The government has virtually declared a war on these peaceful and democratic protestors. It has vandalised their properties, raided their homes, filed false cases against more than 200,000 people, including the charges of sedition and waging war against the state against more than 10,000 people. It has launched a vicious propaganda campaign to malign the movement, including labelling the protestors as being foreign agents, accusing them of being instigated by external powers, of being foreign funded, and what not. Yet, the people have not been cowed down; they continue their fantastic struggle. In reality, it is the rulers of the country who are the real traitors, who are putting the entire future of our country at risk for the profits of Russian / French / American corporations.

If the government of India continues with its diabolical nuclear program, sooner or later, a major nuclear accident is bound to take place in one of our nuclear reactors. It will destroy India. We cannot allow it to happen. We must join the countrywide anti-nuclear struggle and demand of the government of India:

1) **Scrap the Jaitapur and Kudankulam nuclear power projects! Scrap all new nuclear power plants!!**
2) **Shut down Tarapur-1 & 2 reactors immediately.**
3) **Phase out all other operating nuclear power plants as early as possible.**
4) **Invest massively in energy saving and development of renewable technologies!**



ABOUT US: LOKAYAT

Who has become free?
From whose forehead
has slavery's stain been removed?
My heart still pains of oppression…
Mother India's face is still sad…
Who has become free?

Ali Sardar Jafri wrote these lines a few years after independence. But these lines accurately describe the current situation in our country too! Who has become free, is indeed the real question. This country now belongs to the rich; development is now only for them. Giant-sized malls, ultra-modern cars, express highways, imported luxury goods, five-star hospitals… and, on the other hand, the few crumbs given to the poor after independence are also being snatched away.

In the deceptive name of *Globalisation*, giant Multinational Corporations (MNCs) are being invited into the country—the country is now being run solely for the profit maximisation of big foreign and Indian corporations. In connivance with the politicians-bureaucracy-police-courts, they have launched a ferocious assault to dispossess the poor of their lands, forests, water and resources—in order to set up SEZs, huge infrastructural projects, golf courses, residential complexes for the rich, etc. In the name of *Privatisation*, public sector corporations, built out of the savings and by the sweat and toil of the common people, are being handed over at throwaway prices to these scoundrels. Indian agriculture, on which 60% of the Indian people still depend for their livelihoods, is being deliberately strangulated—so that it can be taken over by giant agribusiness corporations. The consequence: nearly 2 lakh farmers have committed suicides in the past fifteen years. There are simply no decent jobs for the youth: big corporations are retrenching tens of thousands of workers, while small businesses are downing their shutters by the millions. Probably nearly half the population is unemployed or underemployed. Even welfare services like education, health, electricity, gas, bus transport, public distribution system, even drinking water supplies, are being taken over by these corporations and transformed into instruments for naked profiteering, with the result that their costs are going through the roof. Today, there is no need for the imperialists to rule us by the force of arms. Our black rulers are themselves handing over control of our wealth, resources, economy to them for their unbridled plunder.

The imperialists are far-sighted. They are not satisfied with just controlling the economy. They also want to control what we eat, drink, see, think, read. And so along with MNC capital, imperialist culture is also flowing in.

The common people have not been silent spectators to this sordid drama being enacted by the MNCs and their Indian collaborators. Like flowers springing up in every nook and corner with the onset of spring, people are coming together all over the country, getting organised, forming groups, and raising their voices in protest. Though these struggles are presently small, scattered, without resources, the future lies in these magnificent struggles. As more and more people join them, they will strengthen, join hands, and become a powerful force which will transform society.

We must stop being skeptics. We must dare to dream of a better future. We must dare to believe that it is possible to change the world. Yes, *Another World is Possible*! A world which promotes cooperation and selflessness, where production is oriented not for the profit maximization of a few but for fulfilling the basic needs of all human beings—healthy food, best possible health care, invigorating education, decent shelter, clean pollution-free environment. But to make it a reality, we must start our own small struggles. These will ultimately unite, like the small rivulets hurtling down the Himalayas to ultimately form the mighty Ganges. And so, we have started this forum, **Lokayat**.

The aim of Lokayat is to bring together ordinary people who wish to take some initiative, and to take up various activities with their cooperation. Some of the activities that we have initiated so far are:

- We organise public awareness campaigns on various issues of deep concern to common people, such as: privatisation of essential services like education-health-electricity, rise in petrol and diesel prices, decaying public transport system, harmful effects of genetically modified foods, etc. We are also active in many national campaigns like 'Boycott Coke-Pepsi Campaign', 'No More Bhopals Campaign', 'Campaign for Judicial Accountability and Reforms', 'Campaign against FDI in retail', 'Campaign in Defence of the Right to Dissent', etc. We use various forms such as street campaigns, poster exhibitions and street plays in these campaigns; likewise we also organise protest programs like rallies, dharnas, etc. on these issues.
- We organise film shows, seminars and talks on issues like displacement and destruction of livelihoods of common people in the name of development, US invasion of Iraq, targeting of minorities in the name of fighting terrorism, gender inequality, the caste question, global warming, etc.
- We publish booklets-pamphlets that discuss and analyse current questions—in order to solve a problem, we must first thoroughly understand it.

One of the important issues on which we have been organising public awareness campaigns for the past few years is the deathly effects of nuclear energy. We have actively campaigned in the Jaitapur-Madban region against the proposed nuclear plant there. We have actively participated in National Campaigns in support of the heroic struggle of the people of Idinthikarai and other villages against the Koodankulam Nuclear Plant. We have organized numerous campaigns and rallies in Pune in support of the nationwide anti-nuclear struggle. For this purpose, we have also brought out numerous pamphlets in Marathi and English. We have also brought out a comprehensive book in English to reply to the falsehoods being propagated by 'intellectuals' like Kalam and Kakodkar. That book has been published by Aakar Books, Delhi. This is a shorter, edited version of that book, for those who would like to read a summary of our arguments. The first edition went out of print in jut a few months. This is an updated and revised second edition. We hope this booklet will inspire you to support and join the people of Madban, Nate, Kudankulam, Gorakhpur, Mithivirdi and elsewhere in their heroic struggles against nuclear energy.

Dear friends, if you would like to know more about us, you may contact us at any of the addresses given below.

Lokayat

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(We meet every Sunday from 4 to 7 pm at this address.)

प्रदर्शन, गाणी अशा कला प्रकारांचा उपयोग करतो, तसेच सेमिनार, व्याख्यान, धरणे, मोर्चे, जाहीर सभाही आयोजित करतो.

- समाजातील विविध समस्या, विशेषत: विकासाच्या नावाखाली उद्धवस्त होत असलेले जगजीवन, जात जमातवाद, चंगळवाद, अमेरिकेचा साम्राज्यवाद, जागतिक तापमान वृद्धी, इ. अनेक विषयांवर माहितीपट-चित्रपट दाखवले जातात, त्यांवर चर्चा घडवली जाते. त्यातून प्रश्न समजून घेण्यास मदत होते.
- समाजातील निरनिराळ्या समस्यांबाबत कला आणि सांस्कृतिक माध्यमांमधून जनजागृतीचा प्रयत्न करतो.
- अभिव्यक्ती या महिल्यांच्या गटाद्वारे महिलांचे हक्क प्रस्थापित होण्यासाठी आणि महिलांच्या प्रश्नावर सामाजिक जागृती निर्माण करण्यासाठी कॉलेजेसमध्ये व वस्तीपातळीवर काम करतो.
- या सर्व प्रश्नांवर काम करताना आवश्यक विषयांवर आम्ही पत्रके व पुस्तकेही प्रकाशित करतो.

मित्रांनो आम्ही तुमच्यासारखेच सामान्य लोक आहोत. तुमच्यापैकी अनेकांना आम्ही परिचित नाही. तरीही आम्ही व्यक्त केलेल्या विचाराशी आपण सहमत व्हाल असा आम्हाला विश्वास वाटतो. पण नुसतेच सहमत नाही, तर आमच्या विविध उपक्रमांमध्ये आपला सहभागही आवश्यक आहे. त्यासाठी खाली दिलेल्या पत्त्यांवर तुम्ही आम्हाला नक्की संपर्क करू शकता.

संपर्क पत्ता

लोकायत, सिंडीकेट बॅंकेसमोर, लॉ कॉलेज रोड, नळस्टॉपजवळ, पुणे-४
(दर रविवारी सायं. ४ ते ७ या वेळेत मिटींग होते.)

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