NUCLEAR ENERGY

Technology From Hell

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Introduction

Part I: Government Plans for Nuclear Energy

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 programme. It expects to have 20,000 MW nuclear power capacity on line by 2020[i] and 63,000 MW by 2032[ii]. The Department of Atomic Energy (DAE) projected that India would have an astounding 275 GW of nuclear power capacity by 2050, which was expected to be 20 percent of India's total projected electricity generation capacity by then.[iii] 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.[iv]

This would be a quantum leap from the present scenario. As of March 31, 2010, the total installed power generation capacity in the country was 159.4 GW, of which the contribution of nuclear power – more than sixty years after the atomic energy program was established and forty years after the first nuclear reactor started feeding electricity to the grid in the country – was just 4.56 GW,[v] or 2.86% of the total. Thus, the projected capacity in 2050 would represent an increase by a factor of over a hundred. According to the Anil Kakodkar, Chairman of India's Atomic Energy Commission (AEC), nuclear power would be 35% of the country's total electricity generation capacity in 2050.[vi] A year later, Kakodkar hiked his estimate and predicted that India's nuclear energy capacity could reach 600-700 GW and account for 40 per cent of the estimated total power generation by 2050.

New Projects

The government has also taken rapid steps to implement this plan. Following the Indo-US Nuclear Deal, it has given 'in principle' approval to setting up a string of giant size nuclear parks all along India's coastline, each having 6-8 reactors of between 1000 to 1650 MW – Chhayamithi Virdi in Gujarat, Jaitapur (in Maharashtra, Kudankulam in Tamil Nadu, Kovvada in Andhra Pradesh and Haripur in West Bengal. It is also proposing to set up 4 indigenous reactors of 700 MW each at Gorakhpur in Haryana, and another 2 similar reactors at Bargi in Madhya Pradesh. To meet the fuel needs of these plants, it is proposing to set up several new uranium mining projects: at Tummalapalle (Kadapa district) and Lambapur-Peddagattu (Nalgonda district) in Andhra Pradesh, Gogi (near Gulbarga) in Karnataka, and Domiasiat and Wakhyn in Meghalaya.

Government Claims

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. We give a few quotes from some of his recent statements below:

- At the inauguration of the fuel reprocessing plant at the Bhabha Atomic Research Centre's in Tarapur, January 8, 2011: He praised the plant at Tarapur as "an outstanding example of **clean, economic and safe energy** that our nation requires".[vii]

- At the Nuclear Security Summit, held in Washington, DC on 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."[viii]

- Statement to the Indian Parliament on July 29, 2005 after returning from a visit to the United States where the first steps were taken towards signing what has come to be known as the 'Indo-US Nuclear Deal': "Energy is a crucial input to propel our economic growth... it is clear that nuclear power has to play an increasing role in our electricity generation plans" ... For this purpose, it would be very useful if we can access nuclear fuel as well as nuclear reactors from the international market... There is also considerable concern with regard to global climate change arising out of CO_2 emissions. Thus, we need to pursue **clean energy** technologies. Nuclear power is very important in this context as well." Since "the US understood our position in regard to our securing adequate and **affordable energy** supplies, from all sources" and because President Bush was willing to "work towards promoting nuclear energy as a means for India to achieve energy security", this was the reason why India has decided to enter into a nuclear cooperation agreement with the USA. (emphasis ours)[ix]

- Speech after dedicating Tarapur 3&4 atomic reactors to the nation on August 31, 2007: A "nuclear renaissance" was taking place in the world "and we cannot afford to miss the bus or lag behind these global developments." Elaborating on the reasons for the growing importance of nuclear energy, he stated: "Our long-term economic growth is critically dependent on our ability to meet our energy requirements of the future... (Since) our proven reserves of coal, oil, gas and hydropower 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". (emphasis ours)[x]

On January 18, 2011, at an 'open house' on the Jaitapur Nuclear Power Project organised by the Chief Minister of Maharashtra in coordination with eminent nuclear scientists and the Nuclear Power Corporation of India Ltd (NPCIL) to clear misconceptions about nuclear power, an entire galaxy of scientists and doctors emphasised that nuclear power was safe, clean and green. They countered the claims of the opponents of nuclear energy that radiation leakage from plants causes horrendous impact on human health, that cancer and birth deformities in children, that mankind has yet to find solution to the problem of what to do with the terribly radioactive waste generated by nuclear plants, and that nuclear plants are prone to catastrophic accidents:

- S K Jain, NPCIL chairman and managing director, pointed out that India already runs 20 nuclear plants without any blemish on its safety record.[xi]
- The experts dismissed claims that nuclear plants harm the environment. Dr. S.P. Dharne from the NPCIL said that nuclear power was clean and green energy, and that it could reduce the impact of global warming since it did not generate carbon dioxide.[xii] Dr Srikumar Banerjee, current Chairman of the AEC, asserted that around the 20 nuclear plants in India, the flora and fauna had actually increased.[xiii]
- Dr. Anil Kakodkar, former Chairman of the AEC, allayed the fears regarding safe storage of nuclear plant waste. He stated that the atomic waste generated by the Jaitapur nuclear plant would not cause any problems, as "there is no question of the waste being thrown in the open areas". He stated that the nuclear waste would be "taken to reprocessing plant after the use", and therefore "(t)here is no hazard of the waste to the bio-diversity of Konkan region."[xiv]
- On the fears about radiation leakages from nuclear power plants, the experts stated that the belief that nuclear plants cause impotency and cancer and deformities among children is due to superstitions because of illiteracy.[xv] Dr Rajendra Badwe, head of the Tata Memorial Cancer Hospital, stated that radiation caused only 0.5 per cent of cancer, affecting only the skin. He dismissed the study by the anti-nuclear activist, Dr Surendra Gadekar, on the incidence of abnormalities in children around the Rawatbhata Atomic Power Station in Rajasthan, saying that the allegations were without any foundation since these had not been peer-reviewed and published in reputed scientific journals. On the contrary, he claimed that radiation was used to cure cancers.[xvi] Nuclear scientists Sharad Kale and Shrikumar Apte said there would not be any effect of radiation on agricultural products and marine life in the area.[xvii]

The propaganda is so intense, that most people in the country, at least those who read the newspapers and watch television, believe that nuclear energy is an environmentally friendly solution to the country's power shortages.

Part II: People's Resistance

However, at each and every place where the government is proposing to set up a uranium mining project or a nuclear power plant, the people have risen in revolt. Protests have stalled the uranium mining project in **Nalgonda** district in Andhra Pradesh for the last five years,[xviii] while a powerful movement led by the Khasi Students Union together with various tribal organisations has held up the mining project in the state of **Meghalaya** for over one and a half decades now.[xix] Likewise, people everywhere are strongly protesting proposals to set up nuclear plants, be it Haripur (West Bengal), Gorakhpur (Haryana), Mithivirdi (Gujarat) or Jaitapur-Madban (Maharashtra).

Kudankulam: The people of Tirunelveli, Kanyakumari and Tuticorin districts have fought long and hard against the two Russian VVER-1000 reactors being built in Kudankulam village in Tirunelveli district of Tamil Nadu. The movement began immediately after the Indian Prime Minister Deve Gowda and the Russian President Boris Yeltsin signed an agreement in 1997 for building the two reactors. The struggle has further intensified after the government signed another agreement with Russia to build four additional reactors there. They have united under the banner of People's Movement Against Nuclear Energy (PMANE), an umbrella organisation in which various organisations of the people have joined together to fight the nuclear plant, and have organised dozens of demonstrations, meetings in practically every village in the area, cycle yatras, seminars against the project.

Construction on the first two reactors was started in 2001, without any environmental clearance, under the excuse that the proposal for these reactors had been first mooted in 1988 when the law was not in force (the law providing for environmental clearance for large projects was passed in 1994). For the additional four reactors proposed, the public hearing on people's objections to the Environmental Impact Assessment report (necessary before a plant is granted environmental clearance) was held on June 2, 2007. Thousands gathered to file their opposition to the plant, despite an intimidating bandobast with 1,200 policemen, nasty riot gear and armoured personnel carriers. Yet, none of this prevented the people from expressing their views. But after just a few people had spoken and voiced their objections as to how even the stipulated official procedure for such a hearing had not been properly followed, the collector brought the public hearing to an abrupt end after two hours, and declared that the people had given their assent to the plant![xx]

Haripur: More than 20,000 people, organised under the banner of “Haripur Paramanu Bidyut Prakalpa Pratirodh Andolan” prevented a team of experts from Nuclear Power Corporation of India Ltd from visiting the area on November 17, 2006, even though they were accompanied by battalions of armed police. The attempt was repeated on the next day. Thousands of men, women and children from villages around the proposed site blockaded all entry points and vowed to embrace instant death rather than rotting through generations as evicted refugees exposed to nuclear menace.

The stakes for building nuclear plants are very high, and it makes for strange bedfellows. While the CPI(M) was strongly against the Indo-US Nuclear Deal, which was crucial for the construction of the Haripur plant to go ahead, and has also been protesting the Jaitapur nuclear plant probably because it is in the opposition in that state, the West Bengal Chief Minister has repeatedly expressed his support for building the plant, and the local goons of CPI(M) have tried to portray the opposition as either Maoists or as being anti-development environmentalists. But repression has not broken the resolve of the people, and they have not allowed a single official of India's Atomic Energy establishment to visit the area for the last 5 years.[xxi]

Mithivirdi: A powerful movement of people of Mithivirdi, Jaspara and nearly 40 surrounding villages in district Bhavnagar of Gujarat has being going on for the last three years against government plans to construct a 6-8000 MW nuclear power plant there. 7000 people attended a public meeting against the project on April 25, 2010. In June 2010, NPCIL officials together with truck loads of police tried to visit the area to take soil samples for testing, but thousands of people surrounded them and firmly told them to go back. After trying to use force, the officials and police finally retreated.[xxii]

Gorakhpur: NPCIL is proposing to set up four indigenous reactors in village Gorakhpur, in Fatehabad district of Haryana. Despite efforts by NPCIL scientists to convince the local people abouts the benefits of nuclear power, the villagers of Gorakhpur and nearby villages have launched a militant protest against the project. They have been sitting on a Dharna outside the office of the District Collector for the last more than three months, in which one farmer was martyred due to the the biting cold wave and many farmers had to be hospitalised. But this has not broken the resolve of the people. Support groups for the struggle have been formed in a number of nearby cities, including Chandigarh.

Jaitapur-Madban: The most recent of these struggles has of course been the heroic struggle of the people of Madban, Nate and nearby villages. The government has forcibly acquired land from 2275 families, after more than 95% of them refused to accept the hiked compensation offered by the government of Rs. 10 lakh an acre and the promise of a job. The few people who have accepted the cheques are mostly absentee landlords. The issue for the people is not displacement. Which is why not just the affected people, but people from dozens of nearby villages too, are waging a fantastic struggle despite intense police repression. Farmers, mango growers, rickshaw drivers, transporters, fisherfolk, shopkeepers, everyone has joined the movement. They are refusing to believe government assurances, given by some of the top official scientists of the country, and intellectuals and politicians of various parties, that nuclear energy is safe, clean and green. They firmly believe that the plant will destroy not just their livelihoods, but will also affect the very sustainability of life in the entire Konkan region for centuries. When the government issued a directive to school teachers to brainwash students into believing that nuclear energy is green, the children boycotted the schools for a few days!

The government has unleashed savage repression on the people. It has promulgated prohibitory orders prohibiting people from holding meetings and demonstrations under Section 144 of the CrPC and Section 37 of the Bombay Police Act. It has resorted to lathi-charges, beatings, indiscriminate arrests, registering of false cases against hundreds of men, women and even children – including the atrocious charge of 'attempt to murder' on many of them. Thousands of people have courted arrest, and many have spent several nights in jail on trumped up charges. Leading activists of the area have been issued externment notices from Ratnagiri district. Eminent citizens of the region who have extended support to the struggle, including former Supreme Court Judge P. B. Sawant, retired Chief of Naval Staff Admiral Ramdas and noted economist Dr. Sulabha Brahme, have been prevented from entering the district! The government is using every trick in the book to divide the people and break their will, by trying to split them along communal lines, labeling activists as Maoists and 'outsiders' with an ideological agenda, setting up police camps in the area to intimidate the people, issuing threats, and so on.

However, the people are standing firm and have refused to be cowed down! They are united in their resolve that come what may, they will fight, till the plant is cancelled!!

Part III: About this Book

We, on behalf of Lokayat, our activist group in Pune, have been campaigning against the government plans to promote nuclear energy for the last three years. We have actively campaigned in Jaitapur-Madban region against the proposed nuclear plant there, and have also campaigned intensely in Pune in support of the struggle of the people of that area. We have also participated in efforts to form a united platform of all anti-nuclear energy struggles taking place all over the country. During our numerous campaigns, we realised that most people, especially the educated people, strongly believed in official propaganda that nuclear energy was safe, green and clean. So we decided to bring out a booklet on this issue to explain the truth to people, and explain the reasons for the intense protests by people against government proposals to build a string of nuclear power plants across the country. We started it in October 2009. On the one hand, as we got more and more very relevant information on the issue and felt the need to include much of it in the booklet, the booklet expanded into a book. However, due to severe time constraints due to the many activities of Lokayat, it has taken us more than a year to finally bring it to completion.

Outline of this book

In this book, we first take a brief look at the history of the global nuclear energy scenario in Chapter 1, as to how after much initial promise, it entered into a long period of stagnation, and then why, over the last decade, everyone, including the Indian Prime Minister, is claiming that a nuclear "renaissance" is underway in the world.

We next take a look at the science of nuclear energy and the various elements of the Nuclear Fuel Cycle in Chapter 2. We then examine the most important claims made about the benefits of nuclear energy, that it is safe (in Chapter 3), it is cheap (in Chapter 4), and it is green and is the answer to global warming (in Chapter 5). In the light of this analysis, we take a close look at the reality of the claims about a "global nuclear renaissance" in Chapter 6, by examining the present scenario and the likely future prospects of nuclear energy in North America and Western Europe.

We then move on to examining the nuclear energy scenario in India. We first give a brief history of India's nuclear energy programme in Chapter 7, and also outline the recent steps taken by the government of India towards massively increasing nuclear electricity generation capacity in the country after the signing of the Indo-US Nuclear Deal. In Chapter 8, we take a look at the present cost of nuclear electricity in India and the likely cost of electricity from the new reactors that are being proposed to be set up in the country, especially the EPR reactors proposed to be installed in Jaitapur. Finally, in Chapter 9, we examine in considerable detail the safety of India's nuclear energy program in its entirety: from uranium mining to India's present reactors, India's much touted fast breeder reactor program, and also the safety issues associated with the latest imported reactors proposed to be constructed in the country – the Russian VVER-1000 reactor and Areva's EPR. We examine the claim made by India's nuclear establishment that India has amongst the best safety records in the world, in the light of the known facts about the existing safety situation at India's nuclear installations, including the accidents that have taken place in the past. On the basis of this analysis of the past performance of India's nuclear establishment, we examine the possible implications of the huge push being made by the government of India towards setting up giant nuclear parks with imported reactors.

In Chapter 10, we take a look at alternate, genuinely sustainable, solutions to India's energy crisis, in the background of similar attempts being made throughout the world. If such solutions exist, why isn't the Indian government seeking to implement these solutions? We attempt to answer this question in the concluding Chapter. But then, what is the point in simply understanding what is going on in the world? All understanding, should lead us into action, to changing the world...

Neeraj Jain

Pune, February 26, 2011

Nuclear Energy: From Slowdown to "Renaissance"

It was in December 1953 in his famous Atoms for Peace speech before the UN General Assembly that President Eisenhower of the United States first spoke of the peaceful uses of the atom, including the generation of electricity from nuclear fission as a solution to the world's growing energy needs.[xxiii] In 1955 the United Nations' "First Geneva Conference", then the world's largest gathering of scientists and engineers, met to explore nuclear power technology. In 1957, the European Atomic Energy Community (EAEC or Euratom) was launched alongside the European Economic Community (the latter is now the European Union), as a special organization for nuclear power. The same year also saw the launch of the International Atomic Energy Agency (IAEA).

Those were the heydays of nuclear power. It was claimed that nuclear power would be abundant beyond belief and help the globe decisively overcome its dependence on fossil fuels. It would be safe, clean and self-sustaining. Above all, nuclear power would be eminently affordable and universally economical – in the words of Lewis Strauss, then chairman of the United States Atomic Energy Commission, "too cheap to meter".[xxiv]

Early Years

On June 27, 1954, the USSR's Obninsk Nuclear Power Plant became the world's first nuclear power plant to generate electricity for a power grid, and produced around 5 MW (megawatt) of electric power. The world's first commercial nuclear power station, Calder Hall in Sellafield, was opened in England in 1956 with an initial capacity of 50 MW (later 200 MW). 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.[xxv] The IAEA euphorically forecast that global combined installed nuclear capacity would reach up to 4,450 GW by the year 2000![xxvi]

Problems and Slowdown

Soon, the problems started becoming evident. As nuclear plant construction costs mounted, the claim that nuclear energy was going to be 'too cheap to meter' went through the roof. It became clear that finding a way of safely disposing of the rising mountains of nuclear waste was going to be very difficult, if not impossible. Several scientists started challenging the prevailing view that the small amounts of radiation released by nuclear power plants during normal operation were not a problem. One of these was John William Gofman, professor emeritus of Medical Physics at UC Berkeley, who emphatically stated in the late 1960s that any amount of radiation, howsoever small, causes damage to human genes and health.[xxvii]

In 1976, four nuclear engineers -- three from GE and one from the Nuclear Regulatory Commission – resigned, stating that nuclear power was not as safe as their superiors were claiming. They testified to the Joint Committee on Atomic Energy that: "the cumulative effect of all design defects and deficiencies in the design, construction and operations of nuclear power plants makes a nuclear power plant accident, in our opinion, a certain event. The only question is when, and where." The three GE engineers announced that announced that they would now work full time for Project Survival, the organization coordinating the anti-nuclear referendum drive in California. These men were engineers who had spent most of their working life building reactors, and their defection galvanized anti-nuclear sentiment across Europe and America.[xxviii]

And then, soon after, their occurred the Three Mile Island and Chernobyl disasters. The catastrophic consequences led to an explosion of protests against nuclear power plants the world over. They succeeded in not only bringing new nuclear plant ordering to a halt, but also forced cancellation of plants whose construction had already begun. In the US, all nuclear plants ordered after 1973 were eventually cancelled.[xxix] Many Western European parliaments (e.g. Italy, Germany, Sweden, Belgium) imposed a moratorium on new nuclear reactors and on phasing out existing ones. World-wide, more than two-thirds of all nuclear plants ordered after January 1970 were eventually cancelled.[xxx]

The nuclear industry went into a tailspin. To give a few examples of the multi-billion losses suffered by the nuclear industry (much of which was transferred to the public): in 1983, the Washington Public Power Supply System abandoned three nuclear plants after sinking $24 billion into them; next year, a new nuclear reactor at Shoreham in Long Island, completed at the cost of $5.3 billion, could not be licensed and had to be scrapped.[xxxi] By 1985, Forbes magazine was calling nuclear power "the largest managerial disaster in history";[xxxii] while energy expert Amory B Lovins, CEO of the Rocky Mountain Institute, has termed it the greatest failure in the industrial history of the world, which has lost more than $1 trillion in subsidies, losses, abandoned projects and other damage to the public.[xxxiii]

The result was that since the late 1980s, worldwide nuclear capacity has risen very slowly: from roughly 320 GW in 1990, it reached just 366 GW in 2005, and has been hovering around that figure ever since.[xxxiv]

Funding a "Nuclear Renaissance"

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, over the last decade, the global nuclear industry has launched a massive funding effort and propaganda drive to revive its fortunes. Helping it along has been the rise of deeply conservative currents in the politics of some developed countries, from the USA to Germany and United Kingdom, due to the deepening economic crisis there. (Discussing the reasons for this shift is beyond the scope of this essay.)

In order to convince the people about the benefits of nuclear energy, the nuclear industry took advantage of the growing crisis of global warming and the increasing public awareness and concern about it, and launched a multi-billion dollar public relations campaign claiming that nuclear energy is the answer to global warming. It has been so successful in its propaganda campaign that today, every political leader in the world – from the President of the United States to the Prime

Minister of the India, every Environment Minister in the world – from the Climate Minister of Britain to our own Jairam Ramesh, and even many scientists, are speaking of nuclear energy being green as if it is a self evident truth.

In the USA, the Nuclear Energy Institute (NEI), the propaganda wing and trade arm of the American nuclear industry has poured out hundreds of millions of dollars not only to bribe politicians and win billions of dollars in new subsidies for the nuclear industry, but also block the implementation of distributed, home-based solar systems that would allow millions of people to break free from having to write big checks each month to their electricity distribution company.[xxxv] The industry has been the third largest influence peddler in Washington, D.C. over the past decade, spending more than $1 billion lobbying Congress and the Executive Branch since 1998, behind only the pharmaceutical and insurance industries.[xxxvi] The larger portion of this money has gone to maintaining its traditional base among Republicans, who are all for building a 100 new nuclear plants: in 2000, it backed the Bush-Cheney ticket with nearly $270,000 in contributions.xxxvii Simultaneously, it has also spent money in building bridges to Democrats in both houses, from House Majority Whip James Clyburb, to White House Chief of Staff Rahm Emanuel and strategist David Axelrod, right up to President Obama – Exelon contributed nearly $210,000 to his Presidential campaign through its employees.xxxviii

Its efforts have borne fruits. Within months of coming to power, the Bush administration announced the "Nuclear Power 2010 program," whose declared objective was to get a new generation of nuclear reactors up and running by "early in the next decade."[xxxix] In 2005, Bush launched the biggest subsidy program since the 1960s to promote nuclear energy, including a whopping loan guarantee of $18.5 billion for new nuclear plants (for more details, see Chapter 3). President Barack Obama has not only continued with Bush's loan guarantees, but also nearly tripled it to $54 billion in his budget request to Congress in 2010.[xl]

Likewise, the nuclear lobby in Europe too is one of the most influential and well-funded groups – in just one year, 2007, the group spent 1.6 million euros ($2.2 million) on lobbying the various arms of the EU.[xli] Simultaneously, it launched a massive propaganda offensive to convince people that nuclear energy is clean and green. Thus, in Britain, the Nuclear Industry Association, the trade association of the country's civil nuclear industry, fashioned a classy public relations campaign targeting politicians, media and the public beginning in 2004[xlii]; it even got the national curriculum changed to make it compulsory for schools to teach all 14-16 year olds about the 'benefits' of nuclear power.[xliii]

It has had the desired results; many European Parliamentarians are promoting the concerns and interests of the nuclear industry.[xliv] In Western Europe, many newly elected governments have announced that they are reconsidering plans to phase out nuclear plants in their countries. The energy ministers of the G-8 countries met in Rome in 2009 and issued a statement emphasizing nuclear power as a means of meeting energy demand and combating climate change. This statement was subsequently endorsed by the heads of states of these countries at their annual Summit meeting held in L´Aquila, Italy in July 2009.[xlv]

Along with the governments of the developed countries, various international organisations controlled by them also began issuing enthusiastic statements in favour of nuclear power and predicting a positive future for it. The OECD‘s *World Energy Outlook* (WEO), the US Dept of Energy's *International Energy Outlook* and the International Atomic Energy Agency (IAEA) have all given very optimistic projections about the future of nuclear energy in their recent reports. For instance, the IAEA in its 2010 report projects that by 2030, nuclear energy generation should rise from 2558 TWh at present (in 2009) to between 4040 TWh (low estimate) and 5938 TWh (high estimate) – an increase of between 58% and 132%; likewise, it also estimates that the nuclear generating capacity should rise to between 546 GW (low estimate) and 803 GW (high estimate) by 2030, from 372 GW at the end of 2009.[xlvi]

Swayed by this offensive, many prominent intellectuals from all over the world have also publicly come out in support of nuclear industry propaganda that nuclear energy is a solution to meet the world's energy needs and simultaneously tackle the growing crisis of global warming. It is a perfect example of what Professor Noam Chomsky, the world renowned scholar, has called "Manufacturing Consent": use of massive propaganda by those in power to control what people think.

The effect has been an echo chamber of support for nuclear power. In jubilation, the nuclear industry and its apologists have started proclaiming: "The "nuclear renaissance is here" (in the words of the US Nuclear Regulatory Commission (Chairman Dale E. Klein).[xlvii]

What is Nuclear Energy?

Part I: What is nuclear power?

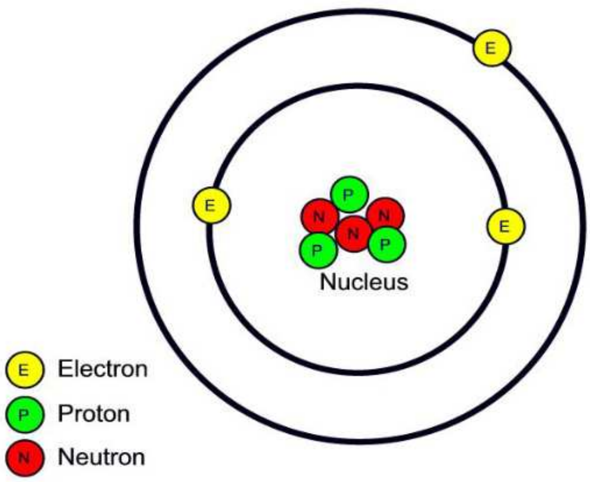
The basic operation of a nuclear power plant is no different from that of a conventional power plant that burns coal or gas. Both heat water to convert it into pressurized steam, which drives a turbine generator. The key difference between the two plants lies in the method of heating the water. Conventional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

In nuclear fission, energy in the nucleus of an atom is released by splitting the atom into two. Before examining a nuclear fission reaction in greater detail, let us first take a brief look at the atom.

The atom

Everything is made of atoms. Atoms bind together into molecules. So a water molecule is made from two hydrogen atoms and one oxygen atom bound together into a single unit. Any atom found in nature will be one of 92 types of atoms, also known as elements (actually, element is a pure chemical substance containing only one kind of atoms). Therefore, every substance on Earth -- metal, plastics, hair, clothing, leaves, glass -- is made up of combinations of the 92 atoms that are found in nature. An ordered list of these 92 atoms found in nature, plus a number of man-made elements, is known as the Periodic Table of Elements.

Figure: Lithium Atom



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. The number of protons is equal to the number of electrons, making the atom electrically neutral. The nucleus and electrons are held together by the coulomb force, the same force that produces static electricity and lightning. The nucleus contains most of the mass of the atom. The protons and neutrons in the nucleus are bound together by very strong nuclear forces, much greater than the electrical forces that bind the electrons to the nucleus. This is why the electrostatic coulomb repulsion between positively charged protons does not lead to the nucleus falling apart.

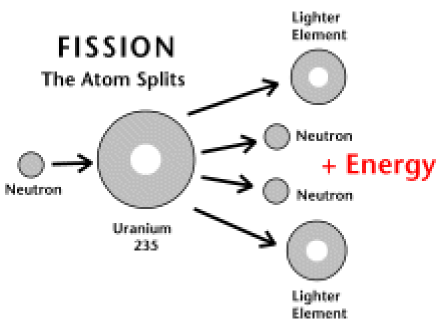
Atoms are so small that they can't be seen except with the help of an electron microscope. An atom is roughly 0.1 nanometers, that is, 0.000,000,0001 meters. In other words, if we make a tiny dot with a pencil, a dot of roughly 1 mm in size, then this dot would have ten million, or one crore, atoms.

Every element is characterised by its atomic mass number and atomic number. The mass number A of an element is the total number of nucleons, that is, the total number of neutrons and protons contained in its nucleus; the atomic number Z is the number of protons. The atomic number of an element (that is, the number of protons in it) determines its chemical properties and its place in the Periodic Table. Hydrogen has the lowest periodic number (Z =1) whereas uranium has the highest atomic number among the naturally occurring elements (Z = 92). Elements with higher atomic numbers, like Neptunium (Z=93) and Plutonium (Z = 94) have been created artificially.[xlviii]

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 with the mass number as superscript; for instance, the three isotopes of uranium are designated as U^{234}, U^{235} and U^{238}. (It can also be written by writing the mass number after the element symbol, such as U-235).

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. The fragments, or fission products, are about equal to half the original mass. 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 (about 0.1 percent of the original mass) has been converted into energy.

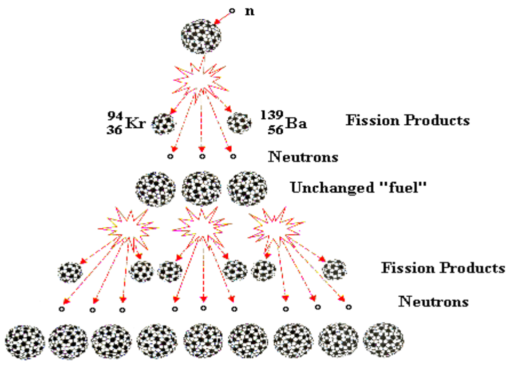


The amount of energy released in this process can be obtained from Einstein's famous equation $E = mc^2$, where E is energy, m is mass and c is the speed of light (approximately 300,000 kilometers per second). The concept behind this equation is simple: that matter and energy are essentially interchangeable – matter can be converted into energy, and energy can be converted into matter.

Typical fission events release about 200 million eV (electron volts) for each fission event, that is, for the splitting of each atom. By contrast, when 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. To get an idea of the energy released in a fission reaction: the energy found in half a kilogram of uranium is equivalent to 4.2 million litres of gasoline. The energy of nuclear fission is released as kinetic energy of the fission products and fragments, and as electromagnetic radiation in the form of gamma rays. In a nuclear reactor, this energy is converted to heat as the particles and gamma rays collide with atoms of the coolant, the moderator, the reactor vessel etc. and give up part of their kinetic energy.

Nuclear Chain Reaction

A chain reaction refers to a process in which neutrons released in fission produce an additional fission in at least one further nucleus. This nucleus in turn produces neutrons, and the process repeats. The process may be controlled (to generate nuclear power) or uncontrolled (to produce a nuclear explosion, as in nuclear bombs).



Nuclear fuel

The isotopes that can sustain a fission chain reaction are called nuclear fuels. The most common nuclear fuels are U-235 (an isotope of uranium) and Pu-239 (an isotope of plutonium). We discuss the use of U-235 as nuclear fuel here.

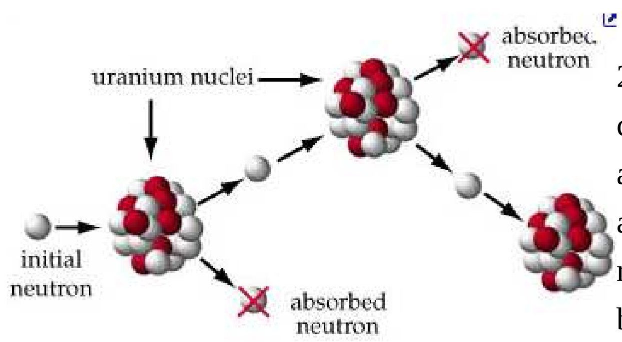
Uranium has many isotopes. Two, uranium-238 primarily, and to a lesser extent, uranium-235, are commonly found in nature. (A third isotope, uranium-234, also exists naturally, but its abundance is only 0.0055 %.) Both U-235 and U-238 undergo spontaneous fission (that is, spontaneous radioactive decay), but this takes place over periods of millennia: the half-life of uranium-238 (half life is the amount of time taken by half the atoms to decay) is about 4.47 billion years and that of uranium-235 is 704 million years. (For more on radioactivity and half life, see Chapter 3, Part I).

What makes U-235 special and useful for both nuclear-power production and nuclear-bomb production is that it has an extra property: U-235 is fissile, that is, it undergoes fission when struck by a **slow moving or thermal neutron**. U-235 is the only isotope existing in nature (in any appreciable amount) that is fissionable by thermal neutrons. It is this property which makes it possible for U-235 (and isotopes like Pu-239) to sustain a chain reaction and so it can be used as nuclear fuel.

However, 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. Therefore, the concentration of U-235 in the uranium mass needs to be increased to about 3-5% by separating out some U-238, in order that it can be used as nuclear fuel. This process is called **enrichment**, and the resulting uranium is called **enriched uranium**. [Note that not all nuclear reactors need enriched uranium, e.g. 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. One possibility is that such free neutrons escape rapidly from the fuel mass and decay. That is because free neutrons are unstable, that is, they are radioactive, each decaying spontaneously, with a half-life of about 15 minutes, into a proton, an electron and an electron-antineutrino. However, the greater possibility is that these neutrons collide with other U-235 nuclei in the vicinity, and induce further fissions, releasing yet more neutrons, thus starting a chain reaction.

Figure: Controlled Chain Reaction

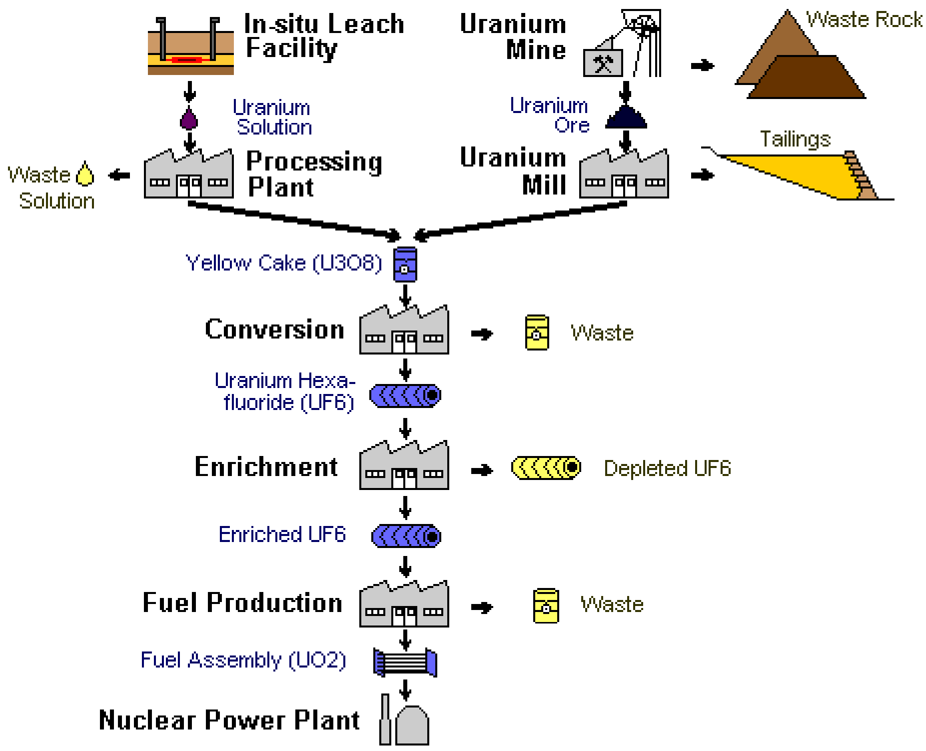


If exactly one out of the average of roughly 2.5 neutrons released in the fission reaction is captured by another U-235 nucleus to cause another fission, then the chain reaction proceeds in a controlled manner and a steady flow of energy results. If the chain reaction sustains, it is said to be **critical**; and the mass of U-235 required to produce a controlled chain reaction is called a **critical mass**. 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 (energy = 1 MeV or speed ~ 107 m/s). At such speeds, the possibility of their being captured by another U-235 nucleus is very low. If they are slowed down, or moderated, the probability of fission rises dramatically. In that case, a critical condition (that is, a controlled chain reaction) can be achieved with lower concentrations of U-235. In a nuclear reactor, the fast neutrons are slowed down using a **moderator** such as heavy water, graphite 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. This entire process is known as nuclear fuel cycle. We now take a brief look at the various stages of this process. The fuel cycle described here includes the phase of uranium enrichment, necessary for obtaining the fuel for light water reactors, which constitute the largest number of the world’s reactors.



- **Mining:** The nuclear fuel cycle starts with mining of Uranium. Most uranium mines are open-pit mines. Since the uranium content of the ore is often between only 0.1% and 0.2%, or in rare instances even less than that, therefore, large amounts of ore have to be mined to obtain the amounts of uranium required.

- **Milling:** The ore is then processed in two stages to obtain the nuclear fuel. The first step is called milling, wherein the uranium bearing ore is ground into fine powder, and then treated with several chemicals to leach out the uranium. (Leaching is the extraction of a material, say a metal, from the solids by dissolving it in a liquid.) The uranium concentrate thus obtained is dried and filtered to yield what is called "yellowcake", 70-90% of which is uranium oxide.

- **Enrichment:**

The uranium oxide obtained from milling contains both the usual isotopes of uranium, the fissile uranium-235 and non-fissile uranium-238. It must now be enriched, that is, the proportion of fissile uranium-235 in it must be increased. For this, uranium oxide must now be converted to uranium hexafluoride. Uranium hexafluoride is the only uranium compound which is gaseous at low temperatures and so is easier to work with. For this conversion, the yellowcake is transported to a processing facility, where it is converted to uranium hexafluoride. The subsequent enrichment of uranium-235 from 0.7 percent to 3-5 percent can be done using one of two basic methods – gaseous diffusion and ultracentrifuge.

The bulk of waste from the enrichment process is **depleted uranium**, so-called because most of the uranium-235 has been extracted from it. It is thus primarily uranium-238, and contains less than one-third uranium-235 as compared to natural uranium.

- **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 tubes of corrosion-resistant metal alloy, usually a zirconium alloy, and then the tubes are 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 grouped in special fuel assemblies that are then used to build up the nuclear fuel core of a nuclear power reactor. A typical 1,000 megawatt reactor contains 50,000 fuel rods – about one hundred tons of uranium.

- **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. We discuss this in more detail in Part III below.

- **Decommissioning and Dismantling:**

Nuclear power plants were originally designed with an operating life of 30 years. However, nowadays, the nuclear industry believes that it can safely operate nuclear plants for around 40 to 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 has become contaminated, all of its parts including the concrete reactor building have become radioactive. The long-term management and clean up of these closed reactors is known as "decommissioning". It involves managing and cleaning up the highly radioactive fuel, residues, massive quantities of radioactive equipment and components, mixed hazardous wastes and the mountain of contaminated concrete and debris (making up the reactor building) that have now accumulated at the plant site.

Only a very small number of nuclear power plants have so far been completely dismantled. Generally, the most common decommissioning method is that the intensely radioactive products, especially the deadly cobalt 60 and iron 55 formed inside the reactor vessel from neutron bombardment, are first allowed to decay considerably. During this period, which can be anywhere from 5 to 100 years, depending upon the decommissioning plan, these huge, intensely radioactive mausoleums must be guarded and protected from damage or unwarranted intrusion. After this, the actual process of dismantling begins. The reactor is now cut apart into small pieces either by humans or by remote control, and the still-radioactive pieces packed into containers for transportation and final disposal at some "low-level" nuclear waste disposal site.[xlix]

- **Disposal of cooling water:** The water that cools the reactor core becomes heavily contaminated with tritium, or radioactive hydrogen, and with carbon-14. Despite this, it is discharged into nearby water bodies, like seas or rivers.

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.[l] A person standing near a single spent fuel rod can acquire a lethal dose within seconds. This spent nuclear fuel is going to be intensely radioactive for tens of thousands of years, therefore it needs to be safely stored for centuries to come.

But it is also thermally extremely hot when removed from the reactor. Therefore, 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. After an adequate cooling period (generally five years in the US[li]), 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 are to be stored for centuries to come, till the radiation diminishes to a point where it is no longer hazardous. Presently, in most countries having nuclear plants, these casks are 'temporarily' stored near the spent fuel cooling ponds.[lii]

Countries having nuclear plants are hoping to build a long-term nuclear waste dump site where this waste can be safely stored for centuries. However, so far, no country including the USA has succeeded in building such a site so far.

- **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. The technology generally used to extract the plutonium (and uranium) from the spent fuel is called the Plutonium-Uranium Redox Extraction (PUREX).

Reprocessing also segregates the waste into high level, intermediate level and low level wastes (HLW, ILW, and LLW, respectively). Because HLW, which contains the bulk of the radioactivity present in the original spent fuel, occupies only a fraction of the volume of spent nuclear fuel, this has been used as an argument by countries like France and India that reprocess their spent fuel waste to claim that reprocessing is a superior way to manage the radioactive spent fuel, when compared to the direct disposal of spent fuel in geological repositories.

Part III: The Nuclear Reactor

The nuclear fuel is fissioned in the nuclear reactor. The principles for using nuclear fission to produce electricity are the same for most types of reactors. The energy released by the fission reaction is harnessed as heat to convert water to steam. This steam is used to drive a turbine and produce electricity. 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 from fission so that they cause more fission. It is usually ordinary water (used in light water reactors), but it may also be heavy water (used in heavy water reactors) or even graphite (used in reactors of certain types, for example the RBMK).

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 to halt it.

Coolant: A liquid or gas circulating through the core so as to transfer the heat from it. In light water reactors, the moderator which is water also serves as the primary coolant. Except in Boiling Water Reactors (BWRs), this primary coolant passes through another heat exchanger, to convert another loop of water into steam. This steam drives the turbine. The advantage of this design is that the radioactive water/steam (that is, the primary coolant) 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 BWR)* or **Secondary heat exchanger**: Here, the primary coolant bringing heat from the reactor is used to convert another loop of water into steam to drive the turbine.

Containment: The structure around the reactor core which is designed to protect it from outside intrusion and to protect those outside from the effects of radiation in case of any malfunction inside. It is typically a metre-thick concrete and steel structure.

Refuelling the reactors: In most reactors, the refuelling is done at intervals of 1-2 years, when a quarter to one-third of the fuel assemblies are replaced with fresh ones. For this, the reactor needs to be shut down. But in the CANDU type reactors, which have pressure tubes (rather than a pressure vessel enclosing the reactor core) and can be refuelled under load by disconnecting individual pressure tubes, the reactor need not be shut down.

Types of Nuclear Power 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); each come in multiple variations.. Heavy Water Reactors can be of different types, one of the most well known being the CANDU (acronym for "CANada Deuterium Uranium") reactors developed by Canada which are a type of Pressurised Heavy Water Reactors (PHWRs).

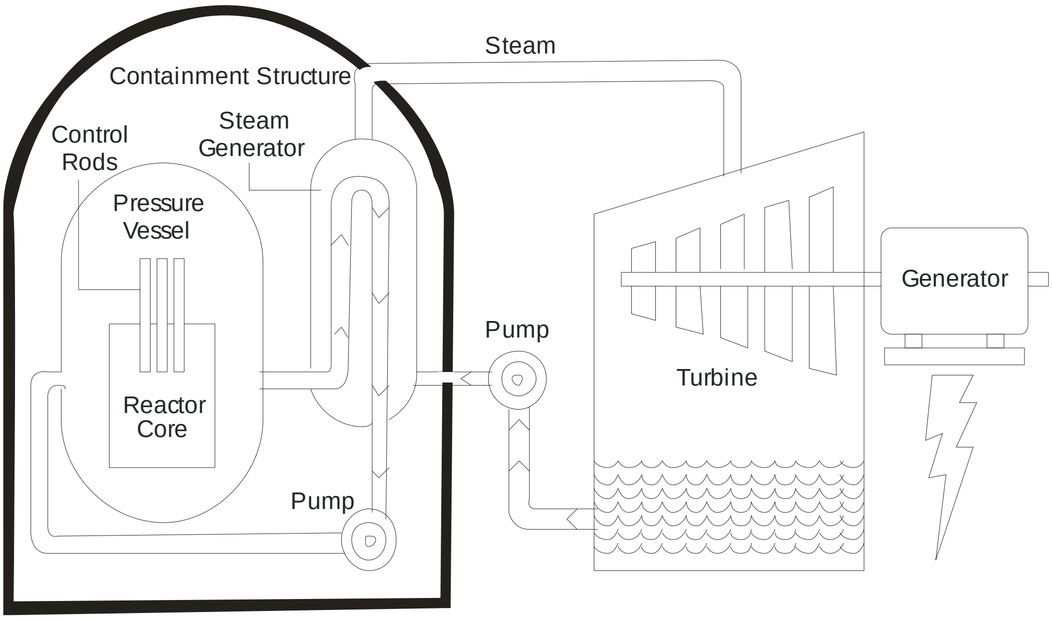
LWRs are the most widespread type of reactors in operation today. Of the 437 reactors in operation at the end of 2009, 357 were LWRs, of which 265 were PWRs and 92 BWRs. Apart from these, the other reactor types in operation were: 45 pressurized heavy-water reactors (PHWRs), 18 gas-cooled, graphite-moderated reactors, (GCRs), 15 light-water-cooled, graphite-moderated reactors (LWGR), and 2 fast breeder reactors (FBRs).[liii]

Below, we discuss the most well-known type of nuclear power reactor – the PWR, the reactor design of most of India's reactors - the PHWR or CANDU Nuclear Power Reactor, and also the Fast Breeder Reactor, which India has been trying to build for many decades and of which there are only two reactors in operation today, a prototype unit in Japan and the BN-600 reactor Russia (which is technically not a fast breeder – See Chapter 9).

(i) Pressurised Water Reactor

This is the most common type, with 265 in use for power generation and several hundred more employed for naval propulsion. PWRs use ordinary water as both coolant and moderator.

It has a primary cooling circuit which flows through the core of the reactor under very high pressure, and a secondary circuit in which steam is generated to drive the turbine. Water in the reactor core reaches about 325°C; hence it must be kept under about 150 times atmospheric pressure to prevent it boiling. Water in the primary cooling 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.



Pressurized Water Reactor

The pressurised 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 and returned to the heat exchangers in contact with the primary circuit.

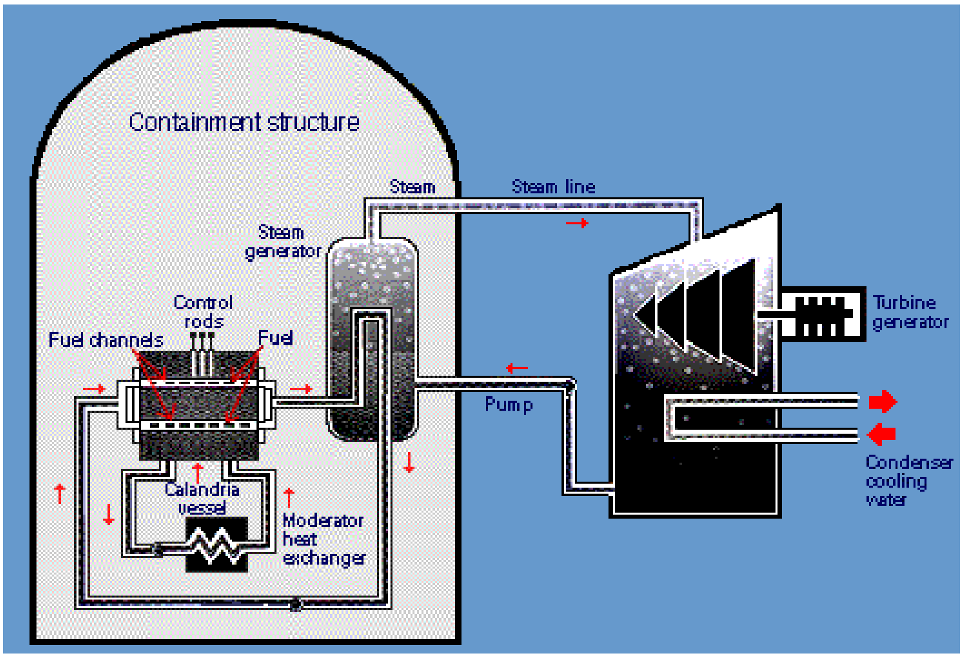
(ii) Pressurised Heavy Water Reactor (PHWR or CANDU)

This design was originally developed in Canada in the 1950s. In this design, unenriched uranium, that is natural uranium (0.7% U-235) oxide, is used as fuel, along with heavy water as moderator, which is a more efficient moderator than ordinary water.

Conceptually, this reactor is similar to PWRs discussed above. Instead of water, heavy water is used as the coolant and moderator. Fission reactions in the nuclear 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 core. The hot heavy water generated in this primary cooling loop is passed into a heat exchanger heating ordinary water in the less-pressurized secondary cooling loop. 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.

Pressurised Heavy Water Reactor



Heavy water is a more efficient moderator than ordinary water as it absorbs less neutrons than the latter. Further, the design of the PHWR is such that most of the moderator which is in the Calandria is at lower temperature than the moderator in PWRs: therefore, the neutrons in PHWRs are at optimum speeds to cause fission, implying that the PHWR is more efficient in fissioning U-235 nuclei. Both these advantages mean that the PHWR can sustain a chain reaction with lesser number of U-235 nuclei in uranium as compared to PWRs, which is why it uses unenriched uranium as nuclear fuel.

Thus, in PHWRs, enrichment costs are saved, but the disadvantage is that heavy water is also very costly, costing hundreds of dollars per kilogram.

(iii) Fast Breeder Reactors

In the uranium fuelled reactors discussed above, U-235 was fissioned by slow moving neutrons, and the energy released in the fission reaction is used to generate steam to run a turbine and generate electricity. Neutrons produced by fission have high energies and move extremely quickly. These so-called fast neutrons do not cause fission as efficiently as slower-moving ones, so they are slowed down using a moderator.

In contrast, a fast breeder reactor uses a mix of oxides of plutonium-239 (or Pu-239) and uranium-238 as the fuel (also called MOX fuel). [Plutonium is usually obtained by reprocessing waste from the uranium fuelled reactor.] Pu-239 is the fissile material. It is even better at fissioning than U-235. The energy released in the fission reaction is transferred via the coolant to produce the steam used to power the electricity generating turbines. All current fast reactor designs use liquid metal (generally sodium) as the primary coolant.

The second difference with U-235 fuelled reactors is that the coolant used in FBRs is not a moderator. So its neutrons are fast moving. While these neutrons are not good at causing fission, they are readily captured by U-238 to transform it into U-239 which then beta decays (that is, emits electrons from its nucleus – see Chapter 3 for more on this) to form Pu-239, which then can be reprocessed and used as more fuel for the reactor.

Thus, in a FBR, while Pu-239 is fissioned to generate electricity, it is also created. In other words, a fast breeder reactor, along with producing power, breeds fuel by producing more fissile fuel than it consumes. In many FBR designs, the reactor core is surrounded in a blanket of tubes containing non-fissile U-238 – this too captures fast neutrons from the reaction in the core and is partially converted to fissile Pu-239, to be reprocessed for use as nuclear fuel.

This is the reason why FBRs have been an attractive option for countries like India which possess limited amounts of Uranium deposits, and that too of low-grade: because these reactors produce (or "breed") more fissile material than they use.

Is Nuclear Energy Safe?

According to President Bush, who very strongly voiced support for nuclear energy in various international meetings, nuclear energy was a "safe and clean" energy source for the future.[liv] His envoy to India, David Mulford, made the same claim at a function to celebrate World Environment Day in 2008.[lv] Echoing the Master's Voice, Prime Minister Manmohan Singh has repeatedly claimed that nuclear energy is a safe, environmental friendly and sustainable source of energy.[lvi] India's top scientists and leading 'intellectuals' are also strongly supporting India's push towards nuclear energy as a safe and clean source of energy.[lvii]

From US to India, politicians and intellectuals are blithely lying about nuclear energy. They believe that if you lie frequently and with conviction, people will believe you.

Even if nuclear power plants are operating normally, the entire complex 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, not just during our lifetime, but for thousands of generations to come – yes, we repeat, 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!

As Dr. Helen Caldicott, a renowned physician and anti-nuclear activist who has worked tirelessly to expose the real threat this technology from hell poses to human survival, wrote in *Nuclear Madness,* her first book: "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."[lviii]

Before we discuss the radiation emitted at each stage of the nuclear fuel cycle and its consequences for the human race, we first discuss what radiation is and how it affects human health.

Part I: What is Radiation?

Stable and Unstable Atoms

Most atoms are **stable**; that is, they do not undergo changes on their own. For instance, if we put an atom of Aluminum (Z[lix] = 27) in a bottle, seal it and open it after a million years, it would still be an atom of aluminum. Aluminum is therefore called a stable atom.

However, there exist some atoms that are **unstable**. 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 by the unstable nucleus is called r**adioactivity**, and the nucleus is said to have undergone radioactive decay, or just decay. In this process, the nucleus changes its composition and may actually become a different nucleus entirely. The process continues till the nucleus achieves stability.

For example, most carbon (Z = 6, A[lx]=12) atoms are stable, with the nucleus having six protons and six neutrons. Carbon has an isotope, C-14, whose nucleus consists of six protons and eight neutrons, which is unstable. In its attempt to achieve stability, a C-14 nucleus gives off a beta particle (that is, an electron emitted by an atomic nucleus). After the C-14 nucleus has lost the beta particle, it now consists of seven protons and seven neutrons. But a nucleus consisting of seven protons and seven neutrons is no longer a carbon nucleus. It is now the nucleus of a nitrogen atom. By giving off a beta particle, the C-14 atom has changed into a N-14 atom.

In the periodic table, elements with atomic number 83 and above are unstable, meaning all their isotopes emit radioactivity.[lxi] Elements with atomic number from 1 to 82 are mostly stable [with the exceptions of technetium (Z=43) and promethium (Z=61)], but some have unstable isotopes.

Types of radiation emitted by radioactive elements

Radioactive isotopes spontaneously emit several types of radiation in the form of photons or high-energy particles while transforming to a stable isotope, of which three are the most common:

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, and are not able to penetrate dead cells in the skin to damage the underlying living cells. Therefore, when outside the human body, alpha particles are not dangerous to human life. However, when alpha particles are inhaled into the lungs or ingested into the gastrointestinal tract, they come into contact with living cells and severely damage them. The biological damage can have serious consequences for human health, 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. Beta particles are lighter than alpha particles – like a bullet compared to a cannon ball – and so while they travel farther than alpha in body tissues, the biological damage caused by them is less. They can penetrate the outer layer of dead skin and damage the underlying living cells. If they are inhaled or consumed or absorbed into the blood stream, then they can damage the tissues and cause cancer. Typically, how beta emitters act is by accumulating in the human body, causing low level exposure over a prolonged period of time, and the main health effect of this prolonged exposure is cancer. Usually, health effects of beta particles develop relatively slowly, typically over 5-30 years. For instance, Iodine-131 concentrates heavily in the thyroid gland, increasing the risk of thyroid cancer and other disorders (How does a nucleus emit a electron? The answer: a neutron breaks up into a proton and electron, and the latter is emitted.)

iii. Gamma radiation: This is akin to X-rays. It is composed of photons, that is, high energy light waves. 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 mutate regulatory or reproductive genes.

Radiation is measured in Becquerel (Bq). One Bq is defined as one disintegration per second. Another unit is curie, defined as: Curie (Ci) = 3.7×10^{10} disintegrations per second.

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, so 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, with many experts saying 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 nuclear reactor have very short half-lives (less than a second) and some extremely long (millions of years).

Part II: Radiation and Human Health[lxii]

Radiation and reproduction

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. All the genes come in pairs, and in the human cell they are organised into the two sets of 23 chromosomes. The human cell thus has a total of 46 chromosomes.

Genes are the very building blocks of life, responsible for every inherited characteristic in all species – plants, animals, and humans. Every person inherits half of his/her genes from the mother, and half from the father. While every human cell has 46 chromosomes, the egg and sperm have 23. At the time of conception, the mother's egg cell unites with the father's sperm, to form the zygote, which has a full complement of 46 genes. This cell then duplicates itself, and develops into the child. 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.

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 according to evolution theory, radiation from the atmosphere and earth's crust (called background radiation) is one of the important causal factors of evolution. While most mutations caused by this radiation were "harmful", causing disease and death in the offspring, some were "advantageous": that is, they produced changes in the offspring that enabled it to better survive and multiply in the hostile environment. Thus, it is because of such mutations that fish developed lungs and climbed out of the water to become land-dwelling amphibians, dinosaur-like creatures developed wings and became the earliest form of birds, and humans evolved from early primates. But this also means that there must have been incomparably more mutations which led to the birth of monstrous offspring which were unfit to survive and died. Mutations are also responsible for thousands of genetically inherited diseases, like heart diseases, cystic fibrosis and sickle cell anemia – medical literature describes 19000 genetically inherited diseases!

Apart from causing mutations in genes, radiation can also cause a break in chromosomes. This can cause a baby to be born with serious mental and physical genetic disorders.

If a pregnant woman is exposed to radiation, then it may so happen that the radiation kills a cell of the fetus that was going to become a leg or a valve of the heart or some other part of some other important organ. Such a mutation, which is not passed on to the offspring as it did not take place in the reproductive gene, is called teratogenic mutation.

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 60 years. Then one day, instead of the cell dividing into two daughter cells in a regulated fashion, it will begin to divide in a random, uncontrolled fashion into millions and trillions of daughter cells, creating a cancer. In many cases it is difficult if not impossible to stop this random growth of abnormal cells. All kinds of cancers can be caused by exposure to radiation: from cancer of the upper digestive tract and lungs to bone cancer and leukemia.

Other impacts of radiation on human health

Radiation exposure causes cancer, but the incubation period can be many years. Apart from cancer, non-cancerous health effects of radiation exposure are also there. It can cause radiation sickness, whose symptoms include: nausea, weakness, hair loss, skin burns and diminished organ function. If the dose is high, it can also cause premature aging and death. Exposure to radiation can damage body cells, causing a wide variety of effects. Thus, it can damage the reproductive system, causing infertility and spontaneous abortion. It deforms red blood cells, inhibiting their passage into the tiny capillaries and depriving the muscles and brain of adequate oxygen and nutrients. This can lead to impairment of many organs especially the kidneys, liver, lungs and cardiovascular system, and can also damage the system that causes formation of blood in the body (known as haematopoietic system). Radiation can also cause disorders of protein and carbohydrate metabolism, leading to symptoms ranging from severe headache to brain dysfunction.

No safe dose of radiation

There is nothing like a safe dose of radiation. Even the smallest amount has the possibility of a lethal outcome. This has been emphatically argued by many of the world's most eminent scientists. To give a few quotes:[lxiii]

- Dr. John William Gofman, professor emeritus of Medical Physics at UC Berkeley: The lowest dose of radiation is one nuclear track (that is, a ray or a particle) through a cell, and there is enough evidence to show that even at this lowest possible dose, it can cause cancer. “The DOE (US Department of Energy) has never refuted this evidence. They just ignore it, because it's inconvenient. We can now say, there cannot be a safe dose of radiation. There is no safe threshold. ... any permitted radiation is a permit to commit murder.”[lxiv]
- Dr. Karl Morgan, world renowned as the father of Health Physics: “There is no safe level of exposure and there is no dose of radiation so low that the risk of a malignancy is zero.”[lxv]
- Dr. Rosalie Bertell, world renowned environmentalist who has been consultant to the US NRC, US EPA and Health Canada: “…there is no safe level of exposure to ionising radiation, and the search for quantifying such a safe level is in vain.”[lxvi]
- E. Wright and other researchers with the Medical Research Council, Harwell, Oxfordshire, United Kingdom: “An important feature of alpha irradiation is that, no matter how low the total dose to the whole body, a substantial dose of radiation is delivered to an individual cell if it is traversed by a single alpha particle.” That is because when radiation in the form of highly energetic particles passes through the human body, any cell in its path may get mutated.[lxvii]

In 2005, a panel of the US National Academy of Sciences charged to investigate the dangers of low-energy, low-dose ionizing radiation also came to the same conclusion, that there is no safe threshold dose. The panel came to this conclusion despite having a number of pro-nuclear individuals; the evidence was simply too overwhelming for them to ignore.[lxviii]

Yet, nuclear regulatory authorities prescribe “safe” radiation doses. In the US, according to standards set by the Nuclear Regulatory Commission, nuclear plant operators cannot legally expose the general public to more than 100 millirems per person annually. Operators must also limit exposure to 5,000 millirems (5 rems or .05 Sv) for adult employees and 500 millirems for pregnant or minor employees.[lxix] 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) and pregnant women 200 millirems for the entire duration of pregnancy.[lxx]

These standards and those set by other governments worldwide are based on risk coefficients for ionizing radiation exposure promulgated by the International Commission on Radiological Protection. A few months ago, on May 6, 2009, a very important conference took place in Lesvos, Greece: the European Committee on Radiation Risk Conference. 16 world experts who participated in the conference issued a "The Lesvos Declaration" which unequivocally stated that existing methods to determine safe radiation doses are clearly outdated. The declaration states that the ICRP risk model was developed before the DNA structure was discovered and before new discoveries such as that "certain radionuclides have chemical affinities for DNA". Therefore, the experts asserted, "the ICRP risk coefficients are out of date", that "employing the ICRP risk model to predict the health effects of radiation leads to errors which are at minimum 10 fold", that "damage to the cardio-vascular, immune, central nervous and reproductive systems" due to radiation exposure is significant but as yet unquantified, and called for more research into the health effects of radiation.[lxxi]

This only means that all the health effects of radiation outlined above are also an underestimate, the full extent of effects of radiation on health of human beings is yet to be understood…

Background Radiation and Man-made Radiation

Cancers have always plagued the human race, and it is generally accepted that most cancers in the past and present are due to this background radiation. Nuclear authorities argue that there is nothing to fear from routine radioactive releases from nuclear plants as it is much less than the naturally occurring background radiation.[lxxii] Even if this fact is correct, that is a strange argument. While we cannot do anything about background radiation, and therefore cannot prevent a certain number of people from developing cancer due to this, should we not try and ensure that this number does not increase by preventing man-made radiation from adding to background radiation.

We are exposed to a background radiation of around 100 millirems per year from the earth and sun.[lxxiii] The US NRC has decided that it is acceptable for the public to receive an additional 100 millirems per year from man-made radiation created through generation of nuclear energy. This means that for the NRC, it is acceptable that the number of cancer patients double (as compared to the number of cancer patients that would have occurred due to naturally occurring radiation)!

The US National Academy of Sciences estimates that man-made radiation in the United States accounts for 18% of human exposure.[lxxiv] But what is not realised is that as more and more of the huge quantity of radioactive waste accumulating near nuclear power plants leaks and contaminates the environment and enters the water and food chains around the world, the percentage of radiation exposure from these sources is going to increase. And since this radiation remains potent for tens of thousands of years, by using nuclear electricity today, we are bequeathing our descendants a radioactive legacy tomorrow.

Part III: Radiation Emission in Nuclear Fuel Cycle, and its Impact on Life

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

1. Uranium Mining

Uranium miners are at great risk because they are exposed to high concentrations of a radioactive gas called radon 222. Radon 222 is a decay product of uranium and is a highly carcinogenic alpha emitter. If inhaled, it can deposit in the air passages of the lung, irradiating cells that then become malignant.

Uranium miners are also exposed to radium 226, another lethal uranium daughter, which is an alpha and gamma emitter with a half-life of 1,600 years. Radium is an integral component of uranium dust in the mine. When this is swallowed, radium is absorbed from the stomach into the body and deposits in the bones. It causes osteogenic sarcoma, a highly malignant bone cancer, and leukemia, because white blood cells are manufactured in the bone marrow.

Uranium daughters present in the ore also emit gamma radiation, which emanates from the surface of the uranium mine. So, miners are also exposed to a constant, whole-body radiation (like X-rays), which irradiates their bodies and continuously exposes their reproductive organs.[lxxv]

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, many of whom were Native Americans, 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.[lxxvi]

Waste rock

The waste produced during mining, called waste rock or mine tailings, is in huge quantities – it is several times higher than the amount of ore mined. This is left lying in huge heaps adjacent to the mine, exposed to the air and the rain. The waste rock contains Uranium ore of too low grade for processing in the mill, and decay products of Uranium.

So long as the uranium deposit was undisturbed, the radiation was trapped underground. But now that the ore is mined, the waste rock piles present hazards to residents and the environment, even after the shutdown of the mines: radon gas can escape into the air; ore dust can be blown by the wind; and uranium and its decay products can seep into surface water bodies and groundwater. Being radioactive and toxic, they contaminate the environment.

Most uranium mines in the USA are situated on or adjacent to indigenous tribal lands of the Navajo nation, located in the Four Corners area (the intersection of Arizona, Colorado, New Mexico and Utah) in the American Southwest. The more than 250 million tons of uranium tailings lying here in the open constantly leak radon-222 into the air, exposing the indigenous populations who live nearby. As they inhale the radon, many of these people have developed or are developing lung cancer. The radioactive debris has also polluted the underground water and the Colorado river; water from this river is used for agriculture and drinking by 30 million people downstream in

Arizona, Nevada, and California. Because it is tasteless and odorless, people in these contaminated populations cannot tell whether they are drinking radioactive water, breathing radioactive air, or eating fish or food that will induce bone cancer or leukemia. These wastes 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 suffered five times the rate of bone cancer and 15 times the rate of testicular and ovarian cancers as other Americans. The people living on these lands will continue to pay this price in the future too, for thousands of years, unless these wastes are cleaned up. But that is a very costly operation, would cost billions of dollars. The US government and the nuclear industry have made no attempts to clean up this massive radioactive pollution, as it is tribals, and not the well-heeled of America, who are affected![lxxvii]

2. Uranium Milling and Mill tailings[lxxviii]

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. Uranium mill tailings are normally pumped to settling ponds, where they are abandoned.

Since the 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. In the US, over the last 40 years, apart from the mine waste, over 100 million tons of mill waste has also accumulated on Navajo lands. In Europe, the largest settling ponds are in Germany: the Culmitzsch tailings dam contains 90 million tonnes of solids, and the Helmsdorf tailings dam contains 50 million tonnes of solids.

Since only the uranium is removed, the sludge contains all the remaining constituents of the ore, including the long-lived decay products of Uranium – Thorium 230 and Radium 226. Further, due to technical limitations, all of the uranium present in the ore cannot be extracted. Therefore, the sludge also contains 5% to 10% of the uranium initially present in the ore.

The sludge thus contains 85% of the initial radioactivity of the ore. One of its deadly radioactive constituents is the uranium decay product, Thorium-230. Thorium-230 is the uranium decay product with the longest lifetime, decaying at a half-life of 80,000 years. This means that it will last for hundreds of thousands of years – in human terms, forever. Thorium is especially toxic to the liver and the spleen. It has been known to cause leukaemia and other blood diseases. It decays to produce radium-226, which in turn produces radon gas (discussed in the previous section on uranium mining), a very powerful cancer-causing agent. Even small doses inhaled repeatedly over a long time can cause lung cancer. 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 radioactivity contained in the tailings and the radon releases will continue to be in significant amounts for hundreds of thousands of years!

The radioactivity from the tailing ponds severely affects residents living near these enclosures.

i. Radon gas can affect people very far away from the tailings pond, as it can travel thousands of kilometres with a light breeze in just a few days.

ii. Heavy rainfall or floods can cause spillover of the sludge into nearby areas; it may also cause a failure of the tailings dam. This has been occurring around the world with frightening regularity. These failures can be huge. For instance, on July 16, 1979, the Church Rock tailings dam in New Mexico collapsed, spilling ninety million gallons of liquid radioactive waste and eleven hundred tons of solid mill wastes into the Rio Puerco River. It is the largest release of radioactive waste ever in the US, and second only to the Chernobyl meltdown globally. Few people have heard of this disaster, because it took place in tribal lands, so the media simply ignored it. The Navajos of course continue to suffer its consequences.[lxxix]

iii. Seepage from the tailing ponds can contaminate the ground and surface water. For example, seepage is known to be occurring at the uranium mill tailings in the city of Pecs in Hungary and Stráz pod Ralskem mill tailings in North Bohemia. Sooner or later, it is going to contaminate the drinking water sources of both these places.[lxxx] Seepage from tailings pond of the Atlas uranium mill in Moab, Utah, USA, had been contaminating the Colorado River for decades. The river is drinking water supply for millions of Americans downstream. After an intense struggle waged by local people for nearly a decade, finally, in 2005, the authorities decided to relocate the tailings pond.[lxxxi]

The tailings have therefore 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 in and take some damage control measures.

3. Uranium Enrichment

The uranium-235 isotope is enriched from a low concentration of 0.7% to 3% for fuel in nuclear power plants (except in PHWRs). Workers at all stages of the enrichment process are exposed to whole-body gamma radiation from by-products of uranium decay. But the most serious aspect of enrichment is the material that is discarded: uranium-238. This is called “depleted uranium” (DU) because it has been depleted of its uranium-235. But it is not depleted radioactively.[lxxxii]

In March 2009, bowing to pressure from the nuclear industry, the US Nuclear Regulatory Commission (NRC) voted to declare that depleted uranium (DU) from enrichment plants is a Class A low-level radioactive waste – the least dangerous kind that supposedly consists mainly of short-lived radionuclides. In actual fact, the depleted uranium becomes more radioactive with time, and hence more dangerous, because of the growth of decay products of uranium like thorium-230 and radium-226. The uranium-238 and its decay products will continue to pollute the environment for thousands of years.

The NRC decision will make disposal of DU cheap for the US nuclear enrichment industry. Currently some 740,000 tons of depleted uranium in unstable hexafluoride form are stockpiled at US Department of Energy sites at Paducah, Kentucky, Portsmouth, Ohio, and Oak Ridge, Tennessee. Even before this ruling, barrels in which this depleted uranium had been stored at these sites had been leaking and disintegrating and had polluted the groundwater. Now the industry can store this even more callously.[lxxxiii]

The situation is much the same in Europe. In France, despite objections of residents, the court ruled that depleted uranium is no waste, but a "directly usable raw material that is effectively used for multiple uses" and allowed the French nuclear fuel company Cogéma to "store" 2 lakh metric tonnes of depleted uranium at the site of the former uranium mill of Bessines-sur-Gartempe (Haute Vienne) near Limoges. Cogema claims that it is storing this depleted uranium at the site for possible future use.[lxxxiv]

Governments led by the US and UK have now found a new way of disposing of at least some of this depleted uranium – they are using it in bombs and have used hundreds of tons of depleted uranium in Gulf War I, the Balkan wars, the Afghanistan war and now the most recent invasion of Iraq that began in 2002. Israel also dropped US made depleted uranium bombs on Lebanon in 2006, and then again on the hapless residents of Gaza during its invasion of December 2008.[lxxxv] Uranium has a half life of 4.5 billion years. It effectively means these lands are contaminated till the end of time.

Hundreds of thousands of US and UK troops who served in Gulf Wars I and II are sick and slowly dying from what their governments say is a "mystery disease", which they have labeled Gulf War Syndrome. Many have given birth to deformed children. The reality is, these diseases have been caused by exposure to depleted uranium! The governments of these killer countries are refusing to admit the truth, because it will mean paying out billions of dollars of compensation to their troops!![lxxxvi] The impact of these bombs on the people of Iraq (and also other countries where these bombs have been dropped) is of course far more terrible. Their lands have become polluted with nuclear material, and they are condemned to die of malignancy and congenital disease for eternity. Because of the extremely long half-life of uranium-238, the food, the air, and the water in the cradle of civilization have been forever contaminated. Already, the effects are visible: leukemia rates have shot up several hundred times, and babies are being born with deformities, including heart defects, cleft lip or palate, Down's syndrome, and limb defects on a scale never seen before.[lxxxvii]

4. Routine Releases from Operation of Nuclear Power 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.[lxxxviii]

The diabolical elements created in the fission reaction leak out through cracks in the zirconium fuel rods: over time the uranium in the fuel rods swells, due to which pinhole breaks appear in the zirconium cladding; some faulty welds in the zirconium fuel rods also rupture. They now find their way into the environment through a number of ways.

(i) The radioactive isotopes leaking from the fuel rods mix with the primary coolant, that is, the water that cools the reactor core, making it intensely radioactive. The primary coolant in nuclear reactors is constantly taken out for chemical treatment, volume control and to reduce its radioactivity. Most of it is then returned to the primary coolant circuit, and the remaining is kept in holding tanks and then after further treatment is periodically released into the environment.[lxxxix] In the USA, nuclear reactors intentionally release about 4000 gallons of primary coolant water into the environment every day, while some just leaks out unplanned.[xc]

(ii) The thermally hot primary coolant is piped through a steam generator to heat the secondary cooling system. This secondary water is converted to steam, which turns the generators to produce the electricity. 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 12 gallons of intensely radioactive primary coolant leaks daily into the secondary coolant via the steam generator through breaks in the pipes. Being at very high pressure, some radioactive steam routinely escapes into the environment from the reactor.[xci]

(iii) Apart from mixing with the coolant water, radioactive gases that leak from fuel rods are also routinely released into the atmosphere at every nuclear reactor. This is known as “venting”. The gases are temporarily stored to allow the short-lived isotopes to decay and then released to the atmosphere through engineered holes in the reactor roof and from the steam generators. Filters are used to remove the most dangerous isotopes.[xcii]

(iv) As we discuss later in greater detail, 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 contained in routine and accidental emissions

Even the nuclear industry admits that it vents gases from nuclear reactors into the atmosphere, but it claims that they are harmless as they are noble gases, while the dangerous gases like Iodine-131 are removed by filters. In reality, noble gases are high energy gamma emitters and they are readily absorbed from the lung, and enter the blood stream. Because they are very fat soluble, they tend to locate in the abdominal fat pad and upper thighs, adjacent to the testicles and ovaries. There, they can induce significant mutations in the eggs and sperm of the people living adjacent to a reactor.[xciii]

More damaging is the fact that many noble gases decay to other more dangerous isotopes, all of which have different actions on the human body. Some of the more dangerous of these isotopes are:[xciv]

- Xenon 137 with a half life of 3.9 minutes converts almost immediately to the notoriously dangerous cesium 137 with a half life of 30 years.
- Krypton 90, half life of 33 seconds, decays to rubidium 90, half life of 2.9 minutes, then to the medically toxic strontium 90, half life 28 of years.
- Xenon 135 decays to cesium 135 with an incredibly long half life of 3 million years.
- Large amounts of xenon 133 are released at operating reactors, and although it has a relatively short half life of 5.3 days, it remains radioactive for 106 days.
- Krypton 85 which has a half life of 10.4 years is a powerful gamma emitter.

Apart from noble gases, small amounts of the deadly radioactive elements created during the fission reaction also escape into the atmosphere fairly frequently during routine emissions from reactors, as they are not entirely trapped by filters. Some of these are:[xcv]

- Cesium-137 with a half-life of thirty years: it mimics potassium and tends to concentrate in the muscle cells in the body, causing cancer.
- Strontium 90 (half-life of twenty-eight years, meaning it remains radioactive for 600 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, with a half life of 8 days: it is both a beta and gamma emitter, and hence very carcinogenic; on entering the body, it circulates in the blood stream and is readily absorbed by the thyroid, to cause the rare thyroid cancer.

Radioactive releases from the Indian Point nuclear power plant in the United States have been polluting the Hudson River. In 2007, strontium-90 was detected in four out of twelve Hudson River fish.[xcvi] A fish taken from the Connecticut River, near the Vermont Yankee nuclear power facility, has also tested positive for strontium-90.[xcvii]

An important toxic isotope that is routinely emitted in large quantities into the air and nearby water bodies from nuclear power plants is tritium (H-3), a radioactive isotope of hydrogen, composed of one proton and two neutrons. Tritium is produced in the fuel rods of nuclear reactors as a fission byproduct. It is also produced in the primary coolant due to interaction of neutrons emitted from the fuel rods with water molecules. Tritium 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 (H3O). When the primary coolant water is filtered to remove some of its radioactivity, tritium is not removed, as it is chemically the same as water. Similarly, tritium water vapour is also not trapped by gas filters, and is discharged into the atmosphere during venting. The tritium produced in the reactors thus continuously finds its way into the atmosphere.[xcviii]

Tritium is a particularly scary material, as it is a beta emitter and is biologically very mutagenic, being readily absorbed through the skin, lungs and the GI tract. On absorption, it behaves like a water molecule and becomes part of the cell. Tritium causes tumors 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, mental retardation, brain tumours, decreased brain weight, loss of reproductive abilities of offspring, and stunted, deformed fetuses.[xcix]

In the US, tritium releases have also occurred quite frequently due to leaks at nuclear reactors, due to malfunctions.c In a recent report released in September 2010, the US Nuclear Regulatory Commission has acknowledged that more than half of America's 65 nuclear sites housing its 104 aging atomic reactors are leaking radioactive tritium. The US Environmental Protection Agency's "allowable" standard ("allowable" does not necessarily equal "safe") for radioactive tritium in drinking water is 20,000 picocuries per liter of water. According to the NRC, since January 2009, that level has been met or exceeded by releases into groundwater (not necessarily drinking water) at 37 reactor sites (out of 65). Radiation levels have ranged from 20,000 picocuries/liter to an astonishing 15,000,000 picocuries/liter (at New Jersey's Salem reactor complex). Radioactive tritium levels above 1,000,000 picocuries/liter were measured at nine nuclear sites covering 18 reactors.ci

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. The elements thus created, which are powerfully radioactive, include cobalt 60, iron 55, nickel 63, radioactive manganese, niobium, zinc, and chromium. These materials slough off from the pipes into the primary coolant. Officially called CRUD, it is so intensely radioactive that it poses a severe hazard to maintenance workers and inspectors. Nuclear reactors during shutdowns for maintenance or refuelling routinely flush out pipes, heat exchangers, etc., to remove the highly radioactive CRUD build-up. Some of the CRUD is sent to radioactive waste dumps while some is released to the river, lake or sea near the reactor.[cii]

To Sum-up

Although the nuclear industry claims it is "emission" free, in fact it is collectively releasing millions of curies annually. The total gaseous and liquid radioactive releases from nuclear reactors vary enormously depending upon accidental and larger-than-normal routine releases. For instance, in 1974, the total release from all reactors in the United States was 6.48 million curies, while in 1993 it ranged between 96,600 curies to 214,000 curies.[ciii]

Even these astounding figures are an underestimate, because not all the emissions are monitored by utilities. These figures also do not include the emissions due to the CRUD removed from reactors or the emissions due to the radioactive elements trapped in the primary coolant filters / gas filters – which are sent to waste dumps, from where the carcinogenic radioactive isotopes will inevitably leak and contaminate water supplies and food chains.

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 caused by radiation in the people living around nuclear power plants. However, there have been very few studies on this issue; the general stand of the environmental authorities, like for instance the US Environmental Protection Agency (EPA) and the US Food and Drug Administration (FDA), has been that these leakages are no cause of panic as radioactive substances pose a threat to our health only when consumed in massive quantities![civ]

The few studies that have been done on this issue have however come up with alarming findings. A study by researchers at the Medical University of South Carolina who carried out a sophisticated meta-analysis of 17 research papers covering 136 nuclear sites in the United Kingdom, Canada, France, United States, Germany, Japan, and Spain found evidence of elevated leukemia rates among children and young people living near nuclear facilities.cv Elevated leukemia rates among children were also found in a recent study that examined areas around all 16 major nuclear power plants in Germany .cvi

5. Radioactive waste: Leaking everywhere

Probably the most monstrous problem created by nuclear power is that of spent fuel, which is intensely radioactive, and is going to remain so for more than two lakh years! Each regular 1,000 MW nuclear power plant generates 30 tons of extremely potent radioactive waste annually.[cvii] 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 off the massive amounts of this lethal waste that it has continued to produce at an ever increasing pace – and scientifically speaking, considering the intensely radioactive and chemically corrosive nature of this waste, it is not possible to find such a permanent storage system. Since there is no way of removing the radioactive nature of these wastes, therefore, these wastes will have to be stored in temporary storage sites and constantly monitored to see that they don't leak. This is clearly iniquitous to future generations since they would have to take care of these wastes and bear the consequences for any leakage, while we use the electricity generated by these reactors. Ethical dilemmas aside, no technology that generates such long lived radioactive wastes can be considered environmentally sustainable.

Radioactive waste from nuclear power plants is currently stored in huge cooling pools, euphemistically called "swimming pools" at reactor sites, or in dry storage casks beside the reactor. Many countries have other temporary storage sites too. In the US, nuclear waste is currently stored at 121 temporary locations in 39 states across the country.[cviii] 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.[cix] Its consequences are going to be with us for the rest of time.

To give an idea of the deathly nature of this radioactive waste, we briefly discuss the health impact on human beings of plutonium, just one of the more than 200 elements created directly or indirectly during the fission process and which are present in this waste. Roughly 1% of the spent fuel created in a uranium-fuelled reactor consists of Plutonium.[cx]

Plutonium[cxi]

Named after Pluto, the Greek God of Hell, it is supposed to be one of the most dangerous substances on earth. An alpha emitter, it is so toxic and carcinogenic that less than one-millionth of a gram if inhaled will cause lung cancer. The half ton of plutonium released from the Chernobyl meltdown is theoretically enough to kill everyone on earth with lung cancer 1,100 times if it were to be uniformly distributed into the lung of every human being.

On being transported to the liver, Plutonium causes liver cancer. Because it is like iron, on inhalation, it eventually finds its way to the bone marrow to be incorporated into the hemoglobin molecule in the red blood cells. Here it irradiates bone cells to cause bone cancer and white blood cells made in the bone marrow to cause leukemia.

Plutonium is also stored in the testicles, and causes mutations in reproductive genes and increases the incidence of genetic disease in future generations. The half-life of plutonium 239 is 24,400 years, so it remains radioactive for half a million years. Therefore, once created, it is going to live on and enter reproductive organs and cause genetic mutations for the rest of time.

As we see below, such horrendously radioactive elements are bound to find their way into the environment from wherever this nuclear waste is stored.

Storing the waste

Spent fuel is highly radioactive and chemically active, and intensely hot – the waste repository will be at temperatures above boiling point for 1250 years, with temperatures inside the canister holding the waste touching 662 degrees Fahrenheit.[cxii] There is no way of guaranteeing that any storage system designed for such waste will not corrode and leak a few hundred years from now. All attempts to build even medium term storage systems for this waste have ended in complete disasters. We look at the attempts in the US and Germany below.

- ***The Yucca Mountain disaster***

All told, the nuclear reactors in the U.S. produce more than 2,000 metric tons of radioactive waste a year – and most of it ends up sitting on-site because there is nowhere else to put it. As of 2008, more than 64,000 tons of dangerously radioactive waste from nuclear power reactors had accumulated in the United States.[cxiii]

The private nuclear industry in the US has never taken responsibility of disposing off the massive quantities of radioactive waste produced by it. Obligingly, the US government passed the Nuclear Waste Policy Act in 1982, promising to take responsibility for it, and in 1987, designated the Yucca Mountain in Nevada as the primary repository for this waste. The project was envisaged as a complex of tunnels deep inside deep inside Yucca Mountain, 100 miles northwest of Las Vegas, where at least 77,000 tons of spent fuel from commercial plants, and government-generated nuclear waste, would be stored and ultimately buried. The site soon ran into huge problems; it also became clear that the site's geology was inappropriate to contain the waste. But the DOE was desperate to somehow make the site qualify for storing the waste; it even went to the extent of relaxing its norms. Despite its best efforts, including incurring costs to the tune of $13.5 billion, the project fell more than a decade beyond schedule because of a series of management missteps, legal challenges and budget cuts engineered by opponents in Congress. Finally, in 2010, President Obama decided to cancel the project, and set up a 15-member panel of experts to chart new paths to manage highly radioactive nuclear waste. Let's see what solutions they come up with.[cxiv]

- ***Germany's model storage system***

The German government has invested several hundred million euros in research at the Asse nuclear storage facility in Lower Saxony, Germany in an attempt to solve the permanent storage dilemma of the nuclear energy industry. Asse is actually an abandoned salt mine; more than a hundred thousand barrels of low-level and medium-level waste has been stored in this facility since the 1960s. Now, it turns out that water has been seeping into the mines for decades, rendering the facility in a precarious condition and in danger of collapsing, causing radioactive contamination of the region. There are also suspicions that highly radioactive waste has also been dumped in this facility without authorization. Authorities are now making an unprecedented attempt to retrieve and relocate hundreds of tons of waste from the site, something that has never been attempted anywhere in the world.

Asse was to serve as a model project for Germany's plans to build a permanent nuclear waste storage facility at Gorleben, also in Lower Saxony. Not only has the plan collapsed, the German Environment Minister Sigmar Gabriel has admitted that the Asse site was "the most problematic nuclear facility in all of Europe."[cxv]

A sobering thought…

Bittu Sahgal, Editor of *Sanctuary Magazine*, Mumbai writes: "If the centralized bureaucracy of Maurya Kings two thousand years ago had discovered nuclear power, we in India and Pakistan would probably be spending half our current national budget storing and caring for or repairing the damage done by atomic wastes." Indeed!

6. Reprocessing Nuclear Waste: Worsening the problem

Currently, six countries with nuclear reactors, China, France, India, Japan, Russia and the United Kingdom reprocess at least some of their spent fuel. Some of the other countries with a nuclear power program have also been shipping their spent fuel to France, Russia or the UK for reprocessing, though most of them have now ended this practice.[cxvi]

Supporters of reprocessing argue that it reduces the nuclear waste problem by reducing the volume of high level radioactive waste. However, decades of experience from reprocessing plants wherever they have been built in the world provides overwhelming evidence that not only is this argument illogical, reprocessing actually worsens the problems created by nuclear energy.

Firstly, reprocessing does not reduce the total amount of radioactivity to be dealt with. On the contrary, it increases the total volume of waste to be dealt with because reprocessing additionally creates a large amount of low-level and medium-level radioactive waste as all the equipment used in reprocessing becomes radioactive. According to US Department of Energy data, reprocessing increases the total volume of radioactive waste by a factor of seven![cxvii]

Neither does reprocessing reduce the waste disposal costs. The general consensus based on cost data from Western countries is that reprocessing as a waste management technique is far more expensive than direct disposal. A study done for the French Prime Minister in 2000 estimated that reprocessing and plutonium recycle increases the cost of nuclear power by about 0.2 US cents/kWh (assuming 5 ₣/dollar).[cxviii] This is primarily because of the enormous capital cost of the reprocessing facility.

Another major problem with reprocessing is that since it segregates plutonium from the spent fuel, and this pure plutonium can be used for making nuclear weapons, reprocessing increases nuclear proliferation and nuclear terrorism risks. In 1976, the US stopped the reprocessing of spent fuel because of proliferation concerns. In 2006, the Bush administration announced a new plan to reprocess spent nuclear fuel in a way that renders the plutonium in it usable for nuclear fuel but not for nuclear weapons, but the Obama administration scrapped these plans in July 2009.[cxix]

Finally, reprocessing plants discharge huge quantities of radioactive waste into the sea and air. The reprocessing plants in Sellafield in UK and La Hague in France are the biggest source of radioactive pollution in Europe. The radioactive contamination in the sea can be traced as far as the Arctic and eastern Canada.

Radioactive discharges from Sellafield

This nuclear complex on the coast of north-west England has reprocessing facilities, fuel fabrication and other installations. It has one of the highest concentrations of radioactive waste on the planet as well as a disastrous safety record with hundreds of accidents involving the release of radioactive substances into the environment and their radiation of workers.[cxx]

The reprocessing plants at Sellafield discharge some 8 million litres of nuclear waste into the sea each day.[cxxi] It has been estimated that over 40,000 TBq (trillion becquerels) of cesium-137, 113,000 Tbq of beta emitters and 1,600 TBq of alpha emitters have been discharged into the Irish Sea since the inception of reprocessing at Sellafield. This means that between 250 and 500 kilograms of plutonium from Sellafield is now adsorbed on sediments on the bed of the Irish Sea. Discharges of the noxious Technetium-99 (half-life 214,000 years) into the sea have also been very high.[cxxii] Radioactive contamination from the Sellafield plant is now reported to have extended through the Arctic Ocean into the waters of northern Canada.[cxxiii]

The radioactive pollution from the Sellafield plant has made the Irish Sea one of the most radioactively contaminated seas in the world. Marine life, in particular algae, plankton, and crustaceans including lobsters, have absorbed significant amounts of radionuclides, in many cases exceeding seafood safety levels by many times. In the vicinity of the complex, groundwater, estuaries and soil are contaminated, with levels in the area around Sellafield exceeding contamination inside the Chernobyl exclusion zone.[cxxiv]

The effects are visible in the local population. Compared to the British average, there has been a ten-fold increase of childhood leukaemia and non-Hodgkin's lymphoma around Sellafield. Plutonium dust has been found in the houses of residents living along the Irish Sea coast.[cxxv]

7. France: A Radioactive Mess

Let us discuss the situation in France in slightly greater detail, because it is the most nuclear powered country in the world. It derives over 75% of its electricity from nuclear energy, a result of a political decision taken by the government in 1974 after the first oil shock to rapidly expand the country's nuclear power capacity.

France's monopolistic dependence on splitting the atom to turn on the lights has come with a huge price – the country has become a radioactive mess, for which the people of France will pay with their health for many centuries to come. As the awareness has spread, polls in the last few years have consistently found more than 60% of French people favouring a phase out of nuclear energy.[cxxvi]

Uranium mining waste dumpsite

France used to be the largest uranium producer in Western Europe for decades; the last uranium mine in the country was shut down in May 2001. 300 million tonnes of radioactive waste are lying at 210 abandoned uranium mining sites in France without any protective measures or surveillance.[cxxvii] These radioactive mine tailings have been used in school playgrounds and ski-resort parking lots. Efforts to force France's state run uranium mining corporation Areva to clean up its mess have been met with resistance from the company.[cxxviii]

Areva's mining waste footprint extends beyond the borders of France, to Niger. Four decades of uranium mining by Areva's various subsidiaries have contaminated the entire region around the uranium mines of Niger with radioactive dust – dust that is going to remain radioactive for centuries. It has poisoned the air, contaminated the soil, and has even polluted the already scarce water sources in this desert region. This is having catastrophic consequences on the health and livelihoods of the local people.[cxxix]

Radioactive leakages

There have been several accidents at France's nuclear plants, which have led to radioactive leakages contaminating the environment, including the soil, air and nearby water bodies. Recently, in a major accident, a massive uranium spill occurred at the Tricastin nuclear complex in 2008, contaminating the nearby Gaffière and Lauzon Rivers. While Areva, France's nuclear corporation, denied the spill endangered human health, nevertheless, French authorities banned the use of water from the Gaffière and Lauzon for drinking and watering of crops for 2 weeks. Swimming, water sports and fishing were also banned. Tricastin wine growers have struggled to market their products since the accident.cxxx A week later, nuclear-safety officials discovered a burst underground pipe at a plant in Romans-sur-Isere, southeastern France, run by an Areva subsidiary; the pipe had been broken and leaking uranium for several years and didn't meet safety standards.cxxxi After initially downplaying the seriousness of the accidents, France's Environment Minister Jean-Louis Borloo finally acknowledged that France's nuclear facilities had experienced a total of 115 "small irregularities" in the first half of 2008.cxxxii

"No leakage" storage systems[cxxxiii]

The Centre de Stockage de La Manche (CSM), in Normandy, France, which contains a massive 520,000 cubic meters of nuclear waste, is one of the largest dump sites of nuclear waste in the world. Dumping here started back in 1969 and continued for 25 years till its closure in 1994. Even though the site was designed to contain low level waste, a government appointed commission found that the site contains unknown quantities of high level waste too. And now, it has been found that the radioactive waste from the storage facility is leaking into the groundwater used by local farmers. In 2005, scientists from a French laboratory found that radioactivity levels in nearby underground aquifers close to the dumpsite averaged 9000 Bq/l, or 90 times above the European safety limit of 100 Bq/l ! The situation is bound to get worse in the coming years, as more hazardous radionuclides, including plutonium and strontium gradually leak out.

After closure of CSM in 1994, the so-called low and intermediate level waste was transported to another dumpsite, the Centre de Stockage de l'Aube (CSA) in the Champagne-Ardenne region. This was claimed to be a state-of-the-art facility, and when the site was being built in the 1980s, people of the area were assured that there would be no radioactive leakage from the site. By 2002, the site had already received over 100,000 cubic meters of nuclear waste. Soon after, in 2006, it was found that the storage site had started leaking. Tritium leaking from CSA was found in underground water! And this is just the beginning; gradually more deadly radionuclides are bound to find their way into the groundwater in the coming years. Moreover, in an attempt to make it a high quality nuclear dump site, the storage site has been designed in such a way that no corrective measures can be taken! The people of this region and all their future generations are condemned to live with this radioactivity and all its consequences till eternity.

La Hague Reprocessing Plant: Polluting the Planet

The dirtiest French nuclear site -- with the cleanest of reputations -- is the vast reprocessing plant at La Hague on the Normandy coast. It is the world's number one plant, reprocessing more than 1700 tons of highly irradiated nuclear fuel rods annually. The plant produces huge volumes of liquid radioactive waste and radioactive gases. These are simply dispersed into the sea and air.

The plant has been pumping as much as 350 million litres of liquid radioactive waste every year into the English Channel – it has been going on since the 1980s, and has radioactively contaminated the seas as far as the Arctic Circle. These liquid wastes have been measured at 17 million times more radioactive than normal sea water according to an analysis by a French laboratory at the University of Breme.[cxxxiv] The dumping of this low-level waste into the sea clearly violates the 1992 OSPAR (Oslo-Paris) Convention for the Protection of the Marine Environment of the North-East Atlantic, signed by 15 European countries and the European Communities. Despite concerns voiced by many European governments, Areva has continued to dump the waste into the sea, taking advantage of a technical loophole in the Convention.[cxxxv]

The site is also one of the world's worst radioactive air polluters. Aerial discharges from La Hague have been found to radioactive krypton-85 at 90,000 times higher values than natural levels. Krypton gas released from La Hague has been traced across the globe.

An analysis of samples of leaves and grasses from around La Hague has revealed that radioactive carbon-14, which had been taken up by the plants in gaseous form, is two to seven times higher than normal background levels.cxxxvi

It is therefore no surprise that health impacts of these radiation releases are showing up in the local population. The British Medical Journal published findings of increased levels of leukemia around La Hague in 1997, findings that were confirmed by the French government's own studies made later in the same year. Subsequently, another study published in the July 2001 issue of the Journal of Epidemiology and Community Health also showed an increased incidence of leukaemia among under-25 year olds living within 10 kilometres of the plant.cxxxvii

Part IV: Impact of Nuclear Reactors on Marine Life

59 out of 103 nuclear plants in the US rely on what are known as 'once through cooling systems' to remove waste heat. In a nuclear plant with a 'once through cooling system', there are a series of three heat exchanging loops of water. The water in the first loop carries the heat from the reactor core to the steam generator, where it is transferred to the secondary loop. The water in the secondary loop is at lower pressure than the first loop, and is allowed to get converted to steam, which drives the turbine to generate electricity.

After the steam passes the turbine, it flows over pipes containing cold water from the river/sea. These pipes constitute the third loop. The contact of steam with this third loop causes the steam to condense back into into water. It can then be pumped back to the steam generator to repeat the process. The water in the third loop, which was sucked from the river or the sea, is then dumped back into the same source. In a typical nuclear plant in the US, the water circulating in the third loop can be many billions of litres a day!

Nuclear plant authorities have always claimed that their intake and discharge of billions of litres of water a day did very little harm to surrounding marine life.

In 2001, a major 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 on February 22, 2001,[cxxxviii] brought 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 water is sucked in at such a high velocity that along with the water, marine life is also sucked in; they are unable to resist the velocity. The bigger marine animals like the endangered sea turtles 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, all very essential to the food chain, pass through these screens, and are drawn into the reactor cooling system where 95% of them are scalded and discharged back into the water body as lifeless sediment. These high destruction rates can overtake recovery rates, resulting in extensive depletion of the affected species. In this way, entire marine communities can lose their capacity to sustain themselves.

With millions of litres of hot water being discharged into the waterway every minute, the total heat dumped into the waterway is tremendous. [How much? Roger Witherspoon, the well-known US journalist, author and editor, in a recent article has given some figures. Citing company records, he points out that 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 the heat which would be generated by exploding a nuclear bomb, the size of the bomb which destroyed Hiroshima, in the waters of Delaware Bay every two hours, all day, every day.[cxxxix]]

Such a huge hot water discharge damages and destroys fish and other marine life and dramatically alters the immediate marine environment. In the immediate discharge areas, the ocean floor is scoured clean of sediment by the force of the thermal discharge, resulting in bare rock and creating a virtual marine desert. Areas farther from the discharge become coated in heavy, life-stifling sediment. The water is discharged into the waterway at a temperature around 10-13 degrees Celsius higher than before. The increased temperature drives away indigenous species and attracts others, thus causing huge changes in the marine environment. Warmer waters also cause fatal disease, and disruption of normal behavior patterns, of some species of fish.

An analysis by the US Environmental Protection Agency has confirmed these findings. It has concluded that power plants with “once through cooling systems” are collectively killing more than one trillion fish annually and disrupting their local aquatic ecosystems with their hot water discharges. More significantly, the National Marine Fisheries Service (NMFS) has also now publicly acknowledged that "once through cooling systems" are vacuuming up trillions of newly hatched fish – those under a half inches in length – and destroying them in their heat exchangers. The NMFS has in fact gone so far as to state that there is "strong evidence" that the decline in fish stocks along the entire northeast Atlantic seaboard is due more to the destruction of baby fish than to over fishing of adults.[cxl]

Despite this overwhelming evidence, such is the clout of the nuclear power companies that environmental and nuclear regulators have not moved to force nuclear plants using "once through cooling systems" to retrofit their plants with cooling towers. Utilities using cooling towers draw in a lowered water intake of about 70,000 litres a minute, reducing damage to marine life by as much as

90-100 %. Cooling towers also eliminate the need to discharge large volumes of heated water into the water source and the resulting damage to the marine environment in the discharge area. It costs just about $1.5 billion to build a cooling tower, which though large in absolute terms represents only a small percentage of the profits of these utilities.

Last year (2010), for the first time in the US, environmental authorities of two states, New Jersey and New York, acknowledged that nuclear plants (and also coal power plants) with 'once through cooling systems' are killing billions of juvenile and mature fish annually, and that this was negatively impacting a wide variety of fish. They are now mounting pressure on such plants in their states to retrofit their plants with modern cooling systems like cooling towers which won't kill fish, or cease operations.

Part V: The Inevitability of Nuclear Accidents

The fission reaction produces such a deadly concoction of radioactive elements that radiation contained within the reactor of a 1000 MW nuclear power plant is equivalent to that of 1000 Hiroshima bombs! As discussed above, some of this will inevitably find its way into the environment and contaminate it, with all its terrible consequences. But 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. Not once, but quite a few times. We discuss the two biggest such accidents below, the Three Mile Island meltdown of 1979 and the Chernobyl disaster of 1986. Then we go on to discuss the performance of the nuclear industry in the 24 years since Chernobyl, to see if it has become any safer.

1. Three Mile Island

Beginning at 4 am on March 28, 1979, a relatively minor problem in the Unit 2 reactor of the Three Mile Island nuclear power plant in Pennsylvania quickly cascaded into a series of automated events that led to the meltdown of the reactor core.

America's private nuclear power industry and government authorities continue to maintain, to this day, that despite the meltdown of almost half of the uranium fuel at Third Mile Island (TMI), there were only minimal releases of radiation to the environment. According to the NRC, in the month after the TMI accident, a total of around 13 million curies of radioactive gases were released into the atmosphere, most of which were noble gases – which the government claims are harmless – and only 13 to 17 curies of it was the dangerous Iodine-131. Strangely, it makes this claim, despite the fact that the government authorities (including the NRC) and the industry made no serious attempt to monitor the radioactive releases after the meltdown. To date, no survey has ever been made by them of the air and soil around the plant for long-lived highly radioactive elements like strontium, americium and plutonium, despite the fact that these must have most definitely escaped from the reactor core due to the meltdown.[cxli] A fact sheet distributed by the NRC says: TMI "led to no deaths or injuries to plant workers or members of the nearby community."[cxlii]

We today know for a fact that the nuclear industry and government are blithely lying. There is a growing body of scientific evidence presented by numerous independent experts which suggests that radiation releases from the TMI plant due to the meltdown were hundreds if not thousands of times higher than what the government and industry have acknowledged.

According to estimates by Dr. Karl Morgan (published in 1982), the Three Mile Island accident released at least 45 million curies of noble gases and 64,000 curies of radioactive iodine. Dr. Karl Morgan was the founder of Health Physics, the science of human health and radiation exposure. It is also known that on day three of the accident, 172,000 cubic feet of high-level radioactive water were released into the Susquehanna River by the nuclear plant company without NRC permission, an event unheard of in the history of the nuclear industry. The Susquehanna River drains into Chesapeake Bay, a major fishing location. Then, in June 1980, large quantities of radioactive krypton 85 were purposefully vented from the damaged reactor in June 1980, exposing even more people to radioactive contamination. Again in November 1990, 2.3 million gallons of radioactive water containing tritium was also purposefully evaporated from the damaged reactor building, exposing many people in the vicinity to dangerous radioactive elements.[cxliii]

Some months ago, at a symposium in Harrisburg (capital of the state of Pennsylvania) to mark the 30th anniversary of the TMI disaster, independent experts presented yet more evidence to prove that the official story that minimal radiation escaped from the TMI meltdown is a big lie. For instance, Arnie Gunderson, a nuclear engineer and long-time nuclear industry executive, stated that it could be deduced from industry data that at least one billion curies of radiation were released. More serious is the finding by these independent experts that hidden in a government commission's technical report is the admission that at least one million curies of Iodine-131 was released into the atmosphere – that is way off from the official admission of just 13-17 curies![cxliv]

The experiences of people living near Three Mile Island also do not match with official claims that the meltdown did not have any health effects on the people living near the plant. On the contrary, their acute sufferings further prove that they were exposed to high levels of radiation exposure. Surveys of nearby residents have revealed a huge increase in cancers, including lung cancer and leukemia, skin and reproductive problems, organ collapse, and chromosomal damage – all associated with high levels of radiation exposure.[cxlv]

The Three Mile Island case eventually went to court, with approximately 2,000 residents claiming that the radioactive releases from the meltdown were much larger than admitted by the nuclear industry and government. After several dismissals and appeals, the sick plaintiffs gave up and decided to settle for out-of-court settlements. They got hardly anything, the largest settlement being $1.1 million for a child born with Down's syndrome.[cxlvi]

This is the real reason why the nuclear industry and its concubine governments refuse to admit to the release of radiation from nuclear power plants, even when there is a major accident: so that compensation payments to the affected people are minimised!

2. Chernobyl

On April 26, 1986, Unit Four of the Chernobyl nuclear power plant exploded, spewing almost all the contents of the deadly radioactive fission products into the environment. This medical 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 various agencies of United Nations maintain a conspiracy of silence over the true effects of Chernobyl on human life on Earth. The World Health Organisation does not independently research the health consequences emanating from nuclear accidents. It signed an agreement with the International Atomic Energy Agency (IAEA) in 1959 subordinating itself to the latter in matters of interest to the IAEA. Dr. Michael Fernex, formerly on the faculty of the University of Basel, who worked with the WHO, said in 2004, "Six years ago we tried to have a conference. The proceedings were never published. This is because in this matter the organizations at the UN are subordinate to the IAEA… The IAEA blocked the proceedings; the truth would have been a disaster for the nuclear industry."[cxlvii]

The IAEA is a cheerleader for the global nuclear industry, and has been actively promoting the construction of nuclear reactors worldwide. Obviously then, the IAEA would seek to obfuscate the true magnitude of the Chernobyl disaster. 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 leukemia 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.[cxlviii]

Let us compare these figures with some of the medical and ecological consequences of Chernobyl that we know today[cxlix]:

- Nearly nine million people living in Belarus, Ukraine and Russia were heavily exposed to radiation. In all, 20% of the land area of Belarus, 8% of the Ukraine, and 0.5% to 1% of Russia – 100,000 square miles – was contaminated, an area slightly less than the area of the state of Maharashtra. It will remain so for thousands of years. Agricultural areas covering nearly 52,000 square kilometers, slightly less than the area of the state of Himachal Pradesh, were ruined.
- While 400,000 people living in the most contaminated areas near the plant – in a perimeter of 30 km around the plant – were evacuated and resettled elsewhere, more than 5 million people continue to live in the affected regions, over 1 million of whom are children, who are inordinately sensitive to radiation. They now live with the knowledge that they and their coming generations are forever contaminated, that they could get cancer anytime, and that their children and grandchildren and great grand children could be born with severe birth defects.
- Several independent studies have shown a many fold increase in leukemia, brain tumours and other forms of cancer in the population of the affected regions in Belarus, Ukraine and Russia.

Till 2005, there were at least 10,000 cases of thyroid cancer in Belarus alone, of which nearly a 1000 were in children – thyroid cancer in children is a very rare form of cancer. Many of the genetic abnormalities and diseases caused by this accident are generations away and will not be seen by anyone alive today.

- Heavy radioactive fallout occurred over Austria, Bulgaria, Czechoslovakia, Finland, France, East and West Germany, Hungary, Italy, Norway, Poland, Romania, Sweden, Switzerland, Turkey, Britain, the Baltic States, and Yugoslavia. Evidence has already started surfacing of its health effects. There have been at least 10,000 additional cases of serious malformation in Europe due to Chernobyl. A recent study from Sweden showed an increase of 849 cancers up to the year 1996 as a result of Chernobyl. There are now claims surfacing in France that people are suffering from thyroid cancer that may be related to the Chernobyl fallout.
- Because cesium-137 and other isotopes such as strontium-90 and plutonium-239 have such long half-lives, food in contaminated parts of Europe will be radioactive for hundreds of years. 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. In the south of Germany, very high levels of cesium in the soil persist; hunters are compensated for catching contaminated animals, and many mushrooms and wild berries are still too radioactive to eat. Cesium-137 in some parts of France is as high as some extremely contaminated areas in Belarus, the Ukraine, and Russia.
- Even though, as the data above shows, food in many parts of Europe is still relatively radioactive, this terrible problem is rarely mentioned in the media or in daily conversation. In a form of psychic numbing, people continue to live their lives as if all were well, and the nuclear power industry continues to broadcast the myth that its product is clean and green.

A new study on Chernobyl

Just as we were finishing this book, we came across a new book from the New York Academy of Sciences published in 2010, on the 24th anniversary of the meltdown at the Soviet facility. The book, "Chernobyl: Consequences of the Catastrophe for People and the Environment," was compiled by authors Alexey Yablokov of the Center for Russian Environmental Policy in Moscow, and Vassily Nesterenko and Alexey Nesterenko of the Institute of Radiation Safety, in Minsk, Belarus. The authors examined more than 5,000 published articles and studies, most written in Slavic languages and never before available in English. Among their important findings are:[cl]

Radioactive emissions from Chernobyl accident, once believed to be 50 million curies, 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.

One nuclear reactor can pollute half the globe. Chernobyl fallout covered the entire Northern Hemisphere. Apart from the Soviet Union, nations which received high doses of radioactive fallout include Norway, Sweden, Finland, Yugoslavia, Bulgaria, Austria, Romania, Greece, and parts of the United Kingdom and Germany. About 550 million Europeans, and 150 to 230 million others in the Northern Hemisphere received notable contamination. Fallout reached the United States and Canada nine days after the disaster.

Of the approximately 830,000 people who were in charge of extinguishing the fire at the Chernobyl reactor and deactivation and cleanup of the site (the so-called "liquidators"), by 2005, between 112,000 and 125,000 liquidators had died.

Nearly one million people (985,000 to be more precise) have died worldwide due to Chernobyl fallout from 1986 through 2004, a number that has since increased.

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!!

3. Post-Chernobyl

Today, 24 years after Chernobyl, nearly 9,000 reactor-years experience has accumulated worldwide.[cli] This post-Chernobyl period has passed without a major accident, large-scale contamination and severe radiological consequences. The question is, is this an achievement or just simply luck? Has the risk from nuclear power plants been mastered and safety been improved to "acceptable standards"?

The nuclear industry claims that safety issues have been adequately addressed after these accidents. It also claims that the Chernobyl catastrophe was only the result of old technology and mismanagement within the old Soviet bloc. And so, over the last decade, it has also launched a counter offensive to resuscitate nuclear power after decades of stagnation.

However, the reality is quite the opposite. In the 24 years after Chernobyl, there have been several near misses at nuclear power plants in the United States and other countries. It is only sheer fortune that another Chernobyl has not happened. This has been very powerfully brought out in a study which was initiated after one such near-miss, the Forsmark incident in Sweden in 2006, when it was possibly only a matter of minutes by which an accident on the scale of Chernobyl was prevented from happening in this reactor. This incident led researchers at the Union of Concerned Scientists[clii], and institutes in Germany and Austria, to jointly carry out a study of the safety records of nuclear power plants in several countries to identify whether any abnormal "events"[cliii] took place in them after Chernobyl, and analyse these events.

The report[cliv], released by the Greens in the European Parliament in 2007, concluded: Many nuclear safety related events occur year after year, all over the world, in all types of nuclear plants and in all reactor designs. Some of these events and incidents could have evolved into serious accidents, had the defects, malfunctions, etc. not been discovered in time (near-misses)! Many of these have remained significantly under-evaluated when it comes to their potential risk. Therefore, the widespread belief that lessons learnt from the past have enhanced nuclear safety turns out ill-conceived.

The report mentions 16 “events” in 9 countries, all of which could have snowballed into a major accident: June 18, 1988, Tihange-1 (Belgium); February 9, 1991, Mihama-2 (Japan); April 3, 1991, Shearon Harris (USA); July 28, 1992, Barseback-2 (Sweden); February 7, 1993, Three Mile Island (USA); May 12, 1998, Civaux-1 (France); December 27, 1999, Blayais-2 (France); July 2000, Farley (USA); March 18, 2001, Maanshan (Taiwan); August 12, 2001, Philippsburg (Germany); December 14, 2001, Brunsbüttel (Germany); March 6, 2002, Davis Besse (USA); August 29, 2002, 17 TEPCO Reactors (Japan); April 2003, Paks (Hungary); March 1, 2005, Kozloduy-5 (Bulgaria); July 25, 2006, Forsmark (Sweden).

Mycle Schneider, the renowned nuclear consultant and coordinator of this study, states, “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.”[clv]

Let us briefly discuss two of these incidents.

David-Besse, 2002

In recent years, the most serious episode involving a US nuclear reactor took place at the Davis-Besse plant in Ohio in 2002. The reactor came within days or weeks of a major catastrophe.

To save money, the owner of the reactor, First Energy, had persuaded the NRC to delay inspection of a vital safety component. When the plant was finally shut down, safety inspectors found that corrosion had eaten away the outer six inch thick carbon steel cover of the reactor vessel. The inner lining of the reactor vessel was of 3/16 inch stainless steel, and high pressure inside the reactor vessel had caused the stainless steel lining to bulge outwards into the cavity caused by the corrosion. Fortunately, the stainless steel bent, but did not rupture. The emergency core cooling system was also not working. Had the stainless steel ruptured, the core cooling water would have leaked, and with the emergency cooling system also inoperable, it would most probably have led to a cascade of events culminating in a reactor meltdown.[clvi]

First Energy knew about the corrosion, but in order to continue production, had delayed informing about it to the NRC. It was ordered to pay a fine of $28 million in 2004, which was barely one percent of its profits in that year.[clvii]

Forsmark, 2006

In an even more serious accident, on July 25, 2006, the Forsmark nuclear power station in Sweden came within just 2 hours of a meltdown. The Forsmark accident was caused by the failure of back-up generators following a problem with the main power supply. Without power supply, the reactor cooling system stops functioning, which can lead to sharp spike in temperature and a meltdown within just two hours. According to a former director of the plant, “it was pure luck there wasn't a meltdown”.[clviii]

Conclusion: Nuclear Reactors are Inherently Accident-Prone

The conclusion is inescapable: nuclear reactors are no more safer today than they were during the 1980s, when TMI and Chernobyl occurred. In the words of M.V. Ramana, one of India's leading nuclear experts: The basic features of all nuclear reactors remain the same. It is a complex technology, involving large quantities of radioactive materials, and relatively high temperatures and pressures. In such technologies, even minor failures or human errors can lead to a cascading chain of events culminating in a major accident. Sociologists and organization theorists have come to the pessimistic conclusion that with such high-technology systems involving extremely hazardous materials, 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.[clix]

4. Inching towards another Chernobyl: Relicensing of Old Nukes

As if this danger wasn't enough, nuclear authorities worldwide, under industry pressure, are granting permission to extend the operating lifetimes of the existing nuclear plants by 10-20 years.[clx] More than half of America's nuclear plants have received new twenty-year operating licenses. Many of these plants have also received "power up-rates" that allow them to run at up to 120 percent of their originally intended capacity.[clxi]

In the words of Robert Alvarez, senior policy advisor at the Department of Energy (DOE) from 1993 to 1999, and presently executive director of the Standing for Truth About Radiation (STAR) Foundation, this is an “invitation to disaster”.[clxii] That is because the risk of accidents increases as plants get older. The reason is obvious: as it is, there is deterioration in any machine as it gets old; but for nuclear plants, the aging is much more because nuclear reactors are subjected to unprecedented amounts of heat, pressure, stress, corrosion and radiation. All these make the various parts of the reactor brittle, increasing the possibility of mechanical failures of one or the other parts of the reactor, which could lead to massive releases of radioactivity into the atmosphere. This is why, as the reactor fleet in the US ages, the vulnerability of the reactors to failures has been increasing. According to David Lochbaum, one of the foremost nuclear safety engineers in the USA and Director of the Nuclear Safety Project for the Union of Concerned Scientists, there have been 47 instances since 1979 in which nuclear reactors in the U.S. have had to be shut down for more than a year for safety reasons![clxiii]

What makes the situation even more fraught with danger is that the NRC, the US government agency overseeing the nuclear industry, has gone about giving licenses for lifetime extensions and power upratings in a very lackadaisical manner. Instead of doing its own research on whether the plant is in a good enough condition to be given permission to operate beyond 40 years, it has simply accepted corporate assertions about safety, and even used industry language verbatim in its reports.[clxiv] With such a casual approach towards licensing, it shouldn’t surprise anyone that the NRC has not rejected a single license-renewal application in the last many years.[clxv]

In an article published in The Nation aptly titled "Zombie Nuke Plants", Christian Parenti, the well-known American investigative journalist, author, and fellow at the Nation Institute, gives the example of the lifetime extension given to the Oyster Creek reactor located in New Jersey to illustrate this lax approach of the NRC. The Oyster Creek reactor is one of the oldest plants in the USA and was scheduled to be shut down in 2009. But before that could happen, the NRC relicensed it on April 8, 2009, extending its life span by twenty years. Just seven days after that, workers at the plant found an ongoing radioactive leak of tritium-polluted water. Four months later, in August, workers found another tritium leak coming from a pipe buried in a concrete wall. The second leak was spilling about 25,000 litres a day and contained 500 times the acceptable level of radiation for drinking water. Obviously, radiation had made the pipe brittle, and so it had leaked. Which means that the pipe was old. But the licensing paperwork claimed that the pipe had been replaced! How many other mislabelled, brittle, old components remain in the plant's guts is difficult to say. Parenti writes: "Unfortunately, stories like this are all too common: crumbling, leaky, accident-prone old nuclear plants, shrouded in secrecy and subject to lax maintenance, are getting relicensed all over the country."[clxvi]

5. Are Generation-III Reactors Safer?

As we have discussed in Chapter 1, the bottom fell out of the nuclear reactor manufacturing industry in the USA and Europe after the Chernobyl accident. Not only did new reactor construction ground to a halt, plants ordered were also cancelled. Over the last decade, in a desperate bid to resuscitate itself, the Western nuclear reactor manufacturing industry has launched a huge propaganda offensive to usher in a "nuclear renaissance". One of the important arguments it is making is that it has drawn lessons from the Chernobyl accident and developed a new generation of nuclear power plant designs which are much safer than the older designs.

The nuclear industry describes its evolution in terms of 'Generations'. Generation-I reactors were developed in the 1950s-60s, and are primitive by today's standards. The majority of the reactors currently operating in 31 countries around the world are Generation-II reactors.

The latest generation of reactors, the Generation-III reactors or "advanced reactors", was developed in the 1990s, following the Chernobyl accident. Within the Generation III, there is now also a Generation III+ design, but the distinction between them is unclear.[clxvii] The World Nuclear Association claims that these reactors are safer, with reduced possibility of core melt accidents. The two European Pressurised Reactors (EPRs) under construction in Western Europe – the first reactors to be constructed anywhere in the USA, Canada and Western Europe in the last three decades (excluding the Civaux-2 reactor in France which was constructed in the 1990s) – belong to this category. The EPR is supposed to be one of the most "advanced" designs, having an improved safety level (in particular, the probability of a severe accident is reduced by a factor of ten), and it also has features to mitigate effects of severe accidents.[clxviii]

Throughout the world there are around 20 different designs under development for Generation-III and III+ reactors. However, a 2005 Greenpeace study on Nuclear Reactor Hazards by four eminent nuclear experts noted that most of these are "evolutionary" designs that have been developed from Generation II (i.e. current) reactor types with some modifications, but without introducing drastic changes. A typical example is the EPR design: it is simply a slightly modified version of the French N4 and German Konvoi reactors (the two latest Generation II PWRs currently in operation in France and Germany respectively), with some improvements. The study noted that it is doubtful if the modifications which are hailed to be safety improvements will work as claimed. On the contrary, it has several other modifications which actually reduce safety.

The study concludes: "All in all, 'Generation III' appears as a heterogeneous collection of different reactor concepts. Some are barely evolved from the current Generation II." The modifications are *primarily aimed at cost-cutting and better economics*, although the nuclear industry fallaciously claims that these new designs are safer as compared to currently operating reactors "*in the hope of improving public acceptance*" of nuclear power (our emphasis).[clxix]

More recently, US and UK regulators reviewing the designs of some of these latest reactors have raised serious concerns about their design (discussed in detail in Chapter 6).

Therefore, these latest series of nuclear reactors no more safer than present reactors. On the contrary, they are inherently more dangerous! That is because many of the Generation III reactors are of large designs, of 1000 MW and above, and so they are inherently more dangerous than the present reactors because they have much more radioactivity in their core. For instance, the EPRs being constructed in Finland and France are of 1650 MW, and so, in the event of a serious accident, the impact would be more devastating than Chernobyl – the Chernobyl reactor was of 1000 MW capacity! Therefore, the EPR needs more stringent quality control just to match the safety level of present day reactors; however, as we discuss in detail in Chapter 6, it is doubtful if even present-day safety standards will be met! In an attempt to reduce costs and complete the project on schedule, the nuclear companies constructing these reactors have selected cheap, incompetent subcontractors, and have overlooked safety-related problems!!

…..................

In her classic work, "Nuclear Power is not the Answer to Global Warming or anything else", Dr. Helen Caldicott, the pioneering Australian antinuclear activist and pediatrician who co-founded Physicians for Social Responsibility writes: "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."[clxx] In its greed for profits, the world's nuclear industry is pushing to making her grim foreboding come true sooner than later.

Even asssuming that there will not be another Chernobyl, the damage caused by radioactive waste from nuclear plants for our future generations will be no less worse than Chernobyl. In the words of Helen Caldicott again:

"Nuclear power produces massive quantities, hundreds of thousands of tons of radioactive waste, which will get into the water, concentrate into the fish, the milk, the food, human breast milk, fetuses, babies, children. Radioactive iodine causes thyroid cancer. Twelve thousand people in Belarus had thyroid cancer. Radioactive Strontium 90 causes bone cancer and leukemia, [it] lasts for 600 years. Cesium 137 - all over Europe now - in the reindeer, in the lands, in the food, lasts for six hundred years, causes brain cancer. Plutonium, the most dangerous substance on Earth, 1 millionth of a gram cause cancer, lasts for 250,000 years. Causes lung cancer, liver cancer, testicular cancer, damages fetuses so they are born deformed.

"Therefore, nuclear waste for all future generations will cause cancer in young children because they are very sensitive, [will cause] genetic disease, congenital deformities. Nuclear power is about disease, and it's about death. It will produce the greatest public health hazard the world has ever seen for the rest of time. *We must close down every single nuclear reactor in Europe and throughout the world*..." (Emphasis ours)[clxxi]

Is Nuclear Energy Cheap?

Part I: New Claims to Resuscitate Nuclear Power

Fuel costs of nuclear energy are remarkably low because a million times more energy is released per unit weight by fission than by combustion. And so, till the early 1970s, nuclear industry and governmental authorities the world over used to claim that nuclear energy would be "too cheap to meter."

That claim went kaput by the late 1970s. In the US, final construction costs of nuclear power plants were coming out to be several times their initial estimates. A 1986 Department of Energy (DOE) study of the 75 nuclear power plants commissioned between 1966 and 1977 found that while the predicted construction costs of these plants had been $45 billion, the actual costs turned out to be $145 billion – a total increase of $100 billion, not including finance or interest charges.[clxxii]

The same was true of operating costs – the actual operating costs were turning out to be much more than the estimated costs. A 1995 EIA (Energy Information Administration, U.S. Department of Energy) study found that real (inflation-adjusted) average annual non-fuel plant operating costs for all plants in operation in the US in 1993 escalated from about $37 per kW of plant capacity to $126 million per kW (in 1993 dollars) between 1974 and 1993.[clxxiii]

The construction cost overruns and sky-high operating budgets was an important reason, apart from safety concerns, that brought nuclear ordering to a halt in the United States and led to more than 100 cancellations of plants at various stages in the construction process.[clxxiv]

In Britain, the poor economics of nuclear energy became evident when the government attempted to privatize its nuclear power plants in 1987-90. Private investors rigorously calculated the costs and found that the operating costs alone were about double the expected market price for electricity, and refused to buy the nuclear assets.[clxxv] The government finally managed to sell off eight nuclear power stations to British Energy in 1996. The deal was an absolute scandal. The British government sold the eight 1200 MW stations for just about £1.7bn, an amount which was about half the cost of building Sizewell B, the newest of the plants.[clxxvi]

Evidence from other countries too pointed in the same direction – that construction costs and operating costs of nuclear power plants were very high.

Apart from the accidents at Three Mile Island and Chernobyl, and the huge problem of disposal of nuclear waste, this unfavourable nuclear economics was another factor that contributed to the drying up of nuclear orders across the world in the 1980s-90s.

New Claims to Usher in a Nuclear Renaissance

However, over the past decade, the nuclear industry has once again launched a huge propaganda offensive to convince the public about the supposed advantages of nuclear power over fossil fuels. It has now come up with a new argument: that it has developed a new generation of nuclear power plant designs, so-called Generation III and Generation III+ designs, which are safer and less expensive. (According to many experts, there is not much difference between these two.[clxxvii] We have discussed the safety issues of these reactors in Chapter 3).

For instance, a report by the World Nuclear Association, an international organization of private sector nuclear power equipment suppliers, aptly titled "The New Economics of Nuclear Power", says that taking into consideration the higher construction and lower operating costs of nuclear power as compared to fossil energy, the "key development in the 'new economics' of nuclear power is that, both costs considered, nuclear power has now become less expensive than fossil and any other form of electricity generation."[clxxviii] It gives the following statistics[clxxix]:

Summary of generating costs in cents per kWh

	5% Discount rate	10% Discount rate
Nuclear	2.1 - 3.1	3 - 5
Coal	2.5 - 5	3.5 - 6
Natural gas	3.7 - 6	4 - 6.3

Part II: Reviewing the New Claims

Electricity Costs from Generation III and III+ Reactors

The most important component of nuclear electricity cost is the 'Fixed cost'. Fixed costs are those that are incurred whether or not the plant is operated. These comprise mainly costs associated with construction and decommissioning but are dominated by the former. The 'rule of thumb' is generally that fixed costs made up at least two thirds of the total cost per kWh.

Other significant elements in the economics of nuclear power are the operating cost, including the cost of fuel, and the waste disposal cost.

Difficulties in Making Cost Estimates

The civilian nuclear power industry has been in operation for over fifty years. During such a long period, technological improvements and experience should have led to learning, and subsequently to enhancements in economic efficiency and falling costs. However, the nuclear industry has not followed this pattern. Like we saw above for the US, in country after country, the construction costs have considerably gone over-budget. Similarly, construction times instead of declining have actually doubled – the average construction time for nuclear plants has increased from 66 months for completions in the mid-1970s, to 116 months (nearly 10 years) for completions between 1995 and 2000.[clxxx] Therefore, it is difficult to draw lessons from past experience to make any estimates of electricity costs for the new designs being promoted by the nuclear industry.

The other problem with making these estimates is that there is very little or no construction experience for these new designs. The only Generation-III reactors currently in operation are the

Advanced Boiling Water Reactors (ABWR) developed in Japan.[clxxxi] By the end of 2009, four ABWRs were in service and two under construction in Taiwan. Total construction costs for the first two Japanese units were reported to be $3,236/kW for the first unit in 1997 dollars and about $2,800/kW for the second. These costs are well above the forecast range. These units have also suffered design problems in the turbine, implying that a new turbine design will be required, which might take several years.[clxxxii] While no Generation III+ reactor has ever been built; only one Generation III+ reactor design is under construction, Areva's EPR, one at Olkiluoto in Finland, one at Flamanville in France, and two in Taishan in China. Obviously, nothing is known about what will be the operating cost of this design; while all that we know about its construction costs is that these have sharply escalated as work has progressed (see below).

Estimates by Independent Institutions

Over the past decade many independent institutions have conducted systematic and detailed studies of nuclear plant costs, and their assessments contradict the claims of the nuclear industry. We give below the results of some of these studies, done by well-respected bodies.

A report from the New Economics Foundation, an independent British think tank founded in 1986 by the leaders of The Other Economic Summit (TOES), titled "Mirage and Oasis: Energy Choices in an Age of Global Warming" concluded that the cost of nuclear power has been underestimated by almost a factor of three.[clxxxiii] Another study by the US Department of Energy's (DOE) Energy Information Administration concluded that nuclear power is more costly than natural gas and coal plants.[clxxxiv] A University of Chicago study in 2004 also came to the same conclusion.[clxxxv]

In May 2006, in response to the so-called 'Nuclear Renaissance', the Centre for International Governance Innovation based in Canada, (an independent think tank led by a group of distinguished academics and supported by the Government of Canada) initiated the 'Nuclear Energy Futures Project' to investigate the likely size, shape and nature of the purported nuclear energy revival to 2030. Its report in February 2010 concluded that one of the important factors constraining the expansion of nuclear energy was its economics: "The economics are profoundly unfavourable and are getting worse. This will persist unless governments provide greater incentives..."[clxxxvi]

MIT Updated Study 2009

Probably the most sophisticated and widely cited study on the economics of nuclear power is a 2003 study by the Massachusetts Institute of Technology (a pro-nuclear institution) titled "Future of Nuclear Power", which was updated in 2009 to take into consideration the sharp increase in construction costs of nuclear as well as coal and gas fired power plants. This study concluded that the "levelised" cost of electricity[clxxxvii] generated by a new nuclear power plant is about 30-35% higher than the cost of electricity from a coal fired or combined cycle gas turbine plant.[clxxxviii]

Cost of Electricity Generation Alternatives

MIT Study Update 2009: In Cents/kWh ($2007)

Nuclear	Coal	Gas
8.4	6.2	6.5

Opinion of Credit Ratings Agencies and IFIs

Credit rating agencies must have strong research capabilities. Moody's, one of the world's leading credit agencies, in a report in October 2007 estimated “overnight” construction costs[clxxxix] for a nuclear plant at US$5000-6000/kW. Standard and Poor's, another world renowned credit agency, in its report of October 2008 says that these costs, after including interest during construction and other inflation factors, can range from $5,000 per kW to $8,000 per kW.[cxc] These estimates are much more than the overnight cost used by the MIT Update of 2009 for its calculations, which was only $4000/kW. Which means that these credit agencies reckon that the cost of nuclear electricity is going to even more than that estimated by the MIT team!

Credit rating agencies are out-and-out pro-corporate bodies; they will not make recommendations based on environmental considerations. Even they conclude that the economics of nuclear power is ruinous. Standard and Poor's stresses: “no utility will commit to a project as large and risky as a new nuclear plant without assurance of cost recovery”. Similarly, Moody’s “believes that many of the current expectations regarding new nuclear generation are overly ambitious.” [cxci]

The World Bank has been willing to finance the most environmentally destructive projects, so long as corporations can make handsome profits. But even it is not willing to give loans for nuclear plants! The economics of nuclear power is so deleterious that with the exception of a 1959 loan to Italy, it has never financed a nuclear power plant and there are no signs that it has changed its financial risk analysis.[cxcii] In fact, the World Bank’s lending advice explicitly states: “Nuclear plants are thus uneconomic because at present and projected costs they are unlikely to be the least-cost alternative. There is also evidence that the cost figures usually cited by suppliers are substantially underestimated and often fail to take adequately into account waste disposal, decommissioning, and other environmental costs.”[cxciii]

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…”[cxciv]

Real Life Scenario: Nuclear Reactor Costs Escalating

That the nuclear industry is understating costs in order to promote a nuclear revival is obvious from the fact that estimated plant construction costs have sharply escalated over the past few years. In Canada, the Ontario government suspended a competitive process for purchase of new reactors in June 2009, because the price quoted in the only valid bid it received was three times the price it was hoping to pay. That bid was from Atomic Energy of Canada Ltd, and it quoted a price of $26 billion for the construction of two 1,200-megawatt Advanced CANDU Reactors, which worked out to $10,800 per kilowatt of power capacity![cxcv]

Likewise, cost estimates of the two new 1350MW ABWRs proposed to be built by NRG Energy at the South Texas Project have zoomed to $13.9 billion, plus an additional $4.3 billion as financial charges (for a total of $18.2 billion), from a preliminary estimate of $5.4 billion. That works out to an overnight charge of roughly $5150/kW (overnight charges, that is, excluding the financing charges).[cxcvi] If at all the plant construction begins, what will be the final cost is anybody's guess!

These examples are not exceptions. "The Economics of Nuclear Reactors," a report released on June 18, 2009 by Dr. Mark Cooper, senior fellow for economic analysis at the Institute for Energy and the Environment at Vermont Law School, analysed over three dozen cost estimates for proposed new nuclear reactors and found that the projected price tags for the plants have quadrupled since the start of the industry's so-called "nuclear renaissance" at the beginning of this decade – a striking parallel to the eventually seven-fold increase in reactor costs estimates that doomed the "Great Nuclear Boom" of the 1960s and 1970s, when half of planned nuclear reactors had to be abandoned or cancelled due to massive cost overruns.cxcvii

Olkiluoto-3 and Flamanville-3

The order for the Olkiluoto-3 (OL3) reactor being built in Finland, the first nuclear order in Western Europe since the Civaux-3 order in France of 1993, was placed in December 2003. It was a turnkey contract and Areva offered to build the 1600 MW plant for €3.2bn ($3.84 bn), that is, for roughly $2400/kW (€1=$1.2)[cxcviii]. Construction began in August 2005.[cxcix] It was supposed to be completed by the summer of 2009.[cc] By early 2009, the project was acknowledged to be at least three years late and €1.7bn over budget, and was now expected to cost close to €5 billion.[cci] In June 2010, Areva acknowledged that the cost had further escalated to €5.9 billion[ccii] (or more than $7.26bn, or US$4500/kW, taking €1=$1.23 which was the rate in June 2010) – nearly double the contract price! This newly announced cost is based on the assumption that OL3 will be operational by end of 2012. That seems to be very doubtful, as the reactor's construction is only just halfway to completion, and the most challenging phases of construction are still to come.[cciii]

The fate of the other EPR ordered in France has been no better. In 2007, EDF (Électricité de France), France's national utility, after much convincing by Areva NP, ordered an EPR reactor, to be located at their Flamanville site. Construction commenced in December 2007. In May 2006, EDF had assessed that the plant would cost €3.3bn. At that time (€1=$1.28), this was equivalent to $2590/kW.[cciv] As construction progressed, its cost estimates too went through the roof. In end-2008, it acknowledged that the expected construction costs had increased to €4 billion.[ccv] Last year (2010), it admitted that the project is two years behind schedule – it has only been under construction for three![ccvi] And that the cost estimate has escalated to €5 billion ($6.5 billion).[ccvii]

For both these cases, the only Generation III+ nuclear reactors under construction (in Western Europe and North America), with cost estimates escalating to nearly double the contract price even before the reactor construction has reached halfway, making a guess of the final construction cost has become hazardous!

Let us compare these costs with construction cost of setting up a coal fired plant in India. The construction cost of the OL3 1600 MW EPR was estimated at €5.9 billion in June 2010. Taking the Euro-Rupee conversion rate as it existed in May-June 2010 of €1=Rs. 57, that works out to Rs. 21 crores/MW – nearly four and a half times the average cost of setting up a new coal power plant (Rs. 4.5 crores/MW in India)!

With such astronomical construction costs, it is obvious that the cost of nuclear electricity from these new reactors is going to be huge, much more than cost of electricity from fossil fuel plants.

Part III: Nuclear Subsidies

The real cost of nuclear electricity is actually more than the above estimates. That is because the above calculations do not take into account government subsidies to nuclear energy.

All governments throughout the world which have a nuclear energy program subsidise nuclear energy. While France claims that its nuclear power costs are "the lowest in the world"[ccviii], the reality is its entire domestic nuclear energy program has for decades profited from numerous government subsidies.[ccix] The French government has subsidised the cost of construction of France's nuclear plants[ccx], which dominate the cost of nuclear electricity. It has nationalised the decommissioning and waste management costs: the waste management costs are estimated at between $21 billion and $90 billion;[ccxi] the decommissioning cost estimates keep rising, and were estimated to be 65 billion euros in 2004.[ccxii] It has also effectively taken over the accident risks – if Electricité de France (EDF), France's nuclear utility, had to insure for the full cost of a meltdown, the price of nuclear electricity would increase by about 300%.[ccxiii]

The Campaign for Nuclear Phaseout, an alliance of anti-nuclear organizations of Canada, in a report prepared in 2003 estimated that the total subsidies given by the Canadian government to the Atomic Energy of Canada Limited (AECL) over the 50-year period 1953-2002 totalled a whopping $17.5 billion! AECL is a Canadian government corporation that manages Canada's national nuclear energy research and development program, including designing and marketing of CANDU reactors. The calculations were based on figures given in AECL's own annual reports.[ccxiv]

In the UK, British Energy, which had already got a huge subsidy when it purchased eight nuclear plants from the government in 1996, got into financial difficulties and went bankrupt in

2002. The government, instead of allowing the company to close, intervened. The rescue is estimated by the government to have cost the taxpayers a mindboggling ELEVEN BILLION POUNDS![ccxv] On top of it, the government has taken over all its liabilities, which means it has taken over all the decommissioning and waste management costs, which amount to nearly a hundred billion euros and will keep on rising as the waste keeps accumulating![ccxvi]

Most subsidies given by governments to the nuclear electricity industry are common throughout the world. We discuss below the most important of these subsidies, with examples mainly from the United States. The only reason for discussing USA in greater detail is not because it gives more subsidies, but because of greater availability of information.

1. Capital subsidies

Investing in nuclear power is considered to be a high risk investment. In most countries around the world, the nuclear electricity sector is in the public sector, and therefore the high costs and huge risks associated with nuclear energy are guaranteed by the government.

In the US, even though the electricity industry has been mostly in private hands, till the 1990s distribution costs were regulated by the states, and regulators allowed electric utilities to pass on their high costs to consumers – to the tune of half a trillion dollars, including:

More than $200 billion (in 2006 dollars) on account of cost overruns of completed nuclear power plants. [ccxvii]

Most of the $50 billion (in 2006 dollars) in construction costs of the abandoned nuclear plants.[ccxviii]

The high electricity generating costs from nuclear plants, which were on the average three cents per kwh more than electricity from fossil fuel plants, for the period 1968 to 1990 – this totalled more than $225 billion (in today's dollars).[ccxix]

A second wave of subsidies was given to nuclear reactors when the electricity sector was deregulated in the 1990s. Regulators allowed utilities to recover the difference between their remaining investments in nuclear plants and the market value of those plants – called 'stranded costs' – from consumers. These payments approached $100 billion in today's dollars.[ccxx]

Without these subsidies, the present nuclear reactor fleet in the US would never have been built![ccxxi]

Post deregulation, that is, since the 1990s, Wall Street has been unwilling to provide capital to nuclear plant developers, except at very high interest rates, as these plants are going to find it very difficult to transfer their high construction costs to consumers. Therefore, over the past decade, the American nuclear industry has mounted pressure on the US government for a fresh round of subsidies – in the form of loan guarantees and other financial assistance – for building new nuclear plants. The introduction of government loan guarantees reduces the cost of financing a new nuclear power plant – and so the price of nuclear electricity – in two ways. First, now the lenders don't care about the risks and are willing to lend funds at low interest rates. Second, the guarantee enables plant owners to use much more of this inexpensive debt to finance the plant – up to 80% in the case of the United States. The impact of loan guarantees on nuclear power generation costs can be dramatic: UniStar Nuclear Energy, which hopes to build a series of reactors across the USA, estimates loan guarantees will reduce its levelized costs[ccxxii] by nearly 40%.[ccxxiii] In fact, without loan guarantees, the nuclear industry will not even think of beginning construction of new plants, as was made very clear by Christopher Crane, President of Exelon Generation, one of the utilities that has expressed an intention to build new nuclear plants in the US: "If the loan guarantee program is not in place … we will not go forward".[ccxxiv]

Obligingly, the US Congress in 2005 passed the Energy Policy Act (EPACT 2005), authorizing loan guarantees of $18.5 billion for new nuclear plants of new designs over the next several years.[ccxxv] (The 2005 Energy Bill also gave several other financial handouts to the nuclear industry, including tax credits on electricity generation and additional support in case of delays in reactor construction.[ccxxvi])That would have financed just 3 reactors, so industry has been mounting pressure on the US Congress to expand that amount. Obligingly, the Obama Administration in its budget proposal for 2011 has proposed an additional $36 billion in new federal loan guarantees, for a total of $54.5 billion.[ccxxvii]

The potential cost of this subsidy to the taxpayers is huge. In 2003, the U.S. Congressional Budget Office estimated, based on historical data, that the risk of default on guaranteed loans for nuclear power plants "to be very high — well above 50 percent".[ccxxviii]

The US Senate is also considering two new bills – the American Power Act (APA) and the American Clean Energy Leadership Act (ACELA) – which propose to give another tens of billions of dollars in subsidies to the nuclear industry, in the form of reduced accelerated depreciation periods, tax credits for investment and production, and so on.[ccxxix] These new subsidies are estimated to be worth at least between $1.3 billion and nearly $3 billion on a net present value basis per new reactor.[ccxxx]

Apart from these federal government subsidies, the nuclear industry is also pressurizing the states to allow utilities to recover construction costs from customers even before the plant has come online. Thus, Georgia has approved a CWIP or 'Construction Work in Progress' law that will allow Southern Company to recover construction costs of the new nuclear plant that it is proposing to build in the state from ratepayers during the construction period itself, that is, even before the plant has generated a single unit of electricity! This effectively shifts the risk of building the plant on the customers, because in case the company abandons the plant for some reason, it will still be allowed to recoup "prudent" costs from their customers. Florida also has such a law in place.[ccxxxi]

2. Government Spending on Nuclear Related R&D

Another government subsidy to nuclear power is in the form of spending huge amounts of public money into research and development (R&D) related to the nuclear fuel chain. During the period 1961-2008, the US government invested a gargantuan 172 billion dollars in energy R&D; of this, the largest share, 36%, or $61 billion, went into nuclear energy R&D. This was more than double the level of support to renewable energy and energy efficiency technologies ($26 billion).[ccxxxii]

3. Guaranteeing against Accidents: Capping Costs to the Operator

Accident risks have been the Achilles heel of the nuclear industry since its inception. For most industries, even a large accident, while catastrophic to the immediately surrounding area, tends to be relatively well-contained geographically. However, a nuclear accident has the potential of rendering a very much larger area – which could be as much as many hundreds of times larger – uninhabitable for centuries, nay, thousands of years!

And so, the insurance industry has not been willing to underwrite nuclear accident risks since the very inception of this industry. In the United States, Congress intervened early, in 1957, and passed the Price-Anderson Act to give the infant technology "protection against potentially enormous liability claims in the event of a nuclear accident"[ccxxxiii], a benefit no other US industry has ever received. The Act has since been renewed (and modified) many times. This law sets a maximum cap on liabilities of nuclear power companies in case of claims arising from nuclear accidents.

Under this Act, power reactor licensees are required to obtain the maximum amount of insurance against nuclear related incidents available in the insurance market (as of 2010, $375 million per plant). Any monetary claims that fall within this maximum amount are paid by the insurer. In the event of an accident that exceeds $375 million in damages, the Price-Anderson fund is then used to make up the difference. This fund is financed by the reactor companies – each of the operating nuclear reactors in the US is obliged to contribute up to $112 million (as of 2008) in the event of an accident. As of 2008, the maximum amount in the fund was approximately $11.6 billion. Any claims beyond this, in the event of a major accident, would be covered by the Federal Government.[ccxxxiv]

The Price-Anderson Act thus provides a twofold subsidy to the nuclear industry. Firstly, it reduces the insurance nuclear power plants need to buy – thereby providing them a huge subsidy in terms of insurance premiums they don't have to pay. Secondly, it caps the total limit of nuclear plant operators in case of a major accident. According to an NRC study, damages from a severe nuclear accident could run as high as $560 billion in 2000 dollars. The $12 billion provided by private insurance and nuclear reactor operators thus represents less than two percent of the potential costs of a major nuclear accident. The remaining hundreds of billions of dollars would have to be paid by taxpayers.[ccxxxv]

Without this liability shelter, nuclear reactors would never have split the first atom. Speaking before a committee of the Canadian House of Commons that is dealing with the Canadian Nuclear Liability Bill, Peter Mason, president and chief executive of nuclear supplier GE-Hitachi Nuclear Energy Canada, explained "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."[ccxxxvi] This has also been conceded by Dick Cheney (when he was the Vice-President of the USA): without the security of the Price Anderson Act, "nobody's going to invest in nuclear power plants."[ccxxxvii]

The way the Act works, it does not mean that the victims of a nuclear accident automatically get their health costs reimbursed. As we have mentioned in Chapter 3, the US government refused to acknowledge that there was any significant radiation release from the Three Mile Accident, told the victims that their health problems were pure imagination, and denied them any compensation. The victims had to go to court, and as normally happens when ordinary people fight giant corporations, the case went on and on, and eventually they got tired and settled out of court.

A similar regime capping the maximum liability to be paid by nuclear plant operators exists in every country in the world having nuclear reactors. For instance, in countries of the European Union which are signatories to the Vienna or Paris international convention on nuclear liability, this is now at the most 700 million euros. Worse, no liability regime now in effect outside the USA provides more than $2 billion in aggregate cover, despite the large populations surrounding many of these plants.[ccxxxviii]

4. Nationalisation of Waste Management Costs

As it is, the cost of storing the highly radioactive waste generated by nuclear power plants is huge. On top of it, the very fact that this waste is intensely radioactive and is going to remain so for thousands of years leads to additional liabilities: one, the waste is bound to inevitably leak and contaminate the surrounding area, as discussed in an earlier chapter; and two: an accident or a terrorist attack at the waste storage site could have catastrophic consequences, much worse than a meltdown at a nuclear reactor.[ccxxxix]

No private firm, howsoever big it may be, has the financial capacity to bear these risks. And so, national governments have stepped in and effectively nationalized both the financial costs and accident liability risks of waste management. Just like the insurance subsidy discussed above, without this subsidy too, it is doubtful if the nuclear power industry would have developed at all.

In the US, the government through the 1982 Nuclear Waste Policy Act has taken over the entire responsibility for permanently disposing off the nuclear waste generated by nuclear power plants, in return for which pay the utilities pay an artificially low flat fee of 0.1 cents per kilowatt-hour of nuclear generated electricity.[ccxl] It is not known how this amount was arrived at; it is not based on actual experience as no long-term fuel disposal facilities exist anywhere in the world; but it is obvious that it is a huge underestimate, in other words, a huge subsidy. To get a rough idea of this subsidy amount, here are some statistics: as of 2009, the nuclear power companies had paid a total of $16 billion for waste disposal services[ccxli]; whereas the US Department of Energy estimated that the Yucca Mountain nuclear waste repository was going to cost at least $96.2 billion[ccxlii]; the Obama government abandoned the project in 2010[ccxliii], but by then more than $13.5 billion had already been spent on the project.[ccxliv]

Not only have governments nationalized nuclear waste management, they have also taken over the responsibility for contamination from the other parts of the nuclear fuel cycle, including the mines, the enrichment and the reprocessing facilities, even when these facilities are in the private sector.

5. Nationalisation of Decommissioning Costs

Decommissioning a nuclear reactor once its operating life ends is a very long term and complicated operation as all the parts of the plant have become radioactive, and hence it is also very costly. 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.

Decommissioning costs are difficult to estimate, because there is little experience with decommissioning commercial-scale plants. Estimates for decommissioning costs range from an average of $ 300 million in the US to £1 billion in the UK per 1GW reactor. The French and Swedish nuclear industries expect decommissioning costs to be between 10 and 15 % of construction costs.[ccxlv]

Almost everywhere, nuclear plant operators have underestimated decommissioning costs and have set aside insufficient funds to cover these expenses, and expect governments to step in and pay the deficit - in another subsidy to the industry. This has already happened in the UK, where failure of arrangements to fund decommissioning costs of the nuclear reactors operated by the private sector company British Energy has resulted in transfer of liability of billions of euros on to future taxpayers; according to an estimate by Steve Thomas, Professor for Energy Policy at University of Greenwich, this could be as much as €90bn.[ccxlvi]

In the US too, in June 2009, the Nuclear Regulatory Commission published concerns that the owners were not setting aside sufficient funds.[ccxlvii] This shortfall is expected to also run into billions of dollars.[ccxlviii] Obviously, considering the grip that the nuclear industry has over the US government, the owners are confident that once the plant has ceased operation, any shortfall would be met by the government!

An Important Comment on Waste and Decommissioning Liabilities: The key point with nuclear energy, as different from all other technologies, is that once a nuclear plant begins operation, *even if the nuclear plant is shut down a few years later if found to be uneconomical, the lengthy time needed to decommission the reactor, and the thousands of years for which the waste will have to be managed, cannot be reduced*. This means that irrespective of how short a time a nuclear plant operates, the waste management and decommissioning expenses cannot be reduced. Therefore, if the private plant operator fails for whatever reasons, the government will have to bear these expenses.

6. Blithely Ignoring Health Costs

So far, we have discussed the overt or covert subsidies given by governments to nuclear energy. Apart from these subsidies, probably the worst part of this nexus between governments and nuclear industry is that governments have allowed the nuclear industry to simply ignore the health costs of nuclear energy. Nuclear electricity cost calculations do not take into account the health costs of the radiation leaked into the atmosphere at every stage of the nuclear fuel cycle. In fact, the nuclear industry does not even admit to these costs, blithely lying that it is clean and causes no health damage to its workers and the people living in the neighbourhood of its installations. And so, these costs are silently borne by the people.

Part IV: Conclusion

A new November 9, 2009 report "New Nuclear – The Economics Say No" by Citi Investment Research & Analysis, a division of Citigroup GlobalMarkets Inc., says: "Three of the risks faced by developers — Construction, Power Price, and Operational — are so large and variable that individually they could each bring even the largest utility company to its knees financially. This makes new nuclear a unique investment proposition for utility companies. Government policy remains that the private sector takes full exposure to the three main risks: construction, power price and operational. Nowhere in the world have nuclear power stations been built on this basis. We see little if any prospect that new nuclear stations will be built in the UK by the private sector unless developers can lay off substantial elements of the three major risks. Financing guarantees, minimum power prices, and / or government-backed power off-take agreements may all be needed if stations are to be built …"[ccxlix]

That's precisely the point we've been trying to make in this Chapter, that nuclear energy is one of the most expensive ways of generating electricity, is definitely much more costly as compared to electricity from fossil fuels, and the only way it can be competitive with conventional electricity is if it is highly subsidised by the government. In fact, Steve Thomas, the renowned independent energy policy researcher based in UK, writes that studies by the British government in 1989, 1995, and 2002 all came to the same conclusion, that in competitive electricity markets, electric utilities would not build nuclear power plants without government subsidies.[ccl]

Apart from public opposition, this cost factor is one of the important reasons why nuclear electricity is on the decline the world over, especially in countries with competitive electricity markets.

Then how come Areva won an order for constructing Olkiluoto-3 in Finland? It is being claimed that this proves that the new Generation III+ reactors are feasible in liberalised energy markets. However, a closer examination of the deal indicates that this is not a commercial order made in a free market without subsidies and guarantees, as the following facts about the order prove:

- Areva deliberately offered a low and fixed price for the project, in order to get its first order in 15 years.[ccli] There were fears that if it did not get an order for its EPR reactor soon, it would lose key staff and the design would become obsolete.[cclii] (Areva is having to pay heavy losses because of this. As mentioned above, the construction costs have zoomed to double the contract price.)

- Areva is majority owned by the French state.[ccliii] So the French government went out of its way to organise low cost finance and loan guarantees for the project. [ccliv]
- The buyer, the Finnish electricity company TVO, is not a normal electric utility, but is an organisation unique to Finland. Its ownership structure is such that it will have a guaranteed market and will be able to pass on the high cost of nuclear electricity to the consumers; it will not therefore have to compete in the highly competitive Nordic electricity market.[cclv]

For all these reasons, Olkiluoto-3 is a special case, and it cannot be expected that other countries in Europe are going to place orders for nuclear reactors very soon. (We discuss this in detail in Chapter 6.)

Similarly, while the nuclear industry is expressing optimism that it will soon renew construction of nuclear reactors in the USA, it is obvious from the above discussion that this is based on its hope that the US government will give it sufficient amount of subsidies to make nuclear electricity competitive.

Is Nuclear Power Green?

Speaking at the inauguration of the Pragati power project in West Delhi on May 24, 2008, Prime Minister Manmohan Singh said that "the Government is committed to the development of nuclear energy as an environment friendly source of power".[cclvi]

The Principal Scientific Advisor to the Indian Prime Minister, R. Chidambaram, while delivering a lecture in Delhi on August 13, 2009 stated that nuclear energy was the only way India could achieve both energy security and combat climate change, and referred to a 2007 IAEA report which said that for the world to keep global warming within two degrees Celsius, nuclear power would have to grow 80 percent by 2030. [cclvii]

The benefits of renewable energy as compared to nuclear power are so obvious, and becoming more so with every passing year, that the nuclear industry should have been in terminal decline by now. Instead, the massive propaganda barrage unleashed by it has given rise to talk that a "nuclear renaissance" is underway. One of the most important arguments it has been making during the past decade in its attempt to revive nuclear energy takes advantage of the growing crisis of global warming, public awareness of which has grown by leaps and bounds. The nuclear industry has spent millions of dollars on advertisements which claim that nuclear energy is cleaner and greener than conventional electricity from fossil fuels.

While it is true that the nuclear reactors do not emit greenhouse gases in the same amount 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, that nuclear fuel cycle utilises large quantities of fossil fuel during all its stages – the mining and milling of uranium, the construction of the nuclear reactor and cooling towers, robotic decommissioning of the intensely radioactive reactor at the end of its 30 to 40-year operating lifetime, and transportation and long-term storage of massive quantities of radioactive waste. The burning of these fossil fuels releases large quantities of carbon dioxide into the atmosphere, the source of today's global warming.

In fact, acting on a complaint by a group of law students from Queen's University, the Advertising Standards Canada, the organisation which regulates the Canadian advertising industry, ruled in September 2010 this year that claims of nuclear power being 'emission free' made in adverts by the Power Workers' Union 'were inaccurate, unsupported, and misleading'. The Union was told to remove its ads.[cclviii]

We take a cursory look at the energy consumed during the various stages of the nuclear fuel cycle.

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 by truck 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 is so energy intensive that if the concentration of uranium 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; in other words, the nuclear fuel cycle becomes energetically non-productive. And most uranium ores are low grade; the high-grade ores are very limited – global high-grade reserves amount to 3.5 million tons – just enough to supply *three years of nuclear power* if all the world's energy needs were met by nuclear energy.[cclix]

The thousands and millions of tons of mine and mill waste should actually be chemically treated and buried deep in the ground where the uranium originally emanated. But if this remediation process is scrupulously observed, as it should be, then extensive amounts of fossil fuel would be needed, making the energy costs of nuclear energy totally unviable.[cclx] And so the wastes are simply left dumped on the ground, emitting radioactive elements to the air and water.

Similarly, the uranium enrichment process is also very energy intensive. For instance, in the US, the Paducah enrichment facility uses the electrical output of two 1,000 megawatt coal-fired plants for its operation, which emit large quantities of carbon dioxide, the gas responsible for 50 % of global warming.

The Paducah enrichment facility and another at Portsmouth, Ohio, release from leaky pipes 93% of the chlorofluorocarbon gas emitted yearly in the US. This gas is the main culprit responsible for stratospheric ozone depletion. But CFC is also a global warmer, 10,000 to 20,000 times more potent than carbon dioxide.[cclxi]

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. Furthermore, construction has become ever more complex because of increased safety concerns following the meltdowns at Three Mile Island and Chernobyl. All this consumes huge quantities of fossil fuels. After the reactor's life is over, its decommissioning is also a very energetic process.

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.

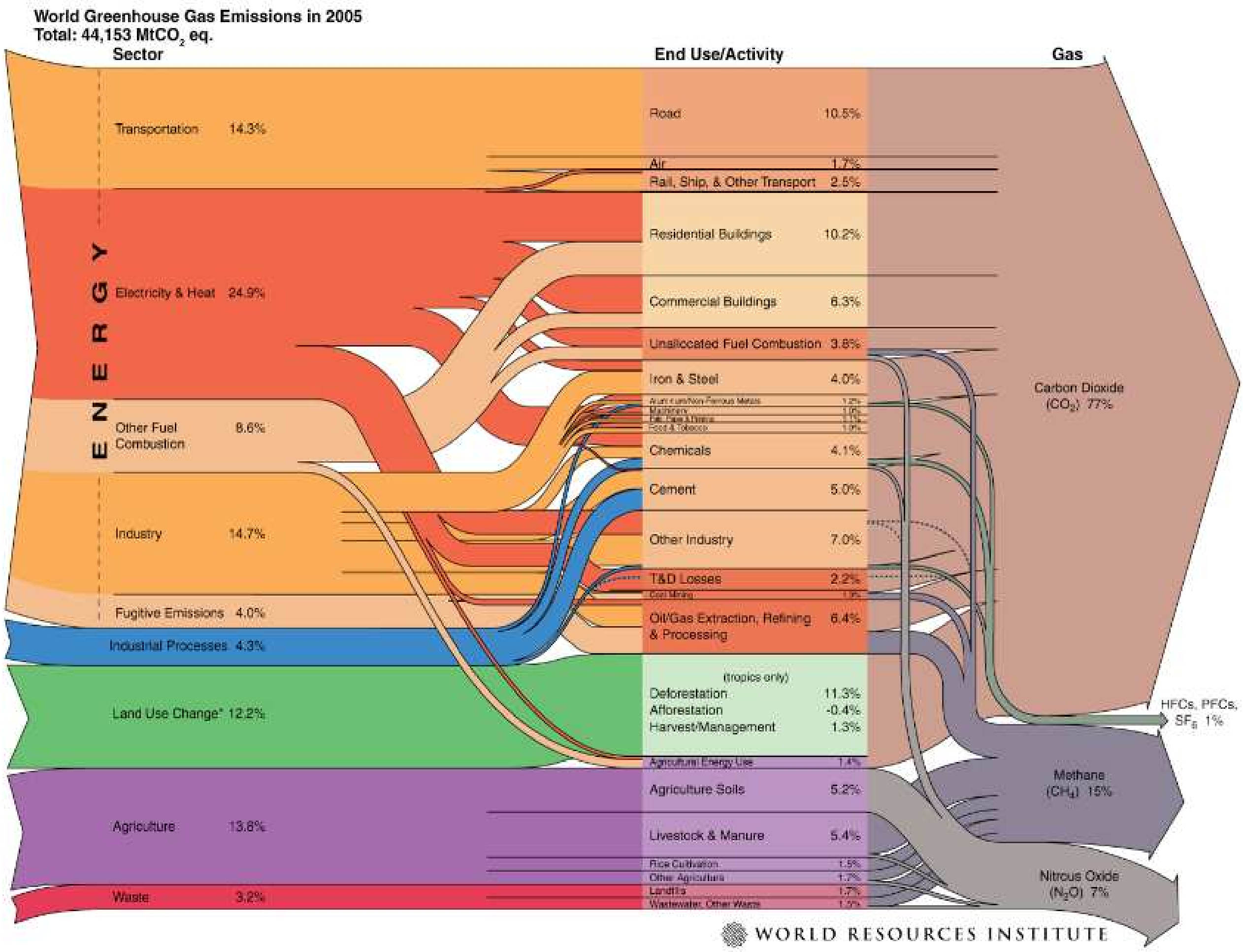
Energy Balance

A superb study made in 2004 at the request of the Green parties of the European Parliament by senior scientists Jan Willem Storm van Leeuwen and Philip Smith, titled *Nuclear Power – the*

Energy Balance attempts to make an estimate of the energy consumed during each stage of the nuclear fuel cycle. Excluding the energy costs of storage and transportation of radioactive waste, they estimate that under the most favourable conditions, the nuclear fuel cycle emits one-third of the carbon dioxide emissions of modern natural-gas power stations. This is assuming 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.[cclxii]

Potential of Nuclear Energy in Reducing Global Warming

However, this represents only half the argument. To estimate the full potential of nuclear energy in reducing global warming, we need to understand what are the various causes in the increase of greenhouse gas emissions. Increased burning of fossil fuels since the industrial revolution is only one of the causes, albeit a large one. It accounts for about 66% of the total global greenhouse gas emissions (See flowchart below[cclxiii]). The other causes are methane from agricultural operations and landfills, nitrogen oxides from the use of massive amounts of fertilizers in chemical agriculture, various chlorofluorocarbons used earlier as sprays and the large scale deforestation going on all over the world's jungles.[cclxiv] Thus, replacing burning of fossil fuels by nuclear energy can at best address only a little more than half the problem.



But there is a problem even with this estimate. Fossil fuels are burnt for various uses, of which generating electricity is only one (though it is the largest). Nuclear power can replace fossil fuels only in large scale electricity generation, and not in its other uses, like in the transportation sector. Worldwide, use of fossil fuels for electricity and heating contributes to only 25% of the total greenhouse gas emissions.[cclxv] Nuclear power can only marginally replace use of fossil fuels in heating supply systems. Therefore, replacing burning of fossil fuels with nuclear energy only reduces a very small percentage of the total greenhouse emissions. (And that too, assuming that the nuclear energy is generated using high grade uranium ore.) By how much? The IEA has made an estimate.

IEA estimates

The Energy Scenario produced by the International Energy Agency[cclxvi] estimates that, even if existing world nuclear power capacity could be quadrupled by 2050, its share of world energy consumption would still be below 10%. What is more significant for our present discussion, even such a massive expansion would help reduce CO_2 emissions by only 4 percent![cclxvii] (We are actually not sure of this estimated reduction too, as we do not know whether in calculating this figure, IEA took into consideration the carbon emissions in the entire nuclear fuel cycle. But let us ignore this for the present.)

That is a very small reduction. The crisis of global warming is very acute, and to tackle it, what the world needs is not marginally reduced emissions, but deep cuts in them – 40 percent by 2020 and 95 percent by 2050.[cclxviii] 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 reactors every year from now until 2050. To put this into perspective, in the 1980s – the decade of the nuclear industry's fastest growth – the industry built an equivalent of 17 large reactors a year. Investment costs for 1,400 new reactors needed would exceed $10 trillion at current prices.[cclxix] That is simply mind-boggling! Given the huge subsidies needed to build just one reactor, this would bankrupt even the richest countries!!

What about renewable sources of energy?

The above discussion compared carbon dioxide emissions from the nuclear fuel cycle with that from gas and coal fired power plants. The entire nuclear lobby focuses on this comparison to make an argument for building nuclear power plants, and not only that, demanding huge subsidies for nuclear energy. But there is another side to the whole debate, which the nuclear lobby very conveniently forgets: renewable energy emits even 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.[cclxx] Therefore, if the growing crisis of global warming is an argument in support of promoting nuclear energy as compared to electricity from burning fossil fuels, by this same logic, renewable energy should be supported as compared to nuclear energy. But the advocates of nuclear energy conveniently overlook renewable energy in their passionate arguments about promoting green alternatives to electricity from fossil fuels. We discuss this alternative in detail in Chapter 10.

Not only does nuclear energy create a significant amount of greenhouse gases, and is on trajectory to produce as much as conventional sources of energy within the next one or two decades, it in fact undermines the real solutions to climate change by diverting urgently needed investments away from clean, renewable sources of energy and energy efficiency. Olkiluoto-3 (OL3) has had a disastrous impact on Finland's renewable energy industry. Prior to the decision to build the new reactor, the Finnish renewable energy industry was thriving. Today, the renewable market has stagnated as 85% of planned investments in new power generation between 2006 and 2010 have been eaten up by OL3. Leading international business advisors, Ernst & Young have ranked Finland as the third least-attractive among 25 countries for investments in renewable energy.[cclxxi]

Global Nuclear Energy Scenario: Reviewing the Renaissance

Part I: Overview of the Global Scenario

1. Recent Changes in Global Nuclear Industry Scenario

Presently, 31 countries have nuclear power plants: 19 in Europe (including Russia and the Ukraine), six in Asia (including China and Taiwan), five in the Americas and one in Africa (South Africa) (see Graph 1).

Graph 1: Nuclear Power Capacity by Country, end of 2009[cclxxii]

At the end of 2009, global nuclear-generating capacity was roughly 370 GW: 33 percent in Western Europe, 30 percent in North America, 21 percent in the Far East, and 13 percent in Eastern Europe and Russia. The rest of the world: Africa, Latin America, the Middle East and South Asia, accounted for only three percent (Table 1)

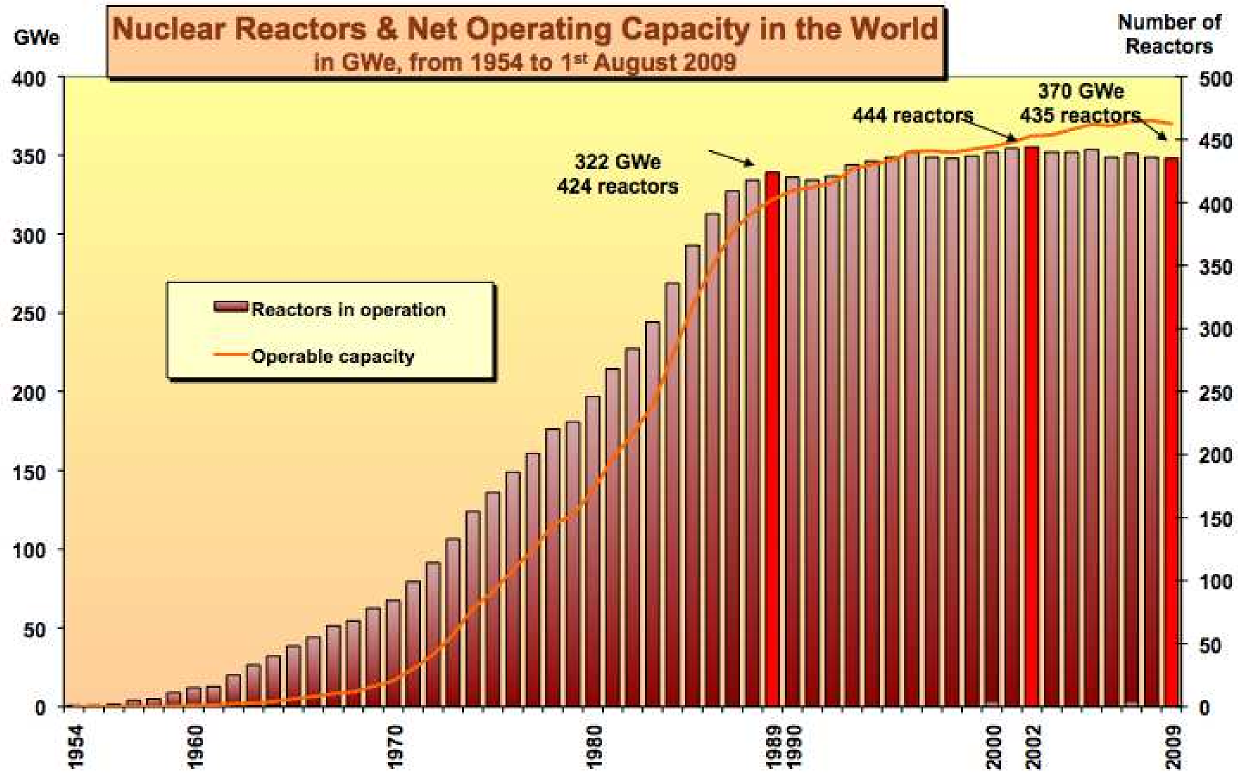
Table 1: Estimates of Total and Nuclear Electrical Generating Capacity[cclxxiii]

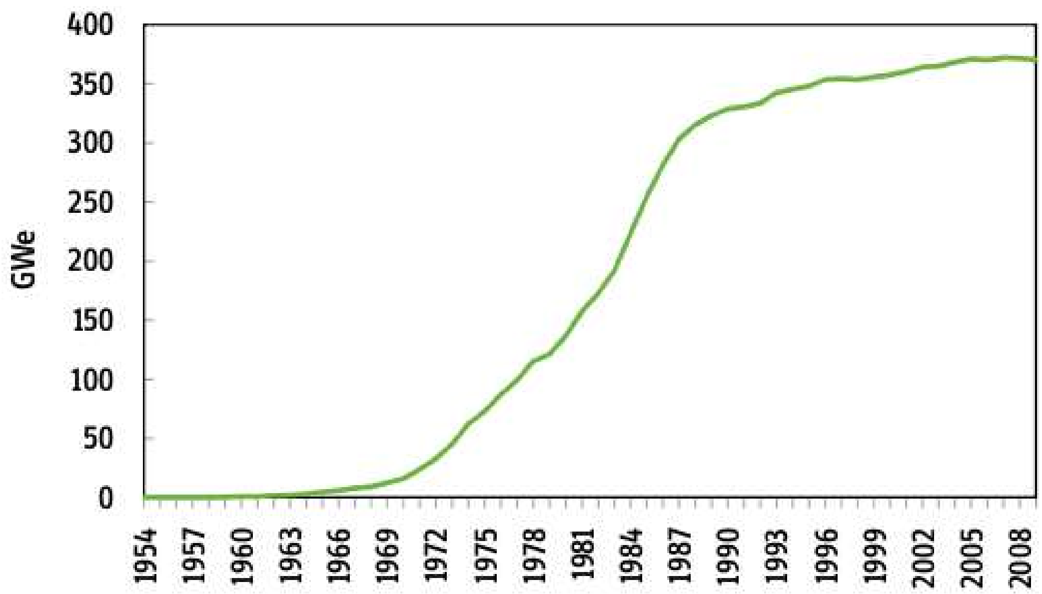
Country Group	Total Generating Capacity, GW	Nuclear Generating Capacity, GW
North America	1251	113.3
Western Europe	800	122.7
Eastern Europe and Russia	471	47.6
Far East (incl. China)	1412	77.9
Rest of World	981	10.3
Total	4914	371.9

Let us now take a look at the changes taking place in the global nuclear power scenario over the past few years, to see if indeed there is some kind of a nuclear renaissance taking place.

- In 2007, world nuclear electricity generation dropped by more than 50 TWh to 2608.2 TWh (Terrawatthour = billion kwh). This decline of 2% over the previous year was the largest decline in a single year since the first fission reactor was connected to the Soviet grid in 1954. The following year, in 2008, global nuclear generation lost another half percentage point (over the 2007 level).[cclxxiv] The 2010 Edition of the IAEA report *Energy, Electricity and Nuclear Power Estimates for the Period up to 2030* records yet more decline: global nuclear energy generation in 2009 fell by another 1.5% over 2008 level to 2558.1 TWh.[cclxxv]
- Compared to the total global electricity generation from all sources, world nuclear energy generation had fallen from 15.2% in 2006 to 14.2% in 2007 to 14% in 2008 to 13.8% in 2009; that it, it has fallen for the third consecutive year in 2009.[cclxxvi]
- Similarly, as we can see from the graph 2 below, ever since the first nuclear reactor came on-line in 1954, till 1990 the number of reactors and the total generating capacity rapidly increased. However, after that, the number of reactors have hovered around 430 and the increase in total capacity has also slowed down, and is presently hovering around 360-370 GW.

Graph 2: World Nuclear Reactor Fleet[cclxxvii]



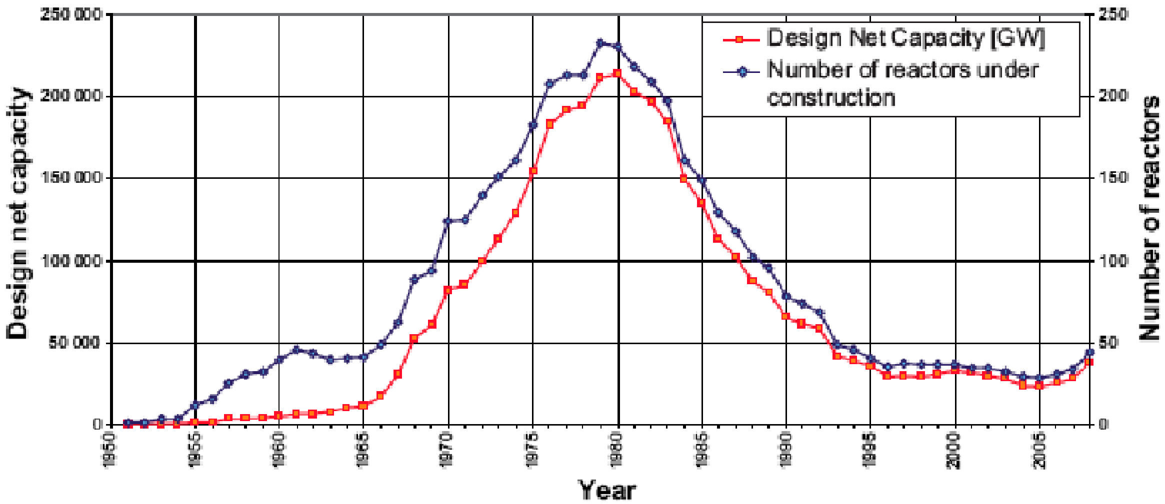


Graph 3: Growth of Nuclear Power Capacity, GW[cclxxviii]

- At the end of 2009, there were 438 nuclear reactors operating in the world, six less than in 2002.[cclxxix] 2008 was the first year in the history of commercial nuclear power that no new nuclear plant came online (although 2 were connected to the grid in 2009).[cclxxx]
- Even though the total number of reactors has declined, the total installed capacity has increased slightly in previous years mainly because of technical alterations at existing plants, a process known as "uprating". The capacity of the global fleet increased between the years 2000 and 2004 by about three gigawatt per year, and then by two gigawatts per year between 2004 and 2007. However, in 2008, uprates were offset by plant closures, resulting in a slight decline in world nuclear capacity by about 0.6 gigawatts over the 2007 level. At the end of 2009, the total installed capacity of the 438 operating nuclear reactors was 371.9 gigawatts.[cclxxxi]
- As compared to the global electricity generation capacity, the global nuclear power capacity has consistently declined, from 8.7% in 2006 to 7.6% in 2009.[cclxxxii]

2. Current Global Trend in Construction of New Reactors

Graph 4: Number of units and total nominal capacity in MW under construction 1951 – 2008[cclxxxiii]



As of August 1, 2009, the IAEA lists 52 reactors with a total capacity of about 46 GW as "under construction". While this represents a slight upswing over the previous five years (since 2004), on the whole, it represents a huge decline from the peak reached in 1979 when there were 233 reactors of total capacity of over 200 GW being built concurrently. Even at the end of 1987, there were still 120 reactors under construction.[cclxxxiv]

A comparison of the total capacity of the nuclear reactors under construction with the global power capacity under construction (from all sources) is also revealing. The total electricity generating capacity under construction (from all sources) in 2007 has been estimated at over 600 gigawatts. Of this, the vast majority was from coal, hydro and natural gas plants; the nuclear share was roughly 4.4%.[cclxxxv]

Let us now take a closer look at the nuclear projects under construction:[cclxxxvi]

13 reactors, one quarter of the total, have been listed as “under construction” for over 20 years. Of these, 8 reactors do not have an official (IAEA) planned start-up date even today.

In fact, of the 52 reactors under construction, 24 projects don't have an official (IAEA) planned start-up date.

Over two-thirds (36) of the units under construction are listed in four countries alone (China, India, Russia, South Korea), with China alone accounting for 16 of them. All of these nations have historically not been very transparent about the status at their construction sites.

Past experience has shown that even a reactor in an advanced stage of construction is no guarantee for grid connection and power supply. The French Atomic Energy Commission (CEA) published statistics on “cancelled orders” through 2002. The CEA listed 253 cancelled orders in 31 countries, many of them in advanced construction stage. After that it stopped publishing statistics on cancellations.

The renowned independent consultant, Mycle Schneider, along with professor for energy policy Steve Thomas, and consultants Antony Froggatt and Doug Koplow, have in their *The World Nuclear Industry Status Report 2009*, calculated the minimum number of plants that would have to come on-line over the next decades in order to maintain the same number of operating plants as there were on August 1, 2009 (435). While many nuclear utilities envisage reactor lifetimes to be of at least 40 years, and some have even applied for and obtained licenses for operating their reactors for more than 40 years, the report points out that these seem to be rather optimistic projections, considering the fact that the average age of all 123 units that have already been closed is about 22 years. Nevertheless, for their calculations, the authors assume that each of the presently operating and in-construction reactors will have a life of 40 years.

With these assumptions, the report finds that in order to maintain at least 435 operating reactors worldwide (the same number as at present) in the coming decades, 42 reactors (16,000 MW) would have to be planned, built and started up by 2015 (that is, one every month and a half), in addition to the 52 units currently under construction; and that further, an additional 192 units (170,000 MW) would have to be constructed and brought on-line over the following 10-year period (which means, one reactor would have to come on-line every 19 days).[cclxxxvii]

Considering that it takes more than a decade of planning, regulatory processes, construction and testing before a reactor can produce electricity[cclxxxviii], this means that it is going to be practically impossible to maintain, let alone increase, the number of operating nuclear power plants over the next 20 years.

Therefore, despite all the optimism shown by the international nuclear industry and its official spokespersons, not only is it presently in decline, all indications are that this trend is going to continue in the near future.

3. In Conclusion

Therefore, despite all the optimism shown by the international nuclear industry and its official spokespersons, not only is it presently in decline, all indications are that this trend is going to continue in the near future.

Part II: Overview of the Nuclear Industry in North America and Western Europe

We now take a closer look at the prospects for a “nuclear renaissance” in the United States, Canada and Western Europe, the region that was at the centre of the first boom in nuclear energy and where 63% of the world’s operating reactors are located (as on August 1, 2009). This is also the region where public opinion is most informed and the debate is the most intense on nuclear energy.

We are deliberately ignoring taking a look at the situation in China and Russia, the two countries where the maximum number of nuclear plants are under construction at present.

Reasons for ignoring China

Speaking at an International Ministerial Conference on Nuclear Energy in Beijing on April 19, 2009, Li Ganjie, the director of China’s National Nuclear Safety Administration, warned that, “if we are not fully aware of the sector’s over-rapid expansions, it will threaten construction quality and operation safety of nuclear power plants”.[cclxxxix] He also stated that China’s nuclear industry is challenged on all fronts: shortage of human resources; insufficient capability of nuclear power research, development, design and mastery of high-end technology; lack of capability in manufacturing and installing of facility; inadequate management; and weak nuclear safety supervision.[ccxc]

Apart from these stray news, not much is known about the safety situation at China's nuclear plants. The dictatorship prevents any information from coming out. The global nuclear industry is more than happy with this state of affairs, as it is only concerned with nuclear plant orders. Not only that, it can hold up China as an example for countries like India to duplicate, and so it is keen to spread the belief that all is fine with China's nuclear plants. Energy consultant Mycle Schneider comments: “Everything goes black when I consider that 16 nuclear plants are being built simultaneously in China, and all we hear is there are no problems there.”[ccxci]

The reason for Schneider's harsh comment is not far to seek. China's attempt at constructing all kinds of giant projects at reckless speed has pushed the country to the edge of a monumental environmental crisis, perhaps the worst in world history. China’s coal-fired plants and giant heavy industry complexes freely dump their toxic wastes into the environment, poisoning the land by a deadly brew of chemicals and metals. One consequence: sixteen of the world's 20 dirtiest cities are located in the People's Republic. The inhabitants of every third metropolis are forced to breathe polluted air, causing the deaths of an estimated 750,000 Chinese each year. Half of China's 696 cities and counties suffer from acid rain. Two-thirds of its major rivers and lakes have become cesspools and more than 340 million people do not have access to clean drinking water. The Yangtze River, once China's proud artery of life, is biologically dead for long stretches. Cancer rates in many villages located near heavily polluting factories have shot up – earning them the name of ‘cancer villages’. Cancer is now the nation’s biggest killer, responsible for one in five deaths in 2007.[ccxcii]

It is therefore not at all surprising that such a dictatorship with such apathy for environmental degradation is making a huge push for setting up nuclear plants.

Reasons for ignoring Russia

While IAEA says that as of end- 2009, Russia is constructing 9 reactors[ccxciii], it does not seem likely that given its gas and oil resources, Russia will invest huge amounts in nuclear power and build new reactors

But even if it does, it still cannot be held as a model to follow. The reason is the extreme, criminal unconcern the Russian government has shown for victims of accidents and radiation leakages from its nuclear plants. A most glaring example is its treatment of the victims of the Mayak nuclear disaster. It makes the stomach churn.

The Mayak nuclear plant in the Southern Urals was the Soviet Union’s largest nuclear complex. In 1957 a storage tank with highly radioactive liquid waste exploded. However, only a few people were evacuated. 217 towns and at least 272,000 people were exposed to chronic levels of radiation. Until the Chernobyl disaster in 1986, it was the worst radiation accident the world had ever seen.

Unbelievably, instead of taking steps to ease the pain of the victims of this world’s second biggest nuclear disaster, the Russian government has over the last many decades exposed them to additional radiation! It has continued to run a spent fuel reprocessing plant at Mayak, and what is worse, even imports spent nuclear fuel from other countries for reprocessing at the Mayak complex! Mayak has reprocessed over 1,540 tons of spent nuclear fuel from several countries including Hungary, Bulgaria, Germany, Finland and the Czech Republic so far. Russia is also planning to sign reprocessing contracts with Switzerland, Spain, South Korea, and other countries. As a result of this, over 3 million cubic meters of liquid low-level and middle-level radioactive wastes has been generated and pumped to nearby ponds, from which it leaks into the surrounding areas.

This half a century of radiation has made Mayak one of the most radioactive places on earth. The thousands of people living in surrounding towns and villages have chronically high rates of malignant cancers, and genetic abnormalities. A recent study by Greenpeace found the rates of malignant cancers among local people to be significantly higher compared to the rest of Russia; while another study found that genetic abnormalities were 25 times higher than in other areas.[ccxciv]

None of the countries shipping their dirty nuclear waste to Russia would allow Mayak to continue operating on their own land. They are exploiting Russia's lack of environmental and health standards to dump their radioactive waste on people who have already suffered the devastating consequences of nuclear contamination for half a century. Mayak is a horrific example of the true face of the global nuclear industry.

1. Reviewing the Nuclear Renaissance in the USA

The United States has 104 operating nuclear power plants (in 2009).[ccxcv] While this number is more than any other country in the world, the number of cancelled projects is even larger. Of the 253 nuclear plants ordered in the US since 1953, 71 were cancelled before construction started, 50 were cancelled after construction began, and another 28 were permanently shut down before their 40-year operating licenses expired.[ccxcvi]

No new order for a nuclear reactor has been placed in the US since 1978, and even that plant was later cancelled. In fact, all U.S. reactor orders after 1973 were eventually cancelled – that is, it is now 37 years since a new order that has not subsequently been cancelled (October 1973) has been placed. The last reactor to be completed was Watts Bar 1, in 1996. Its completion took 23 years.[ccxcvii]

Despite these dismal statistics, the nuclear industry has been claiming that a nuclear renaissance is underway in the USA. Let us take a brief look at the facts on which it is basing its claim:

iv. While the US nuclear power industry has failed in building new reactors, it has been successful in getting plant life extensions. Originally, reactor life was envisaged to be 40 years. But now, utilities are seeking permission to operate reactors for up to 60 years. As of July 2009, 54 US nuclear plants had been granted a life extension license by the Nuclear Regulatory Commission, 16 applications are under review and around 21 have submitted letters of intent.[ccxcviii]

v. Construction on the 1,200 MW Watts Bar-2 reactor has been restarted by TVA. Its construction had begun in 1972 but was frozen in 1985. The reactor is now expected to be completed by 2012.[ccxcix]

vi. Over the last 10 years, the US government has given out billions of dollars in additional financial handouts to the nuclear industry.

vii. In 2007, for the first time in three decades (since the Three Mile Island accident in 1979), utilities applied for a license to build a nuclear plant. As of July 2009, the US Nuclear Regulatory Commission had received 17 applications for a total of 26 units.[ccc]

viii. In February 2010, the Obama administration announced the authorisation of the first loan guarantee of $8.3 billion to the Southern Company to build two new 1,100 megawatt Westinghouse AP1000 nuclear reactors at its Plant Vogtle in Georgia.[ccci]

While the nuclear industry has indeed succeeded in winning billions of dollars in additional subsidies from the US government, the overall future prospects are not as rosy as it is claiming them to be. Despite its multi-billion dollar propaganda campaign to convince the people about the benefits of nuclear energy, public opposition to nuclear energy continues to remain strong, and it has led to powerful setbacks for the nuclear industry. Let us take a look at the other side of the picture.

The most important of these defeats has been on the question of quantum of loan guarantees. As discussed in Chapter 4, without loan guarantees, industry is not even going to think of constructing a new nuclear reactor. The nuclear industry had lobbied hard during the Bush Presidency to get the Congress to give loan guarantees for $50 billion. But campaigning by public interest and anti-nuclear groups got that amount knocked down to $18.5 billion.[cccii] This amount is barely enough to cover loan guarantees for 3 reactors, whereas utilities have asked the DOE for $122 billion in loan guarantees for the 26 new reactors they propose to construct![ccciii] Obviously, only if Congress overrides strong public opposition and sanctions a huge increase in loan guarantees will the nuclear renaissance ever take off!

Many states in the United States have laws which either explicitly or effectively ban the construction of new nuclear plants. The nuclear industry has done intense lobbying to get these states to lift their ban, but has so far completely failed. Thus, for instance, Minnesota has a moratorium in place on construction of new nuclear power plants; while California, West Virginia, Wisconsin and some more states have laws according to which no new nuclear plant can be constructed in the state until there is a national facility which safely disposes of high level nuclear waste. In 2009, the nuclear industry failed in its efforts in all the six states where it tried to get these laws repealed. Similarly, the nuclear industry also failed to get the Missouri legislature to pass a CWIP law that would have enabled costs to be imposed on the state's ratepayers to finance construction of a new nuclear plant, which was then promptly mothballed. Industry efforts to get nuclear declared "renewable" by the states of Indiana and Arizona also failed to achieve results.[ccciv]

Growing public opposition to the expansion plans of the nuclear industry is also putting at risk one of the important recent successes of the nuclear utilities – lifetime extensions of their operating plants. In Vermont, because of a huge grassroots campaign, a whopping 26 members of the 30-member state Senate voted in February 2010 against giving a life extension to the Vermont Yankee Nuclear Plant for another 20 years after its scheduled closing in 2012. Of course, the fight isn't over, Entergy is a powerful corporation and has said it has not thrown in the towel. The House still has to vote and it is to be seen whether it will vote the same way and retire Vermont Yankee. The Vermont Senate vote was the first time a state legislative body has voted to retire a nuclear plant.[cccv]

Apart from these setbacks at the policy level, even the specific plans made by the nuclear industry for construction of new reactors have suffered serious setbacks. President Bush's National Energy Policy had set a target of constructing two reactors by 2010. However, construction on even the first of these reactors has yet to begin even as 2010 draws to a close.

- Of the 26 reactors for which applications had been received by the NRC till the end of 2009, 19 have been cancelled or delayed and every project has suffered a downgrade by credit rating agencies.[cccvi]
- The nuclear plant construction applications received by the NRC cover 5 designs. However, so far, only one of these designs – the ABWR – has been certified by the NRC. Its

certification also runs out in 2012, and major modifications are likely to be needed for it to be re-certified.[cccvii]

- 14 of the 26 reactors whose construction applications are pending before the NRC are of Westinghouse's AP-1000 design. However, in October 2009 itself, the NRC raised serious concerns about the AP-1000 reactor design. The NRC stated that Westinghouse has failed to demonstrate whether the AP1000 nuclear reactor structure can withstand hurricanes, earthquakes, tornadoes and other external impacts. It also stated that the unsuccessful efforts to secure information had gone on for a year.[cccviii] Additional concerns about the AP-1000 design were voiced in a report released in April 2010 which was commissioned by the AP1000 Oversight Group, which involves more than a dozen nuclear watchdog organizations. The report prepared by Arnold Gundersen, a nuclear engineer and a former senior executive in the nuclear power industry, stated that the design was particularly vulnerable to through-wall corrosion.cccix These concerns put in doubt the future of all these projects. And they constitute more than half the reactors proposed!
- One of these AP-1000 projects whose future has now become uncertain is the Vogtle nuclear plant in Georgia which won a loan guarantee from the Obama administration just a few months ago.
- The DOE has shortlisted three more projects for a second loan guarantee: South Carolina Electric and Gas for 2 AP-1000s at the Summer nuclear power plant in South Carolina; EDF-Constellation Energy's proposal to build a EPR reactor at its Calvert Cliffs site in Maryland; NRG Energy for 2 ABWRs at the South Texas Project nuclear plant in Texas.[cccx] However, all three projects have become crisis-ridden:
    - South Carolina Electric and Gas' proposal is for AP-1000 reactors, so obviously its future is in doubt.
    - In October 2010, Constellation Energy announced that it was withdrawing from its joint venture with the French EDF to build the Calvert Cliffs-3 reactor in Maryland; it blamed the US government for insufficient subsidies for the decision.[cccxi] The project is now virtually dead, with their being only an outside chance that EDF would go ahead with it.[cccxii]
    - Cost estimates for building two additional ABWR's at the South Texas nuclear plant have ballooned to $18.2 billion from a preliminary estimate of $5.4 billion, even before the first stone for the project has been laid![cccxiii] There is no knowing what the final costs are going to be! Indications are that this may have stalled the project.[cccxiv]

Clearly, the nuclear renaissance in the United States is stuck in quicksand.

2. Reviewing the Renaissance in Canada

Canada was one of the first countries to invest in nuclear power. It developed the CANDU design, a heavy water reactor. Officially, there are 18 CANDU units in operation; another 4 units are in what the IAEA calls 'long-term shutdown'. The reactors in operation have been plagued by technical problems that have led to construction cost over-runs, shut downs for long periods, and reduced annual capacity factors. In the mid-1990s, one third of Canada's nuclear plants were shut down for technological reasons, the largest shut down in the world.[cccxv]

No nuclear plants have been ordered in Canada since 1978.[cccxvi] However, like in the USA, a number of its operating plants have been refurbished to extend their operating lifetimes. While refurbishing usually takes less time and is less costly than building a new plant, for several of Canada's reactors, there have been several cost overruns that in some cases have made it almost as expensive as new construction.[cccxvii]

Over the past few years, there have been several proposals to build new nuclear plants in Canada. These would have been Canada's first nuclear plants in 3 decades. However, all have come to naught, because of strong public opposition and high financial risks. The President of the Canadian Nuclear Safety Commission (CNSC) has stated that CNSC is "facing many of same issues as the rest of the nuclear industry".[cccxviii]

3. Reviewing the Renaissance in Western Europe

There is no fixed definition of the countries that constitute Western Europe. We have for our purpose defined it to include the following 18 countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.[cccxix]

Nine of these 18 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 as of August 1, 2009. This was 33 units less than in 1988-89 when the number of operating units peaked.[cccxx]

Two reactors are currently under construction in this region, one in Finland and one in France. Except for the French Civaux-2 unit which got underway in 1991 and was coupled to the grid in 1999, and the recent reactor projects in Finland and France, no new reactor order has been placed in Western Europe since 1980 – that is one order outside France in 30 years. On the other hand, dozens of reactors will go offline in the coming years – at least one-third of Europe's nuclear plants would be decommissioned by 2025.[cccxxi]

Despite this, apologists for the global nuclear industry are claiming that a nuclear renaissance is underway in Western Europe. Let us take a closer look at this so-called revival. For our discussion, we divide the 18 countries under discussion into three categories: countries with no nuclear plants which are still anti-nuclear (8), countries with nuclear plants and with previous nuclear phase-out plans which are now considering reversing this phase-out (6), and countries with nuclear plants and without phase out policies (4).

(i) The Anti-Nuclear Countries

We first discuss those countries which do not operate nuclear plants.

Austria, Denmark, Greece, Iceland, Ireland, Luxembourg, Portugal and Norway are declared non-nuclear countries. They do not operate any nuclear plants. While most of them have never had a nuclear power program[cccxxii], Austria and Denmark did have one but decided to scrap it many years ago. Austria had in fact built a nuclear plant in the 1970s, and there were plans to build two more reactors, but a referendum in 1978 against nuclear power succeeded because of which the technically finished reactor was never started. Since then, a majority of the people and all major political parties are against nuclear power.[cccxxiii] Denmark too was once at the forefront of nuclear research and had planned on building nuclear power plants. However, in 1985, the Danish parliament passed a resolution that nuclear power plants would not be built in the country.[cccxxiv]

In recent times, there have been rumours that Greece was planning to go nuclear. However, in a statement in February 2009, the Greece Development Minister trashed these rumours and in fact ruled out investment not just in nuclear plants but also coal fired plants.[cccxxv]

(ii) Countries where Nuclear Policy is in Flux

Rising public consciousness about the terrible environmental consequences of nuclear energy, especially after the Chernobyl accident, led the Netherlands, Sweden, Belgium and Italy to impose moratorium on construction of new nuclear plants and decide to phase out the existing nuclear plants. Italy shut down its last nuclear reactor in 1990;[cccxxvi] the Dutch parliament voted in 1994 to phase out its only nuclear power plant by 2003;[cccxxvii] while Sweden planned to complete the phase out of its 10 reactors by 2010.[cccxxviii] Belgium decided to shut down its 7 reactors after 40 years of operation, which meant they would shut down between 2014 and 2025.[cccxxix]

A powerful anti-nuclear movement ultimately led to the German Parliament voting in 2002 to pass the Nuclear Exit Law, whereby all the 19 operating nuclear plants would gradually shut down and all civilian uses of nuclear power would cease by 2020, meaning construction of new nuclear plants would be prohibited. In accordance with this law, two units have been shut down so far.[cccxxx]

Spain imposed a moratorium on construction of new nuclear plants in 1983. In 2008, the centre-left government of Jose Luis Zapatero came to power on an election manifesto which pledged to gradually replace nuclear energy with renewable energy and also phase out Spain's nuclear plants once they reached the age of 40 years.[cccxxxi]

Nuclear Revival

Powerful lobbying by the nuclear industry has got five of these countries – Belgium, Sweden, Italy, Netherlands and Germany – to reconsider their decision to phase out nuclear energy.

Spain has not reversed its decision but is going slow on its implementation. The policy reversals in these countries are at the centre of what the nuclear industry is proclaiming to be a "nuclear renaissance" taking place in the world. Let us see to what extent these countries have been able to reverse their nuclear policies.

Reviewing the Nuclear Revival

The **Dutch** decision to phase out its sole 480 MW nuclear plant was later abandoned by a conservative government, and in 2006, the government granted permission to extend the life of the plant from 2013 to 2033.[cccxxxii] While there is pressure on the government for allowing the construction of a second nuclear plant, current Dutch policy on nuclear new build remains uncertain with the government putting off a decision on its formal stance until at least 2011.[cccxxxiii]

In 2009, the **Belgium** government announced, without overturning the Nuclear Phase Out Law, that it is postponing the phase out by 10 years so that the phase out does not begin until 2025.cccxxxiv Before it could get its decision ratified by the Parliament, the government fell in April 2010. The elections have led to a stalemate, and as of October 2010, a stable government had yet to be formed. The Greens, who are very strong in Belgium, have announced that they will only join the new government if it agrees to keep the Nuclear Phase Out Law in place.[cccxxxv] Therefore, the situation is much in flux. But one thing is clear – even if the existing plants get a lifetime extension, no new nuclear plants are going to come up in Belgium in the near future.

In **Sweden**, in 2009, the Centre-Right coalition government announced a decision to scrap the Nuclear Phase-Out Law, lift prohibition on construction of new plants, and begin construction of new plants to replace Sweden's aging reactors from 2011;[cccxxxvi] but it took it more than a year to finally get the Parliament to pass the proposal, in June 2010, and that too by a narrow margin of just 2 votes.[cccxxxvii] However, just a few months later, the government lost its majority in the elections held in Sept 2010.[cccxxxviii] With the opposition staunchly opposed to nuclear power, the future of the 'renaissance' looks uncertain. The government has also set ambitious targets for renewable energy and energy conservation, which actually leave very little space for nuclear energy. This makes it very unlikely that a nuclear plant is going to be ordered in Sweden in the near future.[cccxxxix]

In **Italy**, a new right wing government came to power in April 2008, and announced plans to start rebuilding nuclear plants within five years. But restarting building new plants is not going to be easy: public opposition to nuclear plants continues to be strong, and there is as yet no solution to the colossal problem of nuclear waste, hundreds of tons of which continue to be stored in the old shut-down plants.[cccxl] Meanwhile, in March 2010, a majority of the regional councils of Italy voted against any return to nuclear power. This greatly increases the central government's problems, as many of the governors belonged to the ruling Party. With the Berlusconi government continuously besieged by scandals, and having a very thin majority in Parliament, the strong opposition to nuclear power makes the future of the Italian renaissance very uncertain.[cccxli]

In **Germany** too, the new center-right government of Angela Merkel has abandoned the commitment to phasing out nuclear power by 2021. In October 2010, it used its majority in the lower house (Bundestag) to pass a bill to extend the working lives of its reactors by an average of 12 years.

However, Merkel does not have a majority in the upper house (Bundesrat) where Germany's states are represented, so she has not submitted the legislation for approval there as it is sure to get defeated. The opposition parties and the state governments are claiming that this is unconstitutional and are planning to move the Federal Constitutional Court over this. The Social Democrats have declared that they will overturn the legislation if they come to power.[cccxlii] Considering the intense hostility to nuclear power in Germany – recent polls indicate that a majority of Germans are in favour of phasing out nuclear power as soon as possible[cccxliii] – it is doubtful if there would be any significant revival of nuclear power there.

The **Spanish** government is going slow on its election pledge to phase out nuclear energy; in 2009, it extended the operating license of Spain's oldest plant by two years, allowing it to operate until 2013. However, at the same time, the government has also put energy conservation on its top priority. The emphasis on renewable energy has made Spain the world‘s second largest operator of solar power capacity and the third largest of wind power.[cccxliv] With such a huge push towards renewable energy, there is very little scope for revival of nuclear power in Spain; at the most, the existing nuclear plants will be given a lifetime extension for a few years.

(iii) Countries without Nuclear Phase-Out Policy

These are Switzerland, Finland, France and the United Kingdom.

The **United Kingdom** operates 19 reactors, all of which except one are scheduled to be shut down by 2025. The UK nuclear industry is trying hard to get the government to agree to construction of new plants. Nuclear utilities and fuel industries have faced huge troubles in the UK, moving between scandal and bankruptcy. Nevertheless, first Tony Blair's government and then Gordon Brown's government have attempted to keep the nuclear option open, and in 2009, the British government took the first steps towards starting building of new reactors.[cccxlv] But these plans have apparently got a setback with the coming to power of the Conservative-Liberal government in May 2010. While the Conservatives are all for nuclear energy, the Liberal Democrats have long campaigned against it. The new energy minister, who is from the Liberal Party, has said that the Liberals have compromised and agreed not to oppose Conservative proposals to build new reactors, but it is on the condition that no subsidies are given to nuclear energy. If the government sticks to its promise, it is virtually certain that no new nuclear power plant will be built in the UK.[cccxlvi]

Switzerland operates five reactors. Switzerland's nuclear operators have initiated a debate over building replacements for the country's aging nuclear reactors, but the short-term prospects look dim. Referenda over phasing out nuclear energy have never won a majority in the country, but because they were defeated only by a very thin margin, they have effectively acted as a moratorium on the building of new nuclear plants.[cccxlvii]

Finland and France are the two clear cut exceptions as far as nuclear energy policy goes in Western Europe. **Finland** currently operates four units. In December 2003, Finland became the first country to order a new nuclear reactor in Western Europe after 15 years (the last one being the Civaux Nuclear Plant in France in ordered in 1988). The 1600 MW EPR being built by Areva under a turnkey contract was supposed to be constructed in four years, but is already more than four years behind schedule, and its cost has escalated to at least double the contract price. Despite these troubles, the Finnish Parliament approved in July 2010 a government proposal to construct two new nuclear power plants in the country.[cccxlviii]

France is probably the most pro-nuclear country in the world. In 2008, the 59 French reactors accounted for a little more than half of West Europe's nuclear capacity (63.2 GW). France also accounts for one of the two reactors presently under construction in Western Europe. French nuclear reactors produce over 75% of the country's electricity, although only about 55% of its installed electricity generating capacity is nuclear. In other words, France has a huge overcapacity that has led to dumping electricity on neighbouring countries. It also means that France does not need to build any new units for a long time; the only reason why the French government and EDF have decided to go ahead with the construction of a new unit, Flamanville-3, is because the nuclear industry desperately needs new orders to survive.[cccxlix] Construction of the new reactor started in December 2007; as discussed later in this chapter, the construction of this reactor has also encountered numerous problems of quality control and cost escalation.

Part III: Reviewing the Renaissance in Real Life: Olkiluoto-3 and Flamanville-3

The flagships of the 'Nuclear Renaissance' being proclaimed by the global nuclear industry are the two Generation III+ EPR reactors being constructed in Finland and France, Olkiluoto-3 and Flamanville-3 (respectively). However, both of them have got holed below the water line...

Olkiluoto-3

Areva, the largest nuclear builder in the world, in its marketing of EPR worldwide, has promoted it as a nuclear power plant that is safer, cheaper, more mature and more reliable than any other. Its promotional material states: "The EPR is the direct descendant of the well proven N4 and KONVOI reactors, guaranteeing a fully mastered technology. As a result, risks linked to design, licensing, construction and operation of the EPR are minimised, providing a unique certainty to EPR customers."[cccl] However, what is certain about its Olkiluoto-3 project is that none of these promises are being delivered.

Till November 2009, the Finnish nuclear safety authority STUK had detected about 3000 safety and quality problems in the OL3 project![cccli] Alarmingly, these include problems with several key components:

- Control and Instrumentation System: This is the nerve centre of the reactor and controls every aspect of reactor operation as well as emergency systems. In November 2009, Finnish, UK and French nuclear safety authorities raised questions about its design, saying it was at odds with basic principles of nuclear safety.[ccclii]

- Primary Circuit: This is probably the most crucial part of the reactor, as it contains the water coolant which is responsible for safety of the reactor. The primary circuit is subject to extreme heat, pressure and radiation for decades. Its components are hard to replace, some actually impossible to replace, once the reactor is in use. There have been quality problems with almost all the components of the primary circuit: all eight primary coolant pipes had to be recast, and STUK found the refabricated pipes to be inferior too; most of the components of the reactor pressure vessel and the pressuriser had to be remanufactured as they did not meet safety standards; and repairs had to be made in the steam generator too![cccliii]

- Containment Steel Liner: There were serious defects in the welding of the Containment Steel Liner, which constitutes the last barrier against leaks of radioactive substances into the environment in case of an accident. While STUK has acted to get these defects rectified, it has been forced to lower quality standards while doing so.[cccliv]

- Concrete Base Slab: STUK found that even the concrete base slab of the reactor was of inferior quality: the water content of the concrete was too high, because of which its compressive strength as well as chemical resistance are below requirements, and may cause the base to crack in the long run. Even this defect cannot be fully rectified![ccclv]

TVO and Areva failed to spot many of these failures, and only timely detection by STUK enabled them to be corrected. However, STUK itself has admitted that the number of problems is so large that it is possible that it will not be able to detect all of them. The problem of detection has become more difficult because contractors are known to have on several occasions attempted to hide their mistakes by fabricating measurements, covering up defective structures, failing to record shoddy repair work, etc.[ccclvi]

According to a study done for Greenpeace by renowned nuclear expert Dr. Helmut Hirsch,[ccclvii] while STUK has acted to get these defects rectified, there are many issues on which STUK has not provided satisfactory answers, including: the extent of problems during manufacture of the reactor pressure vessel, the procedure for re-manufacturing the primary piping, the overall state of the containment liner after repairs, the effectiveness of the counter-measures planned because of the higher water content of the base slab concrete. He also points out that there are several instances where STUK has relaxed safety requirements and allowed installation of faulty components.[ccclviii]

These are scary facts! Because, the EPR being of 1650 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 dangerous radioactive releases from the reactor. A high burn-up will also lead to much higher toxicity of the radioactive waste; according to an EDF study, EPR waste will have about four times as much radioactive bromine, iodine, cesium, etc. as compared to ordinary

Generation-II PWRs, with other reports putting these figures much higher.[ccclix] Furthermore, the EPR is potentially more dangerous in case of an accident as compared to almost any operating nuclear reactor. In the event of a serious accident, the impact would be cataclysmic, many times more devastating than Chernobyl! As a result, more stringent construction and quality control is needed for the EPR to be able even to match the risk levels of operating reactors. However, the quality control problems at the Olkiluoto-3 site indicate that it is highly questionable whether even present-day safety standards will be kept at this plant.

That is one part of the Olkiluoto-3 fiasco. The other part is that the project has turned into a financial disaster: by mid-2010, quality control problems and design defects have led to construction running four years behind schedule, resulting in estimated costs escalating to double the contract price...![ccclx]

Flamanville-3

The second order for an EPR, Flamanville in France, is doing no better, despite the fact that construction here started two and a half years after Olkiluoto-3. It is being built by EDF, a utility with far more nuclear construction experience than any other in the world. Work on this plant started in December 2007. Two and a half years later, in June 2010, EDF admitted that the project was running two years late and the cost overrun was more than 50 per cent.[ccclxi]

The reason for the delay and cost overruns is the same as that for Olkiluoto 3: quality control problems. The initial blasting to prepare the site had problems. The reinforcing of concrete was not done properly. Cracks were found in the reactor's foundations. In April 2008, the French nuclear watchdog ASN announced that a quarter of the welding they had inspected in the reactor's steel liner was defective.[ccclxii] A year later, it asked for two out of three pressuriser forgings to be remanufactured.[ccclxiii]

Because of the inherently dangerous nature of the EPR reactor, France has witnessed fierce protests against it, with tens of thousands coming out on the streets in the cities of Rennes, Lyon, Toulouse, Lille and Strasbourg, as well as in Flamanville.[ccclxiv]

What is going wrong?

What are the reasons for the quality control problems encountered in construction of both Olkiluoto-3 and Flamanville-3 reactors?

One reason is that both Areva and EDF have tried to cut corners in safety and quality standards in order to reduce costs.[ccclxv] The Finnish Safety Authority (STUK) in a report on the reasons for the delay in construction schedule of the OL-3 reactor stated: "The major problems involve project management ... The power plant vendor has selected subcontractors with no prior experience in nuclear power plant construction to implement the project. These subcontractors have not received sufficient guidance and supervision to ensure smooth progress of their work …"[ccclxvi] For instance, Areva got the Containment Steel Liner manufactured in a Polish machine yard which had no earlier experience of nuclear construction![ccclxvii]

The second and more important reason is design problems with the EPR reactor. In order to cut down lead time, the Finnish and French authorities allowed construction of Olkiluoto and Flamanville reactors to begin before the design was finalised and fully approved by them. Whereas the correct procedure is that designs should be complete and full safety regulatory approval given before construction is allowed to begin, so that in case there are design changes, these do not disrupt construction.[ccclxviii]

Over time, the Finnish and French regulators realised that there were serious design problems with the reactor. They found the design of the control and instrumentation system – the nerve center of the reactor – to be at odds with basic principles of nuclear safety. Its back up system was not sufficiently independent of the main system for it to be able to provide reliable back-up if the main system fails – in other words, if the main control system fails, there is a risk that the back-up system will fail for the same reason.[ccclxix] And so they asked for design modifications. But because construction had already begun on the basis of the old design, making these modifications was difficult.[ccclxx] This is another reason for the serious quality control problems, construction delays and cost overruns of the two reactors.

The Nuclear Installations Inspectorate (NII) of the UK, which is conducting a detailed review of the EPR design, has also expressed similar concerns about the design of the control and instrumentation (C&I) system of the EPR in a letter to Areva. In its letter, the NII said the EPR technology was significantly compromised because of the interconnectivity of what were meant to be independent systems designed to operate the plant and ensure its safety. The letter also highlighted concerns about the absence of safety display systems or manual controls that would allow the reactor to be shut down, either in the station's control room or at an emergency remote shutdown station.[ccclxxi]

The US Nuclear Regulatory Commission, which is also carrying out a review of the EPR design, has in a communiqué issued as recently as July 23, 2010, also expressed reservations on the control systems and other issues.[ccclxxii]

The Roussely Report

As the problems with construction of the EPRs at Olkiluoto and Flamanville mounted, the French government ultimately acknowledged that all was not well with the French nuclear industry and in October 2009 commissioned a former CEO of EDF, Francois Roussely, to review what was going wrong with the EPR. The report, T*he Future of the French Civilian Nuclear Sector* was published in July 2010. Roussely stated in his report that experience with Olkiluoto and Flamanville had 'seriously shaken ... the credibility of the EPR model and of the capacity of the French nuclear industry to succeed in new nuclear plant construction.'

He attributed the problems to the complexity of the EPR model "including ... the redundancy of safety systems." The report suggested that this complexity "is certainly a handicap for its implementation and therefore its cost", and partly explains the difficulties encountered in Olkiluoto and Flamanville.[ccclxxiii]

Future of EPR in Doubt

This is a damning diagnosis. One of the selling points of the new generation plants is that they have incorporated the lessons of Chernobyl and Three Mile Island designed into them from the start. This is supposed to reduce complexity by rationalising the layers of safety systems that had been added to the old designs to take account of these accidents. Now, one of the lessons from Three Mile Island accident was that if a safety system fails, there should be an independent – redundant – back-up system available. But the Roussely report says that the complexity of the EPR is because of its extra back-up safety system. This criticism therefore raises questions on one of the most important advancements in design that is supposed to be incorporated in the EPR – that even while having an independent back-up safety system, the complexity of the design is reduced.[ccclxxiv] (Ironically, the UK and US safety regulators are raising questions about the very independence of this back-up safety system.)

Stephen Thomas, professor of Energy Studies at the University of Greenwich and a researcher in the area of energy policy, especially nuclear policy, for over 30 years, says that reducing this complexity in design is not going to be easy, it would require major modifications in design, which means that Areva would have to seek authorisation of its new design from nuclear regulators all over again. This whole process would probably take a decade![ccclxxv]

To add to the EPR's woes, at both Olkiluoto and Flamanville, the cost of construction has sharply escalated. With all the design and other problems, there is no knowing what the final cost is going to be. Even if they ignore the design problems, no European country nor the USA is going to order another EPR at such an astronomical cost.

Clearly, the EPR is in trouble...

Part IV: Conclusion

From the detailed discussion above, it is obvious that despite intense lobbying and propaganda campaign by the nuclear industry, the "nuclear renaissance" is turning out to be a damp squib. Even though the US administration has expressed its willingness to dole out billions of dollars in new subsidies for new reactors, and the first loan guarantees for construction of 2 reactors in Georgia have been announced, all the proposals for construction of new reactors have run into trouble. Eventually, after all the huffing and puffing by the nuclear industry and their spokespersons in the administration, at the most one or two reactors might start getting constructed. It is indisputable that there is no nuclear renaissance in the US. This is also true of Western Europe, where 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, one of the first countries in the world to invest in nuclear power, have been cancelled. Russia has announced plans to build a few nuclear reactors, but given its huge gas and oil resources, it is unlikely that it will invest huge amounts in nuclear power. China and India are likely to build a few reactors; Korea, Japan and Eastern Europe might also add a reactor or two, but considering that dozens of nuclear plants are scheduled to shut down 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, difficulty in raising loans due to high financial risks, construction delays, and design problems, mankind 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 the nuclear reactor, 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 their plans due to powerful people's protests.

Paying the huge costs associated with nuclear energy, especially because mankind will continue to pay these costs for centuries for power from plants whose life will at the most be 60 years, becomes even more meaningless when we contrast this with the potential of energy from renewable sources like sun, wind and biomass to meet all our future energy needs. As we see in Chapter 10, the cost of energy from renewable sources is rapidly falling, some technologies have already become competitive with electricity from conventional sources, and their economies will further improve as they develop technically.

Other Independent Assessments of "Nuclear Renaissance"

i) Prognos Institute Report[ccclxxvi]

The Swiss "Prognos" institute, based in Basel, was commissioned by Germany's Federal Agency for Radiation Protection in Salzgitter to carry out a realistic estimate of the future development of nuclear energy world-wide till the year 2030. In its report submitted in November 2009, it has also come to the same conclusion:

The world-wide renaissance of nuclear power that has so often been predicted will not take place in the next few decades. Nuclear energy will be on the decline till the year 2030, and will continue to decline in importance globally.

The study finds that although the number of announcements of new nuclear power stations is on the increase, and everything seems to have been prepared for the big renaissance of nuclear power, but it is so only in theory. Many nuclear projects world-wide are already at a standstill. In view of the growing financing problems and political instability, at best only a third of the planned new projects will be realized world-wide. Even if construction begins, there are going to be many problems.

The study concludes:

- Shutdowns of aged plants will lead to a decrease in the total number of reactors, and there will be a significant decline in installed capacity and electricity generation from nuclear power plants.
- Compared to the reference level of March 2009, the number of nuclear power stations in operation worldwide is likely to decrease by 22% by the year 2020, and by about 29% by the year 2030.
- Even by comparison to the forecast rapid growth in world-wide electricity consumption, nuclear energy will decline significantly in importance by the year 2030. The percentage of world-wide electricity generation accounted for by nuclear energy will decline from 14.8% in the year 2006 to an estimated 9.1% in the year 2020, and to 7.1% in the year 2030.

ii) The CIGI Report[ccclxxvii]

In February 2010, the Centre for International Governance Innovation (CIGI), an independent non-partisan think tank based in Canada and supported by the Government of Canada, released the main report of its Nuclear Energy Futures (NEF) project: *The Future of Nuclear Energy to 2030 and Its Implications for Safety, Security and Nonproliferation. The report* was the culmination of three-and-a-half years of research into the purported nuclear energy revival and its implications for global governance.

The report concludes that there are significant barriers to the revival of nuclear energy in the near future, till at least 2030. The key barriers identified by are the same as those that we have discussed above:

2. Unfavourable economics compared to other sources of energy
3. Nuclear energy is too slow to address climate change and to compete with cheaper alternative means of tackling it
4. Demands for energy efficiency are leading to fundamental rethinking of how electricity is generated and distributed
5. The nuclear waste issue remains unresolved with no country currently implementing a sustainable solution
6. Growing fears about safety, security and nuclear weapons remain in the public consciousness
7. Developing countries face additional constraints, including inadequate infrastructure, poor governance, deficient regulatory systems and finance.

India's Nuclear Energy Program

Part I: History

Pre-Independence Period

Much before Independence, during the period 1930-48, a series of outstanding Indian scientists, most notably Drs. C Raman, J.C. Bose and Meghnad Saha, had done great pioneering research work in the field of fundamental physics, including nuclear physics, in various Indian universities. Prof. S.N. Bose had already established his claims to the Bose-Einstein statistics, and the father of nuclear sciences Einstein had read and translated Bose's papers on nuclear fundamental researches. C. V. Raman had won the Nobel Prize in Physics for his work in 1930, and in 1934, was appointed the director of the newly established Indian Institute of Sciences in Bangalore. By the mid-1930s, Professor Meghnad Saha had already published his research papers on Nuclear Physics. In 1941, he introduced a special paper in Nuclear Physics for M.Sc. Students, the first time Nuclear Physics had been included in the curriculum of higher studies of science in the country. It was due to his pioneering efforts that the first Cyclotron was brought to India in 1941 by his brilliant student Dr. B.D. Nag Chaudhuri who received his doctorate from the University of California at Berkeley in the cyclotronic sciences. In 1947, Saha established the Institute of Nuclear Physics in Calcutta, which later was named after him as Saha Institute of Nuclear Physics. It was at the initiative of Saha that in 1939 the Scientific Advisory Committee was formed in the Indian National Congress with the help of Netaji Subash Chandra Bose; Jawaharlal Nehru was also a member in it.[ccclxxviii]

Post-Independence: Bhabha as Dictator

India's first Prime Minister, Jawaharlal Nehru, was very keen to advance research in atomic energy, because, in his words, if India had "to remain abreast of the world, [it] must develop this atomic energy".[ccclxxix] And so he initiated India's nuclear program just a few months after independence with the passage of the Atomic Energy Act of 1948. However, ignoring the whole galaxy of brilliant scientists who had done such wonderful work in nuclear physics and even established institutions of research during the trying years of the freedom struggle, Prime Minister Nehru handed over the reins of India's nuclear energy program to Dr. Homi Bhabha. Dr. Bhabha was also a gifted physicist who had made his mark while a student at Cambridge University in the 1930s, but he was much younger to Saha and others.[ccclxxx]

One probable reason for this was that India's atomic energy program has been undemocratic and shrouded in secrecy from its very beginning, and Saha and others were critical of it. In the words of Saha, "the administrative policy with respect to the development of atomic energy has been extremely retrograde. From the very first there was a veil of secrecy about it. We were not allowed to talk about atomic energy. The Atomic Energy Commissioners never said what they were doing, what researches they were financing..."[ccclxxxi]

Saha was also critical of the centralisation of all research under the Department of Atomic Energy (DAE), and even within the DAE, under a single person, Bhabha. Bhabha was Chairman of the Atomic Energy Commission (AEC), the Secretary of the DAE, the Director of the Atomic Energy Establishment, Trombay (now named after him as Bhabha Atomic Research Centre), and also the Founder-Director of the Tata Institute of Fundamental Research (TIFR). This concentration of several crucial posts with a single person, combined with Bhabha's centralistic style of functioning, gradually led to taking away of all research initiatives from the various Indian Universities, and their centralisation under Bhabha in Bombay. Saha on the other hand favoured a democratic structure for research and did not want the government to take monopolistic control over free scientific enterprise in the country. Speaking in the Lok Sabha in 1954, he stated: "... if you analyse the work done in other countries, you find that atomic energy cannot be developed unless you enlist the services of thousands of scientists in your own country. . . In this particular case, for five years, the scientists of India have been precluded from taking any part in the development of atomic energy. I throw it as a challenge to the party in power, let them justify why they did not take the scientists of this country into confidence in this great work." He went on to make a fervent appeal for democratisation of India's atomic energy establishment and research: "If our young scientists are entrusted with this great task of atomic energy, they can deliver the goods. I would, therefore, request the government to make our atomic energy establishment more broad based than it has been so far."[ccclxxxii] As is obvious from the subsequent history of India's atomic energy program, Saha's fervent appeal was ignored.

Autocracy and Secrecy from Beginning

The Atomic Energy Act of 1948 made atomic energy the exclusive responsibility of the state and allowed for a thick layer of secrecy. It authorised the creation of the Atomic Energy Commission (AEC), the apex body in charge of nuclear policy in India. Dr. Bhabha became the Chairman of the AEC.

There was some criticism of the secrecy provisions in the Parliament when Nehru introduced the bill. One member, Krishnamurthy Rao, compared the bill with the British and American acts and pointed out that the bill did not have mechanisms for oversight, checks, and balances as the US Atomic Energy Act. He also pointed out that in the bill passed in the UK, secrecy is restricted only to defence purposes, and questioned the rationale of extending secrecy to research for peaceful purposes also.[ccclxxxiii]

In 1954, the government set up the Department of Atomic Energy (DAE), whose role is to execute the policies and programs formulated by the AEC. In the same year, the government set up the Atomic Energy Establishment (AEE), as India's primary centre for nuclear research (later renamed Bhabha Atomic Research Centre or BARC after Bhabha's death in 1966). Bhabha was made its first Director.

In 1958, the government passed a new official resolution, furthering strengthening the AEC with full executive and financial powers, and making the Chairman of the AEC the ex-officio

Secretary to the DAE. The 1958 Resolution made the Chairman responsible only to the Prime Minister, and he was empowered to overrule all the other members of the AEC (except in financial matters).[ccclxxxiv]

Bhabha thus became the moghul of the nuclear establishment of India. He had total power to initiate and regulate plans, formulate and execute his own procedure and rules, and had an open ended budget.

In 1962, the government granted yet more powers to the AEC by passing the totally undemocratic Atomic Energy Act of 1962, which replaced the weaker Act of 1948. No democratic country has given such authoritarian powers to its atomic energy establishment. The Act of 1962 grants absolute powers to initiate, execute, and control exploration, planning and manufacture of atomic material and its related hardware and all nuclear research and developmental activities to the sole authority of the Chairman of the AEC. Despite having such immense powers, the AEC does not report to the Cabinet, but directly to the Prime Minister.[ccclxxxv]

The Act also empowers the AEC to restrict disclosure of any information related to nuclear issues.[ccclxxxvi] Eminent jurists like Justice Krishna Iyer have termed this unconstitutional and undemocratic.[ccclxxxvii]

Dr. Bhabha's Ambitious Plans

From the very beginning, plans for the Indian nuclear program were ambitious and envisaged covering the entire nuclear fuel cycle. Bhabha initiated the development of India’s first research reactors at BARC (Trombay, near Mumbai): Apsara, a swimming pool research reactor, was set up in 1956, and Cirus, a 40 MW heavy water moderated, light water cooled, natural uranium fuelled reactor, was set up in 1960. India also developed facilities for mining uranium, fabricating fuel, manufacturing heavy water, reprocessing spent fuel to extract plutonium and, on a somewhat limited scale, enriching uranium. For executing these plans, the DAE set up a number of subsidiary organizations: the Nuclear Power Corporation, which is responsible for designing, constructing, and operating nuclear power plants; the Uranium Corporation of India Limited which is in charge of mining and milling of uranium; the Heavy Water Board, which is in charge of the many plants that produce heavy water; and the Nuclear Fuel Complex, which manufactures fuel for the nuclear reactors.[ccclxxxviii]

Three Stage Program

Simultaneously, Bhabha in 1954 also announced a grand three stage program for the development of nuclear energy in the country. The logic behind this was that India has very little uranium, and the little it has is of poor quality. What India does have is plenty of the element thorium, about 32 percent of the world’s deposits. The trouble is thorium cannot fuel a nuclear reactor by itself; it takes a running uranium or plutonium fuelled reactor to convert thorium-232 into fissionable uranium-233. To ultimately make use of India's thorium reserves to create fissionable uranium-233 and generate electricity from this, Bhabha announced a three phase strategy for the development of this technology. The first stage of this involved natural Uranium fuelled Pressurized Heavy Water Reactors, followed by reprocessing the spent fuel to extract plutonium. In the second stage, this plutonium is used in the nuclear cores of Fast Breeder Reactors. These nuclear cores could be surrounded by a "blanket" of either (depleted) uranium or natural uranium to produce more plutonium. Subsequently, the blanket would be of thorium, which would produce fissionable uranium-233.

But before introducing thorium in the blanket, a sufficiently large fleet of breeder reactors with uranium blankets would have to be commissioned to ensure that there is adequate plutonium to fuel the follow on second stage thorium blanketed breeder reactors. Once there is enough uranium-233, then the third stage can be launched, which involves breeder reactors using uranium-233 in their cores and thorium in their blankets.[ccclxxxix]

The First Atomic Power Plants

Bhabha also initiated discussions with US, Britain, Canada and the Soviet Union for assistance for setting up atomic power plants in the country. The AEC selected the CANDU type heavy water reactors which use natural uranium as fuel as best suited for India's atomic power program. It was decided to go in for natural uranium fuelled reactors as the enrichment process was very costly and also because it made the most efficient use of uranium, whose reserves were limited in the country. These reactors were under development in Canada, and it was willing to offer generous technological and financial assistance for setting up such reactors, as a part of its Colombo plan. Those were the days of the Cold War, and the aim of this plan was to prevent newly independent third world countries from going over to the Soviet bloc.[cccxc]

While all of India's initial reactors were to be of this type, Bhabha negotiated an agreement with the United States for setting up a Boiling Water Reactor also. Since this runs on enriched uranium, the US agreed to supply this fuel for the entire life of the reactor.[cccxci]

In addition to water moderated reactors, the AEC was also keenly interested in fast breeder reactors as they were a central part of the three-stage program. And so it initiated efforts in that direction very early, in the mid-1960s. We discuss India's fast breeder reactor program in Chapter 9.

Targets and Achievements

On the basis of these plans and assuming optimistic development times, Bhabha announced in 1954 that there would be 8000 MW of nuclear power in the country by 1980.[cccxcii] As the years progressed, these predictions were to increase. By 1962, the prediction was that nuclear energy would generate 20-25,000 MW by 1987; and in 1969 the AEC predicted that by 2000 there would be 43,500 MW of nuclear generating capacity. All of this was before a single unit of nuclear electricity was produced in the country – India's first reactor, Tarapur, was only commissioned in 1969![cccxciii]

The reality has been quite different. While total electricity generation capacity in the country (from all sources) has seen a huge increase, from a meager 1800 MW in 1950 to 90,000 MW in 2000[cccxciv] and 169749 MW as on Dec. 31, 2010[cccxcv], installed capacity of nuclear power generation has grown much more slowly: it was about 600 MW in 1979-80, 950 MW in 1987 and 2720 MW in 2000.[cccxcvi] By December 2010, it had grown to 4560 MW[cccxcvii], which was less than 3% of the total electricity generation capacity in the country! The AEC had set a target of achieving 43,500 MW of total nuclear power capacity by the year 2000; even by 2010, it had been able to achieve just 10.5% of this target!

This utter failure has not been because of a paucity of resources. Practically all governments have favored nuclear energy and the DAE's budgets have always been high. The high allocations for the DAE have come at the cost of promoting other, more sustainable, sources of power. In 2002-03, for example, the DAE was allocated Rs. 33.5 billion, dwarfing in comparison the Rs. 4.7 billion allocated to the Ministry of Nonconventional Energy Sources (MNES), which is in charge of developing solar, wind, small hydro, and biomass based power.[cccxcviii] In 2009-10, DAE's budget had ballooned to Rs. 60.3 billion, while the MNES had been allocated just Rs. 6 billion.[cccxcix] Despite the smaller allocations, installed capacity of renewable energy sources was 16787 MW in Dec. 2010,[cd] nearly four times that of nuclear energy (4560 MW), despite the fact that the government expenditure on the latter has been many times that of renewable energy.

Part II: India's Present Nuclear Facilities

1. Uranium resources and mining

The four most promising uranium mining areas in India are: the East Singhbhum district (Jharkhand), West Khasi hills (Meghalaya), the Bhima Basin area (Gulbarga district of Karnataka), and Nalgonda district (Andhra Pradesh). India's uranium resources are modest, with 54,000 tonnes as reasonably assured resources and 23,500 tonnes as estimated additional resources in situ.[cdi]

Mining and processing of uranium is carried out by Uranium Corporation of India Ltd, a subsidiary of the Department of Atomic Energy (DAE). Presently, it operates five underground mines, all in Jharkhand, at Jaduguda and Bhatin (since 1967), Narwapahar (since 1995), Turamdih (since 2002) and Bagjata (commissioned in Dec 2008). The last three are modern mechanised mines. In December 2009, it also commissioned India's first open cast mine, at Banduhurang, also in Jharkhand. UCIL has also begun construction of a seventh mine in the area, the Mohuldih underground uranium mine located in the Saraikela-Kharswan district. The processing of the ore is carried out at two mills, one located near Jaduguda, which processes 2090 tonnes of ore per day, and another at Turamdih, with 3000 t/day capacity.[cdii]

UCIL has also begun work at a new underground mine at Tummalapalle near Pulivendula in Kadapa district of Andhra Pradesh. This is expected to start producing uranium this year (2011). This would be the first mine outside Jharkhand. A second mining project in the state is planned in the Lambapur-Peddagattu area in Nalgonda district.[cdiii] UCIL is also planning a small mine and a uranium processing unit at Gogi in Gulbarga area of Karnataka.[cdiv]

Outside of the Singhbhum area, Meghalaya has the largest reserves of uranium in India. The state is estimated to have 9.22 million tonnes of uranium ore deposits, which are supposed to be of high quality.[cdv] 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 powerful peoples opposition.

2. Fuel Fabrication[cdvi]

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. The main 400 t/yr plant fabricates PHWR fuel (which is unenriched). A small (25 t/yr) fabrication plant makes fuel for the Tarapur BWRs from imported enriched (2.66% U-235) uranium. Mixed carbide fuel for FBTR was first fabricated by Bhabha Atomic Research Centre (BARC) in 1979.

Heavy water for India's PHWRs is supplied by DAE's Heavy Water Board, and the seven plants are working at capacity due to the current building program.

A very small enrichment plant – insufficient even for the Tarapur reactors – is operated by DAE's Rare Materials Plant at Ratnahalli near Mysore.

3. Nuclear Reactors

Presently (as in January 2011), India has 17 small and two mid-sized nuclear power reactors in commercial operation. These are mostly PHWRs, except for two units of BWRs in Tarapur. Another 5 reactors are under construction. As we discuss below, following the Indo-US nuclear deal and the permission given by the Nuclear Suppliers Group to India to import nuclear reactors and uranium from other countries, the Government of India is planning to go in for new nuclear power plants in a big way.

Table: The 19 nuclear power reactors currently in operation in India[cdvii]

Power station	**State**	**Type**	**Units**	**Total capacity (MW)**
Kaiga	Karnataka	PHWR	220 x 3	660
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	**19**	**4560**

Of these 19, the newest are Rawatbhata 5 & 6, both 220 MW PHWRs, which attained criticality in December 2009 and January 2010 respectively[cdviii]. Tarapur 3 &4 are also new, both are 540 MW (490 MW net) PHWR nuclear reactors, and they started commercial operation in 2005-06. Kaiga-3 started up in February and went into commercial operation in May 2007.

Many of these reactors are facing problems and have been downrated (discussed in Chapter 9). Due to these problems and shortage of uranium fuel, in mid-2008 India's nuclear power plants were running at about half of capacity.

Reactors under construction

Table: Reactors Under Construction in India[cdix]

Power station	**State**	**Type**	**Units**	**Expected date of commercial operation**	**Total capacity (MW)**
Kaiga 4	Karnataka	PHWR	220 x 1	2010	220
Rawatbhata 7&8	Rajasthan	PHWR	700 x 2	2016	1400
Kakrapar 3&4	Gujarat	PHWR	700 x 2	2015	1400
Kudankulam	Tamil Nadu	VVER-1000	1000 x 2	2011-12	2000
		Total	**5**		**5020**

Apart from these, a 500 MW prototype fast breeder reactor (FBR) is under construction at Kalpakkam by BHAVINI, a government enterprise set up to focus on FBRs. It was expected to start up in 2010 and produce power in 2011, but as we see in Chapter 9, this timeline is most probably way of the mark.

4. Reprocessing

Unlike other countries, the DAE pursues reprocessing as a way of dealing with spent fuel. India has three full-scale reprocessing plants, at Trombay, Tarapur and Kalpakkam, to extract reactor-grade plutonium for use in the fast breeder reactors. The Trombay plant was commissioned in 1965, the Tarapur plant was commissioned in 1977 but has been functioning much below capacity, while the Kalpakkam Atomic Reprocessing Plant (KARP), with a capacity of 100 tHM/y, was commissioned in 1998.[cdx]

5. Radioactive Waste Management

As discussed in Chapter 3, reprocessing results in large quantities of waste. The DAE classifies the waste from its reprocessing plants into Low Level Waste (LLW), Intermediate Level Wastes (ILW) and High Level Wastes (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. Likewise low level liquid wastes – consisting mostly of tritium but also small quantities of Cesium-137 and Strontium-90 – are released into nearby water bodies, such as the sea in the case of coastal reactors. Data on such releases are scarce – and often conflicting – but suggest that releases at Indian reactors are much higher compared to similar reactors elsewhere. Intermediate level liquid wastes generated in reprocessing plants are concentrated and fixed in cement.

Geological Disposal of HLW Waste

Because it contains the bulk of the radioactivity in spent fuel, the greatest concern is HLW. The DAE deals with this waste by immobilizing 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 stored at the Solid Storage & Surveillance Facility at Tarapur.

The DAE has proposed disposing of vitrified HLW in geological repositories about 500–600 metres below the ground in some appropriate host rock such as granite or basalt. Initially, deep geological formations in the southern Indian peninsula were explored as likely burial sites. A number of bore holes 0.6 miles deep were dug in an abandoned chamber of the Kolar gold mines to test the formation's behaviour under simulated radioactive decay heat. Those tests evidently did not yield the desired results. Then, in 1999, it was reported that an area of about 100 square kilometres in Rajasthan had been identified as suitable for burying wastes. This led to public protests from local communities. Shortly afterwards, the government announced in parliament that it had not taken any decisions on the disposal of nuclear waste, and such a decision might "take another two decades of research and development". So far no geological disposal site seems to have been finalized.[cdxi]

Part III: US-India Agreement and Nuclear Suppliers' Group

Background

One of the biggest symbols of the unjust world order we live in is the Nuclear Non-Proliferation Treaty, which came into force on March 5, 1970. Currently, 189 countries of the world have signed it.[cdxii] The ostensible purpose of this treaty is to limit the spread of nuclear weapons, but it allows five countries to have nuclear weapons – the United States, Russia, the United Kingdom, France and the Peoples Republic of China; they are officially recognised as “nuclear weapon states.” Coincidentally, these five nations also serve as permanent members of the United Nations Security Council. The Nuclear Non-Proliferation Treaty (NPT) recognises the right of NPT signatory countries to develop programs for peaceful uses of nuclear energy, and allows transfer of nuclear technology and materials to NPT signatory countries for this purpose, as long as they can demonstrate that their nuclear programs are not being used for the development of nuclear weapons.

India did not sign the NPT arguing that the treaty did not advance the goal of universal disarmament and instead divided the world into a club of "nuclear haves" who alone are free to possess and multiply their nuclear stockpiles, and a larger group of "nuclear have-nots".

Despite not signing the NPT, India managed to access nuclear technology from Western countries for its nuclear energy program in the 1960s. However, following India’s nuclear tests in 1974, the Western countries decided to further tighten rules governing international nuclear trade. Many of the signatories of the NPT now additionally formed an informal group, the Nuclear Suppliers Group (NSG), to further limit export of nuclear materials, equipment and technology. They formulated a set of guidelines which condition such exports on comprehensive safeguards by the International Atomic Energy Agency, which are designed to verify that nuclear energy is not diverted from peaceful use to weapons programs. Consequently, whatever little collaboration that was taking place between India and the Western countries was terminated by them, and uranium imports also ceased.

By the turn of the 21st century, momentous changes had taken place in the world. In this changed world scenario, India decided to abandon the Nehruvian model of development and globalise the Indian economy. Simultaneously, India also decided to abandon its non-aligned foreign policy and independent defence policy, and align with the United States. As a reward, the US offered India an agreement on nuclear cooperation, which was greedily accepted by India's rulers.[cdxiii]

Indo-US Nuclear Deal

On July 18, 2005, the US President Bush and Indian Prime Minister Manmohan Singh issued a joint statement, wherein among other things, they announced their intention to enter into a nuclear deal. According to this “Joint Statement”, India agreed to separate its civil and military nuclear facilities and place all its civil nuclear facilities under International Atomic Energy Agency (IAEA) safeguards, continue its unilateral moratorium on nuclear testing, and refrain from transfer of enrichment and reprocessing technologies to states that do not have them and support international efforts to limit their spread; in exchange, President Bush promised to get the US Congress to adjust US laws and policies and also work with other countries to modify international regimes to enable full civil nuclear energy cooperation and trade with India.[cdxiv]

The deal took more than three years to come to fruition as it had to go through several complex stages. In its final shape, the deal places under permanent safeguards those nuclear facilities that India has identified as "civil" and permits broad civil nuclear cooperation, while excluding the transfer of "sensitive" equipment and technologies even under IAEA safeguards. On August 18, 2008 the IAEA Board of Governors approved the safeguards agreement with India, and on February 2, 2009, India signed an India-specific safeguards agreement with the IAEA. Once India brings this agreement into force, inspections will begin in a phased manner on the 35 civilian nuclear installations India has identified in its Separation Plan.

Following the approval by the IAEA board, the United States approached the Nuclear Suppliers Group (NSG) to grant a waiver to India to commence civilian nuclear trade. The 45-nation NSG granted the waiver to India on September 6, 2008 allowing it to access civilian nuclear technology and fuel from other countries, without becoming a party to the NPT.

The US House of Representatives passed legislation allowing civil nuclear trade with India on September 28, 2008. On October 1, 2008 the US Senate also approved the agreement, which was signed into law by U.S. President, George W. Bush, on October 8, 2008. Two days later, the Indian External Affairs Minister Pranab Mukherjee and his counterpart the US Secretary of State Condoleezza Rice, formally inked the agreement.

While the US Congress discussed the deal threadbare before approving it, Prime Minister Singh blocked the Indian Parliament from scrutinizing the deal. Not only that, the Bush administration’s replies to questions raised by US Congressmen on the nuclear deal (which were kept under wraps and only made public in September 2008) reveal that the Indian Prime Minister has blithely lied to the Indian Parliament while defending the nuclear deal.[cdxv]

Part IV: New Nuclear Plans after the Deal

1. Uranium Imports

Following the clearance given by the Nuclear Suppliers group, India has signed agreements with a number of countries for uranium supplies, including France, Russia, Kazakhstan, Namibia and Mongolia. On September 1, 2009, unit 2 of the Rajasthan Atomic Power Station (RAPS-2), which had been shut down for some repairs, became the first reactor to supply power to the grid using uranium imported from France and Russia.[cdxvi] During the period January – July 2010, India imported 868 tonnes of uranium from France, Russia and Kazakhstan, and, according to the DAE, as of August 2010, seven reactors were using imported uranium.[cdxvii]

2. New Reactors

Even before the Indo-US nuclear deal opened up the prospects of reactor and uranium imports, the DAE had entered into an agreement with Russia to supply India's first large nuclear power plant, comprising two VVER-1000 (V-392) reactors, under a Russian-financed $3 billion contract. The nuclear plant is coming up in Kudankulam in Tamil Nadu; construction began in 2001. Russia will supply all the enriched fuel, and allow India to reprocess it and keep the plutonium. The first unit was due to start supplying power in March 2008 and go into commercial operation late in 2008, but this schedule has slipped.[cdxviii] According to a news-report in the middle of 2010, the first unit was supposed to be commissioned by the end of 2010, but this deadline too has not been met.[cdxix] The NPCIL website now says that the first unit will be commissioned in June 2011, and the second unit is about 9 months behind it.[cdxx]

In 2005, the government granted approval to set up two more imported VVER-1000 reactors at Kudankulam alongside the two already being built there by Russia, and site clearance was also given to set up two imported 1000 MW LWR units at Jaitapur in Ratnagiri district of Maharashtra.

Following the approval given by the Nuclear Suppliers Group to civilian nuclear trade with India in September 2008, the Indian government has quickly moved to sign civil nuclear cooperation agreements with a large number of countries, including France, Russia, UK and Kazakhstan. The agreement with France was signed as early as September 30, 2008, that is, even before India and the US formally signed the nuclear deal on October 10, 2008.[cdxxi]

With India now able to import uranium as well as reactors from other countries, the Indian government has announced plans to set up a string of nuclear reactors all over the country. These include some of the biggest nuclear power plants in the world. As of January 2010, the government has given ‘in principle’ approval to over 38,000 MW new reactor capacity, indicating that it is looking to scale up India’s nuclear capacity nearly ten-fold over the next decade. Many of these new projects involving big size imported reactors would be set up in 'Nuclear Parks', each having a number of reactors with a total capacity of around 10,000 MW at a single location.

So far, in principle approval has been given for the following Nuclear Parks[cdxxii]:

- Kudankulam in Tamil Nadu: Two more pairs of Russian VVER-1000 units, making it a total of 6 reactors of total capacity 6000 MW.
- Jaitapur in Maharashtra: A total of six EPR reactors from Areva of 1650 MW each, for a total of 9900 MW.
- Chhayamithi Virdi in Gujarat: Six LWR reactors of 1000 MW, to be set up by US based corporations, either GE-Hitachi or Westinghouse.
- Kovvada in Andhra Pradesh: Six LWR reactors of 1000 MW, also to be set up by US based corporations, either GE-Hitachi or Westinghouse.
- Haripur in West Bengal: Six more Russian VVER-1000 reactors to be set up here.

The NPC has obtained all the statutory clearances for beginning construction of Kudankulam-3 &4. It has also completed grading and leveling of the site for these two units. NPC was hoping to finalise the agreement during Russian President Dmitry Medvedev's visit to India in December 2010, so as to begin construction of the reactors in 2011[cdxxiii], but this has got stalled over Russian objections to India's nuclear liability law.

Power reactors planned or firmly proposed

Reactor	State	Type	MWe each
Kudankulam 3 & 4	Tamil Nadu	PWR - VVER	1000 x 2
Jaitapur 1 & 2	Maharashtra	PWR - EPR	1650 x2
Kaiga 5 & 6	Karnataka	PWR	1000 x 2
Kudankulam 5 & 6	Tamil Nadu	PWR - VVER	1000 x 2
Jaitapur 3 & 4	Maharashtra	PWR - EPR	1650 x 2
Fatehabad	Haryana	PHWR	700 x 4
Bargi	MP	PHWR	700 x 2
Mithi Virdi	Gujarat	PWR (US)	1000 x 6
Kovvada	Andhra Pradesh	PWR (US)	1000 x 6
Haripur	West Bengal	PWR (VVER)	1000 x 6
Jaitapur 5 & 6	Maharashtra	PWR - EPR	1650 x 2
Markandi (Pati Sonapur)	Orissa	PWR	1000 x 6

Note: For many of the above projects, the reactor size mentioned is only tentative, the final capacity would depend upon the rating of the reactor selected

The NPC has also obtained all the necessary clearances for the Jaitapur nuclear power project. Land acquisition for the project had been completed on paper (the people have refused to accept the compensation cheques[cdxxiv]), even before the plant received the mandatory environmental clearance, indicative of the fact that the clearance was always going to be a mere formality, and even though the final project agreement has yet to be signed with France. On November 28, 2010, the Environment Minister Jairam Ramesh granted environmental clearance for the project; while giving this permission, the Ministry of Environment and Forests imposed 35 conditions that the project would have to follow.[cdxxv] During French President Sarkozy's visit to India, a framework agreement for the supply of the first two reactors by Areva was signed on December 6, 2010. According to newsreports, operationalisation of the agreement will take some time as negotiations on technical issues like pricing are still underway.[cdxxvi]

According to the Department of Atomic Energy, the process of granting the necessary clearances for the Haripur, Kovvada and Mithivirdi projects has also begun; once this is done, the land acquisition process would begin.[cdxxvii] There are also plans to set up another 6000 MW nuclear park at Markandi (Pati Sonapur) in Orissa.[cdxxviii]

In addition, NPC has got in principle approval to set up 4 indigenous PHWR reactors of 700 MW each at Gorakhpur village in Fatehabad district of Haryana, and another 2 similar reactors at Bargi in Madhya Pradesh.[cdxxix]

India: The True Economic Costs of Nuclear Electricity

In his statement before the Indian Parliament on July 29, 2005 justifying the Indian government's decision to enter into a nuclear cooperation agreement with the United States, Prime Minister Manmohan Singh stated that it would allow us access to nuclear fuel, nuclear reactors and other technologies from outside, enabling us to produce "cheap and affordable" nuclear energy which will "enable India to leapfrog its current pace of economic growth".[cdxxx]

In his speech while dedicating Tarapur 3&4 reactors to the nation on August 31, 2007, the Prime Minister stated that we are placing "so much importance on nuclear energy" because it is "affordable, not only in terms of its financial cost, but in terms of the cost to our environment"[cdxxxi].

Whether nuclear energy is environmentally friendly or not, we shall examine in a later chapter. But definitely, it is not cheap. We have discussed the worldwide costs of nuclear power in Chapter 4, where we had concluded that nuclear energy is one of the most expensive ways of generating electricity, and is definitely much more costly as compared to electricity from fossil fuels. The only way it can be competitive with conventional electricity is if it is highly subsidised by the government.

The situation is the same with India too. It is the enormous hidden subsidies that nuclear energy gets that allows the Prime Minister to claim that nuclear energy is and will continue to be "cheap" and "affordable".

Even officially, nuclear electricity in India is costlier than electricity from conventional sources. Nuclear electricity in India costs between Rs. 2.70 and 2.90 a kilowatt-hour (i.e. per unit) from its reactors built since the 1990s, a price which is far higher than the cost of electricity from coal-fired plants.[cdxxxii]

In reality, this official price has no meaning, as the subsidies given are huge.

Part I: Subsidies for India's Indigenous Reactors

The subsidies given by the government of India to nuclear energy are even more than the massive subsidies given by the US government discussed in Chapter 4.

There is no need to give loan guarantees for nuclear reactor construction in India, as the nuclear industry is in the public sector. Apart from this implicit subsidy, which greatly reduces the capital cost of the reactor, the DAE (that is, the government of India) also gives numerous explicit subsidies to the NPCIL.

The DAE subsidises the NPC in nuclear fuel price, by supplying it fuel bundles from its Nuclear Fuel Complex at much less than the cost of production.[cdxxxiii] It also supplies heavy water (HW) from its heavy water plants for use in NPC's CANDU reactors at subsidised rates. Most of NPC's reactors are CANDU reactors, and heavy water (HW) is a major cost component of producing electricity from these reactors. M. V. Ramana, one of India's leading nuclear physicists who is presently a research fellow with Princeton University, has made some estimates of the subsidy involved. His calculations show even conservatively, as per standard and required accounting practices, a subsidy of over Rs 12,000 per kg is being offered.[cdxxxiv] Let us make a cursory estimate of the total subsidy given. Heavy water reactors need HW initially to attain criticality; once they start operating, they need HW periodically to make up for losses. The initial coolant and moderator inventory requirement for each 220 MW reactor is 70 tons and 140 tons of HW respectively. Once the reactor begins operation, the reactor loses about seven tons of HW per year, which must be therefore replenished.[cdxxxv] This means that the total subsidy given by the DAE in the capital cost of a 220 MW heavy water nuclear reactor would be of the order of 210,000 kgs x Rs. 12,000 per kg = Rs. 252 crores. Let us compare this with the capital cost of a 220 MW reactor. The estimated capital cost of the Kaiga I & II reactors (220 MW each) when they attained criticality in 1999 was Rs 2,896 crores,[cdxxxvi] or Rs. 1450 crores for each reactor. This means that the DAE has been subsidizing the capital cost of NPC's CANDU reactors to the tune of around 17% of the capital cost – and the capital cost of the reactor is the dominant component of the cost of nuclear electricity. Similarly, the total subsidy given by the DAE in annual operating costs of a 220 MW heavy water reactor would be of the order of 7,000 kgs x Rs. 12,000 per kg = Rs. 8.4 crores.

Another important subsidy given to nuclear electricity in India is in the cost of dealing with the radioactive waste from the nuclear power plants. As discussed in Chapter 4, these are very large expenses, and most countries subsidise them; without this subsidy, the nuclear industry wouldn't exist. For instance, in the USA, the US government has taken over the entire responsibility of dealing with the nuclear waste, for which it charges utilities a highly subsidised fee of $277,000 per ton of spent fuel waste, which amounts to roughly 0.1 cents per kilowatt-hour of nuclear generated electricity generated by them.[cdxxxvii] The US government at least charges the nuclear utilities something for taking care of their nuclear waste; in India, the DAE bears all the waste management expenses, and does not charge the NPC which operates India's nuclear reactors a single Rupee[cdxxxviii]!

In fact, the DAE reprocesses this spent fuel, which as we have seen in Chapter 3 is an even costlier way of dealing with spent fuel waste.

Likewise, the DAE is also going to bear the entire decommissioning expenses of India's reactors, as and when they are closed down.[cdxxxix] To get a rough idea of the amounts involved, let us use the estimates made by US Nuclear Regulatory Commission, which estimates that typical decommissioning costs of nuclear reactors would be around 20-30% of the capital costs[cdxl]; for the 2 × 220 MW RAPS III and IV reactors, whose the capital cost was Rs. 2,511 crores[cdxli], this means that decommissioning them would cost at least Rs. 500 crores.

So far as making a provision for insurance liability against accidents is concerned, there is no need for the NPC to do so. It simply ignores radiation leakages and radioactive contamination around the nuclear establishments run by it, and does not even acknowledge minor accidents! Therefore, no remediation is required. And in the case of a major accident, which by 'God's grace' has not happened so far, it assumes that the government will bear the costs.

Finally, like all countries with nuclear power programs, the health costs of nuclear energy in India too are simply brushed under the carpet. The government refuses to admit that radiation from any of its nuclear energy related installations is affecting the health of people living around these plants and mines. Even the courts have refused to hear petitions on these issues. So the question of paying compensation and making provision for health care of radiation affected victims does not arise.

Part II: Imported Reactors: Even more Subsidies

Following the signing of the Indo-US nuclear deal, as a part of its nuclear energy expansion plans, the government is going in for imported nuclear reactors in a big way. As we have discussed in Chapter 6, the foreign equipment suppliers are desperately short of orders, and the government could have done some hard bargaining with them. Instead, it is bending over backwards to give them multiple subsidies.

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-Madban for Areva, Mithivirdi and Kovvada for Westinghouse / GE-Hitachi, Kudankulam and Haripur for Atomstroyexport. It is an unparalleled giveaway – the government has announced these reservations even before the terms of the reactor contract have been negotiated![cdxlii] 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 age old undemocratic laws, wherein land is compulsorily acquired from the people at a cost determined arbitrarily by the government.

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 NPC. Let us take a look at the estimated cost of electricity from the Jaitapur nuclear plant which is going to be built by the French nuclear corporation Areva. (We are not discussing Kudankulam because we do not have any studies of electricity cost estimates from this plant.)

Jaitapur Nuclear Plant

On December 6, 2010, during French President Sarkozy's visit to India, India signed a framework agreement with France's state-run nuclear group Areva for the purchase of two reactors for the nuclear park at Jaitapur-Madban in Maharashtra. So eager has been the government to sign this deal, so powerful are the vested interests behind this deal, that the government is not willing to even discuss the economics of producing electricity from these reactors. While announcing the agreement at a Press Conference, the Prime Minister stated that pricing issues are still “subject matters of negotiations".[cdxliii] Meaning, that the government has agreed to buy the reactor, without finalising the price! Clearly, the government has something big to hide. Let us take a closer look at the Areva deal.

Newsreports have estimated the cost of the two reactors to be about 7.0 billion euros (9.3 billion dollars).cdxliv However, this seems to be a big underestimate. The contract price of the 1600 MW EPR being constructed in Finland was €3.2bn when the agreement was signed in December 2003; as in June 2010, its cost had escalated to around 5.9 billion euros, and the reactor was only halfway to completion.cdxlv Obviously, the final cost is going to be much more. Even assuming that each Jaitapur reactor is going to cost this much, that is 5.9 billion euros, then, taking the current Euro-Rupee exchange rate as in January 2011 of Rs. 59 = 1 euro, this means each reactor should cost at the minimum Rs. 34,800 crores! That works out to a whopping Rs. 21 crores per megawatt (MW), as compared to Rs. 5 crores per MW for coal-fired plants!!

The total installed capacity of the Jaitapur plant when all six reactors are constructed is going to be 9900 MW. At Rs. 21 cr/MW, this means the plant is going to cost a mind-boggling Rs. 2 lakh crores! The cost of an equivalent coal-fired plant would be just Rs. 50,000 crores, implying a saving of Rs. 1.5 lakh crores!!

Given this huge capital cost, what will be the unit cost of electricity from the plant? No one, right from the Prime Minister to the Chairperson of NPCIL, is willing to discuss it. Areva's CEO, Anne Lauvergeon, in an interview to *The Hindu* on November 25, 2010, asserted that it would definitely be below Rs. 4 a unit!cdxlvi This is obviously ludicrous. More realistic estimates put the cost of electricity from the Jaitapur nuclear plant at least Rs. 7-9 per unit: Prabir Purkayastha, the well-known power sector analyst, estimates the cost of electricity assuming the plant is going to cost Rs. 20 cr/MW to be Rs. 7-8 per unitcdxlvii; Dr. Vivek Monteiro, a well known physicist who holds a doctorate from Harvard University, estimates that the cost would be at least Rs. 9 a unit[cdxlviii; Gopal Krishna, a member of Toxicswatch Alliance, also estimates it at Rs. 9 a unit.cdxlix]

Of course, these cost estimates do not take into account the subsidies to nuclear power discussed above, like decommissioning costs, waste management costs, etc.

Clearly, the cost of electricity from the imported reactors is going to be even greater than that from Enron's Dabhol Power Plant in Maharashtra, which made MSEB virtually bankrupt. If the government succeeds in its plans of setting up a string of nuclear parks along the coast, India is going to be saddled with dozens of nuclear Enrons.

Nuclear Liability Bill: Indemnifying Foreign Suppliers

The costs of nuclear electricity are so huge, that the foreign vendors are still not satisfied with these subsidies. American reactor suppliers like General Electric and Westinghouse grunted that they will not invest until India gives them a sovereign guarantee that the **entire liability of any potential catastrophe is borne solely by Indians,** in other words, that they will not be held liable for any accident at the plants supplied by them – they are aware that it could bankrupt them. And so, their concubine, the US government, ratcheted up the pressure on the Indian government to pass such a law. On June 25, 2009, the U.S. Assistant Secretary of State for South and Central Asian Affairs Robert Blake told a committee of the US House of Representatives: "… we are hoping to see action on nuclear liability legislation that would reduce liability for American companies and allow them to invest in India…"[cdl] Obligingly, the government has now got the 'Civil Liability for Nuclear Damage Bill 2010' passed by a pliant Parliament. The provisions of the bill are absolutely outrageous.

The nuclear liability bill has two key clauses. First, in the event of an accident, it indemnifies the supplier from all liabilities. Further, while US Liability Law (see Chapter 4) permits "economic channelling," but not "legal channelling," of liability, thereby allowing criminal proceedings and other lawsuits against any party in courts, the Indian Liability Law channels all financial and legal liability to the operator.[cdli] The law does allow the operator – and only the operator, not the victims of the accident who have been completely denied all rights – to sue the foreign vendor in courts in case the nuclear incident has taken place because of "supply of equipment of material with patent or latent defects or sub-standard services."[cdlii] The problem is, the operator is going to be the government owned NPC. Considering the extent to which the Indian government is selling out the interests of the people of India to foreign corporations and governments – an example being the complete betrayal of the victims of the Bhopal gas tragedy in the case against Warren Anderson, Union Carbide and its successor company Dow Chemicals – it is obvious that the foreign reactor suppliers can sleep easy.

Second, the Law caps the liability of the nuclear plant operator in case of a nuclear accident at a laughable Rs. 1500 crores. Beyond this cap, if necessary, the government assumes responsibility for paying the damages, but subject to a maximum cap of 300 million Special Drawing Rights,[cdliii] equivalent to roughly Rs. 2100 crores.[cdliv] (As on Oct 29, 2010: 1 SDR = $ 1.57; while $ 1 = Rs. 44.4; therefore 1 SDR = Rs. 69.7; 300 million SDR = Rs. 2091 crores.) Since the operator of the reactors is going to be the government owned NPC, it means that the damages for an accident in the foreign reactors are essentially going to be paid by you and me – who are not even remotely responsible for the accident; the foreign supplier is completely let off the hook!

That is precisely the reason why the Indian government pushed the Nuclear Liability Bill through the Indian parliament, overriding the objections raised by a wide range of pro-people intellectuals. This has in fact been admitted by an Indian minister, "The Nuclear Liability Bill … will … indemnify American companies so that they don't have to go through another Union Carbide in Bhopal."[cdlv] For Delhi's moghuls, the perpetrator of the world's worst chemical accident is unfortunately being victimized, and so they are pledging legal protection for a possible nuclear Bhopal.

A secondary beneficiary of the Liability Law is Indian big business, which is expecting subcontracts to the tunes of hundreds of crores from the foreign plant suppliers (See Chapter 9). The Federation of Indian Chamber of Commerce and Industry (FICCI), the oldest and biggest lobbying arm of Indian big industry, had extended its strong support to the passage of the bill through the Indian Parliament, saying that it was essential for participation of both domestic and foreign suppliers in India's nuclear program. And when the debate between the government and the opposition intensified over the inclusion of Clause 17 (b), which allows the operator to sue suppliers in case of defective equipment, FICCI came out strongly for deletion of the clause, arguing that the clause "is neither implementable" nor "justified" and "not desirable", and that it will "completely undo the Government's efforts to accelerate nuclear power generation in our country."[cdlvi]

Supreme Court Decisions Violated

By freeing the foreign suppliers of all liabilities in case of an accident at a reactor supplied by them, the Law violates the principle of absolute and strict liability laid down by the Supreme Court wherein the Court ruled: "Once the activity carried on is… potentially hazardous, the person carrying on such activity is liable to make good the loss… irrespective [of] whether he took reasonable care…"[cdlvii] 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 Law also violates the right to full compensation which has been interpreted by the Supreme Court to be a part of Right to Life guaranteed under Article 21 of the Constitution. Known as the Polluter's Pay Principle, according to this tenet a polluting industry has to not only fully compensate the victims for the accident, it must also fully bear the costs of restoring the environmental degradation. The Nuclear Liability Law violates this principle by artificially capping the total compensation that would be paid out in case of an accident at 300 million SDRs, which translates into a measly $460 million, which is even lower 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. If exchange-rate changes and inflation are taken into account, the sum works out to about one-third of what the Bhopal victims got,[cdlviii] whereas a nuclear accident can be many hundreds of times bigger than the Bhopal gas tragedy! An accident like the Chernobyl reactor core meltdown of 1986 can wreak damage running into hundreds of billions to several trillions of dollars, and make huge swathes of land uninhabitable for centuries. Among the countries having a liability law (which limits the liability of the nuclear operators), US, Germany, Finland, Japan, South Korea and Switzerland have not placed any cap on maximum liability (the excess amount will of course be paid by the government).[cdlix]

Liability Legislation: No International Obligation

Even assuming that the country needs nuclear energy and needs to import nuclear reactors, there was no need to enact a liability legislation. The media and the government of India have created the impression that India needed to pass a liability legislation in order to become compliant with international nuclear liability instruments (like the Convention on Supplementary Compensation for Nuclear Damage, which India signed on October 27, 2010, two months after the Nuclear Liability Bill cleared Parliament,), and that this was necessary for India to engage in nuclear trade with the world. The reality is, India is under no obligation to enact a liability law or become a signatory to an international liability convention to become eligible for engaging in nuclear trade with other countries. For instance, Russia has refused to pass legislation to waive or cap accident liability for its foreign suppliers. While many countries have liability laws, the powerful World Nuclear Association – the lobbying arm of 180 nuclear firms, including GE, Westinghouse and Areva – admits, "States with a majority of the world's 440 nuclear power reactors are not yet party to any international nuclear liability convention, relying on their own arrangements."[cdlx]

US-Russia still not happy

According to newsreports, both the USA and Russia are not happy with the Liability Law approved by the Indian Parliament. They want that India's nuclear liability regime to channel "absolute and exclusive liability to nuclear power plant operators", even if the accident occurred due to negligence on the part of the foreign supplier![cdlxi] As mentioned above, India's Liability Law allows for the Indian operator to sue the foreign supplier in case the accident occurred due to defective equipment supplied by the latter.

Both the US nuclear industry and the Obama administration have mounted pressure on the Indian government to either make amendments to the Law, or find some way to circumvent it. According to the *Wall Street Journal*, the US government, recognising the difficulty of the Indian government in sending the freshly passed Law back to the Parliament for an amendment, is trying for a government-to-government agreement with India that could take precendence over the Law.[cdlxii] Considering the extent to which the Indian government is surrendering to imperialist, especially US corporate interests, it is certain that very soon, as soon as the political atmosphere in Delhi gets more congenial, the Indian government will take steps to address US concerns.

The bloodthirsty imperialists are not satisfied if you just bow before them. They want you to show your absolute submission by doing a sastanga dandavat, that is, pay obeisance by lying down flat on the ground.

To Conclude...

As we have argued elsewhere, India's ruling classes have totally divorced themselves from the people of the country. The country is now being run solely to maximise the profits of foreign multinationals and their Indian collaborators.[cdlxiii] The nuclear policy of the government of India is just another instance of this betrayal…

India's Nuclear Installations: Safety and Other Issues

Part I: India: Nuclear dictatorship

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 by uranium mines and nuclear power plants (some of which we have given in Chapter 3). In India, however, no such information is available. The nuclear authorities in India take refuge behind the draconian Atomic Energy Act of 1962 to deny all information about the state of India's nuclear installations and the various accidents-incidents taking place in them, under the plea that all such information is "classified", and cannot be disclosed in the interests of national security![cdlxiv] Obviously, the DAE has mixed up national security with nuclear safety to cover up its safety lapses, and the Indian courts including the Supreme Court of India have gone along with its interpretation (we discuss this in greater detail in the next section). The Indian Atomic Energy Act of 1962 is so authoritarian that the DAE is not accountable even to the Parliament![cdlxv] In fact, the DAE has used the Atomic Energy Act to prevent nuclear plant workers from accessing their own health records too!![cdlxvi]

India's nuclear establishment has become such a monolithic and autocratic entity that even when major accidents have occurred and news about the accidents have leaked out through the media to become public knowledge, even then the AEC / DAE / NPC / UCIL have refused to admit to radiation releases from their installations. A few examples:

ix. On December 25, 2006, the pipeline carrying radioactive waste from the uranium mill to the tailing pond in Jadugoda (Jharkhand) burst and continued to spew toxic sludge into a creek for nine hours before the flow of the radioactive waste was 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 the communities living hundreds of kilometers along the way.[cdlxvii] However, all that the UCIL website admits is: "The pipe burst spilling tailing slurry in December 2006 … was attended in the shortest possible time and corrective measures were also taken."[cdlxviii] That's all, not a word more!

x. A major mishap in Tarapur in 1980 resulted in thousands of litres of irradiated water gushing out from the reactor. But the Chairman of the Atomic Energy Commission reluctantly acknowledged only a "pinhole" leak, even though the water had gushed out from a 15 cm tube![cdlxix]

xi. On March 26, 1999, six tons of highly radioactive heavy water leaked out from the Madras Atomic Power Plant. The accident was serious enough for the plant management to declare an emergency, which means the plant was just one step away from being evacuated. The plant authorities initially tried to suppress the news. But the workers union revealed it to the press and it created a furore. The plant authorities then played down the incident, claiming that the leak was "insignificant" and "anticipated", and made the ludicrous declaration that the coolant water which spilled was not radioactive![cdlxx]

Kaiga 'incident': Lies galore

Let us discuss a recent accident in greater detail, to illustrate the kind of absurd arguments and lies India's top scientists dish out to cover up the mistakes of the DAE. On November 24, 2009, urine tests revealed that more than 90 workers at Unit One of the Kaiga nuclear plant had high levels of radioactive tritium in their bodies[cdlxxi] (according to Kaiga township residents, 250 workers were affected[cdlxxii]). The incident only came to light on November 28, after the media got hold of the story (the NPC failed to suppress the news probably because too many workers needed hospitalisation). We don't know for how long were these workers exposed to this radiation, and what is their exact medical condition. Under public pressure, the authorities released the radiation count levels, and this showed radiation levels of as high as 1600-2000 microcurie in some of the workers. The maximum permissible amount of tritium in a litre of urine is 100 microcurie. But nothing beyond that was revealed.[cdlxxiii]

After the media broke the story, India's top nuclear authorities immediately went into denial mode, claiming that all was well with the reactor, no accident and no leakage of radioactive tritium had taken place at the plant. Even the Prime Minister Manmohan Singh grandly declared that there was "nothing to worry about the small matter of contamination".[cdlxxiv] India's leading scientists made public statements that there was nothing to fear about the safety of workers as tritium was not poisonous and its presence in the human body would come down on its own.[cdlxxv] They are lying, they are no longer scientists in search of truth, they have become prizefighters. Every health physicist knows that tritium is a very dangerous material. Tritiated water, being chemically similar to water, is easily absorbed and then quickly distributed throughout the body via the blood. While half of it is out of the body within 10-12 days, some of it gets bound to organic molecules and spends much longer time in the body. Tritium is a beta emitter and very mutagenic: it can cause cancer, genetic defects and developmental abnormalities. (We've discussed its effects in greater detail in Chapter 3). This risk increases in direct proportion to the radiation exposure, and there is no threshold below which the risk is zero.[cdlxxvi]

If there was no accident, how did tritium enter the bodies of workers? The official story is: the workers got poisoned after they drank tritiated water (that is, water contaminated by tritium) from a water cooler. And pray how did tritiated water enter the cooler? Due to internal 'sabotage' or 'mischief-making' by unidentified employees: these employees, 'it appears', added tritium-contaminated heavy water to a drinking-water cooler through its overflow pipe.[cdlxxvii] That would have required a pump – how can an employee do that without being discovered! The story becomes even more farcical if one considers that tritium is an extremely costly and a strategically important material. The estimated costs of producing tritium vary from about $30,000 (about Rs. 14 lakh) per gram in Canada to $100,000 (about Rs. 46 lakh) per gram in the US. Strategically, tritium is an extremely sensitive material used in nuclear weapons as a booster.[cdlxxviii] Clearly, the DAE is telling a cock-and-bull story, and in the process, tying itself up in knots.

Challenging India's Nuclear Dictatorship in the Courts

It is commonsense that safety issues at India's nuclear installations have nothing to do with the safety of the country, and information about these issues should be shared with the people of the country. If India's atomic energy establishment is denying us information about these issues, it is clearly violative of the democratic fabric of our country. If it is using the Atomic Energy Act of 1962 to deny us this information, then such an interpretation of this Act is violative of our fundamental rights, and is unconstitutional. Because an accident at a nuclear reactor can kill lakhs of people and render huge areas uninhabitable for centuries, because it is affecting our very Right to Life, we have a fundamental right to know whether all is well at India's nuclear installations, it cannot be left to the whims of our bureaucrats and politicians. Why don't we invoke the Right to Life guaranteed to us by the Constitution of India and ask the Supreme Court of India to end the nuclear dictatorship prevailing in the country? It has been tried by some of India's most eminent lawyers, but unfortunately our courts have upheld the dictatorial powers conferred on the Atomic Energy Commission under this Act.

Following news-reports in mid-1996 that the AERB under the chairmanship of Dr. Gopalakrishnan had compiled more than 130 issues affecting the safety of our nuclear establishments in the country, the well-respected human rights organisation People's Union for Civil Liberties (PUCL) filed a Public Interest Litigation (PIL) in August 1996 in the Bombay High Court. Citing the grounds of Right to Life and Right to Know, the PUCL petition sought, amongst others, disclosure of the adverse report of the AERB, for a direction to the Union Government to make the AERB an independent body so that it might act as an effective watchdog for nuclear safety in the country, and for declaring section l8 of the Atomic Energy Act unconstitutional as it confers on the Central Government untrammeled powers for withholding from the public information about the working of India's nuclear power plants. The Sarvodaya Mandal of Mumbai represented by Dr Usha Mehta, the noted Gandhian and freedom-fighter, also filed a petition in support of the PUCL petition.

The two PILs were heard at length at the stage of admission by a Bench presided over by the then Chief Justice M B Shah. Senior officials of the country's nuclear establishment, including Dr R. Chidambaram, the chairman of the AEC and secretary of the DAE, filed bulky affidavits, opposing the petitions. In his affidavit, Dr R. Chidambaram invoked the provisions of Section 18 of the Atomic Energy Act and stated that the document was a secret document as it related to nuclear installations, and went on to say that publication of the document "will cause irreparable injury to the interests of the State and will be prejudicial to national security."

It is important to note that the petitioners did not ask for any information about India's nuclear arsenal or its storage site or anything related to India's national security and had only expressed a genuine concern that there were not enough safety precautions in nuclear power stations in the country and any accident could have a disastrous affect on human beings, animals, environment and ecology. However, accepting the blatantly false arguments made in the statements and affidavits of officials of the DAE, the Bombay High Court dismissed the writ petition at the admission stage itself.

Both the Bombay PUCL and the Bombay Sarvodaya Mandal filed appeals before the Supreme Court against the decision. The atomic energy department again repeated its argument that disclosure of the documents would harm national security. On January 6, 2004, the bench of Chief Justice of India and Justice S B Sinha dismissed both the appeals.[cdlxxix]

Some months later, another PIL petition was filed in the Supreme Court regarding the hazardous impact of uranium mining being done by the UCIL in Jadugoda, Jharkhand. The petition made a prayer to the Court to direct the UCIL, the AEC and other concerned authorities to take all possible steps under a time bound programme to ensure that the radioactive effluents generated by the mining and allied activities of the Jadugoda uranium mines are controlled and treated properly so that the same do not cause serious hazards to the health and lives of those working or living in or around the Jadugoda uranium mines. In response, the Chairman of the AEC filed an affidavit stating under oath that adequate steps have been taken to check and control radiation arising out of uranium waste. Accepting this bare-faced lie, on April 15, 2004, the Supreme Court dismissed the petition stating that it did not see any merit in it.[cdlxxx]

Let us take a look at the state of India's nuclear installations – it should give all of us sleepless nights!

Part 2: Uranium Mining

Uranium Corporation of India Ltd, a subsidiary of the Department of Atomic Energy (DAE), has been mining uranium in Jharkhand for over four decades now. It presently operates five underground mines in the region, and also commissioned an open cast mine in 2009.

Untruths unlimited

UCIL operates these mines in flagrant violation of Indian laws. Even though India's Atomic Energy Act states that there should be no habitation within five kilometers of a waste site or uranium-tailing pond and even though Jadugoda has been in operation for more than 40 years now, seven villages stand within one and a half kilometers of the danger zone. One of them, Dungardihi, begins just 40 meters away. More than 30,000 people live within the 5 km radius from the tailing ponds.[cdlxxxi]

The corporation's website claims that "UCIL has a track record of adopting absolutely safe and environment friendly working practices in Uranium Mining and Processing activities." It claims that it regularly monitors external gamma radiation, radon concentration, and concentration of radionuclides in surface and ground water; while refusing to make radiation data public, citing the Atomic Energy Act of 1962, it nevertheless asserts that there is no radioactive contamination of the area due to uranium mining.[cdlxxxii] Its website claims that "the diseases prevalent in the villages around UCIL workings are not due to radiation but attributed to malnutrition, malaria and unhygienic living conditions etc."[cdlxxxiii]

Shocking carelessness

The reality is the exact opposite. The mining practices followed by UCIL completely disregard the fact that uranium is radioactive, and that the waste from the mines continuously emits the highly carcinogenic radon-222 gas, and the mill tailings contain uranium decay products like the highly radioactive thorium-230 with a half-life of 80,000 years (see Chapter 3 for a more detailed discussion). It callously dumps the waste from the mines in the open[cdlxxxiv], and the mill waste in unlined tailing ponds[cdlxxxv] – seepage from which will obviously contaminate the soil and groundwater. The three tailing ponds are spread over an area of 100 acres and are estimated to contain tens of millions of tons of radioactive waste.[cdlxxxvi]

The corporation has not taken the slightest precautions to protect the health of the people living in the vicinity of the mines from radiation release. Its utter callousness and unconcern is eloquently brought out in numerous surveys of the area around the mines by independent experts, including: field trips in 2001 and 2002 by Professor Hiroaki Koide from the Research Reactor Institute, Kyoto University, Japan[cdlxxxvii;] surveys by the well known physicist Dr. Surendra Gadekar and medic Dr. Sanghamitra Gadekar in 2000 and then again in 2005[cdlxxxviii;] and the more recent survey by a team of doctors from Indian Doctors for Peace and Development (IDPD), the Indian chapter of 1985 Nobel Peace Prize recipient International Physicians for Prevention of Nuclear War (IPPNW)[cdlxxxix] in 2008. They found that:

- The uranium mines were located on adivasi land. The adivasis were simply removed from their lands by force, but no attempt was made to resettle them at a suitable distance from the mines. Consequently, they continue living on the edge of the mines. Without explaining the risks, they were offered employment as uranium miners, which they willingly accepted as they had been deprived of their lands. They were thus doubly exposed to radiation: as miners, and along with their families, to the radioactive dust blowing from the tailing ponds.
- No safety measures have been taken by the company. The waste is carelessly dumped in the open; the ore is transported to the mills in uncovered dumpers; the tailing ponds are not fenced off properly, and people freely walk across them, not knowing that they are thus getting exposed to gamma radiation.
- The company has also supplied waste rock from the mines for construction of roads and houses!
- It is suspected that radioactive wastes from various parts of India have been abandoned in these tailing ponds. This is suspected because the tailing pond in Jadugoda has a high concentration of Cesium-137, one of the fission products of Uranium which is found in the

spent fuel. There is no other logical way in which this radionuclide could have found its way into the tailing pond!

The state of UCIL's newest mines is no better. A *Tehelka* reporter[cdxc]visited the Banduhurang open cast mine in September 2010. This is UCIL's newest mine, commissioned in 2009. He found no prohibitory signs, no warnings about radiation, no barbed wire and no demarcation of territory. Mounds of radioactive waste from the mines lay scattered everywhere, sometimes inside the villages surrounding the mine. The radioactive waste water released from the mines simply joined a stream flowing through the villages where children were found bathing and women washing clothes. Trucks carrying uranium ore were loosely covered with plastic sheets, radioactive dust flying in the wind. This, when just a few years ago, the Chairman of the DAE had filed an affidavit in the Supreme Court claiming that all precautions were being taken to check and control radiation arising out of uranium waste from UCIL's mines. UCIL officials tried their best to prevent the reporter from visiting the mines and filing his report, slapping all kinds of charges on him, putting him behind bars for 12 hours, seizing his equipment…[cdxci]

Accidents galore

As if this was not enough, due to UCIL's faulty technical and management practices, there have been numerous accidents. Tailings pipelines, carrying uranium mill tailings from the Jadugoda uranium mill to the tailings ponds, have repeatedly burst, causing spillage of the radioactive and toxic sludge into nearby homes and water bodies. The latest such pipeline burst took place on August 16, 2008; before this, bursts had taken place on February 21, 2008 and on April 10, 2007.[cdxcii]

One of the worst such accidents took place on December 25, 2006. The tailings pipeline burst and continued to spew toxic sludge into a creek for nine hours before the flow of the radioactive waste was 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 the communities living hundreds of kilometers along the way.[cdxciii]

Terrible health costs

The impact of all these radiation releases on the health of the people of the nearby villages has been colossal. In 1993, the Bindrai Institute for Research Study and Action (BIRSA), (a research and documentation centre started by intellectuals and activists related to various people's movements of Jharkhand) conducted a survey in seven villages within a kilometre of the mining site, specifically the tailings dams. The field health workers who conducted the survey were trained by Dr. Imrana Qadir of Centre for Social Medicines, Jawaharlal Nehru University (JNU), New Delhi. It took two years to complete the survey. The report revealed that 47 per cent of women suffered disruptions in their menstrual cycle, 18 per cent said they had suffered miscarriages or given birth to stillborn babies in the last 5 years, 30 per cent suffered fertility problem. Nearly all women complained of fatigue, weakness and depression. Further, the survey found a high incidence of chronic skin diseases, cancer, TB, bone, brain and kidney damages, nervous system disorders, congenital deformities, nausea, blood disorders and other chronic diseases. Children were the most affected. Many were born with skeletal distortions, partially formed skulls, blood disorders and a broad variety of physical deformities, most common being missing eyes or toes, fused fingers or limbs incapable of supporting them. Brain damage often compounded these physical disabilities.[cdxciv]

The Gadekars in their medical survey also confirmed increasing cases of congenital deformities, mental retardation, Polydactyl (extra fingers or toes) and Syndactyl (fused or missing fingers and toes) and Lung Cancer in people of the area.[cdxcv] Most recently, the health survey by a team of doctors from the IDPD, the Indian affiliate of the world renowned IPPNW, found clear evidence of increased incidence of sterility, birth defects and cancer deaths among people living in the nearby villages.[cdxcvi]

While the UCIL management doesn't accept the fact that radioactivity has in any way been harmful to either people, animals, trees or plants, senior officials of the Corporation have made arrangements for their own food to come from a government farm about 44 km away![cdxcvii]

Expanding the toxic trail

After destroying Jharkhand, UCIL is now proposing to start uranium mining in Andhra Pradesh, Karnataka and Meghalaya (see Chapter 7 for more details).

UCIL and DAE'S utter disregard for the impact of uranium mining and processing on the environment is evident from its proposal to start mining in the Lambapur-Peddagattu area in Nalgonda district of Andhra Pradesh. This mining site is right above the Nagarjunasagar reservoir and is in the vicinity of the Akkampally Reservoir. The Nagarjunasagar is an important source of irrigation for the districts of Nalgonda, Guntur, Krishna and Prakasham and is also the drinking water source for many towns, while the Akkampally Reservoir is the pumping station of Krishna River water to the twin cities of Hyderabad and Secundrabad.[cdxcviii] If at all uranium mining begins in this area, it is absolutely certain that Nagarjunasagar and Akkampally reservoirs are going to get radioactively polluted, ultimately polluting the food chain of the people of Andhra Pradesh! And as we have discussed in detail in Chapter 3, this is not like industrial pollution which can be remedied. Radioactive pollution will contaminate the state’s water sources for thousands of years!! Fortunately, protests by local people have so far prevented the UCIL from making any headway in its diabolical plan.

UCIL is particularly desperate to begin mining in Meghalaya, which is supposed to have the largest reserves of uranium in the country after Jharkhand. Exploratory mining work done in this state in the 1991 had led emergence of strange diseases among people, fish began to die in nearby rivers, and so the people organized and forced the exploratory mining to close down.[cdxcix] UCIL again revived the project some years ago, but once again, a powerful movement has put a spanner in UCIL's plans.

Part III: 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 nuclear plants in India.

The NFC churns out 50,000 tons of contaminated waste water per day. This huge quantity of contaminated water, containing radioactive materials and chemical wastes, is discharged into a waste storage pond located in the complex. Seepage from this pond has contaminated the underground water, and with the NFC / DAE simply unconcerned, this radioactive contamination is going to increase with time.

As a result, the situation in and around Hyderabad is becoming grave. Mysterious and painful diseases have already visited residents in the vicinity of NFC. The DAE has prohibited residents of Ashok Nagar near NFC from drinking water from underground wells in the area. Eleven villages near the NFC also face the same problem. As the contamination spreads, it will affect the underground water supply to the entire city of Hyderabad. The city has an acute shortage of drinking water, and so many residential complexes install their own borewells. A day may come when it will be highly dangerous to use the underground water and people may have to desert Hyderabad as has happened in the area near Hanford works in the USA.[d]

Part IV: India's Nuclear Power Reactors

As discussed in Chapter 3, release of small or large quantities of radioactivity at nuclear power plants (NPPs) occurs quite often, at every nuclear reactor around the world. These releases can be planned, that is the nuclear plant authorities purposefully decide to vent radioactive gases into the air or release radioactive water into nearby seas and rivers. Or they can be because of human or mechanical error, which the nuclear industry euphemistically refers to as 'incidents', in order to downplay the severity of the accident and mollify public concerns. Several of these 'incidents' have snowballed and have had catastrophic ramifications, the biggest of course being the Three Mile Island and Chernobyl disasters. As discussed in Chapter 3, the technology of nuclear reactors is complex and events can spin out of control in a very short time, all possible accident modes cannot be predicted, all of which means that there is no way to ensure that reactors will not have major accidents.

Thus, even though the nuclear industry claims it is emission-free, nuclear power plants collectively release lakhs of curies of radiation into the atmosphere every year, with deathly consequences for life on planet Earth, consequences which will be with us till the end of time, as many of these radioactive materials released into the atmosphere have half-lives of up to half a million years!

India: World's most unsafe, most contaminated reactors

India's nuclear reactors are even more unsafe. Some years ago, a survey in *Nuclear Engineering International* listed India's reactors in the lowest bracket in terms of efficiency and performance.[di] Helen Caldicott, one of world's best known anti-nuclear-energy activists, writes that India's nuclear plants are amongst the most contaminated in the world, exposing hundreds of workers to excessive doses of radiation.[dii] The US-based watchdog group – the Safe Energy Communication Council (SECC) – has also described the Indian nuclear program, especially its reactors, to be the "least efficient" and the "most dangerous in the world".[diii] Molly Moore's report in the Washington Post published in 1995 is even more damning: "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."[div]

In what may appear to be astonishing, the same opinion was expressed by Dr. A. Gopalakrishnan, Chairman of the Atomic Energy Regulatory Board (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: "Many of our nuclear installations have aged with time and have serious problems." He further added that the current safety status of the nuclear installations under the DAE "is a matter of great concern"![dv]

But then, why didn't Dr. Gopalakrishnan do anything about it when he was in office? The shocking answer is, he had very little authority to do so! The AERB is a toothless body!!

India's safety watchdog: A lapdog

India's rulers are so unconcerned about nuclear safety, they are so indifferent to the possibility of a Chernobyl in India, that they have the most ineffective nuclear safety regulator in the world!

Like other countries having a nuclear power program, India also has a safety regulator, the Atomic Energy Regulatory Board. It was set up in 1983 by the DAE to lay down safety standards, frame rules and regulations in regard to public and worker safety under the provisions of the Atomic Energy Act, 1962 and enforce their compliance in all DAE and non-DAE installations. However, unlike other countries having a nuclear power program, India's nuclear regulator is not independent of the bodies it is supposed to oversee, but is subservient to them! The AERB reports to the Atomic Energy Commission (AEC). The Chairman of the AEC is also the head of the DAE. The Chairman of the Nuclear Power Corporation (NPC) and the director of the Bhabha Atomic Research Centre (BARC) are also members of AEC. However, the chairman of AERB is not a member of AEC! Thus, the regulatory authority is subordinate to the NPC and BARC, bodies it is supposed to regulate! This makes the regulatory process a complete sham. Among nuclear and threshold nations of the world, India is the only country where such a situation prevails.[dvi]

This lack of independence of the regulatory authority in India contravenes the international Convention on Nuclear Safety (CNS), of which India is a signatory. According to this convention, the regulatory body should be provided with adequate authority, competence and financial and human resources to fulfill its assigned responsibilities. There should be an effective separation between functions of the regulatory body and those of any other organisation concerned with the promotion or utilisation of nuclear energy. An additional important function of the regulatory body is to communicate independently its regulatory decisions and their bases to the public.[dvii] The functioning of the AERB violates the CNS on all these three counts. Not only is the AERB subordinate to the body it is supposed to regulate, it is completely dependent on the DAE: the AERB depends, to a major extent, on the DAE for funds, manpower, technical expertise and material resources. And, as we see below, the AERB and DAE do not share any information regarding safety at India's nuclear installations with the people, and are empowered by law for this.

Probably the only time the AERB has attempted to function as an independent safety regulator was in the period 1993-96, when Dr. Gopalakrishnan was the Chairman of the AERB. During his tenure, the AERB undertook to prepare a comprehensive document on DAE's safety status. However, all his efforts to improve the safety situation of India's nuclear installations were stonewalled by the DAE. In Gopalakrishnan's own words (in an article published in the Chennai fortnightly *Frontline* in 1999): "After four months of serious effort by the AERB staff and after referring to more than 700 of the DAE's own documents, the AERB prepared a report titled *Safety Issues in DAE Installations*. It covered about 130 safety issues, of which 95 are of top priority. This document was discussed and approved by the AERB at its 46th meeting on November 7, 1995 and then submitted to the AEC… To date, however, it is not known whether any concrete action has been taken on this report, even though the present Chairman of the AERB, asserts to the press that 'every issue is being seriously looked into'."[dviii]

Failing to make any reforms in the system, all that Gopalakrishnan could do was to voice his concerns before the people of the country upon his retirement. In an interview to *The Times of India*, Mumbai (June 18, 1996), he stated: "During my six-year-old association with the AERB (three years as a member and the remaining period as chairman), I was able to study the nuclear regulatory process thoroughly. I discovered that it was a total farce. I was of the opinion that the government and the public should know this because ultimately they finance the nuclear establishment. My straightforward attitude was not liked by the top bosses of the establishment. The DAE wants the government and the people to believe that all is well with our nuclear installations. I have documentary evidence to prove that this is not so."[dix]

Defending his employer, G.R. Srinivasan, director for health, safety and environment, NPC, stated: "Even if a highly unlikely accident takes place, our nuclear power plants are so designed that the public domain would suffer no harmful exposure."[dx] Unfortunately, the Government of India or the AEC has not instituted an award for 'Sycophant of the Year', otherwise Srinivasan surely deserved it.

Safety Issues at India's Atomic Reactors

Nuclear reactors have the possibility of suffering catastrophic accidents. In order to study the safety situation at India's reactors, we first take a look at the performance of India's reactors so far, based on the little information that has come out through unofficial and occasionally official sources. We next take a look DAE's practices regarding planning, operations and safety.

1. Accidents at nuclear reactors

Practically all the nuclear reactors and other facilities associated with the nuclear fuel cycle operated by the DAE have had accidents of varying severity. Prof. Dhirendra Sharma, author of *India's Nuclear Estate* and Director of Centre for Science Policy, Dehradun, writes that "in India an estimated 300 incidents of a serious nature have occurred, causing radiation leaks and damage to workers".[dxi] That none of these led to catastrophic radioactive releases to the environment is not by itself a source of comfort. According to safety theorists, this absence of evidence of "accidents should never be taken as evidence of the absence of risk" and "just because an operation has not failed catastrophically in the past does not mean it is immune to such failure in the future".[dxii] In fact, quite a many of these caused significant radioactivity releases into the atmosphere, and on at least one occasion, at the Narora NPP in UP, the accident very nearly led to a Chernobyl-like meltdown. Had the catastrophe occurred, it is impossible to imagine its consequences in a densely populated state like UP.

We give below a brief summary of the little information that is available about the actual state of affairs with India's nuclear reactors and the accidents that have taken place.

i) TAPS 1&2

The Tarapur Atomic Power Station (TAPS), located about 100 miles north of Mumbai, was commissioned in 1969. The two boiling-water reactors at the Tarapur station are of vintage US design. Although all similar reactors around the world have been shut down for safety reasons, the DAE continues to flog these reactors. .

The problems with the two Tarapur reactors are manifold. The two reactors share the same subsystems, including the same emergency core cooling system, in violation of all safety standards. Even more disturbing is that use of nitrogen to make the containment inert has been discontinued. Therefore, if the coolant does not perform its function, an explosion is quite likely to occur, leading to reactor meltdown. Besides, many parts of TAPS are uninspectable, and the DAE lacks the equipment and/or technology to correct its problems. The two steam generators in each unit are totally disabled owing to extensive tube failures and because of this TAPS has been de-rated from 210 MW to 160 MW. The plant has suffered innumerable radioactive releases. According to Gopalakrishnan, they "should have been shut down in the interest of public safety long back."[dxiii]

ii) TAPS 3&4[dxiv]

These PHWRs are amongst India's newest reactors, and they are also the biggest, of 540 MW each. On June 28, 2010. panic spread in the villages around Tarapur after people learnt that an accident had occurred at Tarapur 4, due to which the reactor had to be shut down. A snag in the fuelling machine led to a spent fuel bundle getting stuck in it, endangering the lives of thousands of people living around the plant. It took 8 days for experts to rectify the problem.[dxv]

iii) RAPS 1&2[dxvi] and MAPS 1&2

Both these are PHWRs of Canadian design, known as CANDU reactors.

Rajasthan Atomic Power Station (RAPS) at Rawatbhata in Rajasthan has two units, each of 220 MW installed capacity. The first unit went critical in 1972, and the second in 1980. They have faced so many technical problems that neither unit has ever worked at its installed capacity. RAPS-1 was derated to 100 MW very early in its life, shut down for many years in the 1980s for repairs, asked to cease operation again in 2002 for two years, and finally has been shut down since 2004 while the government mulls over its future. It is plagued by a number of serious defects, ranging from turbine blade failures, cracks in the end-shields, a leak in the calandria overpressure relief device, and leaks in many tubes of the moderator heat exchanger. Unit-II has also had tube leakage and other technical problems and it could never operate continuously at its rated capacity; it too has suffered shut down for many years for repairs.[dxvii]

The RAPS reactors have suffered several dangerous accidents: in 1976, the reactors were flooded due to construction errors, because of which the emergency core cooling system got obstructed and this could have led to a meltdown; the reactors were once again flooded in 1992; in 1992, four out of eight pumps of RAPS-2 caught fire;[dxviii] on February, 12 1994, RAPS-1 was shutdown for the repair of its calandria overpressure relief device which leaked radioactive heavy water.[dxix]

Madras Atomic Power Station (MAPS 1&2) at Kalpakkam, around 70 kms from Chennai, also has two units of 210 MW each. These two reactors have created a world record of sorts by being in the gestation phase for more than 15 years. Within a couple of years of commissioning, both their reactor inlets cracked because the DAE had not heeded Canadian advice on how to fabricate the reactors. Both the reactors have been de-rated because of this, to 175 MW. Their continued operation even in this mode is not considered safe. The various safety issues in MAPS 1&2 puts this Tamil Nadu station in a risk category unacceptable anywhere else in the world.[dxx]

MAPS has suffered several heavy water leaks (like the one on March 26, 1999 discussed earlier in this Chapter);[dxxi] in 1990, the turbine blade of MAPS-1 cracked, and the industrial robots were required to solve the problem.[dxxii] On December 26, 2004, a tsunami hit the plant, to what effect nobody knows. All that is known is that the plant was profoundly affected, and many employees lost their lives.[dxxiii]

The biggest deficiency in the Rajasthan and Madras reactors is the absence of a high-pressure emergency-core cooling system (ECCS) for avoiding core meltdown in the case of a loss-of-coolant accident. No pressurized heavy water reactor anywhere in the world currently operates with such an obsolete and unsafe ECCS, according to Gopalakrishnan.[dxxiv]

iv) NAPS

The two reactors of Narora Atomic Power Station (NAPS) in Uttar Pradesh are also of 220 MW each. The first went critical in 1989 and the second in 1991.

The most serious accident that has occurred at an Indian nuclear reactor took place at this plant on March 31, 1993. We discuss it in slightly greater detail to again illustrate the point made in Chapter 3 that because of the inherently complex nature of nuclear reactor technology, even minor failures or human errors can lead to a cascading chain of events culminating in a major accident.

Early that morning, two blades of the turbine at the first unit broke off due to fatigue. These sliced through other blades, destabilizing the turbine and making it vibrate excessively. The vibrations caused pipes carrying hydrogen gas that cooled the turbine to break, releasing the hydrogen which soon caught fire. Around the same time, lubricant oil also leaked. The fire spread to the oil and through the entire turbine building. Among the systems affected by the fire were four sets of cables that carried electricity, which led to a general blackout in the plant. One set of cables supplied power to the secondary cooling systems, which were consequently rendered inoperable. In addition, the control room became filled with smoke and the staff were forced to leave it within just 10 minutes after the blade failure.

The operators responded by manually actuating the primary shutdown system of the reactor 39 seconds into the accident. Although the reactor was shut down, since the fuel rods would continue to undergo radioactive decay even after the reactor was shut down, thereby generating heat which could cause a meltdown, some operators climbed onto the top of the building and, under battery-operated portable lighting, manually opened valves to release liquid boron into the core to slow down the reaction. That instinctive action by the technicians was the fourth and last level of safety protection, and it prevented what would most certainly have led to a partial core meltdown.

It took 17 hours from the time the fire started for power to be restored to the reactor and its safety systems. Operators who were forced to leave the control room because of smoke could not re-enter for close to 13 hours. An attempt was made to take control of the plant from the emergency control room; but, since there was no power available, even this was not possible. Thus, Narora was almost unique in that for many hours, the operators had no indication of the condition of the reactor![dxxv]

v) Kaiga

Unit-1 of the Kaiga Atomic Power Station located in Karnataka was supposed to achieve criticality in 1996. However, the concrete containment dome collapsed on May 13, 1994 during the final stages of construction. Such an accident is unprecedented in the annals of nuclear energy history. Had the collapse taken place during the operation of the nuclear reactor, it would probably have led to a nuclear core meltdown. It led to a delay in its commissioning by as much as four years. The collapse of the dome occurred due to faulty design: AERB had ordered the DAE to carry out certain tests on the containment dome, which were not done. [dxxvi]

vi) KAPS

Kakrapar Atomic Power Station in Gujarat also has two 220 MW PHW reactors of Canadian design. Unit-I went critical in 1992 and Unit-II in 1995.

There was a near-disastrous fire accident in 1991 at the KAPS plant. In June 1994, flood waters entered the plant because sealing arrangements were not provided to prevent water ingress, causing extensive damage. This despite the fact that similar flooding had occurred twice at RAPS in 1976 and 1982, owing to the very same construction errors! In 2004, an unexplained power surge at KAPS-1 forced the NPC to shut down the reactor.[dxxvii]

The Emergency Core Cooling System (ECCS) installed in KAPS (and NAPS), was not tested initially, and it was only after the media blew up the issue that the testing was done in KAPS-2. The system failed the test! Some design and procedural changes had to be made to make the system perform satisfactorily. But whether these changes have also been carried out in KAPS-1 and the two NAPS reactors is not known.[dxxviii]

The KAPS reactors house the first indigenously-developed microprocessor-based control system. However, they have not been tested thoroughly for their reliability; no appropriate facility for such testing exists with the DAE. There have been instances of dangerous and erratic behaviour, such as a shutdown rod coming out when signalled to go into the reactor![dxxix]

vii) BARC

For all the hype about BARC, this premier nuclear research institution is in an even poorer state than India's nuclear reactors. There have been numerous 'incidents' at these research reactors, some of which nearly led to a major disaster. There was an instance of a reactor being started up with an operator inadvertently locked inside a room below. In 1991 Dhruva, a 100 MW research reactor at BARC, operated for almost a month with a malfunctioning emergency cooling system, in complete violation of all safety norms.[dxxx]

Aside from these near catastrophes, there is the more insidious problem of leakage of underground pipes carrying radioactive water at the CIRUS and Dhruva sites at BARC. An even bigger disaster is the two million tonnes of liquid nuclear waste stored in tanks at the BARC site. These tanks are leaking due to aging, corrosion and faulty welds. The result of these leakages is that radioactivity in the form of hundreds of curies of Cesium-137 is reported to be present in the soil, water and vegetation on the BARC sites and the Trombay coast. Considering the long half-life of Cs-137 (over 30 years), this contamination will persist as a threat to the safety of the people and the environment for a long time to come.

The bed of the Thane creek, which is an extension of the sea at Mumbai port, has become highly radioactive because of the nuclear effluents discharged by the research and reprocessing plants at BARC. The Thane creek separates Navi Mumbai from old Mumbai, and the radioactive contamination of the creek spells danger to the whole of Mumbai. The people of Mumbai are going to pay the price for the callousness of BARC officials for centuries to come.[dxxxi]

The safety situation at the Kalpakkam Atomic Reprocessing Plant run by BARC and located near the MAPS at Kalpakkam near Chennai is no better. There have been numerous cases of workers being exposed to high levels of radiation, including a major accident on January 21, 2003 (discussed in a later section).[dxxxii] A report of the United Nations Scientific Committee on Effects of Atomic Radiation (UNSCEAR) says that the routine release of radionuclides from Kalpakkam Reprocessing Plant has been high in comparison to the release from facilities in other countries.[dxxxiii] The reprocessing plants in France and UK are the biggest source of radioactive pollution in Europe, with radioactive releases from these plants polluting the North Sea as far as the Arctic; one wonders how far has the pollution from Kalpakkam spread in the Bay of Bengal / Indian Ocean!

The DAE is totally unconcerned about these terrible radioactive releases from BARC run facilities. Gopalakrishnan writes that during his tenure as Chairman of AERB, the BARC management refused outright to comply with the procedures and corrective actions ordered by the AERB. Some years later, the DAE ended all possibilities of such disputes by putting safety standards at BARC facilities beyond the purview of this benign regulator. In 2000, Dr. R. Chidambaram, then Secretary of the DAE, ordered that the regulatory and safety functions at the BARC and its facilities, exercised till then by the AERB, will henceforth be carried out through an internal committee to be constituted by the Director of the BARC. Wow! This should break all records of nuclear safety regulations!![dxxxiv]

2. DAE: Terrible Safety Management[dxxxv]

In its submission to the IAEA as part of its responsibilities under the 1994 Convention on Nuclear Safety, the DAE stated:

"Safety is accorded overriding priority in all activities. All nuclear facilities are sited, designed, constructed, commissioned and operated in accordance with strict quality and safety standards... As a result, India's safety record has been excellent in over 260 reactor years of operation of power reactors and various other applications."

However, the reality is that the DAE is absolutely nonchalant about nuclear safety. For instance, an essential element of a safety conscious organisation is that it learns not only from its own mistakes, but also from others. DAE does not do both!

Narora Accident

Take the Narora accident of 1993. It has been DAE’s closest approach to a catastrophic accident. What is most worrisome about it is that the accident could have been foreseen and prevented!

That's because the failure of the turbine blades was avoidable. In 1989, General Electric informed the turbine manufacturer, Bharat Heavy Electricals Limited (BHEL), about a design flaw which led to cracks in similar turbines around the world and recommended design modifications. BHEL took prompt action and prepared detailed drawings for NPC, which operates the Narora reactor. However, NPC took no action till after the accident!

Secondly, even after the turbine blade had failed, the accident could have been averted had best manufacturing practices been followed. By the time the Narora reactor was being manufactured, it was common understanding in the world reactor design industry that the power supply should be encased in separate fire resistant ducts. This was one of the lessons drawn from the fire at Browns Ferry in the US in 1975, and was made compulsory in the USA. Other countries also adopted this measure. However, even though Narora plant was manufactured after all these lessons had been drawn around the world, this practice was not followed for the Narora plant! As a result, following the fire in the turbine building, the electric cables too caught fire and led to a complete blackout in the plant.

Repeated Mistakes

The other problem with the DAE is that it does not draw lessons even after an accident has occurred, leading to repeated accidents of the same type in different reactors. This is one of the reasons for the Narora accident too. Excessive vibrations in the turbine bearings have been common in Indian reactors. At RAPS-1, in 1981-82, after repeated shutdowns, it was finally discovered that the problem was due to high vibrations of turbine bearings, and failure of turbine blades was discovered. This led to a prolonged shutdown of more than 5 months; even after this problem had apparently been fixed the reactor had to be shut down once again because of high turbine bearing temperatures. Again in 1983, high vibrations were noticed in turbine generator bearings and it was revealed that two blades in the second stage of the high pressure rotor had sheared off at the root. In 1985, the first unit of the MAPS-1was shutdown repeatedly because of high bearing vibrations in the turbine generator.

Even after the Narora accident of 1993, turbine problems have continued to plague other reactors: Narora-2, RAPS-1 and Kaiga-2 have all had to suffer repeated shut downs due to high turbine bearing vibrations / high bearing temperatures. In 1995, even after repeated shutdowns to mitigate turbine problems, blades failed in the turbine of Narora-2. Not only that, despite the accident in 1993, Narora-1 too had to be shutdown repeatedly in 1995 because of high vibrations of the turbine generator bearing.

Fires have also occurred repeatedly. In Narora-2 in 1996, there was heavy oil smoke from the turbine building. That same year, there was an oil fire in the turbine building of Kalpakkam-2. The following year smoke was observed in Kalpakkam-2, there was a fire in the turbine generator of Kakrapar-1, and smoke was observed from the insulation of the main steam line of the turbine generator in Kakrapar-2. There was a fire due to an oil leak in Kalpakkam-1 in 2000.

Similarly, there have also been numerous heavy water spills. To mention a few instances: there was one such leak in RAPS-1 in 1996, the following year, such leaks occurred at the Kakrapar-1, MAPS-2 and Narora-2 reactors; Narora-2 again leaked in 2000 and 2003.

Yet, the NPC Chairperson, S. K. Jain, has the gall to claim that "India had the best safety record in running nuclear power plants"![dxxxvi] So audacious have the elites of India's nuclear establishment become, that he made this statement at Tarapur, the most dangerous of India's reactors, where some of the worst accidents have taken place, and which should actually "have been shut down in the interest of public safety long back" – to quote A. Gopalakrishnan once again.[dxxxvii]

Attitude towards Worker Safety

In the numerous accidents and mishaps that have occurred at DAE's nuclear plants, thousands of workers have been exposed to high doses of radiation, well in excess of the officially stipulated maximum limits.[dxxxviii] However, each time such an accident has occurred, the DAE has tried to hush it up, and when it has failed to do so, has tried to play down the radiation leakage, and lie about its medical effects on the workers.

Way back in 1982, Praful Bidwai, the renowned journalist, writing in the Times of India, had documented at least 350 cases of workers being exposed to high levels of radiation at the Tarapur plant alone. Bidwai writes, "H.N. Sethna, the then DAE Secretary, did not deny the overexposure but blithely declared that it posed no danger."[dxxxix]

Kalpakkam accident, 2003

One of the worst instances of workers being exposed to high levels ofradiation in India took place at the Kalpakkam Atomic Reprocessing Plant (KARP) on 21 January 2003. On that day, some employees at the plant were tasked with collecting a sample of low-level waste from a part of the facility called the Waste Tank Farm (WTF). Unknown to them, a valve had failed, resulting in the release of high-level waste, with much greater levels of radioactivity, into the part of the WTF where they were working, resulting in six workers becoming exposed to high doses of radiation.

For one, the accident could have been avoided had radiation monitors or mechanisms to detect valve failure been installed in the WTF, which had not been done even though the plant was five years old!

Let's leave that aside. Even more serious is the attitude of the plant management, that is, the BARC, towards the accident. Despite a safety committee's recommendation that the plant be shut down, BARC's upper management decided to continue operating the plant. The BARC Facilities

Employees Association (BFEA) wrote to the director setting forth ten safety related demands, including the appointment of a full time safety officer. The letter also recounted two previous incidents where workers were exposed to high levels of radiation in the past two years, and how officials had always given some or the other excuse to explain away the failure to follow safety procedures. Once again there was no response from management. In desperation, some months later the union resorted to a strike. The management's response was to transfer some of the key workers involved in the agitation and give notice to others; two days later, all striking workers returned to work. Finally, the union leaked information about the radiation exposure to the press.

Once the news became public, the BARC director, in a press conference six months after the accident, grudgingly admitted this was the"worst accident in radiation exposure in the history of nuclear India". In the same breath, he put the blame for the accident on "over enthusiasm" and "error of judgment" on part of the workers! He however refused to reveal anything about the exact medical condition of the workers, including the radiation dosage received by them, except that the workers were "cheerful".[dxl]

A reporter from *Tehelka*, an independent magazine published from Delhi reputed for investigative journalism, in 2010 tried to trace the whereabouts of the six workers who had been exposed to high level of radiation due to the accident. The medical superintendent of the DAE established hospital in Kalpakkam, told him: "One of them died, but not due to radiation. The rest are fine." But his efforts to locate the five surviving worker came to naught.dxli

Tehelka also found evidence of increase of cancer and other diseases among the 30,000 workers living in the five villages that fall within 5 km radius from the plant. While the local public health centre denied information to *Tehelka* about cancer-related deaths among workers saying the information was sensitive, DAE officials maintained that the radiation emission levels were too low to cause problems.[dxlii]

More recently, in the Kaiga incident of 2009 (discussed in Part I above), where different reports say that between 35 and 250 workers were affected, the AERB in its press release of November 29, 2010 said that only two workers received a dose exceeding the 30 millisievert maximum limit stipulated by the Atomic Energy Regulatory Board. India's nuclear authorities also trivialised the hazards posed by tritium and claimed it was a non-toxic substance. Whereas tritium is a beta-ray emitter and can cause extensive, irreversible damage.[dxliii]

The DAE can lie, and lie profusely, about accidents at its plants, deny that any radiation leakage took place, lie about the impact of this leakage on its workers, and nothing can be done about it. The Atomic Energy Act of 1962 makes it totally unaccountable to the people of India.

Temporary workers

The DAE's attitude to temporary workers is even more criminal. While the permanent workers have their union to protect their interests, the temporary workers have no such protection. The DAE ruthlessly takes advantage of their poverty and helplessness to make them do the most dangerous tasks, such as cleaning up radioactive materials. No record is kept of how many such workers are exposed to radiation, and how much radiation they are exposed to. Writing about Tarapur in *Business India* in 1978, Bidwai reported that parts of the plant had become "so radioactive that it is impossible for maintenance jobs to be performed without the maintenance personnel exceeding the fortnightly dose ... in a matter of minutes", and so instead of the regular employees of TAPS, outsiders were employed to carry out maintenance tasks, many of whom did not have knowledge of the hazards they were being exposed to. Obviously, the situation at Tarapur must only have worsened since then! Another newspaper reported that temporary workers were used to repair a leak a major radioactive leak from ill-maintained pipelines in the vicinity of the CIRUS and Dhruva reactors at the Bhabha Atomic Research Centre in 1991. The temporary workers who did this job were later given a bath, a new set of clothes, and packed off home.[dxliv]

There are plentiful such anecdotal evidences of poor worker safety culture and workers health being compromised in DAE establishments. The reason why we have only anecdotal evidence is that outsiders do not have access to the health records of DAE workers.

Part V: India's Nuclear Reactors: Impact on People

India's nuclear reactors are leaking radiation. Dr Gopinath, the then Director of the Health Physics Division at the BARC, disclosed at a meeting of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) in 1993, the numerical values of the radioactive discharges from Indian nuclear power plants. UNSCEAR was outraged and officially told the Indian government that these discharges were higher than the safe limits by about 100 times.[dxlv] That India's reactors are emitting radiation at several times the international norm has also been admitted by S. P. Sukhatme, then Chairman of the AERB, in 2002.[dxlvi]

Not much information is available about the impact of these radiation leakages, both the routine releases of radioactivity and radiation released from the innumerable "incidents" at India's atomic reactors, on the health of people and animal-plant life around nuclear plants in India. The authorities have simply not done any studies. The only skeletal information we have is based on a survey done by two independent scientists in the villages around RAPS and some studies done on impact of MAPS and KARP on life of fisherfolk in the area.

Renowned scientists Drs. Surendra and Sanghamitra Gadekar of Vedhci, Gujarat did a unique survey of the population living in five villages in the vicinity of Rawatbhata nuclear power plant in 1991. It is probably the only survey of its kind ever done in the country. The survey found[dxlvii]:

A huge increase in the rate of congenital deformities

A significantly higher rate of spontaneous abortions, still births and one day deaths of new born babies

A significant increase in chronic diseases especially amongst the young, but no differences in acute infections

Diseases of old age prevalent amongst the youth

A significantly higher rate of solid tumours

Kalpakkam's forgotten people

Kalpakkam houses two nuclear reactors, a fast breeder test reactor and another research reactor, and a fuel reprocessing plant. The 5 km region around these nuclear facilities which is the most affected region has a population of nearly 1 crore people.

Dr V Pugazhenthi and a team of doctors from Alice Stewart School for Epidemiological Studies, Tellicherry, Kerala and St. Joseph Hospital, Tirunelveli, Tamil Nadu, under the guidance of Dr. Rosalie Bertell, the world renowned environmental scientist did a study of the incidence of goiter and autoimmune thyroid diseases (AITD) on the people living in this region in 2007. It is probably the only such epidemiological study in the world. 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 the Madras Atomic Power Station (MAPS), with the incidence of goiter being an astonishing 23% amongst women in the age group of 20-40, and of AITD as high as 7% amongst women in the age group of 30-39 years.[dxlviii] The average prevalence of these disorders near the plant was around 10 times as high as in the region far away from MAPS. The high incidence of these diseases was obviously due to radiation exposure to routine releases of radionuclides, especially radioactive iodine, from the nuclear reactors and plutonium reprocessing plant at Kalpakkam.[dxlix]

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, which are obviously due to exposure of the foetus to radiation. They also detected statistically significant number of cases of multiple myeloma, a rare bone cancer which is linked to nuclear radiation, as well as a case of colon cancer in a young 24 year old worker – it is unusual for people to contract this cancer at such an early age.[dl]

The radioactive effluents have affected the livelihood of fishermen in the coastal areas surrounding plant. The area was rich in lobsters, crabs, shrimp and other varieties of fish, but now the catch has drastically come down. The havoc caused to local life due to the plant is described by Japanese journalist Tashiro Akira and others who visited several nuclear sites in the world including India. Their findings were published in a book titled *Resume*. The fishermen tell them... "The reason why our catches have declined so drastically is the plant. The warm waste water that comes out of these keeps the fish away, particularly in the area within a few miles' radius of the outlet." The villagers added, "Lots of dead fish are floating out there. We gather them up and make karuvadu." Karuvadu is a dish made by salting and drying fish for two or three days. The local villagers told the journalists: "It all goes to market. People here won't touch the stuff because they know where it's come from. The villagers take their catch of karuvadu to Madras and sell it there, where it provides a cheap source of protein for the poor people in the city." When the journalists asked whether it was actually safe for people to eat this fish, the reply was, "Well, they're probably contaminated, but we can't catch anything else, and there is hardly any money coming in at the moment. We don't have any choice." [dli]

Part VI: India's Fast Breeder Reactor Program

The Worldwide Experience with Fast Breeders

Ever since the dawn of the nuclear age, nuclear energy advocates have dreamed of a reactor that would yield more fuel than it consumes. In the sixty years since then, seven countries – the US, UK, France, Germany, the USSR, Japan and India – established plutonium breeder reactor programs. However, their efforts have failed to produce a reactor that is economically competitive with conventional light water reactors. The capital cost per kilowatt of generating capacity of a demonstration sodium cooled fast breeder reactor (FBR) has typically been twice as much as a LWR of comparable capacity.[dlii] Additionally, plutonium which is the basic fuel for fast breeders is extracted by chemically treating highly radioactive spent fuel at reprocessing plants, and this is also an expensive process. This further increases the cost of electricity from fast breeders.[dliii]

But more important than the economical aspect is the safety aspect. While all nuclear reactors are susceptible to catastrophic accidents, FBRs are even more so. There are several reasons why accidents involving fast breeders are both more likely and could cause greater damage to public health. One problem arises from the use of liquid (molten) sodium as the coolant. Plutonium reactors need fast moving neutrons, and so cannot use water as coolant since water is a moderator. To date, all fast breeders have used liquid sodium as a coolant. But sodium has serious drawbacks. It is highly reactive; it burns when exposed to air and reacts violently with water. Therefore sodium cannot be exposed to air or water, which means operating these reactors is going to be very difficult as even a minor leak can be dangerous. In fact, building and operating even test reactors has been very difficult. A large fraction of the demonstration fast breeder reactors that have been built have been shut down for long periods due to sodium-water fires caused by leaks.[dliv]

Another fear of a FBR is that unlike a water cooled reactor, which ceases operation if there is a loss of coolant (a safety feature), fast reactors become even more reactive if there is loss of the sodium coolant. This can result in a core meltdown and a small nuclear explosion. There are fears that if this happens, it can lead to a Chernobyl type release of radioactivity into the environment.

Repairing a FBR is also more time consuming and difficult as compared to LWRs, as air has to be prevented from coming into contact with sodium coolant.[dlv]

Even if success is achieved in building a test reactor, building larger fast breeder reactors will be much more difficult and dangerous as the above problems will multiply in magnitude as the reactor is bigger.

Another kind of problem that plagues fast reactors arises from the use of MOX (mixed-uranium and plutonium oxide) fuel in the FBR. Because plutonium is about 30,000 times more radioactive than uranium-235, huge safety precautions are required during fabrication of fuel, which makes fabricating MOX several times as expensive as the cost of low enriched uranium fuel. Further, the spent fuel from FBR typically has a greater buildup of highly radioactive fission products. Thus, the impact of an accident would be much more severe than in a Light Water or Heavy Water Reactor.[dlvi]

This is why even after six decades and expenditure of $100 billion (in 2007 dollars)[dlvii], the promise of fast breeder reactors remains largely unfulfilled. In the 1970s, breeder advocates were claiming that there would be thousands of reactors in operation by 2010. Today, the dream is nearly dead. The US, UK and Germany have abandoned their breeder reactor development programs. France still claims that fast breeders have a future, but the country has no operating FBRs, not even demonstration units. Superphénix, the 1200 MW flagship of the French breeder program, and the only commercial-size plutonium fueled breeder reactor in nuclear history, was shut down in 1998 after an endless series of very costly technical, legal and safety problems which rendered it inoperative for the majority of its 11-year lifetime. The other remaining 233 MW demonstration reactor Phenix shut down in 2009. No replacement fast breeder reactor is planned for at least a decade. The Japanese prototype fast reactor Monju shut down in 1995 after a sodium coolant leak caused a fire. After repairs and many delays, it finally restarted 15 years later on May 8, 2010. This is only a prototype; Japan hopes to build a follow-on demonstration fast breeder reactor by 2025; only if that succeeds will construction of a commercial fast breeder reactor begin. It is doubtful if these projections will ever be fulfilled, and Tokyo has been reducing the funding for its breeder program for decades.[dlviii]

Apart from India, only Russia is attempting to develop demonstration fast breeders, while China is considering buying two such units from Russia. Russia has one operational fast breeder, the BN-600. But this reactor hardly qualifies as a successful breeder. The Soviet Union/Russia never closed the fuel cycle and has never operated BN-600 with MOX fuel. Furthermore, it has also suffered repeated sodium leaks and fires. Despite these multiple fires, its operators continue to operate it – another example of the extreme callousness of Russia’s nuclear establishment.[dlix]

India's Fast Breeder Program

Despite this worldwide evidence, the DAE continues to persist with its uneconomical and risky fast breeder reactor program.

As discussed in Chapter 7, breeder reactors in India were originally proposed in the 1950s as the second stage of a three-stage nuclear program. This was seen as a way to develop a large autonomous nuclear power program despite India’s relatively small known reserves of uranium ore. However, the DAE began work on fast breeder reactors only in 1965, when a fast reactor section was opened in BARC and design work on a 10-MW experimental fast reactor was initiated. It soon became clear that foreign assistance was required. This project was therefore abandoned, and in 1969, the DAE entered into collaboration with France. It took designs from it for what was to be India's first breeder reactor, the Fast Breeder Test Reactor (FBTR). The DAE sent scientists to France for training, and they formed the nucleus of the Reactor Research Centre (RRC) that was set up in 1971 at Kalpakkam to lead the breeder effort. In 1985, this was renamed the Indira Gandhi Centre for Atomic Research (IGCAR). Over the years, the center has emerged as the main hub of activities related to India's breeder program.[dlx]

The budget for the Fast Breeder Test Reactor was approved by the DAE in September 1971 and it was anticipated that the FBTR would be commissioned by 1976. It was to be a 40 megawatt thermal (MWt)/13 megawatt electric (MWe or MW) reactor. But the reactor attained criticality only in October 1985; and the steam generator began operating only in 1993. Since then, the reactor has suffered numerous failures and accidents, which are actually inherent to sodium cooled fast breeder reactors as discussed above and which make it much more dangerous than water cooled reactors. Overall, its performance has been mediocre. It took 15 years before the FBTR even managed 50 plus days of continuous operation at full power (in 2001). In the first 20 years of its life, the reactor has operated for only 36,000 hours, implying that the availability factor is only about 20 percent. Despite this checkered history, IGCAR claims to have "successfully demonstrated the design, construction and operation" of a fast breeder reactor.[dlxi]

Based on this flawed experience, DAE began making plans for construction of a Prototype Fast Breeder Reactor (PFBR), which will produce 1200 MW of thermal power and 500 MW of electricity. First expenditures on the PFBR were made in 1987-88, and it was reported in 1990 that the that the reactor would be on-line by 2000. In 2001, the chairman of the AEC announced that the PFBR would be commissioned by 2008. Construction of the reactor was finally started in October 2004 and it was now expected to be commissioned in 2010[dlxii]. There is no information about when it will actually be achieved.

Even more worryingly, instead of the carbide fuel used in the FBTR, the PFBR will use plutonium and uranium oxide based fuel. DAE has no experience of working with this fuel. Since MOX is thousands of times more radioactive, in combination with liquid sodium as coolant, it makes the PFBR susceptible to catastrophic accidents.[dlxiii]

Construction of a viable FBR is supposed to be the second stage of the DAE's ambitious three stage nuclear program. Given that India has not even built a properly functioning 10 MW demonstration unit more than fifty years after the plan was first announced, the third stage – breeders involving thorium and uranium-233 – is unlikely to materialize anytime in the foreseeable future. Yet the DAE continues to parrot: "it remains a certainty that thorium-based nuclear energy systems will have to be a major component of the Indian energy mix in the long-term."dlxiv In any case, even if the DAE succeeds in building them, the proliferation, waste, safety and cost problems of thorium reactors differ only in detail from those of uranium reactors.

We should actually be heaving a sigh of relief at this failure of the AEC / DAE. Breeder reactors are much more dangerous than even normal nuclear reactors – which is why most countries who have been willing to take the risk of having nuclear power programs have abandoned their fast breeder programs. And if they are ever constructed, electricity from these is going to be very expensive – at least 80 percent higher than from heavy water reactors – mostly because of the high fuel cycle costs associated with reprocessing and the fabrication of plutonium-containing fuel.[dlxv] Therefore, this failure is actually a blessing in disguise!

Part VI: DAE's New Toys: The Kudankulam and Jaitapur Nuclear Parks

The DAE/NPC 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!

The government of India is so unconcerned with safety at India’s nuclear reactors that we don’t even have an independent safety regulator, the only country in the world having nuclear power programs where such a situation prevails!!

And yet, the government of India is planning to set up a string of giant nuclear parks – with reactors three to eight times[dlxvi] as big as the ones we have installed at present – all along India's coastline. The first of these is coming up at Kudankulam, in Tamil Nadu, for which Russia is to supply six VVER-1000 nuclear power generators. Construction of the first two units began in 2002, and preliminary agreements have been signed for the construction of the next four units.

Preparations for starting construction work at the second nuclear park, at Jaitapur in Ratnagiri district of Maharashtra, have reached an advanced stage. This nuclear plant is going to be even bigger than the Kudankulam plant, with six reactors of 1650 MW each, to be supplied by the French nuclear corporation Areva. The project was hurriedly given environmental clearance on November 28, 2010, to please the French President Nicolas Sarkozy, anointed by Washington Post as "the world's most aggressive nuclear salesman",[dlxvii] who visted India in early December 2010; on December 6, in his presence, the NPC and Areva signed a General Framework agreement and an Early Works Agreement for the construction of the first two reactors.[dlxviii]

Routine Impact

The problems generic to nuclear power will of course destroy the environment and health of the people of these areas for centuries to come.

The routine releases of radioactivity from these plants, and the inevitable leakage from the radioactive waste generated by the plant, will cause the most terrible diseases in the nearby population. This is actually inadvertently admitted to by the DAE and AERB, because their regulations regarding siting of nuclear plants say: 1.6-km radius zone around a nuclear power station must have no habitation; the next 5-km radius area must be a “sterilised zone”, where “the density of population should be small so that rehabilitation will be easier”; finally, in the outlying 16-km radius, “the population should not exceed 10,000”.[dlxix]

Of course, both these august bodies are not bothered about the fact that the siting of Kudankulam and Jaitapur nuclear plants violates these norms. In the case of the Kudankulam plant, three large settlements exist within a 5 km radius zone: Kudankulam (population 20,000), Idinthakarai (population 12,000), and a new tsunami (rehabilitation) colony (population 2,000-plus). Parts of the tsunami colony are actually less than a kilometer from the reactors. At least 70,000 people live in the 16 km radius around the plant.[dlxx] Similarly, the villages Madban (population 1000), Mithgavane (population 2000), Sakhari Nate (population 5000), Jaitapur (population 800), Tulsunde (population 800), Janshipathar (population 500) apart from a few smaller villages lie within a 5 km radius from the Jaitapur nuclear plant; some of these villages are less than a kilometer from the proposed plant; and many more villages are located within a 16-km radius around the plant.[dlxxi]

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, with 3,600 species of flora and fauna, 377 of them endemic.[dlxxii] Likewise, the Madban area (where the Jaitapur nuclear plant is located) lies in the Western Ghats, which is among the world's ten top "Biodiversity Hotspots" with over 5000 species of flowering plants, 139 mammal species, 508 bird species and 179 amphibian species. More than 325 globally threatened species are found in this region, which also has one of the world's highest concentrations of wild relatives of cultivated plants.[dlxxiii] 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 millions of litres of seawater every minute. (The Jaitapur plant will discharge 6 billion litres of seawater a day,[dlxxiv] 4 million litres every minute.) Billions of fish, fish larvae, spawn, and a tremendous volume of other marine animals will be sucked in and killed by these cooling systems (discussed in detail in Part IV, Chapter 3). This high rate of destruction of fish and fish spawn is going to far exceed the regeneration rate, leading to depletion of fish stocks along both these coastal areas.

Additionally, water discharged into the ocean by the cooling system will be carrying a terrific amount of heat – and this will dramatically alter the marine environment (we have discussed this issue too in detail in Part IV, Chapter 3). Needless to say, the biodiversity of both these areas is going to be badly affected.

According to the MoEF, the temperature of the discharged water should not be more than 7 °C; for Jaitapur, it has imposed the condition that it should not exceed 5 °C.[dlxxv] Obviously, this condition is going to be 'more honoured in the breach'. For, temperature increases of the coastal waters at India's coastal nuclear reactors already violate these norms: 7.7°C (Tarapur 1&2), 8.4°C (MAPS 1&2 at Kalpakkam), and 9.5°C (for Tarapur 3&4).[dlxxvi] The plants being built at Kudankulam and Jaitapur are many times bigger than these plants – and therefore, the temperature of the water discharged by these plants is going to lead to an increase in sea temperature of at least 10°C, if not more, irrespective of the assertions being made by Srikumar Banerjee (present Chairperson, AEC) and other spokespersons of the nuclear industry!

This is going to drive away many indigenous fish species. Both these are very rich fishing areas. The annual fish catch of Ratnagiri district is around 1.25 lakh tons, of which as much as 60-70 thousand tons is exported.[dlxxvii] The three coastal districts of south Tamil Nadu – Tirunelveli, Tuticorin and Kanyakumari – account for 70 percent of the state's fish catch, and generate over Rs 2,000 crore in annual exports.[dlxxviii] All this is going to be badly affected, destroying the livelihood of tens of thousands of local fisherfolk.

Severe as these effects are, they pale before the most dangerous aspects of these nuclear parks.

The VVER-1000 Reactor: A Monster Reactor

The operating experience of the Russia built VVER-1000 reactors raises frightening safety concerns! 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, which are supposed to arrest power excursion or reactor misbehaviour, did not move as designed. That can be catastrophic, as the control-rod mechanism is crucial to preventing a runaway fission chain reaction.

VVER-1000 poses other safety issues too, including the integrity of the pressure vessel (which tends to become extremely brittle with routine neutron bombardment), reliability of the steam generator and auxiliary shutdown system, and the layout of the plant, which involves the crisscrossing of a number of steam-lines. In an accident, this could lead to broken steam-lines whipping around and hitting electrical supply and control systems, intensifying the accident and its consequences.[dlxxix]

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

EPR – Serious Design Problems

The reactor to be constructed at Madban, Jaitapur is a European Pressurised Reactor (EPR), which is supposed to be a Generation III+ reactor, that is, it belongs to the most advanced series of reactors in the world. However, 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 around the world, two in China and one each in Finland and France. The little information available about the latter two reactors makes for scary reading.

As discussed in Chapter 3, the nuclear industry fallaciously claims that these reactors have an improved safety level, whereas the reality is that these reactors are inherently more dangerous as they are of huge capacity (1650 MW, as compared to 400-1000 MW for most present day reactors), and so have much more radioactivity in their core. Then, in order to improve the fuel economy, the EPR will use 5 per cent enriched uranium, as against the normal 3.5 per cent in current PWR designs, which will enable its fuel burn-up to reach in excess of 70 GWd/tonne as against 30-40 GWd/tonne in current LWRs. This is being touted as an advantage of the EPR, but what is not being stated is that such high burn-up leads to much higher radioactivity, and much higher toxicity of the radioactive waste. Consequently, radiation doses to the workers and general public during leakages are going to be correspondingly high. Furthermore, it is reported that the higher burn-up in EPR will result in thinning of the fuel cladding, making it more prone to failure.[dlxxxiii] Therefore, the EPR needs more stringent supervision just to match the safety level of present day reactors!

Not only are these reactors in no way safer than the present reactors, they also have worrying design problems. Safety regulators in Finland and France have expressed serious reservations about the design, particularly whether there is sufficient independence in the control systems – in short, there is the danger that if the main control system fails, there a risk that the back-up system will fail for the same reason. (See Chapter 6 for more on this.)[dlxxxiv] The Nuclear Installations Inspectorate (NII), which is conducting a detailed review of the EPR reactor for the UK, and the US safety regulator, have also expressed the same concerns about the technology.[dlxxxv]

As discussed in Chapter 6, because of the huge delay and cost escalation in construction of both the Olkiluoto-3 and the Flamanville-3 reactors, the French government in October 2009 asked Francois Roussely, a former chairman of the Electricite de France (EDF), to evaluate the EPR and the French nuclear industry in general. The Roussely Report (July 2010) concludes that the difficulties encountered in Olkiluoto and Flamanville are partly due to the complexity of the EPR model "including ... the redundancy of safety systems." For emphasis, we repeat what we have written in Chapter 6: This is a damning diagnosis. One of the lessons from Three Mile Island accident was that if a safety system fails, there should be an independent – redundant – back-up system available. The nuclear industry claims that it has incorporated this lesson in the design of the new Generation III+ reactors. The Roussely report questions this claim.

On Areva – the EPR Supplier

Areva, the French nuclear corporation and the biggest atomic operator in the world, which is almost wholly owned by the French government, 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, which has been used to pave school playgrounds and public parking lots. Its mines in Niger have caused an environmental catastrophe that is destroying the lives and livelihoods of the surrounding communities. Its reprocessing plant at La Hague on the Normandy coast dumps more than 370 litres of radioactive liquid waste into the English Channel every year and has radioactively contaminated the seas as far as the Arctic Circle. The plant is also one of the world's worst radioactive air polluters: aerial discharges from the plant have been found to contain radioactive krypton-85 at 90,000 times higher values than natural levels. Uranium spills from Areva's Tricastin nuclear complex, which converts uranium from mines into fuel for nuclear plants, has polluted two rivers, and Tricastin wine growers have struggled to market their products since the accident. (See Section 7, Part III, Chapter 3 for more details.)[dlxxxvi]

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, in order to reduce costs. (See Chapter 6 for a more detailed discussion on this.) The safety and quality standards are so poor that the Finnish Safety Regulator has publicly admitted that it may not be able to detect all the problems, and anti-nuclear activists have called for scrapping the construction of the reactor for this reason alone!

Environment Destruction Ministry

We had stated in our concluding remarks in Chapter 3, citing some of the world's most renowned nuclear experts: Nuclear technology "is a complex technology... with such high-technology systems involving extremely hazardous materials, 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."

As if this risk was not enough, the government of India has seen it fit to import giant reactors, whose safety has been questioned even by experts in their home countries! On top of it, it has passed a nuclear liability bill, indemnifying the foreign equipment suppliers of all liabilities in case of an accident in a reactor supplied by them!

The Kudankulam 1&2 reactors were given approval without an Environmental Impact Assessment (EIA) or public hearing.[dlxxxvii] For the next stage of the project involving construction of another four reactors, a farcical public hearing was held in June 2007.[dlxxxviii]

For the Jaitapur EPR reactors, an EIA was prepared, a public hearing conducted, and finally the MoEF granted its approval on November 28, 2010. That the EIA was a mere ritual, and was prepared because it was mandated by law to do so, is obvious from the fact that it was prepared by the National Environmental Engineering Institute (NEERI), which has acquired a notorious reputation for sloppy work favouring promoters of dubious industrial projects. So far as nuclear reactors go, NEERI, by its own admission, does not have the technical competence to assess radiation related hazards of nuclear reactors.[dlxxxix] And yet, wonder of wonders, NEERI prepared a 1600 page EIA report of the Jaitapur EPR reactor!

Despite its bulky size, the report is a fraudulent exercise is obvious from the fact that it does not deal with any of the serious environmental problems of nuclear power, nor does it deal with the known problems of the EPR reactor!! That based on this flawed report, the MoEF's approval was going to be a mere formality is obvious from the fact that land for the project was acquired even before the Environment Ministry gave its approval. The MoEF actually fast-forwarded its approval, giving the environmental clearance to the NPCIL just 80 days after it received the EIA report from NEERI, a process which normally takes six months or longer![dxc] The reason: so that the agreement with Areva for supply of the reactors could be signed during the French President Sarkozy's visit to India in December 2010. Let us take a brief look at this EIA.

Jaitapur EIA: Phoney Exercise

The EIA does not at all discuss the most important shortcoming of the EPR, its known design problem. Safety regulators of France, Finland, the UK and the USA, all have expressed concern about the design of the Control and Instrumentation (C&I) system of the reactor (discussed in detail in Chapter 6). The C&I system is the "cerebral cortex" of a nuclear power station, governing the computers and systems that monitor and control the station's performance, including temperature, pressure and power output levels. While safety regulators of all these countries have asked Areva to rectify this design problem, Indian regulators don't even mention that there is any such problem – even when the problem identified by French, Finnish, UK and US regulators is public knowledge! The least they could have done is copy their objections, something they are good at!![dxci]

Further, the EIA brushes aside the most important environmental problem of nuclear reactors – the radiation leakages – by making the facile assertion that "the actual releases will be … far lower than the stipulated limits", without giving any scientific explanation or proof for its postulation. And therefore, since the radiation leakage is going to be negligible, it simply ignores the impact of this radiation release on the environment and health of the surrounding population! One is left wondering, whether the EIA is a horoscope or a scientific document!![dxcii]

Earthquake Danger Underestimated

The EIA also belittles another potentially serious problem with the Jaitapur plant – its siting in an earthquake-prone zone. The seismic zone map of India divides the country into five zones, from Zone I to V, depending upon the levels of intensity of past earthquakes in that region, with Zone V being the areas liable for the most severe earthquakes. The EIA contends that the plant is in Seismic Zone III (Moderate Damage Risk Zone), and that there is no earthquake activity around Jaitapur site in a radius of 39 km. The implication is that the plant is in a safe zone.[dxciii]

Firstly, what should be remembered is that this classification is not foolproof, and it is possible for a more intense earthquake to occur at a site which has been classified as being in a less intense zone. Therefore, seismic zone classifications are not permanent, and they can be revised from time to time, as more understanding is gained of the geology and seismic activity in the area. For example, two major earthquakes, at Koyna (1967) and Latur (1993), occurred in areas categorized as Zone I, supposedly the safest, causing these areas to be revised to Zone IV and III respectively.[dxciv]

And secondly, in contrast to the assertion of the EIA that there have been no earthquakes in the Jaitapur region, the truth is that in the past 20 years alone, there have been three earthquakes in Jaitapur exceeding 5 points on the Richter scale! In 1993, the region experienced one reaching 6.3, leaving 9,000 people dead. Last year, an earthquake caused the bridge to Jaitapur to collapse.[dxcv]

Considering both the above points, it is possible that the Jaitapur EPR reactor could be stuck with an earthquake of magnitude seven on the Richter scale; no nuclear plant has ever been hit by an earthquake of this magnitude. And if that happens, then it could lead to a major accident, as an earthquake has the possibility of simultaneously affecting many parts of the reactor.

To consider a real life example, a major earthquake of magnitude 6.4[dxcvi] stuck Japan on 16 July 2007, severely damaging Japan's largest nuclear plant, the Kashiwazaki-Kariwa nuclear power station (KKNPS). The magnitude of the quake was more than twice as strong as the most extreme cases considered while designing the reactor. It caused at least 50 cases of "malfunctioning" and "problems", including damage to the reactor's switchyards, burst pipes, fires, radioactive leakages into the atmosphere and into the Sea of Japan, and the toppling of hundreds of drums of low-level radioactive wastes.

Even more serious is the possibility that an earthquake can cause totally unexpected failures. In the case of the KKNPS accident, underground electric cables were pulled down by ground subsidence, creating a large opening in the outer wall of the reactor's basement – a "radiation-controlled area" that must be completely shut off from the outside. According to a plant official, "It was beyond our imagination that a space could be made in the hole on the outer wall for the electric cables."[dxcvii]

The Jaitapur region has the possibility of suffering an earthquake even more intense than the one that stuck the Kashiwazaki-Kariwa nuclear power station. Considering this danger, constructing such a large number of high capacity reactors in this area is inviting disaster.

No Waste Disposal, Decommissioning Plan

So far as the long-term storage of radioactive waste is concerned, the EIA says: "The radioactive waste depending upon the activity levels are buried in secured earth trenches, in steel containers which are immobilized in secured concrete vault. The solid waste disposal site is fenced, secured and designed to store waste for sufficiently long time of the order of 100 years."[dxcviii] That is, the EIA admits that the plant waste storage system is designed to safely store the waste for only 100 years, which, according to it, is a 'sufficiently long time'! What happens after that? For, the waste is going to remain radioactive for 2.5 lakh years!! Well, India's environmental planners are just not worried, why worry about our coming generations, we'll not be there, they can look after themselves.

The EIA report does not have a decommissioning plan too. It has left this to the future: "At the end of the operating life of the operating units, which would be around 60 years for EPR-type NPPs proposed to be established at Jaitapur site, a detailed decommissioning plan will be worked out." No new nuclear plant can be built in Europe or the US without such a plan.[dxcix]

And yet, the MoEF granted environmental approval to the Jaitapur plant!

Fig Leaf: 35 Conditions

To be more precise, the Minister for Environment and Forests Jairam Ramesh gave environmental clearance to the project with 35 conditions attached, of which there are 23 specific conditions and 12 general conditions.[dc] Much has been made of these conditions, giving the impression that they would take care of the environmental hazards that may be caused by the plant. Let us examine these.

Take the general conditions. They are actually sanctimonious platitudes. Condition 1 reads: "The sand for construction purpose shall be obtained only from the approved quarries." Condition 6 says: "The installation and operation of DG (Diesel Generator) sets shall comply with notified guidelines." It's unbelievable – the MoEF means to say that all other equipment can violate notified guidelines!.

Now, for the specific conditions. Some of them are plain stupid. For instance, condition 12 reads: "During construction of the township and other buildings, it shall be ensured that the buildings confirm to the energy efficiency, water utilization efficiency, as well as the GREHA norms." Probably Mr. Ramesh is also holding the PWD portfolio, and has got confused with his multiple responsibilities.

Most of the specific conditions are actually what the EIA should have tried to prove. Condition 13 reads: "It shall be ensured that the temperature differential of the discharged water with respect to the receiving water does not exceed 5°C at any given point of time." Condition 14 says: "Appropriate safeguard measures shall be taken to ensure that the biodiversities in the sea adjoining Ambolgad are not affected adversely due to the project." Condition 18 stipulates: "The radioactive dose apportionment from each unit shall be as per the limits prescribed by the AERB." And so on... It was the job of the EIA to assess whether the temperature of the discharged water would exceed 5°C or not, whether the biodiversity of the area would be adversely affected or not, whether the radioactive leakages would be within the AERB limits or not, and so on. The EIA has not done any of these assessments! The EIA should have been scrapped, the environmental clearance withheld, and a fresh EIA ordered. Instead, the MoEF gives environmental clearance to the plant, and expresses the pious hope that the plant would fulfill these 'conditions'.

Condition 2 states: "The following additional details shall be submitted within 12 months: A comprehensive biodiversity plan shall be prepared for Jaitapur ...; a special plan will be made to put in place adequate safeguard measures to ensure that the fisheries in the sea adjoining Ambolgarh are not affected adversely due to the project...; etc. etc" Actually, only after completion of these studies and development of these plans should the environmental clearance have been given. Instead, again the pious hope is expressed that these plans would be drafted in a year's time.

Actually, while giving environmental clearance for the project, the Environment and Forests Minister Jairam Ramesh himself stated the real reason for granting the approval: "On the one hand there have been many issues raised on the preservation of marine biodiversity, an area in which India has been very weak. But at the same time there are weighty strategic and economic reasons in favour of the grant of environmental clearance now."[dci]

Or rather, despite the adverse environmental impact, it was "weighty strategic and economic" reasons because of which the project was given the clearance!

The irresponsible DAE!

Let us for a moment keep aside our main argument that nuclear power is deathly, it cannot be the solution to our energy problems, construction of all nuclear plants should be stopped immediately, and all plans to build new nuclear plants should be scrapped. Let us for the moment accept the government of India argument that the country needs nuclear power as a solution to our energy problems. From the description given above about the VVER-1000 and the EPR reactors and the Areva Corporation which is going to supply the EPR to India, 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 – an accident at these reactors would be many times more catastrophic than Chernobyl.

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

- which lie every time an accident takes place at their installations – either they deny it outright, or in case it is not possible to do so, try and play it down by lying about the extent of radiation leakage and its possible impact on their workers and the surrounding population;
- 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! Amongst all countries with nuclear power plants, India is the only country where such a situation prevails!!

Yes, it is scary indeed! At the hearing of the PUCL and Bombay Sarvodaya Mandal petitions in the Bombay High Court regarding the safety of India's nuclear power plants (See Part I above), the Chief Justice, before summarily dismissing the petitions, remarked that so far, no accident has taken place. To this, advocate for the PUCL M. A. Rane asked: "Whether the Chief Justice is waiting for an accident to take place from an NPP?"[dcii] The government of India is apparently of the same opinion, that more and more risks can be taken, till...

If there is an accident at Jaitapur, in the minimum, Western Maharashtra will have to be evacuated; if there is an accident at Kudankulam, in the minimum, Southern Karnataka, Southern Tamil Nadu and much of Kerala will have to be evacuated. For 20-30 thousand years. The surviving part of the country would be crippled for many many decades.

Even if there was no alternative, how can we take this risk of destroying human civilisation 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 way of meeting our present and future energy needs! Read on...

The Sustainable Alternative to Nuclear Energy

Part I: The Official Argument

The Indian government's argument for embracing nuclear energy in a big way rests on the premise that GDP growth requires a huge increase in electricity generation.

In 2005, the Planning Commission of India appointed a high powered committee to make recommendations on the future of India's energy policy. The Committee submitted its final report, the "Integrated Energy Policy (IEP)" in August 2006. According to this report, "India needs to sustain an 8% to 10% economic growth rate, over the next 25 years, if it is to eradicate poverty and meet its human development goals. To deliver a sustained growth rate of 8% through 2031-32 and to meet the lifeline energy needs of all citizens …power generation capacity must increase to nearly 8,00,000 MW (by 2031-32) from the current capacity of around 1,60,000 MW inclusive of all captive plants."[dciii]

It is in the context of this mammoth future demand projection that the government justifies its massive nuclear energy program. It is expecting around 8% of this demand, about 63,000 MW, to be met from nuclear power plants[dciv] – from the 4560 MW at present. Justifying this giant leap in nuclear power generation, Prime Minister Manmohan Singh, while speaking at the inauguration of a power plant in West Delhi on 24 March 2008, stated: "The economy is growing at 8-9 per cent per annum. With growing urbanisation and rising prosperity, the demand for electricity is outpacing existing sources of supply." And so, he added, India needed to widen its choices for electricity, which should include alternative resources like nuclear power.[dcv] The same argument is made by many noted intellectuals of the country.

Part II: The IEP Vision Statement: Unsustainable Projections

The vision statement of the IEP quoted above estimates that future generation capacity needs to increase by 5 times by 2032. The IEP has apparently based its estimation of the required increase in electricity generation on the assumption that demand would grow at a compound annual growth rate (CAGR) of about 6.4% with respect to the base figure of 153,000 MW in 2006.

A number of experts have critiqued the methodology used by India's energy planners to make forecasts of energy consumption. Even assuming that the economy will grow at an average rate of 8% over the next 25 years, by extrapolating from recent figures of growth rate of the Indian economy and growth of electricity generation, they show that these projections are exaggerated.[dcvi] The reason why policy planners make such inflated forecasts is because this then serves as a justification for huge investments in setting up power plants, thereby earning huge profits for the private sector companies who get the construction orders.

However, let us leave aside this issue and analyse the IEP vision statement. According to the IEP:

- A sustained high growth rate of 8-10% for the next two decades is needed for eradicating poverty.
- To deliver such a high growth rate and meet the energy needs of all citizens, would require that the installed electricity generating capacity should increase to between 778 GW (for 8% growth rate) and 960 GW (for 9% growth rate) by 2031-32.[dcvii]

1. Growth for whom?

One problem with this argument is that it assumes that GDP growth leads to increased prosperity and better living conditions for the ordinary people. We have argued in detail elsewhere that today, for the common people, the opposite is the case: "The word 'GDP growth rate' has come to have a sinister meaning for the poor. The upper classes measure their increase in wealth by growth in GDP. For the vast masses, it is a measure of the devastation of their lives…" For instance, during the period 2003-07, a period which saw the Indian economy grow at above 8% per year, total employment in the organized sector actually declined in absolute numbers, farmers committed suicides in record numbers, lakhs of people fell below the poverty line and malnourishment in the country increased further from already record levels, and so on.[dcviii]

Likewise, increased electricity generation also does not mean more electricity for the common folk living in small towns and rural areas. This is borne out by past experience – all the growth in electricity generation during the six decades since independence has gone towards fulfilling the galloping demands of the rich in the big cities in the country. Thus, the total installed electricity generating capacity in the country has gone up by more than a hundred times since independence, from 1.4 GW[dcix]

Table 10.1: Power Generation Capacity in India (MW) – as on 31 March, 2010[dcx]

Thermal				Hydro	Nuclear	Renewables[1]	TOTAL
Coal	Gas	Diesel	Total				
84,198	17,056	1,200	102,454	36,863	4,560	15521[2]	159,398

in 1947 to 160 GW in 2010. Despite this phenomenal increase, more than 44% of the country's households still have no access to electricity even six decades after independence. The situation is

1 Renewables includes wind energy, biomass gassifiers, minihydel turbines (<3 MW), and bagasse fired cogeneration plants; but does not include biogas plants, solar PV panels and solar water heaters.

2 Based on data as on 30.09.2008

especially bad in the rural areas, where about 56% of the households have still not been electrified.[dcxi]

Further, even the 44% villages that have been electrified actually have very inadequate supply of electricity. Most villages have power supply for durations less than 12 hours a day on an average. Even this meagre supply is of very poor quality: it is neither regular, nor is it provided when people need it most. Additionally, the low voltage conditions and frequent interruptions make the electrification a cruel joke on the villagers. Anyone familiar with the rural areas of the country is well aware of this.

A recent survey of five states in four regions of the country carried out by Greenpeace also bears this out. In all these five states, there has been a continuous increase in power availability. However, says the report, "most of the additional power available in each state seems to have gone to the cities and towns to meet their insatiable demands ... whereas the villages continue to suffer with inadequate amount of electrical energy even for basic needs." The government's drive to further add millions of MW of additional capacity based on the present model of electricity generation – conventional power sources and centralised power supply system – will also go towards meeting the ever-growing electricity demand of the urban population, it will not ensure quality power to the rural population and will therefore not lead to their development. Therefore, the report calls for "a paradigm shift in our energy policy."[dcxii]

2. Destructive Projections

Let us leave aside the issue of equitable development, assume that GDP growth is needed, and accept the Planning Commission's argument that for the economy to grow at an average rate of 8% till 2032, it is necessary to increase electricity generation capacity in the country by 640 GW over the next two decades through setting up large centralized coal-hydro-nuclear based power plants. To meet these projections, the IEP assumes a capacity addition of 63,000 MW from nuclear energy and full exploitation of the hydropower potential of 150,000 MW in the country. It also says that coal shall continue to remain India's most important energy source till 2031-32 and possibly beyond, but because of capacity addition from nuclear and hydro, it expects the share of coal-based electricity to drop from 72% at present to 61%.[dcxiii] The problem with these projections is: they are simply unsustainable!

We have already discussed extensively in this booklet the disastrous implications of the government's plans to go in for a quantum jump in nuclear energy generation – from 4560 MW (as of January 2011) to around 63,000 MW by 2031-32. The IEP has drawn up various possible energy mix scenarios for 2032, and even in the most renewable energy friendly scenario, it expects share of coal based electricity to be 270 GW.[dcxiv] Even assuming that the government does pursue this energy mix over the next two decades, the social and environmental costs of setting up coal based thermal power plants of a total capacity of around 190 GW and large dam based hydro power plants of around 110 GW capacity over the next two decades are going to be equally terrible.[dcxv]

(i) Costs of Coal Power

Even in its most renewable energy friendly scenario (where all options other than coal are pushed to their limits), the IEP projects coal based power capacity in India to rise to 270 GW by 2032; while the Central Electricity Authority (CEA) projects installed capacity of coal -based plants to be 412 GW by that year.[dcxvi]

The first problem with these projections is: where is the coal going to come from to feed these power plants? The IEP projects the requirement of coal for power generation to increase from 406 Mt in 2004–05 to between 1580 and 2555 Mt (for the least and most coal intensive option respectively) in 2031–32. Since the domestic supply of coal is limited, IEP projects that high quality coal imports requirement could range from 120 million tonnes to 770 million tonnes (for the least and most coal intensive option respectively) by 2031-32.[dcxvii] The problem is: globally available exportable coal supplies are also running out! A recent study by the Energy Watch Group of Germany predicts that global coal production will increase over the next few years, peak around 2025 and then decline. Clearly then, it is foolhardy to base our future energy security on a resource whose domestic supplies are declining and the global availability of which in adequate quantities beyond 2030 is suspect.[dcxviii]

The second, and more important problem with this projection is: the IEP totally ignores the social, economic and environmental aspects of such a huge increase in coal based power generation. It is going to pose a bigger risk to biodiversity in the Indian subcontinent than all other anthropogenic interferences together did in the past. Each part of the entire coal cycle – from its mining, to burning of coal in power plants, to disposing of coal waste – causes irreparable damage to the environment and the health of people.

Costs of coal mining

The most serious health effect of coal mining is of course on the coal miners – it causes black lung disease, due to the progressive build up of coal dust in the lungs which the body is unable to remove. Apart from that, coal mining causes displacement of entire communities who are forced to abandon their homes because of the mines. The coal is normally located below thick forests, so mining causes widespread deforestation. It also generates huge waste mountains, and blankets surrounding communities with dust particles and debris.

Costs of coal power plants

The burning of coal in power plants to produce heat and generate electricity leaves a similar trail of destruction in its wake. A groundbreaking medical report *Coal's Assault on Human Health* released in November 2009 by the renowned US group 'Physicians for Social Responsibility' has given in detail the devastating effects of coal burning on human health. Coal combustion releases sulfur dioxide, particulate matter, nitrogen oxides, mercury, and dozens of other hazardous substances into the environment, which damage the respiratory, cardiovascular and nervous systems of the human body. In particular, these emissions contribute to some of the most widespread diseases, including asthma, heart disease, stroke, and lung cancer.[dcxix]

Apart from their impact on human health, the sulphur dioxide, nitrogen dioxide and coal dust emissions deposit over large areas, and their synergistic effect is very injurious to vegetation. They adversely affect soil fertility, resulting in a sharp decrease in agricultural yields. When located near forests, like the thermal power plants coming up in the Konkan region, the depositions of these acidic gases put the forests at the risk of forest dieback (a condition in which peripheral parts of trees are killed due to factors like acid rain).[dcxx]

Another major problem with thermal power plants is that they require large amounts of water. Given the growing water crisis in the country, the plants being proposed to be sited in inland areas will worsen this crisis. As a solution to this problem, many new thermal power plants are proposed to be set up along the coast, so that they can use seawater. However, this will impact the fish breeding and spawning areas, threatening the livelihoods of fishermen.

Finally, like coal mining, construction of the dozens of thermal power plants required to meet the coal power generation target for 2032 will also mean acquisition of large chunks of land, leading to displacement of lakhs of people. There is no alternate land in the country to be given to them, they will end up in the slums of big cities. True, they will not be annihilated or taken to gas chambers, but the quality of their accommodation is not going to be any better than in any concentration camp of the Third Reich.

Costs of coal waste from plants

The damage caused by coal doesn’t end once it’s burnt. The combustion waste, also known as coal ash, is very toxic. It contains many chemicals like lead, arsenic, boron and cadmium which can cause cancer and other health effects.[dcxxi] While this waste is supposed to be sluiced with water and let into ash ponds, thermal power plants in India invariably discharge ash into nearby water bodies, polluting them and affecting the lives of thousands of people dependent on these water bodies for their water supplies.[dcxxii] Not that the ash ponds are any better: most ash ponds are unlined or inadequately lined, and a new official report from the US says that such coal ash ponds have poisoned groundwater or surface water in at least 23 states, and they pose cancer risk 900 times above what can be defined as ‘acceptable’.[dcxxiii]

Contribution to global warming

Given the severity of the global warming crisis which is threatening the very existence of life on earth, probably the gravest problem caused by coal based power plants is that they are the biggest source of greenhouse gas (GHG) emissions in the world: according to one estimate, they account for one-third of overall global emissions.[dcxxiv] In the US, which is the world’s biggest emitter of greenhouse gases, the electricity sector (meaning mainly the coal fired thermal power plants) is responsible for about one third of the country's total GHG emissions and 40 percent of total carbon dioxide (CO_2) emissions.[dcxxv] For India, the report “India: Greenhouse Gas Emissions

2007" released by MoEF in May this year (2010) says that about 38% of the total GHG emissions in our country is associated with electricity power sector.[dcxxvi]

To Conclude: Clearly, even assuming that the government manages to find the coal to fuel its projection of 270-400 GW of coal based thermal power in 2032, these plants would destroy the environment and health of the people of the country.

(ii) Costs of Large Hydro Power Plants

Large hydroelectric dams, like coal fired power plants, also wreak havoc on the ecosystems and communities where they are located. The biggest problem with these plants is that the giant size dams displace huge populations of people, leaving them homeless and destitute. The figures of those displaced so far by large dams are mind-boggling. Arundhati Roy, in her wonderful article "The Greater Common Good" quotes N.C. Saxena, Secretary to the Planning Commission, as saying that nearly 4 crore people have been displaced by dams in the country since independence.[dcxxvii] That's more than three times the number of refugees created by the Partition in India! What about rehabilitation? The government of India does not have a National Rehabilitation Policy. What happened to these 4 crore people, where did they go, where are they now, how do they earn a living now that their lands are gone, no one knows. And now, the government is proposing to set up new hydro power plants to quadruple our present installed capacity!

The second and equally severe problem is environmental: dams submerge millions of hectares of lush forests and large chunks of fertile river valley agricultural lands. The other ecological problems caused by dams are less well known. The World Commission on Dams (WCD), formed in April 1997 to research the environmental, social and economic impacts of the development of large dams globally, found that "large dams generally have a range of extensive impacts on rivers, watersheds and aquatic ecosystems" and "have led to irreversible loss of species and ecosystems". Damming of rivers impacts the quantity, quality and pattern of water flow in them, and has caused a huge loss of freshwater diversity: up to 35 per cent of freshwater fish species are estimated to be extinct, endangered or vulnerable.[dcxxviii]

Large dams contribute to global warming

Another myth with regards to large hydro power plants is that they are green, that is, they do not contribute to global warming. Large dams emit greenhouse gases like methane, carbon dioxide and nitrous oxide. The "fuel" for these gases is the rotting of the vegetation and soils flooded by reservoirs, and of the organic matter (plants, plankton, algae, etc) that flows into dams. According to a study by researchers from Brazil's National Institute for Space Research (INPE), the world's large dams emit 104 million metric tons of methane annually, implying that dam methane emissions are responsible for at least 4% of the total global warming impact of human activities.[dcxxix] The study also found that more than one fourth of these emissions, 28% to be more precise, were due to India's large dams! Large dams are in fact responsible for some 20% of India's global warming impact![dcxxx]

While the costs of large dams are huge, the benefits are less than projected. Silting of dams leads to a decline in their actual storage capacity, in many cases severely, due to which the area irrigated by them decreases.[dcxxxi] It also results in decreased electricity generation from their associated power plant. A survey of 208 operational hydel projects in India done by Himamshu Thakkar of South Asian Network for Dams, Rivers, and People (SANDRP) in March 2007 found that power generation at 184 of these (88% of those surveyed) was less than the design capacity. And for 90 of these projects (i.e. for 50% of those surveyed), the actual generation of electricity was less than 50% of the design capacity![dcxxxii]

Therefore, it is not surprising that cost-benefit studies of many large hydro power projects have found that the benefits are less than the costs![dcxxxiii] No wonder that the report of the World Commission on Dams, which was sponsored by the World Bank, concluded that: "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."[dcxxxiv]

In the light of these facts, the proposal of the government to construct large hydro power projects of nearly three times the present capacity of 37 GW over the next two decades is going to be absolutely disastrous, for both the people and the environment.

3. Conclusion

Clearly, then, the government's plans of setting up giant-sized coal, hydro and nuclear power plants to produce the electricity required to power India's future growth:

xii. will not solve the energy crisis of the majority of the Indian people living in the rural areas, who continue to be without electricity even 60 years after Independence;

xiii. will have unacceptable environmental and social costs.

The question then arises: is there a sustainable solution to this crisis, is there an environmentally friendly way of meeting the genuine present and future electricity needs of all sections of the Indian people?

Part III: The Sustainable Alternative: A New Energy Paradigm

It is possible to find a way out of this crisis, but that would call for a totally new approach to energy planning. **Firstly**, we need to reorient our energy planning towards meeting the energy requirements of all sections of the population, and not just the energy needs of the elites living in the cities. The indicator of development must not be statistics showing total energy consumed, but whether the basic energy needs of the people, starting from the poorest sections, are being met. **Secondly**, we need to recognize that what really matters is not how much energy is generated, but how much of it is finally being converted to work by energy devices (what is called "useful" energy). This is, we must focus on increasing the services provided by energy, like lighting, heating, cooling, etc., instead of blindly increasing electricity generation. **Finally**, the energy supply system must be environment friendly, we cannot ignore its environmental costs.

This new energy paradigm has major implications for the energy system. These include:

- Increasing useful energy or end-use of energy does not necessarily mean increasing energy generation, it can also be achieved by:
  - increasing the efficiency of the energy supply system and the energy transmission system, and increasing the efficiency of the devices that convert the energy delivered to the consumer into the required energy services (heaters, coolers, bulbs, etc.);
  - curbing demand, especially by eliminating wasteful consumption of energy.
- Massively increasing the production of energy from renewable sources like the sun, wind, flowing water (here, we are referring to small hydro power plants and not large hydro power plants), waves and biomass – for which there is a huge potential in the country.
- Adopting decentralized energy systems where necessary, as they are often cheaper and more efficient as compared to supplying electricity from a large centralized grid.

We take a look at all these three issues in some detail.

A. Implementing energy efficiency and energy conservation measures

Even a cursory look at the Indian power sector makes it evident that its overall efficiency is very low as compared to international standards, as table 10.2 attests:

Table 10.2: Power Sector Efficiency in India[dcxxxv]

Power Sector Area	Prevailing level of efficiency / loss 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)	20 – 30 %	More than 80%

Demand Side Management	Potential to reduce the effective demand by a minimum of 15 %

1. Improving Generation, Transmission and End-Use Efficiency

The average Plant Load Factor (PLF) of thermal power stations in the country is reported to be about 77%,[dcxxxvi] while the best run power plants of NTPC have PLF of above 90%, and some of them even have PLF of 100%.[dcxxxvii] By renovating and modernizing the plants with low PLF, it should be possible to raise the national PLF to at least 90%. With about 84,000 MW of installed thermal power capacity in the country, this increase in PLF will save the need for about 11,000 MW of additional installed power capacity. Thereby eliminating the need for setting up the Jaitapur Nuclear Power Plant!

Aggregate Technical and Commercial (AT&C) loss includes both transmission and distribution (T&D) losses and also commercial losses like those due to theft, inefficient metering, etc. It is thus a better indicator of total losses in the transmission and distribution system. Overall AT&C losses in the country's network were 32% (and T&D losses were 29%) in 2006-07.[dcxxxviii] By bringing down the losses in the transmission and distribution system to even 15% will reduce the need for additional installed power capacity of about 20,000 MW. This is not a tall order. China's total AT&C losses are 8%; OECD countries' transmission and distribution losses are 7%,[dcxxxix] while South Korea's T&D losses are even lower at just 4%.[dcxl] Assuming a cost of Rs. 4.5 crores per MW for setting up new coal power generation capacity, reducing T&D losses by even 15,000 MW would mean a saving of Rs. 67,500 crores. This matches with the report of the 13th Finance Commission, which warns that the combined transmission and distribution losses at the national level amount to a massive Rs. 68,643 crores in 2010-11, and that these may increase to Rs. 1,16,089 crores by 2014-15 unless steps are taken to improve efficiency.[dcxli]

Finally, as the table indicates, there is huge scope for increasing end-use efficiency in all sectors – from agriculture to industry to offices and homes. For instance, agricultural pumping sets or IP sets consume about 30% of all electricity consumed in the country. They consume about 40-45% more energy than required; by investing just around Rs. 4000 per set, this wastage can be brought down to less than 15%.[dcxlii] Since there were 16 million pumping sets in the country in June 2009,[dcxliii] this means that an investment of roughly Rs. 6400 crores will result in a saving of 30% of the electricity consumption in the agricultural sector, that is, a whopping 14,400 MW. Assuming an investment of Rs. 4.5 crores per MW for setting up new power plants, this would mean a saving of (14400 x 4.5) – 6400 = 58,400 crores![dcxliv]

Savings from Improving Efficiency of Household Appliances

An important way of increasing end-use efficiency in homes is by promoting the use of efficient electrical devices, which give the same output with lesser consumption of electricity. Most of us are not aware about it, but the potential is huge. A recent study by “Prayas Energy Group”, a well-known Pune-based research group on policy analysis, has estimated the energy savings that can be achieved by the use of energy-efficient home appliances in the country. The report focuses on nine appliances which contribute to almost all the electricity consumption in Indian households – fans, incandescent bulbs, tube lights, refrigerators, ACs, air coolers, electric water heater, room heater and televisions (active mode) – and apart from that, stand-by power. Stand-by power is power wasted because appliances are not switched off after use and kept on stand-by mode; the report takes into consideration the stand-by losses of Set-Top-Boxes, DVD Players, TVs and computers.

The report takes 2008 as the starting year for its analysis, and calculates the energy savings that would result if all incandescent bulbs were replaced with CFLs and tube-lights with EE models, and all new purchases of appliances by households were of the most energy efficient appliances available in India. The report comes to the astonishing conclusion that after five years, this would result in an annual savings of about 57 TWh in 2013! That is about 30% of the additional annual consumption that would otherwise have happened under a business-as-usual scenario in that year. Retrofitting of lights accounts for about half the saving while ceiling fans, TVs, refrigerators, and reduction in stand-by power account for another 40% of the savings in households.[dcxlv]

These potential savings correspond to saving more than 25,000 MW in generating capacity addition![dcxlvi] It is equivalent to the total combined capacity of the Kudankulam Nuclear Power Plant, the Mithivirdi Nuclear Power Plant, the Kovvada Nuclear Power Plant and the Haripur Nuclear Power Plant!

Many efficiency measures are very easy to implement, and the investment made would be more than compensated by the savings. One such extremely quick and cheap way of bringing about significant energy savings is: replacing incandescent lamps by Compact Fluorescent Lamps (CFL). This has the potential to reduce the lighting load of the system by about 80%, and the total cost of lighting to a consumer by about 66%.[dcxlvii] It is indicative of the sloppiness and lethargy of our energy planners and their obsession with setting up new power plants that no serious attempt has been made to implement even this in our country.

2. Demand Size Management

Apart from increasing end-use efficiency, another way of increasing the availability of electricity for end-use is by curbing demand, in what is called Demand Size Management (DSM). There is huge scope for this too in the country. One obvious example is better design of buildings and street lighting systems – in fact many buildings are so awfully designed that they need lighting even during daytime in summers, in a tropical country like ours! Similarly, wasteful and unnecessary illumination of commercial buildings and wasteful lighting of roadside hoardings should be curbed. At the very least what can be done is that all such consumers should be asked to immediately install solar lighting systems. Why should scarce electricity from the grid be spent on such absolutely non-essential uses? Restrictions should also be imposed on use of air conditioners, as well as the recent craze for night time sports, which too consume huge amounts of electricity.

Another important aspect of DSM, which also helps in reducing system costs, is implementing measures to reduce the peak demand, that is, the gap between the maximum demand and the average demand. This can be done by proper planning, such as getting industries to diversify the peak load hours.

IEP 2006 also admits to the potential of DSM. It says that if DSM options like energy efficient processes, equipment, lighting and buildings are pursued, electricity demand can be reduced by at least 15%.[dcxlviii]

3. Balance Sheet

All the above mentioned savings resulting from improving generation, transmission and end-use efficiency add up to a whopping 50,000 MW at the minimum. Out of a total generation capacity of 160,000 MW! That means, that just by merely improving the efficiency of the existing electrical infrastructure to even near international standards will reduce the electricity demand by at least 30-40%!

Table 10.3: All-India Power Supply Scenario (2007-08)[dcxlix]

Energy	**Energy Availability**	**Energy Shortage**
739,345 MUs	666,007 MUs	73,338 MUs (9.9%)
Peak Demand	**Peak Demand met**	**Peak Shortage**
108,866 MW	90,793 MW .	18,073 MW (16.60%)

Let us now compare the potential of energy savings in India with the power supply deficit in the country (Table 10.3). If we compare the deficit figures with the potential of reducing the electricity demand in the country by improving system efficiency, it is obvious that the entire power sector deficit can be wiped out only by implementing efficiency improvement measures! Not only that, there would even be a surplus!! That means, even without the addition of any new electrical generation capacities, there will be no electricity deficit in the country for the next few years at least. [dcl]

The cost of implementing these efficiency improvement measures will also be much lower as compared to setting up new generating capacities – saving a unit of energy costs about one fourth of the cost of producing it with a new plant.[dcli]

B. Adopting Renewable Energy

Sources used for electricity generation can be broadly classified into two categories: **non-renewable energy** sources, where the energy source is taken from finite natural resources that will eventually dwindle – such as coal, gas, oil and uranium, as opposed to **renewable energy** sources, which are naturally replenished in a relatively short period of time, such as sunlight, wind, rain, tides, flowing water (that is, hydro) and geothermal heat. Excluding hydro electricity, the other renewable sources of energy are also called **new renewables**, as they have started being used in a big way only in recent times. The non-renewable energy sources plus large hydro projects (which have also been in use for many years) are also called **conventional sources of energy**, while the new renewables are also called n**on-conventional sources of energy**.

A common feature of new renewable energy sources is that they produce little or no greenhouse gases, and rely on virtually inexhaustible natural resources for their fuel. New renewables vary widely in their technical and economic maturity. Some of these technologies are already competitive, and their economies will further improve as they develop technically. In contrast, the price of fossil fuel will continue to rise in future, as the reserves get exhausted. The price of electricity from fossil fuels becomes even more expensive if we give the CO_2 emissions by these fuels and the environmental destruction caused by them a monetary value.

1. New Renewables: Global Scenario

Globally, over the last few years, costs of new renewable energy have fallen sharply and production of energy from these energy sources has rapidly expanded. We briefly take a look at the potential of two of these alternatives, wind and solar.

(i) Wind energy

Harnessing the wind is one of the cleanest and most sustainable ways to generate electricity. Wind power produces no toxic emissions and none of the heat trapping emissions that contribute to global warming. Wind power is also one of the most abundant energy resources. One study, which collated more than 8000 wind records from every continent, found the global wind power potential to be 72 terawatts, forty times the amount of electricity used by all countries in 2000. If just 20% of this wind energy potential could be tapped, all energy needs of the world could be satisfied.[dclii]

However, it is only in recent times, because of growing concerns about global warming, that countries have started investing heavily into research to tap this huge potential. As a result, during the last decade, world wind generation doubled about every three years, making wind energy one of the fastest growing sources of electricity in the world. Global wind power capacity increased by a record 31% over the previous year to reach 160,000 MW by the end of 2009 – more than triple the 48,000 MW that existed in 2004. Total wind energy production in 2009 was 340 TWh, which was about 2% of worldwide electricity consumption.[dcliii]

The US has the highest installed wind power capacity in the world (36.3 GW), followed by China (33.8 GW) and Germany (26.4 GW), as of June 2010. China is presently the locomotive of the international wind industry, adding 13,800 MW within one year in 2009, more than doubling its wind power capacity for the fourth year in a row. Several countries have achieved relatively high levels of wind power penetration; wind power was 20% of stationary electricity production in Denmark, 14% in Ireland and Portugal, 11% in Spain, and 8% in Germany in 2009.[dcliv]

The rise in global wind energy capacity has been accompanied by a sharp fall in costs: wind energy today costs only about one-sixth as it did in the 1980s, dropping from about 25 cents/kWh in 1981 to an average of about 4 cents/kWh in 2008 – a price that is competitive with new coal- or gas-fired power plants (figures are for the USA). With costs expected to further decline in the coming years, and growing concerns about the environmental costs of conventional sources of energy, wind power is expected to exponentially grow in the coming years.[dclv] The Global Wind Energy Council projects global wind capacity will reach 332 GW by 2013, more than double its current size.[dclvi] While wind power now contributes 1.3% of the global electricity supply, this is projected to increase to 8% by 2018.[dclvii]

The variability problem with wind power

The most important question raised about the potential of wind energy is its variability, as variation in wind speed results in variation in power generated. However, electric power generation companies know how to deal with this problem. Even with electric power from conventional sources of energy, electric power companies need to constantly adjust to constant changes in electricity demand, turning power plants on and off, and varying their output second-by-second as power use rises and falls. They also need to meet unexpected surges or drops in demand, as well as power plant and transmission line outages. Therefore, they know how to deal with changes in wind power generation at different wind turbines. In addition, the wind is always blowing somewhere, so distributing wind turbines across a broad geographic area helps smooth out the variability of the resource.

This is also being proved in practice. In the US, which installed a record 8,500 MW of wind power in 2008, capable of producing enough electricity to power more than 2 million typical homes, many electric power companies are already demonstrating that wind can make a significant contribution to their electric supply without reliability problems. Xcel Energy, which serves nearly 3.5 million customers across eight states, currently obtains eight percent of its electricity from wind and plans to increase that to about 20 percent by 2020. There are also several areas in Europe where wind power already supplies more than 20 percent of the electricity with no adverse effects on system reliability. Three states in Germany in fact have wind electricity penetrations of at least 40 percent.[dclviii]

(ii) Solar Energy

In the broadest sense, solar energy supports all life on Earth and is the basis for almost every form of energy we use. The sun makes plants grow, which can be burned as "biomass" fuel or, if left to rot in swamps and compressed underground for millions of years, takes the form of coal and oil. Heat from the sun causes temperature differences between areas, producing wind that can power turbines. Water evaporates because of the sun, falls on high elevations, and rushes down to the sea, spinning hydroelectric turbines as it passes. But solar energy usually refers to ways the sun's energy can be used to directly generate heat, lighting, and electricity.

Potential of the Solar Resource

The amount of energy from the sun that falls on Earth's surface is enormous. All the energy stored in Earth's reserves of coal, oil, and natural gas is matched by the energy from just 20 days of sunshine. Once a system is in place to convert it into useful energy, the fuel is free, emission free, inexhaustible, and will never be subject to the ups and downs of energy markets.

The sun's energy when it reaches the Earth's surface is about 1,000 watts per square meter at noon on a cloudless day. Sunlight varies from region to region. Deserts, with dry air and very little cloud cover, receive the most sun. Sunlight varies by season as well. Averaged over the entire surface of the planet, 24 hours a day for a year, each square meter collects the approximate energy equivalent of almost a barrel of oil (that is, 159 litres) each year, or 4.2 kilowatt-hours of energy every day. It should also be noted that these figures represent the maximum available solar energy that can be captured and used; solar collectors capture only a portion of this, depending on their efficiency.[dclix]

Though solar power has the potential to provide over 1,000 times the present total world energy consumption, it presently provides less than 1% of the total world energy consumption. However, if the rate at which its use has been expanding in the past few years is an indicator, it is poised to become the world's dominant energy source in a few decades from now.

Solar technologies

The simplest and most common use of solar energy is using the sun to heat, cool and light buildings. But apart from this passive use of solar energy, mechanical devices can also be used to tap solar energy, the most common being the use of solar heat collectors, solar heat concentrating systems, and photovoltaic panels to harness sun's energy.

a) Solar Heat Collectors

Apart from using design features to maximize their passive use of the sun, another way in which buildings can use the sun's energy is by installing systems that actively gather and store solar energy – called solar collectors. The most common use of solar collectors is for water heating. Solar heat can also be used to power a cooling system – using the same principle on which conventional refrigerators and air conditioners work.

Solar water heaters are a very simple way of saving grid electricity. Bangalore city has promoted the use of solar water heaters in a big way, and according to one estimate, it is resulting in a saving of 900 MW peak load![dclx]

China is the world leader in solar hot water systems, with 60% of the world's capacity. It presently has nearly 27 million rooftop solar water heaters; the energy harnessed by these installations is equal to the electricity generated by 49 coal-fired power plants. In Europe too, rooftop solar water heaters are spreading fast. Cyprus is the per capita world leader, with 92% of the homes having solar water heaters. 15 percent of all Austrian households now rely on them for hot water. Some 2 million Germans are now living in homes where both water and space are heated by rooftop solar systems. In the United States, heating swimming pools was the dominant application of solar hot water till 2005. In 2006, federal subsidies were introduced, and since then installation of residential solar water and space heating systems has soared.[dclxi]

b) Solar Thermal Concentrating Systems

By using mirrors and lenses to concentrate the rays of the sun, solar thermal systems can produce very high temperatures – as high as 3,000 degrees Celsius. This intense heat can be used boil water and produce electricity. One of the greatest benefits of these solar thermal systems, more commonly known as Concentrating Solar Power (CSP) systems, is the possibility of storing the sun's heat energy for later use, which allows the production of electricity even when the sun is no longer shining. Properly sized storage systems, commonly consisting of molten salts, can transform a solar plant into a supplier of continuous baseload electricity. CSP systems now in development will be able to compete in output and reliability with large coal and nuclear plants.

CSP technology is best suited for the desert regions of the world – including desert regions in the southern United States, North Africa, Mexico, China and India. Typical CSP plants are of between 50 – 200 MW capacity. The first commercial CSP plants were built in the 1980s, but it is only in the last few years that capacity has expanded rapidly. The US is the world leader in installed CSP capacity. While it had only 430 MW in operation in 2009, approximately 7,000 MW are in the process of development, of which 3000 MW is expected to be operational by 2011.[dclxii] The European Renewable Energy Council expects total CSP installed capacity to exceed 1000 MW by 2010 and 20,000 MW by 2020.[dclxiii] China has also announced plans to set up CSP power plants of 2000 MW capacity over the next decade.[dclxiv] Large□scale CSP plans have also been announced in Jordan, South Africa, United Arab Emirates, Egypt, Morocco, Mexico and several other countries.[dclxv]

CSP costs are declining as technology improves and production increases. Existing CSP plants produce electricity for around 12 cents/kWh. These costs are expected to fall to below 6 cents/kwh by 2015, [dclxvi] making it probably cheaper than conventional electricity for decentralized systems. Therefore, CSP-generated electricity is poised for a huge leap in the coming years. A study by 'Emerging Energy Research' (a leading provider of market intelligence on the global energy industry) projects cumulative global installed capacity of CSP to go up to 26,465 MW by 2020.[dclxvii]

Another study by Greenpeace, the European Solar Thermal Electricity Association and the IEA estimates that CSP has the potential to meet up to 7% of the world's energy needs by 2030, and 25% by 2050.[dclxviii]

c) Photovoltaics

A photovoltaic cell (PV) is a device that converts light into electric current using the photoelectric effect. Though the first solar cell was constructed in the 1880s, due to high costs their use was restricted to powering spaceships and satellites till the 1960s. This changed in the early 1970s when prices reached levels that made PV generation competitive in remote areas without grid access. PV panels now started being used for off-grid purposes, powering homes in remote locations, cellular phone transmitters, road signs, water pumps, and millions of solar watches and calculators. These off-grid applications accounted for over half of worldwide installed capacity until 2004.

In recent times, due to growing demand for renewable energy sources together with financial subsidies, photovoltaic production has dramatically expanded. Solar PV power stations today have capacities ranging from 10-60 MW, although proposed solar PV power stations will have a capacity of 150 MW or more. Grid-connected solar photovoltaics (PV) are the world's fastest-growing energy technology: annual world solar photovoltaic (PV) installations were 5.95 GW in 2008, a 110% increase over 2007. At the end of 2009, the cumulative global PV installations surpassed 21 GW. Roughly 90% of this generating capacity consists of grid-tied electrical systems. Germany was the world leader in 2009, installing 3800 MW of solar PV in that year.[dclxix]

For solar PV energy to become a dominant source of electricity worldwide, solar costs must become competitive with grid electricity from conventional sources. At present, solar PV (around 30 cents/kWh in the sunniest locations) is a long way from competing with conventional power generation costs (3-5 cents/kWh). But the advantage with solar PV is that decentralized generation is possible with it, meaning the energy source can be located at the consumer's premises, thereby eliminating the transmission and distribution costs. In that case, the solar PV cost needs to be compared with the electricity tariff being paid by the consumer (around 20 cents/kWh), and not the generation cost of conventional electricity (all cost figures are for the US).[dclxx] This gap is not much. Considering the trend of falling solar PV costs over the last many years, it is expected that solar PV costs (without subsidies) should become equal or cheaper than grid electricity costs in the sunnier parts of the US, Japan and Southern Europe by 2015. In the more temperate part of Europe, this grid parity is expected to happen around 2020. Grid parity without subsidies is already a reality in parts of California. [dclxxi]

Global solar photovoltaic generation is therefore all set to surge in the coming years. The US solar PV industry aims to provide half of all new U.S. electricity generation by 2025.[dclxxii] Greenpeace and European Photovoltaic Industry Association estimate that by the year 2030, PV systems could be generating approximately 1,864 GW of electricity around the world, or 14% of the global demand.[dclxxiii]

Renewable Energies: Poised for a Leap

Given this huge potential, and with costs poised to sharply fall in the coming years due to technology improvements and economies of scale, it is obvious that it should be possible to meet a substantial part of the global future energy needs by harnessing renewable energy sources. Total global new renewable power capacity (i.e. excluding large hydropower) increased by a healthy 16% over the previous year to reach 280 GW at the end of 2008 – of which wind power was 121 GW, worldwide grid and off-grid solar photovoltaic capacity had increased to 16 GW, small hydropower had gone up to 85 GW, biomass power capacity was about 52 GW, and geothermal power capacity had reached over 10 GW. The top four countries in order of installed capacity were China (76 GW), United States (40 GW), Germany (34 GW), Spain (22 GW); India occupied the fifth position with 13 GW.[dclxxiv]

Even more significantly, in 2008, for the first time, added power capacity from new renewables in both the United States and the European Union exceeded added power capacity from conventional power (including gas, coal, oil, large hydropower and nuclear).[dclxxv]

In March 2007, European leaders signed up to a binding EU-wide target to source 20% of their energy needs from renewables, including biomass, hydro, wind and solar power, by 2020.[dclxxvi]

The share of renewable energy in global electricity generation is set to rapidly increase in the coming years. The Energy Watch Group of Germany estimates that 29 percent of the world's electricity and heat requirements could come from renewables by 2030.[dclxxvii] The International Energy Agency also did a somersault in 2008, and reversing its earlier stand of marginalizing renewables, stated that by 2050, if governments support the development of renewables by appropriate policies and incentives, 50% of global electricity supply could come from renewable energy sources.[dclxxviii]

A report prepared by the European Renewable Energy Council (EREC) and Greenpeace in October 2008 titled "Energy [R]Evolution: A Sustainable Global Energy Outlook" is even more optimistic. According to this report, if energy efficiency measures are implemented to reduce consumption of electricity, then, new renewable energies (wind, solar, geothermal, ocean and biomass)[dclxxix] could provide around 62% of the global electricity generation by 2050! The report projects that the global installed capacity of new renewable energy technologies (excluding both small and large hydro) has the potential to grow from 89 GW in 2003 to 5878 GW in 2050, a 66-fold increase in 47 years!!![dclxxx]

The Greenpeace-EREC study shows that it is possible to completely phase out generation of electricity from dirty and dangerous nuclear energy all over the world by 2050, reduce worldwide carbon dioxide emissions by 50% below 1990 levels by 2050, and yet meet the global energy needs needed for growth!

2)The Renewable Energy Potential in India

India is the only country in the world to have an exclusive ministry for renewable energy development, the Ministry of New and Renewable Energy (MNRE). The website of this Ministry gives a large amount of statistics about the vast renewable energy potential of India. Here is a brief summary:

(i) Solar Energy

Being a tropical country, this is the renewable energy source with the most potential for India. India receives solar energy equivalent to over 5,000 trillion kWh per year. The daily average solar energy incident varies from 4 -7 kWh per square meter depending upon the location.[dclxxxi]

According to government figures, more than 35 grid connected solar photovoltaic power plants with a total capacity of 10.28 MW had been installed in the country by the end of March 2010. In addition, total capacity of stand-alone solar PV power plants in rural and other areas to provide power for electrification and running electrical equipments had gone up to 2.46 MWp by the end of financial year 2009-10. The MNRE website also claims that as on March 31, 2010, a total of 5,83,429 PV home lighting systems, 88,297 street lighting systems, 7,92,285 solar lanterns, 7,334 PV pumps and solar water heaters of total collector area of 3.53 million sq. m. had been installed in the country so far.[dclxxxii] In January 2010, the Government of India announced an ambitious “National Solar Mission” with the aim of generating 20,000 MW of solar energy by 2022; of this, in the first phase, 1300 MW of power is to be added by 2013.[dclxxxiii]

With costs of solar energy systems falling sharply the world over, and given the huge potential of generating usable energy from the sun in India, if the government indeed displays the political will it should be possible for solar energy to provide an increasing proportion of electricity generation in the country in the coming years.

(ii) Wind Energy

A total wind power capacity of 10807 MW has been established in the country up to March 31, 2010. India is now the fifth largest wind power producer in the world, after USA, Germany, Spain and China. This is slightly above one-fifth of the total wind power potential of 48,500 MW as estimated by the MNRE.[dclxxxiv]

The actual wind power potential of India may be many times the official estimate, according to many experts. A new report "Indian Wind Energy Outlook 2009" released in September 2009 in New Delhi by the Global Wind Energy Council says that technological improvements and tapping India’s vast off-shore potential could result in a total installed wind power capacity of 231 GW and a power production of 579 TWh by 2030![dclxxxv] That is huge!

(iii) Small Hydro Power

The government of India categorises hydro power projects of upto 25 MW capacity as Small Hydro Power (SHP) Projects, and their responsibility has been vested with the MNRE. These do not have any of the disadvantages of large hydro power plants that have been discussed in an earlier section of this Chapter. On the contrary, they are one of the most environmental friendly ways of providing electricity to remote villages, especially in hilly areas, where providing grid electricity is very uneconomical.

The MNRE estimates the total Small Hydro Power potential of the country to be 15,000 MW. As of December, 2009, a total of 700 small hydropower projects aggregating to 2,558 MW have been set up in various parts of the country – which is about 17% of the total potential. (In addition, 296 projects of about 936 MW are in various stages of implementation.) The MNRE has set a target of harnessing at least 50% of the SHP potential in the next 10 years.[dclxxxvi]

(iv) Biomass

Biomass, that is, plant and animal waste, is the oldest source of renewable energy known to humans, used since our ancestors learned the secret of fire. A large number of biomass materials have been used successfully for power generation, including bagasse, rice husk, straw, cotton stalk, coconut shells, soya husk, de-oiled cakes, coffee waste, jute wastes, groundnut shells, saw dust etc.; and a number of technologies are available for generating grid quality power from these resources.

The MNRE estimates the surplus biomass availability at about 120 –150 million metric tons per annum covering only agricultural and forestry residues, from which about 16,000 MW of power can be generated. In addition, by modernizing sugar mills, about 5,000 MW power could be generated through bagasse based cogeneration in the country's 550 sugar mills. Thus the total estimated biomass power potential in the country is about 21,000 MW.

According to the MNRE, as of December 2009, 829 MW of biomass power projects and 1307 MW of bagasse cogeneration projects had been installed in the country for feeding power to the grid, whose aggregate power capacity was about 2136 MW.[dclxxxvii]

Energy from urban waste

Another form of biomass is the rising piles of garbage in India's cities as a result of increasing urbanization. While these have become a big environmental hazard and their disposal a major headache for city corporations, actually they too are another source of non-conventional energy. An additional advantage is that this reduces the quantity of waste by as much as 60-90 % depending upon the waste composition and the technology adopted, and also reduces the cost of waste treatment and demand for land.

The MNRE estimates that about 50 million tonnes of solid waste (1.15 lakh tonnes per day) and 6000 million cubic meters of liquid waste are generated every year by our urban population, from which over 2600 MW of power could potentially be generated. The MNRE also estimates that there is a potential for recovery of about 1300 MW of energy from solid and liquid wastes generated by various industry sectors such as, sugar, pulp and paper, fruit and food processing, sago / starch, distilleries, dairies, tanneries, slaughterhouses, poultries, etc.[dclxxxviii] Of this potential, 65 MW of grid connected projects and 47 MWeq of off-grid projects have been implemented as on March 31, 2010.[dclxxxix]

Biogas

The country also has a huge potential of setting up biogas plants in the rural areas to produce biogas from organic materials like cattle dung. Biogas can be used for providing cooking fuel, for lighting gas lamps, and for operating duel fuel engines. According to the MNRE, a potential of setting up 12 million biogas plants exists in the country, which can generate an estimated 17,340 million cubic meter of biogas, apart from providing high quality organic manure. So far, 4.12 million family type biogas plants have been set up.[dcxc]

(v) Ocean Energy

The ocean can produce two types of energy: mechanical energy from the tides and waves (known as tidal energy and wave energy respectively), and thermal energy from the sun's heat.

Tidal power converts the energy of tides into electricity or other useful forms of power. Tidal power is very site specific; for India, the most attractive locations are the Gulf of Cambay and the Gulf of Kachchh on the west coast, and the Sunderbans in West Bengal. Wave power uses the energy of the ocean surface waves to do useful work — like electricity generation, water desalination, or the pumping of water into reservoirs. Ocean thermal energy refers to the solar energy trapped by the ocean. Because of this, ocean's layers of water have different temperatures, and this can be transformed into usable energy.

The theoretical potential of ocean energy is huge, several times greater than the global electricity demand. The identified economic tidal power potential in India is of the order of 8000-9000 MW; while India's 6000km long coastline has a wave energy potential of 40,000 MW. The potential of ocean thermal energy is even more. However, most of the technologies to extract usable energy from the ocean remain in the investigation or demonstration phase. The most advanced is tidal energy, wherein a few plants are in commercial operation around the world.[dcxci]

C. Adopting Decentralised Energy Systems

The current energy paradigm in India is to build large centralised power generation systems, mainly thermal plants (coal, gas), large dams, and now nuclear power plants as well. Inherent within such a generation system are very long transmission lines, a hugely complex distribution system, and a network of transformers to step up and step down the voltage of electricity being transmitted. Each of these adds to the complexity, reduces the efficiency, increases the electricity losses, and results in increased capital and operational costs. These factors make centralised generation systems based on large power plants an economical option only for concentrated loads.

Indian villages are spread over wide distances, most do not have large populations, and development levels are low. So they cannot provide the substantial loads that towns and cities can. Therefore, while supplying them electricity from a centralised electricity generation system requires long transmission lines and so is expensive, on the other hand for the same reason it also involves huge transmission losses.

A very simple, efficient and cost-effective solution to this problem is making use of decentralized power generation systems (meaning electricity generated at or near the point of use), based on renewable sources of energy. These can be a mix of wind, micro hydel, solar and biomass, depending on the location and availability of local resources. (We discuss renewable energy sources in the next section.) Since a decentralized generation system is connected to a local distribution network, instead of a high voltage transmission system, the losses are very low. Even if the cost of electricity from this decentralized system is more than generation cost of conventional grid electricity, because of the huge costs and losses involved in transmitting the latter to remote villages, the real end cost of conventional electricity to the consumer would in most cases be more than decentralized electricity. And, as we see below, costs of decentralized electricity are rapidly falling, making it an even more attractive solution. Further, such a system is cheaper, produces less carbon emissions, has none of the environmental, health and social costs associated with large conventional power plants, and finally, also has the benefit that it empowers local people as they can easily control and manage the electricity supply system.

Part IV: The Potential of the Alternate Energy Paradigm

The above analysis shows that it is possible to solve India's energy crisis with an Alternate Energy Paradigm, whose basic elements are:

Maximising energy efficiency, including efficiency of the energy delivery system and end-use efficiency, and eliminating wasteful use of energy.

Making the maximum possible use of renewable energy sources.

Reducing load on the grid by promoting decentralized renewable energy supply systems.

Given the huge scope of improving energy efficiency in the country, if the government indeed implements the energy efficiency measures outlined above, and promotes the use of decentralised energy systems to meet the energy needs of India's far-flung villages over half of which have still to be electrified sixty years after independence, then the additional grid electricity generation required for meeting our future growth needs is substantially reduced – a major portion of this can then be easily met from renewable energy sources.

As discussed above, even the government admits the potential of grid connected renewable electricity generation in the country to be: 48,500 MW of Wind Energy, 15,000 MW of Small Hydro Power, and 21,000 of Biomass Energy, apart from at least 50,000 MW of Solar Energy (the government itself has set a target of 20,000 MW solar energy by 2022).[dcxcii] According to the World

Institute of Sustainable Energy (WISE), the well-known NGO that promotes sustainable energy, the actual grid connected renewable energy potential of the country is much more than this[dcxciii]:

- Wind Energy – 100,000 MW;
- CSP based power generation – 200,000 MW;
- Solar PV based power generation – 200,000 MW.

Therefore, if serious efforts are made to harness this massive renewable energy potential, then only a very limited amount of new electricity generation from conventional sources would be needed. This means:

- There would be no need to set up the giant sized nuclear power plants – with all their deathly consequences – being planned by the government. All the new projects can be scrapped, and the operating reactors can gradually be phased out.
- There would also be no need to set up large centralized coal and hydro based power plants on the scale visualized by the government.

The Paradigm is two decades old…

Actually, there is nothing very original or creative in the above analysis. Some of India's most renowned energy analysts have been writing about the enormous potential of adopting energy efficiency measures since at least the last two decades. For instance, way back in 1991, A. K. N. Reddy critically reviewed the projections made by a Committee set up by the Karnataka State government about the energy requirements of the state by the year 2000. He showed that this could be brought down to only about 38% of the conventional demand, by adopting simple efficiency improvement methods like the replacement of inefficient motors with efficient motors, incandescent bulbs by CFLs, and electric water heaters by solar water heaters![dcxciv]

However, neither the Central government, nor the State governments, ever took these recommendations seriously. The IEP 2006 admits: "In the 1990s, several studies have estimated the potential and cost effectiveness of energy efficiency and demand side management (DSM) in India. Despite these potential studies, actual implementation has been sluggish." The IEP also confesses that though the 10th Five Year Plan (2002-2007) has set targets for energy savings, no financial allocation has been made to achieve these targets![dcxcv] That is, the targets are supposed to be musings.

Yet, it continues to be trashed…

Despite these acknowledgements, the IEP 2006 too does not take into consideration the huge scope of implementing energy efficiency measures in the country while calculating the future electricity generation requirements of the country, and forecasts that the country would need a mind-boggling 788 GW of electrical generation capacity by 2032!

Even more astonishingly, the IEP 2006 gives renewables only a 5% share in total power generation by 2031-32, ignoring even the estimates made by the Ministry of New and Renewable

Energy about the huge potential of renewable electricity generation in the country! It further goes on to say that their role would be marginal role even upto 2050!![dcxcvi]

While the world is rapidly moving towards increasing the penetration of renewable energy in electricity generation, India's energy planners and leaders despite being aware of the potential are deliberately ignoring the enormous potential of energy conservation and generating grid connected electricity from new renewable energy sources. They continue to declare that the country must expand its electricity generation capacity by a whopping five times from the present installed capacity of 160 GW over the next two decades, and that an overwhelming proportion of it would come from conventional energy sources. And so they are mindlessly pushing ahead with setting up extremely polluting coal fired power plants, large hydroelectric projects which render destitute lakhs of people, and deathly giant sized nuclear power plants.

Unite, to Fight this Madness!

Part I: Why this madness?

Why are India’s rulers indulging in this mindless spree of constructing giant foreign-supplied nuclear parks and indigenous nuclear plants? And not just nuclear power plants, but also ultra mega coal power plants, giant hydroelectric projects...

So that Foreign Corporations can Party through the night…

It’s obviously not for meeting the energy crisis of the country: as we have seen above, there are simpler, 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 deal in return for India agreeing to buy $150 billion worth of U.S. nuclear reactors, equipment, and materials.[dcxcvii] And not just nuclear reactors, Indian Prime Minister Manmohan Singh's Special Envoy Shyam Saran also promised that US companies would "benefit for decades" from Indian orders for military hardware orders, ranging from fighter jets and aircraft carriers to anti-nuclear missile shields.[dcxcviii]

The nuclear deal had thus nothing to do with India's growing strength, with the US recognising India's growing clout in the world, etcetera, etcetera. It was all about big business. This is why both US and Indian big corporations lobbied hard to get the deal approved by the US Congress. Ron Somers, the president of the US-India Business Council, put it very straightforwardly in July 2007: "[The U.S.-India nuclear deal] will present a major opportunity for U.S. and Indian companies." He added that the deal would create up to 27,000 "high-quality" jobs per year over the next decade in the U.S. nuclear industry. The Confederation of Indian Industries, a lobbying group of big Indian business houses, funded numerous trips to India for US congressional delegations. Modest estimates place the total cost at about $550,000.[dcxcix]

Even before the deal was finally approved by the US Congress in October 2008, several US multinational energy firms, including General Electric, Bechtel, Edlow International, Nukem, Thorium Power and Westinghouse, sent representatives to New Delhi for discussions on future contracts. (Westinghouse, although a subsidiary of Toshiba since 2006, is based in Pennsylvania.) WM Mining, a uranium mining firm, even negotiated an agreement with the Nuclear Fuel Complex, Hyderabad, to supply 500 metric tons of uranium annually with an expectation of $1.3 million in profits.[dcc] And within months of the deal being signed, GE Hitachi Nuclear Energy and Westinghouse signed memorandum of understandings with NPCIL regarding deployment of their 1350 MW Advanced Boiling Water Reactor and AP 1000 Reactor respectively.[dcci]

Similarly, the 45 member countries of the NSG also gave their approval to ending the embargo on nuclear trade with India, for lucrative business opportunities. In early 2007, anticipating a change in NSG rules, Russia and India signed an agreement for Russia to supply four 1000 MW nuclear reactors to India, a deal potentially worth $10.35 billion.[dccii] All 27 EU countries are members of the NSG; to win their approval, India promised to begin construction of six EPRs designed by French and German utilities as soon as the NSG permitted it to do so.[dcciii] Two days after the NSG gave its green signal for nuclear commerce with India, a British nuclear power industries delegation arrived in India to explore the market (on September 8, 2008).[dcciv] The same month, France signed a bilateral nuclear cooperation agreement with India allowing for the sale of French reactors, as well as other civilian nuclear material. The agreement was ratified in January 2010,[dccv] and the framework agreement for the supply of the first two reactors was signed between the two countries in December 2010. Though the final price has not yet been announced, this deal should be worth at least $14 billion;[dccvi] and France is to supply 4 more such reactors.

Not to be left behind, in November 2009, after a break of three decades, Canada also signed an agreement with India paving the way for Canadian firms to supply nuclear equipment to India, including the ACR-1000 reactor.[dccvii]

Indian big business joins the tango...

India's big business houses are expecting to get subcontracts from these foreign corporations worth thousands of crores of rupees. Speaking to reporters after news came in of NSG granting permission for nuclear trade with India, Venugopal Dhoot, head of the consumer goods-to-energy firm Videocon Group, stated that it was a huge business opportunity for India and that some 40 companies were negotiating nuclear power joint ventures with foreign firms.[dccviii] Amongst the companies that have announced plans to enter this sector are Tata Power, Reliance Power, JSW, GMR and Lanco.[dccix] Many Indian companies have already concluded agreements with foreign nuclear corporations. In 2009, the Mumbai-based Indian conglomerate Larsen & Toubro (L&T) signed four agreements with foreign nuclear reactor vendors. In January 2009, it signed an agreement with Westinghouse Electric Company to produce component modules for its AP1000 reactors. The second agreement was with Atomic Energy of Canada Ltd (AECL) "to develop a competitive cost/scope model for the ACR-1000". In April, it signed an agreement with Russia-based Atomstroyexport primarily focused on components for the next four VVER reactors at Kudankulam, but extending beyond that to other Russian VVER plants in India and internationally. Then, in May 2009, it signed an agreement with GE Hitachi to produce major components for its ABWRs, including the supply of reactor equipment and systems, valves, electrical and instrumentation products. Early in 2010 L&T signed an agreement with Rolls Royce to produce technology and components for light water reactors in India and internationally.[dccx]

Similarly, Hindustan Construction Company (HCC), which has done civil work for eleven of India's nineteen existing reactors, has tied up with UK-based engineering and project management company AMEC Plc to provide design consultancy and engineering services for nuclear power plants in India. It has already completed civil work for the Russians at the two plants in Kudankulam.[dccxi] Meanwhile, Areva has announced that it will be looking at TATA Engineering, L&T and Bharat Forge to provide nuclear components for Jaitapur reactors.[dccxii] In January 2009, even before it signed the formal agreement with the Indian government for supply of its EPR reactors, Areva signed an agreement with Bharat Forge, India's biggest forging company, to build a manufacturing facility for heavy forgings in India by 2012.[dccxiii]

Presently, nuclear power production in India is under government control and only NPCIL can set up and run nuclear power plants. However, the law is very likely to be amended soon to allow the entry of private players. The *Economic Survey* of 2008-09 has already aired the view that the Atomic Energy Act needs to be amended to permit private corporate investment in nuclear power.[dccxiv] In anticipation, big Indian conglomerates like Reliance, Tata, GMR and Essar have begun preparations to set up and own nuclear plants.[dccxv]

In the mad world of capitalism, profits is all that matters, even if it means afflicting and killing tens of thousands of people with the most terrible diseases for centuries. In Charlie Chaplin's epic black comedy film *Monsieur Verdoux* made in 1947, Henri Verdoux is accused of making a business out of robbing and killing unsuspecting women. Verdoux, in his reply, says: “As for being a mass killer, does not the world encourage it? Is it not building weapons of destruction for the sole purpose of mass killing? Has it not blown unsuspecting women and little children to pieces? And done it very scientifically? As a mass killer, I am an amateur by comparison.” Chaplin in this film was referring to the weapons of mass destruction used by both the sides during the Second World War. Nuclear reactors are even bigger weapons of mass destruction than the biggest bombs used during the Second World War!

Nuclear Policy: Part of Globalisation

For their narrow interests of profits and commissions, India's rulers are willing to condemn people living in the area around nuclear plants to suffer from all kinds of terrible diseases and give birth to deformed children for thousands of years! Their greed has made them so shortsighted that they are willing to even risk a nuclear accident – which can render huge areas of the country uninhabitable for centuries, and which, if it is a big accident like Cherbnobyl, can put at risk the very future of human civilisation, if not in the world, at least in India!!

Why is the Indian government mortgaging the interests of the people of the country to benefit big foreign and Indian corporations? It's 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, and taking advantage of this, India's foreign creditors, the USA and other developed countries – also known as the i**mperialist countries** because they are seeking to re-establish their control over the economies of the third world countries that they had once colonised – through the World Bank and the IMF (which are controlled by them), arm-twisted the Indian government into agreeing to this restructuring.[dccxvi] The basic elements of this were:

- Open up the economy to unrestricted inflows of foreign capital and imports;

- Privatise the public sector, including the welfare services.
- Remove all controls placed on profiteering, even in essential services like drinking water, food, education and health.

This restructuring of the Indian 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 the globalisation of the economy has continued unabated.

Unbridled Corporate Plunder

The essence of globalisation is that the Indian government is now running the economy solely for maximising the profits of giant foreign corporations – also known as Multinational Corporations (MNCs) – 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, 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.

In this plunder, India's business houses can only be junior partners of the foreign MNCs, as the latter are gigantic: just 200 MNCs control a quarter of the global economic activity;[dccxvii] of the world's 100 largest economies, 51 are MNCs, and 49 are countries.[dccxviii] But that is all right with them, as their profits too are increasing. They are now not bothered about who is controlling the Indian economy, but only about filling their coffers.

Hoarders and blackmarketeers are having a field day – as laws controlling their activities have been relaxed in the name of freeing the markets. The speculators are ecstatic – they have never had it so good. The swanky upper middle classes are also in raptures over globalization – the world’s most trendy consumer brands are now available in the country. The top Indian intellectuals and the media – faithful servants of the capitalist classes – have launched a massive propaganda offensive to convince the Indian people about the benefits of globalization. In sum, globalisation has become the consensus policy of India's elites. And since it is the elites, especially the big business houses, who finance and thereby control the political parties, all of them, irrespective of their colour, are implementing the economic 'reforms' wherever they are in power (in the Centre and the states).

The government of India has given up all concern about the future of the country, about conserving the environment for our future generations, about the livelihoods of the people of the country, about 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 about 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.

Part II: India on SALE

Let us take a brief look at the kind of policies being implemented by the government of India to enable MNCs and Indian corporate houses to earn multi-billion dollar profits.[dccxix]

Robber Capitalism: The tribal districts of the states of Orissa, Jharkhand and Chattisgarh are home to much of the country's forests and minerals. With the naked connivance of the politicians, police, bureaucracy and the courts, corporations have unleashed a fascist reign of terror on the people of these states, in order to drive them out and seize control of their lands, cut down the forests, and set up mining projects, huge steel, iron and aluminum plants, and ultra mega thermal power plants. Real estate speculators are also participating in this huge land grab, to set up IT parks, golf courses and five star hotels. Investments to the tune of lakhs of crores of rupees are expected into these poor rich states.

Urban Real Estate Loot: The country's metropolises have the potential of attracting billions of dollars of investments in hotels, airports, malls, stadiums, metro rails, flyovers and other urban infrastructure. But for that, land is needed. Where does that come from? The palatial houses of the rich cannot be touched. The only alternative is to evict the poor from the slums, which occupy a considerable portion of the land in the cities. So they are being bulldozed out.

Great Land Grab: In one of the greatest land grabs in modern Indian history, hundreds of thousands of hectares of agricultural land is being transferred to private industry to set up Special Economic Zones (SEZs). Investors in the SEZs are being given the most amazing concessions: no import duties; no controls on imports and profit repatriations; 100% tax holiday for 5-10 years, and what not. Labour laws and environmental laws will not be applicable to these zones. The Development Commissioner of the SEZ will function like a virtual dictator of the area – Indian democracy will end at the border of these zones! The government has even declared that these areas will be considered as foreign territories for the purpose of trade operations, duties and tariffs – the foreigners now no longer have to come with arms to win trade concessions!!

Global Garbage Dump: In its feverish desire to promote foreign investments, the government is allowing the country to be transformed into a toxic and garbage waste dump of the developed countries. Since e-waste recycling is a very hazardous industry which contaminates the soil and groundwater, and causes severe health problems to the workers, the government is allowing developed countries to ship their waste to India – to the extent that over 70% of the electronic waste generated in the developed world is now coming to India. India is also the toxic waste dump of world shipping: toxic ships from around the world, contaminated with thousands of tons of deadly chemicals, are brought to Alang in Gujarat, the world's largest ship-breaking yard, to be broken up. As if this was not enough, the country is also becoming the household waste dump of the developed countries – recycling rubbish in the developed countries is a complicated and costly affair as it is environmentally very polluting, and they find it cheaper to ship it to India where regulations are practically non-existent.

1000 More Bhopals: In the name of development, foreign and Indian corporations are being allowed to set up the most polluting industries in India. Even industries banned in the West are being allowed to operate in India: asbestos, banned in the European Union and USA, is a Rs. 2000 crore industry in India, with annual consumption of over 125,000 million metric tonnes a year; endosulphan, banned in 62 countries as it causes appalling birth deformities, continues to be used as a pesticide in India; the list of such chemicals is very long... The result is that India is home to some of the world's 'top toxic hotspots': the Eloor industrial estate near Cochin, Kerala, which has polluted the Periyar river and nearby villages with persistent organic and inorganic compounds and heavy metals; Sukinda Valley in Orissa, where one-fourth of the people suffer from pollution-induced diseases; the chemical industry belt between Vapi and Ahmedabad in Gujarat, where mercury levels in groundwater are 96 times higher than safety levels... A survery by India's Central Pollution Control Board found that groundwater was unfit for drinking in every one of the 22 major industrial zones surveyed by it!

GM Foods – self-destroying food security: The US agribusiness corporation Monsanto has been desperately trying to push the government of India to permit the growing of Bt Brinjal, a genetically modified (GM) variety of Brinjal developed by it, in the country. Once Bt Brinjal is approved, it will pave the way for introduction of other GM food crops too. GM seeds have to be purchased from the seed company for each sowing. Therefore, as their use spreads in the country, Monsanto which has patented these seeds will be able to charge monopoly prices for them and earn stupendous profits! It will also result in spread of monoculture. With the control of seeds passing from farmers to foreign agribusiness corporations, it will destroy our food security. There is extensive evidence demonstrating that GM crops and foods have adverse impacts on human and animal health, and also on the environment. Further, once released into the atmosphere, GM seeds can never be recalled, because seeds have a life of their own, and propagate themselves in uncontrollable ways. Because of these potentially very dangerous effects, more than 180 countries in the world have banned the growing of GM foods. Nevertheless, the government of India is keen to grant approval to Bt Brinjal, without rigourously ascertaining by scientific tests as to whether it is safe or not! It nearly succeeded last year, but massive protests all over the country forced the Environment Minister to announce a moratorium on its introduction in February 2010. Now, to get around this suspension, the government is planning to move a new bill in Parliament which will enable it to fast track approval to the growing of GM food crops in the country! There is no limit to the betrayal by India's rulers.

Health, Education, Drinking Water ... all on SALE: The government is gradually withdrawing from providing welfare services to the poor at subsidised rates; they are being privatised and handed over to private corporations for their unbridled loot. Government hospitals and municipal schools are being privatized; medicine prices have zoomed; college fees have gone through the roof; electricity prices are rising; bus fares are rising; the public distribution system designed to check speculation in prices of foodgrains is being eliminated; and now, drinking water supply in cities is also being handed over to these corporations, who will then hike its prices 10-15 times.

Consequences

1. Obscene Inequality

Globalization has led to a sharp increase in polarisation in the country. The rich have grown enormously richer: in 2010, the number of dollar billionaires increased by 17, driving the total to a record 69;[dccxx] those with disposable assets of over $1 million (Rs. 4.6 crores) increased by 51% over the previous year to an estimated 1.27 lakh during 2009.[dccxxi] And so they have declared: “India is shining”, India is becoming an “economic superpower”; and now after the 1,2,3 Nuclear Deal, India is on it way to becoming a “nuclear superpower” too.

On the other hand, it has also led to crores of people being pushed into destitution. This is evident from a host of government data. The latest official survey carried out in 2004-05 shows that an appalling 87% of the rural population are unable to access the minimum recommended 2400 calories per day; the corresponding percentage for urban India, where the nutrition norm is lower at 2,100 calories, was 64.5.[dccxxii] Another official report submitted to the Prime Minister says that overwhelming majority of the population – 77 percent, or 836 million people – are living on Rs.20 or less a day.[dccxxiii] According tothe National Family Health Survey of 2005-6, nearly half (46%) of India’s children under the age of three are underweight, an indicator of malnourishment.[dccxxiv] Then how come the government is claiming that poverty in the country has reduced after globalisation? It has managed this by a simple trick of lowering the country's already low poverty line![dccxxv]

2. Heading into a Financial Collapse

As the country's ruling classes ruthlessly push ahead with economic reforms, the economy is getting more and more entrapped in an economic crisis, which is already worse than the crisis of 1991 that pushed the government into globalising the economy. Discussing this is beyond the scope of this book, here we restrict ourselves to giving a few statistics:

- The external debt of the country has gone up to $273 billion as of end-June 2010,[dccxxvi] which is more than three times the debt of $83.8 billion at the end of March 1991![dccxxvii]
- The trade deficit has shot up to $117 billion in 2009-10,[dccxxviii] which is more than 40 times the deficit in 1991-92 of $2.8 billion!![dccxxix]
- The current account deficit rose sharply in the quarter ending June 2010 to $13.7 billion, from $4.5 billion a year ago. Even the Finance Minister Pranab Mukherjee has admitted that it is worrying!!![dccxxx]

This has pushed the country even more into the clutches of foreign corporations and speculators, and their governments, because the Indian economy has become more and more dependent on inflows of foreign capital (also known as Foreign Direct Investment or FDI) to keep it afloat, that is, to prevent a recurrence of the financial collapse of 1990-91.

3. Worsening Environmental Crisis

With the Indian government desperate to implement the most destructive projects, so that FDI can flow in, the country is heading into an environmental catastrophe. We have extensively discussed the terrible environmental destruction caused by nuclear plants in this book. But apart from that, the numerous other projects being implemented in the country are also going to cause enormous environmental ruin, the signs of which are already very evident: the increasing contamination of air and surface waters with industrial pollutants, the contamination of fresh water fish and ocean fish with mercury and numerous industrial organic chemicals, the pollution of groundwater with pesticides and other contaminants of chemical intensive agriculture, the accelerating depletion of groundwater levels all over the country, the extensive destruction of forests, soil degradation which is threatening agricultural productivity of large areas in the country, etc.[dccxxxi] (These problems are actually a part of the growing environmental crisis gripping planet Earth itself, resulting from similar policies being implemented by most countries in the world. But we confine our discussion to India, because that is where we can act to bring about a change.) As these problems worsen, they are going to affect survival of life itself – and the timetable is shorter than earlier thought!

The fundamental reason for this growing environmental disaster is the inherent logic of capital which is playing itself out as capitalist globalisation advances. For capitalists, whether they be foreign or Indian, environment is not a place with inherent boundaries where human beings live together in harmony with other species and which is to be conserved for future generations. Capitalists are not bothered about the future, they are only concerned with maximising their profits in the present. For them, the environment is a just another realm to be exploited as they go about seeking to maximise their profits. If in the process, the environment is destroyed, so be it.

Part III: Unite and Fight, to Save the Future

The solution to this growing economic and environmental crisis is not to replace one political party with another, for they are all the same, all are lackeys of the country's elites, all are in agreement on the issue of globalisation.

People are Beginning to Stir...

The people have been waging heroic struggles against the destructive projects being implemented in the country. The tribals and small farmers of Orissa, Chattisgarh and Jharkhand are waging heroic struggles against giant corporations like Vedanta, POSCO (South Korea, actually USA) and the Tatas who are seeking to take over their lands and destroy their livelihoods. The people of Goa got together to force the state government to cancel all the SEZs in the state. The people of 22 affected villages of Maha Mumbai SEZ which was going to be set up by Reliance in Raigad district of Maharashtra launched a determined struggle, refusing to part with their lands, forcing the government to cancel the project and de-notify the 16,000 acres of land earmarked for the project. The Warkaris of Western Maharashtra rallied in thousands to force the Maharashtra government to cancel permission given to the notorious Dow Chemicals to build a dangerous research centre near Pune. The people of Uttarakhand have launched an intense agitation against the mad scheme of the Uttarakhand government to build bumper-to-bumper dams all along the course of the River Ganges, forcing the government to cancel many of these devastating projects. In Gujarat, thousands of farmers from the Mahuva area in the Bhavnagar district of Gujarat have repeatedly courted arrest to protest the government's sanction for a Nirma factory and limestone quarry in their area. In Andhra Pradesh, people fought hard against plans to build a 1000 km long coastal industrial corridor by acquiring 50 lakh acres of land displacing about 2 crore people, eventually forcing the state government to scrap the project; now, they are organising against another such coastal corridor project in the Vishakhapatnam and East Godavari districts! Farmers' organisations of 14 states fought a fierce struggle to force the Environment Minister to impose a moratorium on the introduction of Bt Brinjal in the country. Amongst the most inspiring of all these struggles has been the heroic struggle of the people of Nandigram, who battled the entire might of West Bengal police and the goondaism of the ruling party and eventually forced the government to back off from setting up a chemical SEZ on their fertile lands.

And of course, as we have mentioned in the Introduction to this book, powerful struggles by the people of 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 are also waging fantastic struggles against DAE plans to build nuclear power plants in Madban (Maharashtra), Haripur (West Bengal), Fatehabad (Haryana), Mithivirdi (Gujarat) and Kudankulam (Tamil Nadu).

Yes, people are beginning to stir all across the country...

Lot more needs to be done

However, these struggles have not prevented the ruling classes from going ahead with their sordid agenda. For every struggle won and project cancelled, the ruling classes have been able to implement ten other projects. Often, if a project is cancelled due to strong protests by the local people, it is simply shifted to another region. Therefore, at the most, these struggles have slowed down the pace of globalization of the Indian economy. We need to do a lot more.

Advance, to build a New World

We need to involve more people in our struggles. We need to unite our different struggles. We need to deepen our struggles, and advance from opposing this or that project, to challenging the entire project of capitalist globalisation being implemented by the ruling classes of the country at the behest of the imperialists.

The ruling classes are claiming: there is no alternative to globalisation! In order to see through their propaganda, in order to be able to understand their real agenda, we must read, think, analyse. We must develop our political consciousness. Only then will we be able to take our struggle beyond the boundaries of globalisation and advance it towards building a new society whose basic logic would not promote individual selfishness and aggrandisement, but collective well-being.

There is actually no alternative to fighting globalisation! The juggernaut of capitalist globalisation is threatening the very existence of life itself (actually, not just in India, but on planet Earth)! We need to advance our struggles to fighting for building a new society which promotes selflessness and co-operation, where production is oriented not for the profit maximisation of a few, but for fulfilling the basic needs of all human beings – healthy food, best possible health care, invigorating education, decent shelter, security in old age, clean pollution-free environment. Only such a society will implement the alternate energy paradigm discussed in the previous chapter, which is oriented towards meeting the energy needs of the poorest sections of the society in the cheapest and most environmentally friendly way.

It is possible to build a new world! The people of Madban, Fatehabad, Mithivirdi, Nandigram, Mahuva, Niyamgiri, Kashipur... are showing the way with their inspiring struggles, braving police lathi-charges, false cases, arrests. Let us DARE to support them, and take our own initiatives!!

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However, the scientists who did this study found that there are a host of problems with this classification system. For one, it is entirely arbitrary, there is no internationally agreed definition as to what is a serious “event”. Secondly, the IAEA has left it to the individual member countries to report on the incidents/accidents taking place in their nuclear plants; and the countries often either do not report them, or, under political pressure, under-report the severity of the event. Then, the INES scale rates the severity of a given event only from a point of view of immediate radiological impact and not from the potential risk. It may so happen that the direct material and environmental consequences of an event are insignificant, but the event may have come very close to a serious disaster.

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