CHAPTER III
KAIGA NUCLEAR POWER PROJECT

The development of human society is inseparably connected with the art and experience of procuring power from natural resources. Like other developing countries India is also in the process of planning and development and as such needs a big quantum of energy for its development. Machine drives in the processing industry, production of aluminium, ferrous alloys, railway transport, lighting and a number of other activities need great quantities of electric energy. The amount of energy consumed is an important indicator of industrial, economic and social development of society. Thus energy is the driving force of industry and indeed of civilisation.

As is so well known electricity changes the course of man's life, because this makes life easier and removes drudgery in our day today routine. It is more particularly so in urban areas. It is electricity which introduces speed and cleanliness in our day today household chores like washing clothes and ironing them, cleaning the floors of the house and above all preparing our food. Use electric lights for working, reading and study has been part of our daily routine for the past many many years. Energy is not easy to define. A famous physicist called it, "The go of things" which, though not an elegant definition, conveys well the most distinctive characteristic. A more useful description is the capacity to lift a weight. It has to be noted that energy is no longer a purely technical and commercial
question; energy has become a political issue affecting the welfare of all mankind for preserving peace in the world. It is therefore important that the right energy decisions are taken and the contribution which nuclear energy can make towards the solution of the energy problem should not be overlooked.

All fuels are sources of energy and such sources may be classified into three categories. The first comprises the foodstuffs, animal wastes and wood. The second comprises the fossil fuels, coal, oil and natural gas. The third one is the nuclear fuels which have an enormously greater energy yield. The energy from these fuels can be extracted by complex and dangerous processes. The renewable sources of electrical energy are water and sun, which are non-exhaustible while fossil fuels such as coal, oil and gas and fissionable materials for nuclear power generation are the exhaustible ones.

In other words, the world's energy comes from a number of different sources, which may be broadly classified into two categories. The first, which include fossil fuels and minerals such as oil, coal, natural gas, uranium etc., comprises sources of energy that are non-renewable. The second category which includes the winds, the waves, the tides, the temperature of oceans and the sun comprises sources that will continue to provide energy in unlimited quantities as long as the earth and the sun exist since, they are inexhaustible.
There has been a change in the pattern of dependence on the fuels. Until the 17th century, man utilised muscle power and burnt animal waste and wood to meet his energy needs. By 1850 coal was established as an important fuel, with wood remaining the principal source. By 1900 use of coal was increasing but oil was not yet a significant contributor. Fifty years later oil became as important as coal and its use was growing more rapidly. In 1960's nuclear fuels began to contribute and their use is also growing rapidly.

Most energy is produced today by burning hydrocarbon fuels drawn from the world's non-renewable reserves. World Energy Conference statistics indicate that almost 88 per cent of the world's potential reserves of fossil fuels are in the form of solid matter, principally coal. Solid fuel potential reserves amount to approximately 11,200,000,000,000 tons of coal equivalent (TCE) or enough coal to fill an enormous cube twice as high as the world's highest mountain. The coal, liquid fuel and natural gas reserves are not plentiful, but are limited. Nature has placed so much of this fossil fuel in remote parts of the globe at depths and in quantities that make its extraction unjustifiable at present in economic terms. But, with the present rate of estimated world consumption, there will be no fossil fuels left after a hundred years.

From the foregoing it is clear that world's energy needs are met entirely from non-renewable sources. The world demand for energy is
growing at a rate of about 5 per cent per annum (doubling in 14 years). With the decline of fossil-fuel energy sources within the foreseeable future, the generation of large quantities of energy from nuclear fuel has an obvious attraction. It is stated that one gram of uranium 235 has the energy equivalent of 2.7 tons of coal. The process of extracting the energy under controlled conditions is a large scale, complex and comparatively dangerous one. So this is unlikely to be a fuel for individual transport or domestic use and its application is for large scale electrical energy generation. Since 1956 electrical power is being generated by this technique and nuclear power stations currently supply more than one per cent of the total electricity generated in the world. Vast sums of money have been spent on research regarding the use of nuclear fuels and the developed countries have expansion programmes for building new power stations. Even developing countries are building or planning their own nuclear projects.

The simplest nuclear process is burning uranium 235. This is comparatively a rare isotope of uranium and occurs as only one part in 141 of natural uranium so that the metal ore must be mined and then subjected to refining and enriching processes before it can be used.5

However there are major aspects of the use of nuclear fuels which indicate the need for cautious development and these relate to safety. Nuclear reactors become unserviceable after about 30 years and then, because they are highly radioactive, they can neither be dismantled nor
shifted but must remain where they are. The wastes which accumulate during the time the reactor is working, are the most dangerous material in man's environment and decay only over long periods of time which must be measured in thousands of years. A single typical nuclear power plant of 1000 MW capacity produces a deceptively small quantity of waste in terms of bulk but its level of radioactivity is extremely high. That is why the American nuclear engineer Alvin Weinberg describes nuclear power as a 'Faustian Bargain' in which man is able to use a prodigious source of energy but only at the cost of eternal vigilance.

For the optimum use of resources and feasible development, we must take into account the depletion of exhaustible resources and the feasibility of harnessing inexhaustible ones in producing electrical energy.

It is possible our children's grand children might find themselves in a world drained dry of natural gas and oil. Thus, we should lose no time in thinking about ways and means of producing artificial oil or artificial gas and above all of producing energy in unlimited quantities from sources which in no way threaten the environment. Solar energy presents problems of high initial cost for exploitation on a large scale. The hydropower generation is a renewable source. But, its installation period is long and initial costs are high. There has been considerable opposition to the development of this source as in the case of Tehri and Sardar Sarovar projects.
The oil problem is basically one of limited production. We cannot freely determine the level of oil production which remains limited. On the other hand in thermal generation of energy using rapidly depleting coal, oil and gas, the extent of environmental pollution is greater. Coal exists in large quantities. Development of earth's abundant coal sources will require new infrastructure, but there are no technical obstacles. There is more intensive use of coal. Though energy producing coal stations can be put up quickly, the investments on these will be high and the extent of pollution is also greater. Gas based stations are ideal because they are least polluting. They require short installation period. But the availability of natural gas is limited.

Then comes nuclear route to power generation. Science is already familiar with different sources and types of energy production. It is learnt that over the past 40 years, nuclear power has developed rapidly as an emerging technology, so that by 1988 there were 429 power reactors totalling 311 GW of capacity in operation in 31 countries, including 11 developing countries. Another 70 reactors were under construction. In 1988 nuclear power contributed 18 per cent of the world's electricity supply, and the large nuclear programmes in France and Belgium resulted in the nuclear share of electricity production reaching 70% and 66% respectively in those two countries. 6
The problem facing mankind is that of reconciling an inordinate growth of population and a limited quantity of resources. If we do not control the population growth, our descendants will not have to worry about man destroying his environment but rather about environment destroying man. Experience suggests that prosperity means power at a reasonable price, is the key, the only key to both these problems. Nuclear power is available now to bridge the gap created by the power supply from fossil sources, gravity, geothermal and solar power production. In providing power, we are providing man with the means of conserving his very existence and also conserving his environment. With modern technology, a well sited well designed, fossil-fueled power station makes so little impact on its environment and makes positive contribution to environmental cleanliness.7

India has significant energy resources. Coal accounts for 57 percent of primary energy consumption, nearly all of it mined domestically (64 percent using open-pit methods). Some 55 percent of coal supply is consumed in thermal power plants. Oil meets 33 percent of primary consumption (63 percent imported) natural gas 7 percent, and hydroelectric power the balance (3%) requirement. Energy demand growth being high (at about 6 percent per annum) efforts are on to tap nuclear energy.

The energy available from coal, oil, gas etc. cannot last more than 50 years if it is used at the present rate of consumption. India has only 0.8 percent of world's coal resources. Hydro-power available is less than
Solar and wind energy sources are still in the developmental stage. Nuclear power thus remains one of the major forms of energy production in the years to come.

In India power generation has increased from 1300 MWe to 55000 MWe, over the last 40 years. There is, at present, still a gap of more than 20000 MWe between supply and demand of electricity in the country. The national per capita consumption is less than 200 KW against a minimum requirement of 1000 KW per annum for an acceptable standard of life. If the per capita consumption of electric power in the developed countries is any standard and indication of the extent of development and advancement of any country, India by this standard, ranks very low. The industrially advanced countries of the world, with hardly around 22 percent of the world's population produce 54 percent of the total energy and consume 84 percent of such energy.

On the contrary the developing countries with 78 percent of the world's population produce 46 percent of energy but consume barely 16 percent. India's per capita consumption of energy is 172 units per annum as compared to over 8000 units in Sweden and the U.S.A, 10000 units in Canada and 18000 units in Norway. The nuclear programme was started in India during the third five year plan by starting a 100 MW plant at Tarapur, near Bombay.
Nuclear energy has the following special characteristics:

1. Fissioning uranium. This releases much more energy than burning coal or oil.

2. This also releases radioactivity which is quite harmful not only to human beings but also to animals and plant life.

3. Nuclear energy thus produced has military as well as civilian uses.

Nuclear energy is the best controlled of all energies and even the different systems of production are very well known, probably because of its dangerousness.\(^{11}\)

The production of nuclear energy involves transformation of the nuclear fuel, generally enriched uranium, which also produces radioactive isotopes. Simpler chemical physics tells us that the burning of one gramme of wood produces enough energy to light up a hundred-watt bulb for 1 minute, and that one gramme of burning coal is enough to light two similar bulbs for the same sixty seconds. One gramme of uranium in a nuclear reactor produces much more energy enough, in fact, to light 2,00,000 bulbs or 20,000 apartments for a whole hour.\(^{12}\)

What has been stated above shows that the real question today is not one of inadequate sources of energy, but of not harnessing it efficiently because of difficulties which stem from arbitrary decisions at the level of production and from irrational patterns of consumption. Energy is the key
element of social and economic progress and its development is linked with social and political as well as scientific and technical problems. In order to ascertain the likely effect of nuclear energy on health, the whole cycle of production of nuclear energy needs to be considered in detail. The setting up of a nuclear power plant in an area which causes the strongest opposition in the local as well as neighbouring populations.

The great scientific and technological innovations of the past have touched off a reaction of refusal in the public opinion because of their innovatory and revolutionary meaning. The grudging acceptance of the invention of the steam engine, its harnessing to marine propulsion and the opposition to the first railways are but a few examples.

The operation of a nuclear reactor, according to the studies made all over the world, do not affect the populations of the nearby sites more than one third of the natural background, since the emission of radioactive gases and water-soluble radioactive compounds is extremely low in comparison with 102 of the average world natural radioactive background.\textsuperscript{13}

The following are the different stages of nuclear energy:

1. Extraction of minerals containing fissile substances.
2. Preparation of the nuclear fuel.
3. Transportation of the nuclear fuel.
4. Nuclear power plant and fission.
5. Re-processing of the nuclear fuel.
6. Transportation of nuclear wastes.
7. Waste disposal.\textsuperscript{14}

The possible of contamination or accident may occur at various stages. There is loss of public confidence about safety of nuclear reactors and more so chiefly after the shock of Three Mile Island, Middle Town, Pennsylvania on 28th March 1979 and the Chernobyl disaster in the form of USSR. Clear evidence is needed that safety, not economy should be the governing factor in designing and operating of nuclear reactors.

A major disadvantage of nuclear power is the considerable cost of decommissioning the facility at the end of its useful life. After the fuel and radioactive waste have been removed for re-processing or storage, the nuclear reactor must be either (i) left intact and continuously surveyed; (ii) entombed; or (iii) dismantled using special remote handling techniques. All the three alternatives are costly. It is estimated that the provision of funds for future decommissioning by any of these alternatives may require an electricity cost increment of about 10 percent of the cost of nuclear power generation.\textsuperscript{15}
Historical Background of Producing Nuclear Energy in India

India has developed expertise in all stages of the nuclear fuel cycle, and created indigenous capabilities in designing, construction and operation of nuclear power plants, re-processing of spent fuel, and manufacture of necessary sophisticated equipment. Capabilities have been created right from exploration and mining of atomic minerals, preparation of high purity nuclear materials, such as uranium, thorium, zirconium etc., production of fuel elements for reactors, production of heavy water, health and safety, instrumentation to nuclear waste management.\textsuperscript{16}

Organised studies in nuclear science began in India in 1945 with the establishment of the Tata Institute of Fundamental Research at Bombay. In 1954 a multi-disciplinary centre for research and development (the Atomic Energy Establishment, Trombay) was set up. In 1967, the centre was renamed as Bhabha Atomic Research Centre (BARC) in memory of its founder, Dr. Homi Bhabha.

The prime objective of the atomic energy programme as defined in the Atomic Energy Act of 1948, is the development, control and use of atomic energy solely for peaceful purposes, namely, the generation of electricity and the development of nuclear application in research, agriculture, industry, medicine and other areas.\textsuperscript{17} To achieve this objective, efforts were initiated to build up a versatile infrastructure of research
facilities. Efforts were also made to train scientific and technical manpower, as also to open raw material processing centres. Facilities were provided to develop the know-how and capability to manufacture nuclear components and electronic equipment with sole aim of supporting the atomic energy programme and make India truly self-reliant.

Thus, India started work on the peaceful utilisation of nuclear energy at a time when it was essentially very much of a frontier science, into which a few developed countries alone had ventured. At a conference held in November 1954 in New Delhi on the development of atomic energy for peaceful purposes in India, the late Prime Minister, Pt. J. V. Nehru, in his inaugural address said, that India needed atomic energy for peaceful purposes and for generating power. Power as is so well known is the most important thing in developing a country’s resources.

The nuclear fuel cycle strategy was chalked out by Dr. Bhabha in 1954, namely a first stage of natural uranium reactor for producing power and plutonium, a second stage of plutonium based fast breeder reactor for producing power and more plutonium as well as uranium-233 using thorium, and a third stage of uranium-233 thorium breeder reactor for producing power. As today considerable financial and manpower resources have been invested in India on atomic energy. India has developed capabilities in
respect of the complete fuel cycle right from uranium exploration, mining, extraction and conversion, through fuel fabrication, heavy water production and reactors to re-processing and waste management. In collaboration with U.S.A., India's first power station at Tarapur near Bombay became operational in late 1969. By 1973 the second atomic power station located in Kota near Rawatbhata in the state of Rajasthan based on Canadian design became operational. The third atomic power station in Kalpakkam near Madras in Tamil Nadu state became operational in 1985. The fourth at Narora in Uttar Pradesh in 1987-88 and the fifth at Kakrapar in Gujarat in 1990-91 have been commissioned.

**Kaiga Project**

In India out of the total installed power-generating capacity of 42,491 MWe by March 1985, the share of thermal power was 27,082 MWe. (The expected generating capacity by 1989-90 was 64,736 MWe.) The rest comprised 14,314 MWe of hydro-power and 1,095 MW of nuclear power. The target for installed capacity for nuclear power by 1989-90 was expected to be 1800 MWe and 10000 MWe by the end of the century.21

Karnataka depends mainly on hydro-electric power. Some of the main hydro-electric power stations are at Supa, Jog, Kali river complex, Tungabhadra, Shivasamudram near Mysore, etc. which are all monsoon dependent. So at times they would be operating at low power level causing acute power shortage in Karnataka. Recently a thermal power station has been commissioned
Nuclear Power plants in India

[Source: Nuclear India]
at Raichur in Karnataka and a few more thermal power plants are under consideration. Karnataka state is trying for an optimal mix of various forms of power generation like hydel, thermal and nuclear.

The Indian pressurised heavy water reactor which uses natural uranium as fuel produces heat. It produces heat to convert water into steam, which spins the turbine generator to produce electricity. However, unlike coal there is no combustion in the nuclear reactor. Heat is produced by the fission (splitting) of atomic nuclei in the reactor. As nuclear energy is released in the form of heat, a separate circuit of heavy water coolant transports the heat from the fuel in the pressure tubes to heat exchanges (boilers) where steam is made to drive the turbine. Since the state of Karnataka does not have adequate water and coal resources it is but inevitable to opt for nuclear power.

In June 1987 the government of India sanctioned the sixth power station with 2 units of 235 MWe capacity using Pressurised Heavy Water Reactors (PHWR) at Kaiga, near Karwar in Karnataka. Four more units of 235 MWe are also planned in Kaiga. The plant belongs to the Mark IV type of Indian PHWR design evolution and incorporates several new safety features developed as a result of 20 years of designing and operating experience.
Transmit to homes and factories
Generate electricity

Wind power or hydroelectric plant

Kaiga project: Generating electricity
Kaiga second Reactor under construction

[Courtesy: The Hindu]
The Nuclear Power Corporation of India has a target of increasing the installed nuclear capacity in the country from 1230 MWe in 1987 to 10,000 MWe by the end of the century. This will increase the contribution of nuclear energy from 3 percent to 10 percent, whereas there are already 13 countries already generating more than 25 percent of their total electricity consumption by nuclear power generation. By the year 2000, 32, reactors will be in operation in India with 26 reactors based totally on our design and technology. Today Indian nuclear plants have an indigenous content of about 90 percent.

**Location of the Project**

Kaiga nuclear power project is located around Kaiga village on the left bank of Kali river about 13 km upstream of the proposed Kadra Dam in the thick western Ghats, which are fertile and picturesque regions of India. The track is hilly with thick vegetation and elevation is below the mean sea level. The site is surrounded on three sides with hill ranges. Kaiga is about 60 km east of Karwar town in Uttar Kannada district in Karnataka. The Nagzari hydropower station also in the same district is at a radial distance of 45 kms from the Kaiga site. The nearest rail head is at Hubli 150 kms away. National high way No.17 passes through Karwar. Kaiga site is connected by road to Karwar as well as to other towns through state high ways. The nearest airport is Dabolim in Goa at a distance of about 150 kms by road. Kaiga plant is being constructed for generating electricity. Two units of 235 Mwe capacity each are at present under
Location of Kaiga
[Courtesy: CANE]
Site for locating the nuclear power plant is selected only after most careful consideration of all aspects of safety, environment and several other factors. The siting criteria include evaluation of factors like population density, agriculture and livestock, water usage, distance from towns and cities with large population, site geology and hydrology, seismic consideration, transportation of heavy and over-dimensioned components, power demands of the region etc. The evaluation is done by a site selection committee constituted by the Department of Atomic Energy which also has a member from the Central Electricity Authority. This committee has experts from various domains like engineering, health, physics, geology, seismology etc. A number of sites in Karnataka as suggested by the state government were examined by the site selection committee and Kaiga was the only site which fulfilled the site selection criteria in all respects and hence chosen for setting up of the nuclear power station.

The criteria for the site selection requires the establishment of two zones - an exclusive zone and sterilised zone. The exclusive zone is the area immediately around the plant that would be under the exclusive control of the station authorities and within which no public habitation is allowed. The sterilised zone extends from the boundary of the exclusive zone within which the overall expansion of public activities is controlled, with only natural
growth being permitted. Even outside these zones, attention is paid to the
distribution of population up to a 30 kms radius surrounding the plant to
minimise the impact of the station on the public. This site has been cleared
by the Ministry of Environment and Forests stating the following merits of
Kaiga over other sites in Karnataka.

1. Far from coal fields,
2. No conflict in priorities in water use,
3. Very low populated zone,
4. Good foundation conditions,
5. Need for strengthening the western part of the southern region
    with base load generation.

Electricity is the most versatile form of energy. It is believed that
to maintain a modest standard of living about 1000 units of electricity
per person per year would be required. But in India the consumption rate
of electricity at present per person per year is quite meagre and falls much
below the expected standard. In order to increase the availability, the
current installed capacity of 53,000 MWe would have to be increased to
about 1,50,000 MWe by the year 2000 A.D. This is a pressing task.

**Budget of the Project**

Each 235 MWe unit is estimated to cost about Rs.365 crores at 1988
price level. It has been estimated that the two units would cost about Rs.730
crores. Apart from the sanctioned two units, additionally 4 more units would ultimately cost more than Rs.2190 crores and increase the production capacity to 1410 MWe. \(^{25}\)

**Area Covered under the Project**

A total forest area of 120 hectares has been acquired for the construction of the reactor plant building. But, only about 25 hectares of land would be required for the first two units of 235 MWe plant. The site has a total potential to support 2000 MWe installed capacity which would require about 120 hectares of land for plant buildings. Out of the total land (2 km radius) acquired for Kaiga project, the major portion would remain as it is.

M.V.Rao, Planning Officer, Nuclear Power Corporation, Kaiga Project, mentioned that, an area of 1277 hectares of land has been cleared by the Ministry of Environment. Forest land situated in the exclusive zone (excluding Kadra submergence) is 665 hectares. Forest land permitted for erecting transmission lines for carrying power is 612 hectares. Out of 665 hectares in the exclusion zone, 120 hectares will be used for locating buildings and structures. Balance area of 545 hectares will remain as forests and is declared as protected zone. \(^{26}\)
The anthropogenic activity in this zone will be nil or negligible. In other words, they are ideal locations for conservation activities and can become repository of plants and animals.\textsuperscript{27}

On account of the area being occupied by the project, a total of 85 families are displaced and quantum of compensation as decided by the state government for the land and rehabilitation is paid to these families.\textsuperscript{28} To the land affected and displaced persons, the Karnataka state government has allotted suitable land located not far away from the Kaiga project. Preferential employment opportunities in the Kaiga project commensurate with their skills, education and experience are provided. Displaced persons are also assisted in settling at the new places. The Nuclear Power Corporation (NPC) is assisting in developing infrastructure of roads, water supply, sanitation etc., in this area.

Z. R. Ansari, then Environment and Forest Minister informed V. Krishna Rao [ Congress (I) ] in the Parliament on 5th April 1989 that, in order to protect the nature around the Kaiga project, Karnataka forest department was to be given 133 lakhs of rupees by the Nuclear Power Corporation. For this purpose during 1988-89 the NPC gave Rs. 68 lakhs and the remaining amount was to be sanctioned in 1989-1990.\textsuperscript{29} An amount of Rs. 6.75 lakhs was also sanctioned separately for development of Dandeli Wild forest. Mangalore University had prepared a plan to protect the environment of Kaiga. According to the plan in the next 5 years, different
plants and trees would be planted with an estimated expense of Rs. 25 lakhs. Vittal, Additional Secretary, Bhabha Atomic Research Centre, Bombay, was of the view that with the proposed Kaiga nuclear power plant there will not be any disastrous effect on the living species or the forest. On the contrary when the project is completed the state will get a renewed industrial boost. By establishing of the Kaiga nuclear power plant there will not be any adverse effect on the living beings. He also said whether there was any adverse effect created by Kalpakkam and Tarapur projects, and that the felling of trees was far less compared with the felling of trees while constructing hydro-electric projects. At the time of starting nuclear plants at Bombay, it had no trees. It was a ravine land. Now it is flourishing with trees. Finally he stated that “we, nuclear scientists, are not enemies of the environment. Homi Bhabha was a lover of trees and had great concern for nature”.

**Effect of Kaiga on Fishery**

There will be no loss of fishery in the coast of Arabian sea by the establishment of the Kaiga project. The loss of fishery may occur when the water is contaminated or polluted due to radio-activity. In Kaiga project, however, water would be drawn from the river Kali, which is a small westward flowing river in the Western Ghats of Utter Kannada District, joining the Arabian sea at Sadashivagad near Karwar.
This river water is used only for the purpose of condenser cooling. The steam turbines, condenser and the associated equipment which form part of the conventional island, are identical to the equipment in the thermal power station and as such are not associated with radiocactivity. Therefore, there is no possibility of any release of radioactivity in the river by this route:

**Production of Electricity**

The first reactor was scheduled to be commissioned during June 1995 and the second was to be commissioned in December 1995. On completion, this power station will be connected to the Southern Regional Grid and the power will be distributed through the Karnataka State Electrical Grid. Karnataka state will be entitled to get 35 percent of the electricity produced by the Kaiga project. Out of the total 14,000 MW electricity produced, 30 percent will be reserved for the central government and the remaining 70 percent will be shared by Karnataka, Andhra Pradesh, Tamil Nadu and Kerala states. After the criticality of the project, it is estimated that electricity will be supplied in Karnataka at the rate of Rs. 0.95 paise per unit.

A comparative study of the investment per kilowatt and the cost of generation per kilowatt in typical hydro, thermal and nuclear stations in the country shows that the cost per kilowatt hours is 2.9 paise for hydro, 4.6 paise for coal based thermal and 5.8 paise for nuclear stations.
The nuclear stations operate at a higher plant factor and for a factor of 75 percent the cost gets reduced to 4.7 paise.\textsuperscript{34} This is cheaper than thermal power produced at coal based stations located far away from the collieries.

The demand for power is running far ahead of supply, although several huge projects have been constructed during the past two decades. The Kaiga nuclear power plant will supply power to the south Indian region, one of India's industrialised zones.

**Industries**

The entire Kaiga region has virtually no industries. Kaiga is extremely underdeveloped and isolated. After completion of Kaiga nuclear power project and Kadra hydro-electric power project, the area gets tremendous potential to develop tourism, fisheries and industries. The aim of this project is to generate more employment opportunities for the people.

There are some constraints in respect of promoting industries. Forest policy of the government, non-availability of raw-materials, lack of infrastructural facilities and poor transportation facilities have been the inherent bottlenecks in the district in general and the Kaiga project area in particular. These hamper industrial development.

However, taking into consideration the upcoming Kaiga and other public sector projects and based on discussions with local chamber of
commerce, leading persons in the district, medium and large-scale industrialists in the district, departmental officials - animal husbandry, PWD, agriculture, fisheries, atomic energy officials and public sector agencies - the potential products have been identified. Care has been taken in respect of position of the existing units, their performance, before similar product has been suggested. In order to develop the district after completion of Kaiga project, 36 new industries have been identified to be established in Uttar Kannada District.

After completion of the project, it is expected that a large number of people in the Uttar Kannada district will get a number of employment opportunities. Now, out of the 622 persons working there, 504 are from Karnataka. According to information collected in the next three years, 1300 people will get job opportunities and the local people will get preference. The establishment of Kaiga project will result in large scale electrification of villages, development of irrigation facilities, drinking water supply, employment opportunities and general improvement in quality of life of the local people.

**Safety measures**

The overall safety measures adopted in the Kaiga project based on the principles enunciated by the founders of the atomic energy programme are "Radioactive materials and sources of radiation should be handled not only in a manner which fully ensures that no harm can come to workers
in the establishment or anyone else but also in an exemplary manner so as to set a standard which other organisations in the country may be asked to emulate.\textsuperscript{35}

The design of the proposed Kaiga reactors incorporates a number of safety measures which supplement the natural safety measures offered by the site. It is known as defence-in-depth safety approach. Design and construction of all component system and structures associated with reactor safety follow the best applicable codes, standards, and practices. Factors influencing common cause failures are identified and corrective action taken in design.

Every stage in design, construction, commissioning and operation of the nuclear power plants takes into account aspects of safety and reliability. Well documented methods are adopted during procurement, quality assurance, erection and commissioning of systems.

A radiological safety programme is established by nuclear power plant to assure that exposure of persons to radiation due to plant activities is avoided where possible. This is kept As Low As Reasonably Achievable (ALARA) where unavoidable. Any such unavoidable radiation exposure of plant personnel and members of the public would be in conformity with the limits and guidelines established by Atomic Energy Regulatory Board (AERB).
Kaiga nuclear plant with heavy water type of reactors uses naturally occurring uranium as fuel. Natural Uranium is invariably accompanied by the danger of radiation. To prevent such danger all possible safety measures stipulated by AERB have been taken. There are two independent parts with automatic shut-down systems. One of them is a stand by. The shut-down of reactor occurs as soon as any unacceptable deviation in operating parameters occurs during the operation of the plant. Even under the most unlikely event of dual failure consisting of the shut-down systems and emergency core cooling, any release of radiation from the core of the reactor will be contained within the reactor building containment and not released into the environment.

There are five barriers of defense before the radioactivity can reach the environment. The first barrier against release of radioactivity is the uranium dioxide pellets and the second is zircaloy cladding of the fuel. They are in turn housed in zircaloy pressure tubes. Even if these barriers were to break, the reactor is contained inside two sealed concrete buildings forming double containment constituting the last two barriers. With these provisions, the escape of radioactivity into the environment is practically ruled out.36

The primary safety measure is to ensure that the probability of a serious release of fission products is negligibly small. For ensuring safety in the plant, systems have been separated into two categories: 1) Process
Barriers to release of Radioactivity

[Courtesy: Nuclear India]
system and 2) Special safety system which are designed to prevent failures of the process system or mitigate the consequence. Special safety systems are sufficiently separated and independent of process systems and also of each other, so that the likelihood of a cross linked failure will be less than that calculated for dual failure, i.e., simultaneous failure of process and safety systems.\textsuperscript{37} Further, to protect the plant against man made incidents such as fire, missiles, etc., that could affect process and safety related system at the same time, the two group systems are physically separated so that the incidence would not disable more than one of these groups.\textsuperscript{38}

Environment at Plant Site:

The early planners of nuclear energy development have shown foresight in improving the environment at the sites of all its installation. Tree plantation is given prime importance not only from an aesthetic point of view but also to reduce the impact on the environment due to the plant operation both during normal and accident conditions. Tree planting also minimises dust load, reduces heat radiation and improves microclimate around the nuclear power stations and laboratories which house sophisticated machinery and equipment. Kaiga site has a natural setting of greenery with trees around and this characteristic will be maintained and improved by the nuclear power plant.
To ensure safety of environment, limits are prescribed for radioactive discharge into the air and water body around the plant site. Bye-products like ash, oxides of nitrogen, carbon, sulphur, etc. are not generated in the nuclear power plant. Radioactive bye-products such as tritium which is an isotope of hydrogen, small amounts of iodine etc. are generated in the form of gas. The release of such gases is strictly controlled within the limits prescribed by the Atomic Energy Regulatory Board. These limits are well within the international standards and are in line with the recommendations of International Commission on Radiological Protection. Operation of nuclear power plant at Kaiga will not be a cause for pollution of air.

The impact of a nuclear power station on environment is as follows:

1. The impact due to acquisition of land needed to set up the plant, buildings and other support facilities.
2. The impact due to discharges into the environment which include radioactive material, conventional chemical pollutants, if any and thermal plumes.
3. The potential impact due to the unlikely event of an uncontrolled release from the plant reaching the public domain.

In order to control spread of radioactive contamination if it takes place, the plant areas are divided into the following four zones.
Zone 1. Contamination free zone
Zone 2. Normally free from contamination but occasional possibility of contamination exists.
Zone 3. Areas containing potential sources of contamination.
Zone 4. Areas containing sources of contamination.\textsuperscript{41}

To minimise the adverse impact on the environment the following measures are adopted:

a. The plant operations shall not interfere in any manner with utilisation of environmental resources in the area outside its control.
b. No deleterious effects either of an acute or chronic nature shall accrue from plant operations.
c. The ecological balance of life forms including humans shall not be disturbed.
d. The discharges of radioactive/non radioactive pollutants from the plant into the environment shall be at such levels and quantities that the resultant accumulation of the pollutants in any component of the environment including the life forms will not affect them in a manner detrimental to the eco system.\textsuperscript{42}

The Kaiga power plant has to comply with the provisions of a number of environmental and safety related Acts like:\textsuperscript{43}

10. And various other statutes pertaining to law and order, labour etc.

Waste Disposal:
Nuclear power plants in the course of operation produce solid, liquid and gaseous radioactive wastes. These wastes are classified as low, intermediate and high and are dealt with appropriately by suitable treatment. High level wastes are not expected in any significant quantities. The solid wastes are classified as non-compressible and compressible. Compressible wastes are reduced in volume by using balers (Hydraulic presses). All solid wastes are buried in the specially constructed tile holes, and combustible inactive wastes which are burnable are incinerated.

The radioactive liquid wastes are converted into solids to reduce their volume by mixing in cement. These are then kept in concrete lined drums and concrete trenches. Liquid with extremely low activity is allowed to be let out after it is treated and properly diluted to the extent of becoming potable before discharging to common body of river water.
The gaseous effluents are passed through pre filters and High Efficiency Particulate (HEPA) filters or combined charcoal and HEPA filters to ensure that no radioactive particulates are discharged. During normal operation, the discharges are only insignificantly a small fraction of the permissible discharge.

The waste burial grounds are located well above the water table. Bore holes are provided around the facility to monitor/detect any leak. The waste handling facilities are operated by trained staff. These are all subject to regulatory check and clearance.44

**Economics of Kaiga Nuclear Power:**

Nuclear power in India has been competitive with coal based thermal power right from the first station which commenced commercial operation at Tarapur in 1969. The atomic power stations in Rajasthan and at Madras are currently supplying power to their respective grids at a price which is competitive with the thermal stations. A committee setup by the Department of Atomic Energy in 1984, reported that:

Taking into account capital and operational costs for existing stations, nuclear power compares favourably with thermal power from stations at load centres. In the years to come, the studies indicate that the cost of nuclear power would be cheaper than from thermal stations even at pit head.45
An overall comparison of nuclear and thermal fuel cycle investment at 1983 prices covering mining, fuel preparation, transportation, and power production shows that contrary to general belief, the over-all capital investment for the nuclear option would be lower than that for thermal power involving transportation.

The cost of power at Tarapur, Kota and Madras is about 43, 48 and 49 paise per unit respectively in 1988 as against about 64, 76 and 62 paise for Wankbori (Gujarat), Kota (Rajastan) and Tuticorin (Tamil Nadu) thermal power stations respectively.\(^46\)

The cost of generation at Kaiga project which is expected to be commissioned by 1995, would be comparable with the thermal power plants likely to be commissioned around mid-nineties. The reactor life of the plant is taken as 25 years for the purpose of calculation of cost of power. The actual operating life of the plant with adequate maintenance could continue for a longer period. Extending duration of the life of the nuclear plant is under study. At the end of the usual life span, the plant is taken for decommissioning to dismantle and store its radioactive components safely and ultimately restore the ground area to its original condition.\(^47\)

The actual decommissioning costs are not available. In some countries it has been worked out in the range about 10 percent of the capital cost. In India, the unit energy price includes contribution towards a decommissioning fund which is expected to defray the cost of decommissioning of the stations.
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In the beginning we shape our technology, but if we are not careful in the end it will shape us. It is for the democratic process to operate to see that it does not do so in a way that damages our central rights and liberties. There is no issue more urgent than the democratic control of nuclear power.

Tonny Benn
(U.K. Energy Minister)
1974-79