



न्यूक्लियर पावर कॉर्पोरेशन ऑफ इंडिया लिमिटेड
Nuclear Power Corporation of India Limited

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(भारत सरकार का उद्यम)
**NUCLEAR POWER CORPORATION
OF INDIA LIMITED**
(A GOVT. OF INDIA ENTERPRISE)

WHY NUCLEAR POWER

Directorate of
Corporate Planning And Corporate Communication

WHY NUCLEAR POWER

Introduction

Lord Shri Krishna says in Bhagwat Geeta Chapter 3, Shloka No. 5,

न हि कश्चित्क्षणमपि जातु तिष्ठत्यकर्मकृता। कार्यते ह्यवशः कर्म सर्वः प्रकृतिजैर्गुणैः ॥

Which means that everyone is forced to act helplessly according to the qualities he has acquired from the modes of material nature; therefore, no one can refrain from doing something, not even for a moment. And every activity requires energy. Energy is at the heart of all processes in nature, including all human activities. And electricity is the most versatile form of energy. Electrical power offers great flexibility in its use and has truly revolutionized the world. The ancient man watched the electrical thunderbolts in the sky and feared this 'magical' force of nature, believing it to be caused by the fury of the Gods. Well, thanks to science, electricity is no longer a nature's mystery, nor is it something to be feared. It is indeed a friendly energy in the service of the mankind.

In today's world, power (generation of electricity and the per capita consumption) is an important measure, the Power of any country. It almost drives anything to everything in today's world. World without electricity is not imaginable.

The need for Power

Power drives the progress of a nation. It is a vital input to the socio-economic development of any nation. Power is essential for industrial and commercial growth as well as for daily needs of people, such as for lighting, mass transportation, education, communication, water supply, agriculture, businesses, industries, hospitals and healthcare services, to name a few.

Power contributes directly or indirectly to every aspect of our daily life. Greater availability of power improves the standards of living as well as helps in expanding employment opportunities, and thus leads to a stronger economy and prosperity for all.

Electricity is essential for:

Lighting

Agriculture

Industries and businesses

Mass Transportation

Education

Water supply

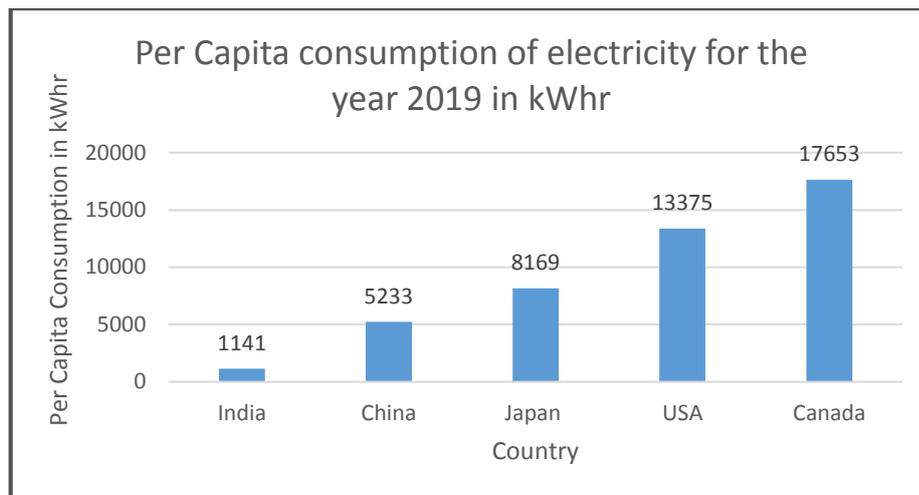
Hospital and Health Services

Better and expanded employment opportunities etc.

In fact, it is difficult to point out any area / work where requirement of electricity is not there. The modern day world has become so much dependent on electricity for everything.

Power Scenario in India

India, with its present population of about 138 crore people (as of December 2020), is the second-most populous country in the world and aspires for a better life. Indeed, faster growth in power generation is a vital key to achieving higher economic growth rates. India needs more electricity to drive progress by powering industry, agriculture, urban growth centres as well as rural areas. Greater power generation leads to greater opportunities for job creation through faster economic growth in the country. Higher economic growth rates bring greater prosperity.



(Source: data collected for the year 2019 (latest available data) from the website ourworldindata.org)

In order to embark on a rapid economic development trajectory of higher GDP growth on sustainable basis, the power-generation capacity addition in the country must also grow at matching speed.

India's population is huge and growing. Our nation's energy demands are growing fast, so we must speed up power generation in the country using all viable sources of energy. And in this regard, nuclear power, based on its unique merits, has a definitive role to play in the energy mix of the nation.

Means of Electricity Generation

Electricity is a form of energy and since we already know that energy can neither be created nor destroyed so it can only be converted from one form to the other. So in order to generate electrical energy (electricity), we convert one or the other form of energy such as heat, potential or kinetic energy etc. into electrical energy. Depending on the fuel used and the mode of generation of electricity, it can be through renewable or non-renewable sources.

The overall evaluation of an energy source is based not only on how clean it is; it also has to be **reliable**, **accessible** and **affordable**. To evaluate the options available, understanding fundamental facts about what type of energy are available and what trade-offs each presents is helpful.

Technology to utilize the forces of nature for doing work to supply human needs is as old as the first sailing ship. But attention swung away from the renewable resources as the industrial revolution progressed on the basis of the concentrated energy locked up in the fossil fuels. This was compounded by the increasing use of reticulated electricity based on fossil fuels and the importance of portable high density energy source for transport – the era of oil.

As the electricity demand escalated, with supply depending largely on fossil fuels plus some hydro power and then nuclear energy, concerns arose about the carbon dioxide emissions contributing to possible global warming. Attention again turned to huge sources of energy surging around us in nature – sun, wind and seas in particular. There was never any doubt about the magnitude of these, the challenge was always in harnessing them so as to meet demand.

Today we are well advanced in meeting that challenge, while also testing the practical limits of doing so from wind and solar. The relatively dilute nature of wind and solar mean that harnessing them is very material intensive – many times that from energy dense sources.

Wind turbines have developed greatly in the recent decades, solar photovoltaic technology is much more efficient, and there are improved prospects of harnessing the energy in tides and waves. Solar thermal technologies in particular (with some heat storage) have great potential in sunny climates. With the government encouragement to utilize wind and solar technologies, their costs have come down and are now in the same league per KWHr as the increased costs of fossil fuel technologies, especially with the likely carbon emission charges on electricity generation from them.

However, the variability of wind and solar power does not correspond with most demand, and as substantial capacity has been built in several countries in response to the government incentives, occasional massive output from these sources creates major problems in maintaining the reliability and economic viability of the whole system.

Energy Mix is the need of the hour (worldenergy.org)

The energy equation grows even more complex day by day. This complexity is not going to diminish by 2050. Working towards ensuring a sustainable mix is therefore a major challenge for the 21st century. Therefore, The energy system complexity increases. There are substantial system integration costs due to increased network expansion costs in both transmission and distribution systems, especially where a large proportion of renewables is involved.

There is no global solution to the energy supply issue. Reaching a solution involves solving each of the individual parts to reach the global goal of sustainable, affordable and secure energy supply for all. Critical uncertainties remain, especially regarding solar and the future development of energy storage technologies, that are scalable in economic terms. The individual governments of the countries play a crucial role in determining and establishing frameworks for markets to function. Industries and markets need to provide efficient solutions.

Brief about the various energy sources other than nuclear with their advantages and limitations:

1. FOSSIL FUELS – THE CONVENTIONAL ENERGY SOURCE

Fossil fuels formed over millions of years ago as dead plants and animals were subjected to extreme heat and pressure in the earth's crust. This natural process converted bones and other organic matter into carbon-rich substances that, when burned, generate heat. There are three main fossil fuels – Petroleum, Coal and Natural Gas.



Use of fossil fuel energy sources comes at a high, and often irreversible cost to the environment. Carbon emissions, or the amount of CO₂ these fuels release into the atmosphere, add up over generations and cannot be taken back. Moreover, there is only a finite amount of these resources on earth.

2. SOLAR ENERGY (solarmagazine.com)

Solar Energy has taken a lead in overall green energy sources. There are many advantages of solar energy. Among these are its increasing affordability. Adapting solar will take urgent action to combat climate change and its impacts. Panels once installed have long term warranty and low maintenance costs.

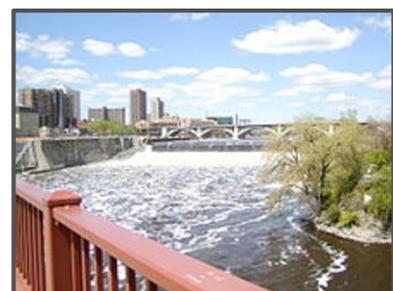


The limitations of solar include the large amount of space required which may not always be available, relatively higher investment and longer return on investment (ROI), the generation of power is dependent on weather. The solar cell production uses a number of toxic metals lead, gallium arsenide and cadmium. Also one very important limitation is that it is an intermittent source of power supply and cannot provide electricity 24 X 7.

3. HYDRO POWER

Hydro power is created when rapidly flowing water turns turbines inside a dam, generating electricity. It is a clean and a renewable source of energy. It does not pollute the air.

However, damming water to build reservoirs for hydropower flood valleys, disrupting local ecosystems and livelihoods. In tapping energy from hydro, large areas of human habitation and agricultural fields are submerged. Moreover, dams can be built only at selective locations where there are large water bodies. Fish population can be impacted if they do not migrate upstream of the dam. Moreover, in case of a draught in any year, the hydro power plants cannot produce electricity. They are dependent on the nature's water cycle. As is true with solar, same is the case with hydro power that it has a practical limitation of being an intermittent source of power supply.



4. WIND POWER

It is created when wind spins a turbine, or a windmill, which can be located on land or offshore. It is a renewable and a clean source of energy with low operating costs and efficient use of land space. But it is an intermittent source of power which depends on the flow of the wind and hence its efficiency is quite low.



Comparison of per unit cost of electricity to the consumer by different means of energy sources

The table below gives a comparison of the per unit cost of electricity generated from different sources

S. No.	Energy Source	Range of rate of Sale of Power min. to max. in paise/kWh for the year 2017 – 18
1.	Hydro	55 – 689
2.	Thermal-Gas	238 – 656
3.	Thermal – Coal	192 – 927
4.	Nuclear	205.83 – 409.04
5.	Solar	244*
6.	Wind	243*

Source: CEA Executive Summary Report for December, 2020.

* Record low tariffs for the year 2017. Range not available

Also comparing various other parameters as tabulated below for the major electricity generation sources in India, we have (* for the PHWR Fuel)

Source of Energy Generation	Submergence / Land Required (in hectares)	Fuel Required (in Te/year)	Emissions in (Te /year)	Waste / Ash Generation (in Te/year)
1000 MWe Hydel power plant	2000 – 5000	----	-----	-----
1000 MWe Nuclear Power Plant	20	120 * (12 trucks per year)	Negligible	< 1
1000 MWe Coal Fired Plant	70	26, 00,000 (5 train loads of 1400 Te each per day)	CO2: 70,00,000 SO2: 45,000 NOx: 20,000	12,00,000

Climate Change

Climate change is rapidly altering our world in profound ways. Human activity has already increased the earth's atmosphere by about 0.83°C over the past century and as the planet continues to warm, the dangers intensify. Climate change's effects are far-reaching and varied and touch virtually every aspect of life on the earth. Extreme heat events, melting of glaciers, rising sea levels, deeper droughts, desertification, bigger wildfires and more intense storms.

Since the Industrial Revolution, rising emissions of greenhouse gases including carbon dioxide, methane, nitrous oxide and others have been the driving force behind the climate change. Because the climate change poses an extraordinary threat to the planet, it needs to be counteracted. There are no clear-cut answers to this global challenge, but it is not insurmountable.

The Paris Agreement

On December 12, 2015 in Paris, 195 governments agreed to the text of the most significant global climate agreement in history. Known as the **Paris Agreement**, the international deal commits nearly every country in the world to lowering greenhouse gas emissions in an effort to curb the dangerous effects of climate change.

The Paris Agreement, which entered into force on November 4, 2016 aims to prevent global temperatures from rising above pre-industrial revolution temperatures by 2°C . Ideally, the Paris Agreement strives to limit the global temperature increases to 1.5°C , as the scientists caution that the effects of temperatures rising any higher would be catastrophic and potentially irreversible. The global annual temperature has increased at an average rate of 0.07°C per decade since 1880 and over twice that rate i.e. 0.18°C since 1981.



Nuclear Power and its distinct advantages

Compelling Merits of Nuclear Power

Nuclear Power has huge potential, is a high energy intensity fuel, and requires less land per MW compared to other base load (the electricity technologies which supply power on continuous basis, 24X7) like thermal power plants.

Nuclear power is a clean and green source of electricity which does not emit greenhouse gases like Carbon-dioxide, oxides of Nitrogen. Further, it generates very small quantity of radio-active waste that is manageable. This clean source of energy has potential to provide the country long term energy security and is sustainable.

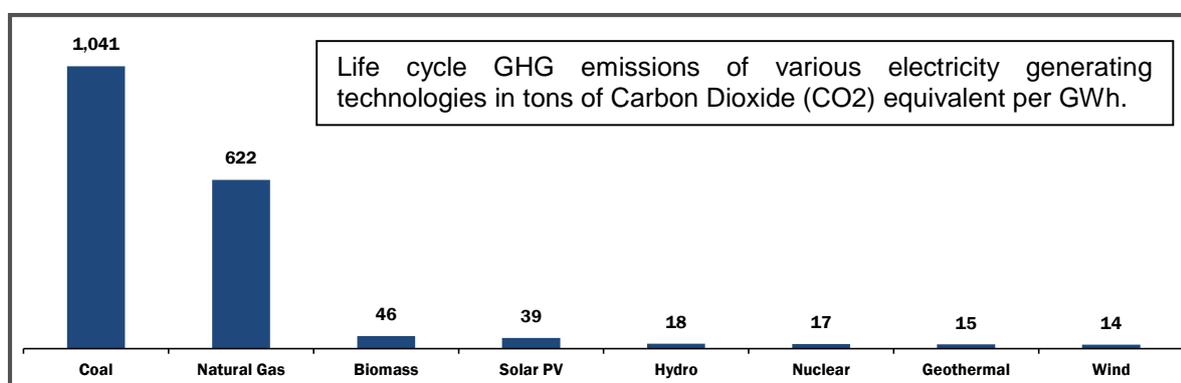


WHY NUCLEAR POWER

Nuclear power is a High Energy Density Source

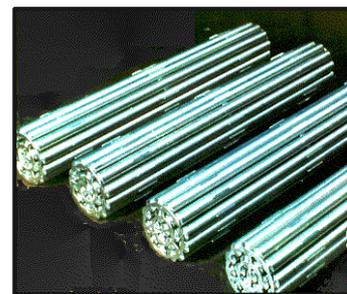
In a nuclear power plant (NPP), energy (heat) is generated by fission (splitting) of Uranium atoms. In thermal power plants, heat is generated by chemical combustion of Coal/Oil/ Gas (Carbon). The energy generated by splitting a single uranium atom is a million times more than that generated by burning of a carbon atom.

Nuclear power plants have no greenhouse gas emissions and are clean. The lifecycle Greenhouse Gas (GHG) emissions of nuclear power plants are comparable to those of renewable like Hydro & Wind. Deployment of Nuclear Power to produce electricity avoids emission of Carbon dioxides, thus help in decarbonisation of environment. A 1000 MW nuclear power plant thus saves about 6-8 million tons of CO₂ emissions annually. Figure below shows the life cycle GHG emissions of various electricity generating technologies in tons of Carbon Dioxide (CO₂) equivalent per GWh.



Nuclear Fuel

Nuclear fuel is an intense energy source, and very small quantities of fuel are required to fuel a large power plant. For instance, the annual fuel requirement of a 1000 MW nuclear power plant (PHWR type) would be about 120 tons of uranium (about 12 truckloads per year) and for a LWR type NPP, only about 30 tons of enriched uranium (about 3 truckloads per year), as against 2 to 3 million tons of coal (about 5 to 6 trainloads of 1400 Te each per day) for thermal power plant of similar capacity. The latter puts immense pressure on rail, port and other infrastructure, apart from the emissions arising out of transporting such large quantities of coal and the resulting environmental impact.



Nuclear Power: Proven safe

The commitment to safety is amply reflected in India's impeccable nuclear safety track record over the years. In fact, in the entire history of 51 years of nuclear power generation in India, there has not been a single unsafe accident in any of the nuclear power plants affecting local population.

Safety: The Highest Priority at Every Stage

'Safety First, Environment Foremost' is NPCIL's motto and it reflects the design philosophy and safety culture at our nuclear power plants.

Safety is a top-most priority at every stage of design, setting up and operation of a nuclear power plant, with the objective of ensuring safety of members of the public, occupational workers, as well as protection of the environment.

Nuclear Power is reliable

Nuclear Power Plants are sources of continuous, reliable, large scale and round the clock electricity. It is not subject to changing weather or climate conditions. Nuclear Power Plants maintain high availability and capacity factors. In India, various operating units have recorded continuous operation of more than a year several times.

Nuclear Power is economical

Nuclear power is cost competitive with other forms of electricity generation. Also, in case of nuclear power, decommissioning and waste management costs are internalised in tariff, whereas in case of fossil fuel base power plants, impact of CO₂ emission is not internalised in the tariff. NPCIL's average tariff of nuclear power generation during the year 2019-20 was about Rs. 3.38/KWh.

Huge potential

Nuclear power has a huge potential and can ensure long term energy security of the country in a sustainable manner by utilizing the vast indigenous thorium resources for large scale electricity generation for centuries.

A Holistic Approach to Nuclear Safety

Well-defined principles of defence-in-depth, redundancy and diversity are adopted to provide multilevel safety in the design of the nuclear power plant. Also, a detailed probabilistic safety analysis postulating a whole spectrum of challenging and adverse conditions is carried out and safety of the design demonstrated.

Safety criteria are defined for every stage – right from site selection to construction, assembly, commissioning, operation and maintenance, waste management, and decommissioning. Nuclear equipment and components are made to the highest and most exacting standards. This ensures uncompromising safety even under severely stressful circumstances. These high standards are indeed the hallmark of nuclear industry.

Trained and Certified Personnel

The operation of a nuclear power plants is carried out strictly in accordance with procedures defined and approved by the regulatory authorities, with safety limits defined for various system parameters, which are never exceeded. The reactors are operated by highly trained manpower, licensed by the regulatory body. Key operating personnel are trained on simulators to handle all possible situations during operation.

Indeed, safety is firmly rooted in the work culture at nuclear power plants.

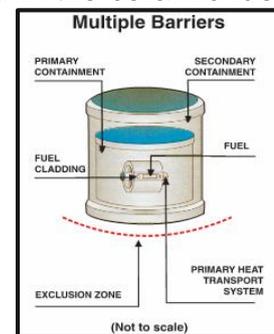
Defence-in-Depth: Multilevel Safety

A defence-in-depth approach is adopted to provide **successive barriers** and multilevel safety systems. **Principles of redundancy and diversity** are employed to ensure **multilevel safety** that is effective even under severely stressful conditions.

Our state-of-the-art nuclear reactors have **overlapping safety systems with active as well as passive features**. Passive safety systems add a new dimension to safety, as these are based on the **unfailing natural principles** such as gravity, inertia/conservation of momentum, pressure differential, convection, etc.

The following successive physical barriers contain radioactivity and fission products within the reactor.

1. **Fuel matrix:** Fission products are formed and retained within the ceramic fuel pallets.
2. **Fuel Sheath:** Fuel pallets are enclosed within a special metal-alloy fuel sheath
3. **Heat transport system** contained in piping
4. **Primary containment** and **Secondary containment** made up of thick high-strength concrete walls enclose the reactor core and reactor internals
5. **Nuclear Island:** The plant premises, also called 'nuclear island' is isolated from population
6. **Exclusion zone** around the plant (described in more detail in the 'Safety of Local Populations' section)

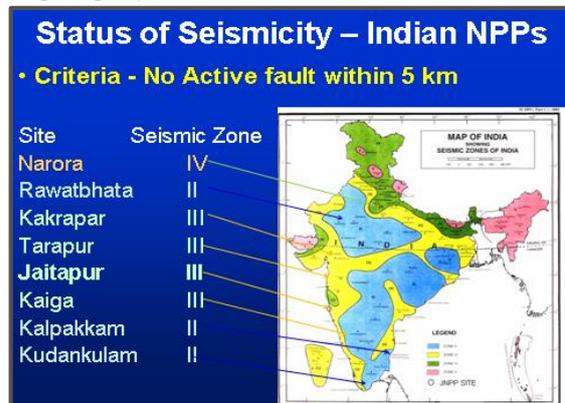


Protection against Natural and External Events

Protection against Earthquakes

Nuclear power plants are set up in geographic locations that have low 'earthquake' potential. The landmass of India is categorized into four 'Seismic Zones' – I to IV – that are defined from the point of view of seismicity (that is, the potential for earthquake activity). The image below shows Indian nuclear power plants and the respective seismic zones in which they are located.

Nuclear power plants are seismically qualified and are designed to withstand even the severest of earthquakes, with ample of safety margins.



Indeed, for many years now, all the nuclear power plants in India have safely withstood earthquakes. For example, Kakrapar Atomic Power Station (KAPS) continued to operate safely during the 7.7-Richter Bhuj earthquake of 2001. Also, in the case of 2004 Indian Ocean tsunami, Madras Atomic Power Station (MAPS) was

ought to a safe shutdown state without any damage to the plant or involving any lease of radioactivity and it was restarted within 6 days.

Protection against Tsunamis

Tsunamis occur as a result of high-intensity undersea earthquakes. The energy of the ground motion is carried by the sea waves, which can reach the shores with a wave height of several meters.

Indian nuclear power plants are designed to provide adequate safety against tsunamis and are located at safe levels of height to avoid flooding. There are also additional provisions like leak-tight doors with gaskets to prevent water ingress. Shore protection measures are provided to prevent erosion and to reduce impact of the waves, both during normal sea conditions and during events like storms, tsunamis etc. These include civil structures like bunds, break waters, walls etc.

Protection Against Man-made External Events

Nuclear power plants are also designed taking into account external hazards. The thick concrete double-containment around the core, for example, is designed to withstand a light aircraft impact. There are provisions for withstanding other external effects such as fire, shock waves etc.



Safety of Local Populations

Nuclear safety is a comprehensive approach that extends beyond the plant itself to ensure protection of the neighbourhoods.

An '**Exclusion Zone**' surrounding the plant is also provided as a part of 'defence-in-depth' philosophy to ensure that the radiation release remains well below the acceptable levels for dose to public during normal and abnormal operating conditions. An exclusion zone of 1.6-kilometers radius surrounds the plant. This distance has been further reduced to 1 km in the new plants based on the experience gained in the case of operating plants. No human habitation is allowed within the exclusion zone. The area within 5-km radius from the centre of nuclear power plant is called **Natural Growth Zone**. In this zone, normal growth of population and development of the area is permitted but no immigration of public or industry is allowed.

Land Requirement

Land requirement for setting up nuclear power plants (per MW) is among the lowest of the contemporary electricity generating technologies. Coal power plants require additional land for coal and ash handling facilities and for hydro it involves submergence of significant amount of land. Renewable like solar and wind require large land area.

Nuclear Power Enriches its Surroundings, thus facilitates prospering of Flora and Fauna

About 20% to 30% of the land acquired for setting up nuclear power plants is used for locating plant buildings and facilities. *The remaining land is acquired for establishing an 'exclusion zone' around the plant. This is maintained in its pristine form and further enriched by establishing a green belt of endemic species.* This attracts a lot of native and migratory birds, animals and other forms of life and a unique natural ecosystem flourishes around nuclear power plants.

Scientific Studies have established that there is no Impact from NPP operation on marine and aquatic environment

Nuclear power plants are similar to thermal power plants as they use cooling water for condensing steam. The condenser cooling systems of nuclear power plants are designed to meet the stipulation of the Ministry of Environment, Forests and Climate Change (MoEFCC) norms in this regard. Further, thermal ecology studies carried out by expert agencies at nuclear power plants have shown that there is no adverse impact on the fish and other aquatic species. This can also be evidenced by the abundant fish catch near nuclear power stations like Kalpakkam, Tarapur etc.

The radioactivity releases to the environment from nuclear power plants are well within the limits stipulated by the Atomic Energy Regulatory Board. As a matter of fact, the actual releases of effluents as monitored over several years are less than 2% of the stipulated regulatory limits.

Waste Generation

India follows a closed fuel cycle policy where the spent (used) fuel is not treated as waste but is reprocessed to obtain fuel for the next stage of the nuclear power programme. This minimises the waste generation.

At the nuclear power plants, the wastes generated are of low and intermediate radioactivity level. These constitute filters, resins, washes of laboratories, exhaust air from active areas etc. These are appropriately treated, concentrated, immobilized in inert substances like cement or polymers and stored in specially designed structures at the site with constant monitoring. The activity level of these wastes reduces to natural background levels over a few tens of years.

The high level wastes generated during reprocessing of spent fuel are very small in quantity. The rest (over 95%) is useful resource material recovered from reprocessing. The radioactive wastes generated during reprocessing is immobilised in glass matrices by a process of vitrification, sealed in double walled containers and stored in specially designed facilities under constant monitoring.



Nuclear Waste

The **volume of waste generated in a day** for supplying electricity to a metro city like Mumbai or Delhi would be **just 6 kg = about 2 bricks**

The regular environment surveillance of the area around these facilities has concluded over several years that there is no difference in environmental condition before and after storage of immobilised waste.

A comparison of the wastes generated by a coal fired plant and nuclear power plant of 1000 MW in a year is given below:

Coal Power Plant	Nuclear Power Plant
Ash 12,00,000 tonnes	High level - 3 Cubic Metre after reprocessing and vitrification
CO ₂ 7 Million tonnes	Intermediate level - 310 tonnes
SO ₂ 45,000 tonnes	Low level - 460 tonnes
NO ₂ 20,000 tonnes	

The radioactivity level of the stored waste reduces with time and by the end of the plant life, falls to normal levels. All Indian nuclear power plants have fully developed technology to manage spent fuel effectively and store it safely.

Wealth from Waste

India is pursuing the 3-stage nuclear power programme, a closed fuel-cycle policy, involving fuel reprocessing.

In fact, the waste generated in a nuclear power plant is really not 'waste' and is called 'spent fuel.' This spent fuel contains in it freshly formed fuel, which is valuable. Reprocessing of spent fuel is done later to recover this 'new' fuel to be used in reactors in the next stage.

Environmental Monitoring

A comprehensive Environmental Impact Assessment (EIA) of the nuclear power plant is carried out in accordance with the MoEF notification before setting up of nuclear power plants and work on any nuclear power project is taken only after receipt of Environmental Clearance from the MoEF. All stipulations laid down in the environmental clearance are implemented rigorously.

In addition, for monitoring of radioactivity in the environment, an independent Environmental Survey Laboratory (ESL) is set up at the site before start of operation of the site. The ESL monitors environmental matrices like air, water, soil, vegetation, crops, fish, meat in an area of 30 km radius around the plant for radioactivity. It first establishes the natural background radioactivity before the start of the operation of the plant for comparison with the data after start of operation of the plant.

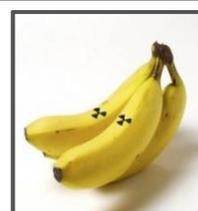
The data collected over 51 years around Indian nuclear power plants has shown that there is no significant rise in radioactivity level, when compared to the natural background established before start of operation of nuclear power plants.

Radiation & Health

Radiation Facts

Radiation – Our Constant Companion

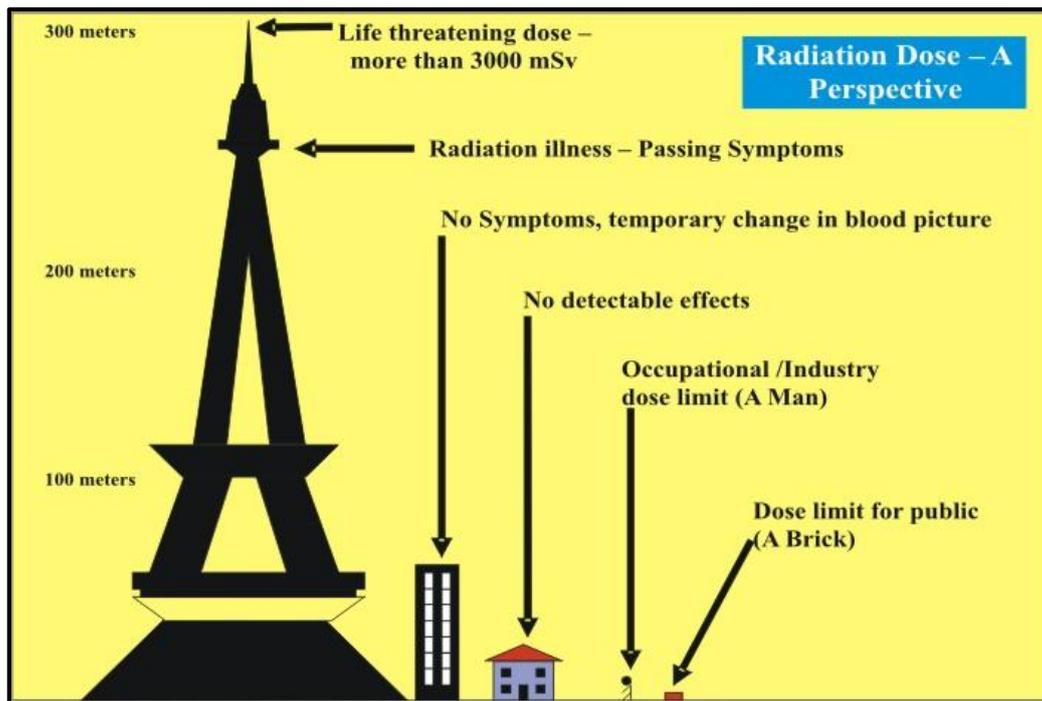
- Radiation is present in nature everywhere and at all times.
- The sun is a source of radiation.
- Earth's crust (the earth's topmost layer containing rocks and soil) contains naturally radioactive elements, which emit radiation constantly. All of us are exposed to this natural radiation all the time – day and night.
- Apart from earth's soil and rocks, we also receive radiation from the space.
- The houses in which we live, the air we breathe, the water we drink, and the food we eat are all sources of continuous natural radiation.
- Also, everyone on our planet is exposed to radioactive radon gas released as a result of the natural radioactive decay of radium. Radium, in turn, is a natural decay product of uranium and thorium present in the earth's crust. Even inside our homes, we are exposed to radioisotopes of radon gas (Rn-222 and Rn-220) emitted by house walls. This natural radon exposure is unavoidable, since the radon gas enters our body through the process of breathing air. Indeed, radon exposure is the largest source of natural radiation doses received by humans.
- The constant radiation present everywhere in nature is called the 'natural background radiation,' or simply 'background radiation'.
- Radiation emitted from a nuclear power plant is negligible and indeed much less than the natural background radiation, and it doesn't have any adverse effect.
- In some regions of the world, the natural background radiation levels are very high. Even in such areas, there have been no adverse health effects observed.
- Even a single medical chest X-ray delivers far more radiation than a nuclear power plant in a span of one year.



Eating one banana daily for one year gives more dose than living for full one year near a nuclear power plant.



**A single medical chest X-ray
=
Living for around 20 years near
a nuclear power plant**



As you can see in the above 'comparative' illustration, the dose levels for the public are extremely small and safe. The actual doses for Indian nuclear power plants are not only insignificant, but also lower than the prescribed limits. This means living near a nuclear power plant is absolutely safe.

We are continuously bathed in radiation from natural sources like the sun, space, rocks, soil and even the food we eat. The radiation dose, a measure of effect of radiation, from natural background varies from place to place depending on the location, soil etc. The average background is 2400 micro-Sievert per year (Units of Radiation). The radiation dose at boundary of nuclear power plants (over natural background) is found to be 1 to 26 micro-Sievert per year, which is an insignificant fraction of the natural background and within the variations in natural background.

The additional radiation dose (beyond natural background) received by a person staying on 24X7 basis for a year at the boundary of nuclear power plant would be that received from eating a banana (that contains naturally radioactive isotope potassium-40) a day! Further, the radiation doses from medical procedures like X Rays, CT scans, and even long-distance air travel, are many times higher.

Epidemiological surveys for health assessment in respect of employees working in close proximity to radiation and their families at each of the operating nuclear power plants have been carried out.

Nearby villages have also been covered in the studies to the extent of employees and their families residing there. The studies have established that there has not been any rise in cancer incidence/mortality, birth defects or any other ailments among the employees, who work or live in close proximity of nuclear power plants, in comparison to the national average.

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The scientific data from annual medical examinations collated and analysed by NPCIL, during 1995 to 2010 (16 years) has found that the cancer prevalence among the employees is lower at 54.05 per lakh population, compared to national prevalence of 98.05 per lakh population.

Livelihood

Nuclear power plants do not affect the traditional means of livelihood like agriculture, horticulture, fishing etc. Crops abound field around Narora and orchards around Tarapur site. The fish catch around Tarapur, Kalpakkam and other coastal sites has remained as it was earlier and has not reduced.

In addition, nuclear power plants have brought in economic prosperity, bringing opening new vistas for employment and business opportunities.

Nuclear power is thus environment-friendly in all respects.

Nuclear Power in India

Presently, NPCIL operates 22 reactors with an installed capacity of 6780 MW. In addition, KAPP-3 (700 MW) attained criticality on July 22, 2020 and was synchronized to the grid on January 10, 2021. It will start commercial operation soon.

The nuclear power reactors under construction are as follows:

State	Location	Project	Capacity (MW)	Type
Gujarat	Kakrapar	KAPP-3&4	2 x 700	PHWR
Rajasthan	Rawatbhata	RAPP-7&8	2 X 700	PHWR
Haryana	Gorakhpur	GHAVP-1&2	2 X 700	PHWR
Tamil Nadu	Kudankulam	KKNPP– 3&4	2 X 1000	LWR
Tamil Nadu	Kudankulam	KKNPP– 5&6	2 X 1000	LWR
Total			8200	

PHWR – Pressurized Heavy Water Reactor: LWR – Light Water Reactor.

In addition to this, the Government has accorded administrative approval and financial sanction for setting up 10 more indigenous Pressurised Heavy Water Reactor (PHWR) units are to be set up in fleet mode with a total capacity of 7000 MW. The details are as given below:

WHY NUCLEAR POWER

State	Location	Project	Capacity(MW)	Type
Madhya Pradesh	Chutka	CMAPP - 1&2	2 X 700	PHWR
Karnataka	Kaiga	KGS - 5&6	2 X 700	PHWR
Rajasthan	Mahi	MBRAPP-1&2	2 X 700	PHWR
	Banswara	MBRAPP-3&4	2 X 700	PHWR
Haryana	Gorakhpur	GHAVP - 3&4	2 X 700	PHWR
Total			7000	

PHWR – Pressurized Heavy Water Reactor: LWR – Light Water Reactor

The Government has also accorded 'In-Principle' approval of the following sites for setting up nuclear power reactors in future:

State	Location	Site	Capacity (MW)	Type
Maharashtra	Jaitapur	JNPP, Units- 1 to 6	6 x 1650	LWR
Andhra Pradesh	Kovvada	Kovvada, Units- 1 to 6	6 x 1208	LWR
Gujarat	Chhaya Mithi Viridi	Chhaya Mithi Viridi, Units - 1 to 6	6 x 1000*	LWR
West Bengal	Haripur	Haripur, Units – 1 to 6	6 x 1000*	LWR
Madhya Pradesh	Bhimpur	Bhimpur, Units- 1 to 4	4 X 700	PHWR

*Nominal Capacity, PHWR – Pressurized Heavy Water Reactor: LWR – Light Water Reactor

Pre-project activities at new sites, for which 'in principle' approval by the Government of India exists, have been initiated so as to enable early launch of projects at these sites. In the short term, the existing nuclear power capacity of 6780 MW is proposed to be increased to 22480 MW by 2031 on progressive completion of projects under construction and accorded sanction.

Long Term Nuclear Power Program of the country

India's long-term nuclear power programme is based on the potential to utilize the vast indigenous thorium resources for large-scale electricity generation for centuries.

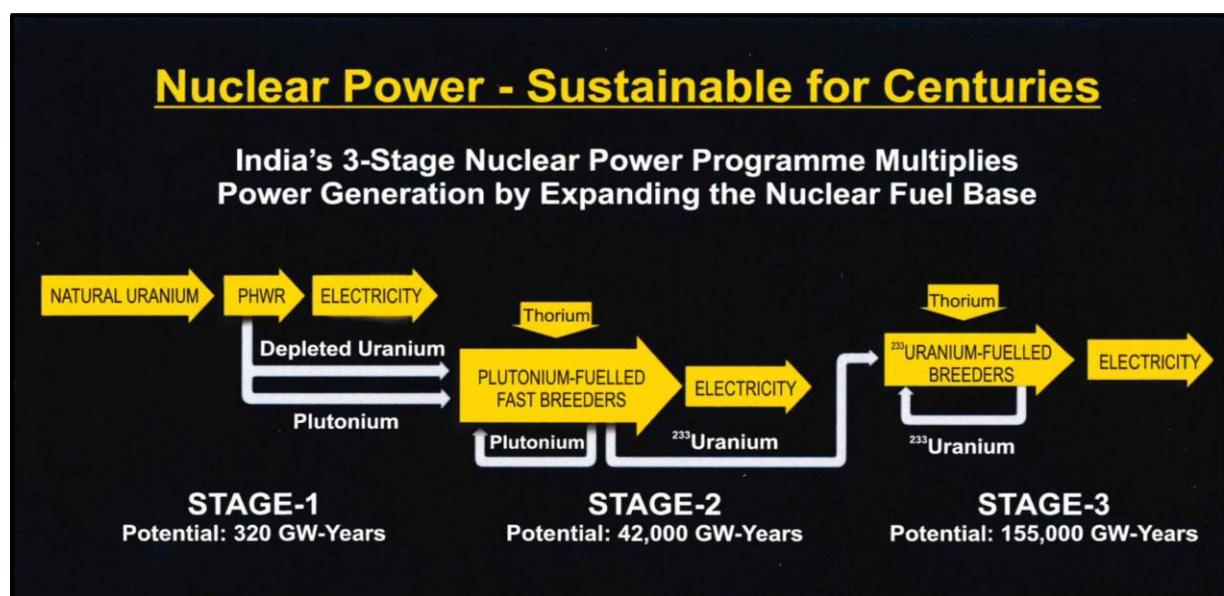
WHY NUCLEAR POWER

India's modest uranium resources can support a first-stage programme of over 10,000 MW based on Pressurised Heavy Water Reactors (PHWRs) for next around 35 years using natural uranium as fuel and heavy water as moderator and coolant. The energy potential of natural uranium can be increased to about 3,00,000 MW in the second stage of the programme in the coming years through Fast Breeder Reactors (FBRs), utilizing depleted uranium and plutonium obtained from the recycled spent fuel of the first stage along with thorium as blanket, to produce U-233. With the deployment of thorium in the third-stage Breeder Reactors (BRs), using U-233 as fuel, the energy potential for electricity generation is substantially large and sustainable for centuries.

Indigenous industrial infrastructure for reactor programme is well developed. Special infrastructure for the production of fuel, heavy water, reactor control and instrumentation have been developed within the Department of Atomic Energy (DAE). Indian industry has gained valuable experience and reached a stage of maturity in manufacturing equipment, components and handling of mega package contracts for these reactors.

Indian Three Stage Nuclear Power Programme			
	Fuel	Type of Reactor	Energy Potential (GW-Yrs)
1 st Stage	U-235 (Nat U, Low Enriched U)	PHWR*	320
2 nd Stage	Pu-239	FBR	42,000
3 rd Stage	U-233	BR	155,000

*Light Water Reactors (LWRs) are additional for nuclear power capacity expansion.



Nuclear Power around the world

Nuclear power is the second largest source of low-carbon electricity in the world and the first among OECD countries. At the end of 2021, there were 440 operable reactors in 31 nations, about 50 new reactors under construction (including five new construction starts), and six new units came online. Notably, Belarus, Turkey and the UAE are newcomers to nuclear energy.

There are a few countries, including Germany, Belgium and Spain, that are contemplating the permanent shutdown of their existing fleet but on the other hand we have a very large number of countries, not only in Europe but all over the world, that are actually trying to expand nuclear, for example, eastern European countries, and some of them for the first time, such as Poland. Also, the UK, France, Finland and the Netherlands are putting a strong focus on continuing nuclear.

Entrenched Opposition

If you care about the environment and if you have questions, learn, go and be inquisitive, find the truth rather than what's in a headline. Look at what nuclear energy has been doing and what it can do in the future. By 2050, if we don't max out on getting to net zero, we will lose 99% of the world's coral reefs, all of the polar ice caps, and God knows what's going to happen to the coastal areas of most of the world, and we will have devastation of a catastrophic planetary dimension. Nuclear power is safe. In terms of deaths per watt generated, it is among the safest in the world. If we care about saving the planet, let's get nuclear right; let's not throw it out the window. The choice to use nuclear energy must remain a decision for every individual country, but it would be "irresponsible" to deprive future generations of that choice. We can't close the door to this technology just because of the opinions we have right now. The key to sustainable development is energy and electricity. As we try to get people all over the world out of poverty and into the middle class, then having abundant and clean electricity that does not affect the environment is key. Nuclear has to be part of that.

Conclusion

The nuclear fuel is a very high energy-intensity source and consequently a few truck loads per annum per plant will suffice. Nuclear power plants do not produce greenhouse gas emissions during operation, and over the course of its lifecycle, nuclear produces the same amount of carbon-dioxide equivalent emissions per unit of electricity as wind and one-third of the emissions per unit of electricity when compared with solar. Hence, the nuclear power generation does not lead to GHG emissions, generates considerably low volume of waste that can be safely stored and does not affect the marine/aquatic and other natural environment. The establishment of nuclear power plant (NPP) requires much less land. The exclusion zone land areas around the NPP have become a warehouse of rich flora and fauna, since a sound natural ecosystem flourishes (with native and migratory birds, and endemic species) around NPPs.

Environmental monitoring practices have been instituted prior to setting up facilities (to collect baseline data of pre-project period), as well as during regular operations. No significant difference has been found due to NPP operations; e.g. no increase in background radioactivity level was found in the data collected around NPPs over 52 years.

The radioactivity releases from the NPPs are only about 2% of the prescribed limit for emissions (which in itself has already a large safety margin in-built) and they also fall well within the range of the variations in the natural background radiation in different parts of our country. The health survey of staff of NPPs (and of other staff working close to radiation) as well as representatives of public living in areas nearby NPPs has shown that there is no increase in cancer or birth defects or other ailments, compared to national average.

Nuclear power is thus a clean and sustainable source of electricity and it has the potential to provide our country long-term energy security.

The Road Ahead.....

We have different technologies now. The Gen III reactors that were designed and built over the past 20 years are now operating. And something the nuclear industry has shown is that, once you have a nuclear reactor, the costs go down, the standardisation increases, and so you can replicate what you've done before and with success. Now at a global level we also have **small modular reactors** that are slowly being developed and which are promising to be cheaper, safer, better, and that's going to provide more discrete financial solutions for [units] that are going to be built in series. Also advanced stage research and demonstration work is going on in the field of **Enhanced Accident Tolerant Fuels** which are much more resilient in case of accidents. The fast breeder reactors are also in the pipeline and the fusion nuclear reactor technology promises a bright future and the road to harnessing nuclear fusion energy is not very distant.

Nuclear Power Plants & Sites in India



Capacity In Operation (6780 MW)
 Capacity Under Construction (8200 MW)
 *Out of these units, RAPS-1 (100 MW) is owned by the DAE and managed by NPCIL

- Plants Under Operation
- ▲ Plants Under Construction
- ◆ Sanctioned New Projects Under Pre-Project Activities
- Sanctioned Sites
- # Nominal Capacity

Turning towards cleaner energy sources means factoring in economic and energy needs alongside environmental ones.



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