International Atomic Energy Agency
(1957)
Safeguard from Nuclear Weapons

Non-Proliferation Treaty
(NPT)
1968

Comprehensive Nuclear Test Ban Treaty
(CTBT)
1996

Only five countries as weapon states

China, France, Russian Federation, United Kingdom and United States

Bans all nuclear explosions in all environments, for military or civilian purposes.

If India Sign NPT :
-It has to become a Non-Nuclear Weapon State
- It's kind of discrimination
- It is threat to India's Security

India refused to sign CTBT
-India finds CTBT a threat to national security
- No time-bound disarmament schedule for nuclear weapon states
- **Does** not ban other activities related to nuclear weapons, such as sub-critical (non-nuclear explosive) experiments, or computer simulations.

India as de facto Nuclear Weapon State under NPT

US Legislation for Nuclear trade with India
December 2006

Nuclear Cooperation Agreement
July 2007

Nuclear Suppliers Group (NSG)
Exempted India from rule of prohibiting trade with non members of the NPT
September 2008

Bilateral trade agreement with US Congress and Russia and France

Civil nuclear Trade with US
Nuclear trade agreement with France.
October 2008

Safeguards agreement along with additional protocol with IAEA
2009

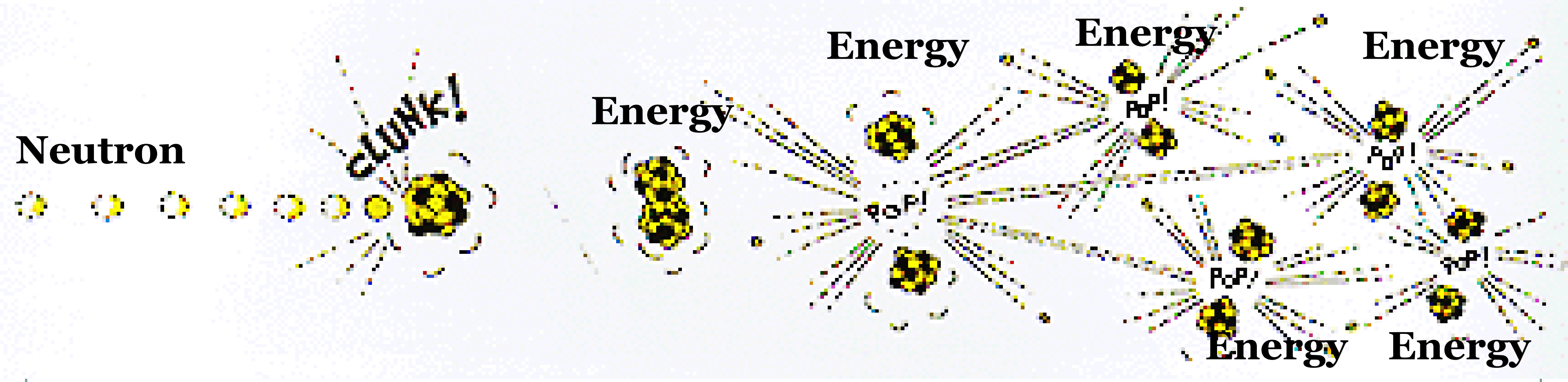
Ratification was announced under the new government June 2014

THREE STAGE PROGRAM

	STAGE - 1	STAGE - 2	STAGE - 3
	Pressurised Heavy Reactor	Fast Breed Reactor	Thorium Based Reactor
Input:	Natural Uranium U-238	Processed Plutomium-239 + Mixed Oxide Fuel (u-238)	Th-232 + U-233 U-233 (transmuted p-239)
By Product:	Plutonium - 239	Plutonium - 239	Self sustaining Stage
Misc:		In this stage reactor will give more plutonium 239 than it will take as input. Hence the name Fast Breeder Reactor.	AKA Thermal Breeder Reactor, which in princile can be sustained by supplying thorium.

Uranium

Radio-Active element used to produce huge amount of Energy through Chain Reaction triggered by bombardment of Neutrons

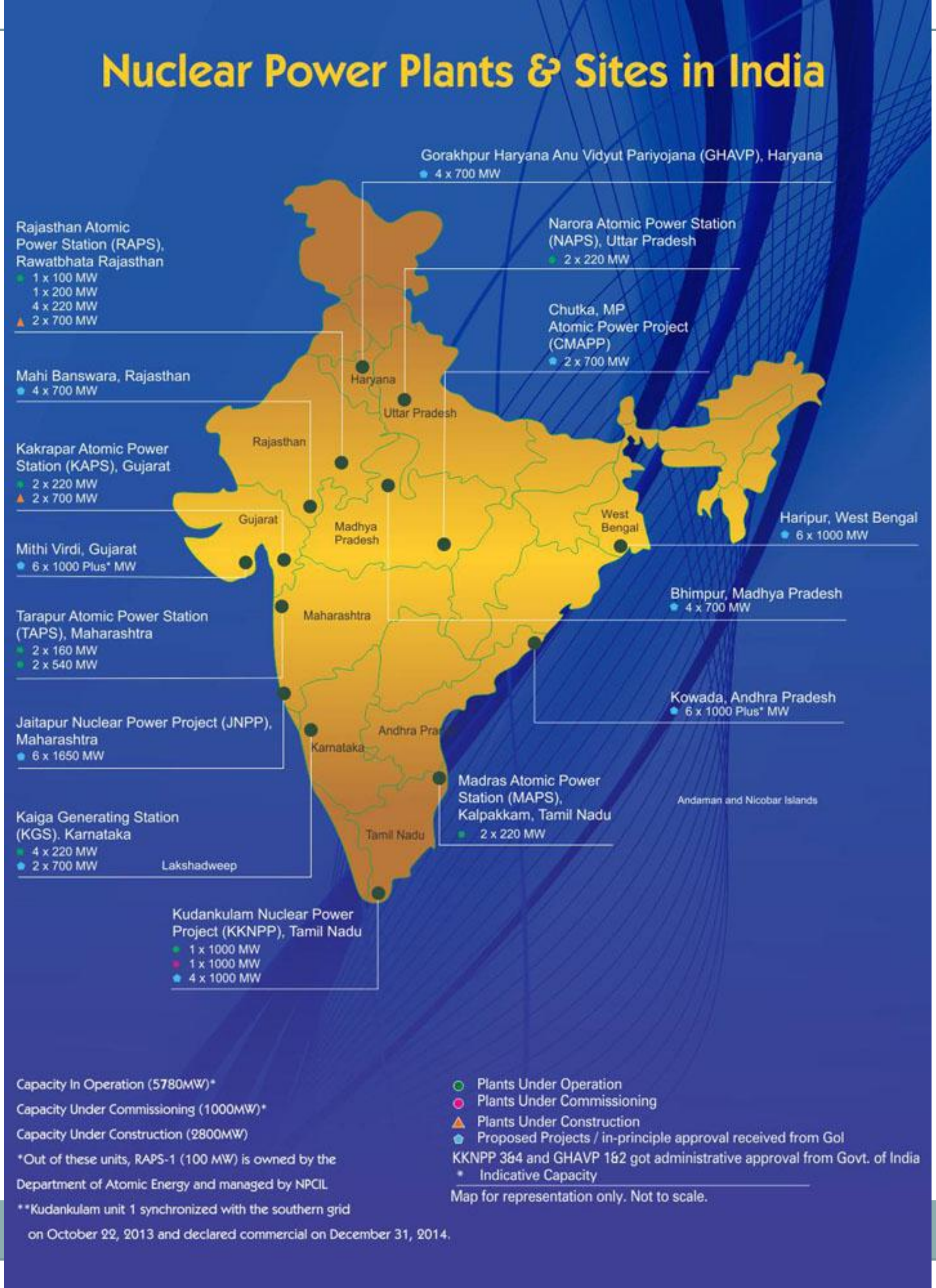


Chain Reaction

Nuclear Plants in India

Operational7 Plants with 22 Units

Total Capacity: 6780 MWe



Present Nuclear Power Status

Total Nuclear Power Plant Capacity : 6780 MWe

Year	Gross Generation (Million Units)
2017-18 (Upto August - 2017)	14380
2016-17	37674
2015-16	37456
2014-15	37835
2013-14	35333
2012-13	32863
2011-12	32455
2010-11	26472

India has a flourishing and largely indigenous nuclear power programme and expects to have 14.6 GWe nuclear capacity on line by 2024 and 30 GWe by 2032. It aims to supply 25% of electricity from nuclear power by 2050.

Plant under Construction

RAJASTHAN ATOMIC POWER PROJECT	2 x 700 (Mwe)
KAKRAPAR ATOMIC POWER PROJECT	2 x 700 (Mwe)

Uranium and Throium in India

Majority of these resources occur in following 5 Uranium provinces.

(i) Cuddapah uranium province

(ii) Singhbhum uranium province

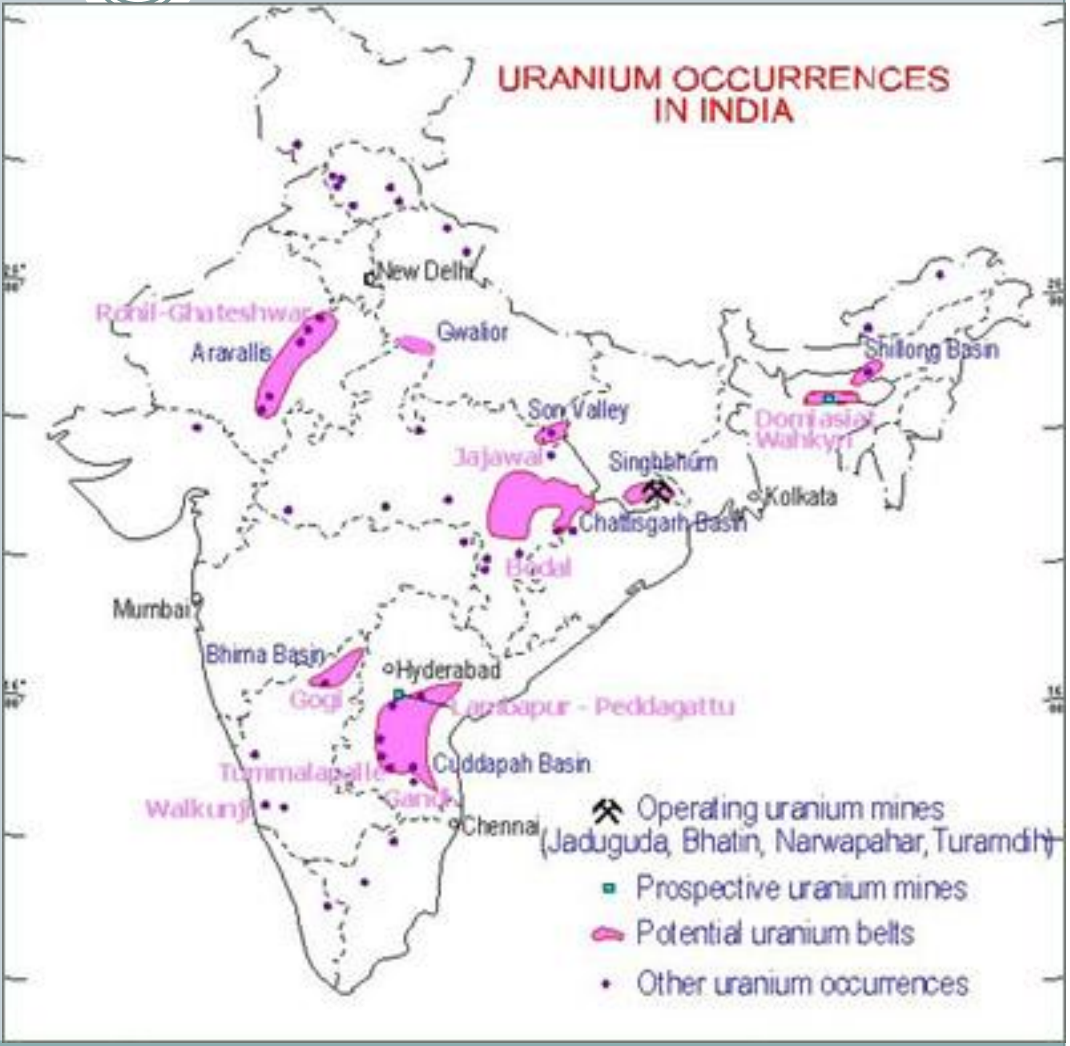
(iii) Mahadek uranium province

(iv)Albitite belt of Rajasthan and Haryana

(v) Bhima basin

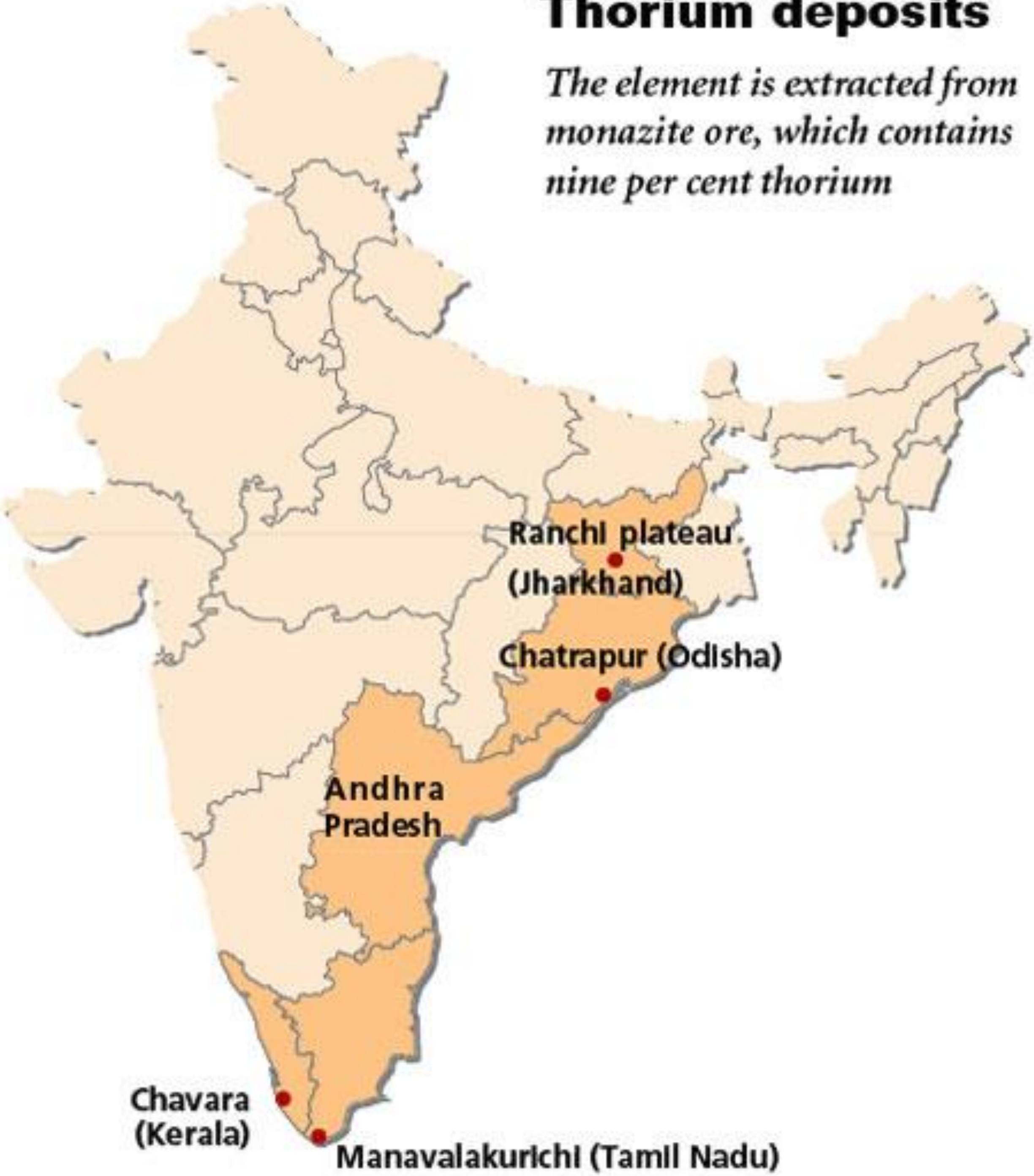
THORIUM DEPOSITS

Thorium deposits, in the form of the mineral, Monazite that is associated with other beach placer minerals like ilmenite, rutile, garnet, sillimanite and zircon, occur at many places along the East and West Coasts of India . Notable ones of these are at Chhatrapur-Gopalpur in Orissa, Bhavanapadu-Kalingapatnam- Bhimunipatnam in Andhra Pradesh, Mavalakurichi, besides Teri inland placers, in Tamil Nadu, Chavara in Kerala and Ratnagiri in Maharashtra .



Thorium deposits

The element is extracted from monazite ore, which contains nine per cent thorium



Share of Nuclear Energy in Total

The Indian population is misled Western nations are ending their nuclear programme, or that Japan is reconsidering nuclear power plant expansion.

Prosperous nations are extracting about 30-40 per cent of power from nuclear power and it constitutes a significant part of their clean energy portfolio, reducing the burden of combating climate change and the health hazards associated with pollution. Meanwhile in India, we are not generating even 5000 MW of nuclear power from the total of about 150 GW of electricity generation, most of it coming from coal.

Country (ranking in the order of total nuclear power)	**Total nuclear power capacity** (MegaWatt)[ix]	**Share of nuclear power in the total electricity generated**[x]	**GDP (PPP) per capita** (adjusted to purchasing power)[xi]
United States (1)	101,433	19.59%	46,860
France (2)	63,130	74.12%	33,910
Japan (3)	47,348	29.21%	33,885
Russia (4)	23,084	17.09%	15,612
Republic of Korea (5)	18,785	32.18%	29,997
Ukraine (6)	13,168	48.11%	6,698
Canada (7)	12,044	15.07%	39,171
United Kingdom (8)	10,745	15.66%	35,059
India (15)	**4,385**	**2.85%**	**3,408**

Note: *India's data given for a statistical comparison and is not in the order of ranking*

Clean Energy?

- "Clean" might not be the first word people associate with nuclear energy – but when it comes to GHG emissions, it is an accurate statement.
- But what about radioactive waste produced that pollutes the environment for generations?
- India three stage programme will result in less production of nuclear waste

Nuclear Shutdown

Three nuclear accidents have influenced the discontinuation of nuclear power:
1979 Three Mile Island partial nuclear meltdown in the United States
1986 Chernobyl disaster in the USSR.
2011 Fukushima nuclear disaster in Japan.

From Europe to Japan to the U.S., nuclear power is in retreat, as plants are being shuttered, governments move toward renewables ……

Following the March 2011 Fukushima nuclear disaster, **Germany** has permanently shutdown eight of
its 17 reactors and pledged to close the rest by the end of 2022.

Italy voted overwhelmingly to keep their country non-nuclear and is the country that has closed all of functioning nuclear plants

Switzerland and Spain have banned the construction of new reactors.

Japan's prime minister has called for a dramatic reduction in Japan's reliance on nuclear power. Taiwan's president has done the same.

As of 2016, countries including Australia, Austria, Denmark, Greece, Ireland, Italy, Latvia, Liechtenstein, Luxembourg, Malaysia, Malta, New Zealand, Norway, Philippines, and Portugal have no nuclear power stations.

Nuclear Shutdown

Lithuania, Kazakhstan have shut down their only nuclear plants, but plan to built new ones to replace them. Armenia shut down its only nuclear plant but subsequently restarted it.

Austria never used its first nuclear plant that was completely built. Due to financial, politic and technical reasons Cuba, Libya, North Korea and Poland never completed the construction of their first nuclear plants, although North Korea and Poland plan to.

Azerbaijan, Georgia, Ghana, Ireland, Kuwait, Oman, Peru, Singapore, Venezuela have planned, but not constructed their first nuclear plants.

Between 2005 and 2015 the global production of nuclear power declined.

India

by 2050, in all likelihood the demand could go even higher, and the per capita energy demand would be equal to about 6000 W per capita. To fulfill such demands with large Thorium deposits India is continuing with it's nuclear programme.

Use of Thorium

Thorium is a basic element of nature, like Iron and Uranium. Like Uranium, its properties allow it to be used to fuel a nuclear chain reaction that can run a power plant and make electricity (among other things). Thorium itself will not split and release energy. Rather, when it is exposed to neutrons, it will undergo a series of nuclear reactions until it eventually emerges as an isotope of uranium called U-233, which will readily split and release energy next time it absorbs a neutron. Thorium is therefore called *fertile*, whereas U-233 is called *fissile*.

Reactors that use thorium are operating on what's called the Thorium-Uranium (Th-U) fuel cycle. The vast majority of existing or proposed nuclear reactors, however, use enriched uranium (U-235) or reprocessed plutonium (Pu-239) as fuel (in the Uranium-Plutonium cycle), and only a handful have used thorium.

India's thorium deposits, estimates about 360,000 tonnes, far outweigh its natural uranium deposits at 70,000 tonnes. The country's thorium reserves make up 25 per cent of the global reserves. It can easily be used as a fuel to cut down on the import of Uranium from different countries.

Use of Thorium

So can thorium be used directly in reactors?

No.

Thorium too would go through a three stage process which would convert it into Uranium-233 and only then it can be put into reactor assembly.

Thorium is also a fertile substance, but not a fissile substance by itself. It requires work to make a usable in a nuclear reactor. The process through which Thorium can be made usable in the reactor is a three stage process.

At present, India is far from taking benefits of the large reserves of Thorium as it hasn't yet developed the mechanism through which Thorium can be processed and made usable to put into the reactor.

Bhabha Atomic Research Centre (BARC), however, is working on the research and development of the Advanced Heavy Water Reactor (AHWR), a Thorium fuel based vertical pressure tube type, heavy water moderated and boiling light water cooled reactor. The development of this reactor with a likely capacity of 300 MWe is in final stages.

So, with the presence of Thorium in India in quite a big amount, isn't it a better option to use it rather than importing Uranium from abroad?

Use of Thorium

Key Challenges

Long lasting expectation of the reactor - the designers want it to last a 100 years, compared to the 40-year design life for current reactors. That puts significant challenges on the materials of construction like concrete and steel.

Recycling of spent fuel - The key challenge with the thorium fuel cycle is the recycling of spent fuel. It's very difficult because you have to separate three streams: thorium, uranium, and plutonium," The gamma-emitting 232U in the spent fuel, which makes weapons proliferation harder, also complicates thorium separation. You need shielded facilities that become costly. Indian scientists have only done this separation at a small experimental scale so far.

Use of Thorium

India Will Be the Second Country in the World To Use a Fast Breeder Reactor but would use thorium

Prototype Fast Breeder Reactor (PFBR) at Kalpakkam

Prior to India's PFBR, the only commercially operating fast breeder nuclear reactor was Russia's Beloyarsk Nuclear Power Plant, located in the Ural Mountains. Russia's fast breeder reactor utilizes elemental uranium, though, so India's is truly one of a kind.

Plutonium: Global repercussion

It takes about 10 kilograms of nearly pure Pu-239 to make a bomb (though the Nagasaki bomb in 1945 used less). Producing this requires 30 megawatt-years of reactor operation, with frequent fuel changes and reprocessing of the 'hot' fuel. Hence 'weapons-grade' plutonium can only be made in special production reactors by burning natural uranium fuel

Plutonium does not exist in nature, but can be extracted from the spent fuel in nuclear reactors by means of reprocessing.

This is the main global concern that nuclear reactors all around the world producing electricity are producing bomb grade plutonium or could produce.