MODULE - 1
NUCLEAR ENERGY

BASICS

→ **Isotopes** → Elements with [same atomic no.], [diff mass no]

→ e.g. ISOTOPES OF HYDROGEN → H^1 → Light water → H_2O

→ D^2 → Deuterium [heavy water] → D_2O

→ T^2 → Tritium [radio active]

→ Uranium → U^{233}, U^{235} [undergo Nuclear fission] — fissile (break down when targeted by neutrons)

→ U^{238} → fertile (undergoes transformation → to a new fissile substance)

$n \rightarrow U^{233/235} \rightarrow$ Kr + 3n + heat → Energy

y

e.g. $U^{238} \rightarrow Pu^{239}$; $Th^{232} \rightarrow U^{233}$ — artificial

Indian Nuclear [illegible] are based on fuel (Pu^{239})

→ **Uranium Enrichment** → Process of enhancing the % age of fissile elements using centrifuges.

[Naturally occurring U] → U^{235} → 0.7% – fissile

→ U^{238} → 99.2%

Low Enriched Uranium ($U^{235} \leq 20\%$)

→ used for civilian purposes
- e.g. power production, healthcare, industrial application etc

→ countries can share for peaceful purposes

High Enriched Uranium ($U^{235} > 20\%$, upto 90%)

(AKA weapon grade Uranium)

→ employed for Nuclear Test, nuclear warhead

→ cannot be shared

→ sharing → proliferation

{ Nuclear Proliferation (illegal) }

NUCLEAR COOPERATION AGREEMENTS

[affordable, env. friendly energy to everyone, everywhere]

→ B/c of climate change → norms of [energy security] → changed.

→ focus shifted toward Non-Carbon based energy resources.

→ TARGET SET BY INDIA → [By 2050] → 25% of total electricity → nuclear

[for 2032] → target was 63K MW scaled down 27KMW,

[for 2020] → 20K MW (target) but 6780 MW (produced)

(3% of total electricity)

→ Obstacle in achieving target

(*) Lack of availability of nuclear fuel domestically (we only have 90% of total requirement)

∴ → India opted for [civilian Nuclear Agreements (co-operation)]

→ Argentina, AUS, Canada, France, Japan, Kazakhstan, Mongolia, Namibia, RUS, S. Korea, UK, US, Uzbekistan
also with Sri Lanka, Bangladesh, Vietnam.

India was promised :- Nuclear fuel

ENR → Membership of NSG needed → China doesn't want us

clear Reactors → 12 (Rus) ✓
6 (US) ✓
6 (FR) ✓

R Technology → Enrichment and Reprocessing
Extracting useful elements like Pu^{239} from spent fuel rod.

b/c we will become greatest owner of nuclear fuel and boost their economy.

→ India's obligations

Note
→ India is not a member of Nuclear Non-Proliferation Treaty (NPT)

IND, PAK, ISRAEL Not signed

NPT → 1970 → Nuclear weapon states (P5)
→ Non-NWS (all others)

93+2 Programme
b/c 90's → Hidden sites were found (N. Korea, Iran, etc)

- NWS → not give N.W. Tech to Non-NWS
- Peaceful use of Nuclear tech
- Inspection by IAEA (declared sites)
- Additional safeguard (Inspection other than declared sites)

① [Seperation Plan] → Nuclear facility ← civil / military

② [Safeguard Agreement] → civil → bought under inspection of IAEA

6th country to have ~~become~~ Nuclear weapon

India is the only country other than 5 NWS to have military Nuclear Reactor → NWS

IAEA (Nuclear Watchdog) — add protocol to increase presence in Nuclear programme of non-NWS

③ [Additional Protocol] → Denied by India

Negotiated New one :-
→ (i) Civilian Reactor under Inspection by IAEA
→ (ii) India will inform IAEA if it exports Uranium to Non NWS
→ (iii) " " " " " " " Thorium " "

④ [Nuclear Liability Act, 2010] → to define liabilities.

⑤ [Self Imposed Moratorium on Nuclear Testing]

* NPT → S. Sudan Not member, N. Korea withdrew 2003
* India wants complete disarmament → Not signed NPT

Provided to counter China (US counter China)

INDO-US NUCLEAR DEAL | 123-Agreement

[2005] → USA decided to share Nuclear Technology with India

[2006] → India (under PM Manmohan Singh) refused to sign NPT

[123 Agreement] why?

Sec 123 of US Atomic Energy Act, 1954 → If a country has signed NPT and US President is satisfied then Nuclear Tech for peaceful purposes can be shared with that country.

[India was not a signatory of NPT] → [Sec 123 was ammended] through [HYDE ACT] domestic law of US; not binding on IND.

(Done away with NPT as far as India is concerned)

→ As per Vienna Convention on legally binding treaties
If conflict b/w Domestic law & Intl. treaty
(Intl treaty (agreement) prevail)

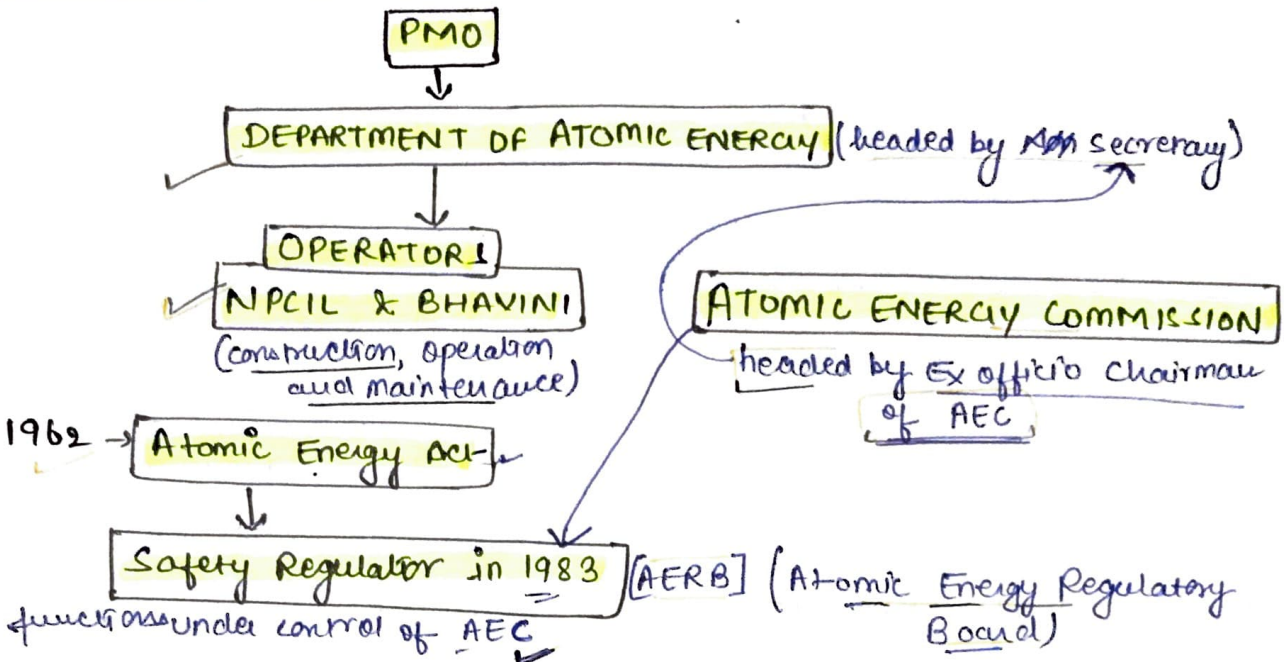
(Highlights of INDO-US NUCLEAR AGREEMENT)

1. US will supply India [fuel] (help in maintaining strategic reserve of uranium)
   (civil → 1 year fuel in advance)
   → If US fails to give → we will ask other countries to do so
2. US will supply [Nuclear Reactor] to India → [WESTINGHOUSE → 6 Nuclear Reactor for Kovvada, AP]
3. Reprocessing of spent fuel allowed but put in a place a [centralised Reprocessing facility safeguarded with IAEA.] (previously US was reluctant)
4. If India ~~test~~ conducts Nuclear Test → US will try to understand circumstances
   [at first US was trying to link Testing with deal termination]
   → followed by talks b/w two countries, complete in one year
5. Any of the two can terminate deal by giving 1 year Notice in ~~Advance~~.

14 civilian Reactors - safeguarded under IAEA (Imported fuel)	8 military Reactors
- Rawatbhata - 6 PHWR - Imported/Indigenous	Kaiga - 4 PHWR - Indigenous
- Narora - 2 PHWR - Indigenous	[Tarapur - 2 PHWR "]
- Tarpur - 2 BWR - USA	Madras - 2 PHWR "
- Kakrapar - 2 PHWR - Indegenous	we get Pu from these.
- Kudankulam - 2 - BWR → Imported. (Imported from Russia)	
- P. FBR - 1 - FBR Indegenous.	

Table 1.1

GOVERNANCE STRUCTURE OF NUCLEAR ENERGY IN INDIA



[Certain issues]

1. **Conflict of Interest** → Operator & safety Regulator controlled by one individual.
   → Role of these two are antagonistic to each other.
2. AERB **NOT AUTONOMOUS**
3. 95% of personnel of AERB → deputation from DAE
4. **Lack of Transparency** → Not mandatory for AERB to notify each and every Nuclear Incident.

[Acc. to IAEA CONVENTION ON NUCLEAR SAFETY → {Operator, safety regulator should be seperate.}]

Govt said → AERB enjoys complete functional autonomy.
Critics → Must have de-jure autonomy.

[2011] → Nuclear Safety Regulatory Authority Bill was drafted
[2015] → Presented again. [If gets passed] →

1. Nuclear Safety Authority (in place of AERB)
2. Mandatory to Notify all Nuclear Incidents within 15 days.
3. Council on Nuclear Safety headed by PM → to review the Nuclear Safety Policy.

NUCLEAR POWER PROGRAMME

Table 1.2

STAGE	FUEL	REACTOR	OPERATOR	STATUS	
I 24 Reactors (on paper)	U^{235}	BWR/PHWR/ PWR/FBR	NPCIL	Commercialised	Imported/ Indigenous
II	Pu^{239} (Reprocessing)	FBR (FBTR)	BHAVINI	Technology. Demonstration	1986 Indigenous (7th country to have)
III	U^{233} (obtained from Th)	AHWR/CHTR/ ADS/MSR	XXX	R&D	"

→ Nuclear Power Programme was announced in 1958 ✓ [Nehru + Bhabha Architects of NPP]
→ India gave concept of 3 stage Nuclear Power Programme.

ASIA's FIRST RESEARCH REACTOR → APSARA by BARC (Bhabha Atomic Research Reactor)

① CIRUS → supported by Canada & US — BARC

③ PURNIMA 1, 2, 3 — BARC

④ ZERLINA — BARC

⑤ DHRUV — BARC → only one still working.

⑥ KAMINI - Kalpakkam Mini — IGCAR → Indira Gandhi Centre for Atomic Research.
[$Th^{232} \longrightarrow U^{233}$] - world's first and only to use U^{233}

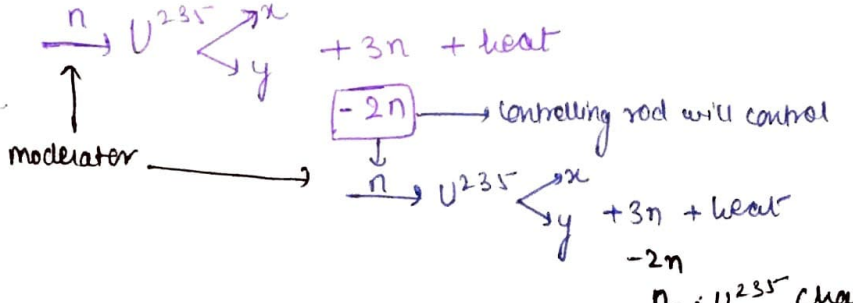
⑦ FAST BREEDR TEST REACTOR — IGCAR → Rapsodic Model of France.

⑧ PROTOTYPE FBR — IGCAR (Not started yet)

[APSARA → [Shut 2009]
2008 → [APSARA - U] (LEU, Light water - coolant, moderator)

BASIS OF DIFFERENCE OF NUCLEAR REACTOR

→ Fuel → , → coolant → light water, heavy water, gas, Liquid sodium
→ Controlling Rod
→ Moderator → slowdown the neutron,



STAGE - 1 → BOILING WATER REACTOR (BWR); Pressurised Heavy WATER REACTOR (PHWR); PRESSURISED WATER REACTOR (PWR)

[1962] - USA - India signed agreement → US → India → Nuclear Tech. but took hands off from any liability and compensation.

GE agreed to supply two Reactors, 2 BWR

BOILING WATER REACTOR

- Light water as moderator and coolant
- fuel → 2.5-3.5% Enriched Uranium (from US)
- Installed in Tarapur, MH (2)

[1964] China became Nuclear power, India wanted to have Nuclear weapons. So, we decided to have a reactor that works on Natural Uranium.

[1965] India signed agreement with Canada, ~~they~~ (Atomic Energy Canada Ltd.)

PRESSURISED HEAVY WATER REACTOR

- Heavy water as moderator and coolant
  → (Circulated under pressure to avoid vapourisation)
- fuel → Natural Uranium (No enrichment Required)

AKA → CANDU → Canadian Deuterium Uranium

[1972] - ~~It~~ PHWR Constructed at Rawat Bhata on Chambal River

[1974] → Pokhran Nuclear Test → Canada stopped working on reactor.
" " supply of Heavy water
USA " " of fuel.

We have signed friendship treaty with USSR who gave us Heavy water!

CANADA gave - 220 MWe
- India upgraded → 540 MWe
→ Aiming → 700 MWe.

- India has → PHWR → 2 Tarapur Indigenous, 6 Rawat Bhata Imported / Indigenous

[Ref. Table 1.1 (notes)]

→ Apart from these 16 Reactors are in development

safeguarded → IAEA can inspect (b/c Imported fuel)
Civilian

Gorakhpur (HR) → 4
Mahi Banswara (RJ) - 4
Kakrapar - 2
Chutka - 2
Rawat Bhata - 2
Kaiga - 2

* We are building PHWR b/c they [do not require enrichment] (Natural Uranium req.); [give more electricity]; [Pu - Efficiency] [expertise] [fuel available]

Q Why India is focusing on PHWR? (All military reactor → PHWR)

PHWR over PWR → More Pu than PWR ✓
→ More Tritium ✓
→ ↑ Efficiency ✓
→ Expertise available ✓
→ No enrichment req ✓ (natural U)
→ India can export as part of Nuclear diplomacy ✓

PRESSURISED WATER REACTOR (PWR) | III+ Gen Safety

- AKA Light water Reactor.
- " " Moderator, coolant
- Pressurised → avoid vapourisation ✓
- Enriched uranium as fuel ✓

Under Nuclear Co-operation Agreement
⇒ VVER 1000 - Russia ✓ 6 - Kudankulam ✓ 6 - ? (undisclosed)
[12 Reactors from Russia] [6 " " France] [6 " " USA] } will be supplied.

- Vodo Vodo Energy Reactor - 1000
- [(Water in Russian)] → 1.5 Enriched Uranium as fuel
- Produces 1000 MWe electricity in 24 hours)
- [12 - Reactors → 12000 MWe]

[1989] → 2 were finalised
[2002] → Construction started

Faced protest following the Fukushima incident (based on safety, loss of livelihood, displacement)

Why? mains

points of defence

① **Safety** → Protestors → Reasoned on Fukushima Incident
→ Japan → I grade security ✓
[while India has III+ security]

note:
- Reactors are built after seeing location's
- water body presence
- seismic zone

→ Japan is virtually on Pacific Ring of fire → prone to Tsunami, while [India is 13000km away from Pacific Ring of Fire] (Tsunamis will take two hours)
→ Japan has best Tsunami warning system but none b/c of above Reason. (Shortage of time)
→ India has [2nd best Tsunami warning system (7 minutes)]
→ PWR Reactors can be [shut down in 4 seconds].

note :- Agreements were signed in 1988, 2005, 2008, 2018.
[2018] → IND-RUS → to take up joint construction of Reactors in 3rd country.
Construction of 2 VVER-1000 Reactors at Bangladesh (Rooppur)

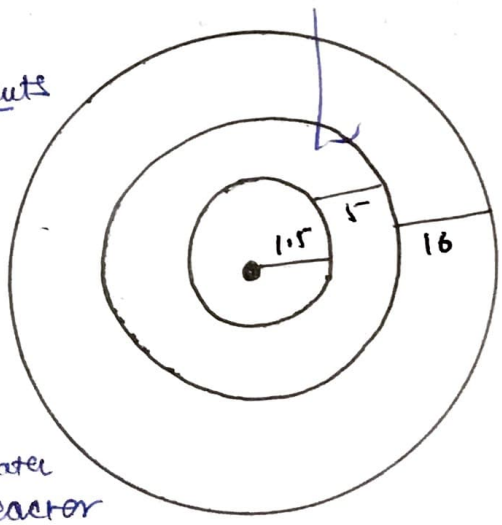
- Fukushima Tsunami was 9m high reactor was on 7m, while in case of India [2004 Tsunami was of 9.5 m, construction of our reactor → 9m+ from sea level]
- NPCIL → additional safety features
- Yet again → Petition was filed under Article 21 (Right to life) in Supreme court.
  SC → to NPCIL → [Submit safety Report]
  → Instructed NPCIL to start the Reactor.
  ↳ "India needs Nuclear Power for socio-economic progress"

Q Should India phase out from Nuclear Technology?
OR
" " continue with " " ?

→ India should continue
→ Hostile Neighbours → counter
→ Need of Energy to sustain
→ " " " " boost economy.
→ Solar and wind energy is expensive / sensitive to seasonal fluctuation.
→ SC said →

② **Displacement**

→ Radius 1.5 Km Exclusion zone – No residents
  +5 Km Sterilization "
  +16 Km Emergency planning zone
  [Residents allowed but with some restrictions.]



③ **Loss of Livelihood**
Why protest?

→ Reactors → usually near water body, hot water will be put out from Reactor
↳ less oxygen → less fish

6 Reactors in Kudan Kulam → 1 and 2 → started
3 and 4 → Under construction
5 and 6 → Not started.

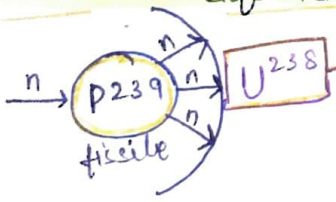
→ EPR-1650 → European Pressurized Reactor
→ By France → French Company AREVA
→ 5% Enriched Uranium [1650 MWe 24 hours] → 6 Units for JAITAPUR in MH
[6 × 1650 = 10,000 MWe] [World's largest capacity]
→ Light water → moderator and coolant
→ AKA → Evolutionary Pressurized Reactor

Resistence by people → Reasons:-
1. Environmental Pollution → water disposal
2. Safety → Areva also supplied for Fukushima (but EPR 1650 is advanced)
3. Farmers demanding land for land compensation.

→ AP-1000 → American supplier Westing House ready to transfer
6 such reactor for KOVVADA AP - Sikakulam
→ Protest → Safety, Rehabilitation, Waste Disposal

STAGE 2 - FAST BREEDER REACTOR (FBR)

→ Fuel → Pu^{239} (obtained from U^{238}) → spent fuel (Reprocessing)
→ It is called Breeder b/c they produce more fuel than they consume.
PRODUCTION > CONSUMPTION
→ No moderator is used. → AKA Fast Neutron Reactor
→ coolant → Liquid sodium → " Light metal FBR



$U^{238} \rightarrow Pu^{239}$ → weapon grade → ∴ indigenous
→ not included in civilian list as per seperation plan

$n \rightarrow Pu^{239} \begin{cases} x \\ y \end{cases} + 3n \rightarrow 2n \rightarrow U^{238} \longrightarrow Pu^{239}$ (20% Extra)

→ These reactors are indigenous.
→ We need this plutonium for our Nuclear weapon.
→ To extract this we need Reprocessing and for that we need NSG membership
→ These reactors are also capable of transforming $Th^{232} \longrightarrow U^{233}$ (fuel for 3rd stage)
↓ Need NSG for reprocessing

Closed fuel cycle →
I $U^{235} \longrightarrow Pu^{239}$
II $Pu^{239} \longrightarrow U^{233}$
III U^{233}

First FBR in India

KALPAKKAM → 500 MWe Not Yet started :-

Why?

- Not enough stock of fuel (Reprocessing Unit)
  - we use domestic fuel in Nuclear weapon
  - " " Imported " " civil reactors

- Centralised Reprocessing Unit / Facility
  - Pu^{239} → FBR → SG/A → IAEA
  - we cannot Reprocess Imported fuel (spent fuel) because not a member of NSG

for weapon

* In future, if any FBR will use the Pu obtained from centralised reprocessing facility SG → IAEA → that will also be safeguarded —— some FBR will be Civil and some will be military

These reactor will emerge as Bedrock of CREDIBLE MINIMUM DETERENCE

[not constant] Change with time.

[part of Indian Nuclear policy that India will always have min. no. of Nuclear warheads to cause unacceptable damage.]

STAGE III - ADVANCED HEAVY WATER REACTOR (AHWR); COMPACT HIGH TEMPERATURE REACTOR (CHTR); ACCELERATOR DRIVEN SYSTEM (ADS); MOLTEN SALT REACTOR (MSR)

→ Utilize Vast Reserves of Thorium in Coastal Belt
→ Uses of Th ~~offers~~ → Abundant than U, per unit mass gives more energy, waste product is ~~more~~ less harmful.

BARC is working on following.

AHWR	CHTR	ADS (HISPA)	MSR
Fuel → $Th^{232} + U^{233}$ Moderator → Heavy water Coolant → Light water 300 MWe	AKA Indian HTR Fuel same as AHWR but primary objective to produce Hydrogen by Thermonuclear splitting of water molecules. → for desalinisation of water → Electricity Generation → Hydrogen as fuel.	nu lost > nu produced High Intensity Super Conducting Particle Accelerator Particle Accelerator → Proton → Lead → neutron. → $Th^{232} + U^{233}$ → heat → steam → Turbine → electricity (out) BARC + FERMI LAB (USA) → Initially → to convert Nu waste to non hazardous (sub critical Reactor)	only a concept → Fuel, coolant, Reactor (everything) → Molten R & D not yet started.

NUCLEAR WEAPON PROGRAMME

→ India Established Dhruva (Indigenous) ; CIRUS (Imported from Canada)

1974 → **OPERATION SMILING BUDDHA** (Nuclear Test, Pokharan)

→ Described by INDIRA GANDHI As "peaceful nuclear explosion"

→ 3 Explosions → All of them were fission Devices (Plutonium Used)

1 device ① KiloTonne Device $y > 1KT$ Strategic Nuclear Weapon

2 devices ② SubKT " $y < 1KT$ Tactical " "

y = yield → energy obtained from Nuclear Test

e.g. $y = 50KT$ → means 50KT TNT Energy (Tri Nitro Toluene)

y of Pu > y of U

After this bunch → Program of SLV-3 was started with the aim of acquiring the technology of **INTERMEDIATE RANGE BALLISTIC MISSILE**

1983 **INTEGRATED GUIDED MISSILE DEVELOPMENT PROGRAM** announced

AGNI (5), PRITHVI (3) → Nuclear Capable Missiles

AKASH, NAAG

SAGARIKA (1) NIRBHAY (1)

International fallout → formation of NSG → Cartel meant for controlling Transfer of Technology of Nu. Tech. (Presently 48 countries)

AFTER 1974 Test (To counter India's Nuclear Programme)

NUCLEAR SUPPLIER GROUP (1974) (AKA LONDON CLUB)

→ China became member in 2004 (All countries with proven nuclear capabilities are members)

→ If a country wants to receive Nuclear Technology from members :-

① Sign NPT and

② Adopt full scope safeguard i.e, All present and future reactors under inspection of IAEA.

For Membership of NSG, CONDITIONS ARE DIFFERENT

① Sign NPT or any of the 5 Nuclear weppon Free Zone Treaties (NWFZ)

- Treaty of Pelindaba → Declared Africa NWFZ
- " " Bangkok → " SE Asia as NWFZ
- " " Rorotonga → " Islands as NWFZ
- " " Tlatelolco → " Nations [Fiji, Tonga, Papua, New Guinea, Aus, Newzealand] → Latin America NWFZ
- " " Semipalatinsk → Declared Central Asia NWFZ

(India does not Qualify for any one)

② Must take step to stop proliferation

③ Capable of Exporting Nuclear Technology. ✓ VVER-1000 (at Bangladesh)

④ Compliance with guidelines of NSG → Non proliferation, full scope safeguard

⑤ Mechanism to address proliferation Domestically.

2005 Till the start of Nuclear Deal (US) → India not concerned about NSG.

But talks started that } why Russia, France, US export Nuclear Tech to India would be allowed by NSG?

After INDO-US NUCLEAR DEAL → Next hurdle to get clearance from NSG.

2008 SPECIAL CLEAN WAIVER

→ There were 45 countries → NSG decides by consensus.

→ Sept 2008 → External affairs minister (Mr. Pranab Mukherjee) was sent to address the members of NSG and gave two commitments

oral commitments
① No First Use (NFU)
② Self Imposed Moratorium on Nuclear Testing (SIMONT)

→ US Sought resolution in NSG that in case of India → None of the two conditions will apply and it can receive Nu. technology from USA (members of NSG) → Special Clean Waiver

All members supported

(such a resolution has been passed only once in the history of NSG)

2010 NUCLEAR LIABILITY ~~AGREEMENT~~ ACT (Disagreement b/w Ind & US)

"If there is a latent and patent defect in technology & supplier is responsible for accident, then consumer can sue supplier for 1500 crore"

US - Angry (Targetted at India)

2011 NSG CHAIRMAN → LETTER TO IAEA → that those countries which are receiving Nuclear Technology without fulfilling the conditions must do so.

→ USA, Russia, France Backtracked from their commitment for reprocessing technology.

→ Since then India has shifted towards MEMBERSHIP OF NSG

2015 Barack Obama came to India → Put condition upon India → that it will cover the liability of supplier also

∴ India Announced INDIAN NUCLEAR INSURANCE POOL (1500 cr) to cover the liability of operator as well as supplier.

2016 India Applied for membership of NSG → 48 members.

→ A year earlier PM Modi visited China → China said that PAK should also get membership

note

BELT AND ROAD INITIATIVE → under this CPEC (60 Billion USD)

→ Xi Jinping will become tallest leader in china if this gets successful

→ Pak has 3 Nuclear Reactor (2 China + 1 Canada) → aims at 32.

→ If PAK's ~~ecs~~ economic condition improves due to CPEC, Xi Jinping's Project will be successfull.

→ China will give 30 more Reactors to PAK and brings them to NSG. → Put the Debt trap policy → and Acquire Pakistan's Gwadhar, and other strategic locations. Just like it doing in Sri Lanka, Nepal, Bangladesh → Wants to encircle India.

→ countries were willing to take India into NSG without NPT but not Pakistan b/c of pathetic past.

→ 38 out of 48 → voted for India

→ 10 out of 48 → against (China included)

China's Argument → NPT is mandatory [But no where in charter that NPT mandatory. Never signed yet never violated look at performance not criteria]

→ China wants to club us with PAK, N.Korea etc.
→ China then proposed a 2 step formula for membership of non-NPT countries like INDIA, ISRAEL, NKOREA, PAK → but they have failed to come up with the proposed formula.

Options for India → working on it

① It has entered into MTCR, Australia Group, Wassenaar Arrangement
↓
Missile Tech. Control Regime.

② India asking close allies → to convince opponents.

③ " working to improve relation with China → Wuhan Summit, Mahabalipuram "

→ Either build relation with China or Isolate China (get support of 47 countries)
(Russia can help us through)

Implications of Membership

① Will be able to export Nuclear Technology on its own.
Agreement with SL, BD, Vietnam will materialise
Help pursue India nuclear diplomacy → emerge as strong component of Neighbourhood First along with space diplomacy.

② Access to Reprocessing technology → help in pushing NPP towards utilization of Thorium.

1998 – OPERATION SHAKTI (Nuclear Test, Pokhran)

5 Nuclear Explosions (Pu) ← 4 (fission device) – atom bomb * don't use this term.
1 (Thermonuclear – fusion – Device)

→ After few days Pakistan also conducted Nuclear Test → Chaigai Hills, Baluchistan.

In order to give message to global community that India's weapon not to attack but to defend itself

1999 PM – Atal Bihari Vajpayee seeked advice from NSAB (govt. Think tank)
K. SUBRAMANIAM to Draft **INDIA'S NUCLEAR DOCTRINE**
→ made public in 1999.

2003 India Adopted Nuclear Doctrine

① **No First Use (NFU)** → Pragmatism (supporting NFU)
→ Maximalism (favour of NFU)
→ Rejectionism (favour as situation demand) – no policy.

→ finally NFU was adopted

"India will never be the first to use Nuclear weapon but if attacked with nuclear weapons → will go ~~was~~ for MASSIVE RETALIATION"
→ Unacceptable Damage → **SECOND STRIKE CAPABILITY**
→ Credible minimum deterrence

② **Second Strike Capability**
→ For this we should have **NUCLEAR TRIAD** esp. (Army, Airforce, Navy)
→ Navy must have a submarine which can use nuclear missile → **INS Arihant** → India's Nuclear Power Submarine (instead of Engine → Nuclear Reactor)
→ Sagarika → Nuclear Missile → more needed.

(a) Clause was added → Irrespective of ~~being~~ the fact whether a country is a NWS or Non NWS → if uses biological weapon
- Chemical "
- Nuclear "

India will retaliate with Nuclear weapon.

③ **Deterrence**
tell enemy → there will be larger losses on their part
→ to keep enemies in confusion.

2010 Shankar Menon NSA
→ NFU only for Non NWS

④ **No Nuclear weapon on Non-NWS**

- **PROS OF NFU** → Against First Use

① If two countries have NFU policy → possibility of nuclear war is very less
If " " " FU " → " " " " " high.

② By NFU Arms Race can be avoided.
But FU no. of weapon should be more than adversary that should be backed.

③ B/C of NFU → special clean waiver in NSG and JAPAN nuclear Deal.

④ First use policy will put political leadership under pressure.
NFU → No pressure

⑤ Infrastructure of Nuclear Arsenals needs modification in first use policy.
FU → no. and NFU → strength

- **Points in Favour of First Use**

ⓐ India's tech. capability → transformed → has the required fire power for first use.

ⓑ China – India → has gap b/w conventional war capacity → and has increased → first strike is an option.

ⓒ PAKISTAN → Proxy war → first use can be a deterrent.

Instead of Dropping NFU → India must Strengthen –
- Anti ballistic missile system →
- Air Defence system → S-400
- Surface to Air Missile → Akash S2A, Medium Range S2A (2nd – Israel)
- Nuclear Triad.

⑤ SELF IMPOSED MORATORIUM

⑥ NUCLEAR COMMAND AUTHORITY
- Political Council → Headed by PM (Final Decision)
- Executive Council → " " NSA
- National Security Advisory Board (NSAB)
- Strategic forces Command → headed by officers of Rank of Air Marshall (Executive Decision)

FUSION POWER → need → to produce electricity

→ Fusion → Thermo Nuclear Reaction as it requires huge temperature.
→ It is the reason behind energy of sun, stars.

* Lighter Nuclear combine to form heavier nuclei to Harness
- the process of fusion power generation.

1985 → **SUPERPOWER CONFERENCE**
- attended by USSR, US, EU, JAPAN

1989 They formed a consortium → **INTERNATIONAL THERMONUCLEAR EXPLOSION REACTOR (ITER)**
→ 1991 due to collapse of USSR → consortium progress stopped.
2003 China and south Korea were invited as members.
2007 India was invited as member → first scientific project (International) where India was invited as a full fledged partner.

→ It is represented by BARC, Kolkata based SAHA Institute of Nuclear Physics and ~~Abd~~ Ahemdabad based Institute of Plasma Research.

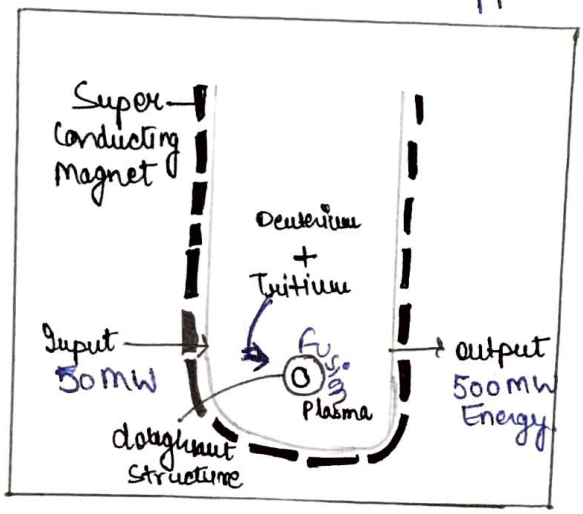
ITER ~~is coming up with a project~~
↳ is constructed at a place **CADARACHE in south France**
~~Expected~~
- will be available from 2022 under name DEMO.

→ **PROJECTS OF ITER**

→ Based on **MAGNETIC CONFINEMENT OF PLASMA**

•Plasma → 4th state of matter — produced at a very high temperature
→ when the atom disintegrates into the charged particles.

→ Russia has ~~donated~~ supplied world's largest superconducting TOKAMAK.



→ Cylindrical device fitted with extremely powerful superconducting magnets
→ Inside this plasma will be produced by heating Deuterium + Tritium at 50MW electricity
→ Plasma will form doughnut shaped structure which will be used to carry out fusion to produce 500 MW electricity
→ Input/output ratio = 1:10
→ At ITER target is to attain the temperature which is 10 times the temperature found in the core of sun.

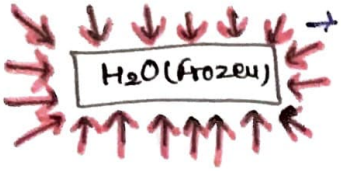
INDIA → working on its own TOKOMAK → ADITYA → developed by Institute of Plasma Research Ahemdabad.

CHINA → EAST → Experimental Advanced Superconducting TOKAMAK
Heifei → AKA Artificial Sun
→ It is also based on magnetic confinement of plasma.

SOUTH KOREA → K-STAR → Korean Superconducting TOKAMAK Advanced Research

GERMANY → SYNLIGHT → Synthetic Light → fusion power project.

USA → LIFE → Laser Inertial Fusion Energy
→ Lawrence Livermore National Laboratory
→ Most powerful 192 Lasers in an experiment were arranged.
→ Directed on a frozen hydrogen.
→ Under the impact of heat of LASER, hydrogen melted and formed plasma
→ By using lasers, plasma underwent fusion, electricity based on this approach called LIFE



↓ melt

PLASMA → Fusion → Produce Electricity

MERITS OF FUSION POWER

1. NO SOLID WASTE → No radioactive solid waste.
→ At the way there will be gaseous radio isotopes with a half life of around a week.
2. Only $_1H^2$, $_1H^3$ needed for fusion reaction. No need of Resources like Uranium or plutonium.
3. OUTPUT > INPUT → will be Commercially successful
4. Will help in phasing out thermal power. In context of climate change, decarbonisation of energy sector is very important therefore alternate source of energy have to be established.

DEMERITS OF FUSION POWER

1. ELITIST TECHNOLOGY - Only some countries have technical and financial, & man power capacity to implement.
2. Temperature used 10 times more than temperature at core of sun, How will it be obtained and sustained?

IRAN NUCLEAR DEAL

AKA → JOINT COMPREHENSIVE PLAN OF ACTION (JCPOA)

→ Signed b/w IRAN and P5+1. → Germany – [July 2015]

→ Iran is a member of NPT – safeguard
– Additional protocol
– Right of people of Nuclear Technology.

⇒ BACKGROUND

→ During Cold War Era, Iran was very close to USA.
→ The King of Iran was a puppet of USA.

1967 Iran received nuclear technology from USA under "Atoms for Peace program"

1979 Islamic Revolution in Iran → resulted in Establishment of Democracy under Sharia laws
→ USA got irritated as puppet was removed.
→ There was tension in IRAN-USA Relations
→ Iran created two power centres
→ Ayatollah Khomeni (Spiritual leader)
→ Democratically elected President.

1980 Iran was at war with Iraq. Meanwhile Israel attacked the Nuclear Reactor of Iraq.
Now, Iran realised it could be them the next time.

→ Iran started building Nuclear weapons out of this vulnerability and started enriching uranium in a clandestine manner.
→ International community was not aware of this till 2000. (Hidden Reactors)

2000 A video emerged which was about details of enrichment program. IAEA had no idea about it.

→ International Community's response was that there should be international investigation by IAEA.
→ Iran Refused to fulfill obligation.
→ But acc to rules IAEA had no right to refuse. Sanctions were imposed on Iran.
• No oil from Iran. (Export of oil ↓) → stop payment for oil.
→ Resolution against Iran.

2005 India voted against Iran (US wanted India to vote against Iran)

2006 " " " Iran → Iran cancelled the deal of LNG.

2009 " " " "

2010 Obama administration brought legislation **CISADA** (Comprehensive Iran Sanction and Accountability Divestment Act)

→ This law said, If any nation is doing significant business with Iran, they cannot do business with USA.
→ India made it clear that it will implement only those sanctions which are routed through UN.
→ India asked Iran to open an account in Indian Bank (for payment for oil in Indian currency.

2012 Obama became president for second time. He wanted to resolve the issue and to leave a legacy.
→ Also, USA was looking for substitute of Saudi Arab in West Asia.
→ Negotiation started. These talks were based on:- **Iran and P5+1**
→ These talks were based on two points:-
① Iran should stop Nuclear Enrichment Program and Nuclear Plant.
② To ease sanctions on Iran.

Important Centres of IRANIAN NUCLEAR PROGRAM

SAGHANDH → Main nuclear production centre (uranium mining site)
NATANZ → " Enrichment centre
FURDO/FORDO → Also " "
BUSHEHR → Russia has constructed Iran's first ever Nuclear Reactor (PWR)
ARAK → Iran is building first indegenous reactor (HWR)

2015 (July) → JCPoA was signed
→ Two countries were unhappy → Israel and Saudi Arabia (B/c regional rivals of IRAN)

→ **PROVISIONS OF JCPoA (Restrictions on IRAN)**

for Uranium

① Iran will not have any stock of uranium enriched beyond 20%.
② Had 7500 kg of LEU → can retain only 300 kg → remaining quantity shipped back to Russia.
③ It can enrich only upto 3.67% (It will be used for fuel that Iran will build @ Arak)
④ It has to destroy almost 70% of its centrifuges. For 15 years neither it can develop nor can it acquire such technology.

for Plutronium

- P5 +1 proposed → Iran should stop construction @ Arak. Their of

agreement → From spent fuel Iran can reprocess Plutonium and use it for weapons.

- Iran was permitted to build the reactor but with restrictions :—

(1) Change design of core of reactor → so that very little U^{238} is converted to Pu^{239}.
(2) Spent fuel to be shipped out.
(3) Never acquire any reprocessing technology.
(4) Complete co-operation to inspections by IAEA.

→ Historical aspect of Iranian program & involvement with N. Korea (will be settled seperately)

→ In return of all this → Sanctions will be eased in a phased manner.

→ IAEA reported → Iran has complied with all the conditions.

2015 **DONALD TRUMP Decides to walk out**

→ Reasons cited by USA

(1) Iran might develop N. weapon after expiry of deal.
(2) It does not cover ballistic missiles
(3) Iran is supporting terrorist organisations
(4) " " influencing countries in the region.

2018 **CAATSA (Countering America's Adversaries Through Sanctions Act)**

→ Against N. Korea, Russia and Iran
→ Provisions of secondary sanctions to be imposed on countries which will have defence and energy relations with RUS, IRAN, N. KOREA.
→ Effective from Nov. 2018
→ Nov. 2018 + 180 days India was exempted from sanctions.
→ Then India stopped buying oil for Iran.
→ Impact → China has gripped over Iran.

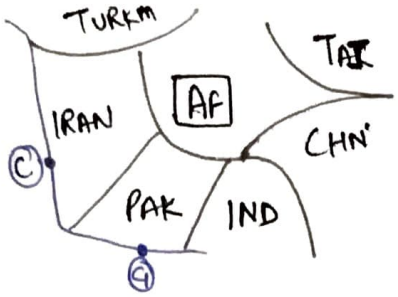
→ **IMPLICATIONS FOR INDIA**

(A) → From 2002 India has maintained that Iran should not develop Nuclear weapons and USA should not counter via defence actions.

→ B/c for us Iran is of strategic importance to us in view of connectivity.

2015 → JCPOA → sanctions Removed.
2016 → PM went to Iran → Chabahar Port
This project was no Iran's table since Vajpayee's time and nobody

could invest due to sanctions



→ Chabahar in Iran → link with Af through Iran-Afghan Border (Railway)
→ This will be linked with Zaranj Delaram Road in Af.
→ In future Highway can be extended into Tajikistan
→ strategically significant

* **Connectivity in central Asia**
→ Chabahar Port is few km from Gwadar which represents one of vital node under BRI (China). → Gas pipeline in China.
→ India's long term strategy is that Afghanistan should not use any port of PAK for import and export.
→ this can be achieved by providing alternative
→ India will join all initiatives except BRI.
→ India has signed Ashgabat Agreement → connecting Central Asian countries with ports of Iran and Oman.
* Duqm (Oman) and Islands of Seychelles and Mauritius will help India in est. itself as the "net Security Provider" in Indo Pacific.
→ Since 2011 → India, Iran and Russia are pursuing Int. North South Transport Corridor (INSTC) that will link Arabian sea and Russia (probably Eastern Europe)
→ Our goods will find market in Iran & Russia. Even Uranium can be imported from Central Asia.
→ Transport cost will come down. Transport route will be cut short.

(B) → Energy Involvement with Iran
→ (i) **Upstream Investment** → India has been acquiring oil fields and gas fields in Iran which can be developed by companies like ONGC Videsh Ltd. but this got affected b/c of sanctions.
→ later Iran said that it will allocate oil and gas fields through open bidding.
→ Possible acquisition for India was Farzad-B gas field but later both countries failed to arrive at concensus which it comes to pricing.
→ (ii) **LNG** → Oman → Liquified gas for Iran, Mumbai based South Asia gas Enterprise has proposed an undersea pipeline to bring gas from Oman to W. coast → couldn't move forward b/c of sanctions.
→ (iii) **Gas Swap** → Iran, India, Turkmenistan (T → Ir → I)
→ Iran → additional gas to India.
→ (iv) **Buyer-seller Relationship** → Iran one of the top 5 oil supplier to India.
→ It accounts for 11-12% of the total import.
→ Iran was to help India to maintain strategic reserves of petroleum.

COMPREHENSIVE TEST BAN TREATY (CTBT)

→ Introduced in 1996

→ CTBT says that, "A country cannot conduct a nuclear test in Air | on water | on land neither underground, nor underwater."

→ Not yet enforced b/c - one of the provisions that there are 44 country with the nuclear programme - all these countries must sign and ratify. [then it will be enforced]

[US → not ratified] [Ind. | Pak. | N. Korea — not signed]
China, Egypt, Iran, Israel

India's Arguement → "forced into entry clause violates sovereignty

→ CTBT does not explicitly covers computer based simulation Test.

→ CTBTO has been organised → INTERNATIONAL MONITORING SYSTEM
of Sensors have been installed in diff. countries to pick up Nuclear Test.

→ Not discriminatory like NPT.

FISSILE MATERIAL CUT OFF TREATY (FMCT)

→ FISSILE MATERIAL → Used for making weapons < Highly Enriched Uranium, Weapon Grade Plutonium

→ FMCT prohibits production of fissile material for All nations.

→ Yet to be formally drafted.

3 Models of FMCT have been drafted and presented -

One by US, other two by Greenpeace and International panel on fissile material (independent think tank which advices IAEA on the matters related to nuclear proliferations.

→ US has shown lot of interest in FMCT b/c in 2011 → NEWSTART Treaty with Russia which mandated that they should reduce their no. of weapons to 1550.

→ Britain & France announced a moratorium on no. of weapons.

→ US is worried that at some time in future, India and China might acquire more nuclear weapons than it has.

→ FMCT is not adopted yet because it -

Q1 What should be definition of fissile material?
→ HEU and weapon Grade Pu.? or
→ Tritium and Uranium 233? — not decided.

Q2 What should be the scope of the treaty?
→ Retrospective | Prospective?

→ For India, FMCT is a complicated issue b/c :-

- it will adversely affect its credible ~~Minimum~~ Minimum Deterrence
- it is having two hostile neighbours with nuclear weapons
  - if it favours future production to be stopped, India will have an edge over Pakistan but china will also have edge over India.
  - if it favours the inclusion of existing stock then it will lose edge over Pakistan.

→ India wants that only future production should be stopped.

Q What should be the nature of investigation?

→ IAEA ~~→~~ Countries defined as nuclear weapon state by NPT are demanding monitoring and verification should be similar to that of NPT while these countries have the final say where IAEA can visit but this have been strongly opposed by non-nuclear weapon countries, they want that inspection should be same for all the countries.

P5 countries → limited
other " → very strict

NUCLEAR LIABILITY ACT, 2010

AKA → Civilian Liability for Nuclear Damages Act 2010

→ Purpose → To operationalise Indo-USA nuclear deal, as per the domestic legal requirements of US. It is mandatory for supplier to get the insurance cover before selling the reactor.

[General Electrical had to get nuclear reactor insured in USA itself.]

→ India had no such rules, insurance company demand for insurance ~~company~~ for General Electric as there was no mechanism to deal with accident insurance in India.

→ In case of accident they would have to pay in full rendering them bankrupt. → [They asked GE to formulate Nuclear Liability Act]

→ USA criticized the Indian legislation → ground → it is against international nuclear liability regime which comprised of 3 conventions.

- IAEA → Convention on Nuclear Liability.
- OECD → Organization for Economic Co-operation & Development Convention
- Convention for supplementary compensation.

→ All these conventions are based on 4 pillars :-

- Liability is limited in time (20 years)
- " " " " amount (1500 cr. / reactor)

- Liability of the operater is absolute
- " is exclusively channelised to the operator.

⇒ INDIAN LAW HAS LAID DOWN FOLLOWING PROVISIONS

① Liability of GOI shall not exceed 300 mn SDR → if exceed → India will have access to funds under convention for supplementary compensation
→ 1500 cr by operator and if need arises remaining 1100 crore will be paid by govt

② Irrespective of defect ← latent → supplier did not know about it
patent- → supplier knew about it
→ if accident happens operater can sue the supplier for 1500 crore.

③ To facilitate the payment of compensation claims Commissioners have been appointed there the victims of the accidents can ask for compensation in these two categories.
- A - Damages to property (duration 10 years)
- B - Health damages (duration 20 years)

Right to Recourse

→ USA, Russia, France weren't happy with this → US was more vocal opponent among them.

→ 2015, Obama → India Announced → Indian Nuclear Insurance Pool
→ Pool of 1500 cr. for each reactor
(750 cr. will be given by govt.;
750 cr. covered by insurance company)
∴ Liability of the operater and supplier both taken by govt and insurance company.

→ So India agreed to exempt USA from our NLA and exclude them (their supplier) from any liability in case of nuclear accidents.

→ legal consequences will be borne by operator.

→ In return USA had supported us in NSG.

→ Insurance premium put by operater - 16 → PHWR
24 → PWR
40 × 1500 = 60,000 crore