

NUCLEAR DILEMMA

Nuclear Energy ☺
VS.
Nuclear Weapons ☹

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NUCLEAR ENERGY
OR
NUCLEAR WEAPONS
...
NEITHER?





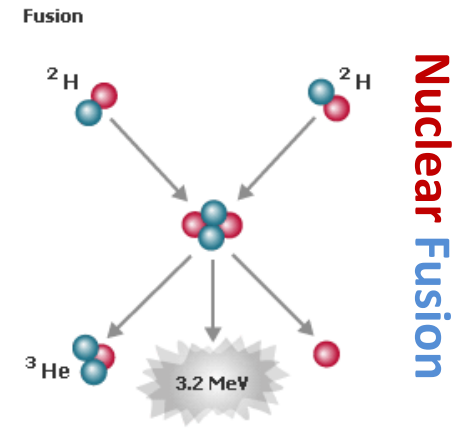
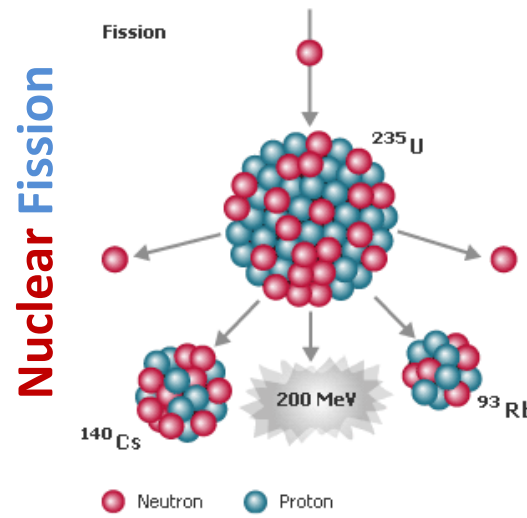
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A word about nuclear reactions and nuclear materials

Fission and Fusion

Fission chain reaction in nuclear material...



Why and How fission happens?

1. Instability: Electric force (long) suddenly overcomes nuclear force (short)
2. Result: Nucleus splits in two smaller parts
3. Consequence: Energy is released in a form of kinetic energy which turns into heat

- Fission (U-235, Pu-239): release of electric potential energy (200 Mev)
- Fusion (T, D): energy release due to defect of mass (3.5 Mev)

Curiously, occurrence of fission in nature is pure “luck”, for better or worse:

- No fission, no nuclear energy – minus...
- No fission, no nuclear weapons – plus...

Nuclear materials for energy and weapons

Natural Uranium: ^{238}U isotope – 99.3%, ^{235}U isotope - 0.7%

The difference? Just 3 neutrons...

- **^{235}U isotope** (Uranium) – **industry** (enrichment 3-4%) and **weapons** (enrichment 90%)
- **^{239}Pu isotope** (Plutonium) – **weapons** (93% of ^{239}Pu) and **industry** (MOX fuel)
- **^3H** (Tritium) – **weapons, so far**; **industry + energy** – hopefully soon!

How to make them...

^{235}U : Mechanical Enrichment by isotope separation (**centrifuges**)

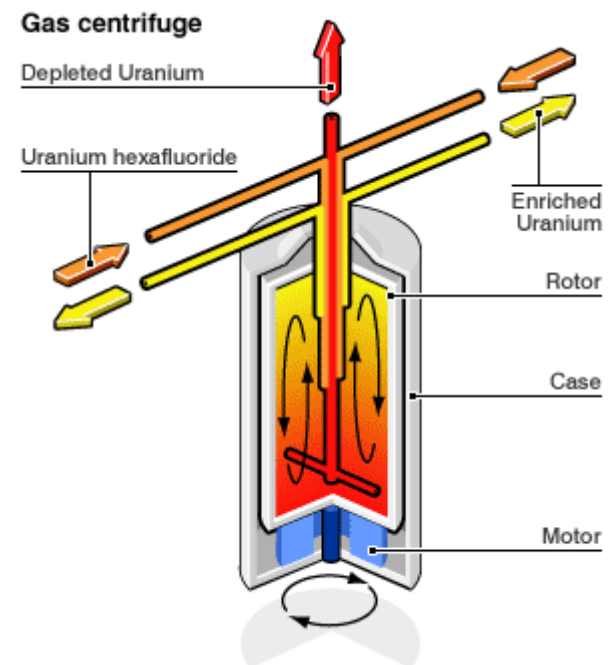
^{239}Pu : Chemical extraction and purification of Uranium fuel burned in special nuclear reactors **OR** reprocessing of spent fuel from power reactors

^3H : **Bombarding** ^6Li in nuclear reactors by neutrons and **producing T** (and He)

Uranium Enrichment: getting rid of ^{238}U isotope...



...by processing $^{238}\text{UF}_4$ / $^{235}\text{UF}_4$ mixture – a chemically deadly gas



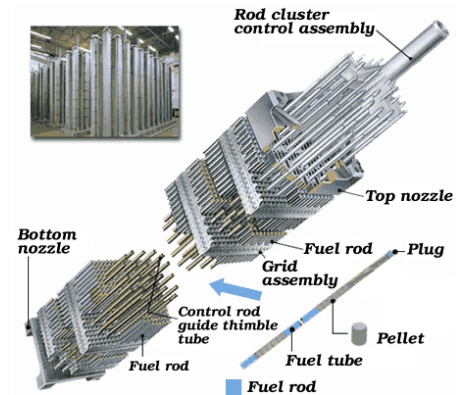
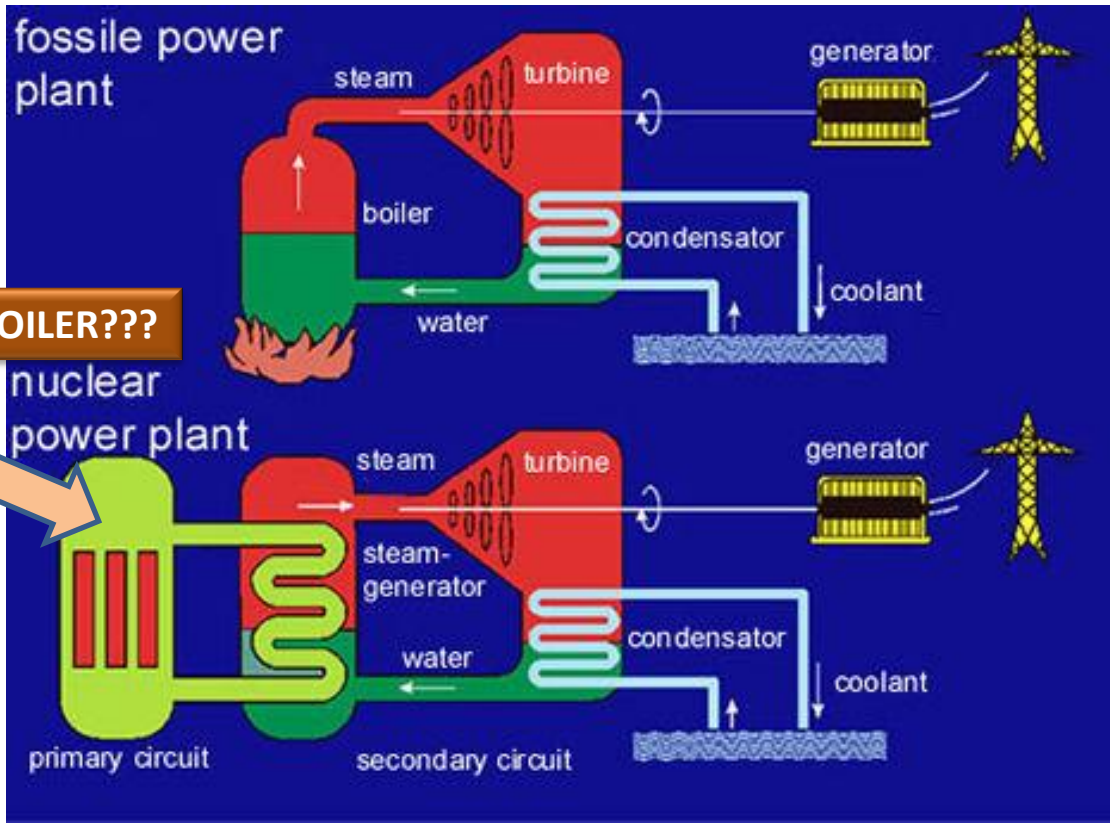
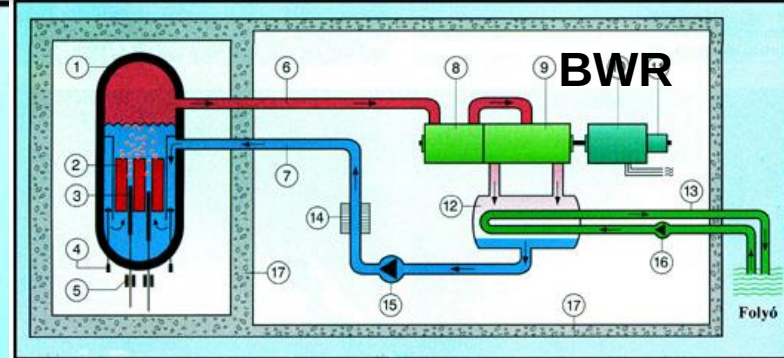
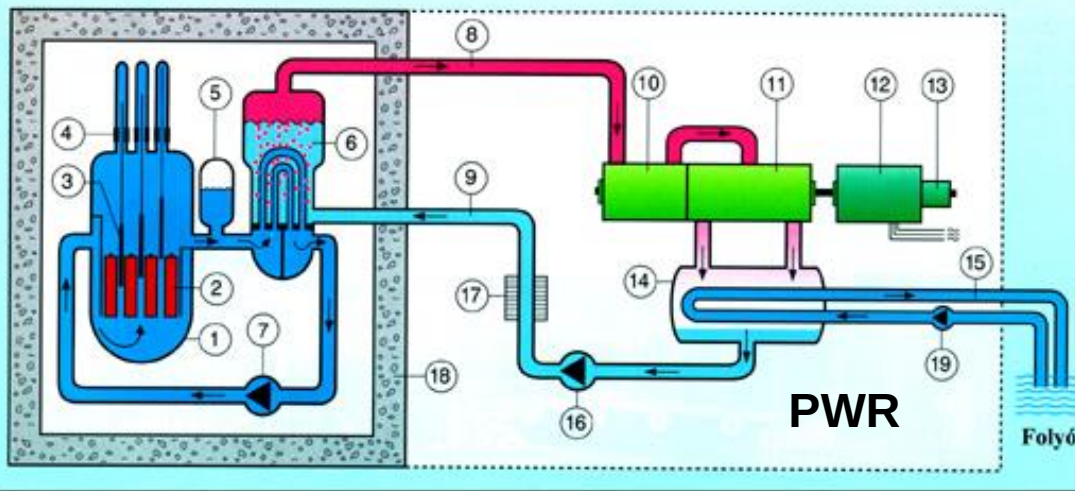
Centrifuges spinning with very high speed; require ultra-precise mechanical design

Plutonium production: chemically **extracting** Pu from highly radioactive materials. Environmentally very “dirty” business leaving behind enormous amount of dangerous waste materials.

Stopped in the U.S.

Nuclear power plants & Electricity production

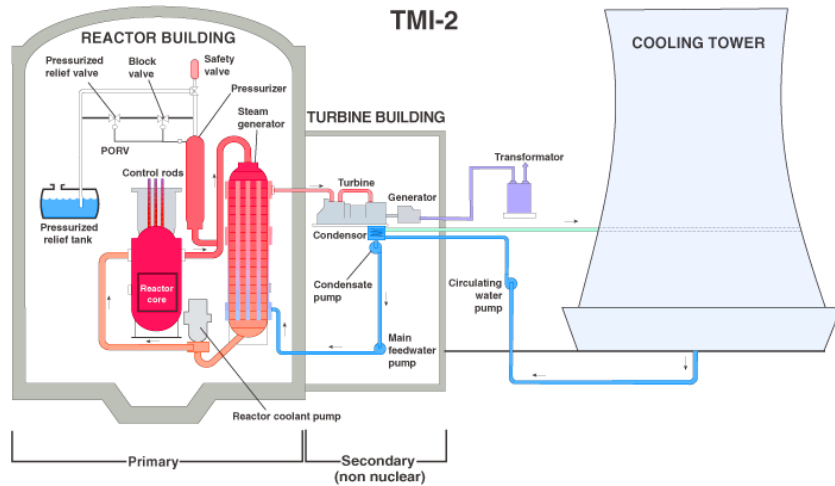
ENERGY PRODUCTION IN NUCLEAR POWER PLANTS



Nuclear Energy: Negatives

Dealing with Nuclear Power Plant Accidents

Three Mile Island – 1979, US



Fukushima – 2011, Japan

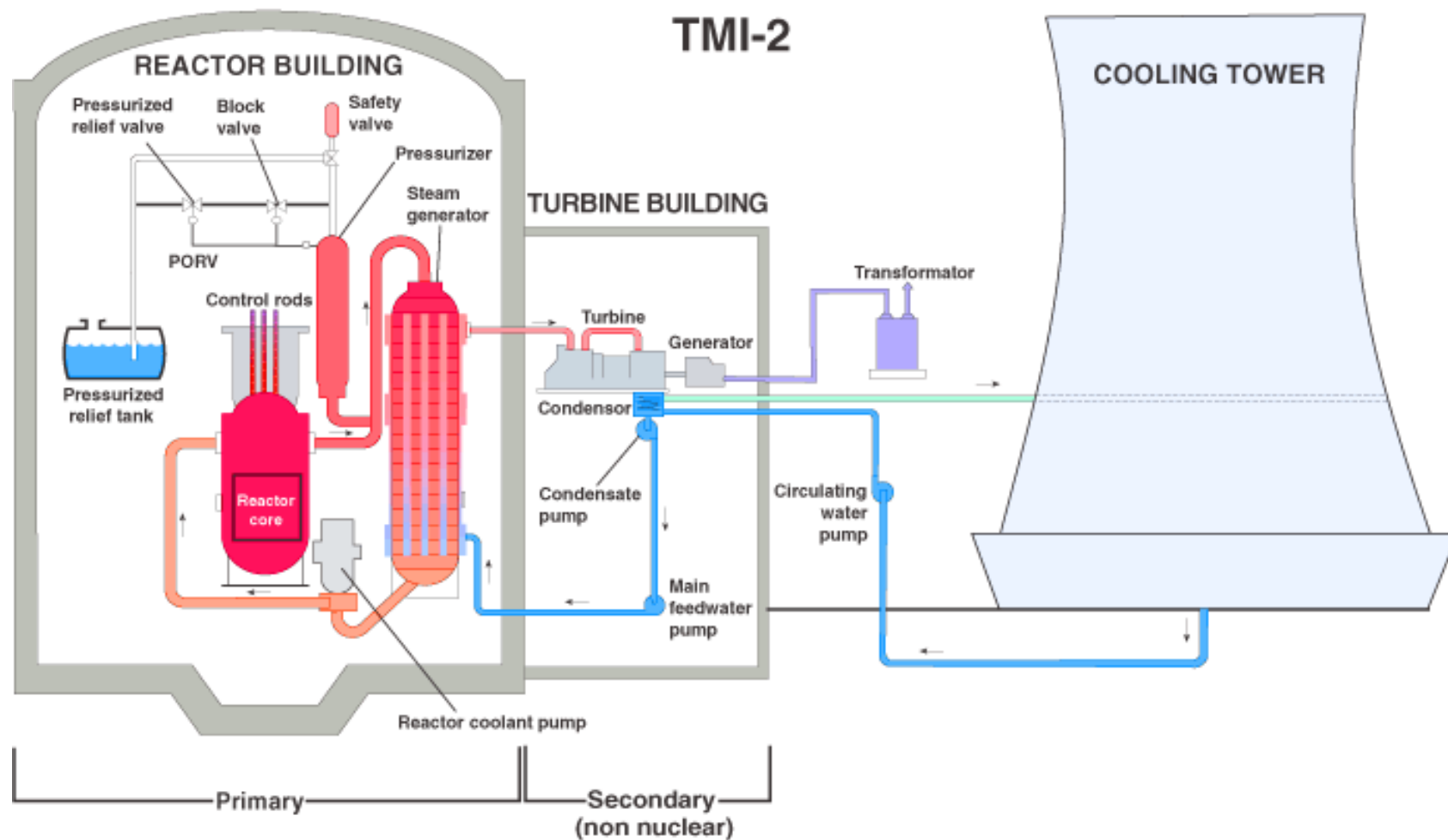


CHERNOBYL



Chernobyl – 1986, Russia

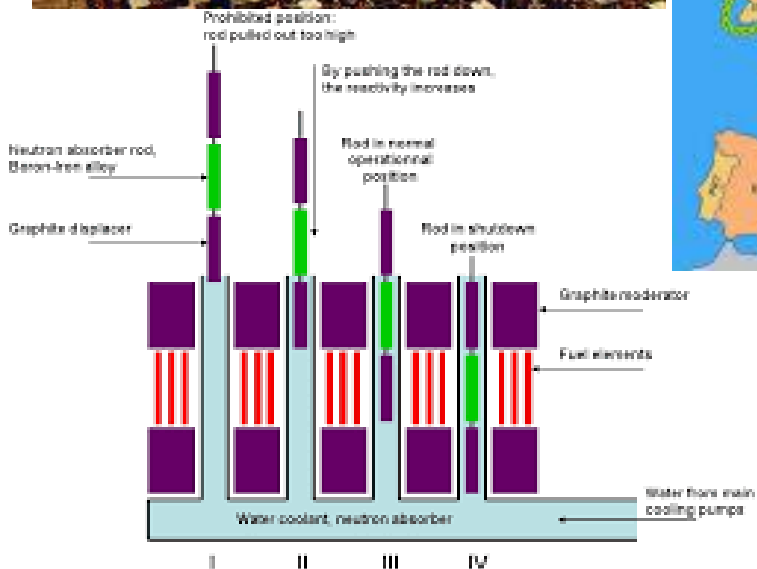
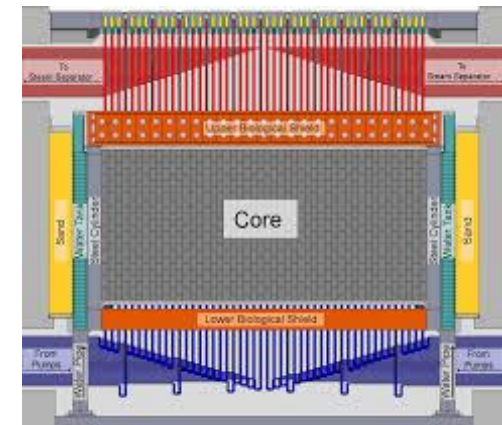
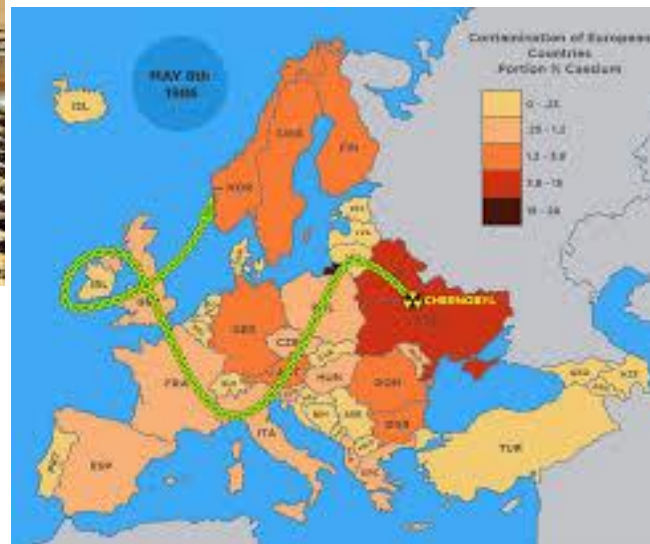
Three Mile Island Accident - 1979



No Radiological Consequences



Chernobyl Accident - 1986



Global Radiological Consequences



Today

Fukushima Daiichi Accident – 2011, Japan

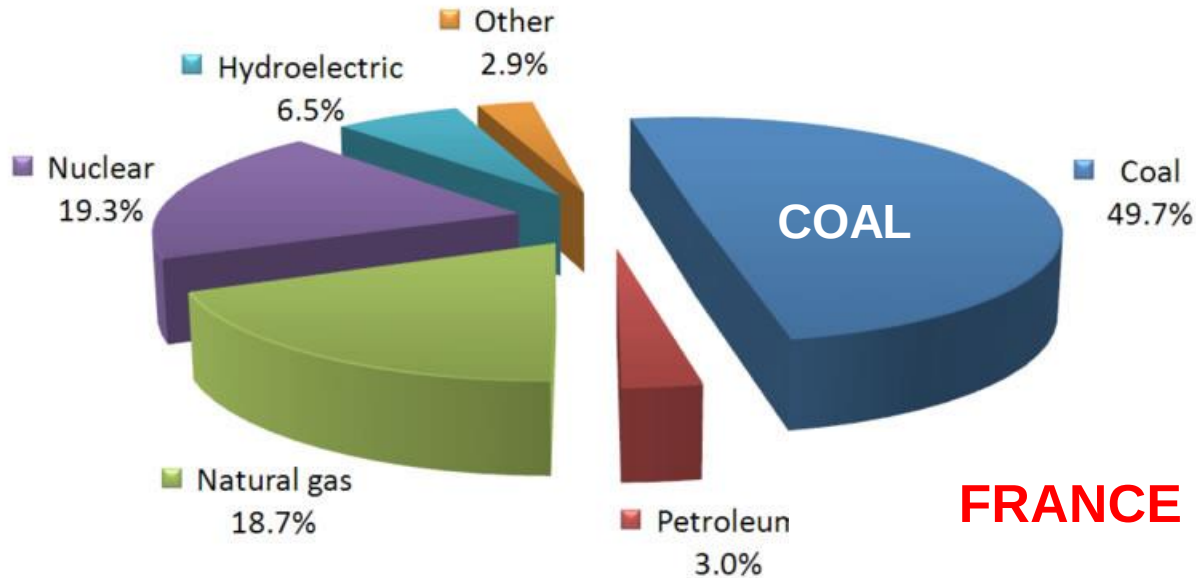


- Earthquake, magnitude 9
- Tsunami (50 ft)
- Disabled external electric power
- 3 reactors lost cooling and melted
- 100,000 people evacuated
- No deaths due to radiation
- 1000 deaths during evacuation

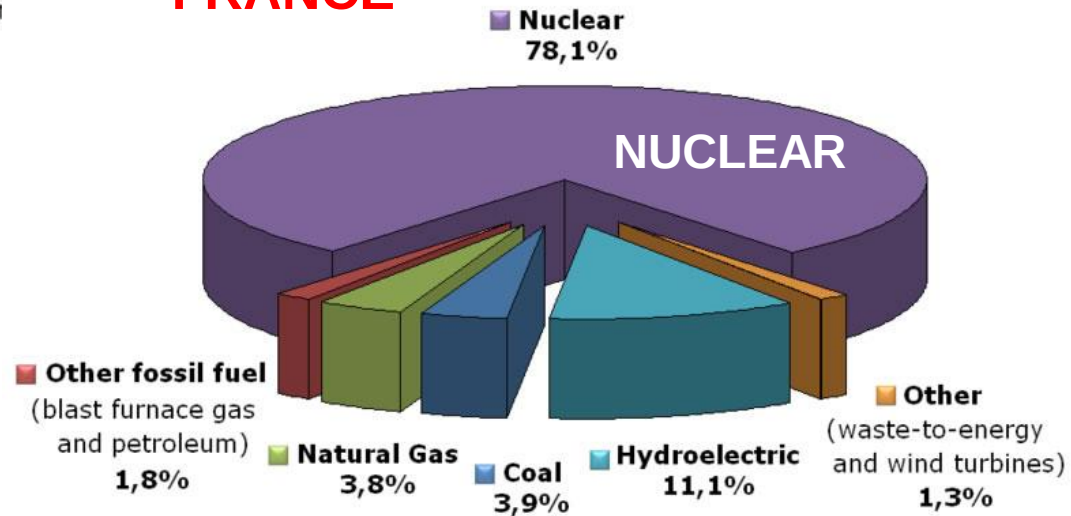
Nuclear Energy: Positives

World Benefitting from Electricity Produced by Nuclear Power

US



FRANCE



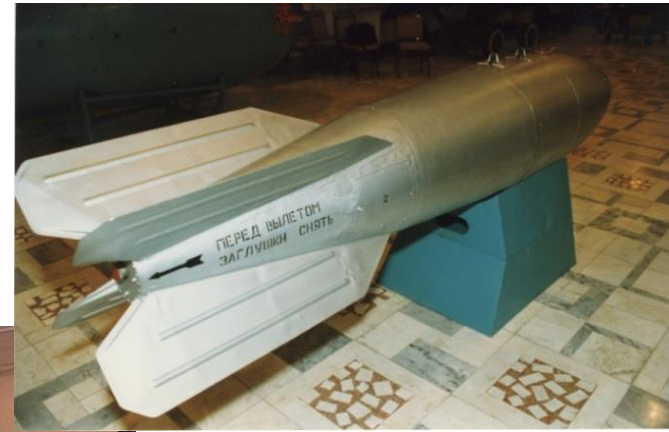
Nuclear weapons: **Negatives**

Russian Nuclear Complex





NUCLEAR WEAPONS



SUGGESTION...



NUCLEAR PROPULSION

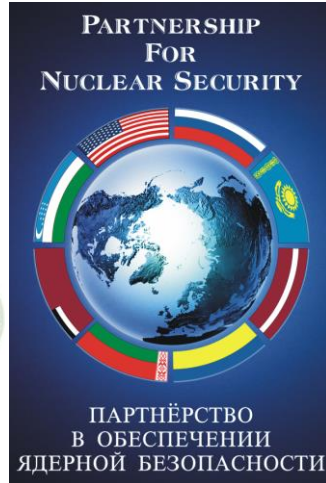
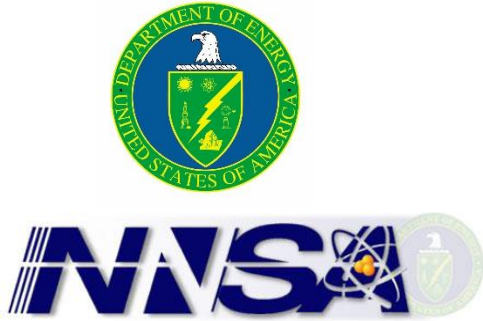


Dealing with Radiological Terrorism



U.S. AND INTERNATIONAL **NONPROLIFERATION** PROGRAMS

Path 1: Nuclear Material Protection, Control and Accounting (MPC&A)



Path 3: International Agreements & Monitoring



Path 2: Control of WMD Expertise



Iran



STUXNET



North Korea



Nuclear weapons: Positives

No accidents!

No uses in wars!

Nuclear Deterrent. So far...

Nukes forever?

NUCLEAR WORLD

RISKS vs. BENEFITS

BENEFITS: POWER PRODUCTION

- Widely used for electricity production
- Environmentally friendly
- Can become a key source of energy
- On the way to satisfy transportation (electric cars)

RISKS: PROLIFERATION OF NUCLEAR WEAPONS

- How to minimize them?
 - **DISCOURAGE** countries from nuclear weapon programs.
 - **CONTROL** nuclear materials and quickly discover their theft.
 - **PROTECT** nuclear materials physically at nuclear facilities.

BALANCING RISKS AND BENEFITS
IS AN ONGOING GAME...





***Text me your questions and
comments, now or later...***



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