



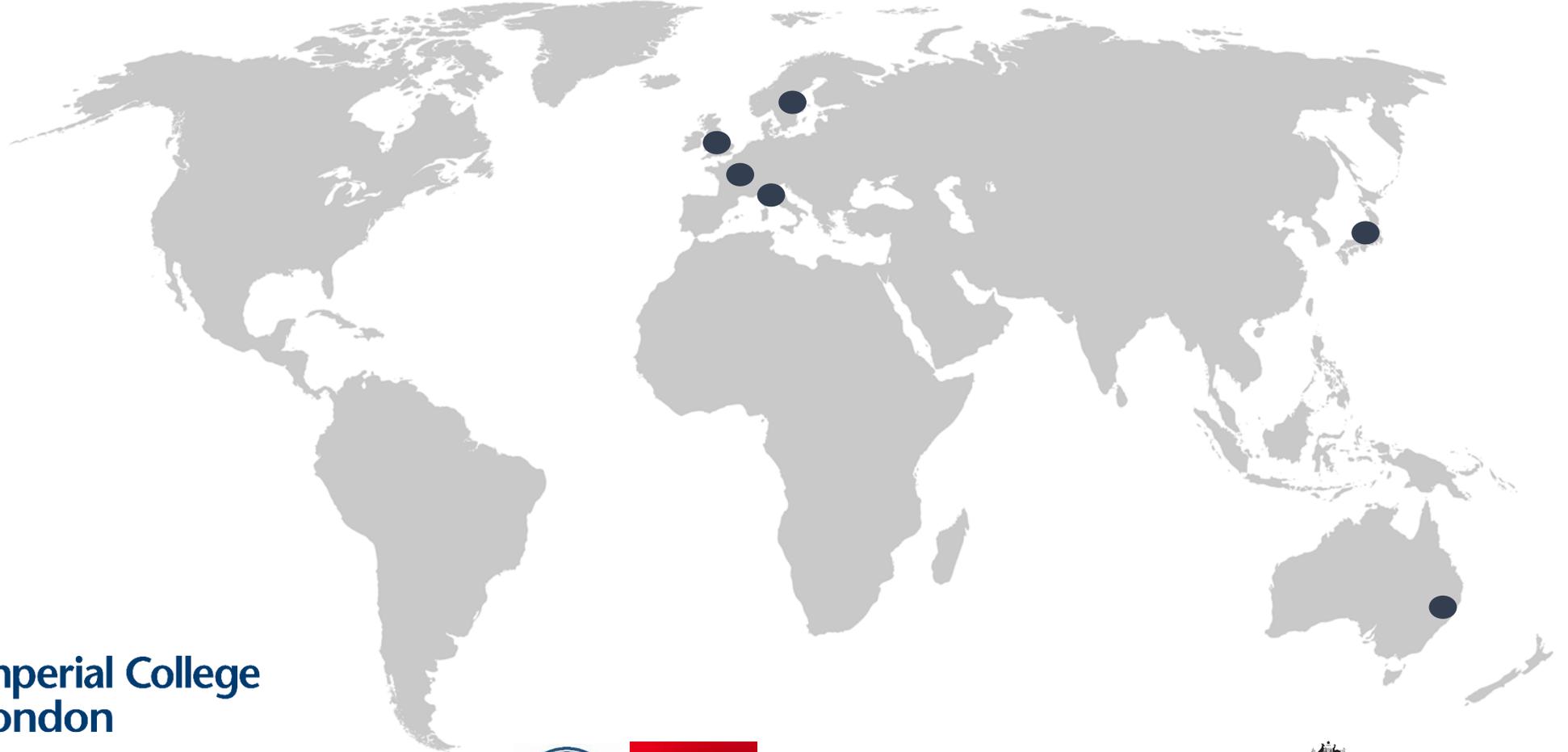
The diverse world of nuclear

Dr. Claudia Gasparri

Associazione Italiana Nucleare

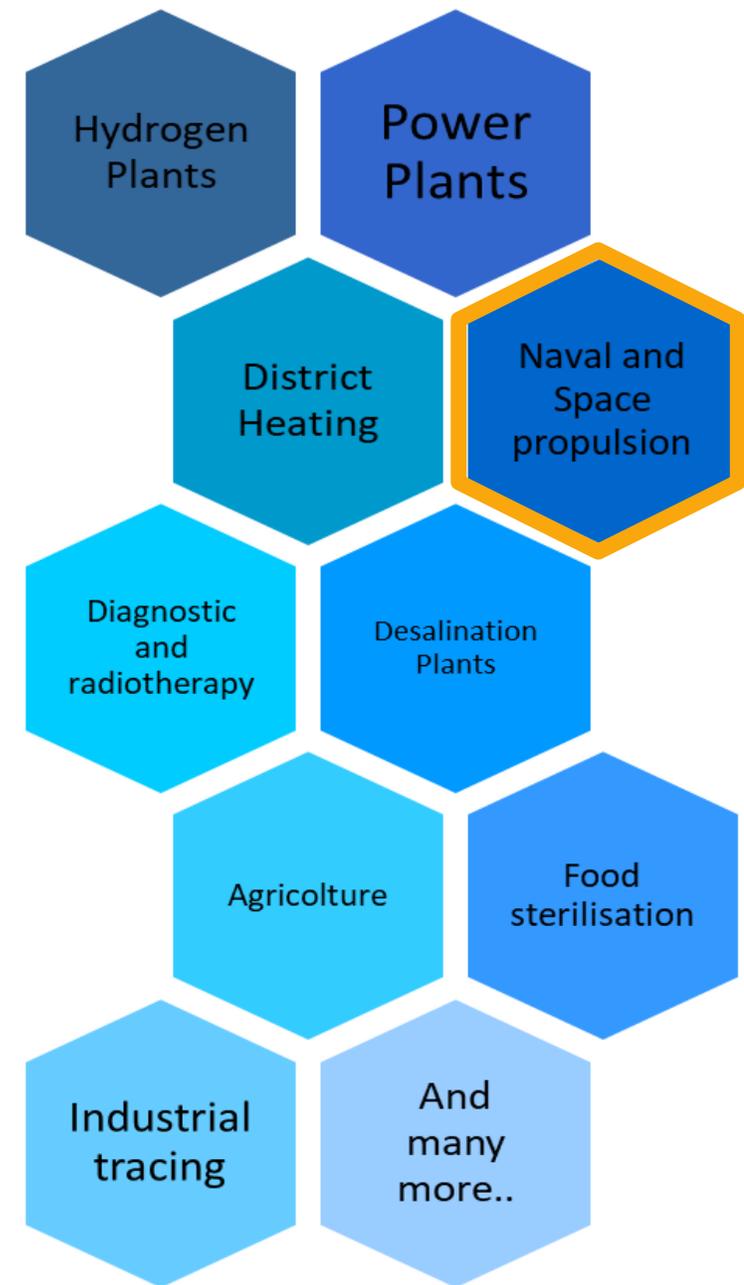


My background: nuclear fission and fusion



Nuclear

One technology, several solutions
for energy & electricity,
environment, medicine, food and
industry!





CO₂ Emissions

Electricity and heat



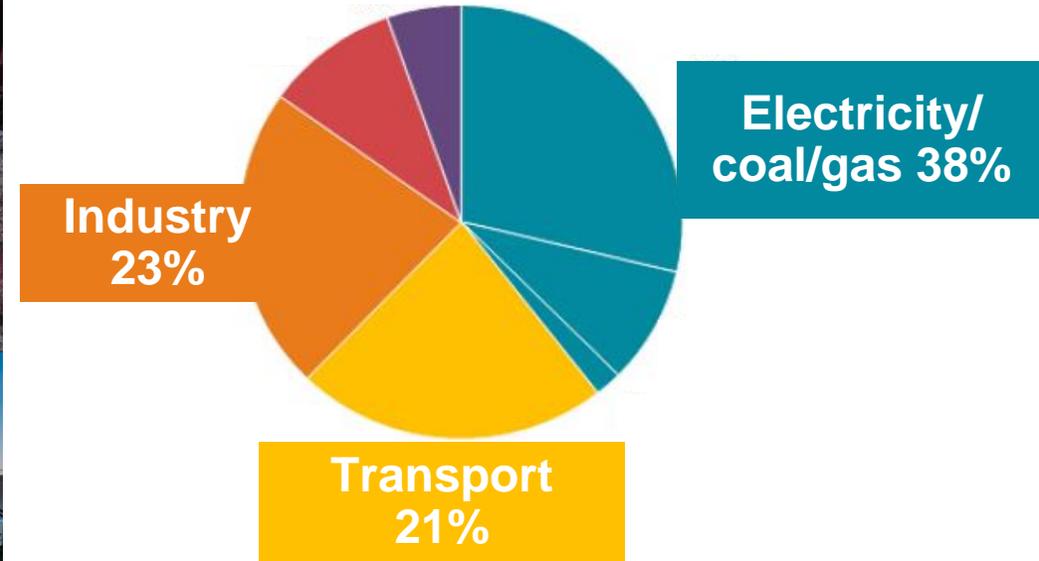
Industry



Transport



Global CO₂ emission by sector



IEA. All rights reserved.

<https://www.iea.org/data-and-statistics/data-browser/?country=WORLD&fuel=CO2%20emissions&indicator=CO2BySector>
core.windows.net/assets/ccdcb6b3-f6dd-4f9a-98c3-8366f4671427/The_role_of_CCUS_in_low-carbon_power_systems.pdf



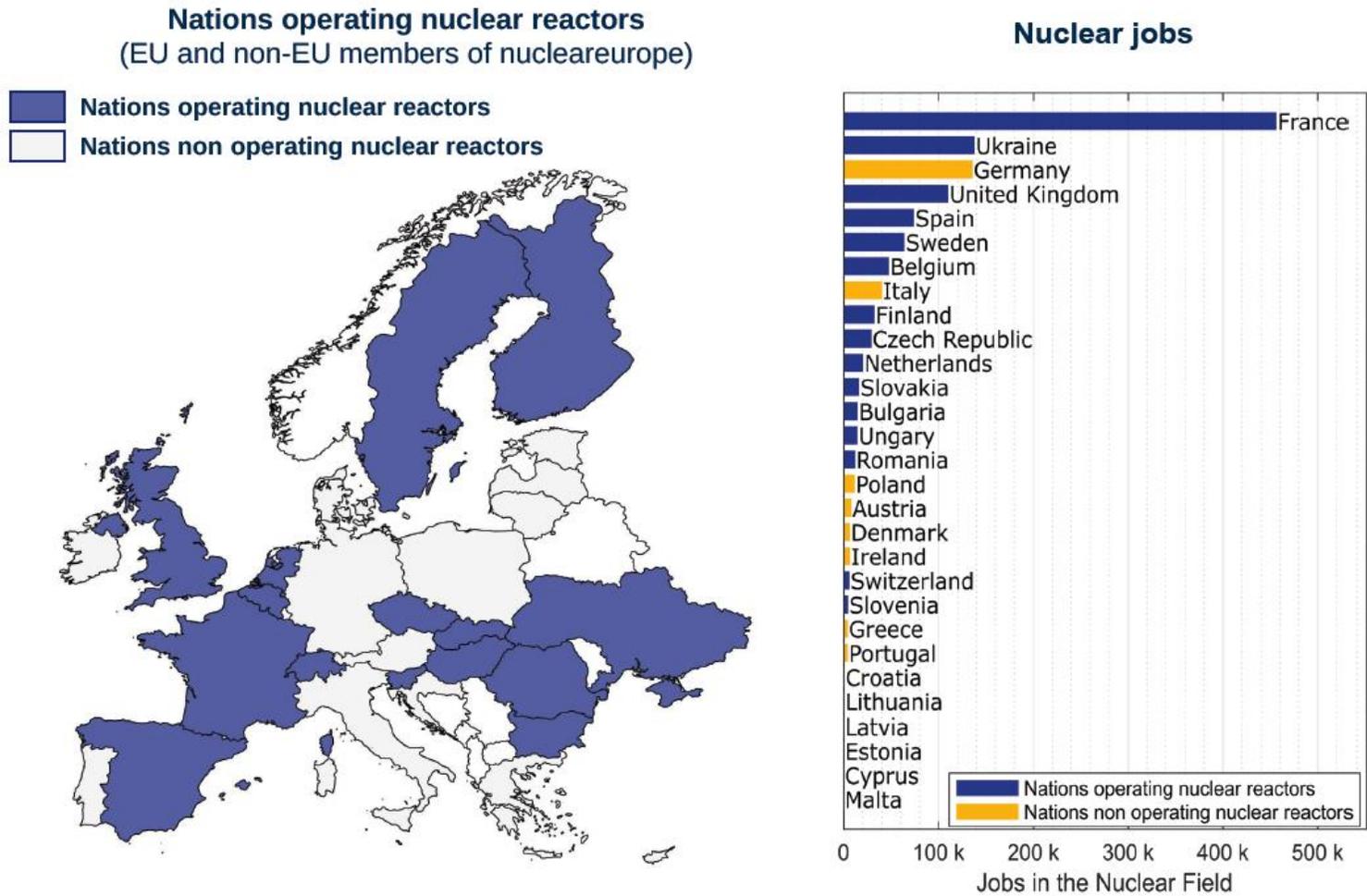
Nuclear power plants operating in the world



**Nuclear fission:
10 % total electricity
30 % low carbon electricity**



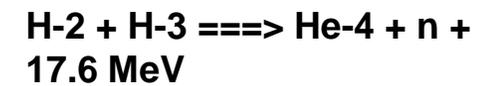
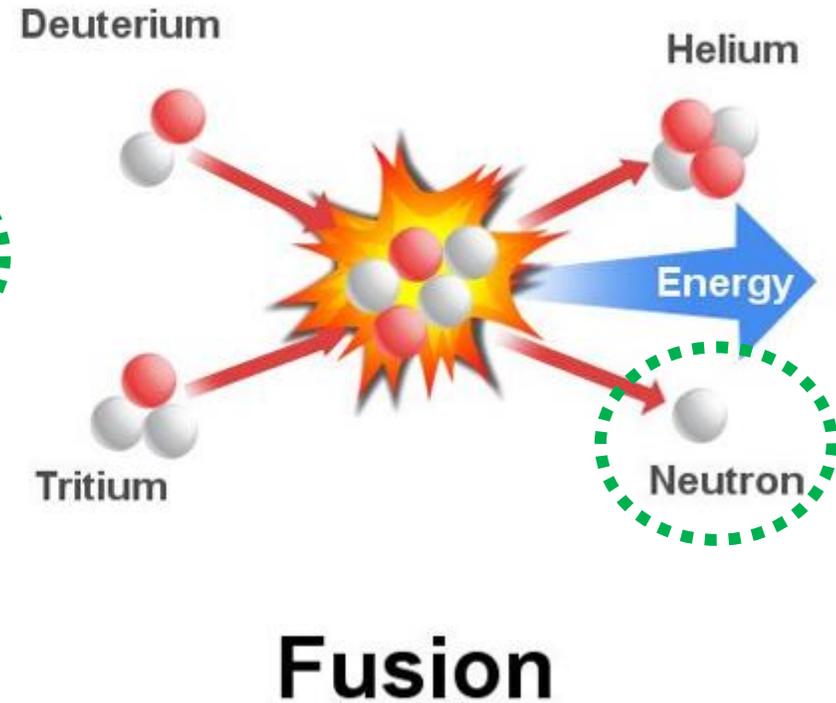
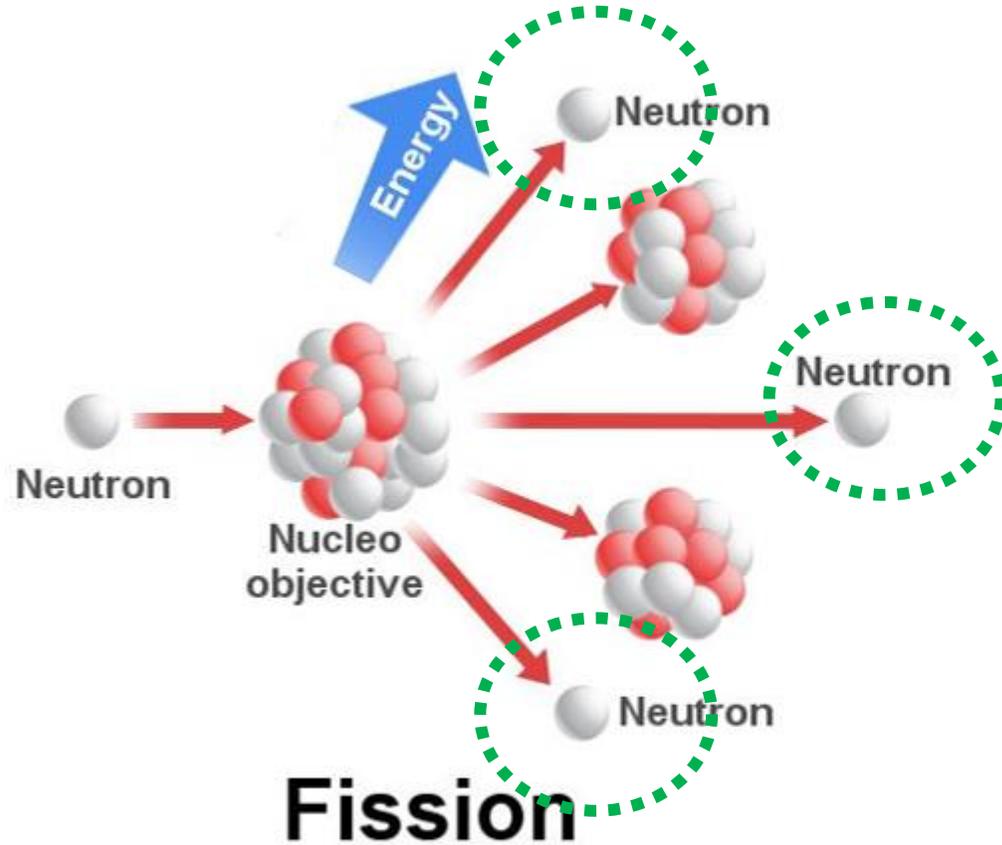
Nuclear in Europe: jobs



Associazione Italiana Nucleare Position Paper Figures. www.associazioneitaliananucleare.it



Nuclear fission and fusion





Nuclear technology needs

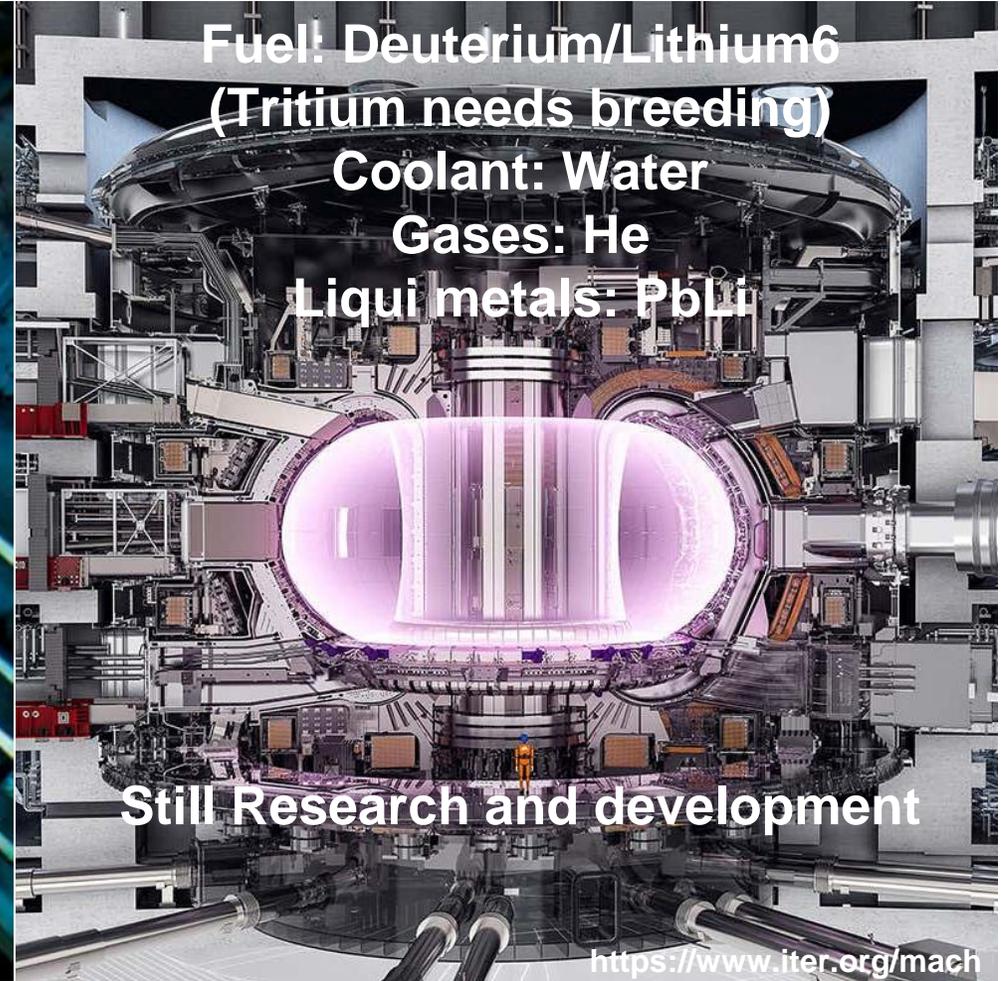


Fuel: Uranium/Thorium
Coolant: Water/Deuterated water
Gases: He or CO₂
Liqui metals: Na (NaK), Pb (PbBi)
Molten salts: FLiNaK, FLiBe
Operation since the 1950s

Research and development on current reactors, Gen IV and space applications

Fission

Traditional and Innovative



Fuel: Deuterium/Lithium6 (Tritium needs breeding)
Coolant: Water
Gases: He
Liqui metals: PbLi

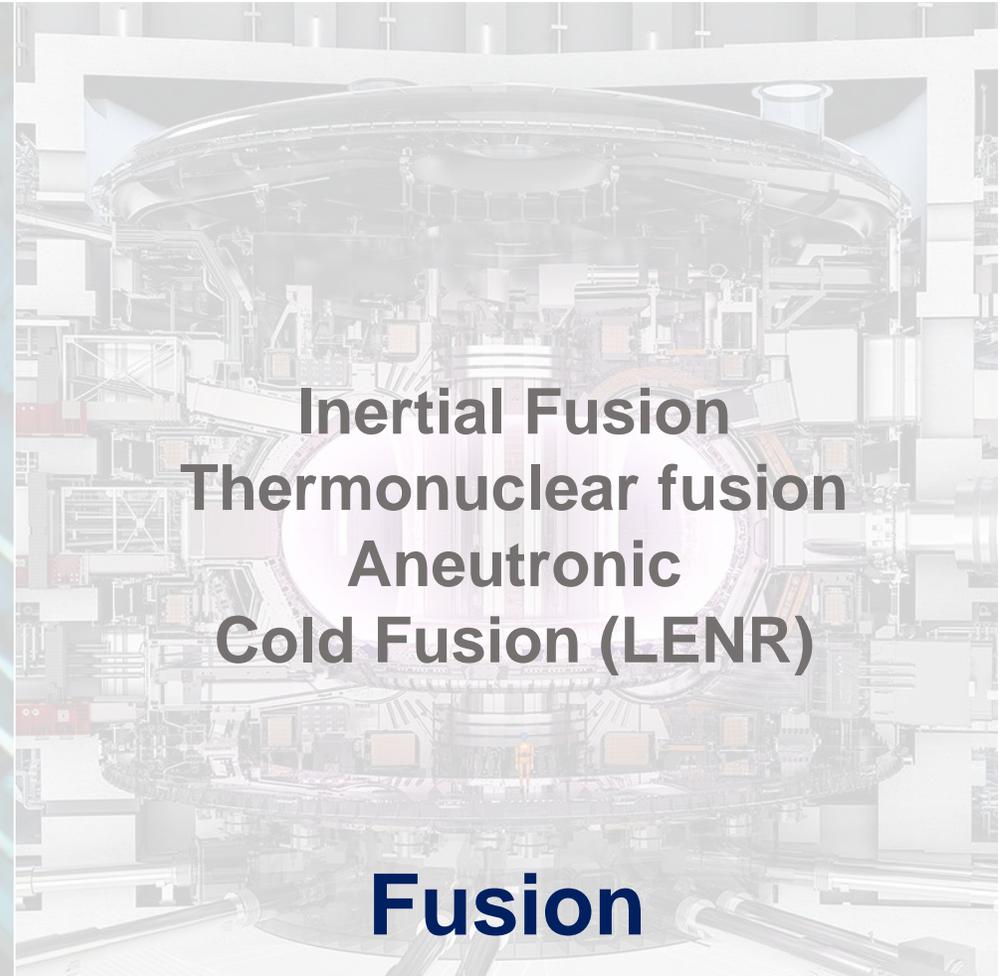
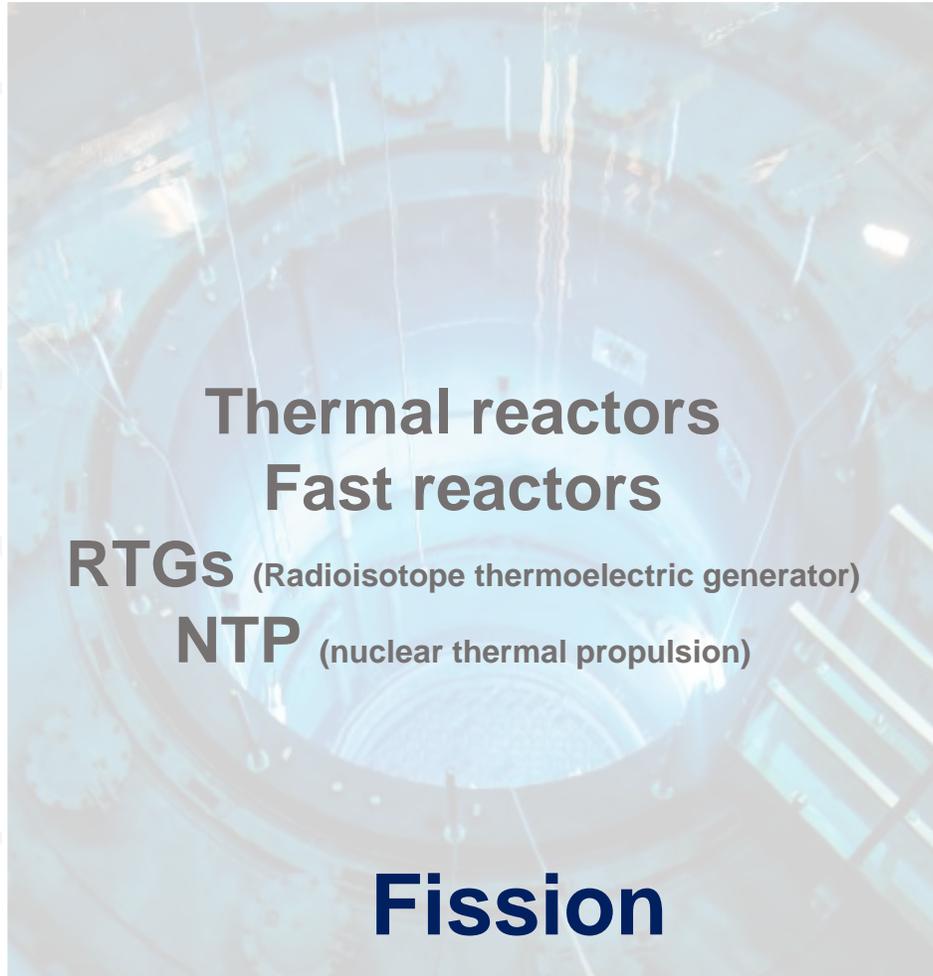
Still Research and development

<https://www.iter.org/mach>

Magnetic confinement fusion

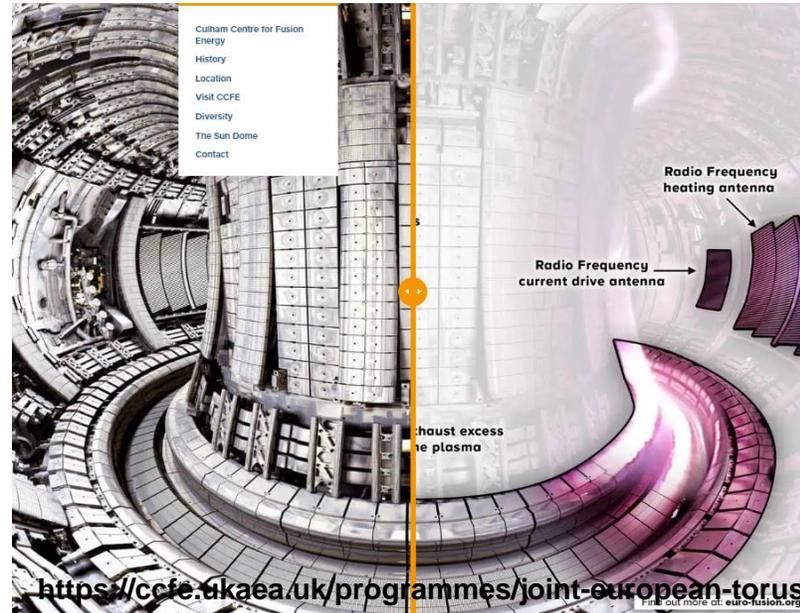


Nuclear types

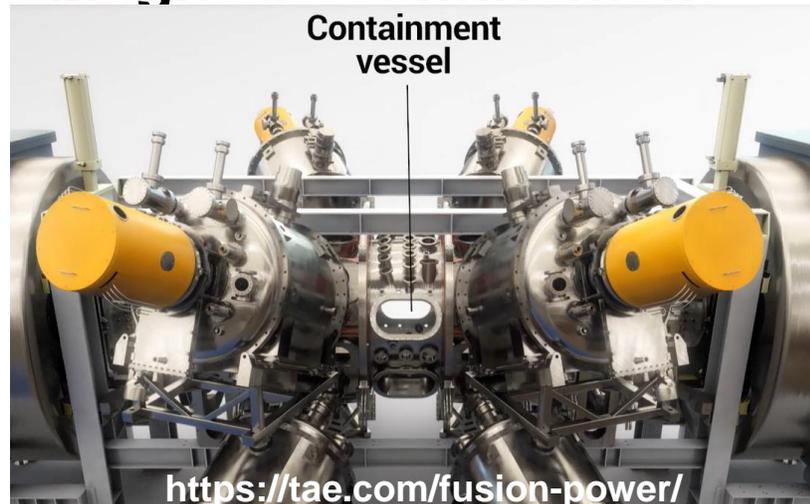




Nuclear fusion



Magnetic confinement



Aneutronic



Inertial

Next presentations!

LENR

Nuclear fission



Traditional



Evolutionary



Small and Modular



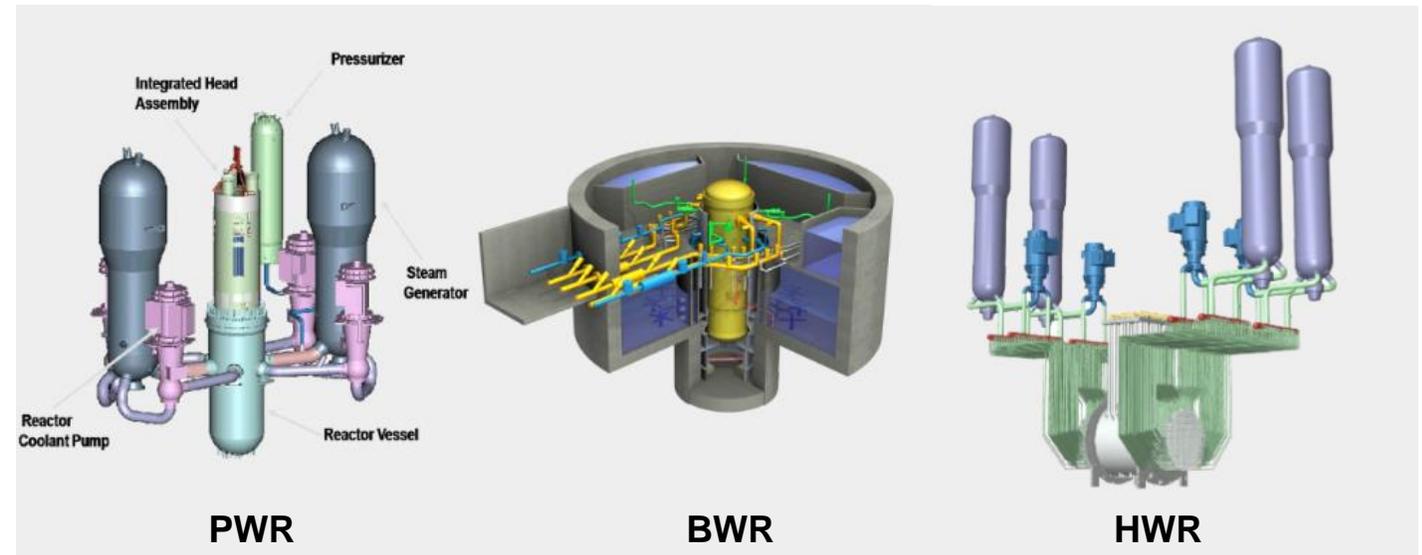
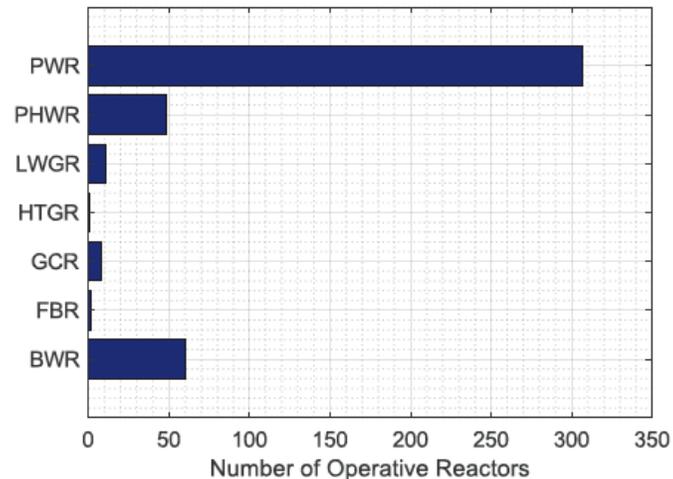
Innovative



Traditional Nuclear

Most reactors worldwide are water cooled

Baseload source of energy and electricity



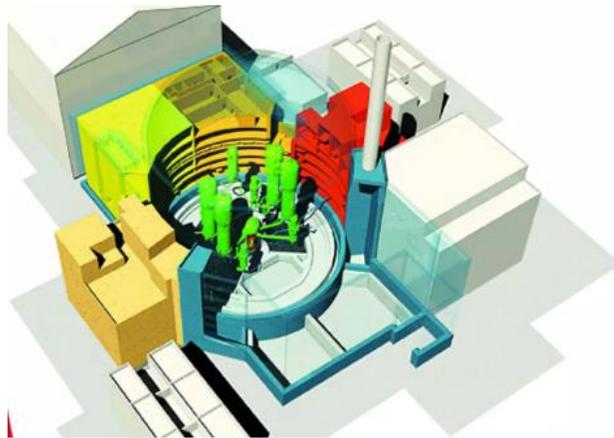
<https://aris.iaea.org/>



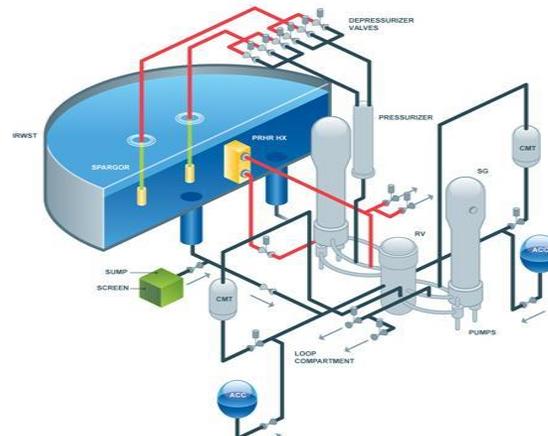
Evolutionary nuclear

Gen III reactors are being built and operated in France, Finland, US, UAE, UK, ..

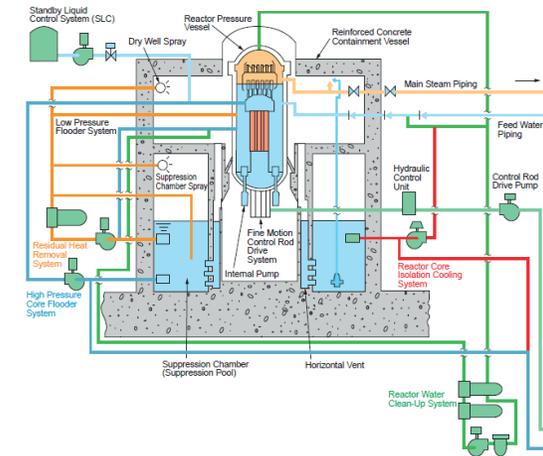
Baseload source of energy and electricity, improved performance
1000 – 1600 MWeI



<https://www.slideshare.net/AREVA/epr-the-1600-mwe-reactor-2009-issue>



<https://www.westinghousenuclear.com/energy-systems/ap1000-pwr/safety/passive-safety-systems>

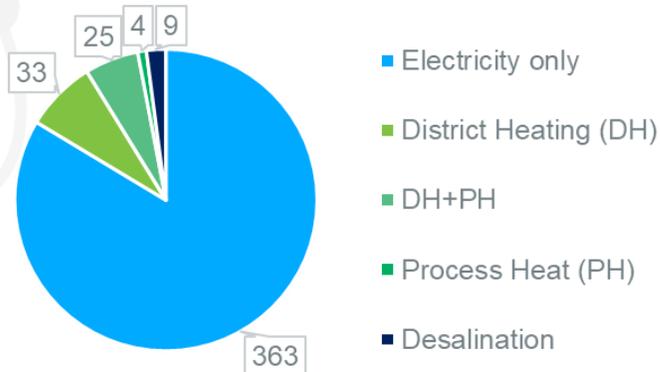


<http://www.hitachi-hgne-uk-abwr.co.uk/downloads/abwr-diagram.pdf>



Innovative Nuclear

Gen IV reactors (lessons learnt from reactors being developed in 1950s-60s): uranium reuse and recycle, new fuel production, high temperature steam and fluids, consume nuclear waste



Source: Nuclear Power Reactors in the World, IAEA, RDS No.2, 2022 Edition

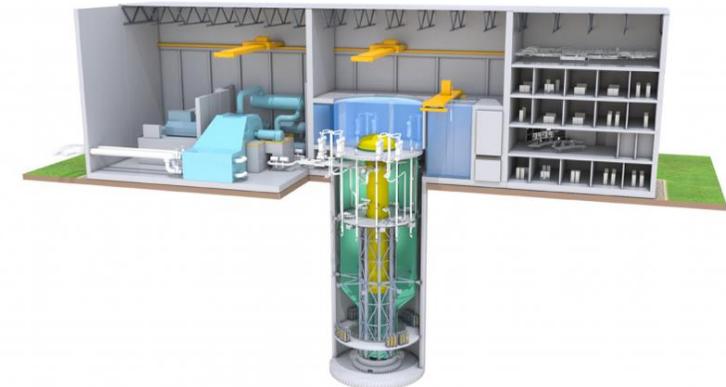
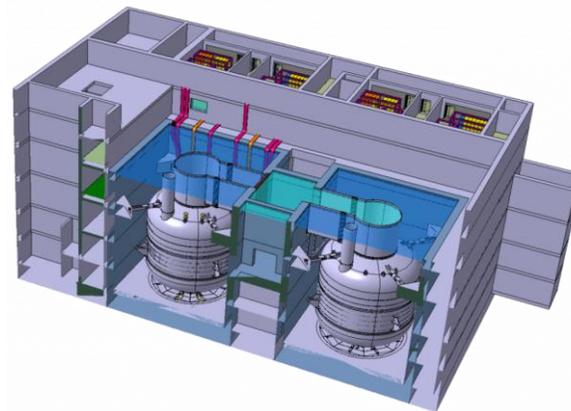
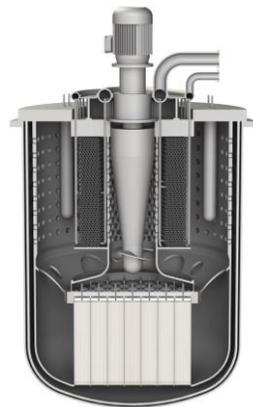
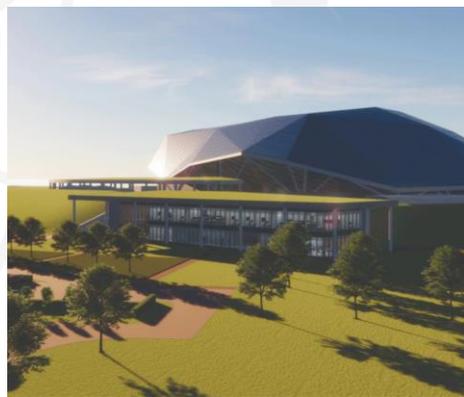




Small Modular Reactors

New business models (attract private investments)
Small, safe and modular

From 5MWe1 to 450 MWe1
1-2 Billions \$ (*)



<https://www.rolls-royce.com/innovation/small-modular-reactors.aspx>

<https://www.newcleo.com/>

<https://www.nuward.com/en>

<https://nuclear.gepower.com/bwr-x-300>

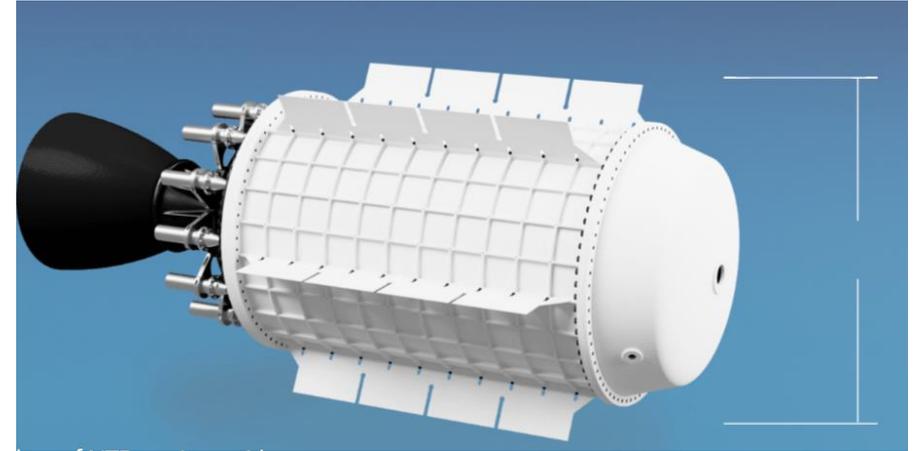


Microreactors and space propulsion



1 – 20 MWth
**Application in remote areas or
transport**

<https://www.energy.gov/ne/articles/infographic-what-nuclear-microreactor-0>



**Nuclear space propulsion to shorten
Moon – Mars trips**

<https://www.usnc.com/ntp/>



Nuclear maritime applications



N.S. Savannah was built in 1959 under the Atoms for Peace program but was never optimized for long-haul cargo



Russian Akademik Lomonosov icebreaker is currently in operation

Many sizes and types: 6 MWeI, 35 MWeI, 125 MWeI



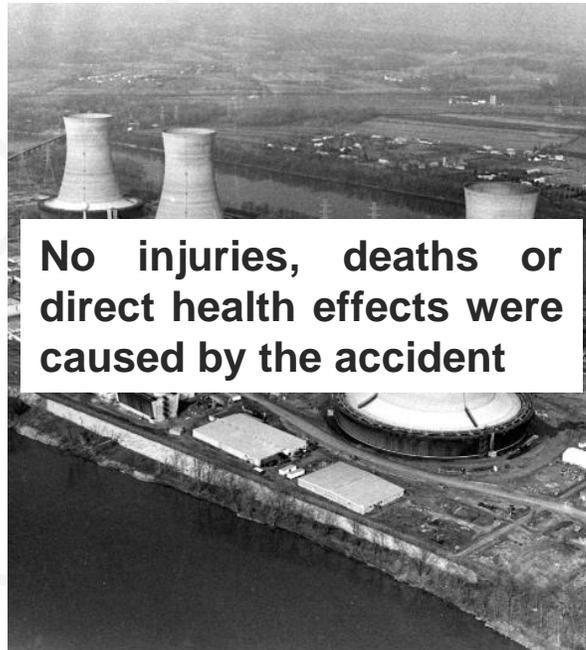
Nuclear power plants accidents

United Nations Scientific
Committee on the Effects of
Atomic Radiation

SOURCES, EFFECTS AND RISKS OF IONIZING RADIATION

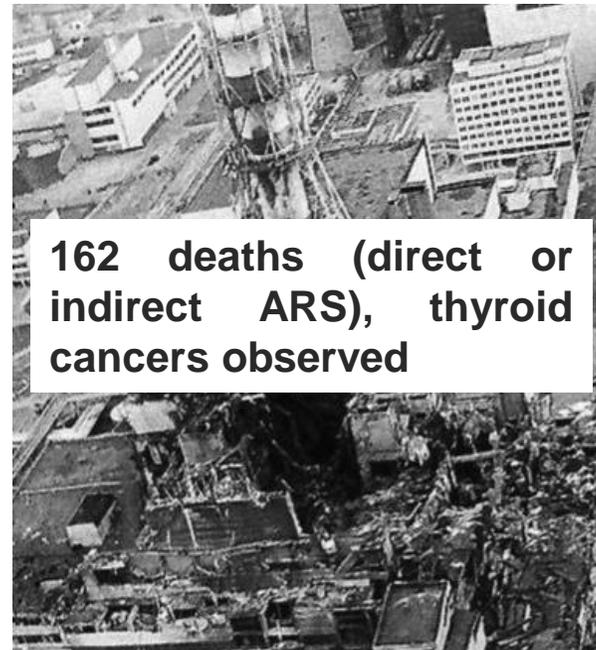
UNSCEAR **2020/2021 Report**

HEALTH EFFECTS IN EMERGENCY AND RECOVERY WORKERS*			
Early	ARS	134	None
	Deaths attributable to ARS ^a	28	None
Late	ARS survivors	Skin injuries and radiation induced cataracts. Some increases in other diseases probably due to ageing and other factors not attributable to radiation	Not applicable
	Other emergency and recovery workers	Evidence of a dose related increase in the incidence of leukaemia and cataracts among those who received higher doses; no evidence of other health effects that can be attributed to radiation exposure	None to date (Nuclear Emergency Workers Study ongoing)



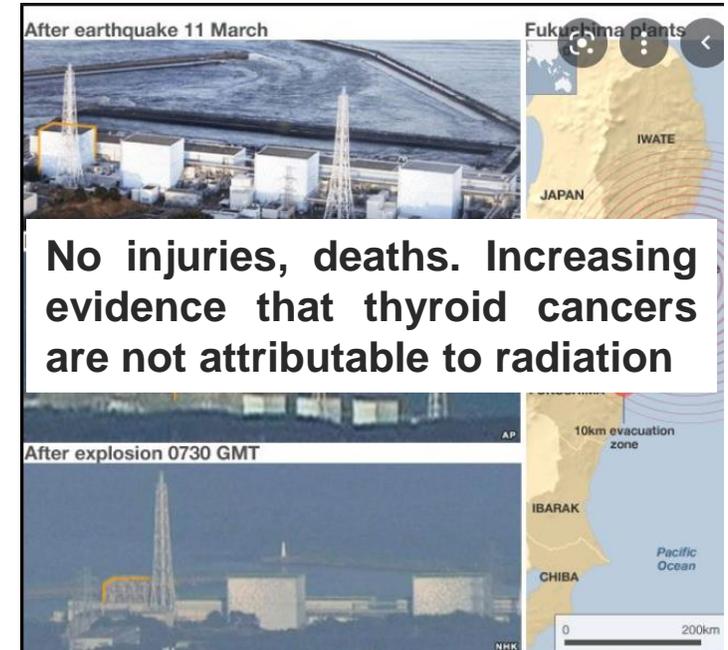
No injuries, deaths or direct health effects were caused by the accident

Three Mile Island 28th March 1979



162 deaths (direct or indirect ARS), thyroid cancers observed

Chernobyl Accident 26th April 1986



No injuries, deaths. Increasing evidence that thyroid cancers are not attributable to radiation

Fukushima Accident 11th March 2011

<https://www.pennlive.com/news/2019/03/three-mile-island-40-years-later-a-timeline-of-events-as-they-occurred-on-march-28-1979.html>

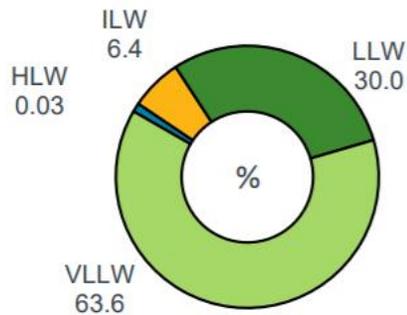
<https://www.sciencedirect.com/science/article/pii/S1350448712001680>

ARS: Acute Radiation Syndrome



Nuclear waste

An example: the total amount of radioactive waste in the UK considering the waste already stored and the waste that is going to be produced until 2125 would occupy a volume = Wembley stadium



Total reported volume = 4,490,000 m³



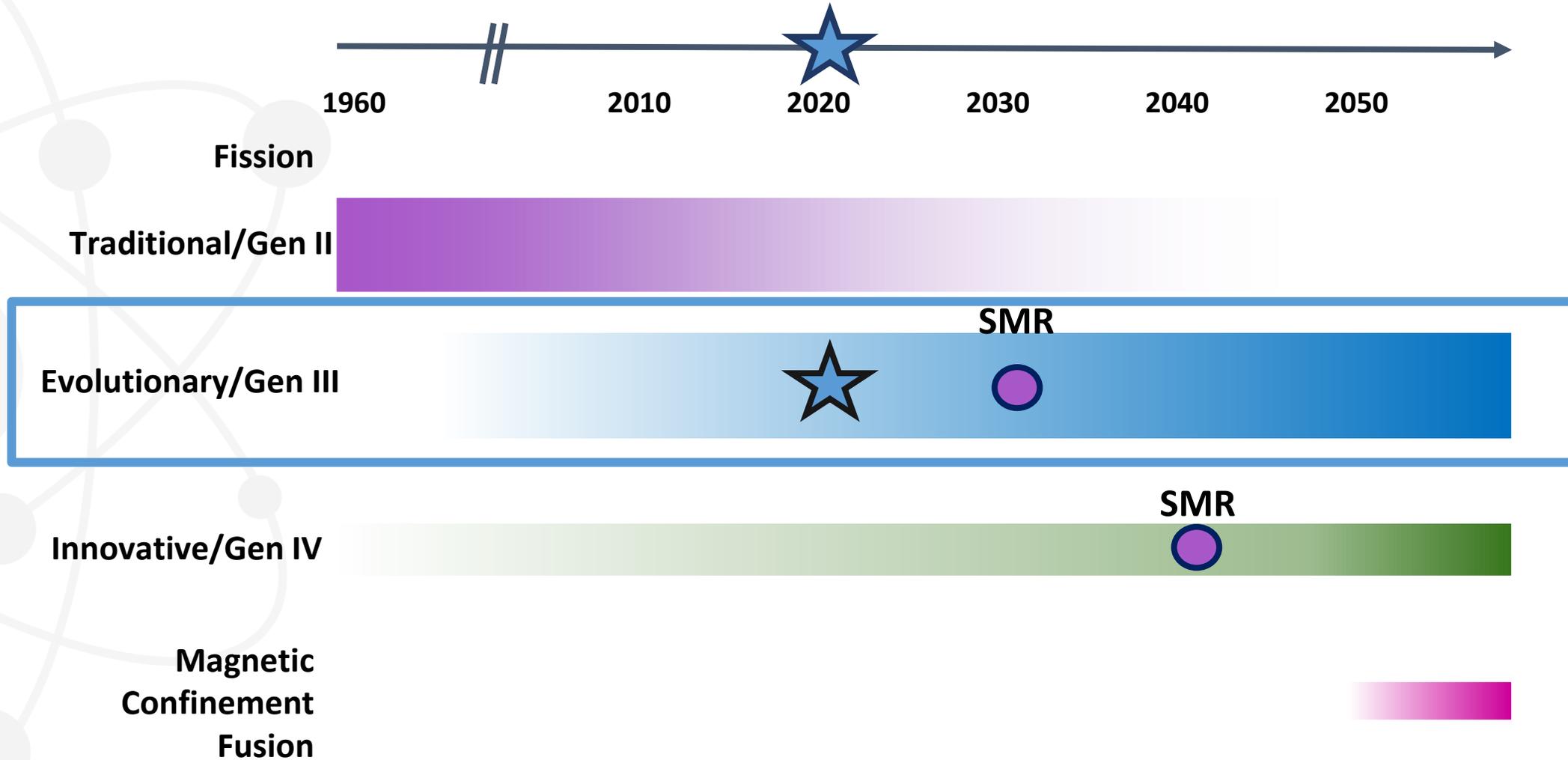
Vitrified Product Store for HLW canisters



<https://ukinventory.nda.gov.uk/wp-content/uploads/sites/18/2014/01/2016UKRWM-UK-Radioactive-waste-inventory-report.pdf>



Nuclear readiness (*)



(*) many private companies are stating different timescales, technology is yet to be proven



The diverse world of nuclear

Thank you!

Dr. Claudia Gasparri



Nuclear is dense

Land Use by Energy Source
acres per million megawatt-hours

