# Nuclear: Why small is beautiful

## Oxford Energy Seminar Series – 21 May 2024

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# Introduction

# A *new*, innovative player in nuclear energy

**REACTOR DESIGN:**

**Small Modular (SMR) + Lead-cooled Fast Reactors (LFR) = AMR**

*new*cleo is working to design, build, and operate Gen-IV Advanced Modular Reactors (AMRs) cooled by liquid lead

**FUEL MANUFACTURING:**

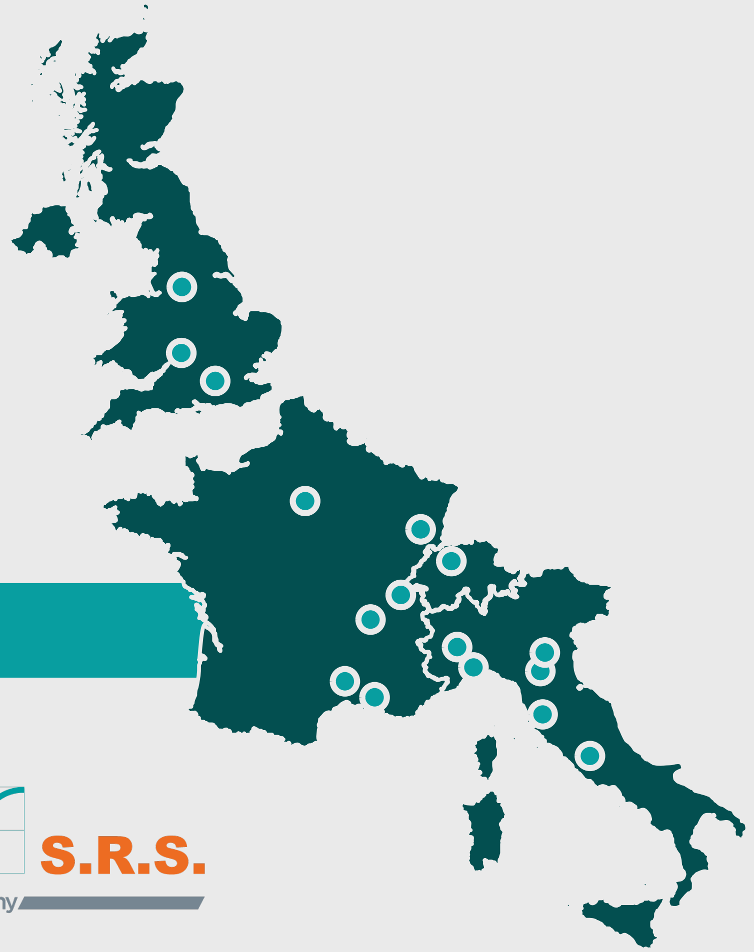
**Mixed Uranium Plutonium Oxide (MOX)**

MOX and Fast Reactors allow the multi-recycling of nuclear waste into new fuel with no new mining for generations

**SAFE AND AFFORDABLE** | **CLEAN AND RELIABLE** | **CIRCULAR**

Launched in **SEPTEMBER 2021**

Presence across **Europe**



**ACQUISITIONS**

FUCINA ITALIA – A newcleo company

S.R.S. – A newcleo company

RÜTSCHI – A newcleo company

**700** EMPLOYEES

**25+** YEARS OF RESEARCH

**14+** PATENTS

**EUR400+ MILLION** of private funds

**~EUR50 MILLION** turnover in **2024**

Currently raising up to **EUR1 BILLION**

# A long-term vision centred on safety and sustainability

**Reactor technology:**
**AMR: SMR - LFR**

## LEAD-COOLED

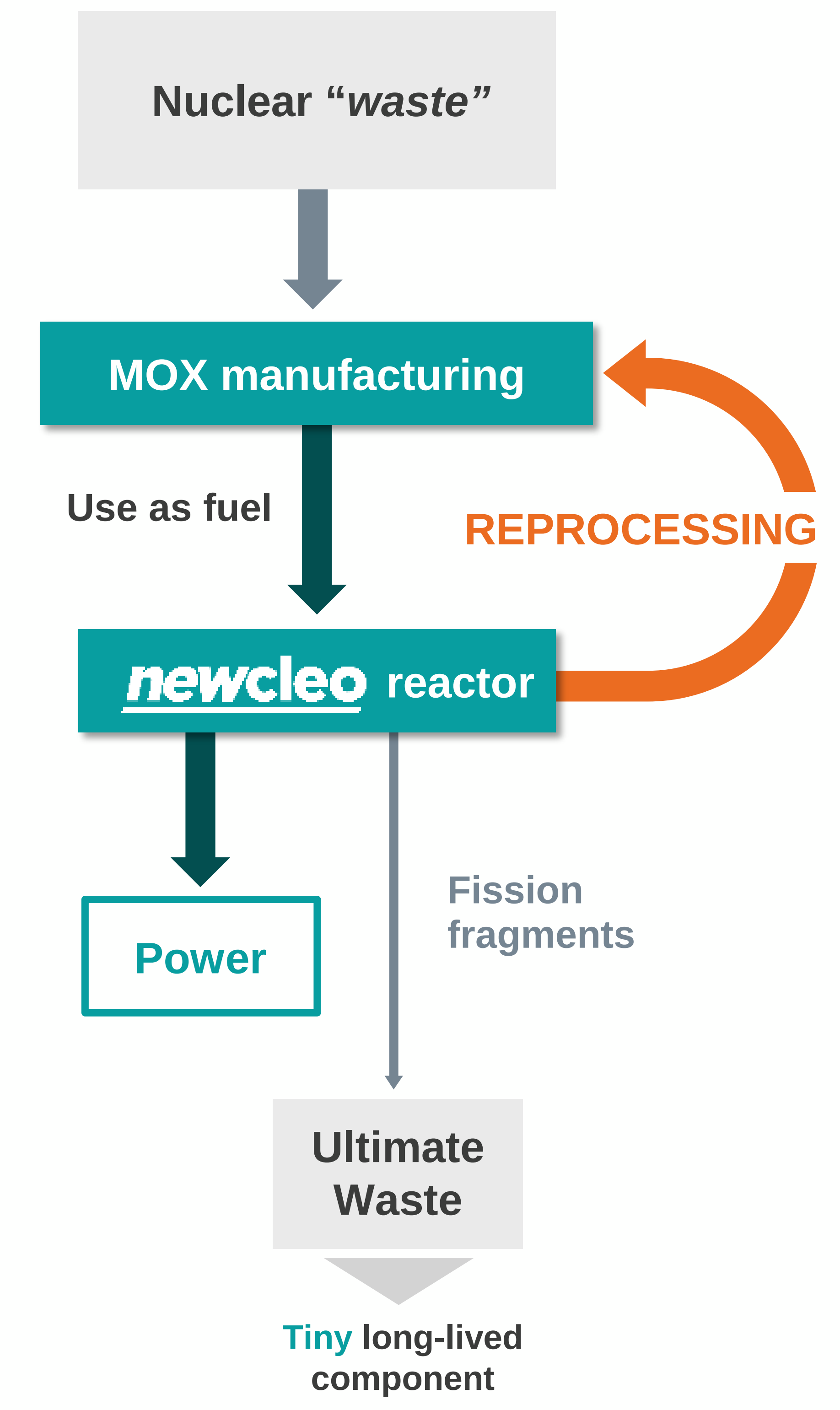
High performance | Compact and simple | Intrinsic safety

## FAST

Efficient use of uranium resources | Able to recycle reprocessed spent fuel

## SMALL MODULAR REACTOR

Plant manufactured | Site flexibility | Modularisation and economies of learning




**Fuel: MOX**

- A clean solution to the issue of costly and long-lasting nuclear **waste disposal**, using depleted uranium and plutonium that today have little use
- The **long-term strategy** will eliminate the need to mine new uranium, enable energy independence, and reduce the volume headed to geological repository
- Spent fuel will be **reprocessed** multiple times, reducing byproducts: less than **1t of fission fragments** from one year's generation by a 1GWe *new*cleo LFR vs. **199t** goes to waste from conventional reactors

# Short history of the Nuclear Industry

# The early years of nuclear energy

## 1896 - 1913

1896 – Bequerel discovers uranium ore emits energy

1898 – Marie and Pierre Curie coin the term ‘radioactivity’

1902 – Rutherford shows that emitting radiation changes the chemical element of a material

## 1913 - 1932

1913 – Rutherford and Bohr conceive new model of atom with electron orbiting nucleus

1932 – Chadwick discovers the neutron

## 1938

Hahn and Strassman demonstrate nuclear fission in uranium. Meitner and Frisch explain fission theoretically and discover that a huge amount of energy is released

## 1939

Discovered that fission releases extra neutrons that can trigger new fissions, the U-235 isotope is much easier to fission.

It is realised that a fission chain reaction in U-235 is possible and would release energy on an incredible scale.

## 1941

The UK concludes an atomic bomb is feasible. Churchill approves nuclear weapons programme under codename ‘Tube Alloys’. USA enters war and begins active development of an atomic bomb

## 1942

Manhattan Project commences, General Leslie Groves approves creation of sites at Los Alamos, Hanford and Oak Ridge. Fermi’s team construct world’s first nuclear reactor underneath the University of Chicago stadium.

## 1943

Oppenheimer leads laboratory at Los Alamos. Tube Alloys is merged with the Manhattan Project. Reactors at Oak Ridge and Hanford begin producing plutonium for atomic bombs.

## 1945

16 July – Oppenheimer tests first atomic bomb at Trinity site

6 August – ‘Little Boy’ bomb dropped on Hiroshima, Japan

9 August – ‘Fat Man’ bomb dropped on Nagasaki

## 1949

UK decides plutonium-producing reactors should also produce electricity

# Early nuclear power generation

## Magnox Reactors

**1956:** Queen Elizabeth II officially opens the world's first commercial power reactor at Calder Hall, Sellafield. Its primary purpose is production of plutonium for nuclear weapons, but it is also used to power the grid.

The Calder Hall reactor was the first 'Magnox' reactor. It used natural uranium metal as fuel, graphite as a moderator, and $CO_2$ gas for cooling.

**26 Magnox reactors were built from 1956-1971**, with the last one operating until 2015.

## 2nd Generation: Advanced Gas-cooled Reactor (AGR)

**1965:** the design for the UK's second phase of nuclear power is announced: the AGR.

The AGR design is an evolution of the Magnox, optimised for power generation and using enriched uranium fuel.

**14 AGR reactors were built across six sites between 1976-1988,** providing a power output of around 8.4GW. Four reactors are still operational and supply the UK grid, at Hartlepool, Heysham and Torness.

## 3rd Generation: Pressurised Water Reactors

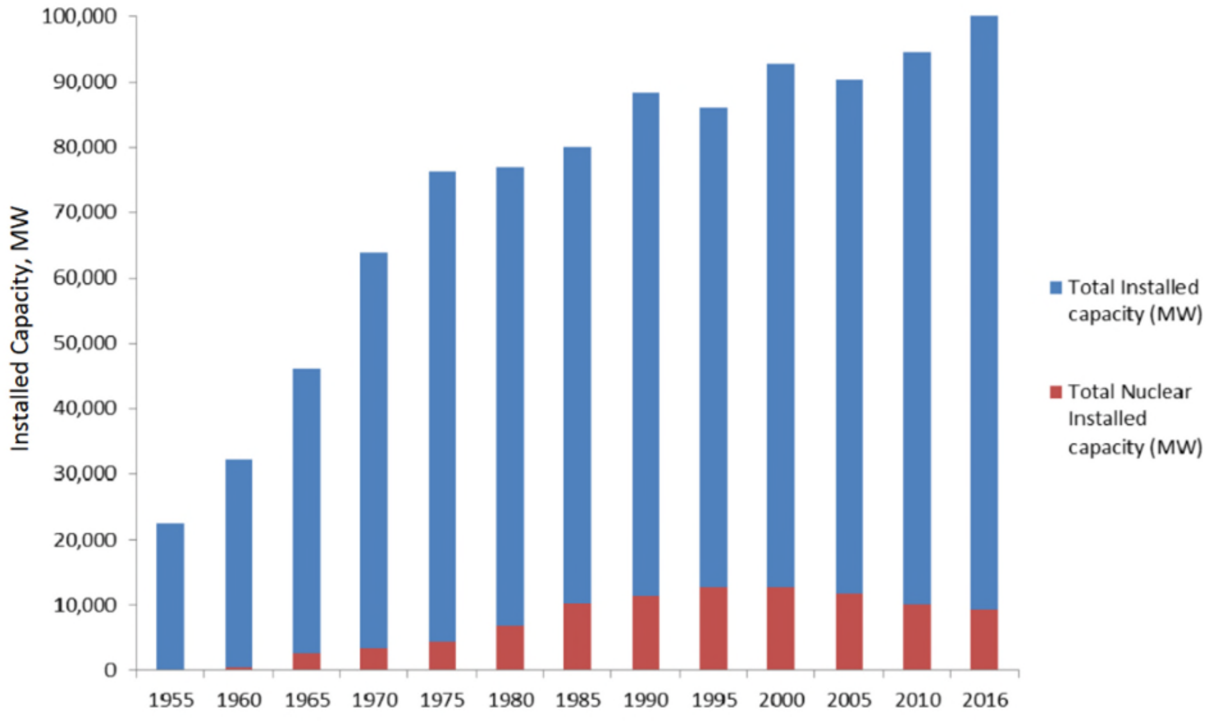
**1979:** the government proposed a third-generation fleet of **10** PWRs, to be built between 1982 and 1992, providing 8GW of power to the grid. This design was a huge advance on the AGR and uses water as both coolant and moderator.

The 2-year 1983 Sizewell B public enquiry was the most expensive in the UK's history.

Whilst Sizewell B was built and began operating in 1995, after Chernobyl (1986), plans for the 9 other sites were scrapped.

**Meanwhile in France…** a total of 70 reactors were built from 1959 to 1999 with a total of nearly 67GW capacity!

# UK Nuclear capacity peaked around the turn of the millennium




UK Nuclear Power as a proportion of total capacity, BEIS

## A new framework for UK nuclear was created which led to Hinkley Point C and Sizewell C

**2007 Energy White Paper**

AREVA

Westinghouse

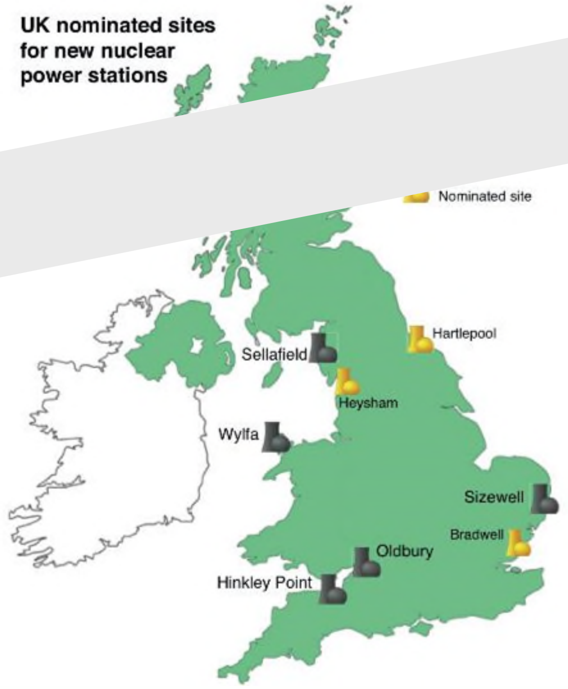
Environment Agency

ONR Office for Nuclear Regulation

**2007 EPR and AP1000 GDA Commenced**

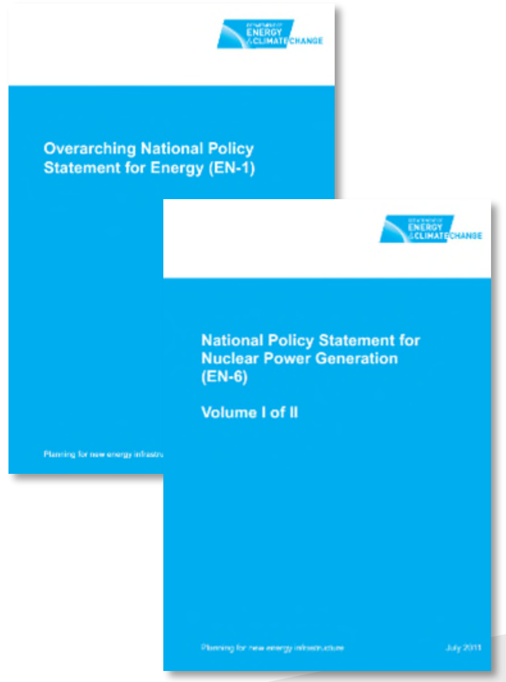
**2008 – 2009 Developer Landscape Emerges**

- Sites Exchange Hands
- Developers Nominate Sites into SSA Process
- "Big Six" Backed




**11 Mar 2011 Fukushima Daiichi**

Merkel announces phase out of Nuclear in Germany




**2011 National Policy Statements**

8 Site Nominated for Nuclear Development

e.on RWE HORIZON NUCLEAR POWER EDF centrica ENGIE IBERDROLA sse NU'GEN

**2011 – 2013 Developer landscape transitions from "Big Six" backed to "Equipment" backed**


- In 2016, the UK Government finally supported Hinkley Point C with a Contract for Difference and EDF/ CGN took a Final Investment Decision for construction of two PWR units, to generate 3.2 GWe, began in March 2017
- In November 2022, the UK Government announced direct investment in Sizewell C – a close replica of Hinkley Point C

# The nuclear fuel cycle and waste

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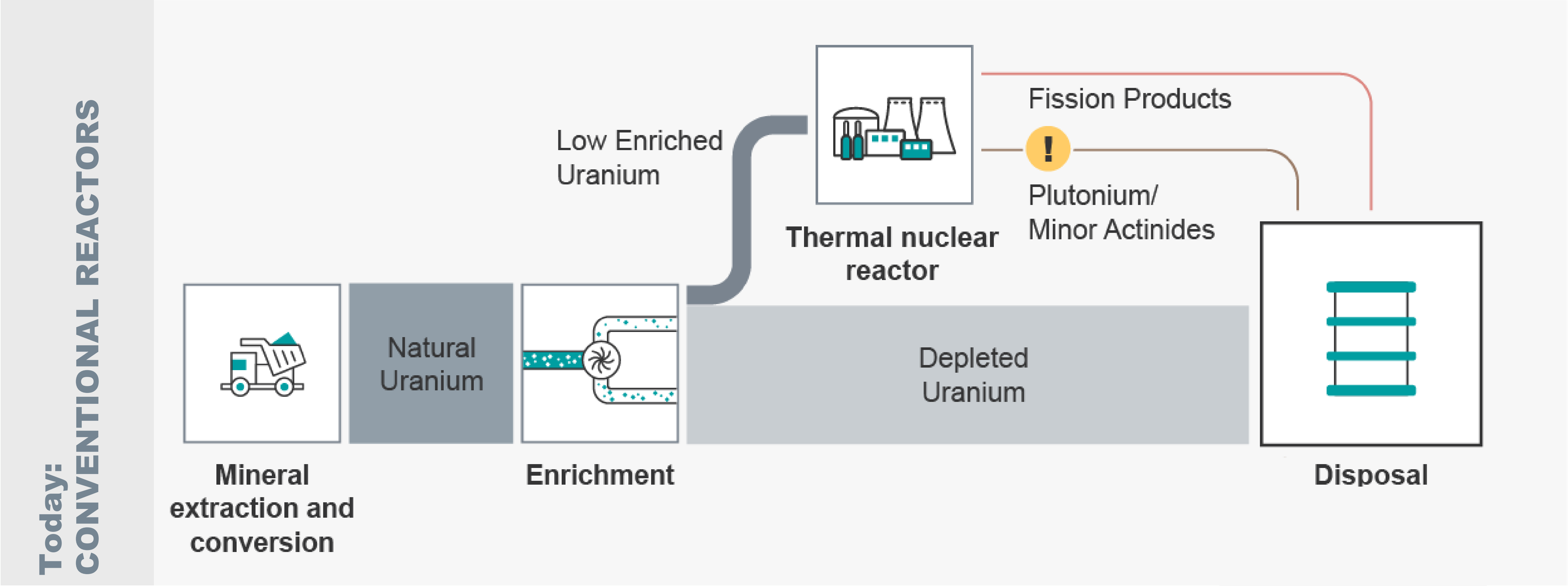
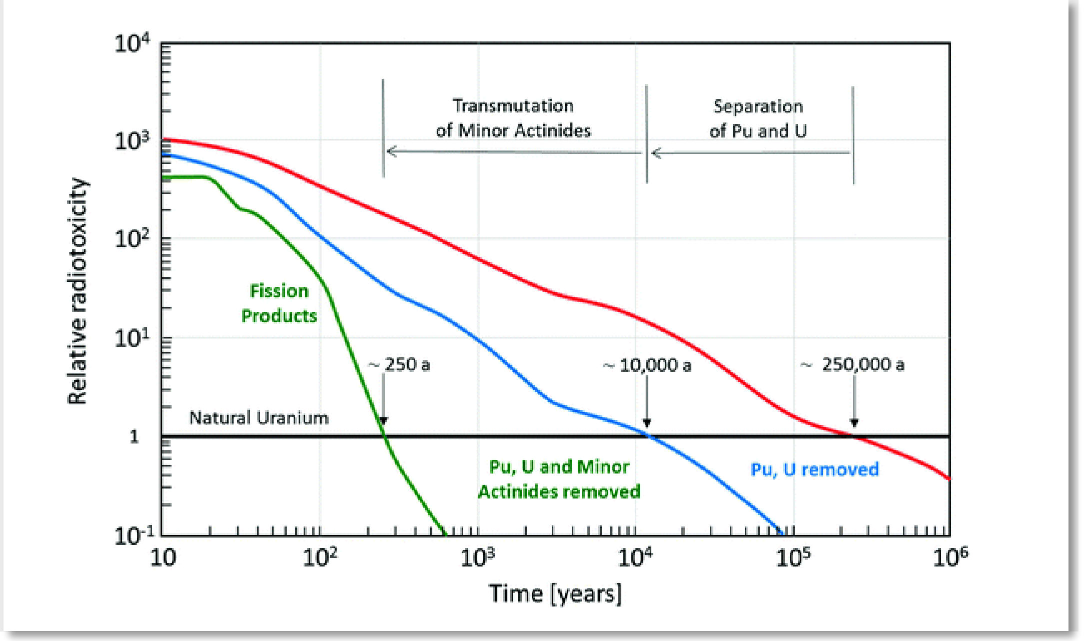
# The nuclear fuel cycle

An open fuel cycle requires the mining of uranium, and results in disposal of 'waste' fuel after use.




**Thermal fission reactors use a very small portion of the extracted uranium:** an average 1GWe LWR uses every year 200t of mined uranium of which only 1t is fissioned (Fission Products), the rest is not used

**Managing the long-term responsibility**

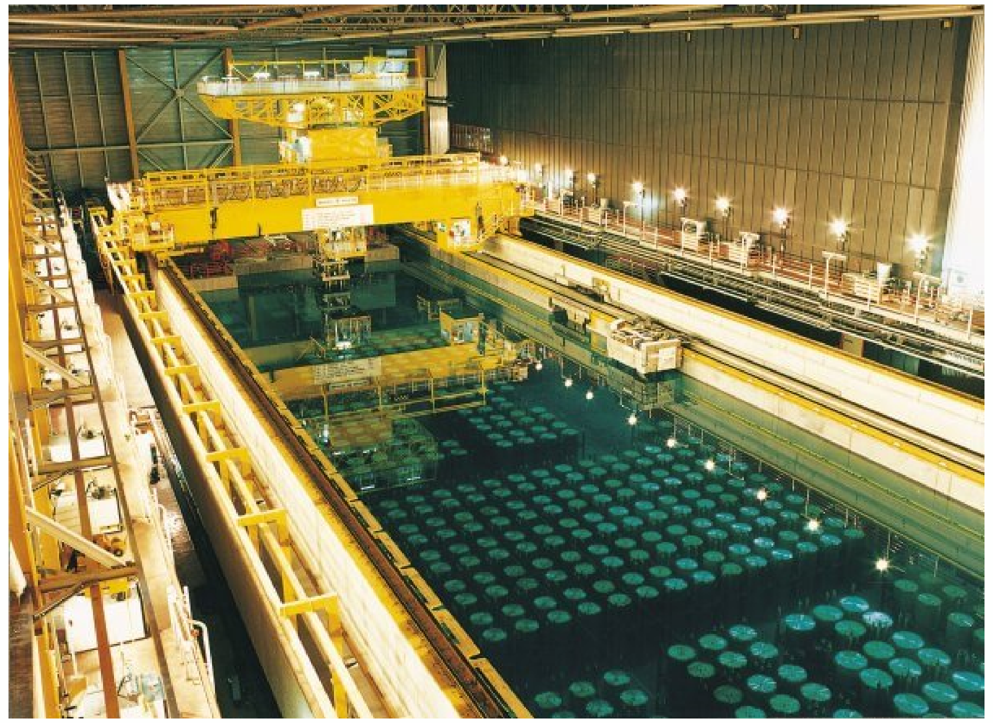



Currently, spent fuel is stored in drums and kept in pools to reduce the activity, while waiting for long term disposal at a Geological Disposal Facility.

The Nuclear Provision is the best estimate of how much it will cost to clean up 17 of the UK's earliest nuclear sites over a programme lasting around 120 years. The estimate is based on the expected costs of:

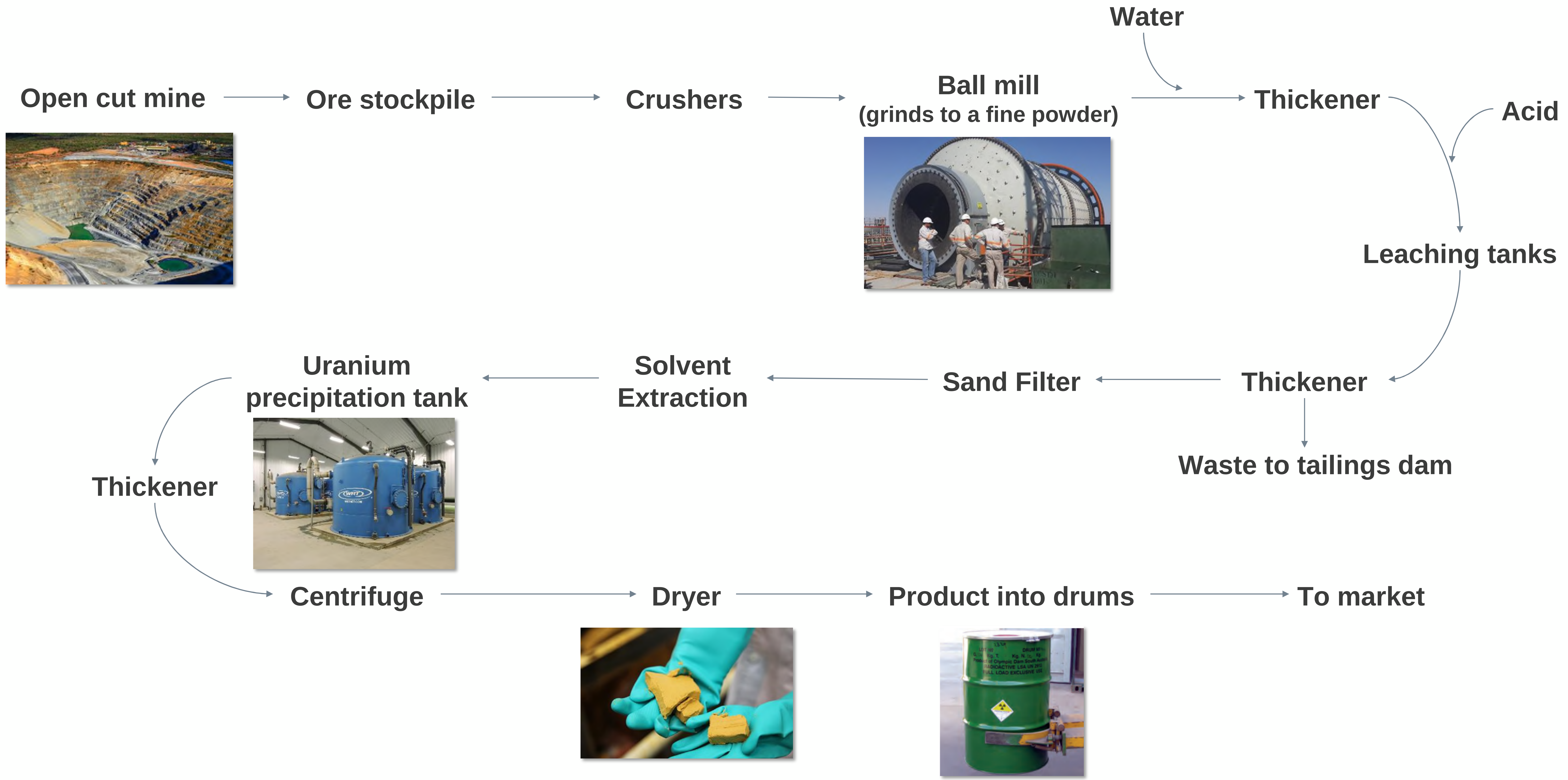
- decommissioning
- dismantling and demolishing the buildings
- managing and disposing of all waste
- remediation of land

The NDA has estimated this cost to be around £130 billion

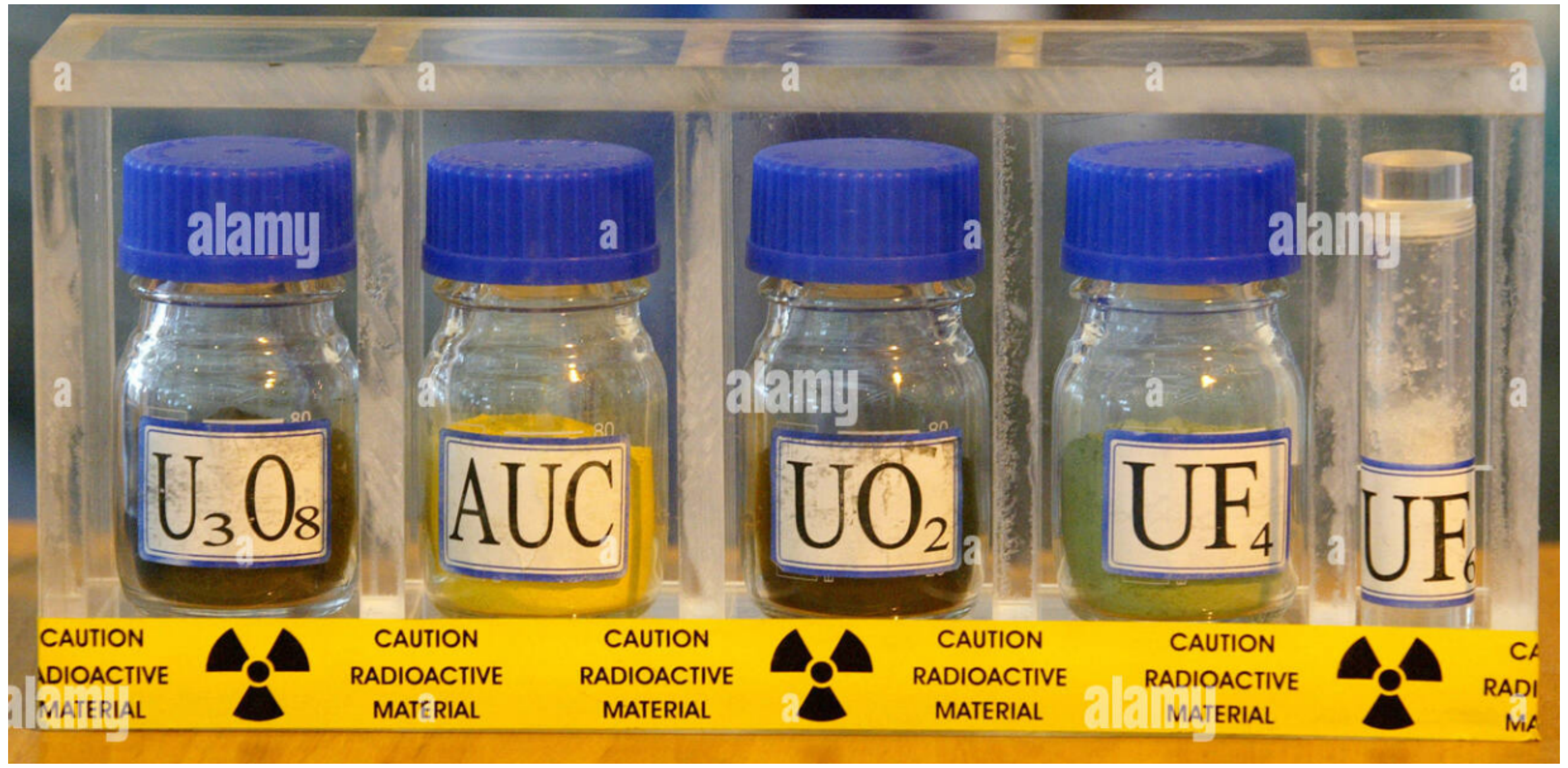


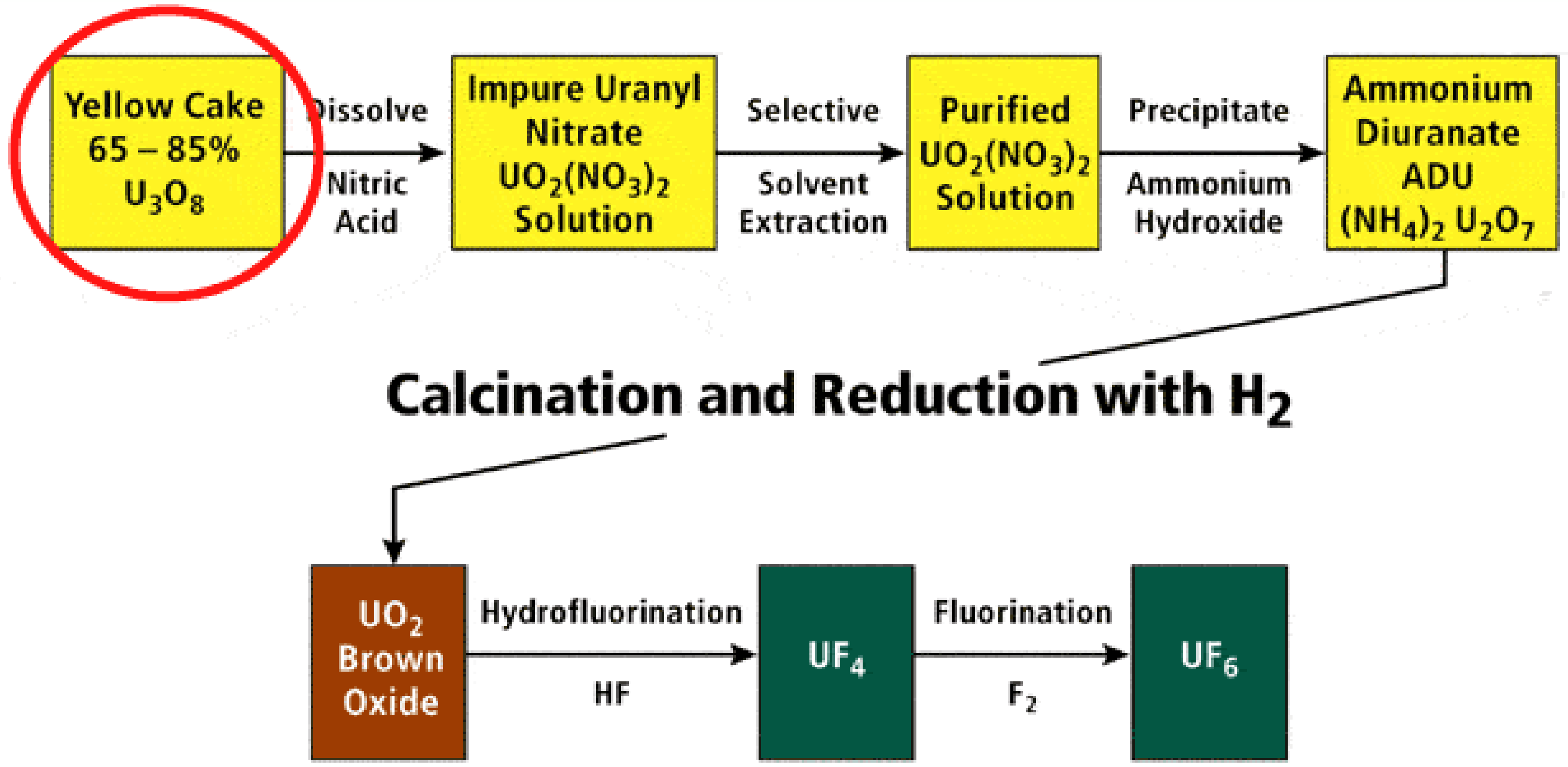
The wet storage facility at Sellafield, UK

# From Mined Uranium to Yellow Cake



# Conversion from Uranium Oxide Powders to Fluorines




Process of turning uranium oxide (U3O8) to uranium hexafluoride (UF6)

*48Y Cylinder with outer protection*

*30B Cylinder with PSP*

*Type 48Y Cylinder*

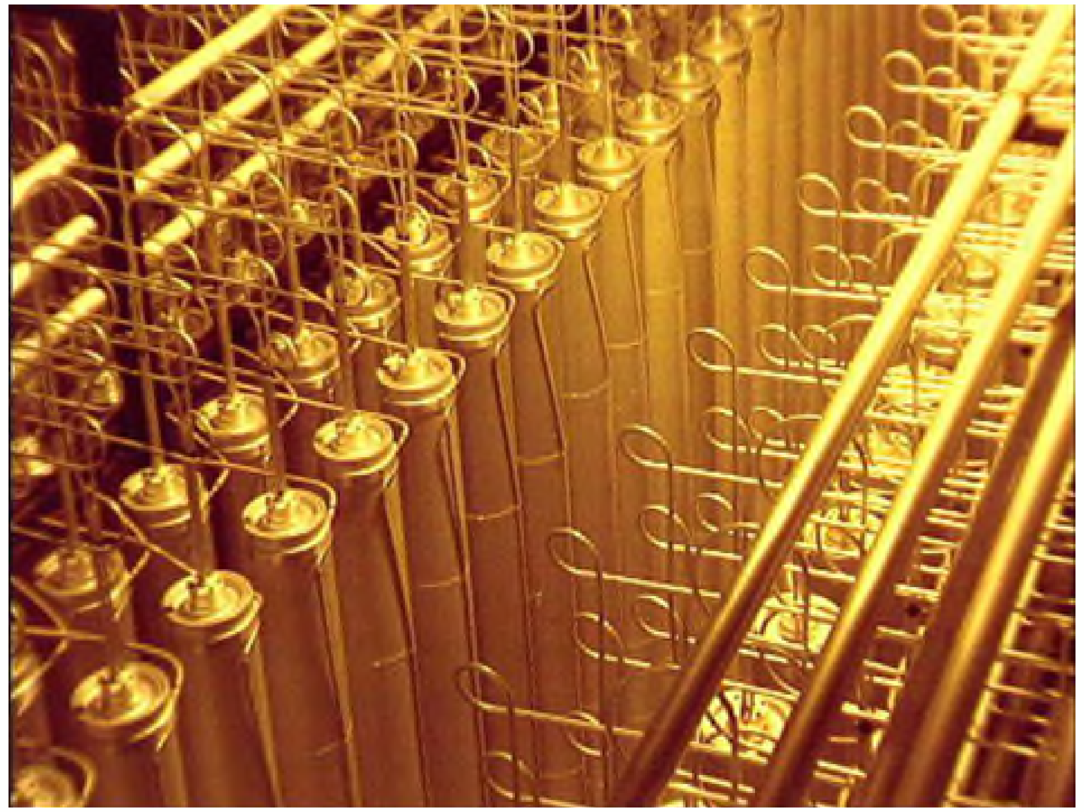
*Type 30B Cylinder*

48Y Cylinder
Diameter: ~ 1,25 m (48 inch)
Length: ~ 4 m
Wall thickness: 16 mm (5/8 inch)
Volume: ~ 4000 l
Tare weight: ~ 2500 kg
Max. fill: 12500 kg
Gross weight: ~ 15000 kg
Proof pressure: 28 bar
(5-year inspection)
Max. Operating temp.: 121°C/250°F

30B Cylinder
Diameter: ~ 0,75 m (30 inch)
Length: ~ 2 m
Wall thickness: 12,7 mm (1/2 inch)
Volume: ~ 750 l
Tare weight: ~ 635 kg
Max. fill: 2275 kg
Gross weight: ~ 3000 kg
Proof pressure: 28 bar
(5-year inspection)
Max. Operating temp.: 121°C/250°F

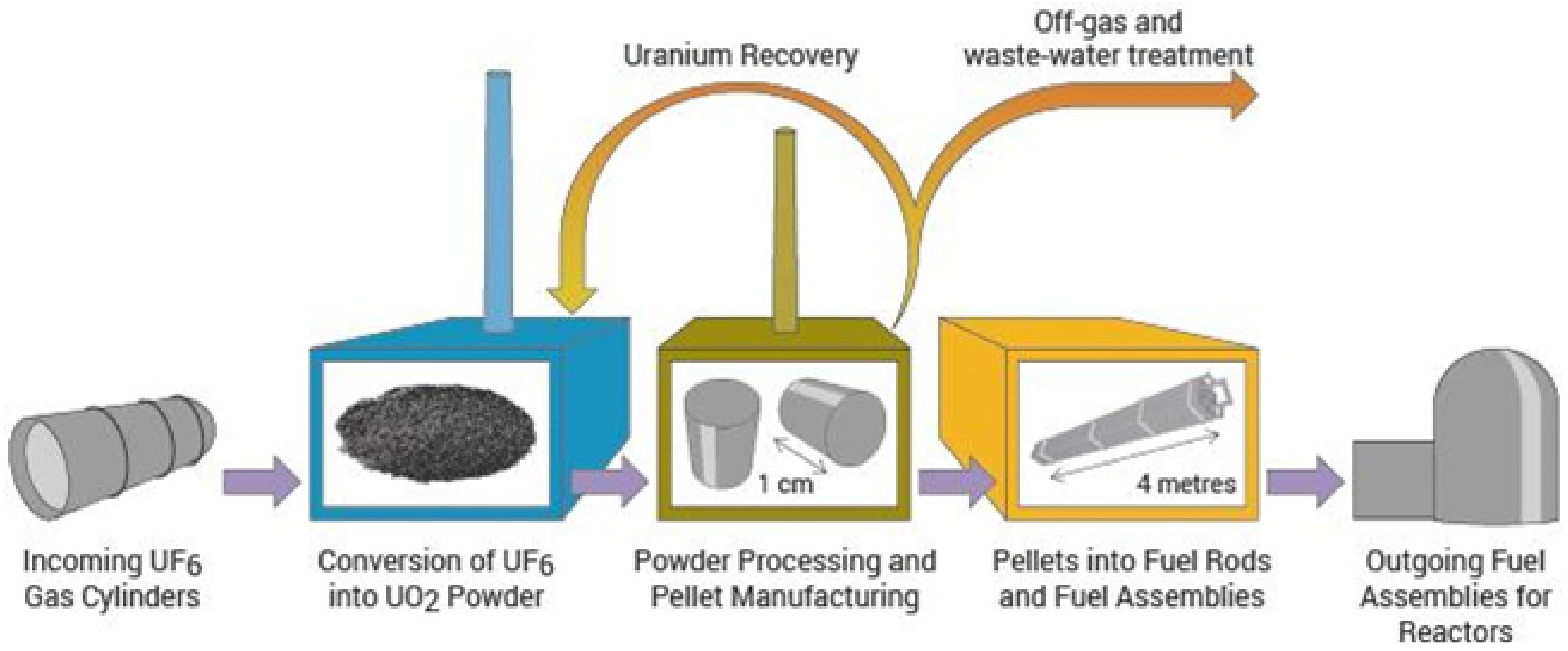
Transport of uranium hexafluoride (UF6) – World Nuclear Transport Institute

# Enrichment and Fuel Fabrication

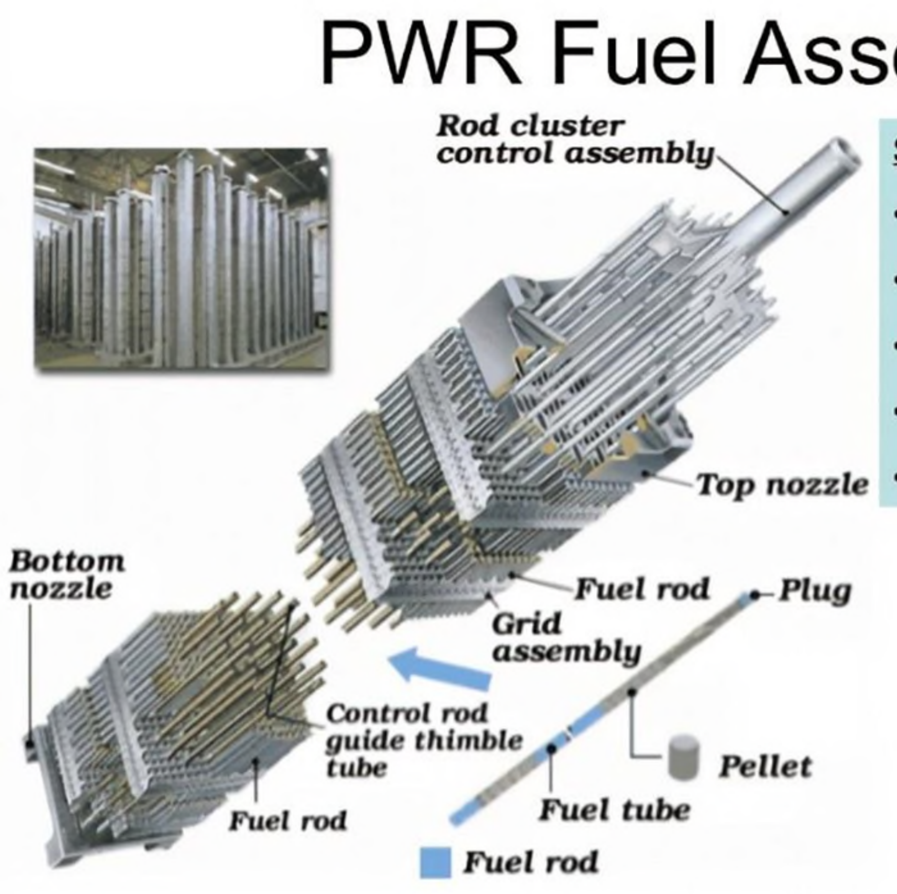


Uranium Enrichment at Urenco – Word Nuclear Association

Oak Ridge K-25 Gaseous Diffusion Process Building – Department of Energy




Nuclear Fuel and its Fabrication – World Nuclear Association




Sample PWR Fuel Assembly

- Array of 14X14 rods
- 179 fuel rods
- 16 control rods - ganged
- 1 instrumentation rod
- Assembly is 7” X 7”, 12 ft tall

Fuel: U-235 enriched from natural concentration of 0.71% to a few %

Fission of U-238 possible only with fast neutrons

# Radioactive Waste Management

**Radioactive Waste arises from all stages of the fuel cycle:**
Mining and Fuel Fabrication – Operations – Spent fuel management (including reprocessing) – Decommissioning

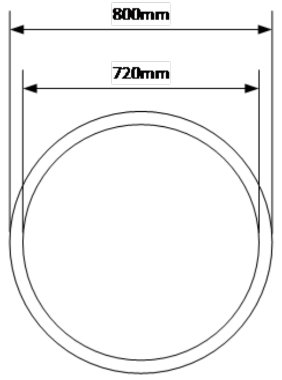
**Waste Classifications** – in the UK, we are closely aligned to the IAEA's classification framework:

| | Classification | Description | Management Route |
|---|---|---|---|
| **Exempt Waste** | **Exempt** | Concentration of radionuclides in exempt material is so low, that specific radiation protection measures are not required | Exempt from 'Regulatory Control' - managed through conventional waste routes |
| **Lower Activity Waste (LAW)** | **VLLW** – Very Low Level Waste | Building structural materials and excavated soil from nuclear sites | Engineered surface landfills |
| | **LLW** – Low Level Waste | Covers a wide range of wastes including operational (PPE, spent HVAC filters etc.) | Engineered near-surface disposal. e.g. LLWR in the UK |
| **Higher Activity Waste (HAW)** | **ILW** – Intermediate Level Waste | Relatively large quantities of long-lived radionuclides. Generally, heat generation is not accounted for in the management of ILW | Immobilised in cement, then interim storage until geological disposal is available |
| | **HLW** – High Level Waste | Spent fuel and by-products of nuclear fuel reprocessing | Vitrification, interim storage until geological disposal is available |

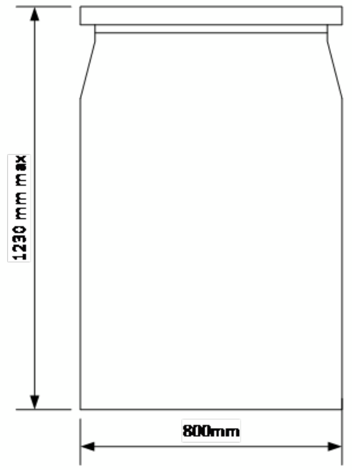
**Radioactive Waste from nuclear fission is well understood and has underpinned long term management routes**

# Typical Radioactive Waste Packages - UK

## ILW – 500L Drum




Plan

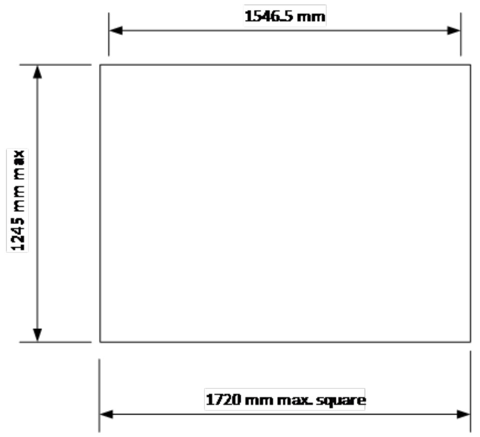



Side Elevation

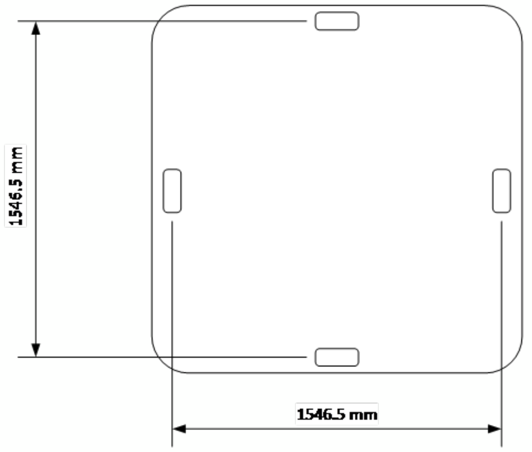
## LLW – Half Height ISO

## ILW – Overpack Store

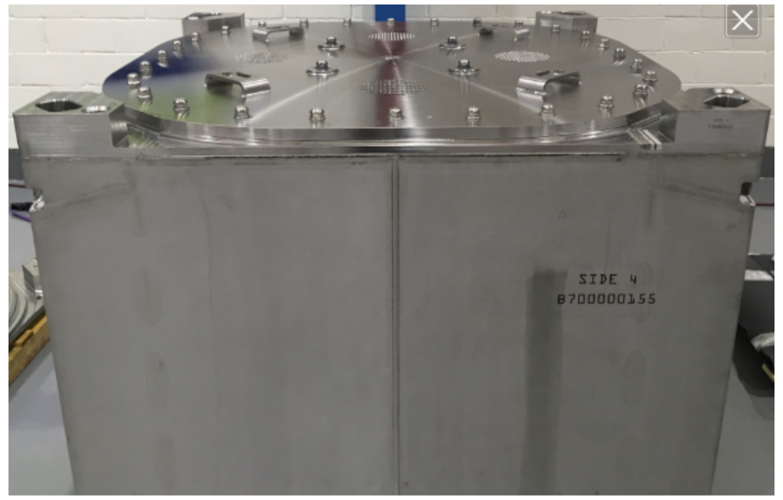
## ILW – 3m³ Box




Side Elevation




Plan



# Spent Fuel Management

Both wet and dry spent nuclear fuel management routes are deployed across the global industry

### Wet Fuel Storage

- Spent nuclear fuel can be stored in large pools of water
- The water helps to cool the spent fuel as the radioactivity decays and is able to shield workers
- This method is typically used immediately after the fuel is removed from the reactor because it effectively dissipates the heat generated by the spent fuel

### Dry Fuel Storage

- After initial cooling in wet storage, spent fuel can be transferred to dry casks
- The fuel is placed in steel or concrete containers that provide radiation shielding and passive cooling
- Dry storage is used for long-term storage. It is safer and more cost-effective for long-term management as it does not require active cooling systems

Industry has built up decades of experience in storing, handling and transporting spent nuclear fuel

R&D is a continual process, particularly for long term cladding degradation mechanisms

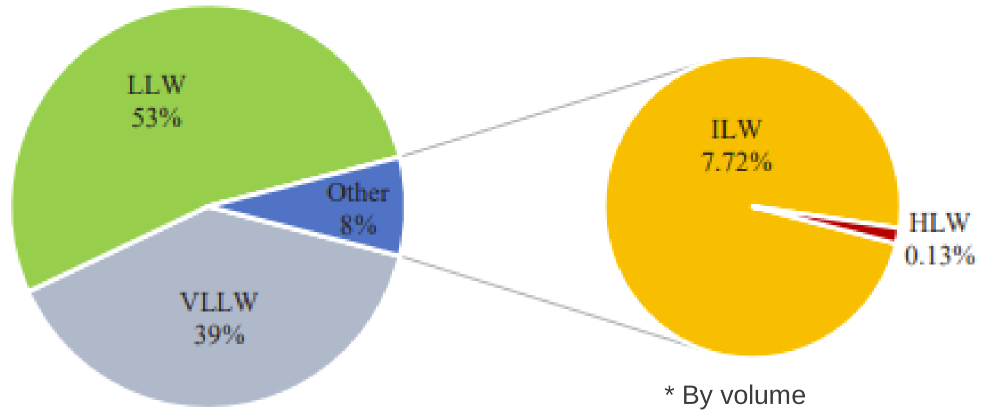
*Central Interim Storage Facility for Spent Nuclear Fuel – Swedish Nuclear Fuel and Waste Management Company*

*Cask Storage Hall at ZWILAG in Switzerland – ZWILAG*

# Overall view of the radioactive waste inventory

## Typical Annual Proportions of Radioactive Wastes (IAEA, 2016):

- More than **90%** of the **radioactive waste volume** is in the **LAW** classification
- More than **95%** of the **total radioactivity** is contained within the **HAW** classification



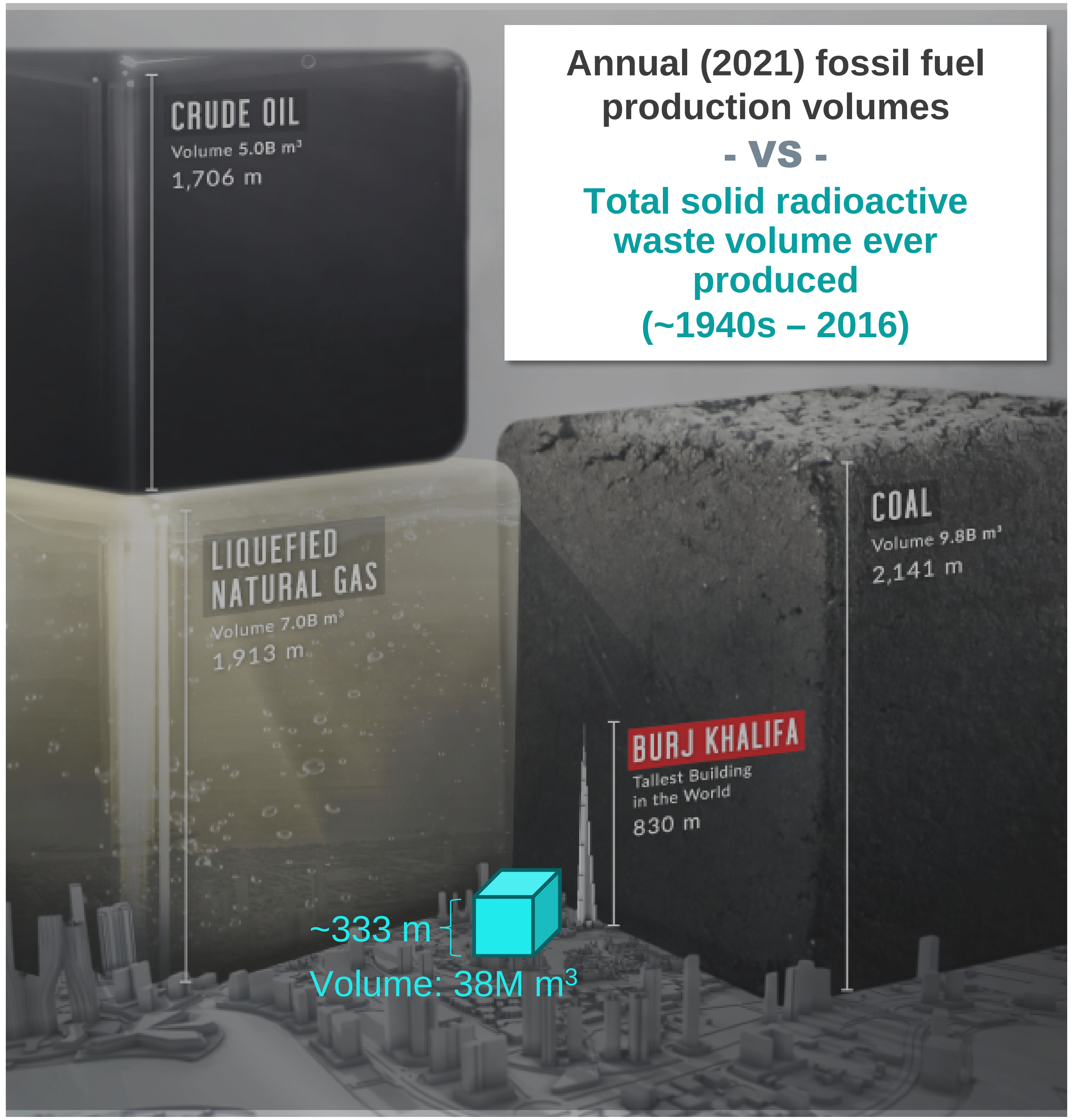

* By volume

## Global waste summary

Comparison of stored and disposed waste based on IAEA data:

| Solid waste | 2013 data | | | 2016 data | | |
|---|---|---|---|---|---|---|
| | Storage | Disposal | Total | Storage | Disposal | Total |
| VLLW ($m^3$) | 2 356 000 | 7 906 000 | 10 262 000 | 2 918 000 | 11 842 000 | 14 760 000 |
| LLW ($m^3$) | 3 479 000 | 20 451 000 | 23 930 000 | 1 471 000 | 18 499 000 | 19 970 000 |
| ILW ($m^3$) | 460 000 | 107 000 | 567 000 | 2 739 000 | 133 000 | 2 872 000 |
| HLW ($m^3$) | 22 000 | 0 | 22 000 | 29 000 | 0 | 29 000 |
| Total | 6 317 000 | 28 464 000 | 34 781 000 | 7 157 000 | 30 474 000 | 37 631 000 |
| NPP spent fuel (t HM) | Storage | Reprocessed | Total | Storage | Reprocessed | Total |
| | 250 000 | 120 000 | 370 000 | 263 000 | 127 000 | 390 000 |

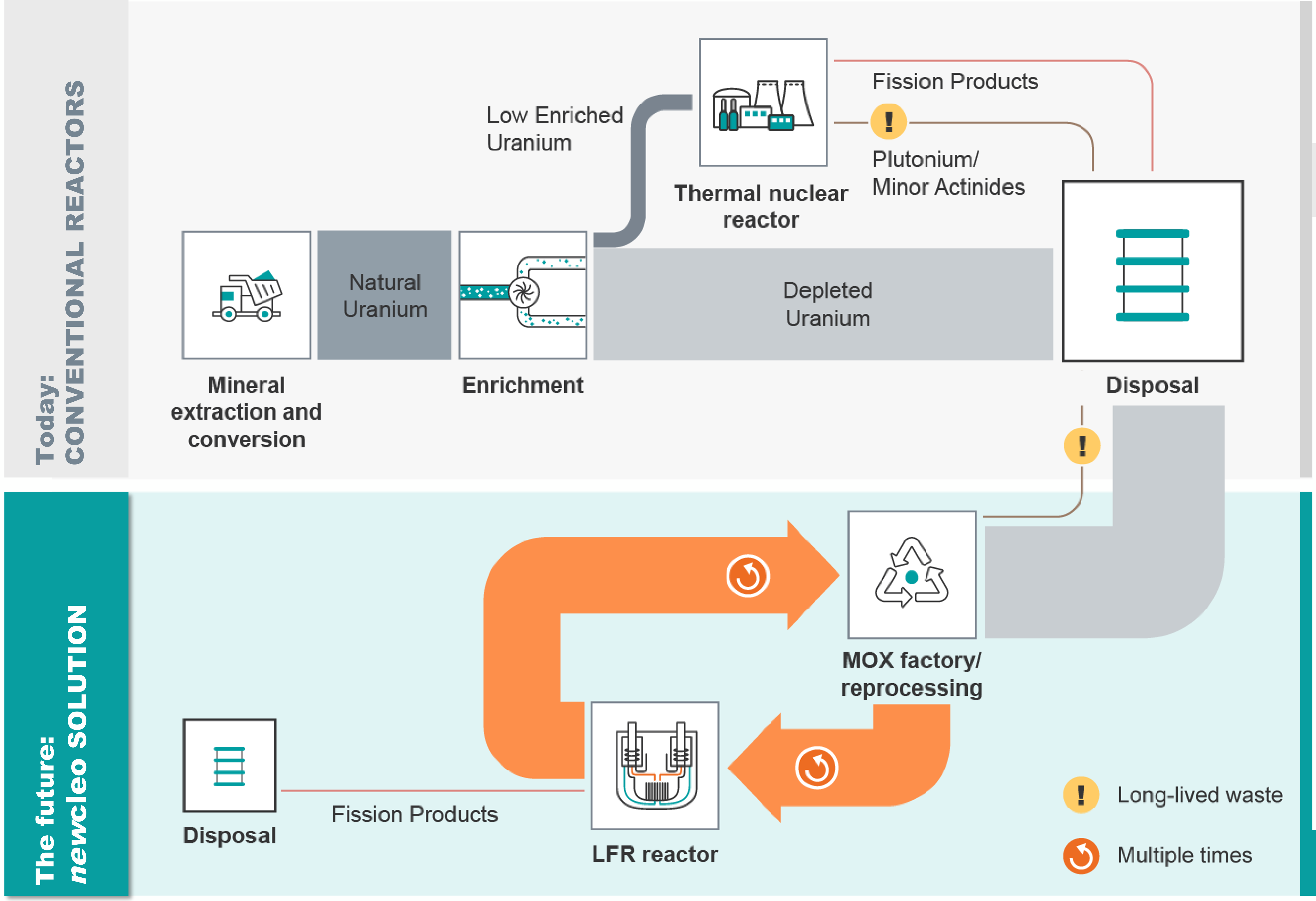
Spent Fuel and Radioactive Waste Information System (SRIS), IAEA




Elements, Visual Capitalist, 2023

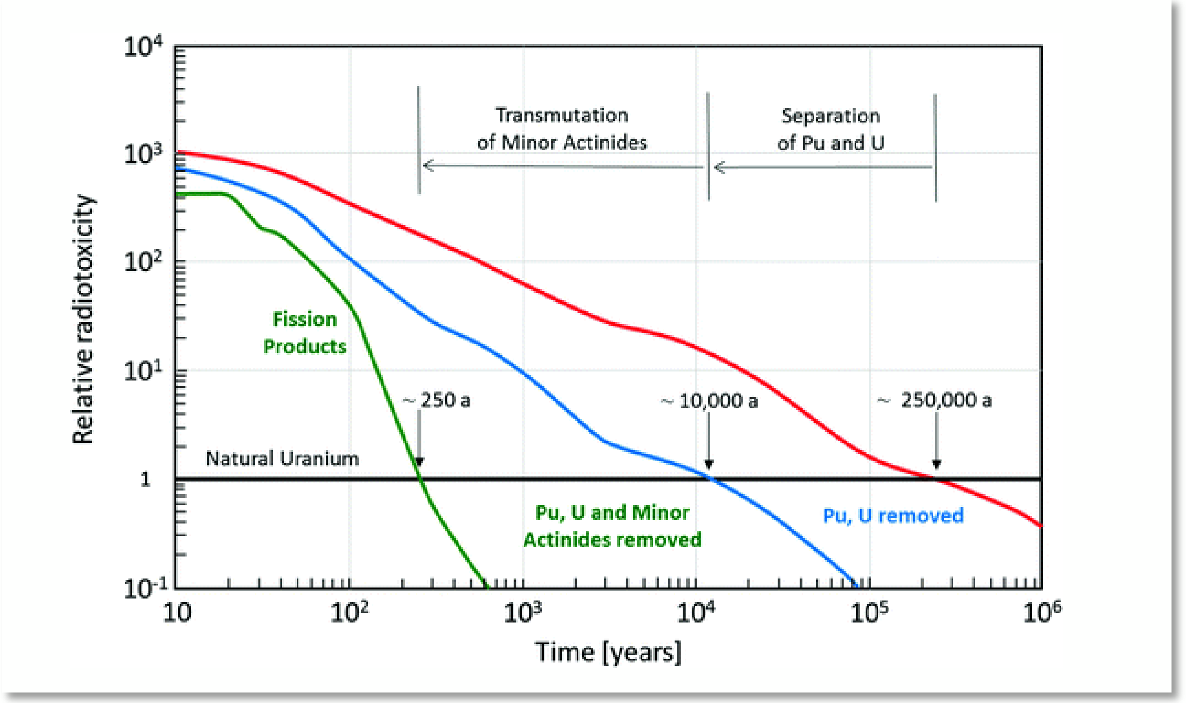
# Closing the fuel cycle: MOX

Including MOX (Mixed Pu-U Oxides) for cost effective, cleaner, and virtually inexhaustible production of nuclear energy, with no need of mining




**Thermal fission reactors use a very small portion of the extracted uranium:** an average 1GWe LWR uses every year 200t of mined uranium of which only 1t is fissioned (Fission Products), the rest is not used

**High-level waste has become an expensive liability**




Today MOX for thermal reactors is used in a few countries, in a mono-recycling scheme. **Fast Reactors and fuel reprocessing** can extract energy from existing material and at the same time reduce radiotoxicity of residual waste to dispose: Fission Products return to value of the natural uranium ores after ~250 years

**All artificial radioactivity created by reactors is virtually gone**

newcleo Futurable Energy

# Conventional vs. Fast Reactors

## Conventional Reactors

Fuel is **sourced from uranium mines**. This ore contains 0.7% fissile content which requires conversion and enrichment.

Spent fuel is sent to stockpiles and then will be eventually **destined for a geological disposal facility**.

In 2022, it was reported by the Nuclear Decommissioning Authority that the UK possesses **1990m$^3$ of high-level waste**.

Spent nuclear fuel can last in depositories for **hundreds of thousands of years** before becoming stable.

The conventional reactor industry is **reliant on global uranium markets** and enrichment facilities.

## Fast Reactors

**Stockpiles of spent fuel can be used** to create Mixed uranium-plutonium Oxide fuel (MOX).

Spent fuel can be **reprocessed to be used as new fuel**, with only specific fission products being disposed of.

*new*cleo's vision, comprising LFRs, MOX and reprocessing, aims at minimising waste production, **fully utilising nuclear material**.

Fast reactors can burn long-lived elements, like minor actinides, to reduce the time taken for waste to stabilize to **~250 years**.

Fast reactors **reduce market dependence** by reprocessing spent fuel in multiple times, and "breeding" new fuel during use.

# Enter the small(er):

SMR and AMR

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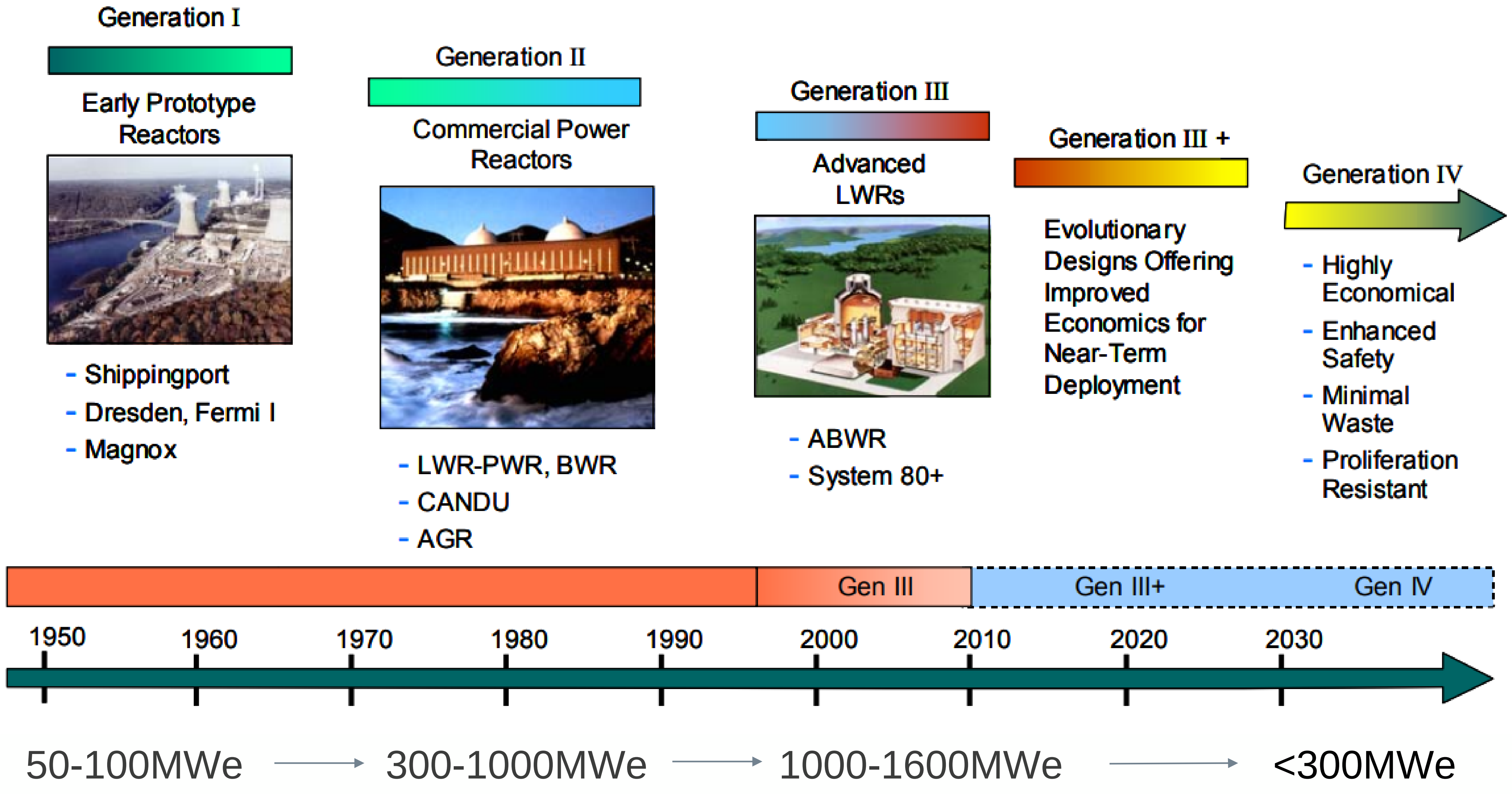
# Evolution of Nuclear Power Plant technologies

## Traditional Coolants:

- Light Water ($H_2O$)
- Heavy Water ($D_2O$)
- $CO_2$

## Reactor Types:

- PWR – Pressurised Water Reactor
- BWR – Boiling Water Reactor
- HWR (CANDU) – Heavy Water Reactor
- Magnox – Gas-cooled Reactor
- AGR – Advanced Gas-cooled Reactor

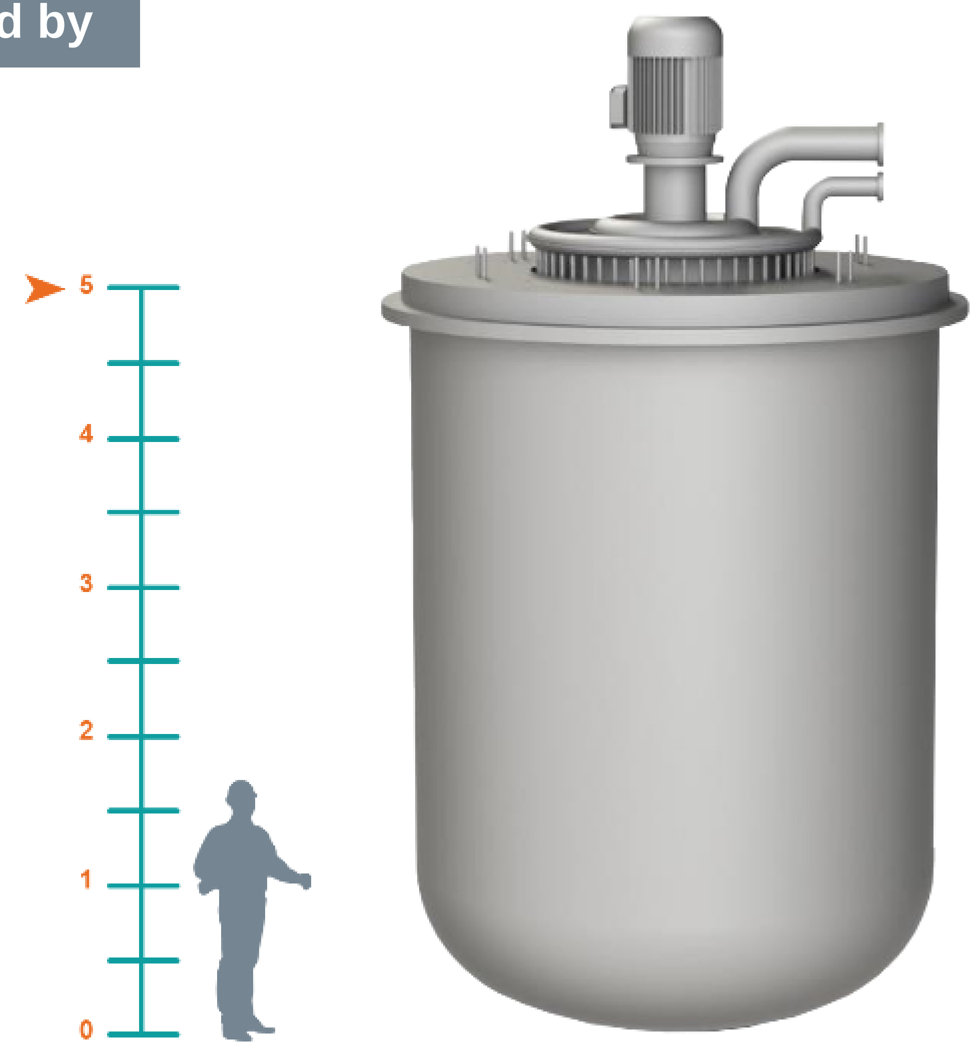


# SMRs improve economics and flexibility in nuclear

Small Modular Reactors (**SMRs**) are nuclear fission reactors. Smaller than conventional nuclear reactors, they are designed to be manufactured at a plant and transported to a site for installation

**ECONOMIES OF SCALE**
Large reactors > 1GWe

**replaced by**




**ECONOMIES OF SERIES**
Small, standardised designs < 300MWe

### Serial production
**Reduced costs and risks of overrun**

- Learning curve and economies of series
- Centralised factory production to limit onsite costs
- Transportable on site

### Modularisation
**Shorter construction time**

- Modular construction
- Multi-module deployment enabling "chain" financing of one module to the next

### Simplification
**Enhanced safety**

- Reduced complexity enhancing overall safety, while limiting costs (e.g., passive safety) and reducing local permitting requirements

### Limited capital intensity
**Better affordability**

- Lower upfront capital costs
- Limited financing risk, with greater access to private capital

### Smaller footprint
**Greater site flexibility**

- Reduced site size
- Reduced emergency planning zone

### Flexible applications
**Wider range of users**

- Remote locations and small grids, suitable for fossil plant replacement
- Non-electrical applications (e.g. desalination)
- Marine based (floating, propulsion)

# Gen-IV objectives

### Sustainability

- Sustainable energy generation that meets clean air objectives and provides long-term availability of systems and effective fuel utilisation for worldwide energy production
- Minimise and manage their nuclear waste and notably reduce the long-term stewardship burden, thereby improving protection for the public health and the environment

### Economics

- Clear life-cycle cost advantage over other energy sources
- A level of financial risk comparable to other energy projects

### Safety and Reliability

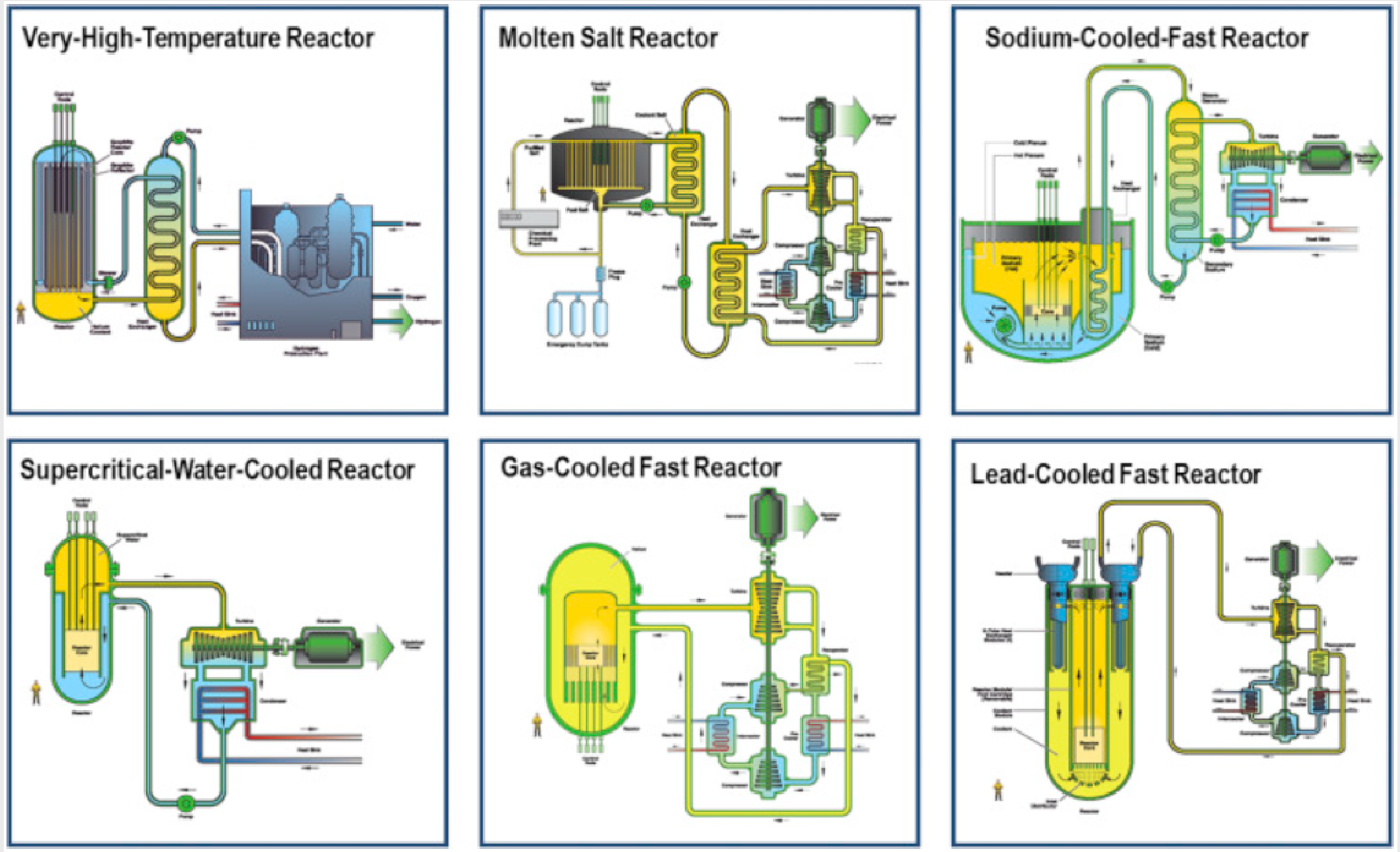
- Excel in safety and reliability
- Very low likelihood and degree of reactor core damage
- Eliminate the need for offsite emergency response

### Proliferation Resistance and Physical Protection

- Increase the assurance that they are very unattractive and the least desirable route for diversion or theft of weapons-usable materials, and provide increased physical protection against acts of terrorism

# Gen-IV technology

**Gen-IV Reactor Types:**




Since 2000, an international forum coordinated by the DOE has prioritised six **Generation IV** nuclear technology systems for development.

Only Fast Reactors (GFR, LFR, SFR, some MSR) allow closing the fuel cycle, a sustainable use of nuclear energy.

| **Gen-IV Objectives** | **Gen-IV Approaches** |
|---|---|
| **Economic** | **Coolants** |
| **Environmentally Friendly** | **Fuels Types** |
| **Safe** | **Fuel Forms** |
| **Secure** | **Neutron Energy** |

# Gen-IV technology approaches

## 01

### Coolant

- Liquid metals (lead, sodium)
- Molten Salts
- High temperature gas (He)
- Supercritical fluids (CO2)

- High thermal efficiency
- Atmospheric pressure ops
- Freeze at room temperature
- Retains fission products
- Enables process heat apps

## 02

### Fuel types

- LEU
- HALEU
- MOX
- Thorium cycle

- Longer life, higher burn-up
- Enables fast reactor spectrum
- Recycled fuel (U and Pu)

## 03

### Fuel forms

- Oxide, Nitride, Carbide
- TRISO
- Accident tolerant fuels
- Liquid

- Retains fission products
- Multiple barriers
- Very high melting points

## 04

### Neutron energy

Thermal vs Fast Neutrons

- Longer life fuel, higher burnup
- Burning of minor actinides
- Potential for fuel breeding

# Gen-IV in the energy mix, the grid and beyond

**Process heat applications:**

- Pulp and paper
- Chemical processing
- H2 production
- E-fuel production (airplanes, ships)
- Desalination

**Micro / parallel grids:**

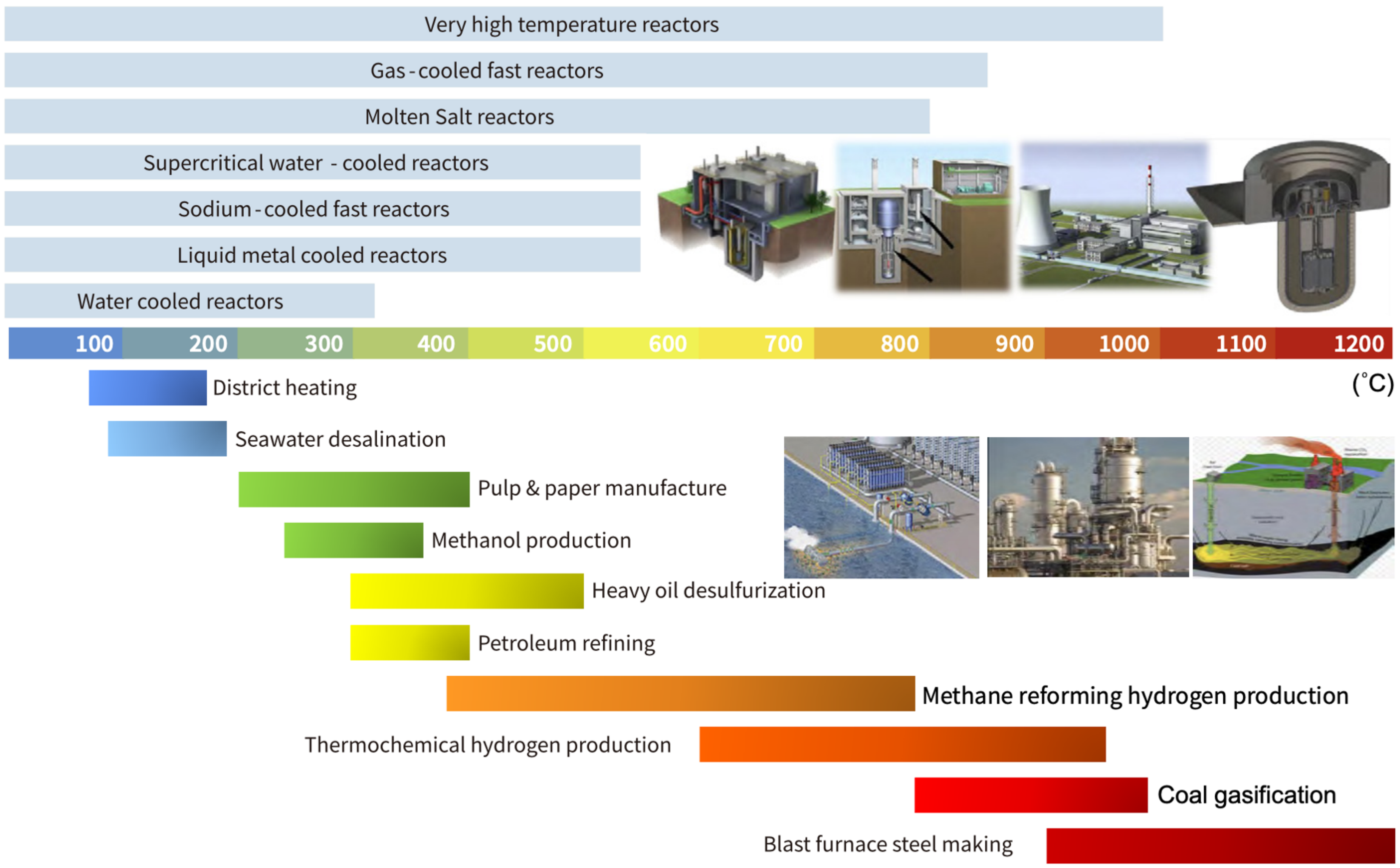
- Archipelagos, remote areas
- Ships
- Ports
- Mines

**The balance:**

Matching the reactor size and type to the local and regional demands. Not one size fits all.

Small, medium, and large reactors

Fits in with the wider energy suppliers



# Heavy Liquid Metal: Lead-cooled Fast Reactors


Lead properties enable design simplification (hence **economic benefits**) and a high degree of inherent safety:

- No significant energy release in case of vessel failure, hence **high pressure-resistant containment not needed**
- Coolant boiling practically eliminated, hence **safety injection systems not needed**
- Significant thermal inertia in case of a loss of heat sink
- Lead fission product retention capability, gamma radiation shielding
- **High plant efficiency (40-50%)**
- **High operating temperature enables non-electrical uses**

**Unique properties for fast reactors design**

| Absorption cross-section | Boiling Point | Heat transfer properties | Density @400°C |
|---|---|---|---|
| Low | 1737 °C | Good | 10580 kg/m$^3$ |
| Large fuel pin lattice, low core pressure loss | | Reduced risk of fuel cladding overheating | No risk of core compaction |

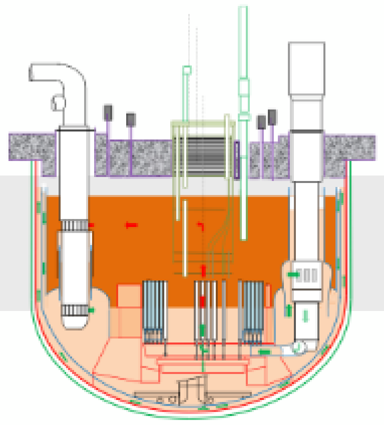
**But it also has properties that discouraged some designers**

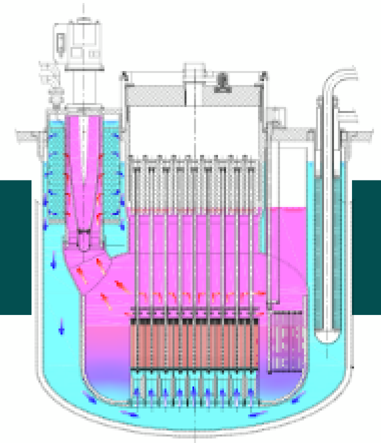
| Density @400°C | Melting Point | Opacity | Compatibility with structural materials |
|---|---|---|---|
| 10580 kg/m$^3$ | 327 °C | Yes | Corrosive |

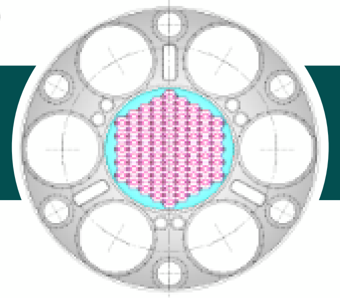
**80 effective reactor-years of Lead Bismuth Eutectic reactors**: 15 among land-based and submarines in Russia starting in the 1950s

Construction started in Jun-2021 for an LFR

# *new*cleo's design: simplification is key







| CLASSICAL | *new*cleo |
|---|---|
| Pump in the cold | **hot** collector |
| Primary fluid inlet in the upper | **lower** part of the heat exchanger |
| Vertical | **Radial flow** of the primary coolant in the steam generator |
| Fuel element fully immersed in | with **heads out** of the primary coolant |
| Fuel element fixed at the bottom | **top** |
| Primary pumps between | **inside** the steam generators |
| Control rods inside | **outside** the core |
| Inner vessel larger at the top | **bottom** |

**INNOVATIVE COMPONENTS/SYSTEM**

**STEAM GENERATOR, REFUELLING SYSTEM, DHR SYSTEM, CONTROL RODS, FUEL ELEMENT**

**Compact and dense primary system**

| ~4x less than Superphenix | Short reactor vessel: only 6.2 m |
|---|---|

**Compact reactor building**

| No intermediate loops | Compact primary system | No risk of LOCA |
|---|---|---|

*new*cleo identified technical solutions to minimise the impact of lead's unfavourable characteristics and in some cases has also drawn design advantages. We innovate by reimagining the classical solution, resulting also in the elimination of several components no longer needed

# Delivering AMRs in the UK

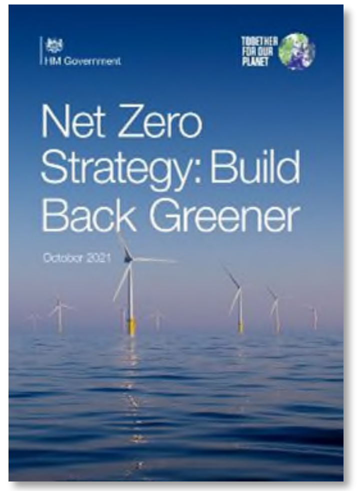
# Renewed policy support for nuclear in UK


- Commitment to GW nuclear and providing “development funding”
- £385m Advanced Nuclear Fund

**Prime Minister’s 10 Point Plan: June 2020**

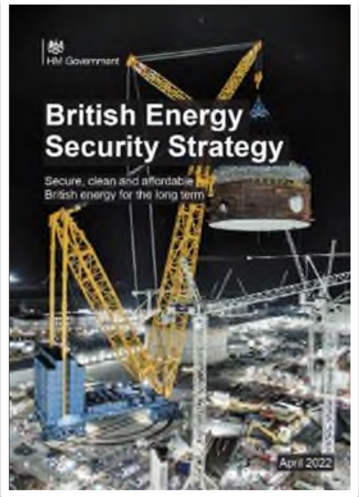

- At least one GW to FID by end of parliament
- Opening of GDA to SMRs in 2021 (implemented by 2030s)
- SMR/ AMR global market worth £250-£400bn by 2035

**Energy White Paper: December 2020**



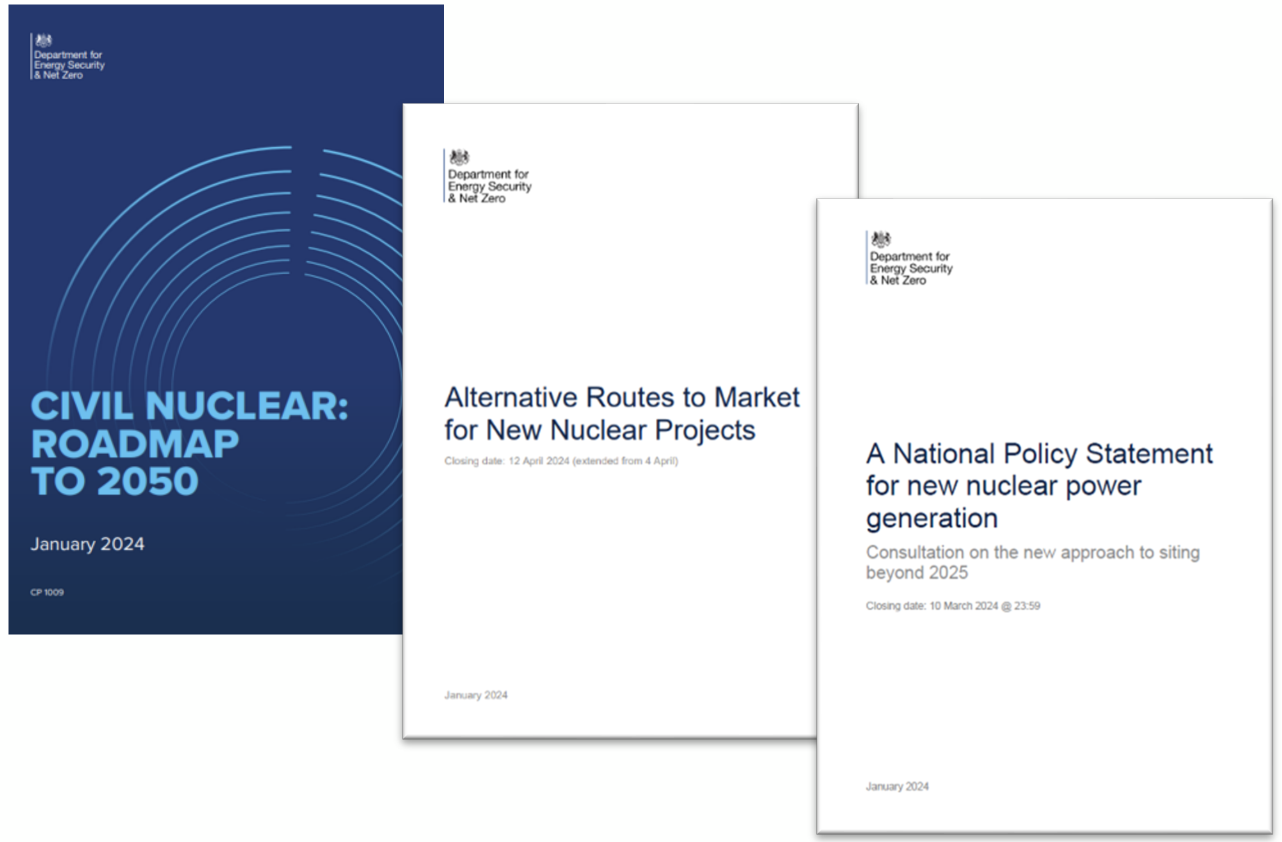

- £120m Future Nuclear Enabling Fund launched (barriers to entry)
- Nuclear is critical, but not clear how much

**Net Zero Strategy: October 2021**




- Up to 24GW by 2050 (25% of demand)
- Great British Nuclear vehicle to be set up
- Funding to support projects to “investment ready”.
- A selection process for further projects.

**British Energy Security Strategy: April 2022**




**Civil Nuclear Roadmap and associated consultations:**

**January 2024**

# Mirrored by a European surge of interest in nuclear

- **June 2021:** European Commission organized the first-ever **EU Workshop on Small Modular Reactors** to engage EU industrial actors in building a common strategy on practical developments for the deployment of SMRs in the EU.

- **2022:** International Atomic Energy Agency (IAEA) launched the **SMR Platform and Nuclear Harmonization and Standardization Initiative** and the **Technical Working Group on Small and Medium Sized or Modular Reactors**. In its 2022 report, the IAEA counted more than 80 SMR designs under development.

- **July 2023: G20 Energy Ministers Meeting** called for cooperation on nuclear energy. The Ministers agreed to collaborate on research, innovation, development, and deployment of civil nuclear technologies, including advanced and small modular reactors.

- **Dec 2023:** at **COP28**, more than 20 countries established the **Declaration to Triple Nuclear Energy Capacity by 2050**, recognizing the key role of nuclear power in reaching net zero. Signatories included Bulgaria, Croatia, Czech Republic, Finland, France, Hungary, Moldova, the Netherlands, Poland, Romania, Slovakia, Slovenia, Sweden, and the UK, among others.**COP28's Global Stockade Assessment**, which analyses where the world stands on achieving the objectives of the 2015 Paris Agreement, explicitly included support for nuclear as an important renewable energy source.

# ... and more

- **Feb 2024:** European Commission launched the **European Industrial Alliance on Small Modular Reactors**, aiming to facilitate SMR development in Europe by the early 2030s.

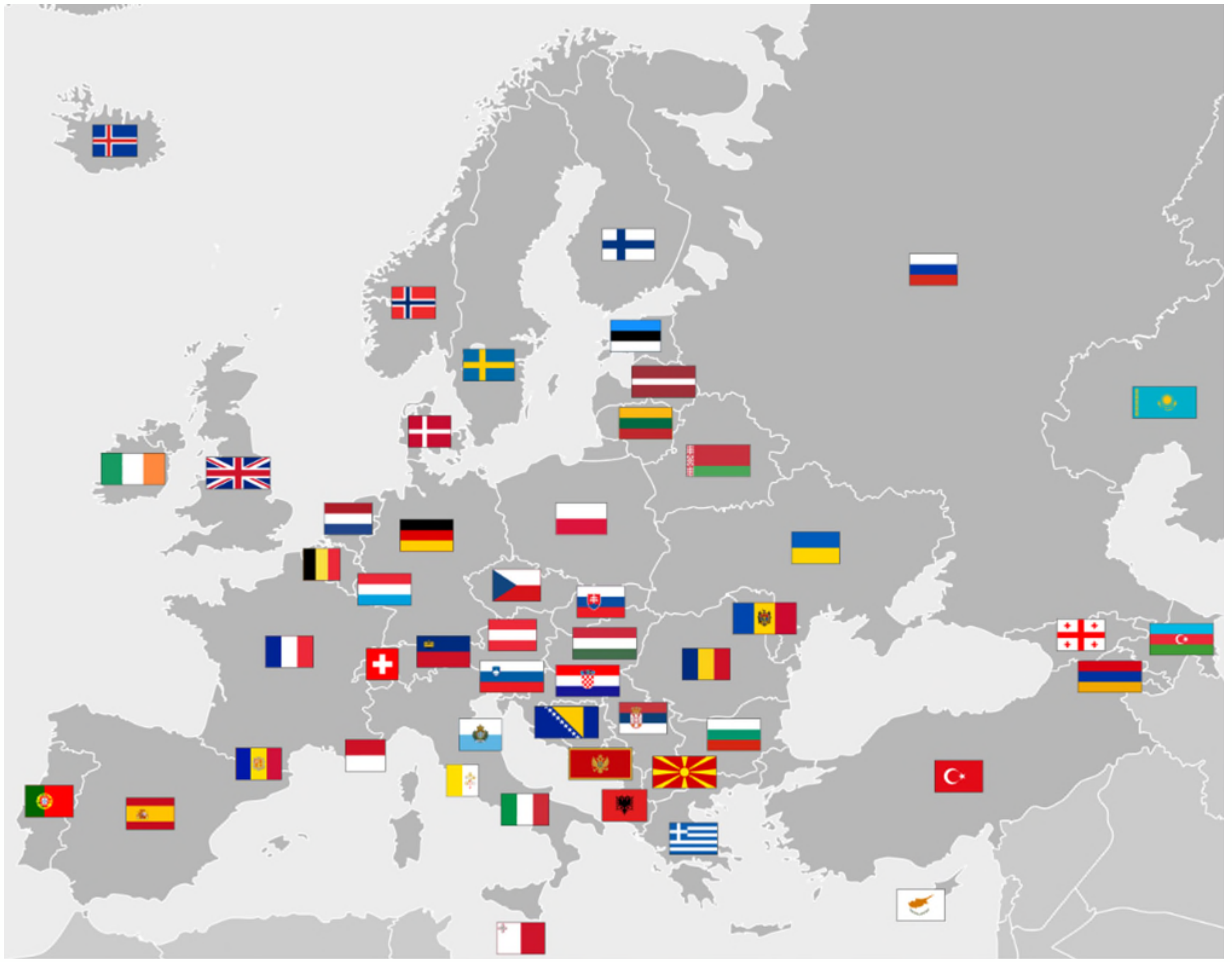
- **Mar 2024:** Brussels hosted the **IAEA Nuclear Energy Summit**, the world's first high-level meeting focused entirely on nuclear energy. The summit emphasized the importance of using nuclear energy to achieve energy security, climate goals and drive sustainable development. Calls of support for nuclear development came from 32 world leaders including EC President Ursula von der Leyen, President Emmanuel Macron, PM of Belgium, PM of the Netherlands, Turkish Minister of Foreign Affairs, Vice Premier of China, US Advisor to the President.

- **April 2024:** Hosted by ***new*****cleo**, the **G7 Ministerial Meeting on Climate, Energy and the Environment** committed G7 members to support multilateral efforts to strengthen the resilience of nuclear supply chains. Industry associations issued a **Nuclear Industry Statement** to Italy's Minister of Energy Security calling for G7 governments to further embrace nuclear deployment as a priority.

- **France** continues to push forward with its nuclear renaissance policy led by President Macron

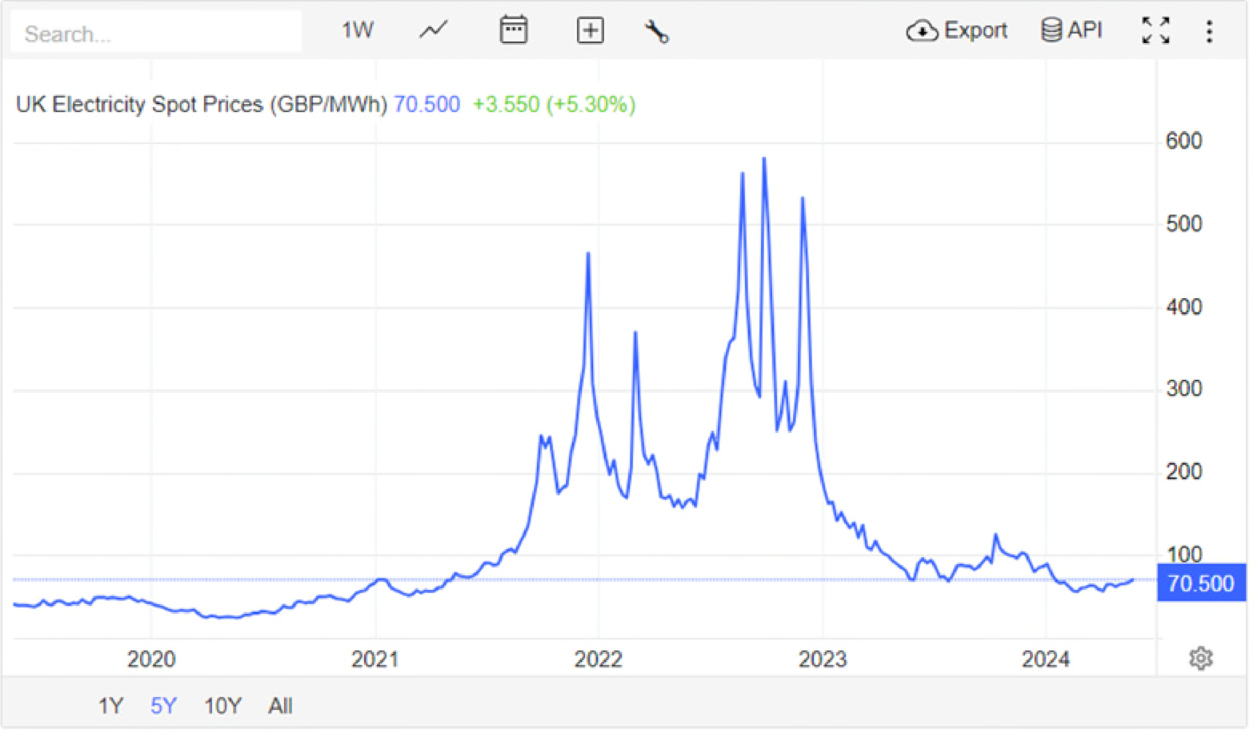
- **Italy** has increasingly opened up to considering the renewed role of nuclear, and specifically SMRs, in the country's future energy generation mix

- **Countries all over Europe** continue to pursue energy independence, especially from Russian supply

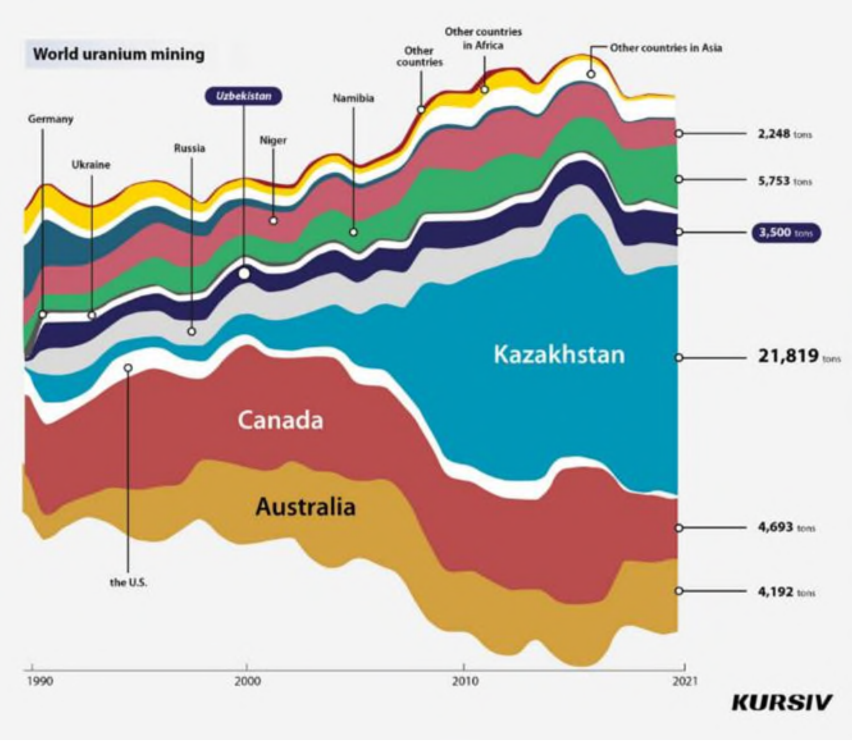


# Market drivers / needs

## Energy Security and Independence

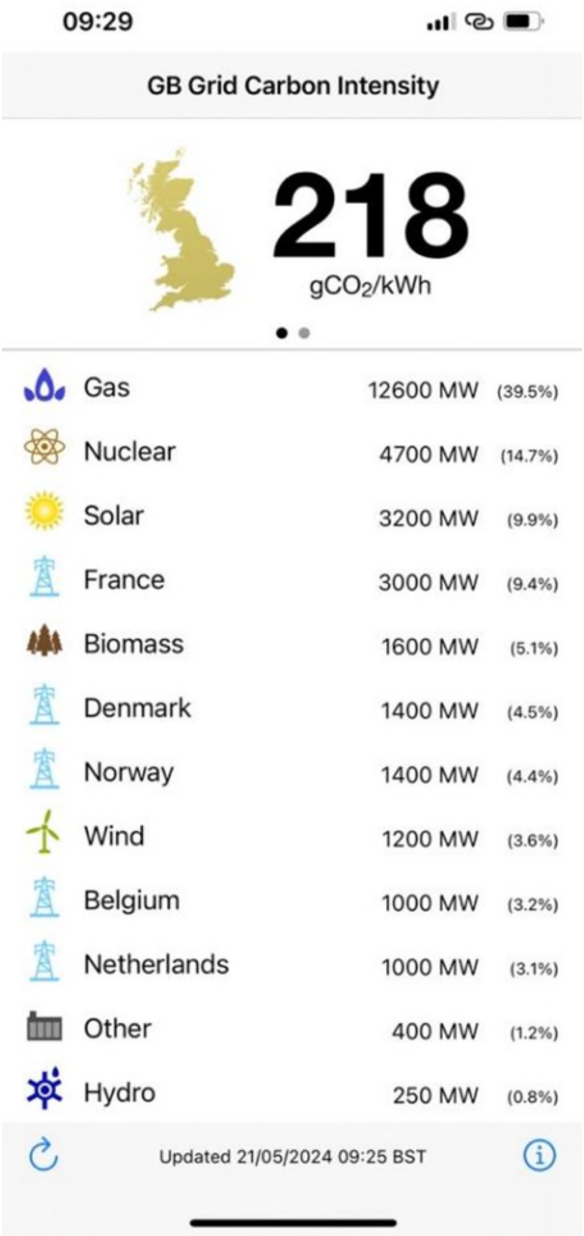



Source: tradingeconomics.com



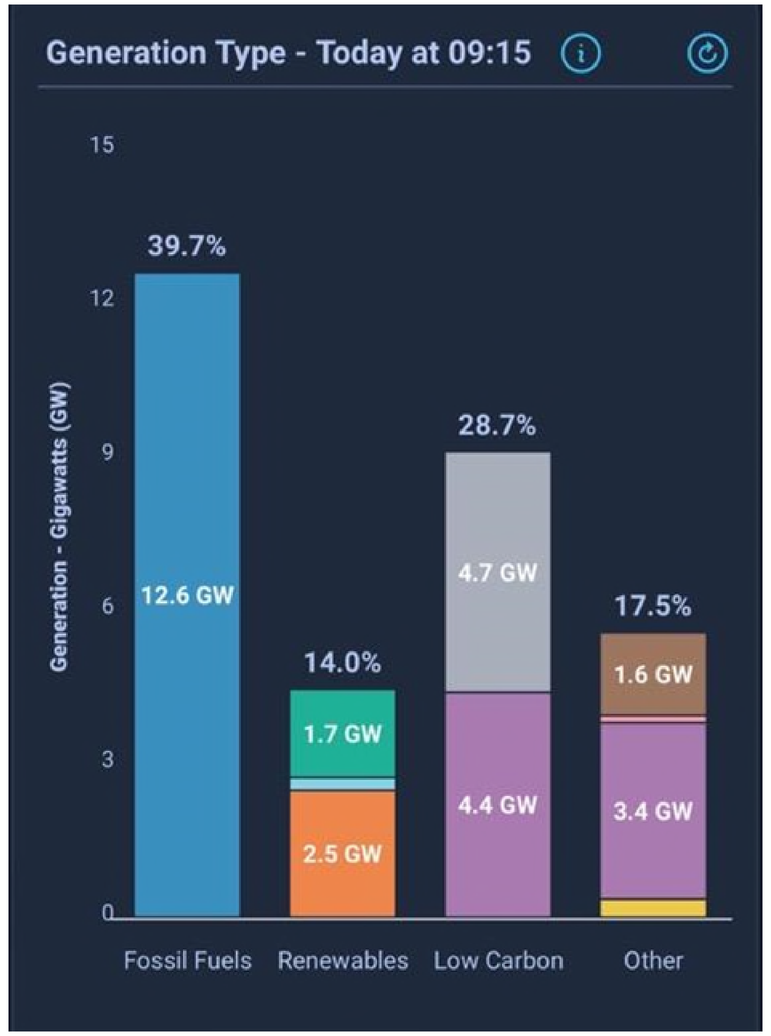

Source: kursiv.media

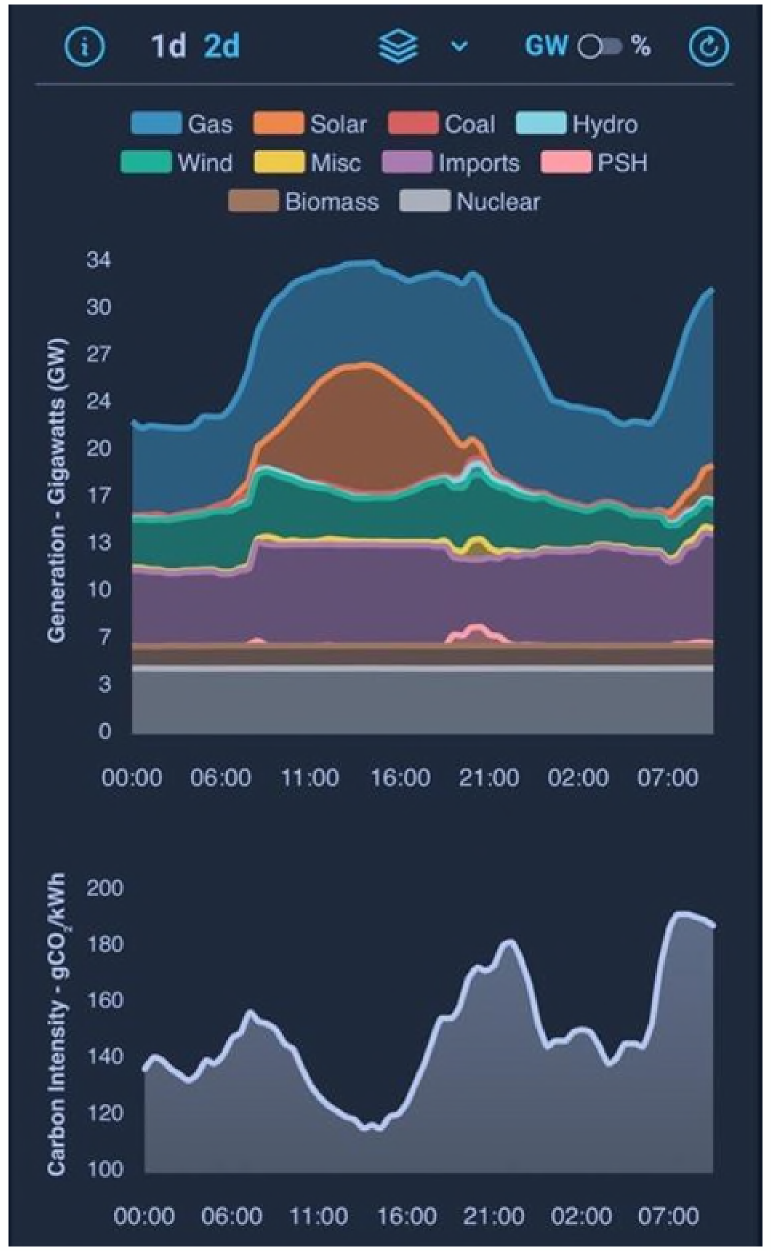
## Net Zero



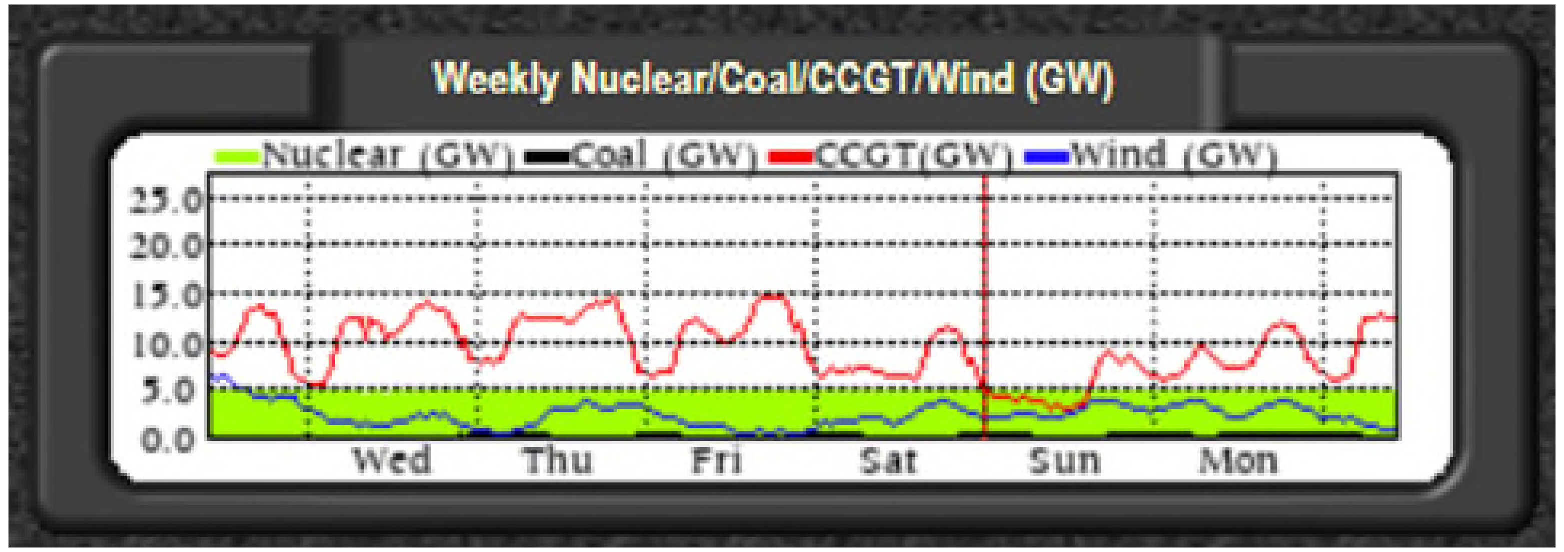

Source: Grid Carbon app

## Grid stability and base load




Source: energydashboard.co.uk




Source: gridwatch.templar.co.uk

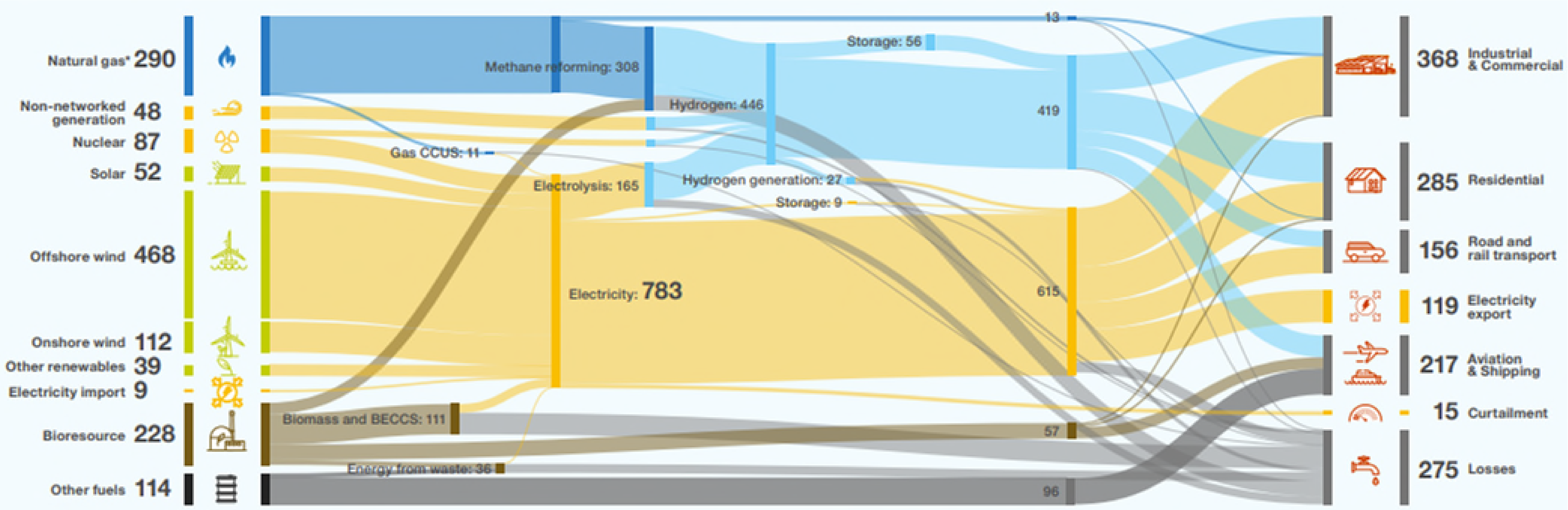
newcleo Futurable Energy

# Future energy scenarios

## Energy supply and demand in 2050

**System transformation (1447 TWh)**

- Highest proportion of hydrogen across the scenarios with widespread use for home heating, industry and HGVs
- High natural gas use for hydrogen production from methane reformation
- Highest level of bioresource use – bioenergy used to procude both hydrogen and electricity, mostly alongside CCUS for negative emissions
- Electricity production more than double that of today, partly to meet highest demand for electrolysis




*excluding exports

Source: National Grid ESO Future Energy Scenarios

# Further market needs for AMRs

## Economic and Industrial Development

The deployment of AMRs can **stimulate economic growth and create high-skilled jobs**. Investing in this can position the UK as a leader in advanced nuclear technology, leading to export opportunities in a growing global market for advanced nuclear technologies.

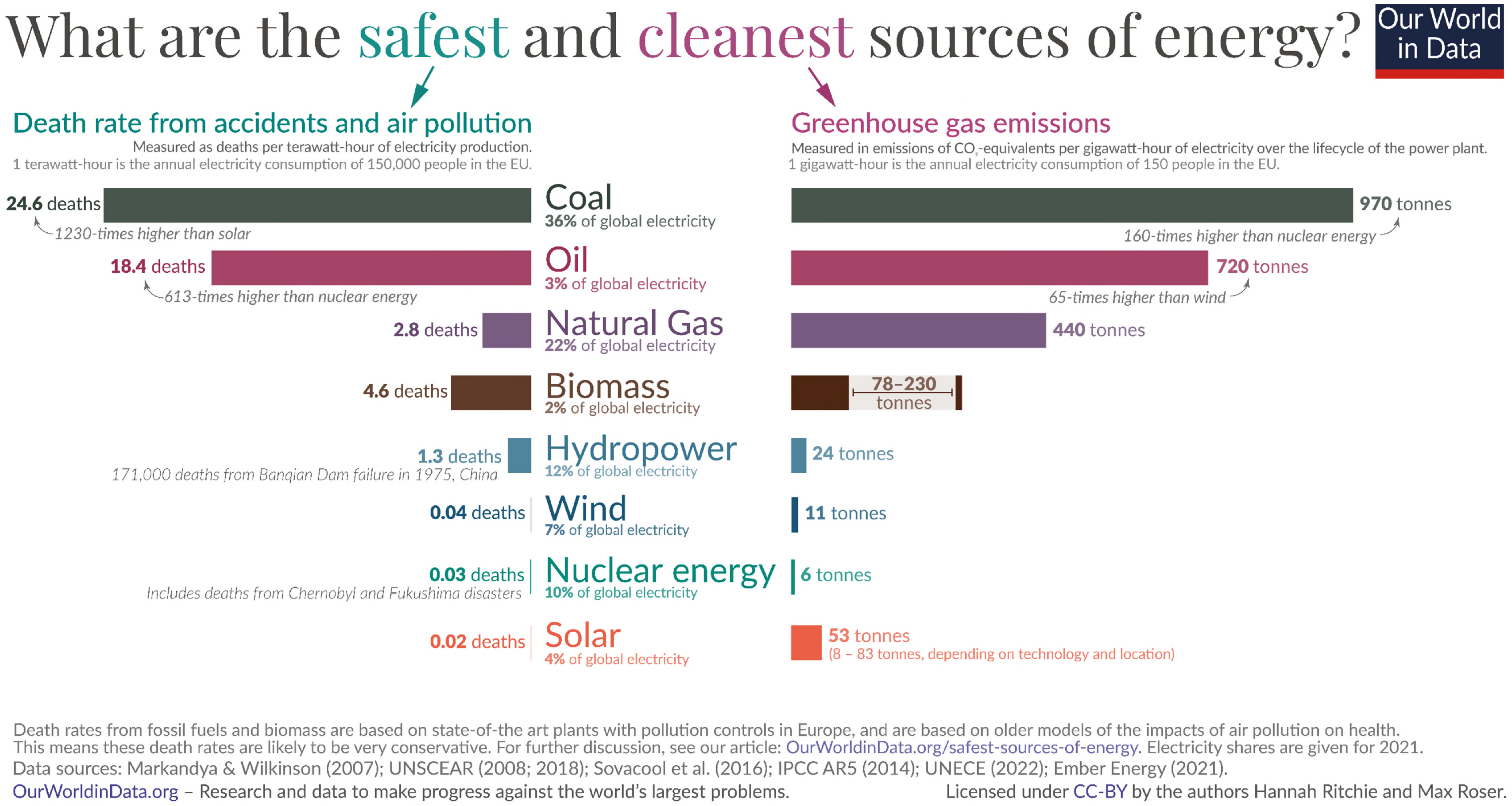
## Waste Management and Sustainability

AMRs are designed to utilise nuclear fuel more efficiently, **producing less waste compared to traditional reactors**. *new*cleo will use **existing nuclear *waste* as fuel**, addressing the long-term waste management challenges and enhancing the sustainability of nuclear power.

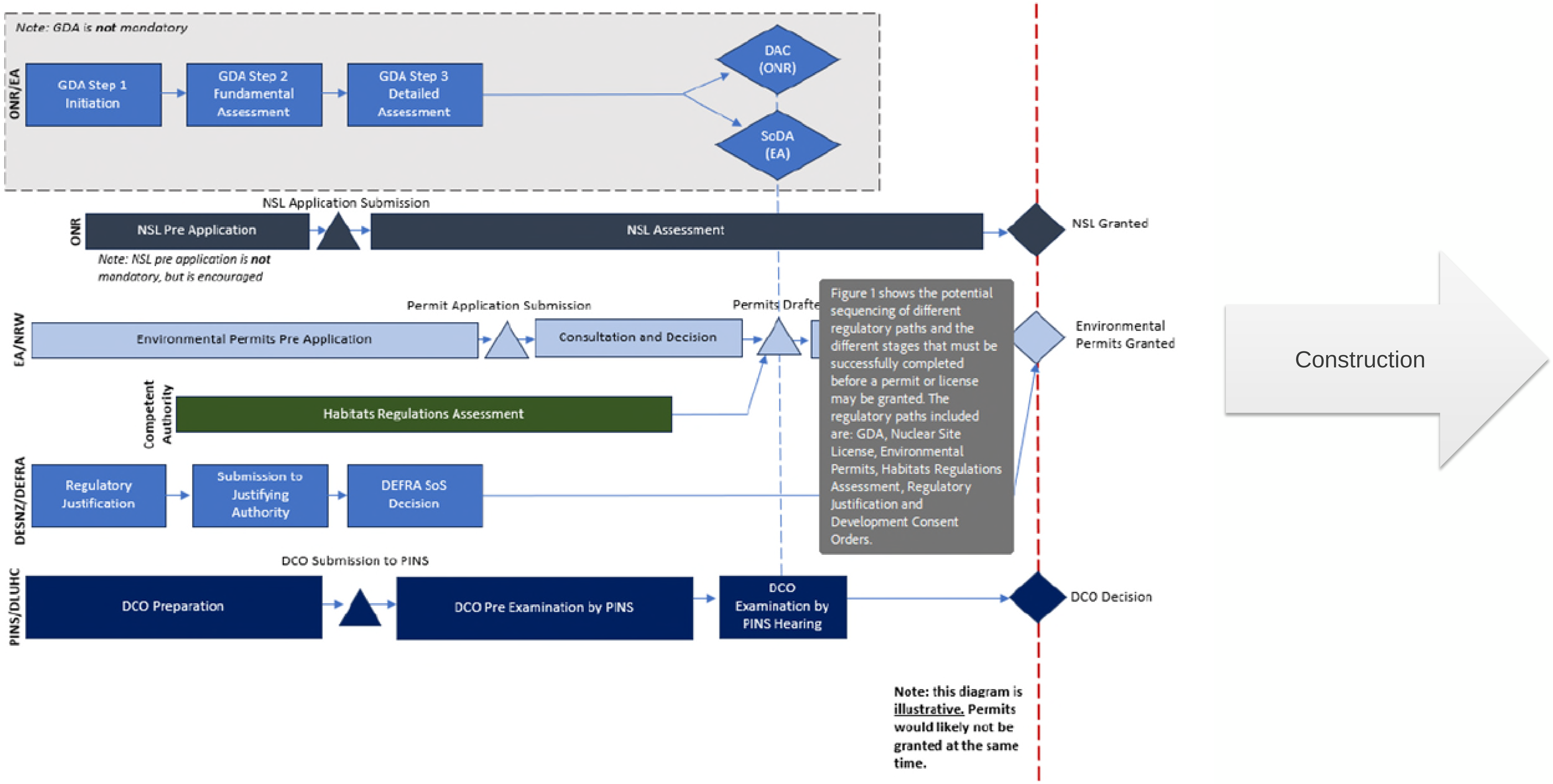
## Flexibility and Scalability

AMRs offer flexibility in terms of deployment locations and scales. They can be built in modular units, allowing for **incremental capacity additions and reducing initial capital expenditure**. This scalability makes them suitable for a variety of applications, from powering small remote communities to supporting large industrial complexes.

# AMRs in the industry



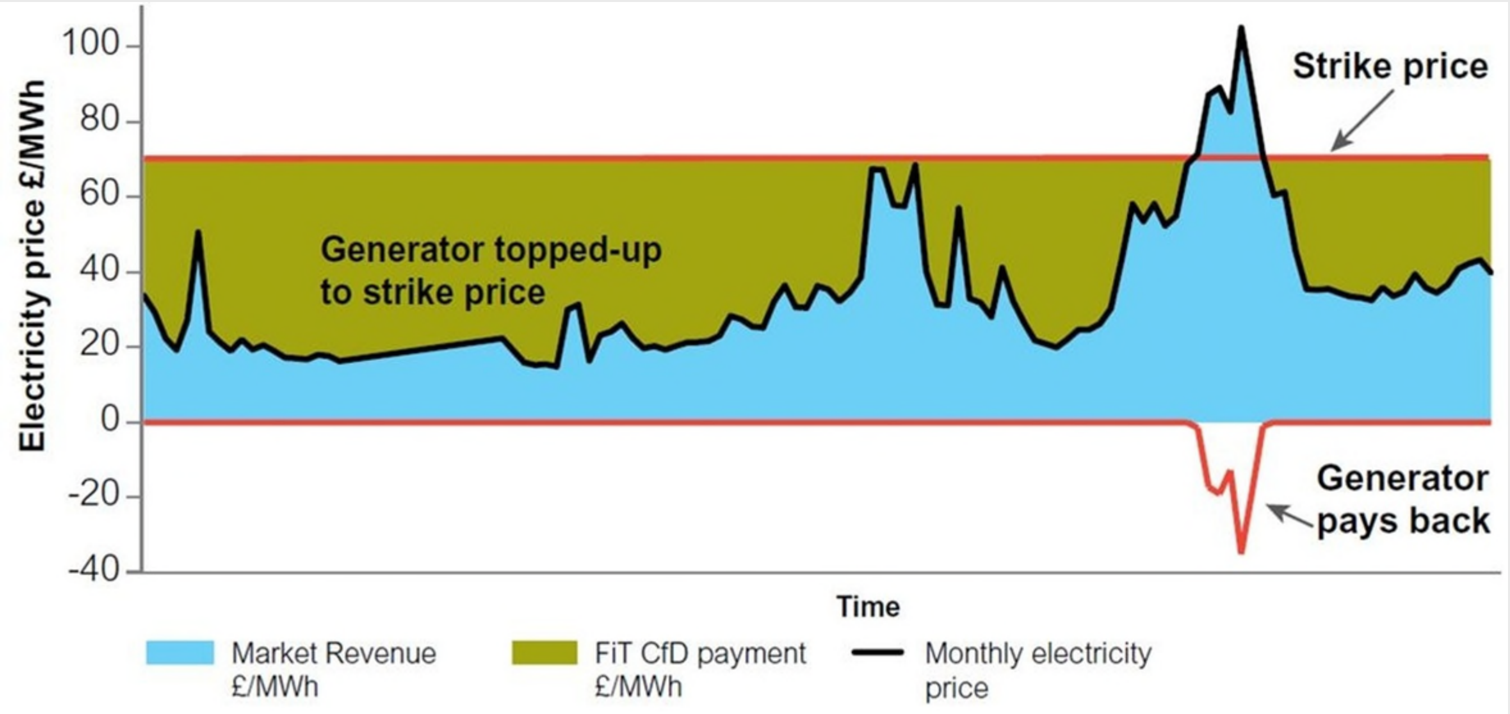
# A clear but complex pathway for project development




Source: UK Government – Alternative Routes to Market Consultation

# Funding/ financing support

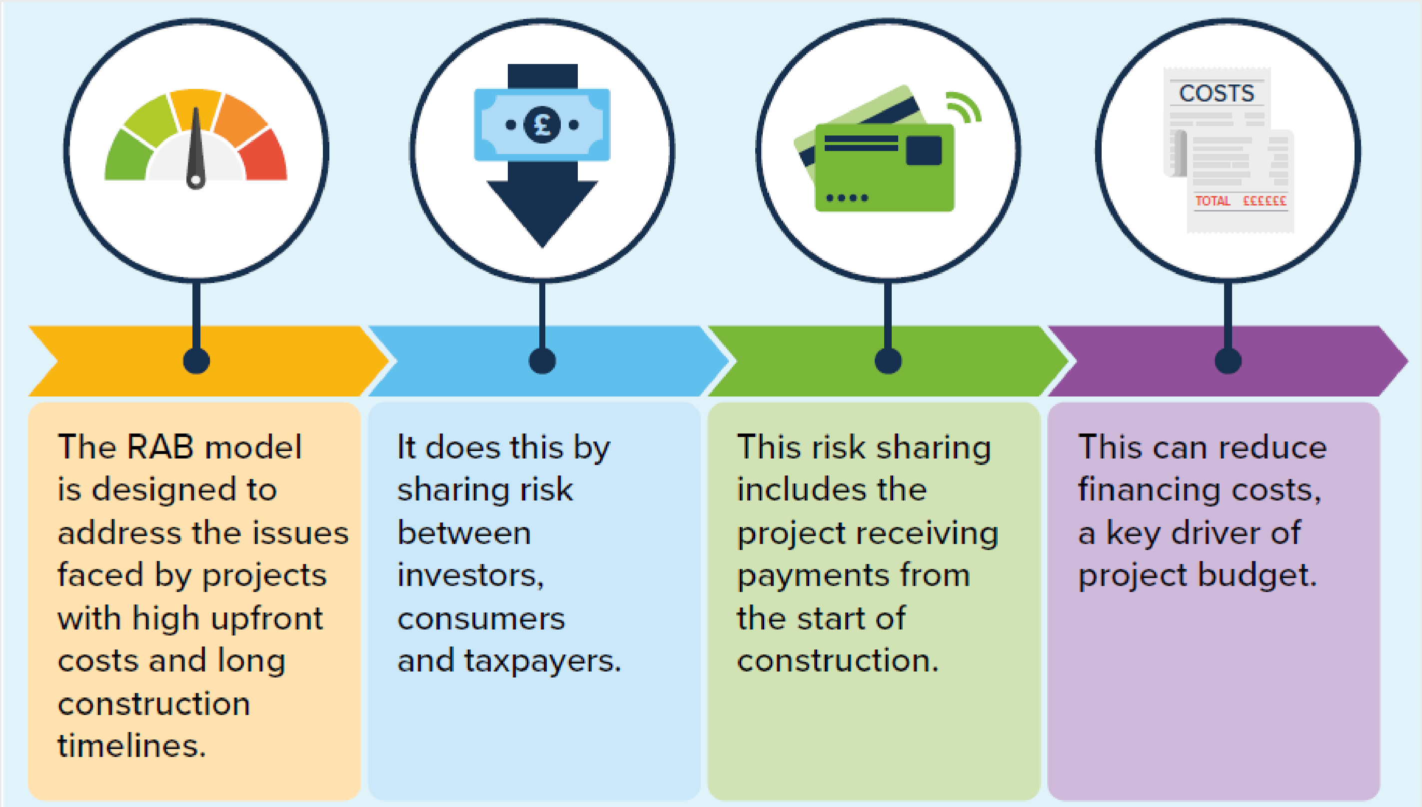
## Contract for Difference




Source: Researchgate.net

- Stable power price
- Higher financing costs – long duration from investment to return
- Development company takes construction risk
- Consumer obligation is capped

## Regulated Asset Base




Source: Nuclear Roadmap, HMG

- Stable revenues
- Lower financing costs
- Pain sharing on construction costs
- Consumer savings
- Incentivising flexible operation?

# What is needed?

| | |
|---|---|
| Developer/ Funding | Programme/ Fleet Approach |
| Sites | Government Sponsorship/ Stable Policy |
| Future Operator | Route to Market |

# *new*cleo's vision for the future

# A *new*, innovative player in nuclear energy

**REACTOR DESIGN:**
**Small Modular (SMR) + Lead-cooled Fast Reactors (LFR) = AMR**

*new*cleo is working to design, build, and operate Gen-IV Advanced Modular Reactors (AMRs) cooled by liquid lead

**FUEL MANUFACTURING:**
**Mixed Uranium Plutonium Oxide (MOX)**

MOX and Fast Reactors allow the multi-recycling of nuclear waste into new fuel with no new mining for generations

**SAFE AND AFFORDABLE** | **CLEAN AND RELIABLE** | **CIRCULAR**

Launched in **SEPTEMBER 2021**

Presence across **Europe**

**ACQUISITIONS**

FUCINA ITALIA — A newcleo company

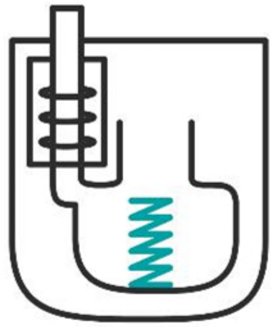
S.R.S. — A newcleo company

RÜTSCHI — A newcleo company

| | | |
|---|---|---|
| **700 EMPLOYEES** | **25+ YEARS OF RESEARCH** | **14+ PATENTS** |

**EUR400+ MILLION** of private funds
**~EUR50 MILLION** turnover in **2024**
Currently raising up to **EUR1 BILLION**

# *new*cleo's plan-to-market



**2026**

## R&D and Precursor

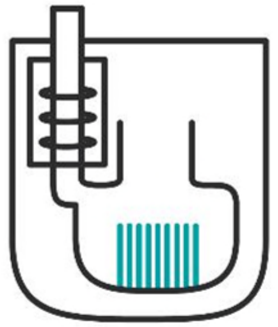
Several R&D facilities, and a **10 MW** non-nuclear facility with turbo-generator

**MOX**

**2030**

## MOX production

**FR-MOX production facility**, starting from available (separated) material in France

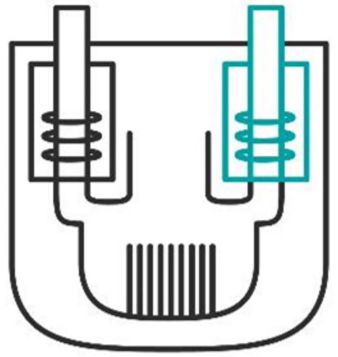


**AS-30**

**2031**

## LFR-AS-30

**30 MWe** nuclear irradiation reactor with core outlet at 430/440° (later 530°)



**AS-200**

**2033**

## LFR-AS-200

**200 MWe FOAK**, also for non-electrical uses (e.g. cogeneration and chemicals production)

# Increasing numbers of partners and suppliers

## Creating a global strategy supporting our delivery

### UK

TÜV, NIA, pillsbury, nexa, Freshfields Bruckhaus Deringer, DWD, NATIONAL NUCLEAR LABORATORY, MOTT MACDONALD, FRAZER-NASH CONSULTANCY, DALCOUR MACLAREN, wnti, dwf, NI Nuclear Institute, TECNIMONT, mace, NUCLEAR AMRC, Jacobs, NTS, ATKINS, ge, Hydrock, LSE The London School of Economics and Political Science

### FRANCE

EDF, framatome, cea, afcen, ONET, assystem, naarea, orano, GEVOLYS, Gifen, Nuclear Valley, INGEROP, SFEN, SIEPS

### ITALY

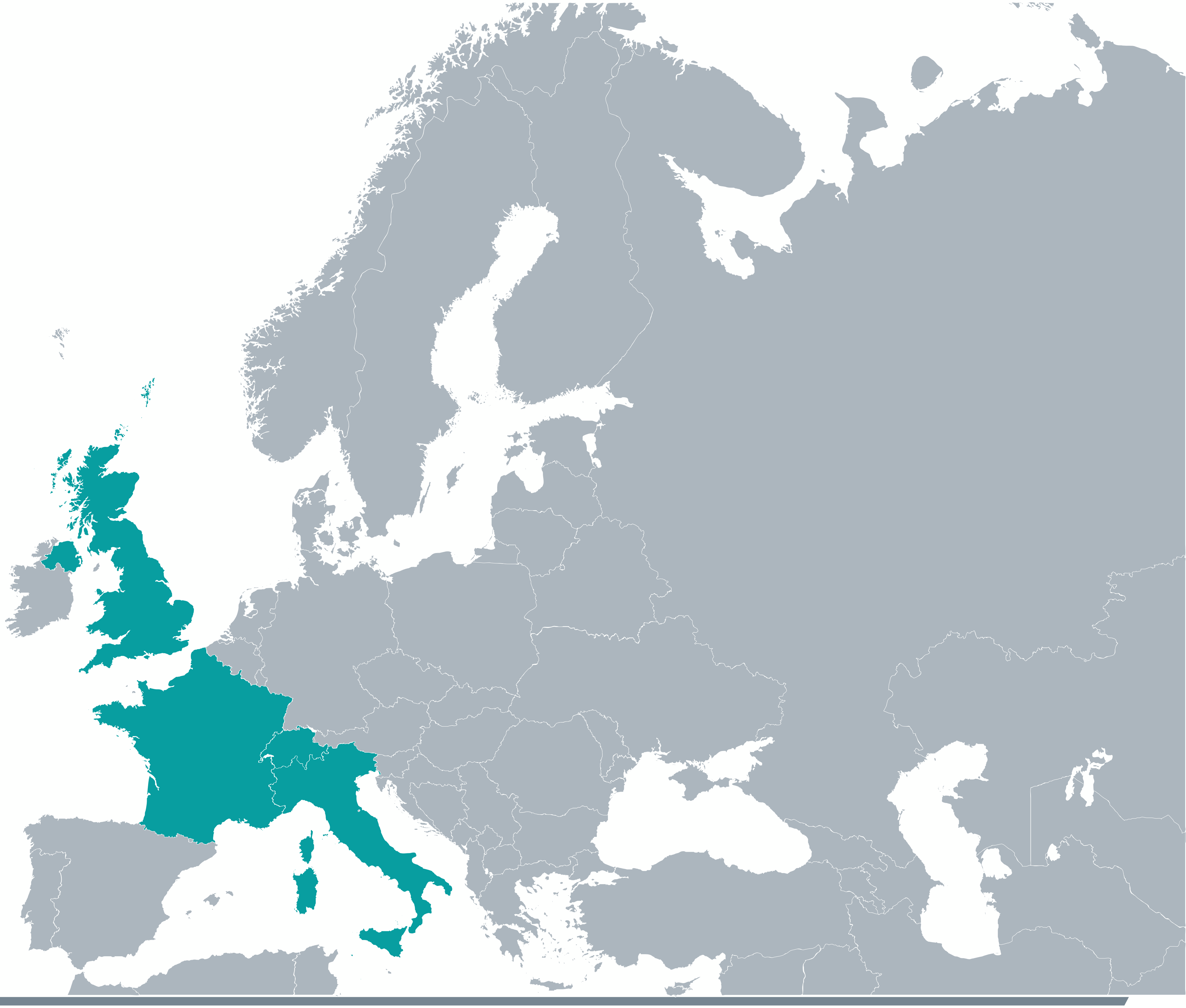
iit Istituto Italiano di Tecnologia, Politecnico Milano 1863, Politecnico di Torino, Sapienza Università di Roma, Alma Mater Studiorum Università di Bologna, tosto, AIN Associazione Italiana Nucleare, THERMOCOAX, SIMIC S.p.A., CARAGLIO, ENEA, RINA, FINCANTIERI, enel

### US

NEI Nuclear Energy Institute

### GLOBAL

World Nuclear Association, SNETP




Thank you