NUCLEAR INNOVATION AND RESEARCH OFFICE

Nuclear Energy in the UK and the Role of Advanced Nuclear Technology

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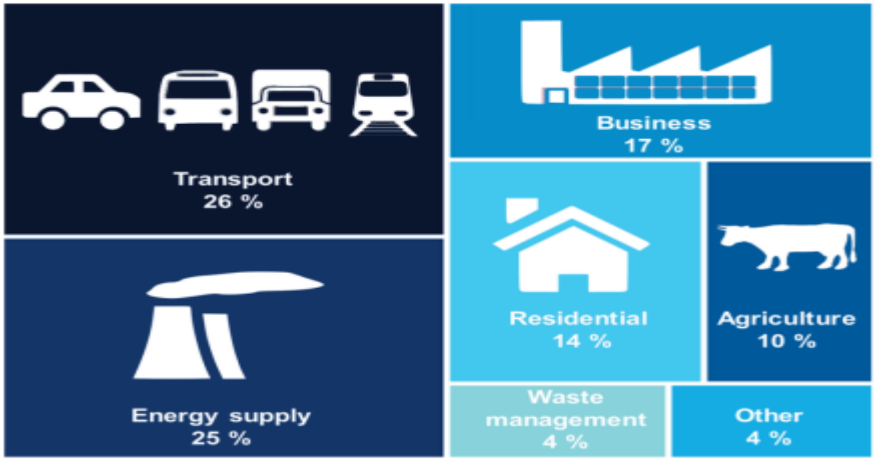
BEIS - Delivering against the Climate Change Act

- The UK **Climate Change Act** sets an 80% decarbonisation target for the UK by 2050 - the path to this target is based on 5 year carbon budgets. We are in the 3rd carbon budget, and at 42% decarbonisation (against 1990 baseline level).
- Over same period UK GDP has grown by 67%, so growth and emissions can be decoupled.
- Energy use, including transport, accounted for more than 80% of UK greenhouse gas emissions in 2015 – so it's a primary area to target for emission reductions.
- Achieving our targets with current technologies at current costs will be difficult and perhaps impossible so innovation is critical.

Transport becomes the largest emitting sector of UK 2016 greenhouse gas emissions



Source: BEIS 2018

Clean Growth Strategy Innovation

…has a very strong focus on innovation to drive clean growth:

INVESTMENT IN INNOVATION FOR CLEAN GROWTH

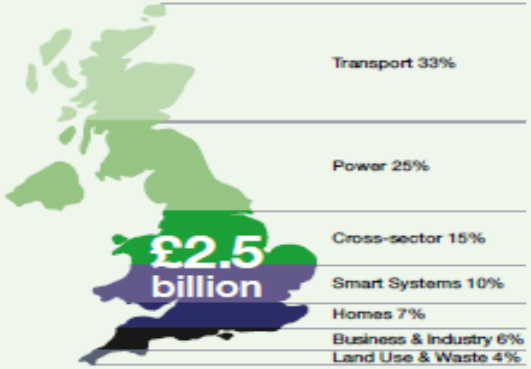
To achieve the clean growth we want, the UK will need to nurture low carbon technologies, processes and systems that are as cheap as possible.

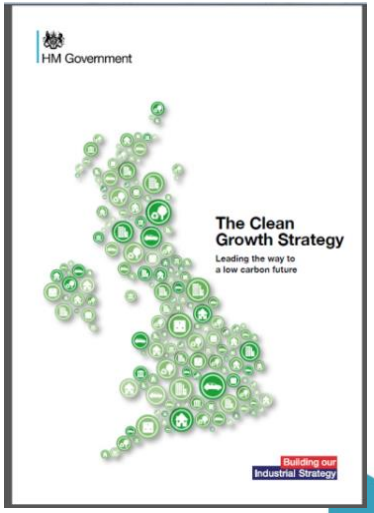
It is only through innovation that we will see new technologies developed and the cost of clean technologies come down.

Government has significantly increased its investment in low carbon innovation

allocated
2015-2021

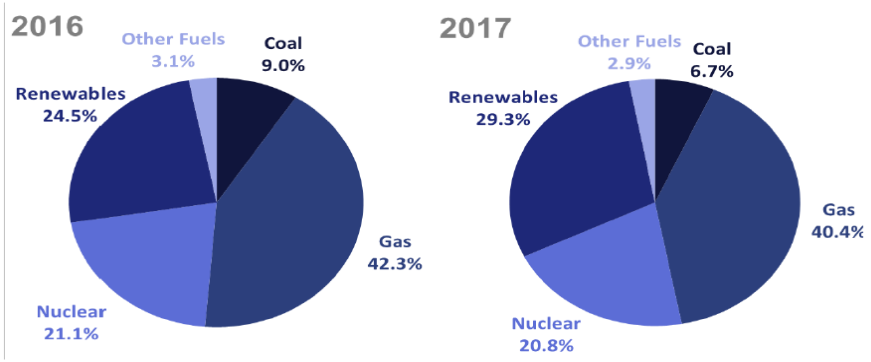
This strategy sets out, for the first time, where Government funding is targeted





UK Nuclear:
Current Status

Shares of Electricity Generation by Fuel

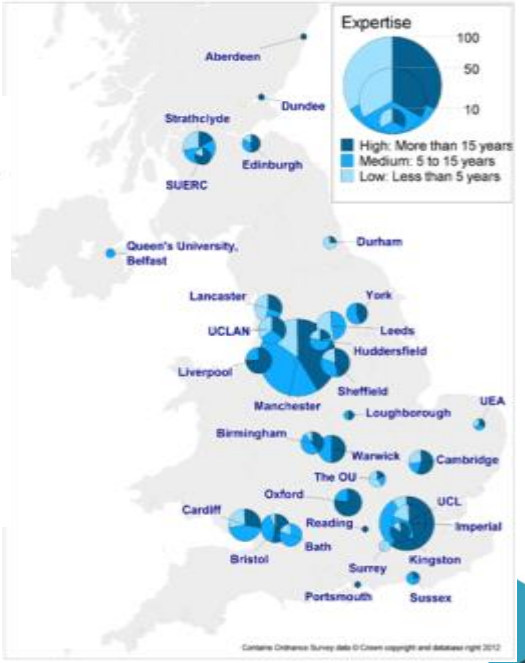


Source: Digest of UK Energy Statistics (DUKES) 2018; Chapter 5

UK currently has 15 reactors (AGRs and PWR) generating ~ 21% of energy mix but almost half of this capacity is to be retired by 2025

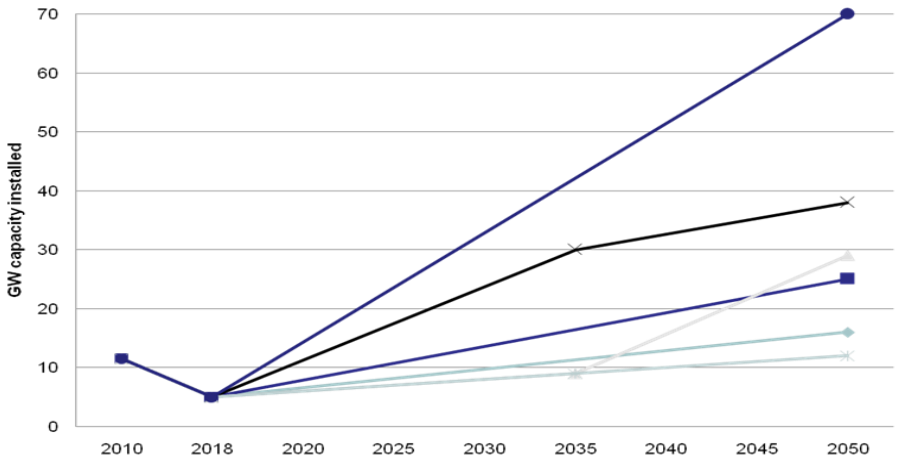
The first of some 19GWe of new-generation plants is expected to be on line by 2025 of which there is a expectation that 16GWe of new nuclear capacity will be operating by 2030

UK Nuclear:
Current Capability



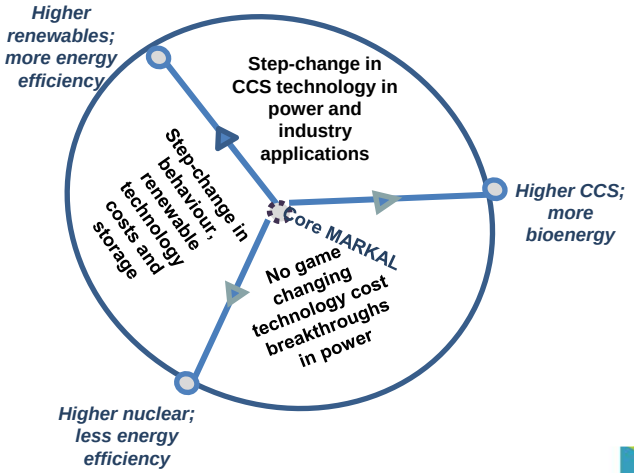
~200 companies : 88 000 people : 30 universities

Beyond 2050:
Scenarios for deployment



Technology
- LWRs
- SMRs
- ANT - Gen IV systems

"In 2018 Nuclear Energy makes up 21% of the UK Energy Mix" Source WNA

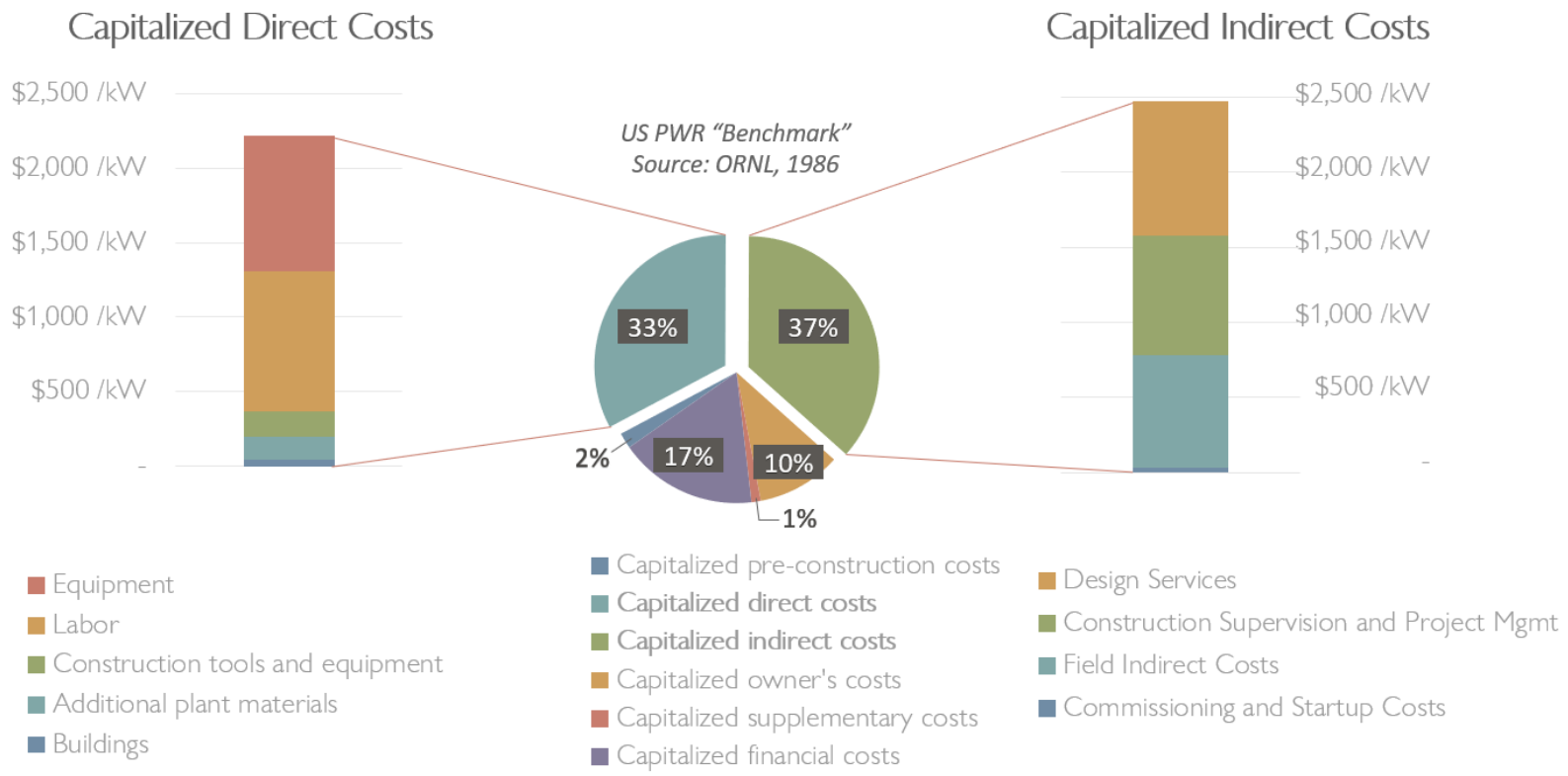


Deliver long term secure energy on the way to a low carbon energy future

Nuclear Energy Innovation Programme
Advanced Nuclear Technologies

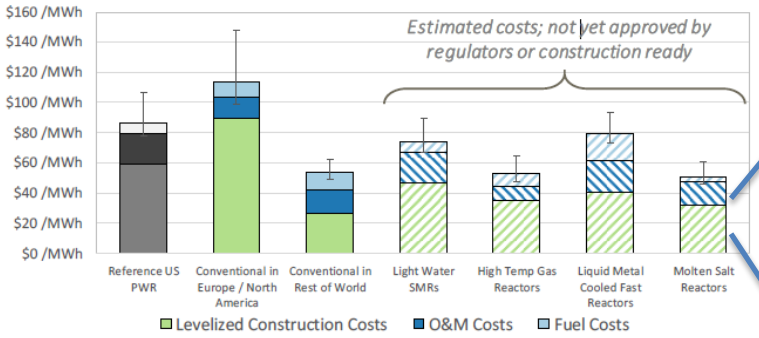
- Small reactors offer the potential to boost skills and create jobs in the UK, as well as reducing the cost of energy through modularisation.
- Government has been working closely with industry to explore this potential.
- The advanced nuclear market is diverse and includes a range of technologies, at different levels of maturity and market readiness.
- Focus – Cost, Flexible Supply, Waste and Alternative Applications

Capitalised Cost Breakdown of the US PWR Benchmark



Reference: The ETI nuclear cost drivers project: summary report

Advanced reactor strategies to reduce construction costs



Economy of scale replaced by economy of volume & factory production

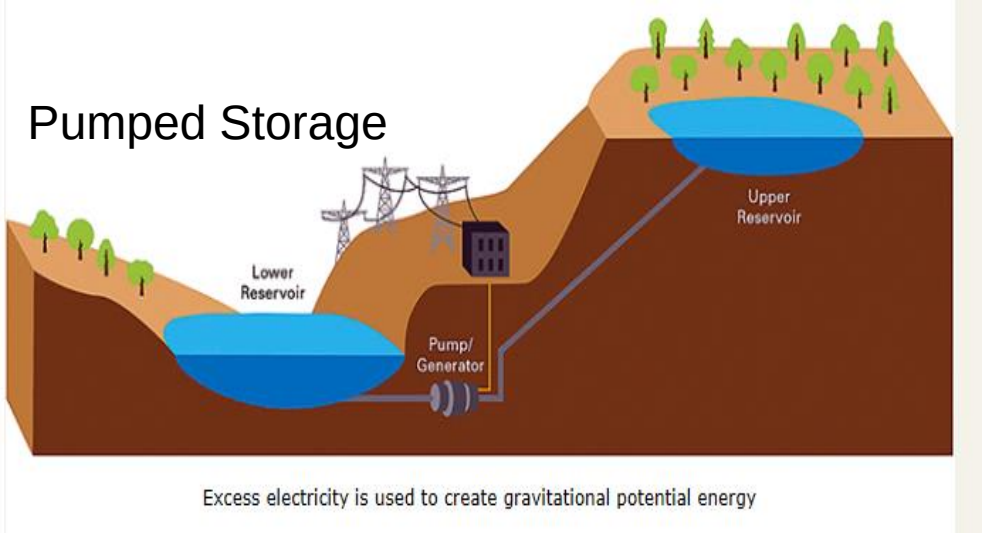
Intrinsic passive safety simplifies safety systems

Higher energy density reduces footprint & materials

Deep burn fuel reduces ops costs

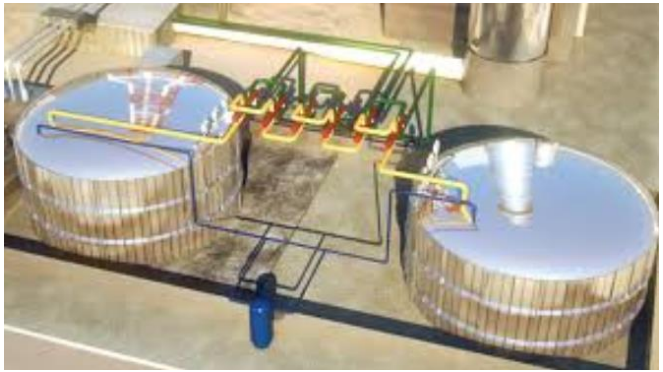
Flexible Supply

Pumped Storage

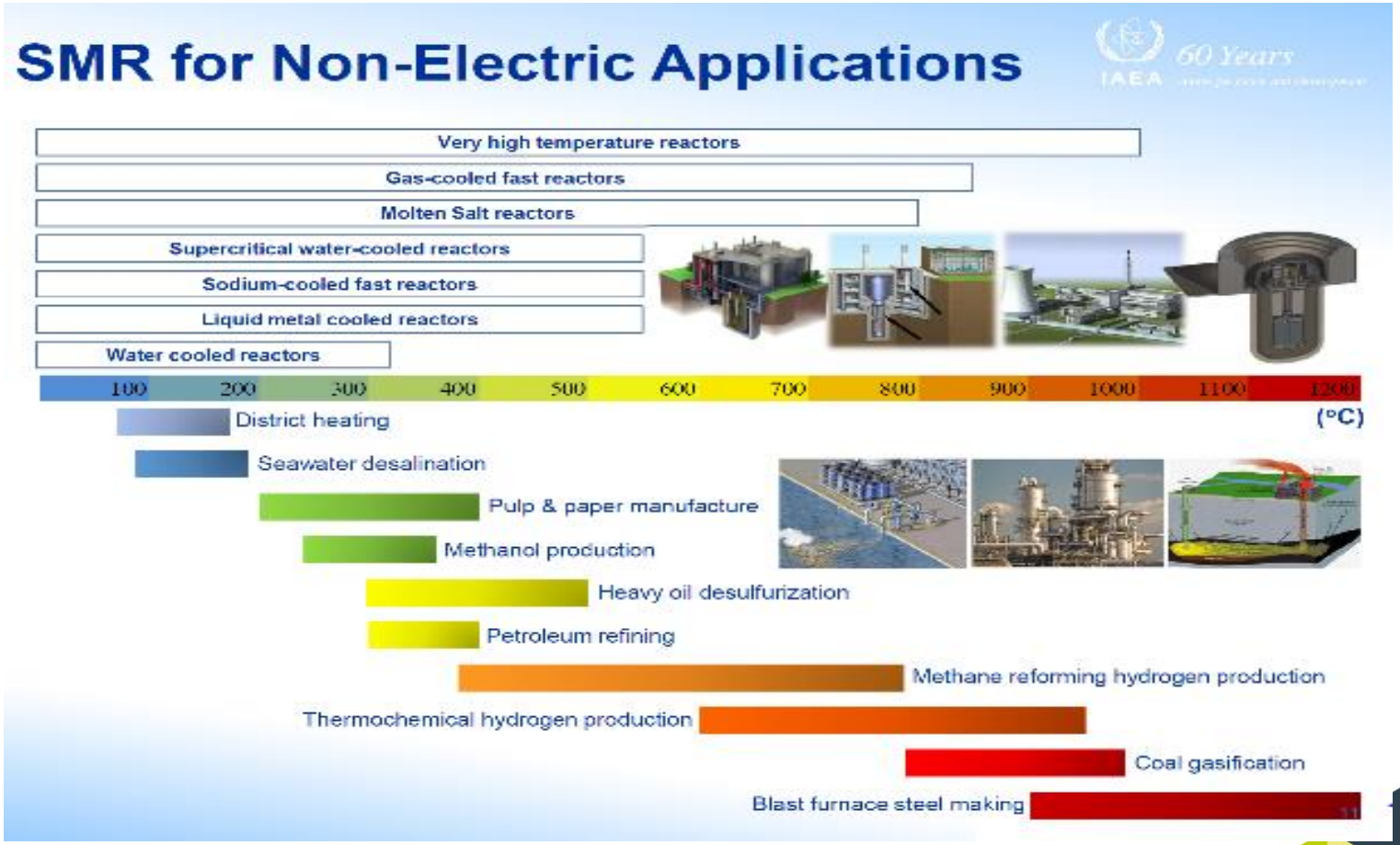


Excess electricity is used to create gravitational potential energy

Thermal storage



Alternative Applications

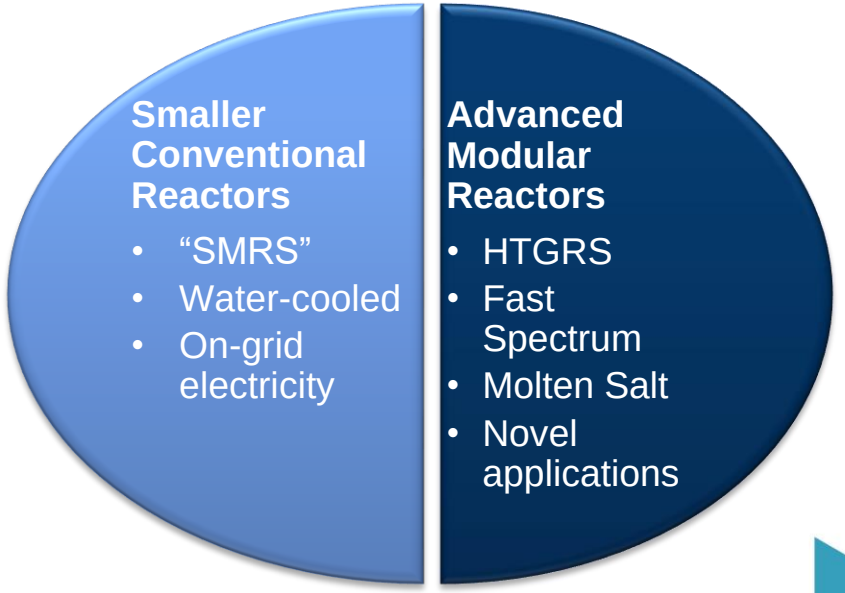


Advanced Nuclear Technologies

Looking to the future, in addition to conventional nuclear power plants, the **UK Government recognises the potential of small and advanced reactors.**

Announced Policies:

- **The Advanced Modular Reactor (AMR) Programme**. Up to £44m to assess the feasibility of innovative reactors projects and to accelerate the development of promising designs.
- **Funding for the UK Regulators**. Up to £12m to ONR/EA to increase the capability and capacity to assess and license new designs. This includes funding for a 1-to-1 vendor/regulator engagement programme.
- **The Expert Finance Working Group**. Tasked with exploring the financial models of small and advanced reactor developers and advising Government on how small reactor projects could raise private investment. Due to report in May.




Department for Business, Energy & Industrial Strategy

Policy paper

Advanced Nuclear Technologies

Published 7 December 2017

"The advanced nuclear sector has the potential to play an important part in the UK's Industrial Strategy building on our existing economic strengths and competitive advantages in nuclear while shaping new advanced nuclear markets and contributing to tackling the Clean Growth Grand Challenge."

https://www.gov.uk/government/publications/advanced-nuclear-technologies/advanced-nuclear-technologies

Advanced Modular Reactors:
Demonstrating the feasibility of design

Low cost electricity

Westinghouse UK Ltd
Lead Cooled Fast Reactor (LFR)
UO2 enriched or MOX fuel

Leadcold, SEALERUK (Small, Economic and Agile Lead-cooled Reactors for the UK)
Lead Cooled Fast Reactor (SFR)
Uranium Nitride fuel

Advanced Reactor Concepts LLC,
ARC-100
Sodium Cooled Fast Reactor (SFR)
U enriched metal alloy fuel

Increased flexibility

Moltex Energy Limited
UK Stable Salt Reactor
Molten Salt Reactor (MSR)
Fuel, NaCl / UCl3
Coolant, ZrF4/KF/NaF

Increased functionality e.g. heat

Ultra Safe Nuclear Corporation
High Temperature 'Micro Modular Reactor' (HTR)
UO2 kernel, TRISO in an SiC matrix (FCM pellet)
Coolant, Helium
Moderator, Graphite

DBD Ltd
High Temperature Reactor (HTR)
UO2 kernel, TRISO in graphite pebble
Coolant, Helium
Moderator, Graphite

U-Battery Developments Ltd
High Temperature Reactor (HTR)
UO2 kernal, TRISO, prismatic
Coolant, Primary – Helium, Secondary – Nitrogen
Moderator, graphite

Tokamak Energy Ltd, the spherical tokamak
Fusion Reactor (FR)
Deuterium and Lithium fuel
Coolant, Lithium

Advanced Nuclear Technologies:
Market Enabling Framework

The UK wishes to create a ‘Market Enabling Framework’ to foster the conditions needed for developers to bring new technologies to market. Other initiatives still in development are:

- **Enabling regulation** to recognise that small and advanced reactors may have differently regulatory requirements and undertaking work to understand these;
- Identifying **international collaboration** opportunities to de-risk technology development and develop relationships with our key international partners;
- Demonstrating the deliverability of cost savings through a **supply chain development** initiative that may feature in the nuclear sector deal;
- Considering the **siting** parameters for small reactors with the recognition that there is market interest in using NDA sites; and
- Understanding the **public acceptability** of advanced nuclear technologies.

Enabling Regulation:
Development and implementation of plans to:

- engage with SMR industry
- ensure that the regulators' processes and guidance are fit for the purpose of assessing and licensing SMRs
- extend ONR & EA's engagement with international regulators

Market Framework for Financing Small Nuclear
Recommendations from Expert Finance Working Group

Key Recommendation: HMG should help de-risk (perceived and real risks) the small nuclear market in order to enable the private sector to develop and finance projects.

Additional Recommendations:

1. HMG should enable small nuclear through a clear policy and market framework – rather than down selecting technologies
2. HMG should work with stakeholders from energy, nuclear and finance sectors to develop a common understanding of risks
3. For technologies capable of deployment by 2030, HMG should focus resources on bringing FOAK projects to market (only providing grants to enhance UK capability of in exchange for IP
4. HMG should establish an advanced manufacturing supply chain initiative (as with off shore wind) to drive new manufacturing capability with respect to balance of plant
5. HMG should work with regulator to review regulatory processes to develop an optimised and flexible GDA process
6. HMG should make sites available to FOAK small nuclear projects and should consider maintaining the UK's existing Site Licencee capability to de-risk the licence role for small nuclear projects
7. For technologies capable of deployment by 2030 HMG should focus resources by enabling reduction in cost of capital (e.g. direct equity, Contracts for Difference, Power Purchase Agreements etc.)

https://www.gov.uk/government/publications/market-framework-for-financing-small-nuclear

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