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EDF ENERGY

Spent Fuel Management – EDF Energy Perspective

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Agenda

- Context of nuclear new build
- Issues in managing waste and spent fuel
- Technical options for spent fuel storage
- Sizewell B dry store
- Planning application for Hinkley Point C
- Funded decommissioning programme

EDF and EDF Energy

- EDF: a major multinational energy group
  - Operates nuclear, hydro, renewables, gas generation plant
  - 37 million customers worldwide
  - Largest nuclear operator in the world
- EDF Energy: UK subsidiary of EDF
  - Supplies over 5 million UK homes and businesses
  - Operates a fleet of 15 nuclear reactors at 7 sites generating 17% of UK electricity
  - Plans to build 4 new EPRs (2 at Hinkley Point, 2 at Sizewell)
  - Operates 2 coal and 1 CCGT station with further CCGT being commissioned and several wind farms with plans for more

Our mission is to “lead the energy change”

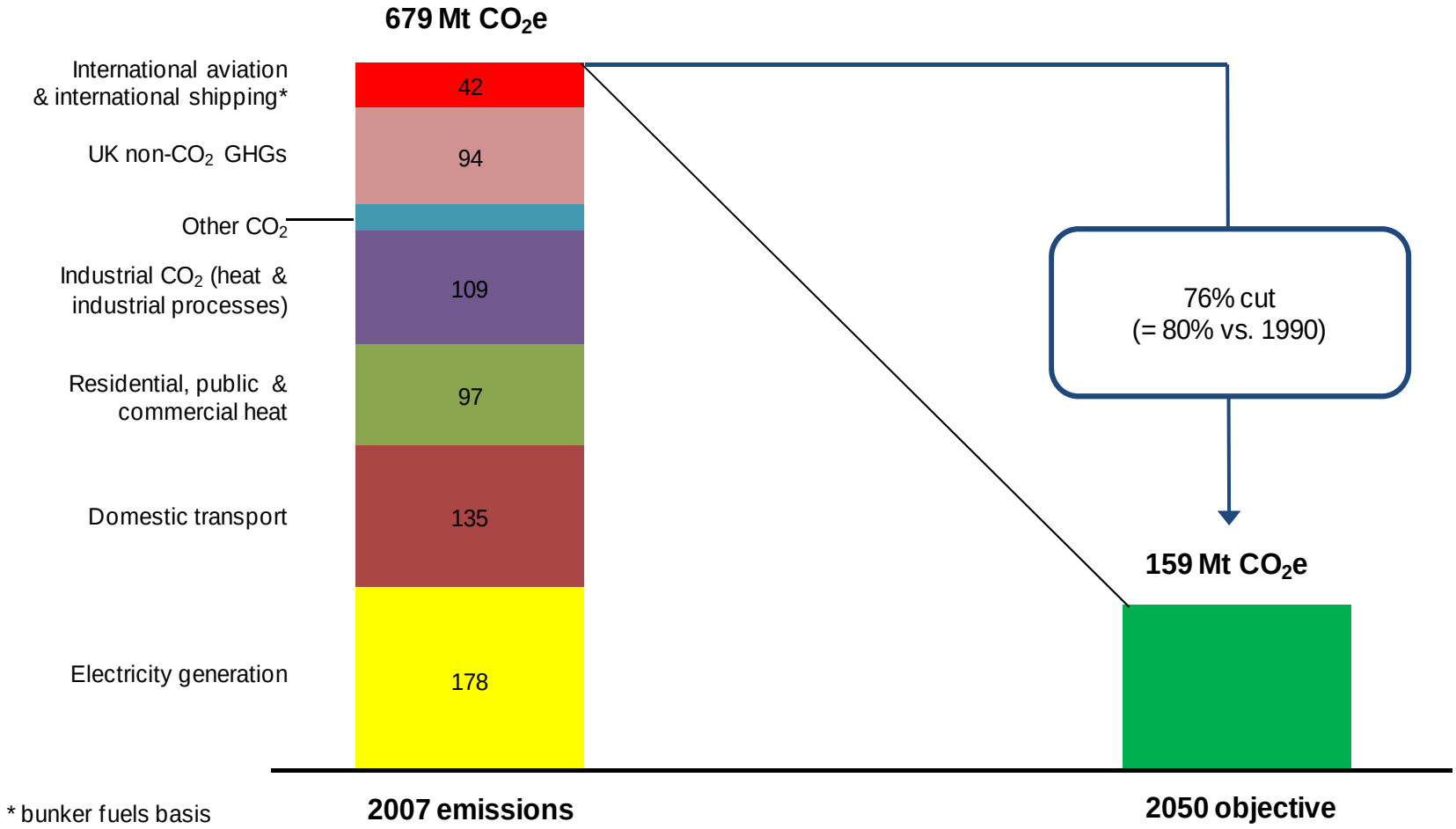
The challenge for the electricity sector

Diverse and secure energy mix

Decarbonisation of electricity

…and do it in a way we can afford

The budgets to put the UK on a path to reducing emissions by 80% by 2050

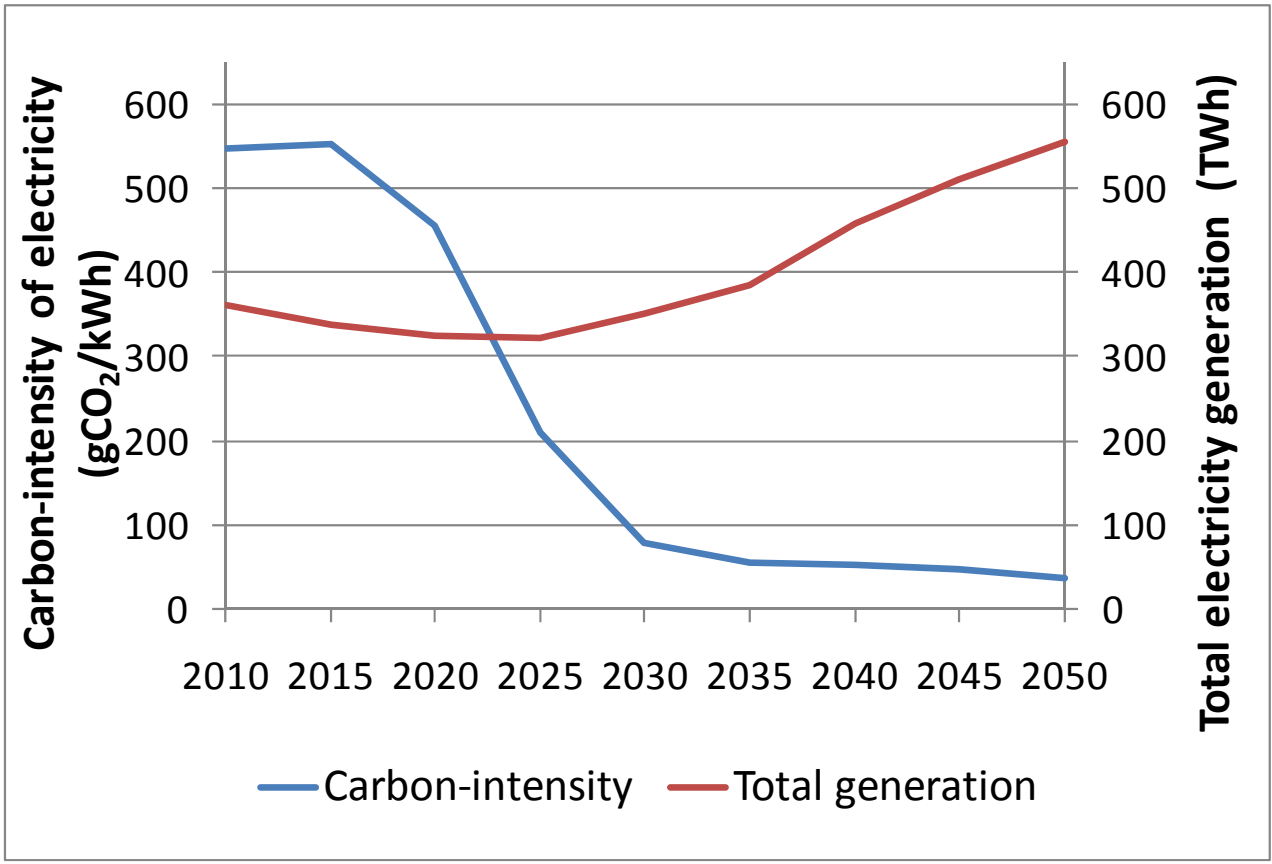


Source: Climate Change Committee Report (October 2009)

Power is central to wider economy decarbonisation

The **electrification** of other sectors will see demand increase in 2020s and 2030s

Therefore we need to **significantly** decarbonise electricity generation by 2030



Source: Climate Change Committee Report (October 2009)

UK Context

- There is a "national need" ….and it is becoming more urgent
- Strategically suitable sites for power station construction have been identified
- But, as yet, no site has been selected for a UK GDF
- International designs are going through a "Generic Design Assessment" by Office for Nuclear Regulation (ONR) and Environment Agency (EA)
- Delays to nuclear new build could place at risk:
  - UK security of supply
  - UK's current attractiveness for investment
  - Achievement of UK's climate change goals

Government Policy - Spent Nuclear Fuel (and Waste)

"Our policy is that before development consents for new nuclear power stations are granted, the Government will need to be satisfied that effective arrangements exist or will exist to manage and dispose of the waste they will produce." (January 2008 Nuclear White Paper)

"…the Government is satisfied that effective arrangements will exist to manage and dispose of the waste that will be produced from new nuclear power stations. As a result, the IPC should not consider this question. However, there may be planning issues relating to the on-site management of radioactive waste which it is appropriate for the IPC to consider as part of the development consent application."

(National Policy Statement for Nuclear Power Generation (EN-6), July 2011)

The implications for both existing and new nuclear operators are that our plans must be robust against uncertain timescales and must provide for interim storage of higher activity wastes and spent fuel.

Reprocessing

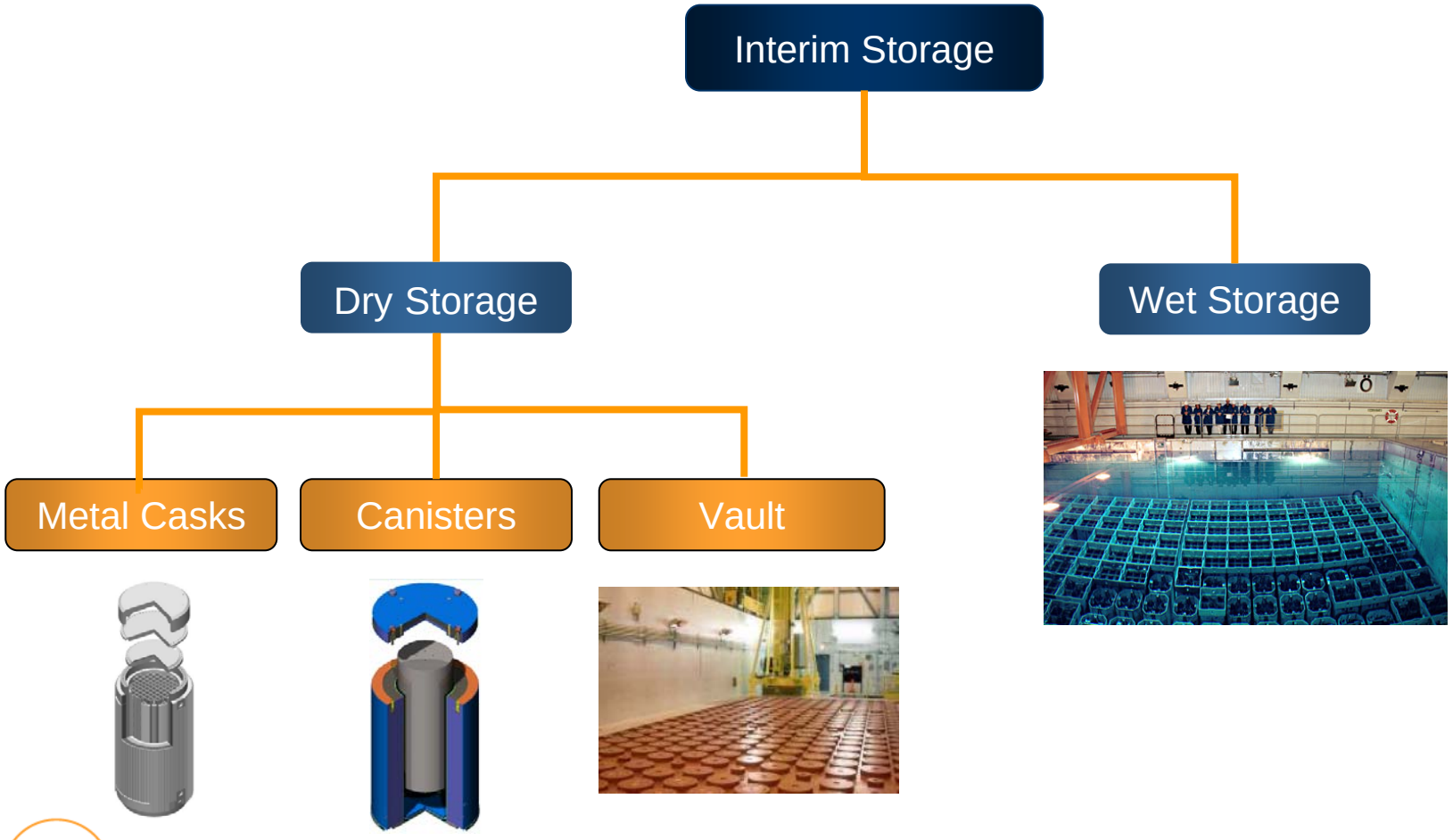
- Spent fuel from EDF Energy's 7 AGRs is both stored and reprocessed at Sellafield
- Sizewell B's fuel is not reprocessed and is stored on site

"Having reviewed the arguments and evidence put forward, and in the absence of any proposals from industry, the Government has concluded that any new nuclear power stations that might be built in the UK should proceed on the basis that spent fuel will not be reprocessed and that plans for, and financing of, waste management should proceed on this basis.

We are not currently expecting any proposals to reprocess spent fuel from new nuclear power stations. Should such proposals come forward in the future, they would need to be considered on their merits at the time and the Government would expect to consult on them." January 2008 White Paper

EDF Energy's plans for new build are consistent with this approach

Spent Fuel Interim Storage – The Technology Options



Spent Fuel Interim Storage – UK Regulation

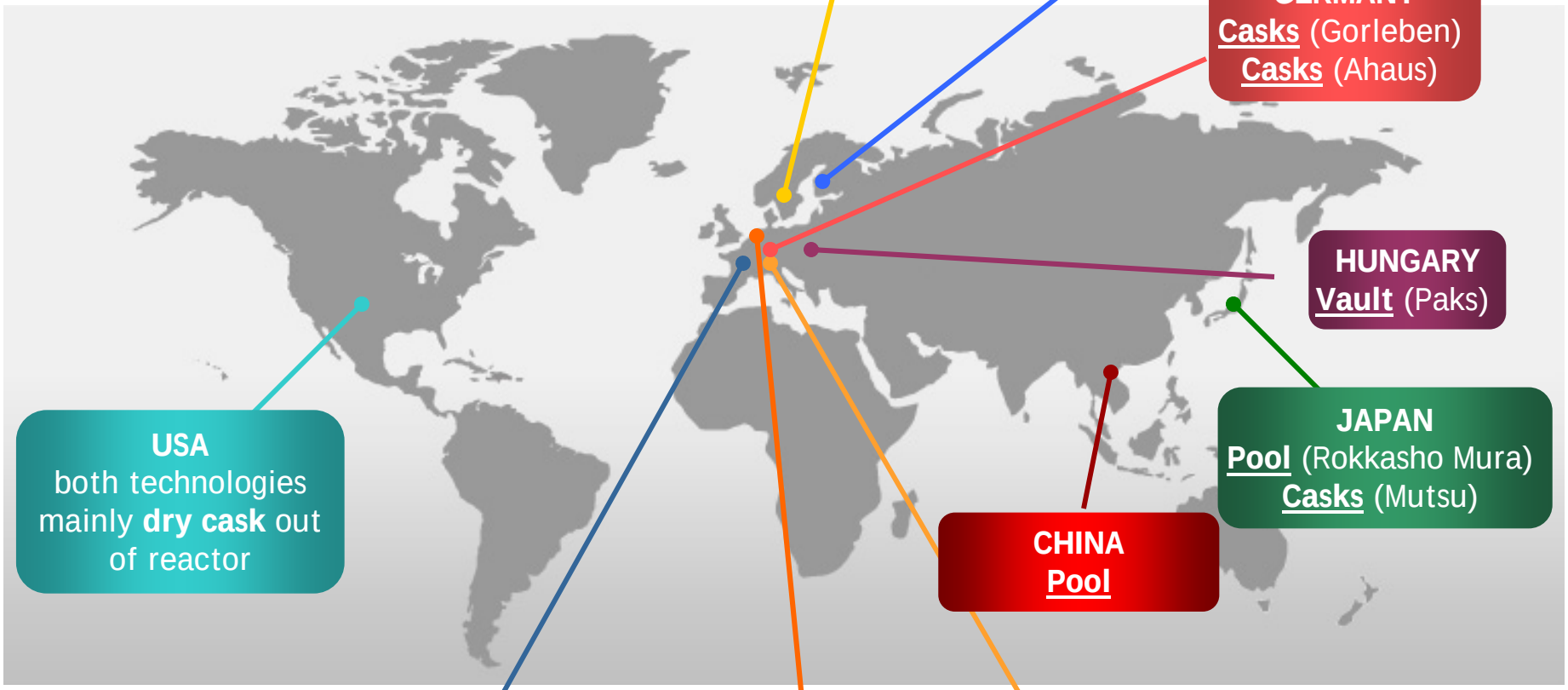
- Must be acceptable to ONR and EA
  - Safety case
  - Security
  - "Best Available Techniques" (BAT) requirement
- Must be demonstrably capable of transport offsite
  - IAEA and ONR/Dept for Transport requirements
- Must fit with (future) requirements for disposal in UK GDF
  - Encapsulation
  - Package size
  - Heat load

Comparison of some of the technical and safety features

		WET STORAGE	DRY STORAGE
Type of cooling		Water circulation	Natural convection
Flexibility to changes	In fuel quantities	May need extension to pool (add modules)	Flexible solution (add casks)
	In fuel type	Copes easily with wide range of fuel (burn-up or MOX)	Higher sensitivity to heat load
Retrievability of fuel		Easy	Possible but less easy
Fuel integrity		Lower cladding temperature	Cladding temperature higher and constraint on loading
Monitoring of fuel condition		Easy	More difficult
Radiological and chemical discharges		Very low	None
Solid rad-waste generation		From pond clean-up systems	None
Footprint on site		Compact for large fuel quantity	Less compact
Aircraft crash		Requires building to protect	Cask provides primary protection

Summary: No clearly superior technology, each has its strengths

Widespread use of both wet and dry storage



SWEDEN
Pool (CLAB)

FINLAND
Pool (Olkiluoto, Loviisa)

GERMANY
Casks (Gorleben)
Casks (Ahaus)

HUNGARY
Vault (Paks)

JAPAN
Pool (Rokkasho Mura)
Casks (Mutsu)

CHINA
Pool

USA
both technologies mainly **dry cask** out of reactor

FRANCE
Pool (La Hague)

BELGIUM
Pool (Tihange)
Casks (Doel)

SWITZERLAND
Casks
Pool (Gösgen)

Generic Design Assessment

- Evidence provided on:
  - Ponds
  - Casks
  - Canisters
  - Vaults

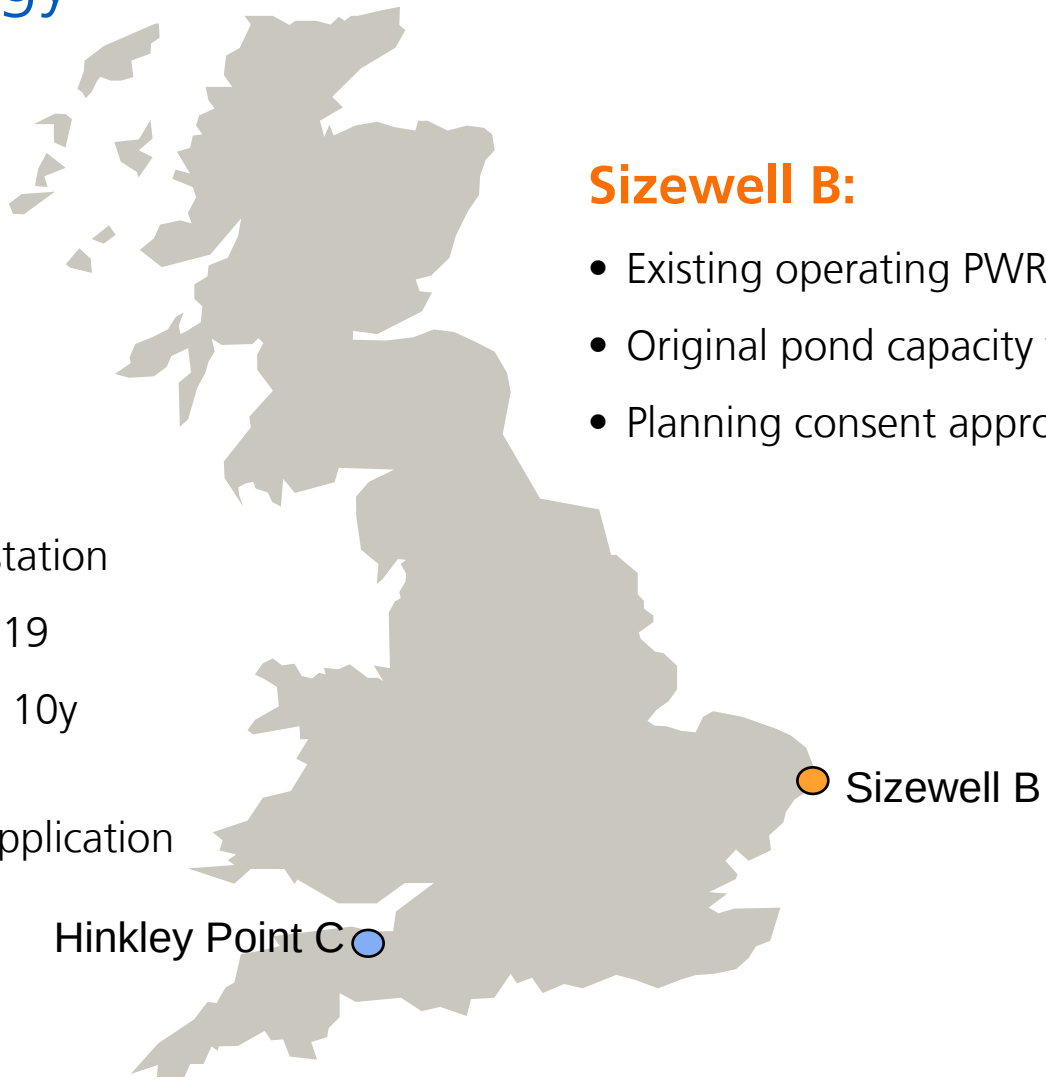
- Objective: underpin future flexibility across new build programme
  - Each technology is potentially licensable by ONR, and
  - Each is capable of satisfying the Environment Agency's BAT etc. requirements and can be permitted

Timescale for spent fuel storage – new build

- Modern nuclear units designed to operate for 60 years
- Around 10 years initial cooling in reactor fuel pool
- Around 50 years (or more) in interim spent fuel store
- Encapsulation prior to disposal
- Planning assumption that GDF available from 2130*.

*date when GDF will be available for new build spent fuel uncertain, so need to allow for this.

Specific Interim Storage Proposals made by EDF Energy



Sizewell B:

- Existing operating PWR station
- Original pond capacity full in 2015
- Planning consent approved

Hinkley C:

- Planned new twin EPR station
- First unit operational 2019
- Reactor ponds will have 10y capacity
- Development consent application accepted by IPC

Approach adopted to identify preferred option

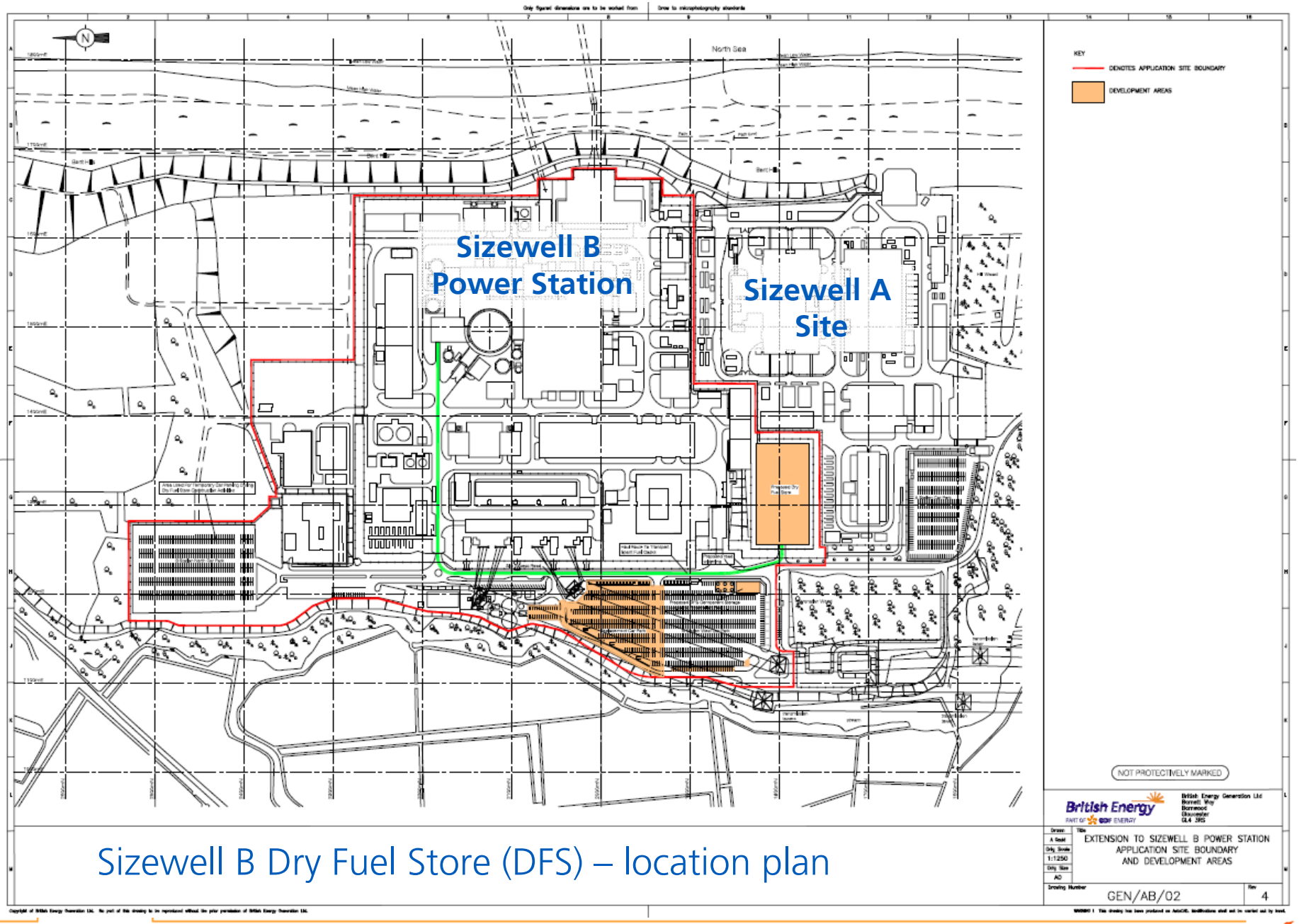
- Review available technologies and obtain current information from all available sources
- Clarify constraints – policy, regulation, site specifics
- Engage wide range of stakeholders
- Take advantage of EDF Group experience
- Use multi-attribute decision analysis (MADA) to help inform choice

Broadly the same approach was applied to both the Sizewell B and the Hinkley Point C decisions

What we learned

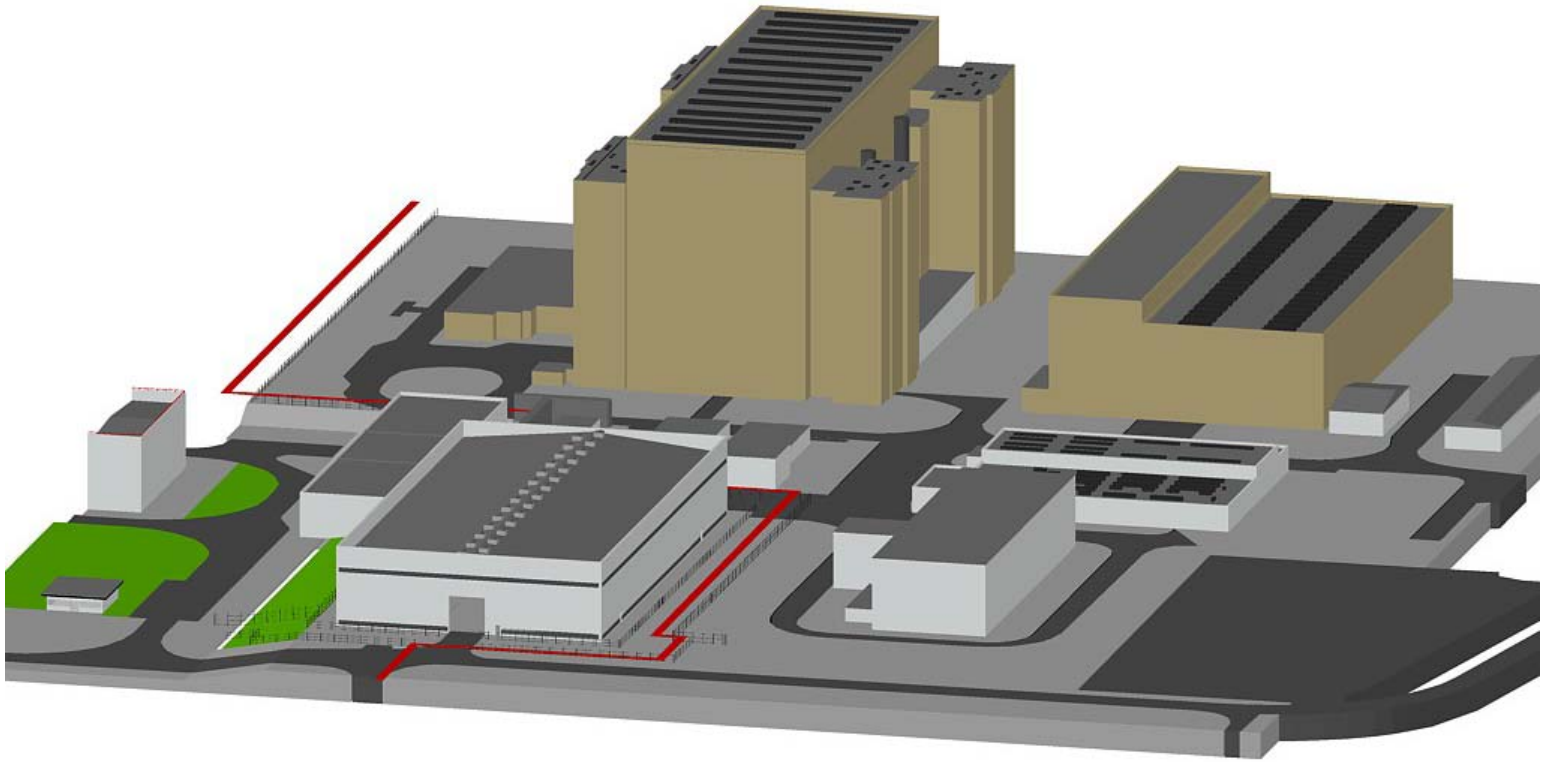
- There is no clear-cut "best choice" technology for UK
  - All options studied could meet the most stringent safety and environmental standards required in the UK
  - Each could be argued to offer advantages under certain possible futures…… but these future scenarios are themselves uncertain
  - The economic assessment does not determine the decision
- The decision has to be a judgement based on:
  - The detailed factors that apply at the particular location
  - Minimising project risk while providing a totally robust solution
  - Providing flexibility to meet future possible developments

Although for EDF Energy safety, security and environmental requirements remain paramount, they do not on their own lead to a clear preference as to spent fuel storage technology



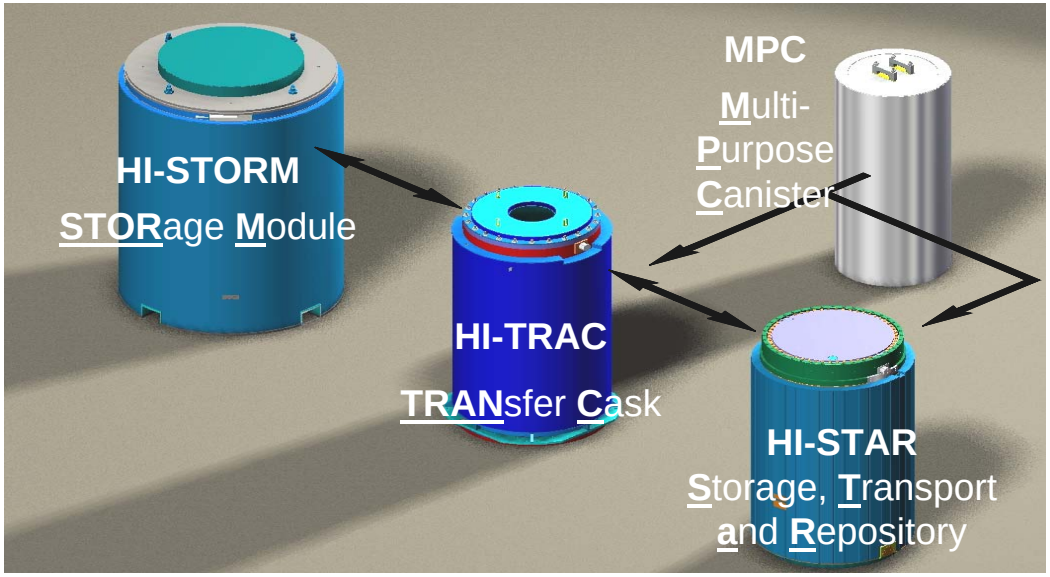
Sizewell B Dry Fuel Store (DFS) – location plan

3-D Visualisation of Sizewell B Dry Fuel Store



Sizewell B Proposal

- Store vertically inside concrete overpack within DFS building
- Natural convection cooling, heat output from assemblies dictates canister loading
- If needed, inspection possible at reactor facility (during station life)
- Flexibility
  - Alternative cask designs available
  - Contingency option to transport some fuel to Sellafield if dry store delayed

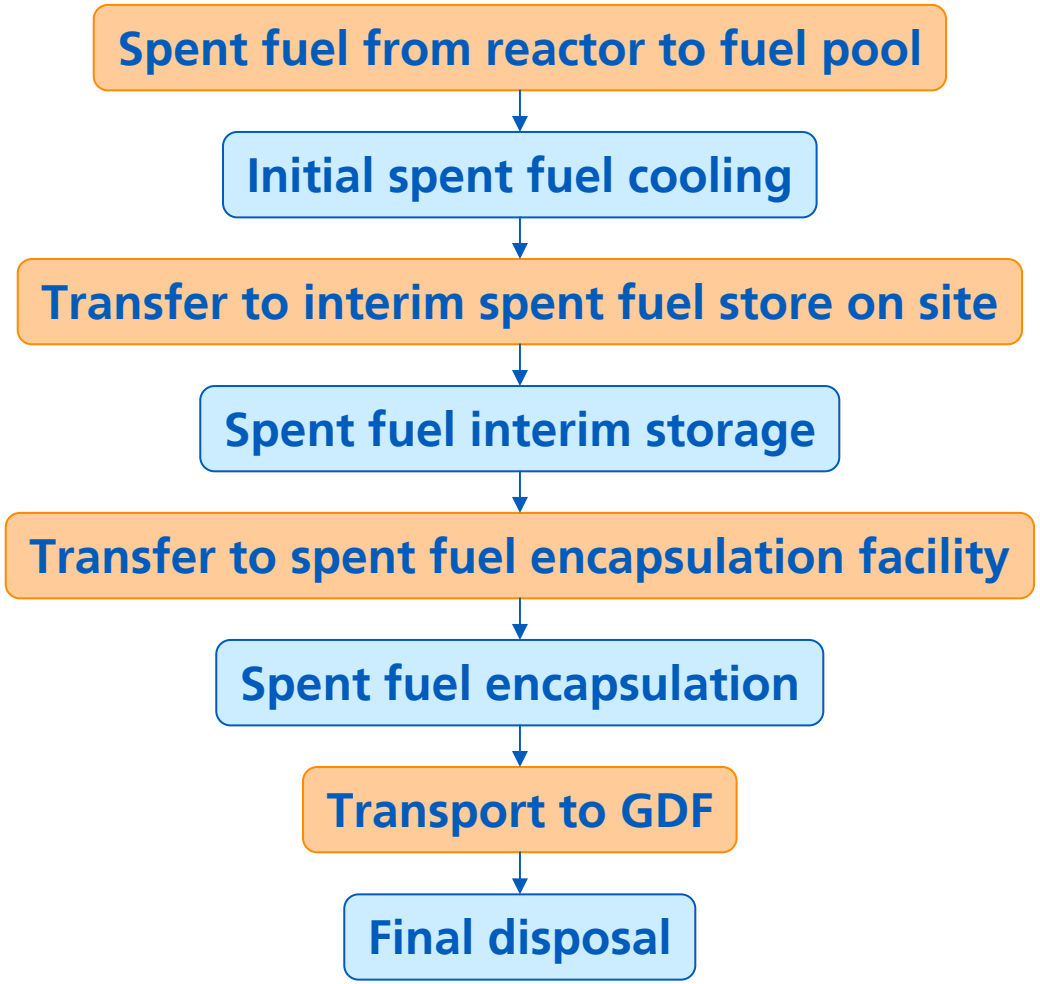


Components within the Holtec Fuel Storage and Transport system

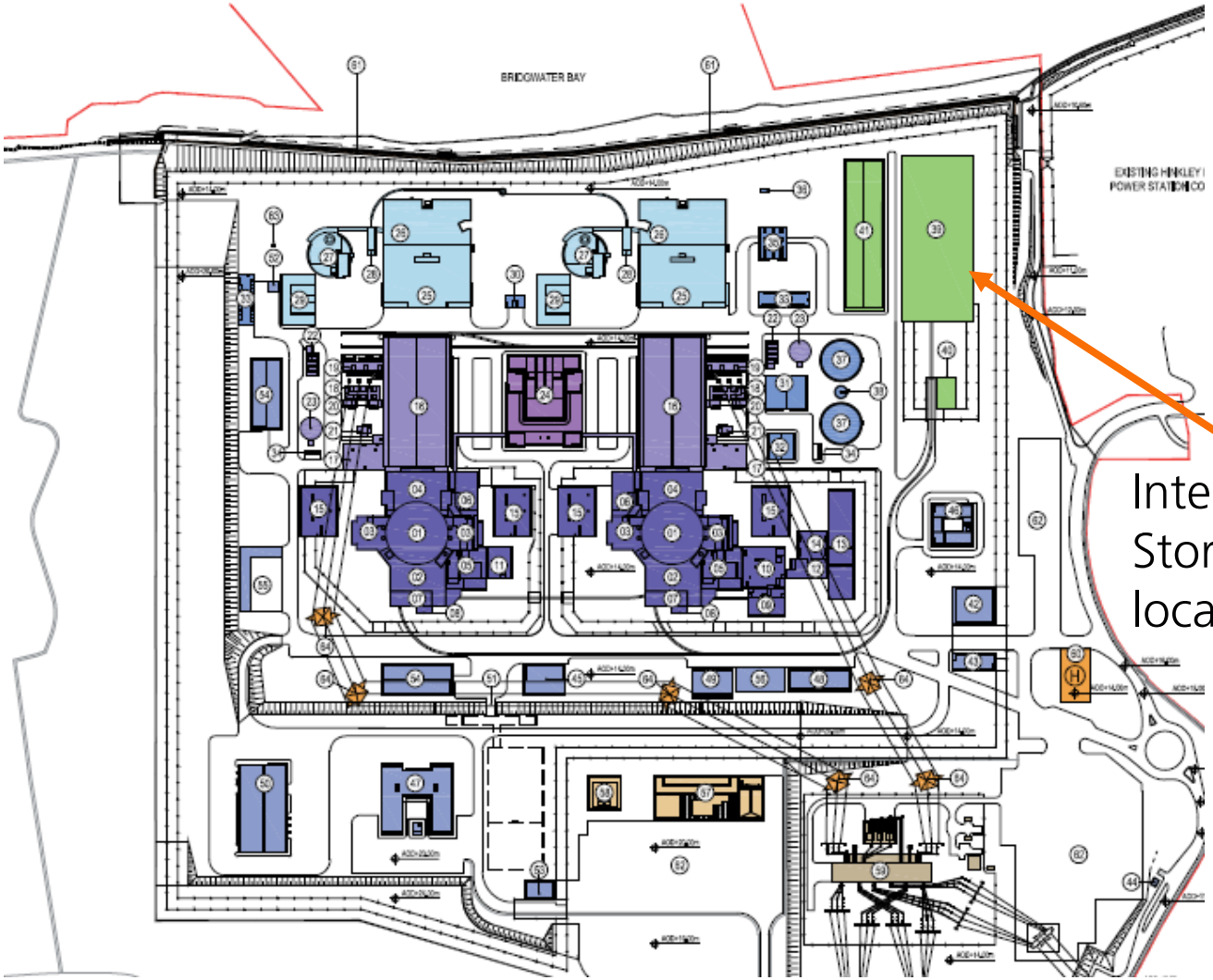
(illustrative only)

Spent fuel storage casks

Hinkley Point C – Spent Fuel Management



Hinkley Point C Proposal (1)



Interim Spent Fuel Store (proposed location)

Ref: Hinkley Point C Design and Access Statement, Appendix D, Figure D4

Hinkley Point C Proposal (2)

- Store will be designed to address external hazards
- Inspection of fuel possible throughout life
- Flexibility
  - Fuel removal from store straightforward
  - Pond option has greatest capacity to adapt to different fuel cycles over station lifetime

Illustrative only
(Cap La Hague)

Key areas of difference affecting our choice of preferred solution

- Burn-up
- Time in reactor pond before transfer
- Fuel quantity
- Fuel transfer design and the benefits of replication
- Modifying existing plant during operation vs. designing facility as part of overall station

The choice of technology for Hinkley Point C has been reviewed in the light of events at Fukushima, and the selection of wet storage confirmed as the best solution.

[Ref: The Choice of Interim Spent Fuel Management Storage Technology for the Hinkley Point C UK EPRs, NNB-OSL-STR-000034, October 2011]

Hinkley Point C – Intermediate Level Waste (ILW) and Low Level Waste (LLW)

ILW

- Ion exchange resins, filters, sludges and operational wastes
- Wastes conditioned and packaged on site
- Interim storage in standard pre-cast concrete casks
- Interim storage facility to take lifetime ILW arisings
- Disposal to GDF when available

LLW

- Aim to minimise arisings through use of waste hierarchy and application of BAT
- On site conditioning and packaging
- Off site treatment (e.g. supercompaction, incineration, recycling) or disposal

Financing - Funded Decommissioning Programme (FDP)

- Energy Act 2008 created the legal duty to establish a FDP, which must be approved by the Secretary of State.
- The FDP must set out arrangements for:
  - treatment, storage, transportation and disposal of hazardous material during the operation of a nuclear installation on the site
  - the decommissioning of any relevant nuclear installation and the cleaning-up of the site
- The FDP must also set out how these arrangements are to be financed.

Conclusions

- Spent fuel management is an important long term issue
- Proven technologies are available to ensure safety, security, and environmental protection
- EDF Energy has had to make specific proposals
  - to enable Sizewell B continued operation beyond 2015, and
  - to inform the planning application for Hinkley Point C
- Our proposals had to be developed against today's context; they use our best judgements about the future
- We are contributing to work to help optimise UK strategy for both legacy and new build waste management
- Our proposals include flexibility to respond to future developments, if necessary