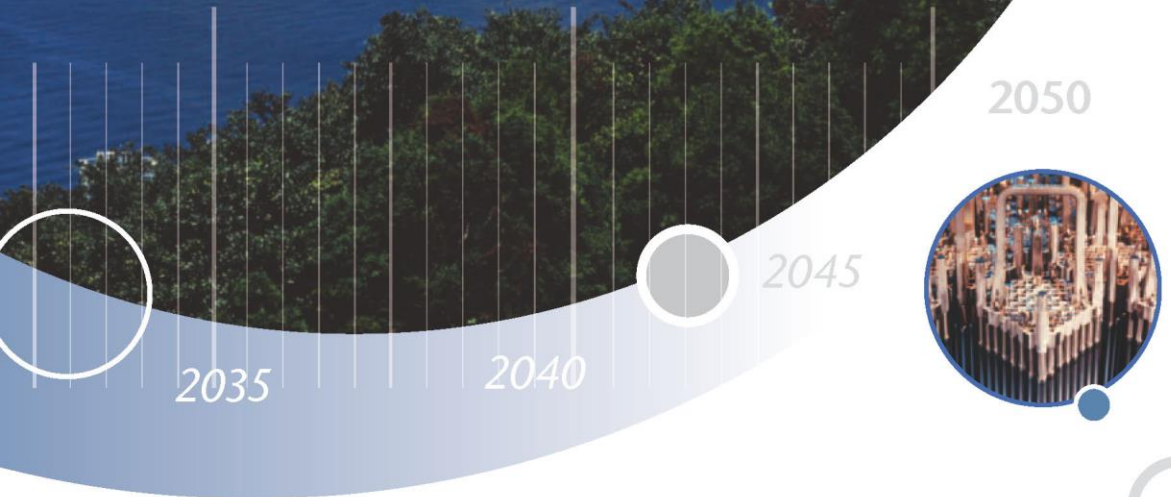


# DRAFT Milestones and Recommendations: Fuel Cycle

## Technology Roadmap

Nuclear Energy





■ **Fuel cycle:** - established technologies for all steps of the NFC, though R&D can help improve technologies, reduce costs, ...

- **Front end: uranium supply, enrichment, fuel fabrication**
  - ◆ Alternative to U-cycles: role of Thorium?
- **Back end: (includes waste management)**
  - ◆ Once-through / recycling
  - ◆ Interim storage
  - ◆ Geological disposal
- **Decommissioning**



# Milestones / metrics (1)

## ■ Front end:

- Uranium supply (Red Book, 2012): current resource base more than adequate to meet high case demand up to 2035 but investments in environmentally sustainable U production should be made given long lead time of mining operations.
- gas centrifuge enrichment now the most common technology. In the future, laser isotope enrichment could bring costs down (by how much?).
  - 1<sup>st</sup> commercial laser enrichment plant in operation by 2025?
- “accident tolerant fuels” – more attention since Fukushima Daiichi accident – designed to offer additional coping time in case of SA (but fuel will cost more). New fuel qualification will take time...
  - 1<sup>st</sup> test assembly by 2020 & commercial use by 2030?



## Milestones / metrics (2)

### ■ Back end:

- Deep geological disposal for HLW, whatever the strategy (once through or recycling). But developing a DGD requires long term planning, political commitment and engagement with local communities. No “wait and see” strategy should be recommended.

→ 1<sup>st</sup> DGD for once-through cycles in Finland / Sweden by early 2020s

CASE STUDY?

→ 1<sup>st</sup> DGD for recycle option in France by 2025

- Regional repositories? International repositories? Would allow cost sharing... but difficult to establish



# Milestones / metrics (3)

## ■ Back end:

- Extended storage of spent fuel – needs to be considered and studied (R&D) for countries that have no short to medium prospects of having an operational DGD site (and that have NPPs in operation for several decades). Should not be considered an alternative to DGD
- Recycling: strategy followed by many countries (France, Russia, Japan, China, India...), with advantages in terms of resource management (important in the long term) & conditioning of HLW (and sizing of DGD). Cost of recycling comparable to once-through.

CASE STUDY?

- ◆ Necessary step towards closing of FC with Gen IV reactors
  - Demonstration of use of Minor Actinide-bearing fuel in Fast Reactor by... 2030?
- Newcomer countries should also define a strategy for the backend of the NFC.





## Milestones / metrics (4)

- **NFC: “Fuel Services” – what role in supporting further development of nuclear energy?**
  - **Purchase of U concentrates, conversion, enrichment services**
  - **Service of reprocessing spent fuel produced in another country (vitrified waste sent back, separated material used to produce fresh fuel)**
  - **Fuel leasing**
  - **“Fuel banks”**
  - **Role of international cooperation / agreements...**
  - **Importance of nuclear security (transport)**



# Milestones / metrics (5)

## ■ Decommissioning:

- With increasing number of NPPs to be shut down in the coming decades, decommissioning will become a growing industrial activity. Public acceptance of NE requires demonstration that old plants can be decommissioned/dismantled safely → “greenfield”
- Technology exists, and can be further developed to reduce decommissioning costs (e.g. increased use of robotics)
- Also, newer designs take decommissioning into account (designed to facilitate disassembling of components)

CASE STUDY?



# Recommendations:

	Timeline
Investments in environmentally-sustainable uranium mining should proceed to address expected long term demand	2015-2025
Governments should ensure that policies are in place to allow for deep geological disposal of high level waste, and should not defer decisions, “wait and see” is not an option	2015-2025
In countries where there is no short to medium prospects for having an operational DGD site, studies should be carried out to ensure extended (dry) storage of SNF satisfies highest safety and security requirements.	On-going
Governments should continue to cooperate to discuss international fuel services as a means to support the safe development of nuclear power.	On-going
Nuclear operators should ensure that shut down nuclear facilities are decommissioned in a timely, safe and cost-effective manner.	On-going
Governments should continue to support R&D in advanced recycling technologies to reduce volume and toxicity of high level waste	On-going