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Belgian nuclear energy policy

Enabling a sustainable phase-out of nuclear energy

Investing in the next gen nuclear reasearch infrastucture

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Agenda

1. **The Belgian energy policy**
2. **Focus on some recent developments:**
   - Offshore development
   - Capacity Remuneration Mechanism
3. **Belgian nuclear energy policy**
4. **Conclusions**

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THE BELGIAN ENERGY POLICY

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The Belgian energy landscape

- Planned nuclear phase-out
- Centrally located and densely populated
- Highly import dependent
- Decreasing energy intensity
- Pioneer in offshore renewables
- Well interconnected
- Complex institutional framework

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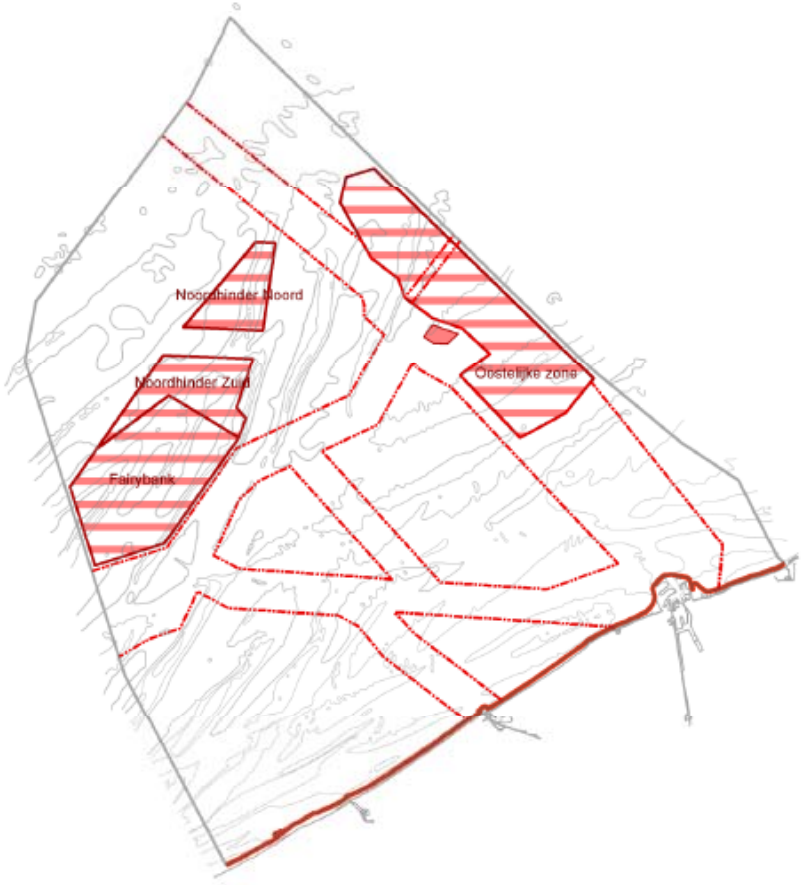
Offshore development



- First zone
  - All concessions granted
  - Support scheme agreed
  - MOG under construction
  - Essential in reaching the BE 2020 objectives

- Second zone
  - Second zone determined in marine spatial plan
  - Legal framework for tendering procedure approved
  - Network development plan of Elia approved, including onshore and offshore reinforcements
  - Essential in reaching the BE 2030 objectives

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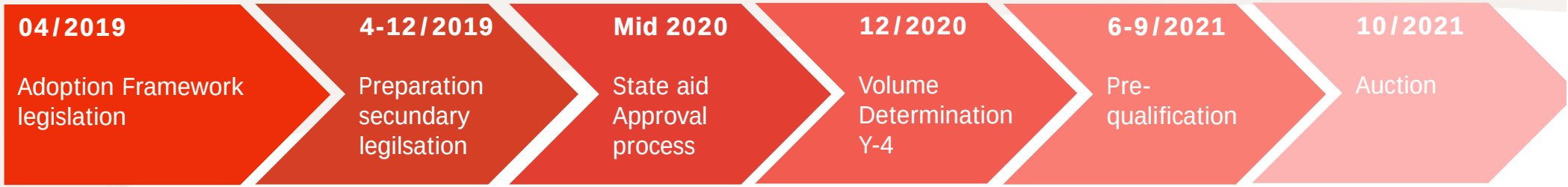
Capacity Remuneration Mechanism

Context

- Energy transition
- Nuclear phase-out by 2025
- Ageing centralized production park
- “Missing money” for new capacities

Design options

- Reliability option
- Ensuring sufficient capacity, while limiting windfall profits
- Y-4 and Y-1 auctions
- In line with State Aid Guidelines and Clean Energy Package: measure of the last resort, clear problem identification, proportionate, technology-neutral, cross-border participation, …



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Future priorities

- Finalize and implement the Integrated National Energy and Climate Plan
- Ensuring security of supply throughout the energy transition
- Implementing Clean Energy Package & evaluating existing market coupling projects
- Focus on improving gas market functioning at EU, regional and bilateral level (market integration, LNG strategy, infrastructure development, L-gas transition, renewable gas)
- Looking into potential economies of scale for offshore renewables by the development of an integrated network in the Northern Seas

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Ministry of Economy and Energy competences in the nuclear sector

- Funding of nuclear public activities
  - R&D Fusion
  - R&D Fission (eg: SCK•CEN)
    - Nuclear Materials & Fuels, LTO, Adv. Nuc. Systems, Fusion, Geo. Disp., D&D, Medical applications, Radioprotection, …MYRRHA (SCK•CEN)
  - Radioisotopes: Mo-99 refining and Radiopharmaceuticals production (IRE)
- Management of nuclear historical liabilities (SCK•CEN, IRE and Belgoprocess)
- Belgian Advisory Committee for the Non-Proliferation of Nuclear Weapons
- Belgian Advisory Committee for the Nuclear provisions
- Belgian Committee for the management of spent fuel and radioactive waste
  - covering all types of spent fuel and radioactive waste under its jurisdiction and all stages of spent fuel and radioactive waste management from generation to disposal.
- Nuclear liability
- Metrology
- International cooperation

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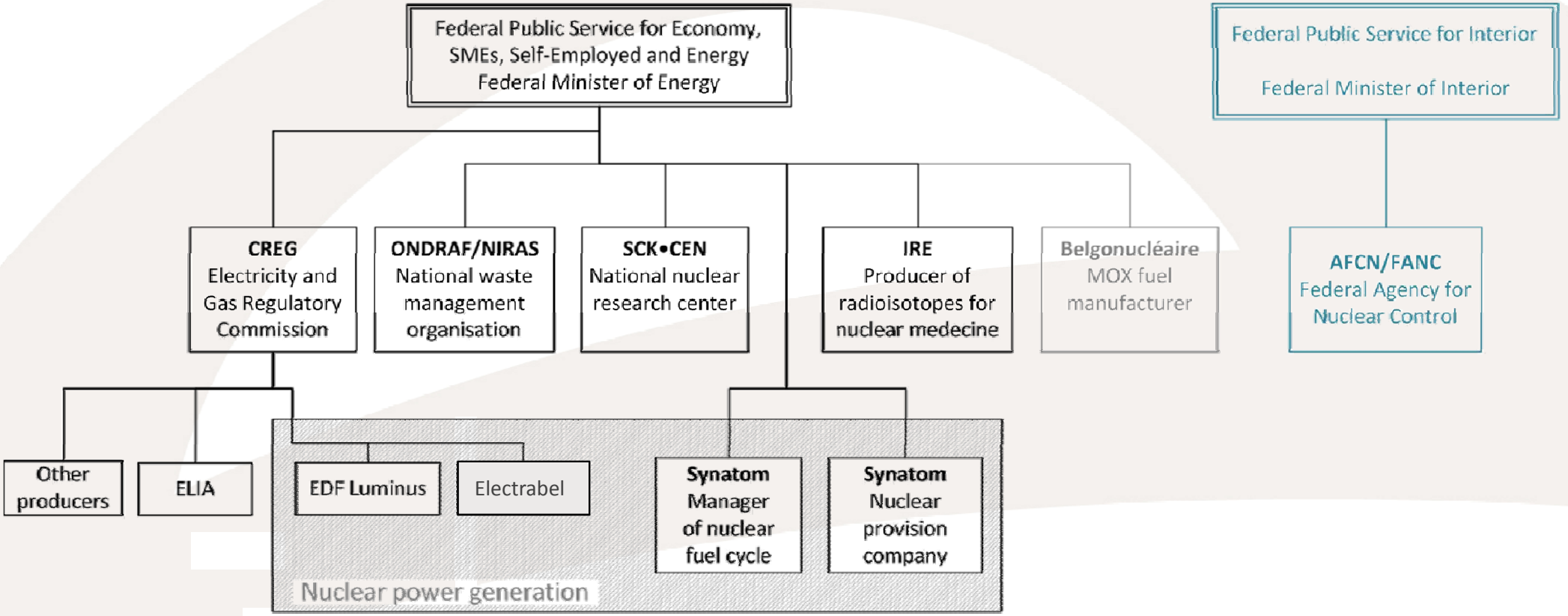
Nuclear sector in Belgium in a nutshell



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Overview NPP's in Belgium

- 2 sites: Doel and Tihange (7 units)
- Total installed capacity (2019) 5.931 MW
- Only one nuclear operator: ELECTRABEL - ENGIE (part of ENGIE (FR))
- EDF BELGIUM owns 50% of Tihange Unit 1
- EDF LUMINUS owns 10,2% of Tihange 2 & 3 et Doel 3 & 4

Reactor Unit	Type	Net Capacity [MW(e)]	Status	Operator	Reactor Supplier	Construction Date	First Criticality Date	First Grid Date	Commercial Date
DOEL-1	PWR	445	Operational	ELECTRAB	ACECOWEN	1969-07-01	1974-07-18	1974-08-28	1975-02-15
DOEL-2	PWR	433	Operational	ELECTRAB	ACECOWEN	1971-09-01	1975-08-04	1975-08-21	1975-12-01
DOEL-3	PWR	1006	Operational	ELECTRAB	FRAMACEC	1975-01-01	1982-06-14	1982-06-23	1982-10-01
DOEL-4	PWR	1039	Operational	ELECTRAB	ACECOWEN	1978-12-01	1985-03-31	1985-04-08	1985-07-01
TIHANGE-1	PWR	962	Operational	ELECTRAB	ACLF	1970-06-01	1975-02-21	1975-03-07	1975-10-01
TIHANGE-2	PWR	1008	Operational	ELECTRAB	FRAMACEC	1976-04-01	1982-10-05	1982-10-13	1983-06-01
TIHANGE-3	PWR	1038	Operational	ELECTRAB	ACECOWEN	1978-11-01	1985-06-05	1985-06-15	1985-09-01

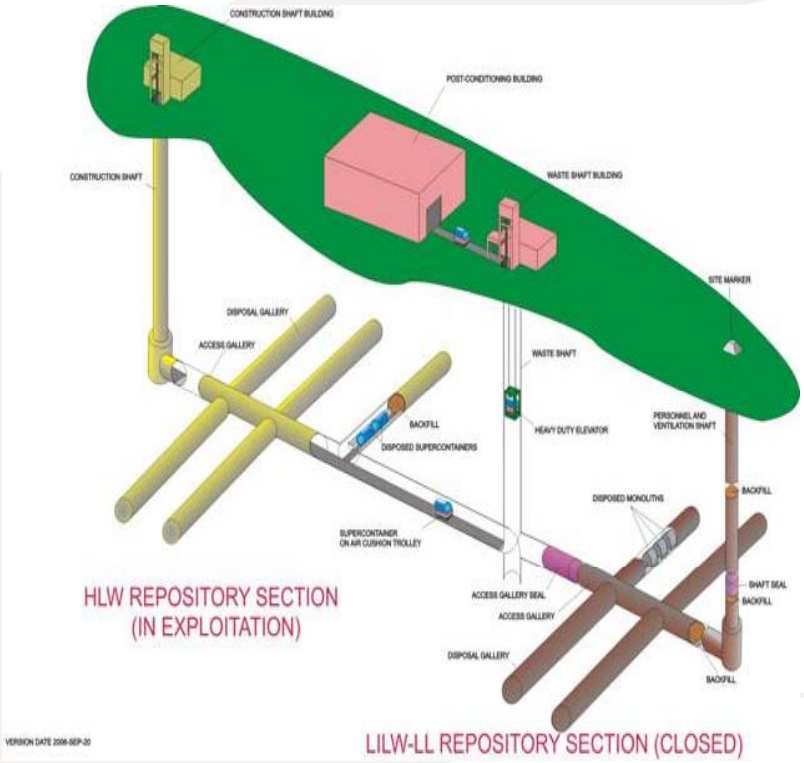
Nuclear waste management in Belgium

- Low and intermediate level short-lived waste
  - 2006: government decided on near surface disposal at Dessel (cAt)
  - 2012: request to obtain the license for the disposal facility has been introduced with the safety authorities (FANC)
  - February 5th 2019: new safety case introduced by ONDRAF/NIRAS with FANC
- Medium high-level and long-lived waste
  - R&D program since 1974 on geological disposal started by SCK•CEN, presently managed by ONDRAF/NIRAS
  - ONDRAF/NIRAS prepared a « Waste plan » in 2011 that was submitted to the government to obtain a decision-in-principle on the geological disposal in clay (Boom & Ypresian clays)
  - ONDRAF/NIRAS asked to open the siting to all types of suitable host formations
- In 2016 Belgium and Luxembourg signed a bilateral treaty for the final disposal of Lux waste in Belgium
- First National Programme on nuclear waste management published in 2016 (transposition of the EU nuclear waste directive 2011/70)
- https://economie.fgov.be/fr/binaries/National-programme-courtesy-translation_tcm326-279459.pdf

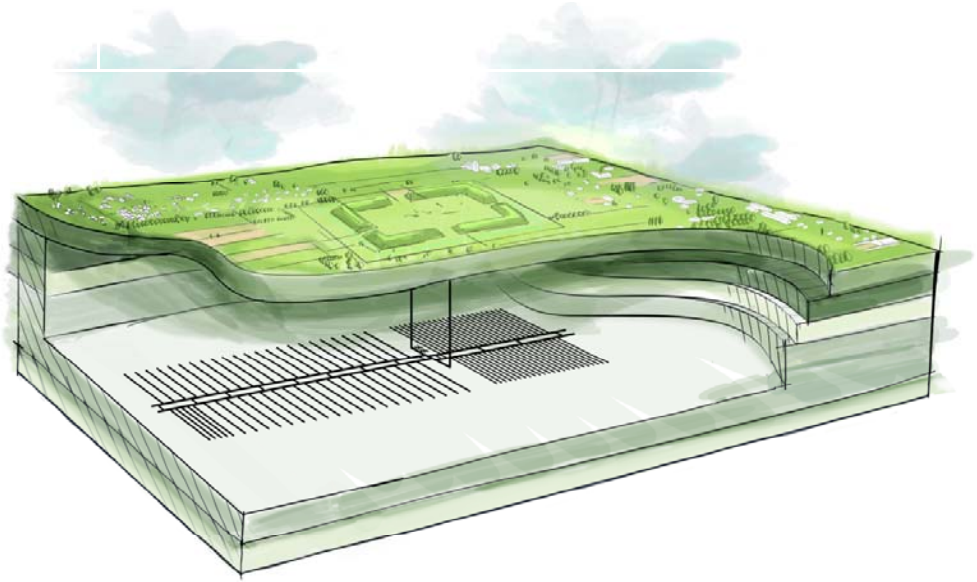
New reference scenario ONDRAF/NIRAS for intermediate and long-lived waste (including spent fuel)

- No decision yet on host formation and site by the government
- It is a financial reference scenario that serves as an input to calculate the financial contributions of the waste producers
  - Repository for both intermediate (B) and long-lived waste (C)
  - Based on the reference programme of the waste producers
  - Spent fuel: change from 100% reprocessing of spent fuel to +/- 30% reprocessing of the spent fuel – change in volumes of types of waste
  - Presumption of 400 m depth for the repository
  - New dual-tube layout with experimental zone
  - Includes measures to favor reversability and retrievability
  - Operational safety aspects taken into consideration

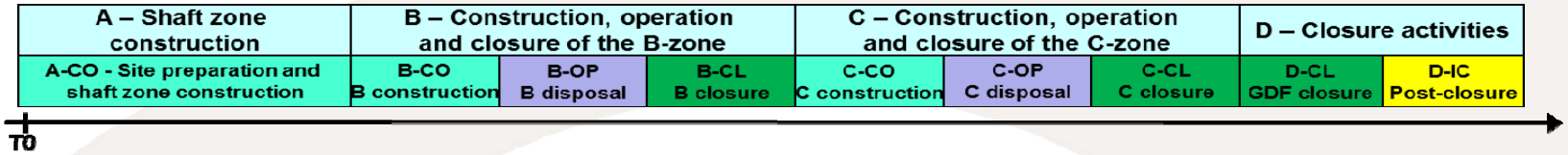
2013


CONSTRUCTION SHAFT BUILDING
POST-CONDITIONING BUILDING
CONSTRUCTION SHAFT
WASTE SHAFT BUILDING
SITE MARKER
DISPOSAL GALLERY
ACCESS GALLERY
WASTE SHAFT
BACKFILL
HEAVY DUTY ELEVATOR
PERSONNEL AND VENTILATION SHAFT
DISPOSED SUPERCONTAINERS
DISPOSED MONOLITHS
BACKFILL
SUPERCONTAINER ON AIR CUSHION TROLLEY
HLW REPOSITORY SECTION (IN EXPLOITATION)
ACCESS GALLERY SEAL
SHAFT SEAL
ACCESS GALLERY
BACKFILL
DISPOSAL GALLERY
BACKFILL
VERSION DATE 2006-SEP-20
LILW-LL REPOSITORY SECTION (CLOSED)

2018



Planning



Phase	Phase	Start date	End date
National Policy			2018
Participative process for site selection		2019	2035
Preparation of the license application		2035	2045
Review of the license application by the Safety Authority		2045	2050
Granting of the creation and operating license			**2050**
Preparation of the site, construction of the shafts and of the shaft zone, and construction of the B-Zone	CO	2050	2070
Construction of the post-conditioning facility for the B-waste	OP	2065	2070
Disposal of the B-Waste	OP	2070	2090
D&D of the post-conditioning facility for the B-waste	CL	2090	2095
Closure of the B-Zone and Construction of the C-Zone	CL/CO	2090	2110
Construction of the post-conditioning facility for the C-waste	OP	2105	2110
Disposal of the C-Waste	OP	2110	2130
D&D of the post-conditioning facility for the C-waste	CL	2130	2135
Closure of the GDF	CL	2130	2135
Post-Closure activities	IC	2135	

Costing

- Total costs concept 2018 for B and C category waste respository
  10,7 $GEUR_{2017}$ including ~40% margins for uncertainties (EPRI-methodology)
- Potential optimisation margin : 2,7 $GEUR_{2017}$
  - Optimalisation to follow – analysis ongoing by all parties
  - 2 years of study on these potential optimisations
  - In 2020 new bottom-up costing
- Basis for contributions by waste producers
  - total *overnight costs*: 7 982 $M€_{2017}$
- Recommendation for nuclear provisions accounts 10,7 $GEUR_{2017}$

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National policy for spent fuel management

- The national policy for the management of spent fuel from commercial nuclear power plants is the safe storage of spent fuel followed by its reprocessing or direct disposal

Table 7 – Synoptic view of the national programme for the management of spent fuel and radioactive waste, at 31 December 2014, according to several key indicators. [✓ : yes; ✗ : no; ● : interim situation]

	MANAGEMENT BY PRODUCERS / OWNERS					TRANSFER	MANAGEMENT BY ONDRAF/NIRAS										
							SHORT AND MEDIUM TERMS (treatment, conditioning and storage)					LONG TERM (disposal)					
	National policy?	Regulation: general?	Regulation: dedicated?	Operational management?	Financing mechanism?		National policy?	Regulation: general?	Regulation: dedicated?	Operational management?	Financing mechanism?	National policy?	Regulation: general?	Regulation: dedicated?	RD&D?	Operational management?	Financing mechanism?
Very short-lived waste	✓ [1]	✓	✓	✓	✓		not applicable					not applicable					
Category A waste	n.a. [2]	✓	✓	✓	✓	⇒	✓ [3]	✓	✓	✓	✓ [4]	✓ [5]	✓	● [6]	✓	✗ [7]	✓ [4]
Category B waste	n.a. [2]	✓	✓	✓	✓	⇒	✓ [3]	✓	✓	✓	✓ [4]	✗ [8]	✓	● [6]	✓	✗	✓ [4]
Category C waste (reprocessing)	not applicable					[11]	✓ [3]	✓	✓	✓	✓ [4]	✗ [8]	✓	● [6]	✓	✗	✓ [4]
Category C waste (spent fuel)	not applicable						✓ [3]	✓	✓	✓	✓ [4]	✗ [8]	✓	● [6]	✓	✗	✓ [4]
Spent fuel from Synatom	✓ [9]	✓	✓	✓	✓		not applicable					not applicable					
Spent fuel from SCK•CEN	✓ [10]	✓	✓	✓	✓		not applicable					not applicable					
Radium-bearing radioactive waste (UMTRAP and Bankloop)	n.a. [2]	✓	✓	✓	✓	⇒	✗	✓	✓	✗ [12]	✓ [4]	✗	✓	● [6]	✗	✗ [12]	✓ [4]
"Potential" radium-bearing radioactive waste [13]	n.a.	✓	● [14]	✓	✓	⇒ ? [14]	✗	✓	✓	✗ [12]	✓ [4]	✗	✓	● [6]	✗	✗ [12]	✓ [4]
"Potential" NORM radioactive waste [13]	n.a.	✓	● [14]	✓	✓	⇒ ? [14]	✗	✓	✓	✗ [12]	● [15]	✗	✓	● [6]	✗	✗ [12]	● [15]

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Prospective study on the strategies for the management of Belgian nuclear spent fuel

- We considered 6 different strategies/options/possibilities
  - direct disposal
  - full reprocessing
  - partial reprocessing
  - advanced separation /partitionning
  - transmutation
  - additional research

- We integraded major planned milestones from different public authorities and private actors to identify critical policy « cross roads »
- https://economie.fgov.be/fr/themes/energie/sources-denergie/nucleaire/gestion-du-combustible-irradie

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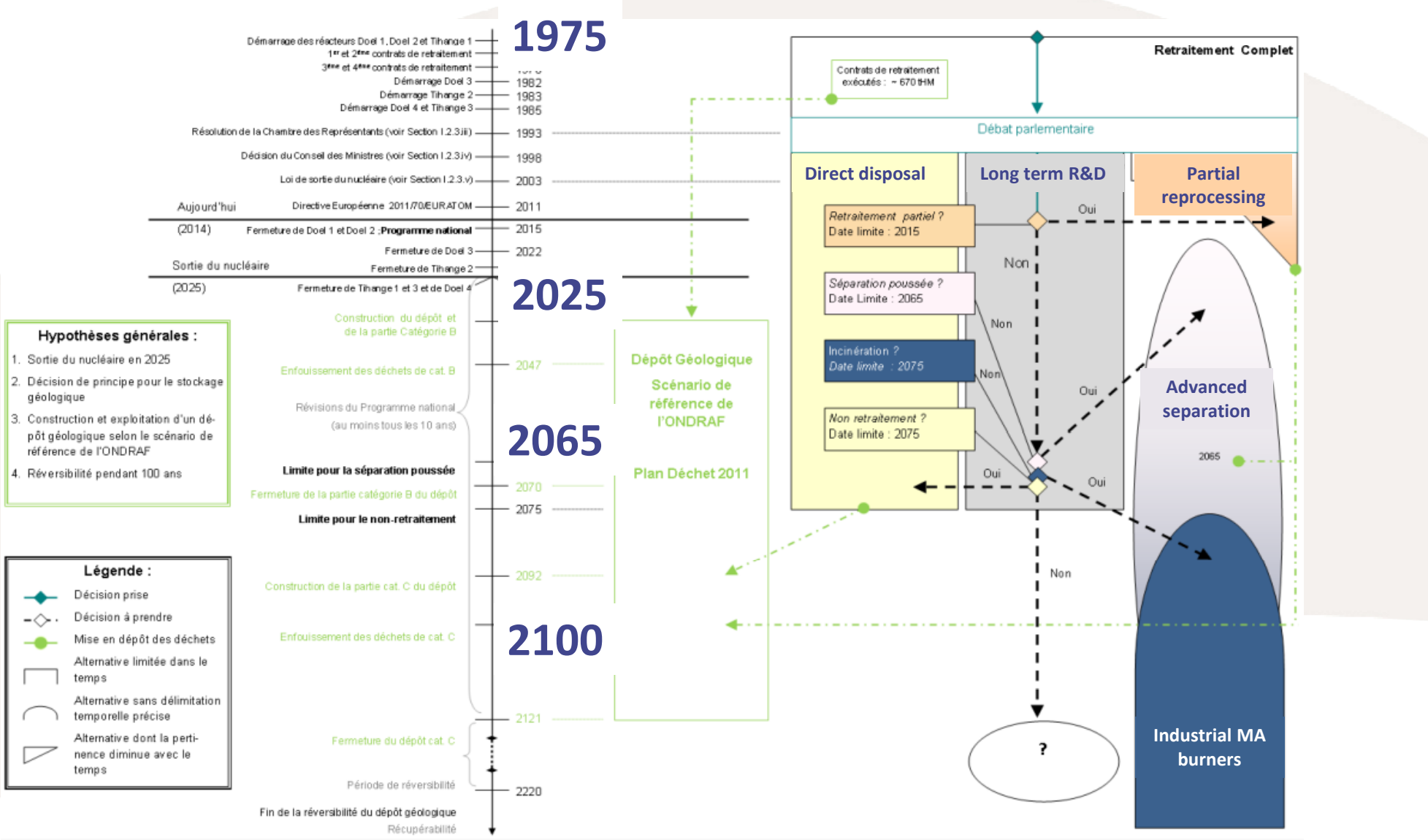
What are the major milestones?



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Belgium decided to build a new large nuclear research infrastructure MYRRHA

- Belgium will continue investing in nuclear research despite her decision to progressively phase out nuclear electricity production in 2025
- Belgium intends to remain at the forefront worldwide in :
  - Transmutation (Partitioning & Transmutation) of radioactive waste.
  - Nuclear medicine and medical radioisotope production
  - Accelerator technology
  - Research in new materials
- The MYRRHA project consists of three phases:
  - Phase 1:
    - MINERVA: Accelerator 100 MeV + target stations (ISOL and Fusion material testing facility)
    - Fully modular infrastructure able to function independently as of 2026-2027, and generate scientific results and revenue
  - Phase 2: accelerator upgrade to 600 MeV
  - Phase 3: Nuclear reactor

MYRRHA applications portfolio

Spent Nuclear Fuel/ Waste

Multipurpose
h**Y**brid
Research
Reactor for
High-tech
Applications

Radioisotopes

Fusion

Fundamental research

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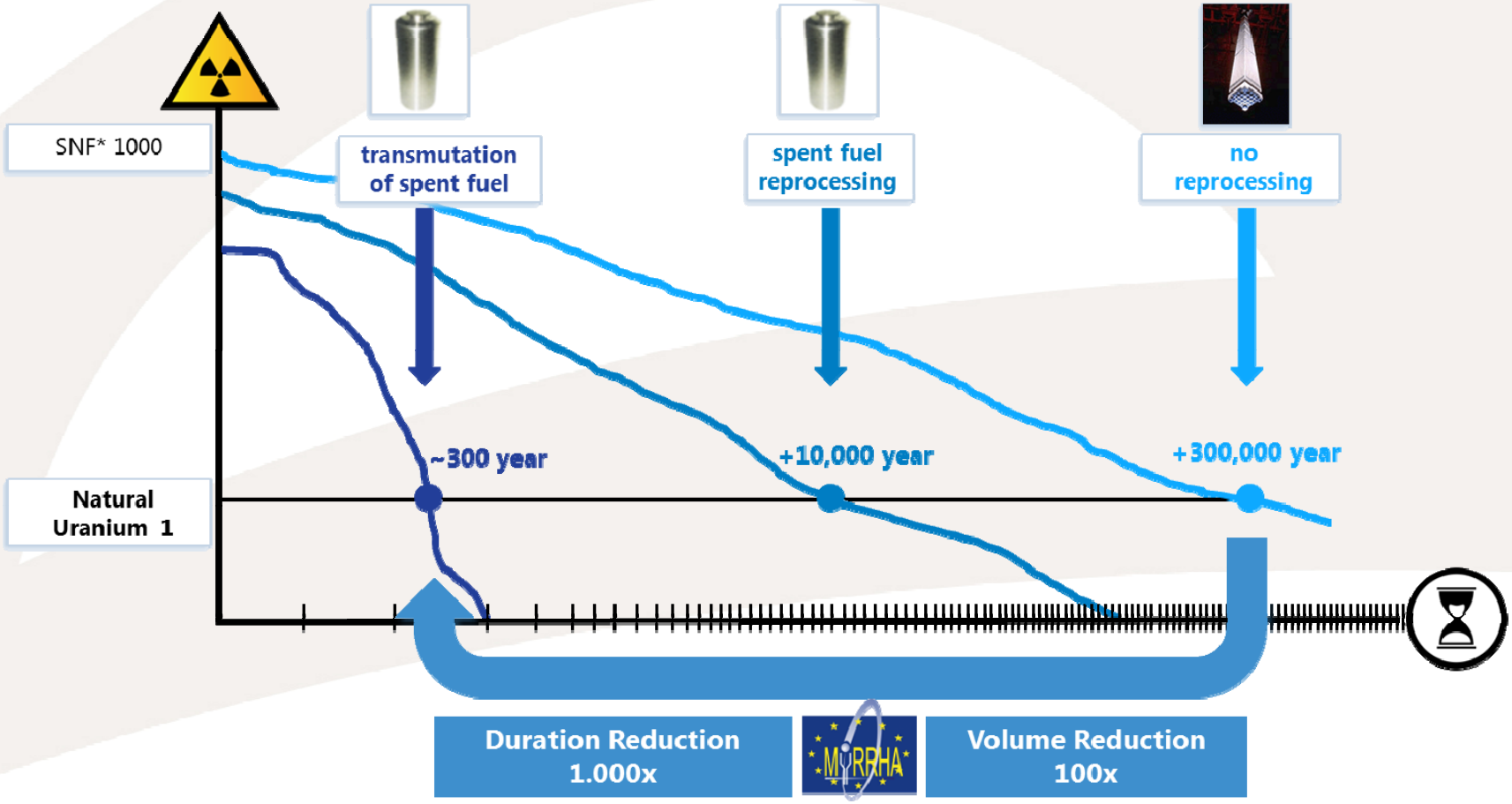
MYRRHA key objective: Pre-industrial demonstrator of transmutation as viable solution for Spent Nuclear Fuel



*SNF = Spent Nuclear Fuel

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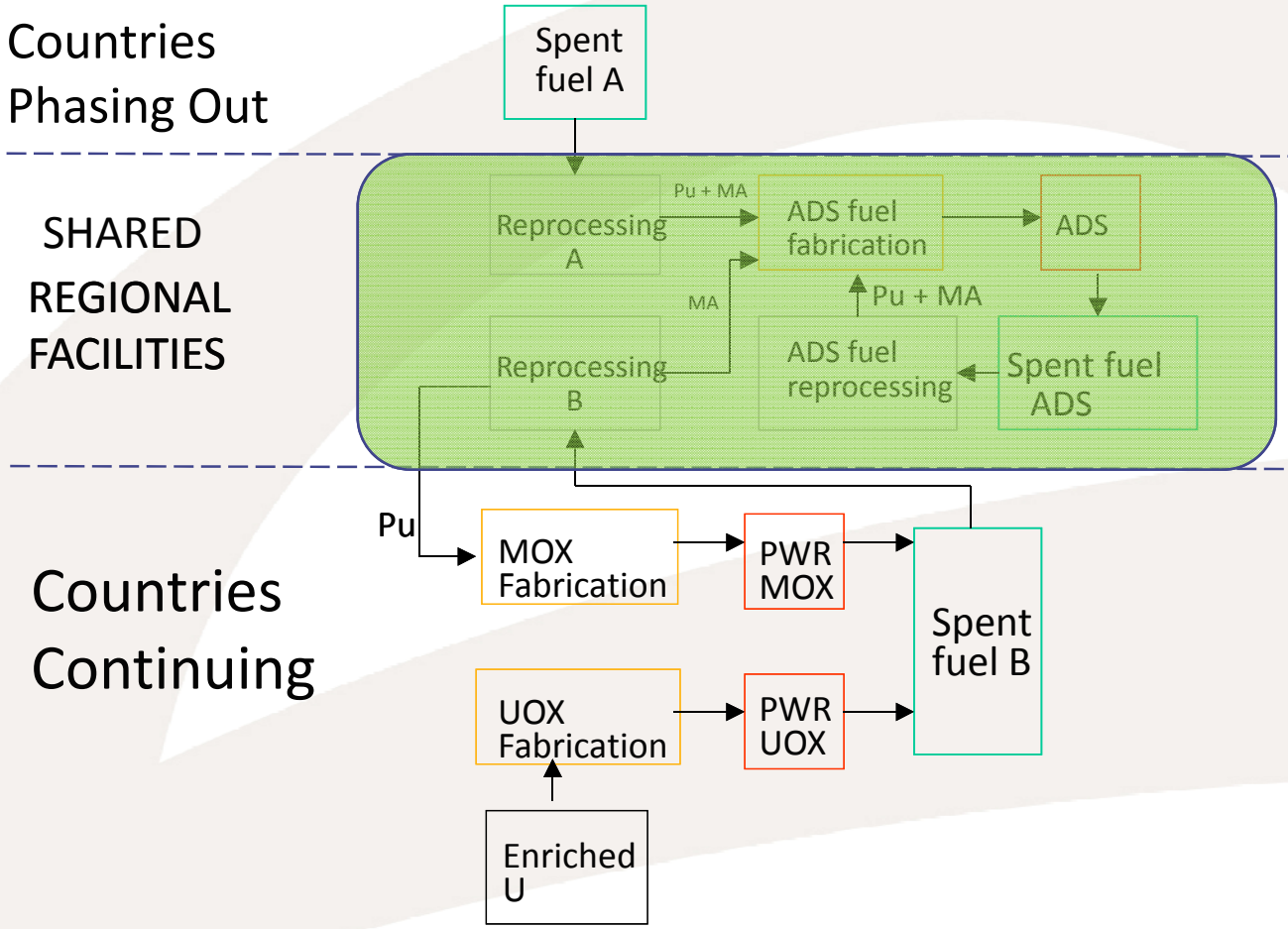
Even with completely different national policies European solution for HLW works with ADS



Advantages for countries phasing out

- ADS shared with B
- ADS burn A's Pu& MA
- Smaller Fu-Cycle units & shared

Advantages for continuing

- ADS shared with B
- ADS burn B's MA
- A's uses B's Pu (part) as resource in FR
- FR fleet not contam with MA's
- Smaller Fu-Cycle units & shared

EU FP6 PATEROS project

Scenario 1 objective: elimination of A's spent fuel by 2100

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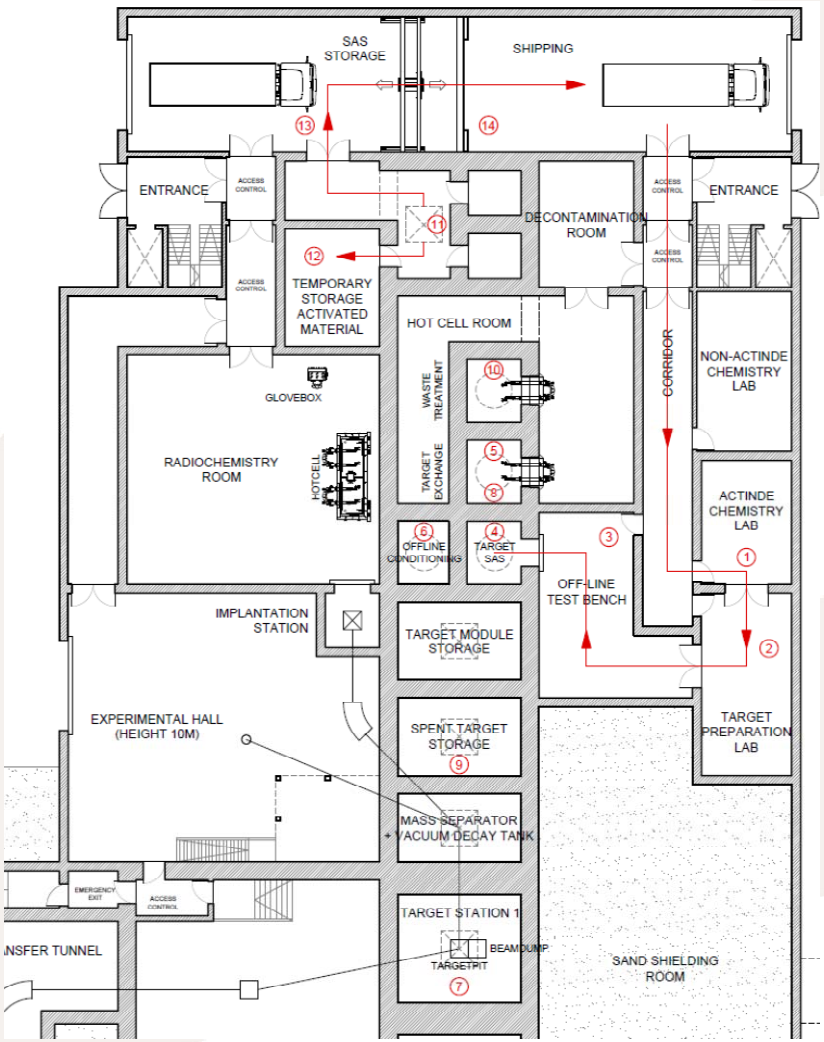
MYRRHA Phase 1: MINERVA: a 100 MeV + Proton Target Facility (Acc. Reliab., RI, ISOL Physics, Fusion Mat. R&D)



Source:SCK•CEN MYRRHA Project Team

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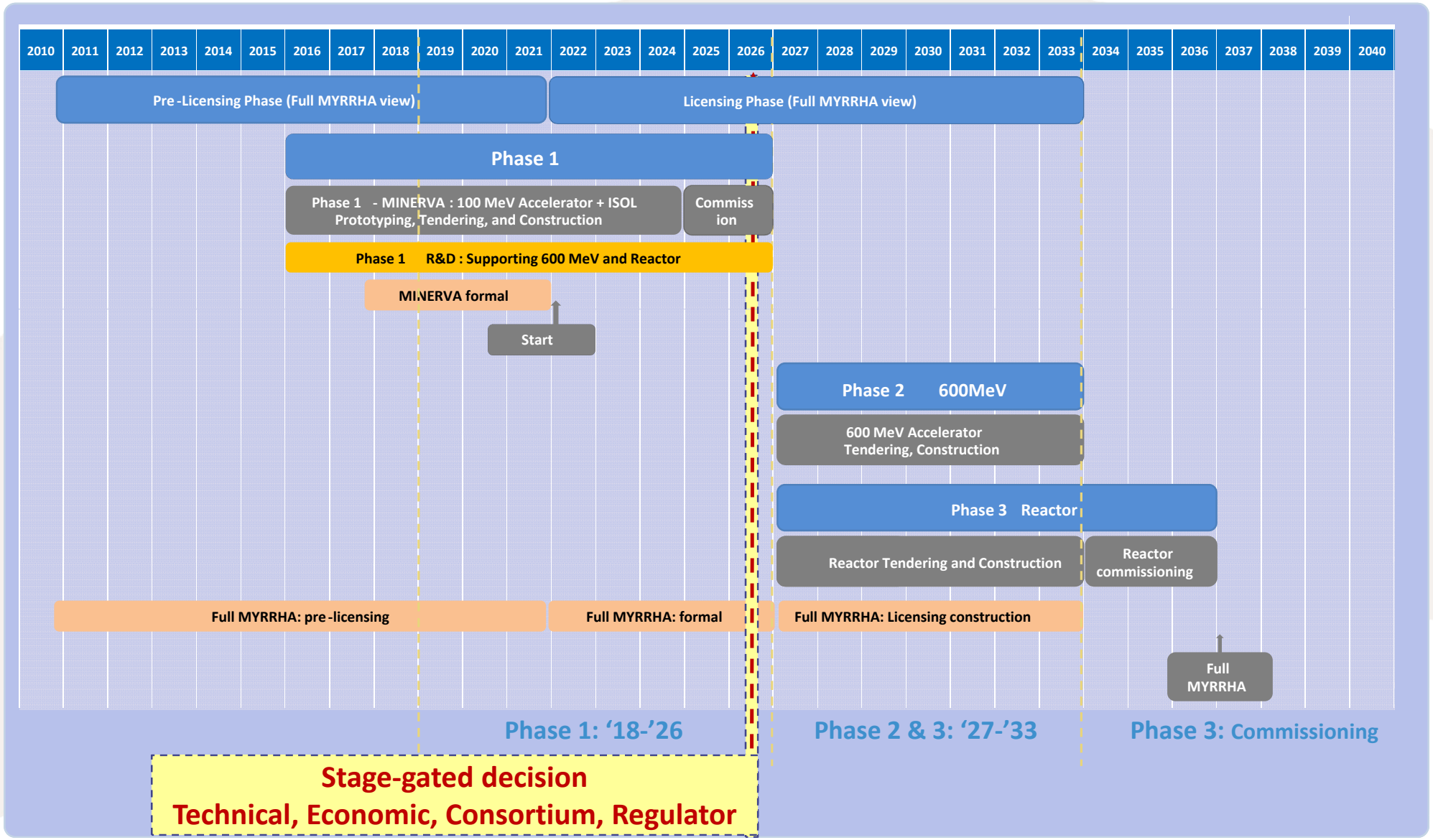
MYRRHA phased implementation with a stage-gated decision in 2026 (2018-2040)



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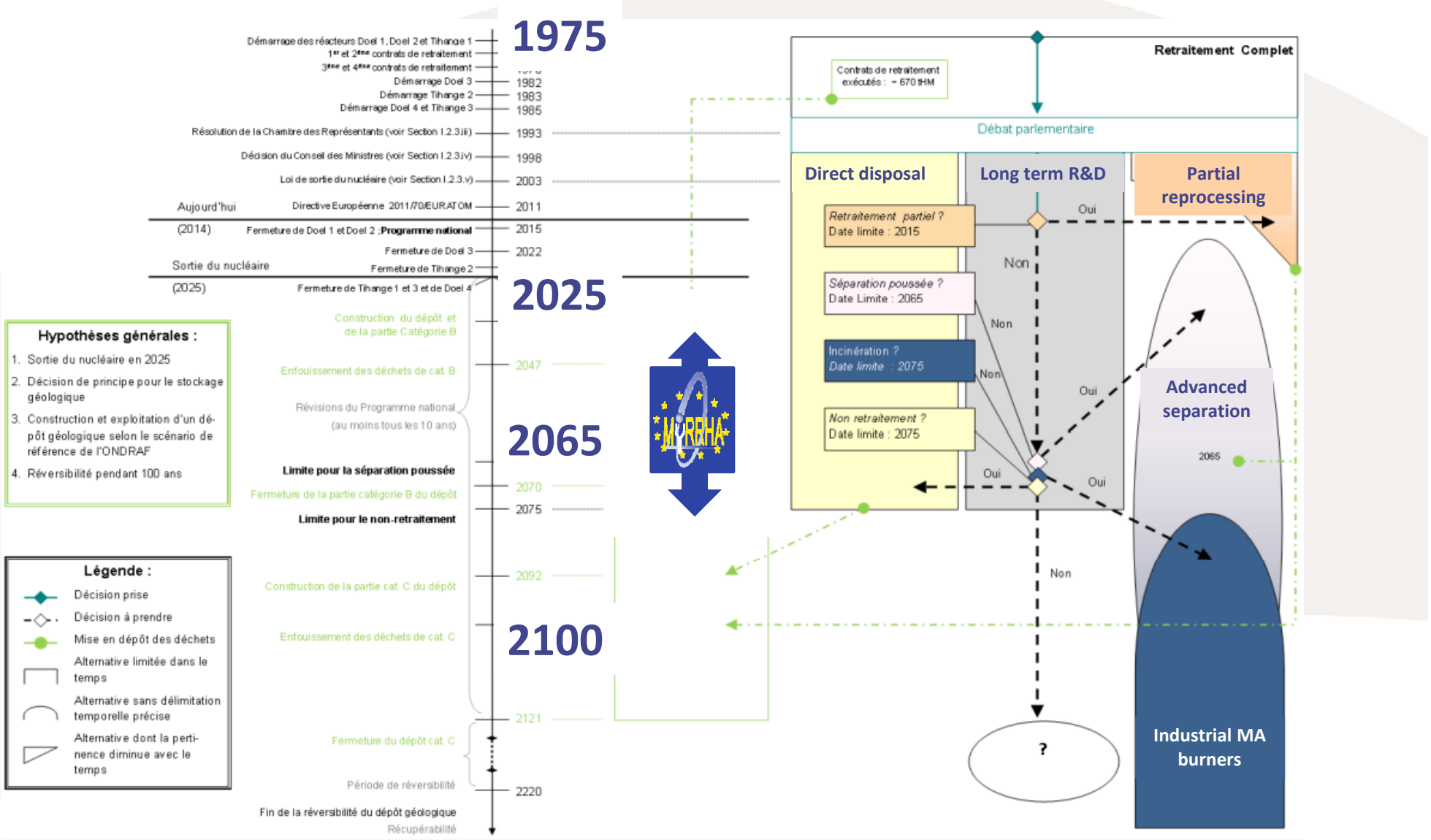
Where does MYRRHA fit in the timeline of Belgian nuclear phase out?



Financing of MYRRHA in an nutshell

- Belgium allocated 558 $MEUR_{2018}$ for 2019 – 2038:
  - Phase 1
    - 2019 – 2026: 287 MEUR investment (CapEx) for building MINERVA (Accelerator up 100 MeV + PTF)
    - 2027 – 2038: 156 MEUR for OpEx of MINERVA
  - Phases 2-3
    - 2019 – 2026: 115 MEUR for further design, R&D and Licensing
- A stage-gate decision will be taken in 2026 whether to proceed with phases 2 and 3, either sequentially, or in parallel
- Belgium will establish an International non-profit organization (AISBL/IVZW) in charge of the MYRRHA facility for welcoming the international partners

Conclusions

- Belgium will continue nuclear research despite her decision to progressively phase out nuclear electricity production in 2025
- Belgium will continue its R & D and innovation activities and maintain or develop a high level of expertise.
- Nuclear know-how will remain a priority for Belgium for the coming decades. Through the MYRRHA project, Belgium will pursue, in an international context, the necessary research concerning innovative solutions for high-level radioactive waste and the qualification of materials for fusion reactors.
- Belgium will continue to invest in education and training to train the next generations of nuclear engineers and scientists

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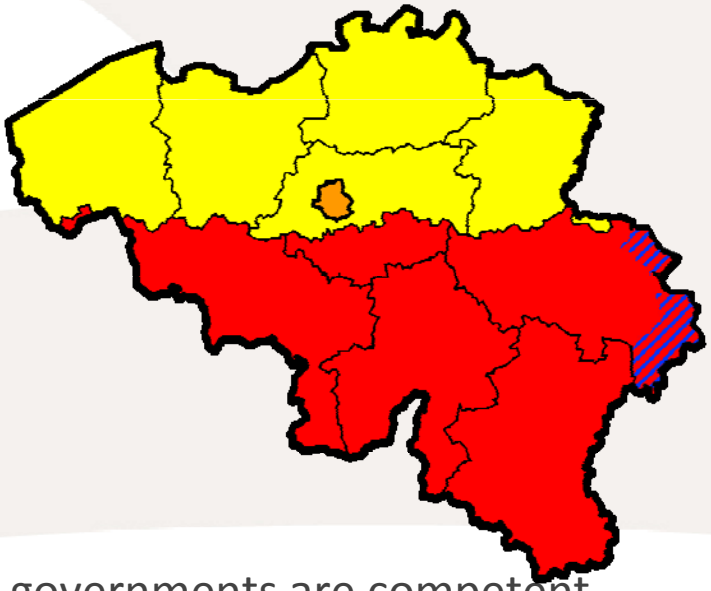
THANK YOU FOR YOUR ATTENTION

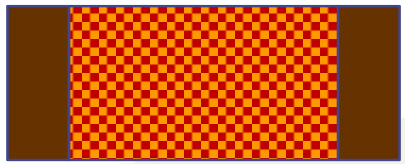
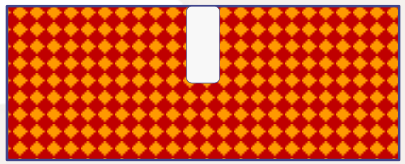
Belgium is a federal state with a division of competences

- The constitutional reforms in the 1970s and 1980s led to the creation of a federal state with:
  - three communities
  - three regions
- These institutions have powers and responsibilities for the different fields
- The Federal government has:
  - Residuary competences: all competences that are not explicitly assigned to communities or regions
  - Shared competences: federal and regional /community governments are competent equally
  - Explicit competences: clearly assigned to the Federal government
- Nuclear fuel cycle and nuclear R&D is an explicit federal competence



Three options for Minor Actinide transmutation

EU is presently considering two approaches for transmutation: via FR or ADS (ARCAS FP7 Project)

FR heterogeneous	FR homogeneous	ADS
		
Driver fuel Blanket with MA	Fuel with MA Blanket	Fuel with MA

Core safety parameters limit the amount of MA that can be loaded in the critical core for transmutation, leading to transmutation rates of:

- FR = 2 to 4 kg/TWh
- ADS = **35 kg/TWh** (based on a 400 MW_{th} EFIT design)

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Financing commercial spent fuel and waste management in Belgium

- Since 2003 a legal specific arrangement to organize the prudential control of the provisions (existance, suffisance and availability)
- All provisions (decommissioning and spent fuel) are to be managed in a designated company, Synatom
  - Synatom = 100% daughter company of Electrabel SA (Engie) but a separate legal unit
  - All owners must pay their part into the same fund
- Creation of a supervising body : Commission on nuclear provisions
- Methodology:
  - the net present value of future liabilities must be present in the accounts of the nuclear provision company (Synatom)
  - built up during exploitation of the reactors whith yearly interest yield
  - if shortage when decommissioning: deficit must be covered by the nuclear operators
  - every three year: audit of the methodology