Realisation of a New Researche Infrastructure for P&T in Belgium:

MYRRHA

Contribution to the EU strategy towards industrialization of P&T

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Innovation in Belgium for Europe and beyond
For sustainable & innovative nuclear energy and applications

Belgian Government decision on September 7, 2018

- Belgium decided to build a new large research infrastructure at Mol : MYRRHA
- Belgium allocated 558 M€ for the periode 2019 – 2038:
  - 287 MEUR investment (CapEx) for building MINERVA (Accelerator up 100 MeV + PTF) for 2019 - 2026
  - 115 MEUR for further design, R&D and Licensing for phases 2 (accelerator up to 600 MeV) & 3 (reactor) for 2019-2026.
  - 156 MEUR for OpEx of MINERVA for the periode 2027-2038
- Belgium requests to establish an International non-profit organization (AISBL/IVZW) in charge of the MYRRHA facility for welcoming the international partners
- Belgium continue to mandate Secretary of State for Foreign Trade Mr Pieter De Crem for promoting MYRRHA and negotiating international partnerships

Brief recent history of ADS activity in Europe

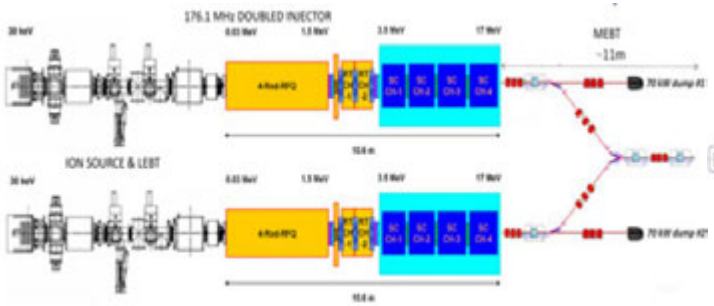
- 1993 C. Rubbia, energy amplifier (CERN)
- 1994 H. Aït Abderrahim & Y. Jongen, ADONIS (BE)
- **1995 M. Salvatores, MUSE experiments (FR)**
- **1995 C. Rubbia et al., FEAT/TARC experiments (CERN)**
- 1996 C. Rubbia et al., EA-80 ADS Demo joint programme ENEA, Ansaldo Nucleare, INFN (IT)
- 1998 H. Aït Abderrahim et al., MYRRHA (BE)
- 1999 B. Carluec & M. Salvatores et al., EFIT-Gas AREVA,-CEA (FR)
- 2001 C. Rubbia et al., TRADE ENEA-Casaccia (IT)
- **2001 A. Kievitskaya et al., YALINA experiments (Belarus)**
- 2002 V. Shvetsov et al., SAD facility in DUBNA (JINR/Russia)
- **2007 H. Aït Abderrahim et al., GUINEVERE (BE/FR)**
- **2010 H. Aït Abderrahim et al., MYRRHA in ESFRI & BE-Gov. Declaration support for contruction (BE)**
- 2011 A. Zelinsky et al., Neutron Source based ADS at KIPT (Ukraine)
- 2015 iThEC, iThEC ADS Project at INR in Troitsk (CH/RU)
- **2018 H. Aït Abderrahim et al., BE-Gov. Decides the start of contruction of MYRRHA and opens it to international participation**

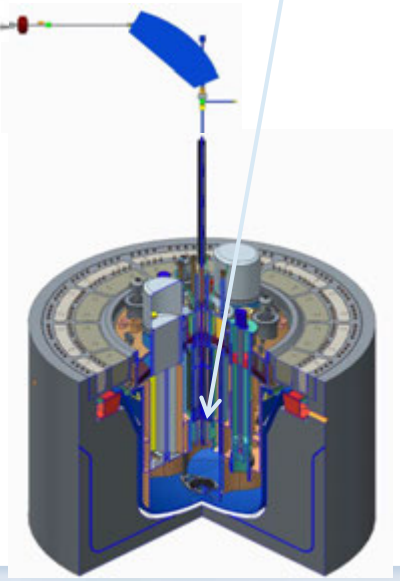
Source: SCK•CEN MYRRHA Project Team

Key technical objective of the MYRRHA-project: an Accelerator Driven System

- MYRRHA – An Accelerator Driven System
  - Demonstrate the ADS concept at pre-industrial scale
    - Can operate in critical and sub-critical modes
  - Demonstrate transmutation
  - Fast neutron source → multipurpose and flexible irradiation facility

Target	
main reaction	spallation
output	$2 \cdot 10^{17}$ n/s
material	LBE (coolant)

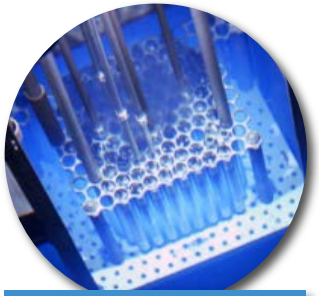




Accelerator	
particles	protons
beam energy	600 MeV
beam current	2.4 to 4 mA

Reactor	
power	65 to 100 MW_{th}
k_{eff}	0,95
spectrum	fast
coolant	LBE

MYRRHA application portfolio



Fission GEN IV

SNF*/ Waste

Multipurpose h**Y**brid **R**esearch **R**eactor for **H**igh-tech **A**pplications

Fusion

Fundamental research

Radio-isotopes

Support to SMR LFR

*SNF = Spent Nuclear Fuel

Source: SCK•CEN MYRRHA Project Team, MYRRHA Business Plan

Why do we need Partitioning ?

- Only for P&T transmuting MAs?
- For better use of resource
- For environmental reasons
- Conclusions

Source:

ADOPT Th.N. : European Strategy for P&T (2005) with objective of possible industrialisation from 2030-35

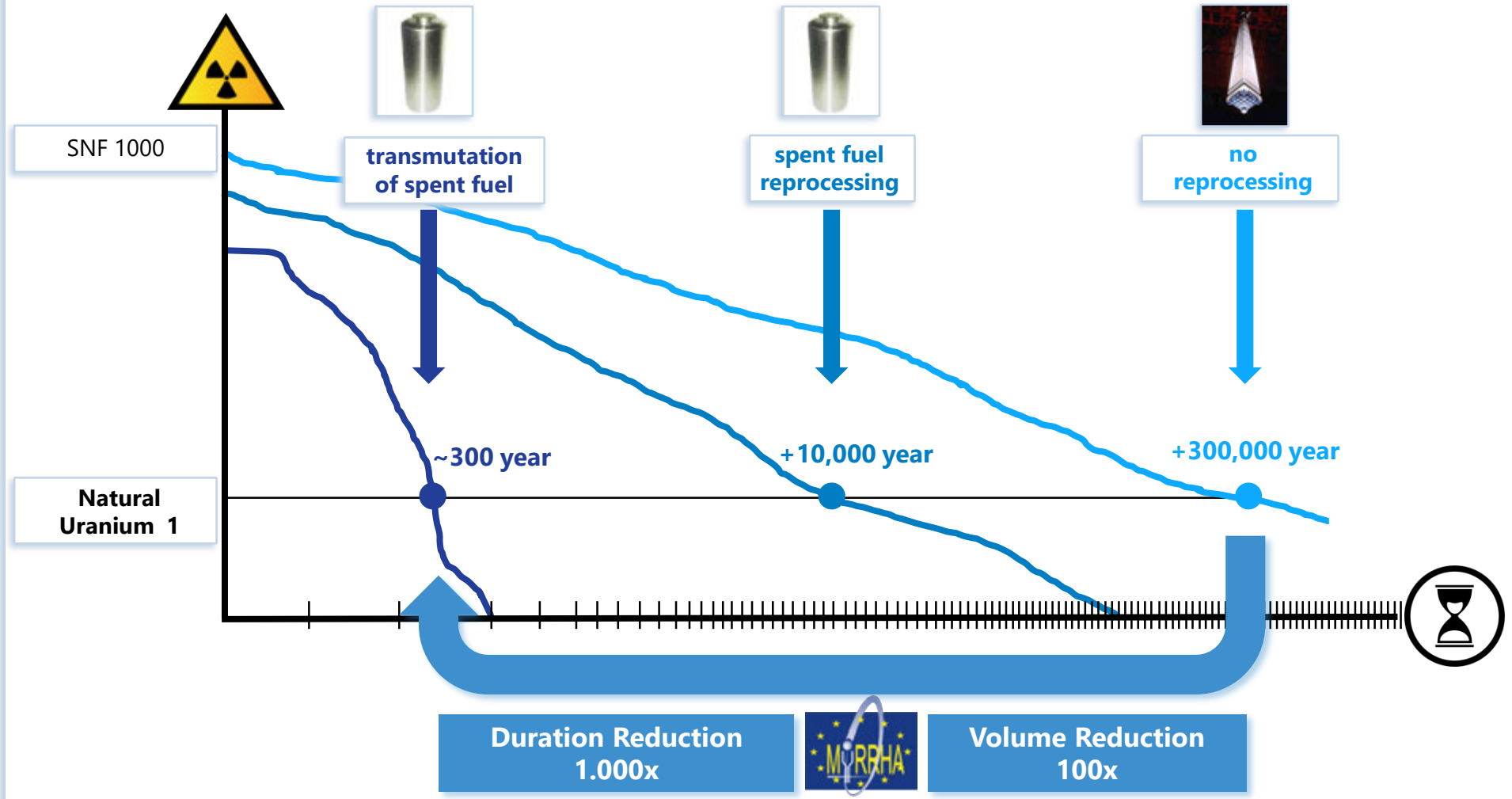
EU P&T Strategy 2005: *"The **implementation of P&T** of a large part of the high-level nuclear waste **in Europe needs the demonstration of its feasibility at an "engineering" level**. The respective **R&D** activities could be **arranged in four "building blocks"**:*

P&T building blocks	Description	Name & Location
1 **Advanced Partitioning**	▪ Demonstrate capability to process a sizable amount of **spent fuel** from commercial Light Water Reactors to **separate** plutonium, uranium and minor actinides	▪ Atalante (FR)
2 **MA Fuel production**	▪ Demonstrate the capability **to fabricate** at a semi-industrial level the **MA dedicated fuel** needed to load in a dedicated transmuter	▪ JRC-ITU (EU)
3 **Transmutation**	▪ **Design and construct one or more dedicated transmuters**	▪ **MYRRHA (BE)**
4 **MA Fuel reprocessing**	▪ Specific installation to process fuel unloaded from transmuter ▪ Not necessarily the acqueous reprocessing but **pyroreprocessing & electrorefining**	

The European Commission contributes to the 4 building blocks and fosters the national programmes towards this strategy for **demonstration at engineering level**

Source: European Commission Strategy Paper on Partitioning & Transmutation (2005)

Transmutation is the better solution for Spent Nuclear Fuel

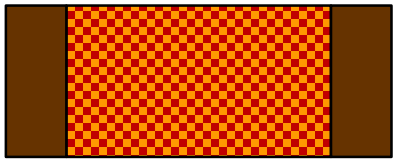
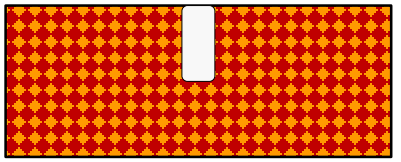


*SNF = Spent Nuclear Fuel

Source: European Commission Strategy Paper on Partitioning & Transmutation (2005), SCK•CEN MYRRHA Project Team

Three options for Minor Actinide transmutation

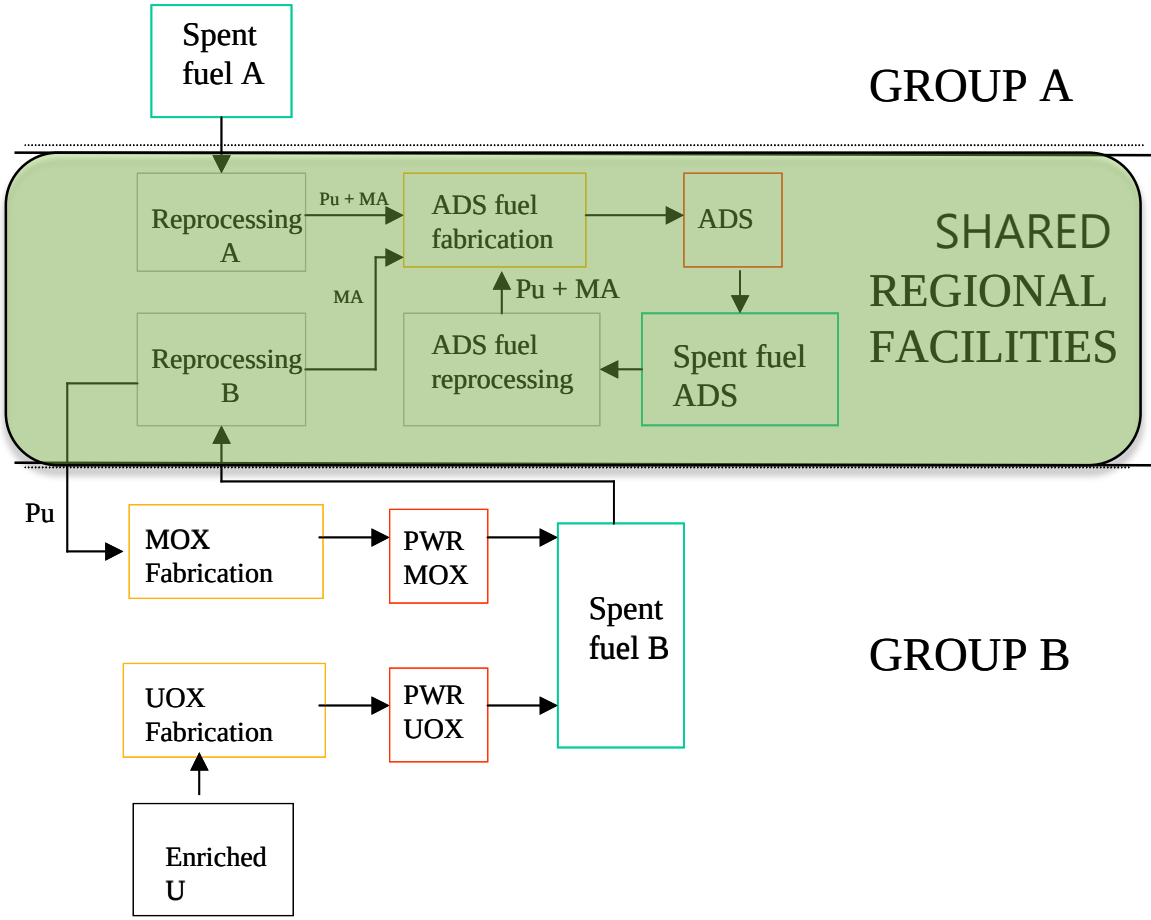
EU is presently considering two approaches for transmutation: via FR or ADS (ARCAS FP7 Project)

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)

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



❑ Advantages for A

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

❑ Advantages for B

- ADS shared with A
- 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

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

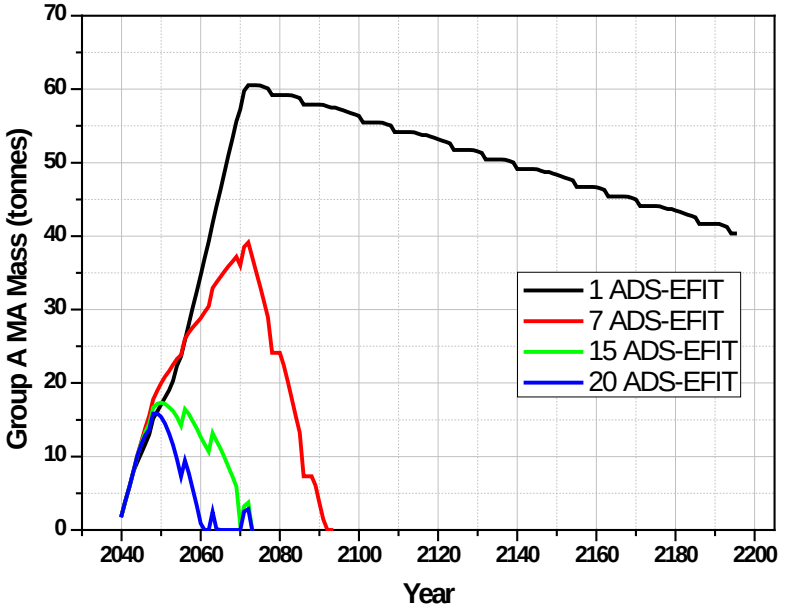
A = Countries Phasing Out, B = Countries Continuing

FP6 PATEROS project

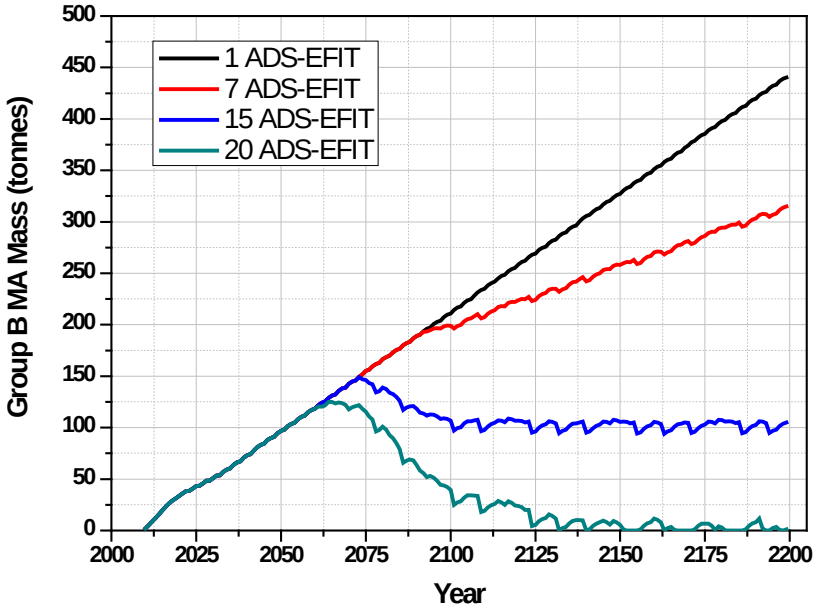
Industrial implementation of ADS in a regional approach

From PATEROS FP6 project

EU countries phasing out NE



EU countries continuing NE



- ADS technology enables present generation to avoid transferring the burden of HLW to future generations

* SCK•CEN (BE), Ansaldo Nucleare (IT), CEA (FR), CIEMAT (SP), CNRS (FR), ENEA (IT), AREVA NP (FR), FZK (DE), ITU (EU), KTH (SE), NRG (NL), NRI (CZ), PSI (CH), UPM (SP), ITN (PT), Nexia Solutions (UK), Manchester University (UK)

Why do we need Partitioning ?

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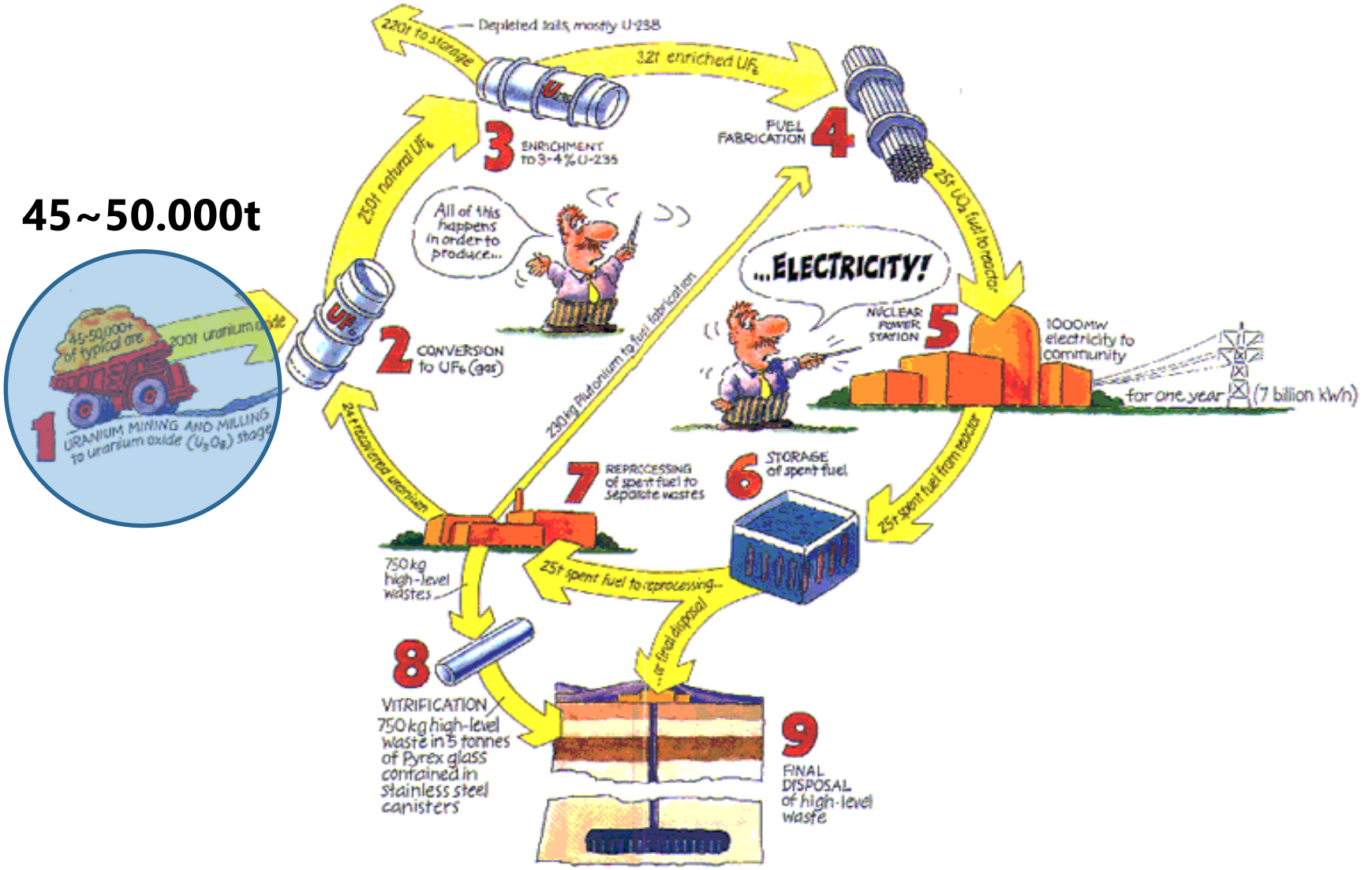
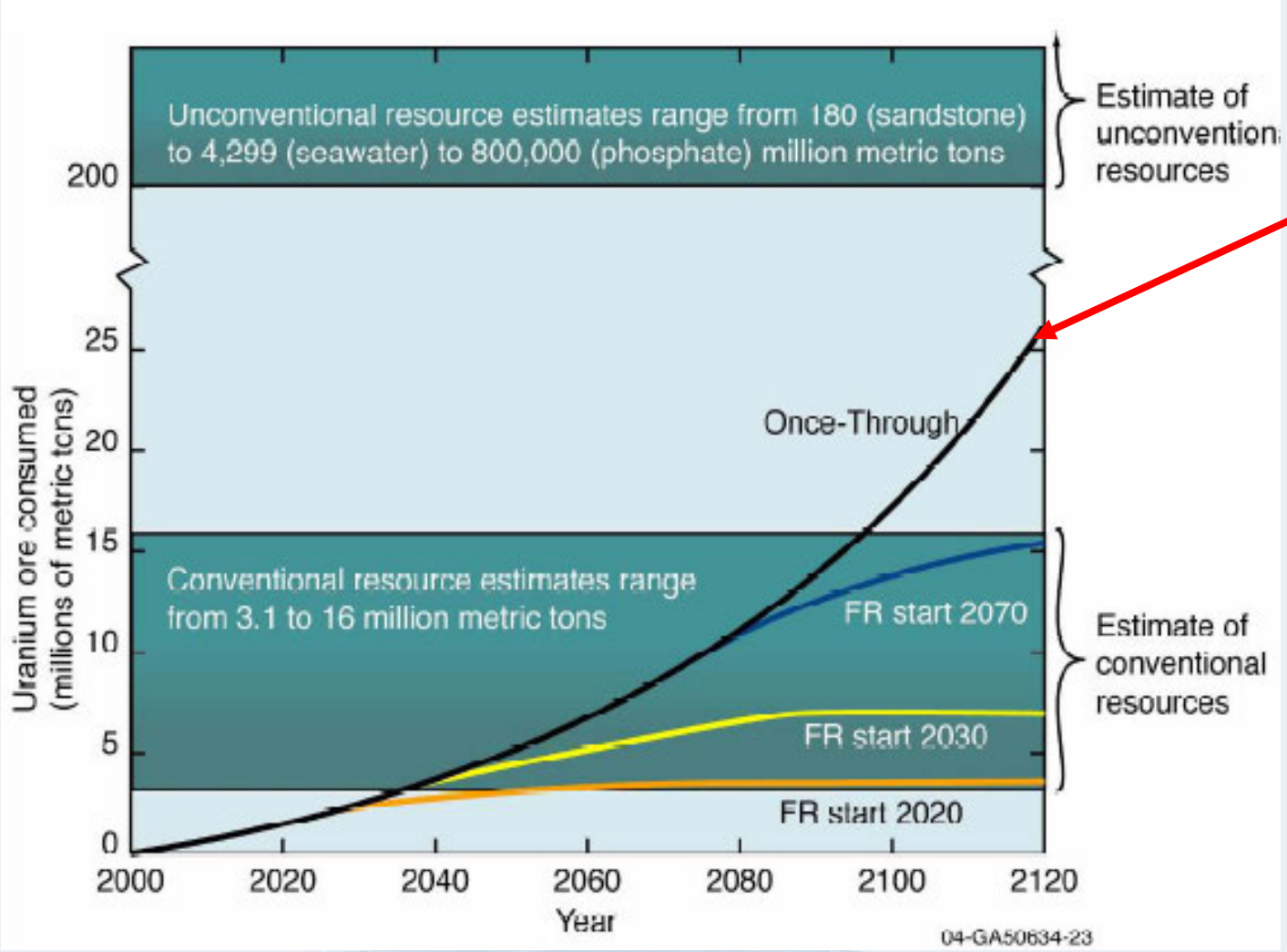
Source:

Fuel cycle for a 1000 MWe PWR



Uranium resources projection



NE growth hypothesis 1.8% /y

Nuclear Energy sustainability doable through FR

➔ **Partitioning**

Why do we need Partitioning ?

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Source:

SCK•CEN ACADEMY organized very interesting cycle of conferences

DE LA RECHERCHE À L'INDUSTRIE

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www.cea.fr

SCK•CEN ACADEMY
FOR NUCLEAR SCIENCE AND TECHNOLOGY

Van Geen SCK-CEN chair

❺ Nuclear energy environmental footprint

Is nuclear energy so little environmental-friendly ?

Prof. Christophe POINSSOT

Head of the Research Department on mining and fuel recycling processes, Nuclear Energy Division, CEA

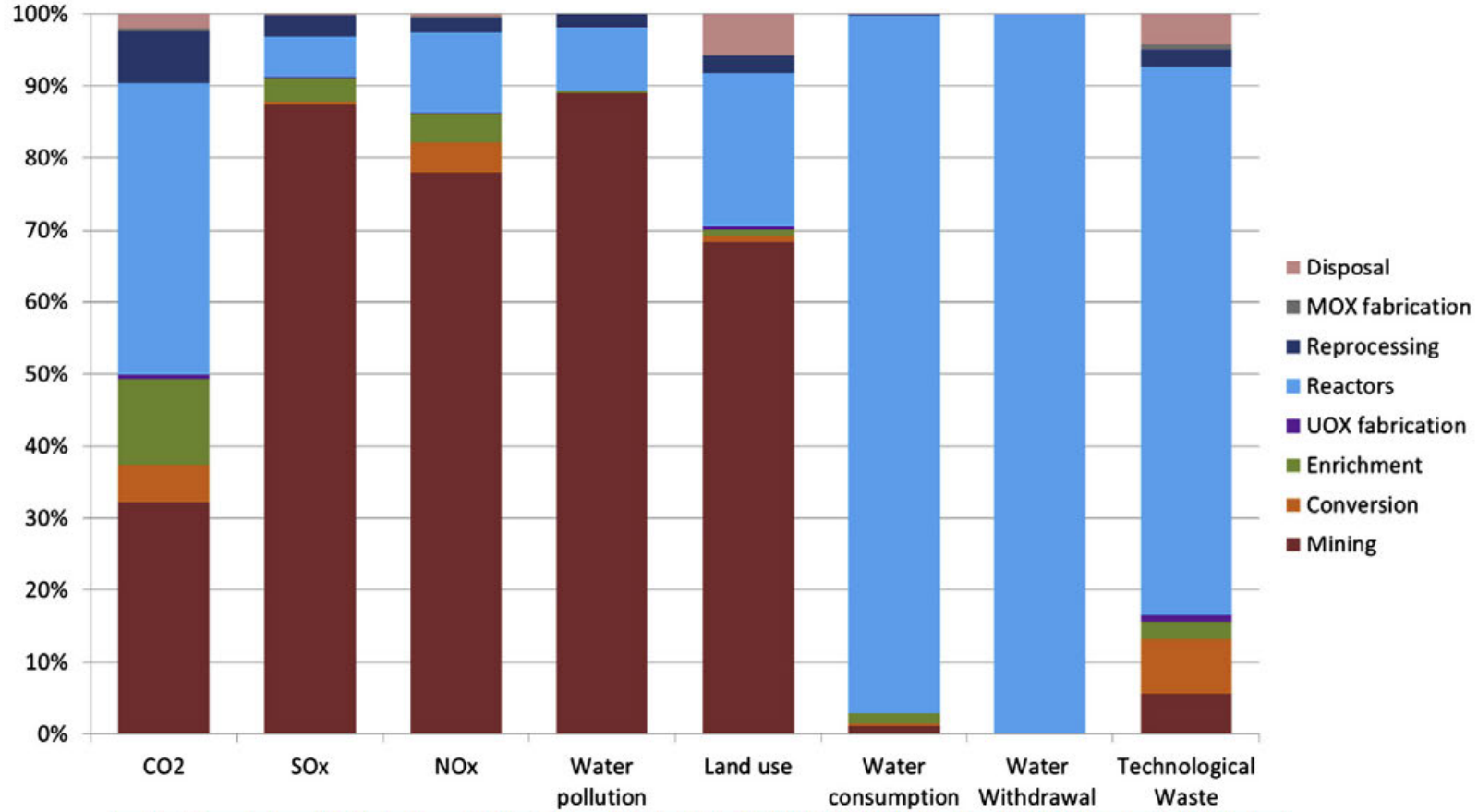
Professor in Nuclear Chemistry, INSTN

christophe.poinssot@cea.fr

With the contribution of **Stéphane BOURG**

Source:

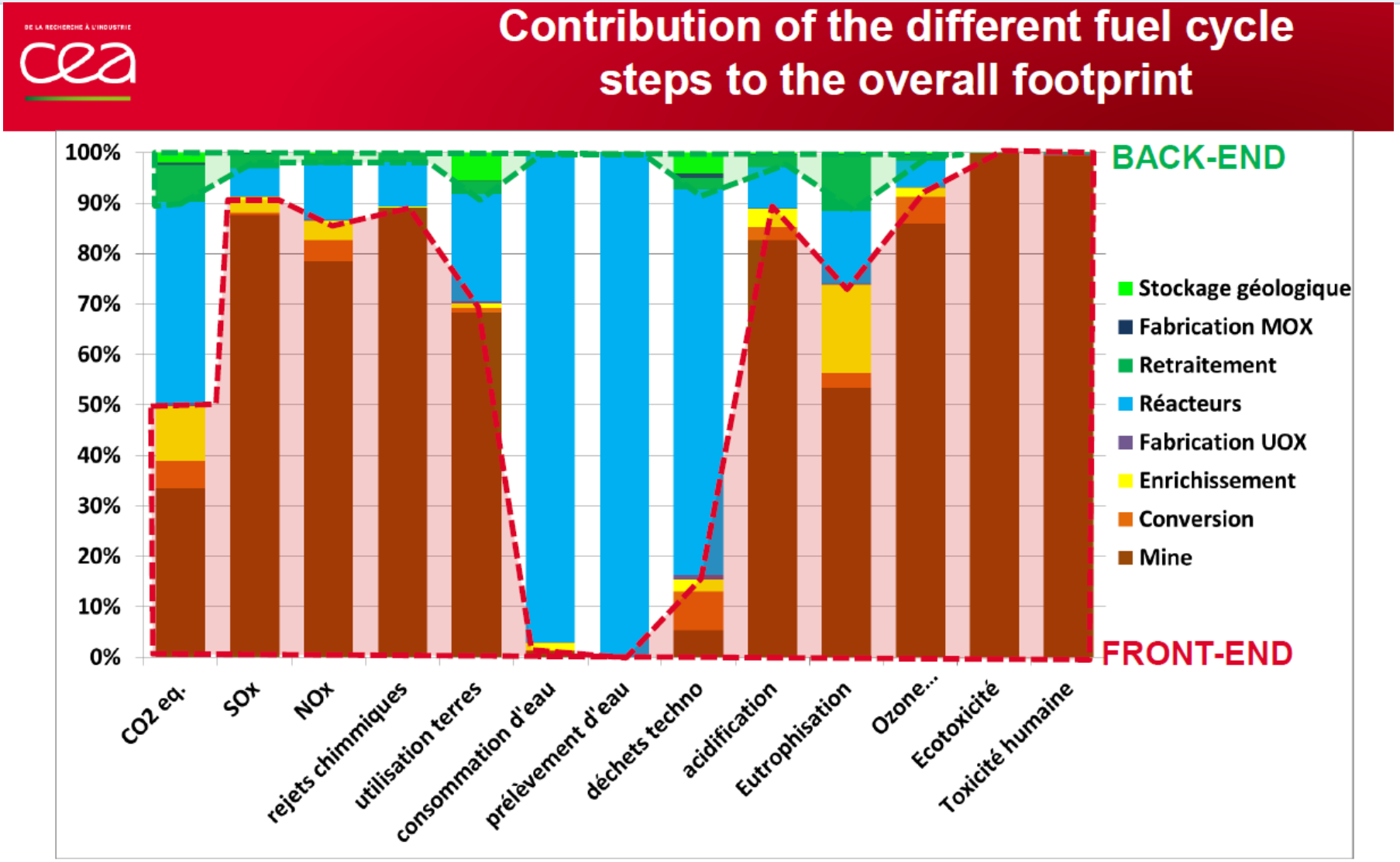
The general environmental indicators of the TTC



(gCO_2 eq/kWh_e)	(mg/kWh_e)	(mg/kWh_e)	(mg/kWh_e)	(m^2/GWh_e)	(L/MWh_e)	(L/MWh_e)	(g/MWh_e)
5,29	16,276	25,30	287,53	211,0	1507	72364	93,9

Source:

Reducing the environmental footprint of NE
Reduce the Front End activities → Partitioning



Source:

Summary

- Partitioning may need Transmutation but Transmutation must have Partitioning
- With what I showed you I hope you don't doubt that Partitioning has a future and can do it without Transmutation
- But Transmutation needs advanced reprocessing thus **A**dvanced Partitioning and here we are mainly talking advanced fuel cycle and thus Advanced Partitiong
- Aqueous advanced reprocessing is progressing in Europe but a pre-industrial Engineering demo-facility is still not yet decided
- In 2005 at the EC level thanks to ADOPT Thematic Network we came with a global strategy to get all elements in hand for deciding for industrialisation of P&T or not

Source:

Objectives of ADOPT

- In Europe there is a strong interest to **explore** the potential **scientific, technical and industrial possibilities of P&T**.
- Integrating the total European efforts (EC & MS) to **speed up the development and put the European R&D at lead in this field**.
- **The specific objectives of ADOPT are:**
  - **to promote consistency between P&T FP5 projects and nat. prog.**
  - to define rules for info. dissemination and access to national R&D programme data
  - to review results of the P&T FP5 projects and avoid duplications,
  - to identify gaps in the overall programme,
  - to inform the members about the ongoing activities in P&T and ADS outside the EU (Intern. Org., USA, Japan, Korea, former CIS)
  - **to give input to future research proposals and guidelines for further R&D orientation towards industrialisation,**

ADOPT Th.N. : European Strategy for P&T (2005) with objective of possible industrialisation from 2030-35

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Source: European Commission Strategy Paper on Partitioning & Transmutation (2005)

Belgium is giving a strong message on its ambition to maintain a high level of expertise in nuclear know-how and P&T, it offers MYRRHA for international collaboration

With the positive full phase 1 decision on September 7, 2018,

we will break ground in 2021

Conclusions

- Are we dreaming to industrialize P&T ?
- Life without dreams is not worth
- MYRRHA is decided then we need **A**dvanced Partitioning
- We need to join forces again between P and T
- **I call for a CA on P&T European strategy in the next work programme of EURATOM** where we can consolidate a European vision that we can feed in the OECD/NEA NI2050 Template, under finalization :

Advanced Fuel Cycle and P&T

steps towards possible industrialisation

- Example of international collaboration between JP & BE can be the example to follow

Source:

History of fruitfull collaboration between Japan & Belgium

- Japan is a pioneer in research on closed fuel cycle: OMEGA project through OECD/NEA launched in mid-80's
- Belgium pioneer in MOX fuel technology development & qualification for FRs and LWRs
- During the 90's decade a strong cooperation between Belgium (SCK•CEN & Belgonucléaire) and Japan Industry (MHI, TOSHIBA, CRIEPI) on MOX qualification for use in Japanese PWR's and BWR's
- Under EURATOM-Japan agreement: in 2004 first collaboration between EUROTRANS FP6 / JAEA on MYRRHA/ADS Design and associated technologies
- In 2006, first agreement between JAEA and SCK•CEN on ADS development

SCK•CEN / JAEA Collaboration Signature in Brussels 23.11.2006

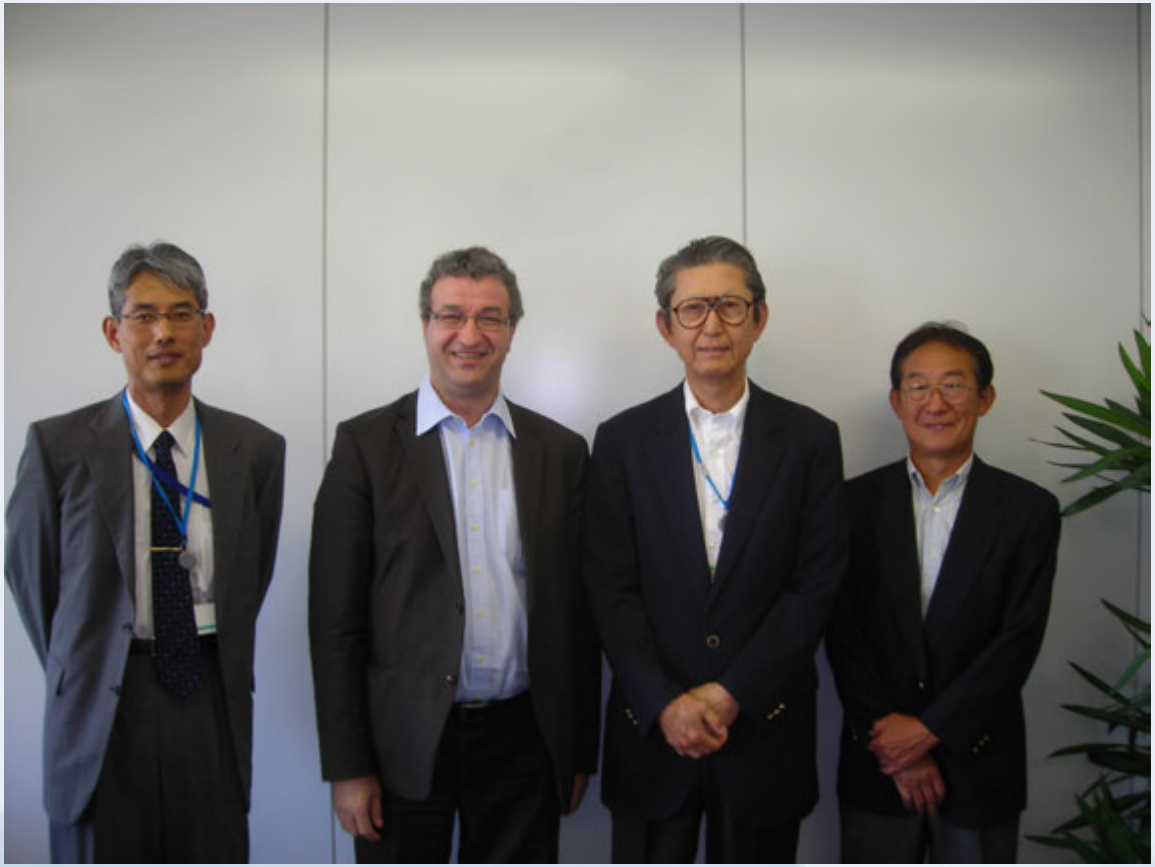
General Agreement in Nuclear Energy:

- Topic on ADS Development:
  1. **ADS design including experimental ones**
  2. **material study for fuel cladding**
  3. **Pb-Bi technology**
- Agreement renewed in 2011

26

In 2012 EoI in MYRRHA sent by JAEA

Prof. Suzuki asking to start negotiation for Letter of Commitment
Beginning of 2013



27

Interest of Japan and Belgium to collaborate on ADS GUINEVERE/TEF-P/TEF-T/MYRRHA/Industrial ADS

- JAEA and SCK•CEN are sharing a clear view on the role of ADS in a double-strata closed fuel cycle strategy
- SCK•CEN
  - has built from 2007 to 2009, licensed and is operating GUINEVERE a Zero Power Pb-based ADS driven by a D-T source. Presently it is used for running an experimental programme for preparing the licensing of MYRRHA
  - Since 1998 is advancing the design of MYRRHA a 100 MWth experimental ADS facility aiming to be the first worldwide power ADS to demonstrate the reliable and efficient operation of ADS
- JAEA has planned to build 2 experimental ADS facilities:
  - TEF-P: the Transmutation Experimental Facility for Physics a Zero Power ADS based on a spallation source generated with a proton very low power beam : 600 MeV* 17 nA that will act as GUINEVERE
  - TEF-T: the Transmutation Experimental Facility for Technology a spallation source generated with a proton average power beam : 600 MeV* 0.33 mA without a sub-critical core. TEF-T is intended as a small scale irradiation facility for ADS structural and fuel qualification.
- KURRI has coupled the KUCA reactor to a FFAG Accelerator
- **These facilities will pave the road towards the experimental large scale ADS (600 to 800 MWth)**

JAEA – SCK•CEN 12 year of fruitful collaboration on ADS

JAEA publication

SCK•CEN publication

Source:


MYRRHA

SCK•CEN
Studiecentrum voor Kernenergie
Centre d'Etude de l'Energie Nucléaire
Belgian Nuclear Research Centre

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