Radioactive waste and spent fuel management strategies in OECD NEA member countries.

Selection of strategies and influencing factors.

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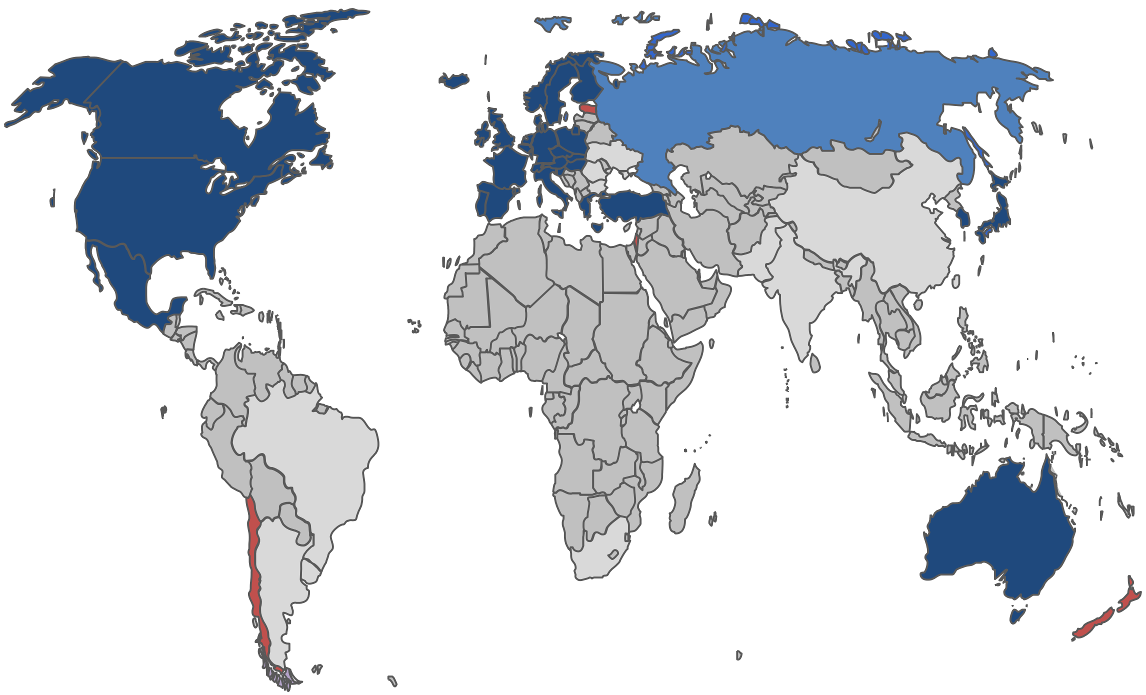
NEA member countries and mission

Chile, Estonia, New Zealand and Israel are OECD members but not NEA
The Russian Federation is an NEA member, but not yet member of the OECD

- **To assist its member countries in maintaining and further developing**, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical **use of nuclear energy** for peaceful purposes.
- To provide authoritative assessments and to forge common understandings on key issues as **input to government decisions on nuclear energy policy** and to broader OECD policy analyses in areas such as energy and sustainable development.

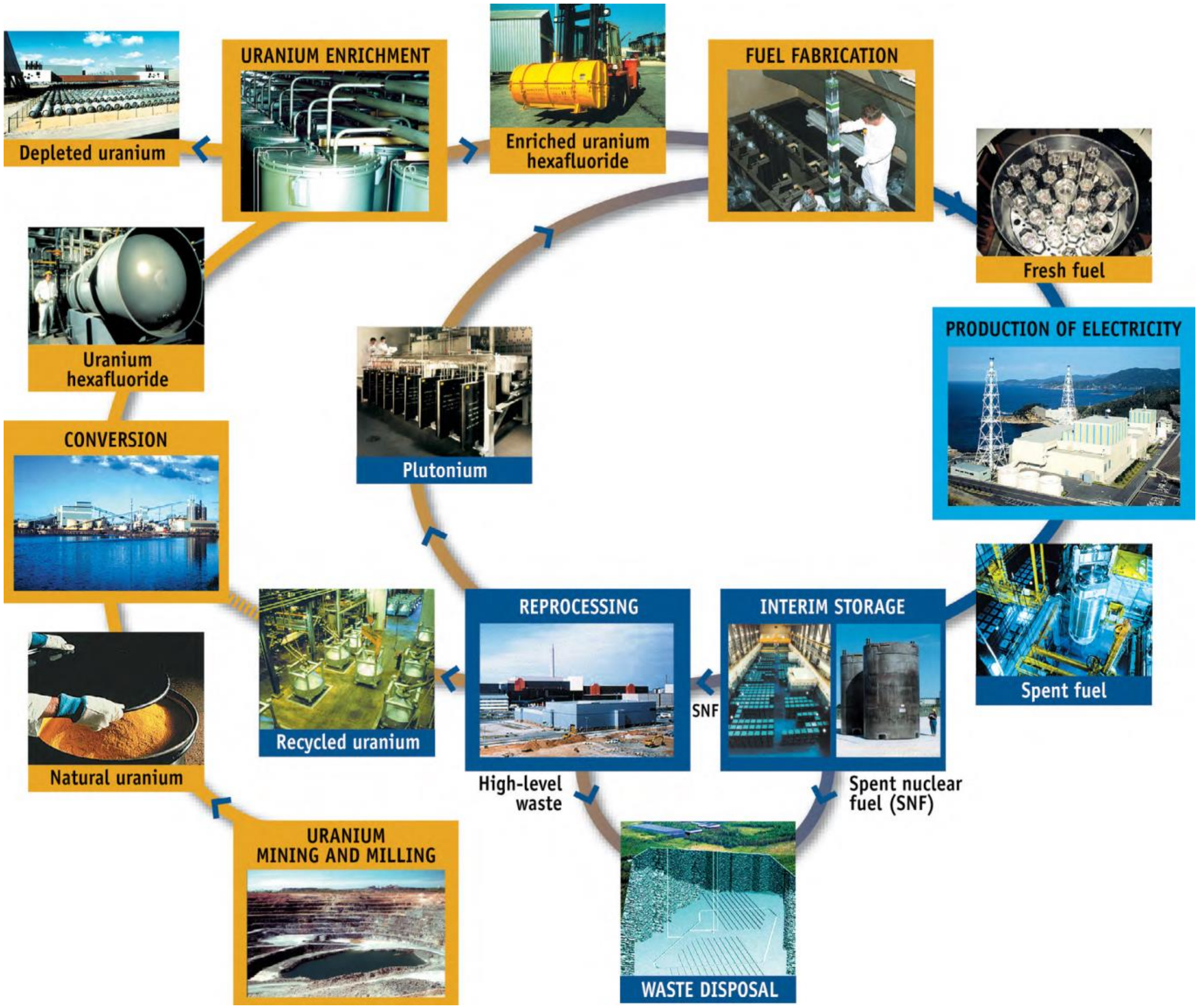


The NEA's current membership consists of 31 countries in Europe, North America and the Asia-Pacific region.
Together they account for approximately 90% of the world's installed nuclear capacity.

Review. Background.

- RWMC decided to establish the Expert Group on Inventorying and Reporting Methodology (EGIRM 2014) for development of a methodology for SF/RW inventory presentation in common format.
- First aim is to develop the methodology and propose to the “Status and Trends” inter-agency (EC, IAEA and OECD NEA) initiative as a tool of data presenting and comparison.
- Reviewing of RW/SF management strategies in NEA countries was performed at the initial stage of work to provide a base for the methodology development.

Fuel cycle



Fuel Cycle Steps (OECD/NEA, 2011, Trends towards Sustainability in the Nuclear Fuel Cycle, Nuclear Development, OECD Publishing
http://dx.doi.org/10.1787/9789264168268-en

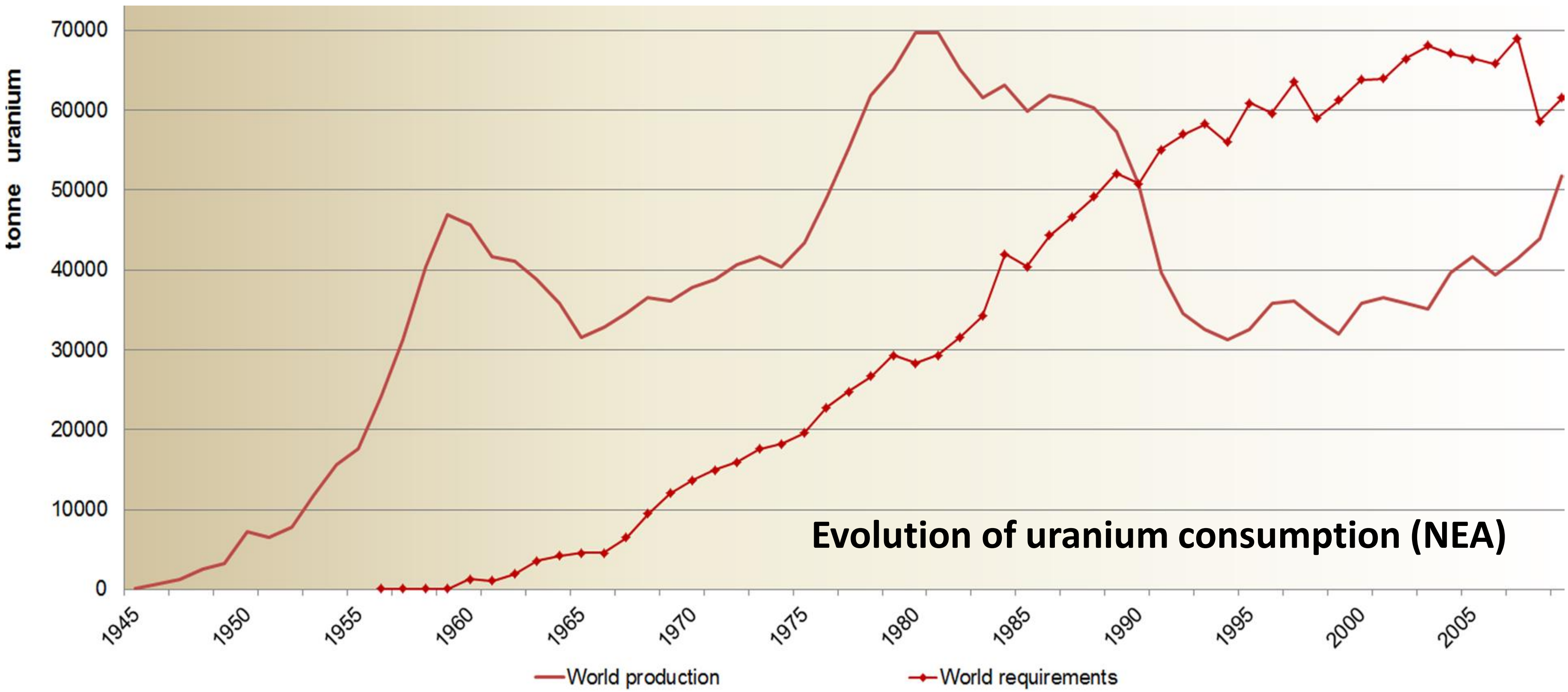
Criteria for SF safe and sustainable management strategy

- Covering of all the stages from the generation to final disposal (SF/HLW) in accordance with a well-defined practical plan.
- Feasibility with a sustainable impact level.
- Provision with realistic financing plan.
- Ability to demonstrate that it is technically and economically viable.
- Protection of human health and the environment and has no greater impact on the health of future generations than is allowed today.
- Addressing the present needs but without impose burdens on future generations.

Decision factors

- Political factors (international agreements, conventions, etc.)
- Technical (sustainability):
  - *the availability and use of natural resources*
  - *the SF handling and treatment*
  - *RW disposal*
- Safety;
- Non-proliferation and security:
  - *short term - control of SF storage, handling and (if applicable) reprocessing; and*
  - *the long term - control of the DGR.*
- Economics;
- Public acceptance.

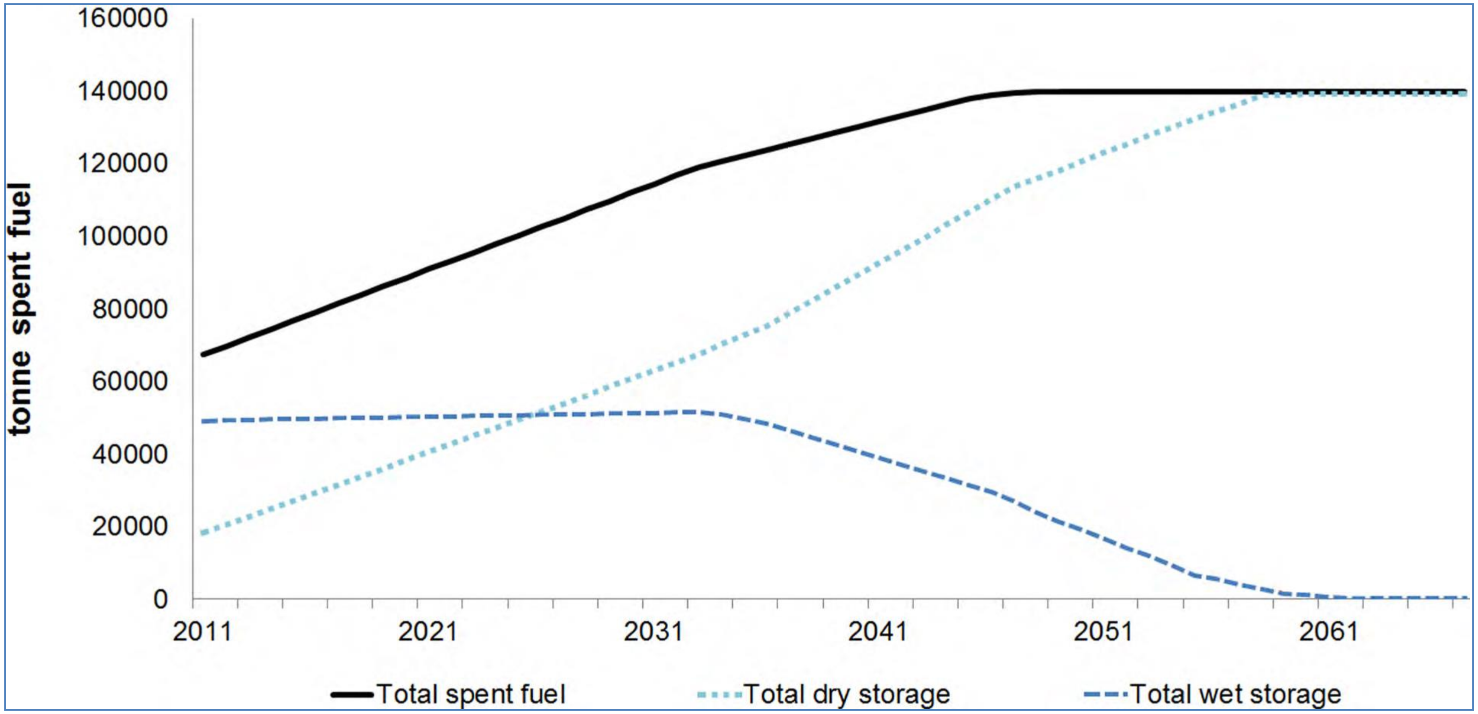
Sustainability (availability and use of natural resources)



"Trends towards Sustainability in the Nuclear fuel Cycle", OECD/NEA, 2011.
"Advanced Nuclear Fuel Cycles and radioactive waste Management", OECD/NEA, 2006.
"Uranium 2011: Resources, Production and Demand", A Joint Report by the OECD/NEA and the IAEA, 2012.
"Trends towards Sustainability in the Nuclear Fuel Cycle", OECD/NEA, 2011.

Sustainability (SF handling and treatment process)

- Complexity of the techniques;
- Level of the techniques maturity and required developments;
- Long term feasibility, dependence on internal and external factors;
- Flexibility and reversibility of the process.



Evolution of interim storage of spent fuel in the U.S.

Sustainability (RW disposal)

- Repository footprint (demand on disposal area) – open (150000m^3)- part.cl.(23000m^3)-closed(13000m^3) (ANDRA);
- Required longevity of the repository (timescale over which the isolation function remains important);
- Retrievability and recoverability of the disposed waste.

"Potential Benefits and Impacts of Advanced Nuclear Fuel Cycles with Actinide Partitioning and Transmutation", OECD/NEA, 2011
"Concept of Waste Management and Geological Disposal Incorporating Partitioning and Transmutation", 10th Information Exchange Meeting on Partitioning and Transmutation, OECD/NEA, 2008.
"International understanding of reversibility of decisions and retrievability of waste in geological disposal", OECD/NEA, 2011.

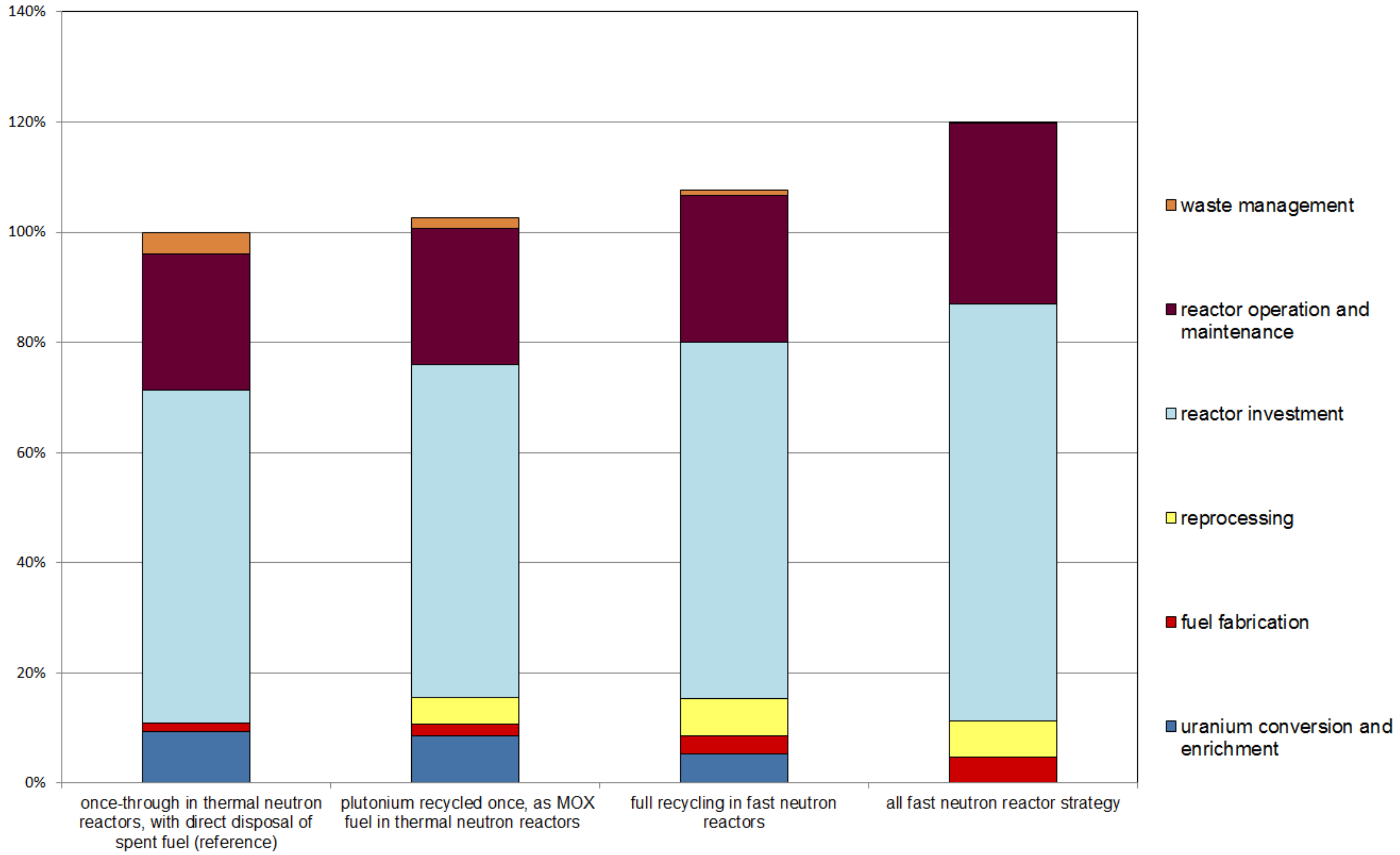
Safety

- Front-end related safety requirements:
  - Mining, enrichment, fuel fabrication – open>part.cl.>closed;
- Back-end related safety requirements:
  - Interim storage – open<part.cl.<closed;
  - Processing (HLW management) - part.cl.≈ closed;
  - Transport - open<part.cl.≈closed;
  - DGR – open (>200000y)<part.cl. (>100000y)<closed (≈30000y) ->(400y with partitioning and transmutation).

Non-proliferation

Factor /provisions on	No reprocessing	Reprocessing	
		Particularly closed	Fully closed
Short term – SF storage and handling	(+) no separation of fissile material (Pu) (+) fuel is self-protecting (+) limited number of handling steps	(-) separation of the fissile material (Pu)	(-) separation of the fissile material (Pu) (+) no or nearly no U enrichment required
Long term – SF geological disposal	(-) disposed SF contains fissile material	(+) SF contains fissile material	+ no fissile material disposed

Economy



"Advanced Nuclear Fuel Cycles and Radioactive Waste Management", OECD-NEA No. 5990, 2006.

"The Economics of the Back End of the Nuclear Fuel Cycle", OECD-NEA No. 7061, 2013 (http://www.oecd-nea.org/ndd/pubs/2013/7061-ebenfc.pdf)

Public acceptance

- Decision-making on nuclear fuel cycles inevitably initiates long-term commitments exceeding the life span of an individual, irrespective of the option;
- Stakeholder involvement should be a constructive contribution for successful implementation of a decision;
- Public participation is a part of the process of siting nuclear facilities and it leads to a broadening of the objectives, beyond solely optimizing technical and safety criteria.

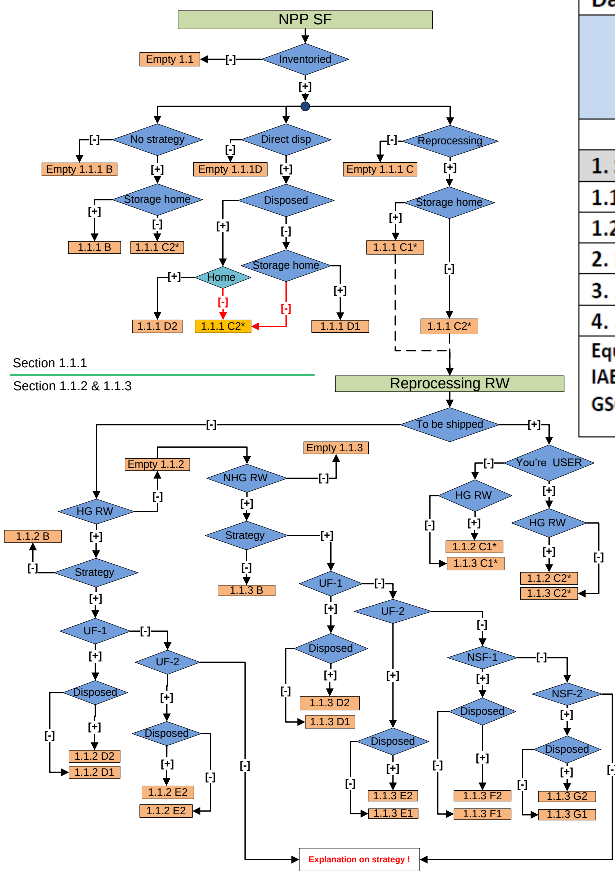
SF management scenarios

- Direct disposal
- Reprocessing:
  - Inside country (own);
  - Abroad (shipment for service);
- No defined strategy (storage waiting for strategy)
- HLW management is connected to SF management strategy (DGR)

Non Heat-Emitting RW management

- ILW, LLW and VLLW consideration
- Strategies of management - conditioning when necessary and:
  - Disposal in NSF;
  - Disposal in UF;
  - No strategy (waiting for solution).
- Factors defining the strategy selection:
  - Period of potential danger of RW;
  - Total volume of RW;
  - Economy;
  - Existing of legacy;
  - State policy.

Visualisation of review results



Spent fuel and radioactive waste inventory presentation

Country:______________________

Date of inventorying:_______________

SF/RW types (in national terms)	No strategy	SF reprocessing/ service		Disposal in:								
		home	abroad	UF-1		UF-2		NSF-1		NSF-2		Others
(A)	(B)	(C1)	(C2)	(D1)	(D2)	(E1)	(E2)	(F1)	(F2)	(G1)	(G2)	→
1. SF												
1.1. NPP												
1.2. Other reactors												
2. HLW, [m³]												
3. … class, [m3]												
4. … class, [m3]												
Equivalence with IAEA GSG-1 2.	HLW	HLW	HLW	HLW								
3.												
4.												

Report with completed methodology will be published in June, 2017

http://home.nea.fr/rwm/pubs/2016/7323-radioactive-waste-inventory-strategy.pdf

Inventory reporting methodology

- To provide comparability of national SF/RW inventory data through application of common format of presentation;
- To facilitate understanding of SF/RW management situations in different countries;
- To provide ability to present the SF/RW inventory data with connection to accepted management strategy and disposal routes;
- To support NEA members in preparing their National Report for the Joint Convention and the European Directive 2011/70 with above mentioned method.

Main points

- Methodology does NOT provide any new RW classification scheme it is just a valuable additional instrument to GSG-1 (IAEA) for comparison and compilation of data from different countries.
- It is a mostly technically oriented tool based on technical aspects of RW/SF management strategies accepted in countries and final disposal routes.

Advantages

- SF and RW inventories combined in one scheme;
- SF origin presented as – “NPP – other reactors”;
- SF/RW inventory data presented in framework of national management strategies;
- SF/RW currently being without management strategy presented;
- SF/RW as a subject of international service presented;
- Disposal routes accepted for each kind of RW presented;
- Correlation between national RW classes and classes of IAEA classification (GSG-1) presented (transfer to GSG-1 performed by countries);
- Each potential SF/RW management scenario can be presented.

Presenting table

Spent fuel and radioactive waste inventory presentation

Country:________________________
Date of inventorying:_____________

SF/RW types (in national terms)		No strategy	SF reprocessing/ service		Disposal in:								
			home	abroad	UF-1		UF-2		NSF-1		NSF-2		Optional
(A)		(B)	(C1)	(C2)	(D1)	(D2)	(E1)	(E2)	(F1)	(F2)	(G1)	(G2)	→
1. SF													
1.1. NPP													
1.2. Other reactors													
2. HLW, [m³]													
3. … class, [m3]													
4. … class, [m3]													
Equivalence with IAEA GSG-1	2.	HLW	HLW	HLW	HLW								
	3.												
	4.												

Footnotes for additional explanations (when necessary)

Disposal routes (main group)

Type of facility	Features	RW classes (in terms of GSG-1) that can be disposed of	SSR-5 equivalent (1.14)
UF			
UF-1	- no direct, open connection with surface during construction or operation stage (i.e. ramp, shaft or borehole access); - intensive application of artificial barriers; - heat emission is considered in design; - package for SF/HLW/ILW – be sure.	SF; HLW; ILW; LLW; VLLW; (NORM; TENORM) – solid	Geological disposal
UF-2	- no direct, open connection with surface during construction or operation stage (i.e. ramp, shaft or borehole access); - rather wide application of artificial barriers; - heat emission is not considered in design; - package for ILW – be sure.	ILW; LLW; VLLW; (NORM; TENORM)	Disposal on intermediate depth + geological disposal + borehole disposal
NSF			
NSF-1	- open air at construction stage; sometimes also during operation; - rather wide application of artificial barriers; - heat emission is not considered in design; - package for ILW – be sure.	ILW; LLW; VLLW; (NORM; TENORM)	Near-surface disposal + disposal on intermediate depth (particularly)
NSF - 2	- open air at construction stage; sometimes also during operation; - minimally reasonable application of artificial barriers; - heat emission is not considered in design; - package for LLW – be sure.	LLW; VLW; (NORM; TENORM)	Near-surface disposal; Landfilling

Other disposal routes

Type of facility	Features	RW classes (in terms of GSG-1) that can be disposed of	SSR-5 equivalent (1.14)
Other routes			
BH – 1	- no direct, open connection with surface during construction and operation stage; - no excavated underground space for RW emplacement; - heat emission is not considered in design; - package for RW - possible	DSRS, ILW, LLW	Intermediate depth boreholes
BH – 2	- no direct, open connection with surface during construction and operation stage; - no excavated underground space for RW emplacement; - heat emission is considered in design; - package for RW required	SF, HLW, DSRS (1st category)	Deep boreholes
BH - 3	- no direct, open connection with surface during construction or operation stage; - conditional application of artificial barriers (around boreholes); - heat emission is considered in design; - package for waste – no.	Liquid ILW; LLW	No analogue
SDL	Past practice of disposal, banned now, performed as dumping of liquid RW into sea/ocean	LLW	Now banned
SDS	Past practice of disposal, banned now, performed as dumping of solid RW into sea/ocean	ILW; LLW	Now banned

Testing (example)

Spent fuel and radioactive waste inventory presentation

Country: Germany_________________

Date of inventorying:_31.12.2013

SF/RW types (in national terms)	No strategy	SF reprocessing/ service		Disposal of in:							
		home	abroad	UF-1		UF-2		NSF-1		NSF-2	
(A)	(B)	(C1)	(C2)	(D1)	(D2)	(E1)	(E2)	(F1)	(F2)	(G1)	(G2)
1. SF											
1.1. NPP				8216							
1.2. Other reactors				9.5							
2. RW with HG, [m^3]			859 [1)]	569[2)]							
3. RW with negligible HG [m^3]						120.000[3)]	83683[4)]				
Equivalence with IAEA GSG-1 classification: 2.			HLW/ILW	HLW							
Equivalence with IAEA GSG-1 classification: 3.						LLW/ILW	LLW/ILW				

[1)] HLW stored in UK and France and to be sent back 764 m^3 (Fr) + 103 m^3 (UK)

[2)] 569 = 554 m^3 after NPP SF reprocessing (volume given "as is" – 180 l canisters) + 15 m^3 after other reactors' SF reprocessing;

[3)] RW to be disposed in UF-2 "Konrad";

[4)] 83683 = 36753 m^3 (disposed in UF-2 "Morsleben") + 46930 m^3 (disposed in UF-2 "Asse")
(in future, retrieval from "Asse" is planned and will increase the "to be disposed of" volume).

UF-1: future HLW disposal
UF-2: Konrad; Morsleben; Asse

NEA Workshop

- International Workshop **« Implementation of the Expert Group on Inventorying and Reporting Methodology (EGIRM) methodology for presenting of national RW and SF management programmes»**, organised by OECD NEA will be held on 19-20 September, 2017 in NEA building, Boulogne-Billancourt, France.
- **Session 1:** «RW/SF inventory, management strategy and disposal routes – need to harmonise reporting and presenting»
- **Session 2**: «EGIRM methodology – history of development, background, EGIRM objectives, requirements to the methodology »
- **Session 3**: «The methodology in details»
- **Session 4:** «Practical exercises on the methodology application on proposed examples»

http://home.nea.fr/download/rwm/egirm/documents/Concept_128.04.17.pdf

Thank you for attention!

http://www.oecd-nea.org