SAPIERR II
regional repositories

Safety and Security Aspects

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Structure of the presentation

- Aims and approach
- Common ground on safety and security
- Questions for this presentation
- Comparative assessments
  - the system
  - safety assessment
  - security assessment
- Conclusions

Aims, approach, common ground and questions

Aim of the work package

- SAPIERR concept
  - one or more geological repositories developed in collaboration by two or more European countries to accept SF, vitrified HLW and other long-lived radioactive waste from those countries
- Aim of the work package and report
  - to make an outline examination of the safety and security aspects of implementing one or two regional repositories within the EU, relative to a larger number of national repositories
  - the focus is on nuclear safety and nuclear security

Approach in the report

- To survey the safety and security standards that would apply to a multi-national radioactive waste management system leading to final disposal within one or more shared repositories in the EU
- To confirm that methods and techniques are available to assure safe and secure accomplishment of all the necessary waste management steps, and to indicate their performance
- To make simple generic comparisons and assessments of safety and security aspects of implementing such a system, compared to that of implementing a number of national systems

Common ground

- High levels of safety and security will be applied to the management and disposal of radioactive waste and spent nuclear fuel in both national and shared projects
- The report confirms that
  - the required safety and security standards are achievable for all required steps
  - a shared project presents no technical issues that will not have to be overcome in national projects
- International treaties, conventions and guidance, and national regulations and controls ensure that a shared RWM system will be at least as safe and secure as national RWM systems

Boundary conditions for safety & security

- International treaties and agreements
  - Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management
  - Treaty on the Non-Proliferation of Nuclear Weapons
  - Convention on the Physical Protection of Nuclear Material
  - G8 Global Partnership Against the Spread of Weapons and Materials of Mass Destruction
- Treaties and directives of the European Union, e.g.
  - Euratom safeguards and radiation protection directives
- IAEA objectives, principles and requirements, on
  - safety, security and nuclear safeguards
- Nuclear best practice
- National laws and regulation

Achieving safety and security

- For most hazards and threats, safety and security are achieved by a process of
  - safe and secure design
  - implementation of safety and security features, controls and procedures
  - monitoring of safety and security performance
- Geological disposal offers a special challenge
  - the disposed waste should remain safe and secure even without monitoring or further protective actions
- The stages of transport and operation offer more potential for accidents risks, but are subject to active control, supervision and correction

Key questions

- Are there safety benefits in developing multinational repositories ?
- Are there security benefits in developing multinational repositories ?

Important caveats on the assessments

- Common international guidance and EU laws
  - will apply to any national or international radioactive waste management system developed within the EU
- High standards of safety and security
  - will be demanded by society and national governments, sought by the developer and enforced by regulatory bodies
- Hence any radioactive waste management system developed in the EU will be safe and secure
  - as safe and secure as it can reasonably be made (applying BPM, ensuring doses and risks are ALARA and risks of attack or subversion are minimised) and in compliance national laws and regulations

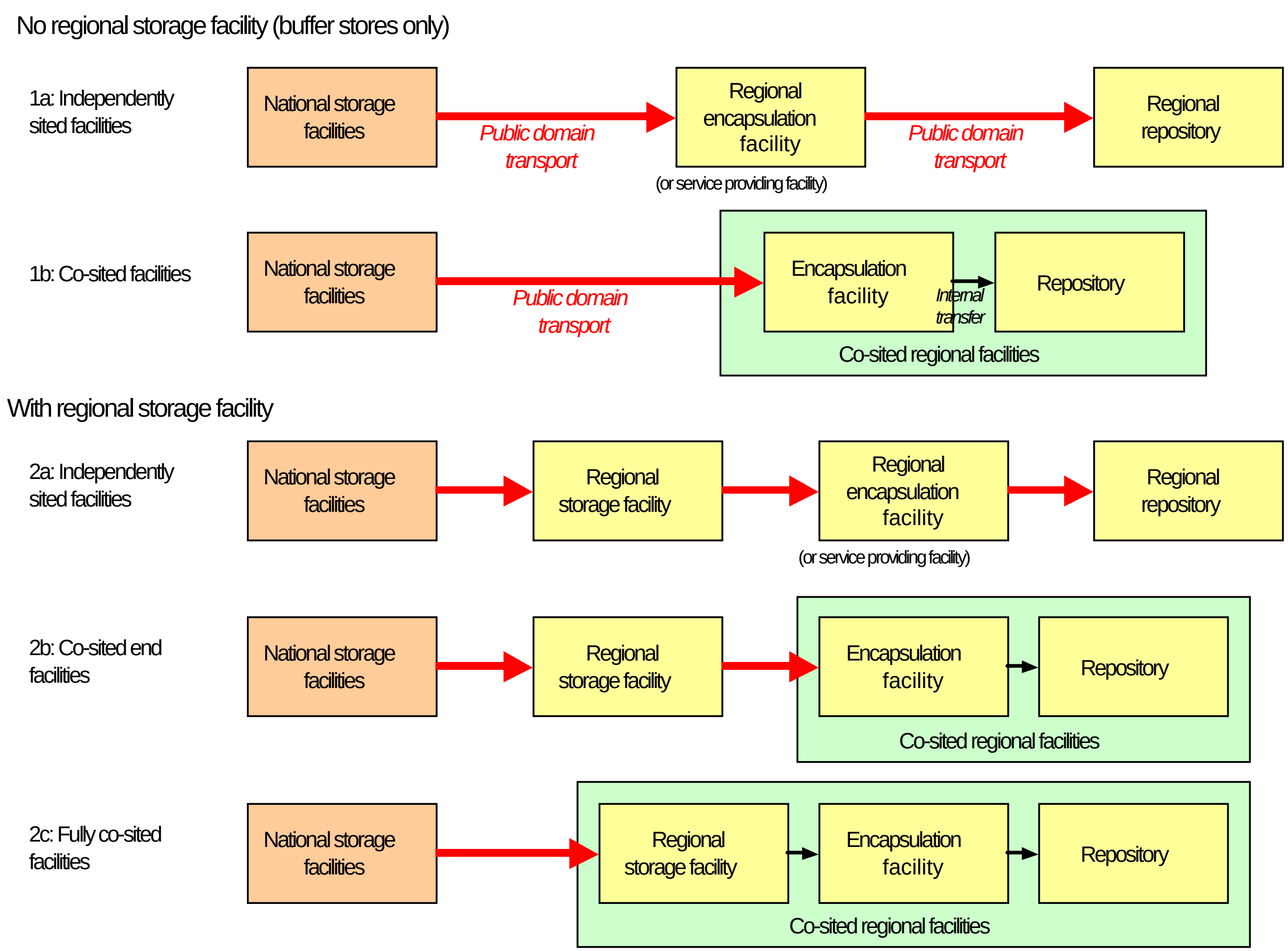
- It is not possible to make detailed or firm assessments of a system that exists only as a broad concept
  - the assessments are indicative and for comparative purposes

The system

Scope of comparative assessments

- The system considered
  - is the complete chain of activities and facilities that would be needed take radioactive waste safely and securely from storage facilities at nuclear power plants, or from centralised national storage facilities, to final disposal in one or more regional deep geological repositories
- Nuclear safety and security is considered
  - during radioactive waste and nuclear material transport
  - during operations of facilities
    - encapsulation, storage or disposal facilities
  - after final closure of a disposal facility or repository
- Many arrangements and options are possible …

Example options for a shared radioactive waste management system

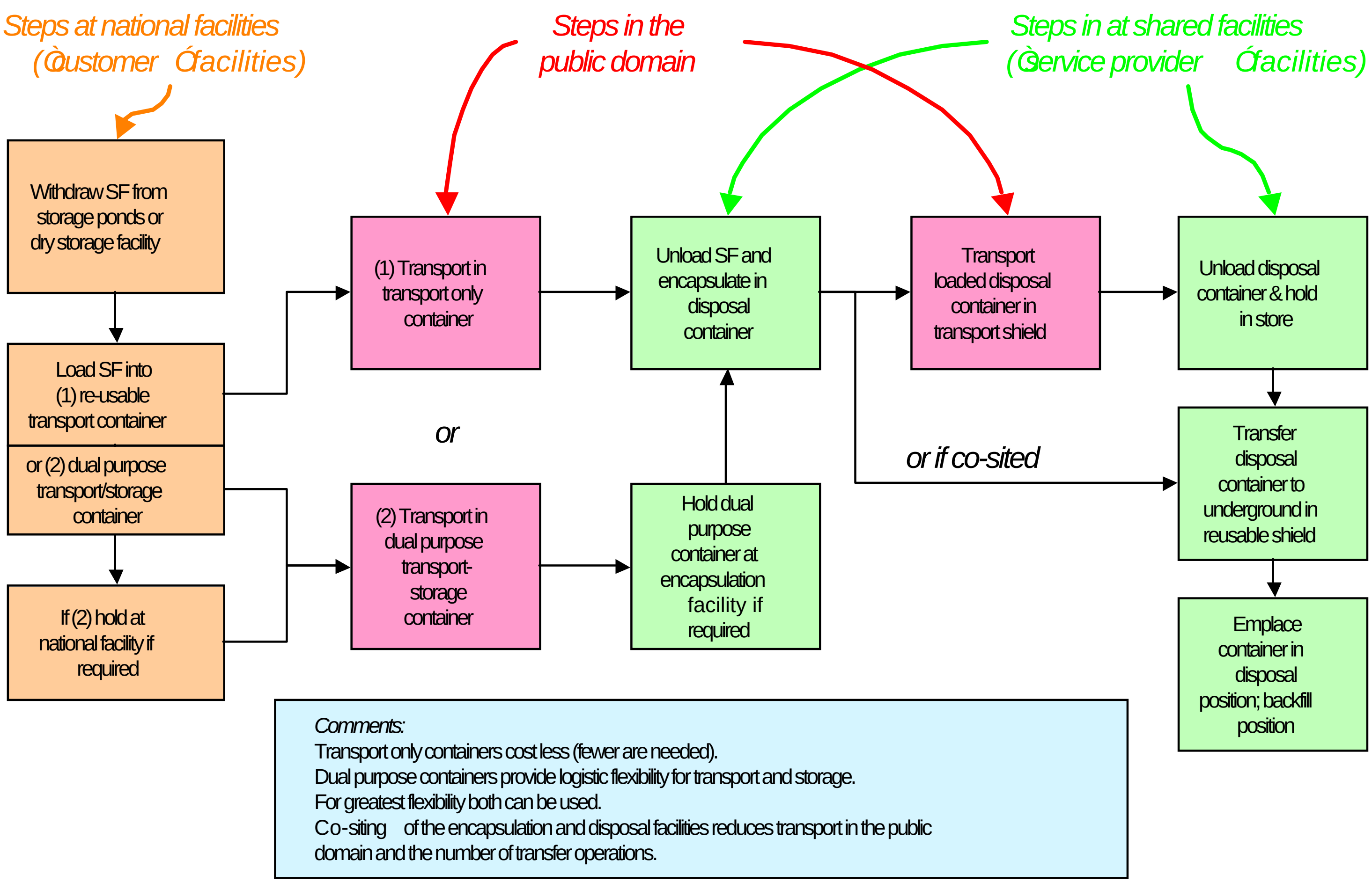


System characteristics

- Inventory for disposal
  - SAPIERR-I “Reference” and “Small” inventory
- Number and arrangement of encapsulation facilities and repositories
- Transport routes and distances arising out of different arrangements of facilities
- Timing of encapsulation and disposal
- Operational steps

(Focus on spent fuel as the dominant waste type)

Steps in the movement of SF from national stores to emplacement in a shared repository



Data for notional small national spent fuel disposal systems and illustrative European shared spent fuel disposal systems

	National spent fuel management systems			Illustrative shared systems	
Capacity, t SF	1000 t SF	2500 t SF	4000 t SF	6000 t SF	25 000 t SF
Arising from	national	national	national	3 countries	10 countries
Notional make up for shared system				1 x 1000 2 x 2500	3 x 1000 4 x 2500 3 x 4000
Time in national storage	50 years	50 years	50 years	40 years	40 years
Transport distance	100 km	100 km	100 km	400 km	1200 km
Repository operating period	10 years	15 years	20 years	25 years	50 years

Safety assessment

Illustrative design targets for a shared European waste management system and comparison to accepted limits and natural background

	Illustrative design targets	BSS/EURATOM limits	Natural background
For facility operations and transport			
Monitored radiation workers	2 mSv/a	20 mSv/a	Average 2.4 mSv/a Range 1 to10 mSv/a
Other workers	0.5 mSv/a	5 mSv/a	
Members of the public	0.2 mSv/a	1 mSv/a	
For the post-closure period of a repository			
Up to 10,000 y Calculated dose as a performance indicator	0.1 mSv/a		As above
From 10,000 to 1,000 ,000 years Quantitative and qualitative arguments for continued safety	0.1 - 0.3 mSv/a		
Beyond 1,000,000 years Qualitative arguments			

Safety criteria and ALARA requirements will be no different than for national systems

Comparison of indicative collective doses to workers for national and shared SF management systems of the same total capacity

	National spent fuel management systems		Shared spent fuel management systems	
See text for assumptions	3 countries	10 countries	Small inventory	Large inventory
	6 000 t SF	25 000 t SF	6 000 t SF	25 000 t SF
	Collective doses, Sv (rounded)			
Storage				
if wet storage	11	38	8.4	30
if dry storage	1.1	3.8	0.84	3.0
Cask loading	2.4	10	2.4	10
Transport	0.006	0.025	0.024	0.30
Unloading and encapsulation	2.4	10.0	2.4	10.0
Repository operation	0.29	1.2	0.28	1.5
Total from loading to disposal	5.1	21.2	5.1	21.8
Total including national wet storage	15.6	59	13.5	52
Net dose saving			2.1	6.9

Note:
The corresponding collective effective doses to reactor workers are 2,600 and 10,800 man-Sv.

(6000 and 25,000 t equate to 575 and 2400 Gw.a)

Observations on the indicative collective doses to workers

- Collective doses are small compared to those related to the corresponding reactor operations
- They are not a significant discriminating factor between individual national and shared spent fuel management systems of the same total capacity
- The estimated net dose saving is only about 1/1000th of the CD related to the corresponding reactor operations
  – and arises from the assumption that early development of a shared disposal facility would reduce the time that spent fuel is stored at national disposal facilities

Comparison of indicative collective doses to the public for national and shared SF management systems of the same total capacity

	National spent fuel management systems		Shared spent fuel management systems	
See text for assumptions	3 countries	10 countries	Small inventory	Large inventory
	6 000 t SF	25 000 t SF	6 000 t SF	25 000 t SF
	Collective doses, man-Sv (rounded)			
Storage (from ^{14}C) Local and regional Global to 1000 y	 0.23 9.6	 0.95 40	 0.18 7.7	 0.76 32
Cask loading	0	0	0	0
Transport (local)	0.006	0.025	0.024	0.30
Unloading etc.	0	0	0	0
Repository operation	0	0	0	0
Post-closure to 10,000 years	0	0	0	0
Total incl storage Local and regional Global to 1000 y	 0.23 9.6	 0.97 40	 0.21 7.7	 1.06 32
Net saving Local and regional			0.02	- 0.09
Net saving Global to 1000 y			1.9	8.0

Note:
The corresponding collective dose to members of the public from reactor operations are 120 and 500 man-Sv in local and regional domains and 1000 year global commitments of 2,000 and 8,000 man-Sv.

Observations on the indicative collective doses to the public

- Collective doses, and global dose commitments are dominated by doses related to storage
- They are small compared to those related to the corresponding reactor operations
- They are not a significant discriminating factor between individual national and shared spent fuel management systems of the same total capacity
- The estimated net saving in global collective dose commitment to 1000 years is only about 1/1000th of that related to the corresponding reactor operations
  – and arises from the assumption that early development of a shared disposal facility would reduce the time that spent fuel is stored at national disposal facilities

Results from indicative safety assessments

- There is little difference between calculated radiological impacts for a shared European SF management system and several national systems with equivalent capacity.
- Any potential dose reduction arises from the assumption that timely development would reduce the average time that spent fuel is stored at national facilities
- The calculated collective dose reductions (to workers and the public) are only about 1/1000th of those from the reactor operations that produced the spent fuel
- Post-closure radiological impacts do not figure because no releases to the environment are expected until many thousands of years after closure

Long-term safety as a special factor ?

- Greater choice of geological situations and sites
  - but it will not be the intention to find a “best site”
  - choice may rest on other factors, e.g. technical and regulatory infrastructure … and willingness to host
- Greater international and/or multinational scrutiny
  - but national programmes also have access to international and multinational expertise
  - and control will be under national regulations
- A larger pool of financial and human resources
  - fuller consideration of safety and technical issues and a better quality of implementation ?

Security assessment

Security Aspects

- Physical protection of facilities and nuclear material
  - protection against non-state actors - terrorists, activists, saboteurs, countered via
    - intelligence, define DBT,
    - system of administrative and physical barriers
      - hardware, personnel, procedures, facility design and layout
    - deter – detect – assess – delay – respond
- Nuclear safeguard and non-proliferation
  - protection against state diversion, countered via
    - control of nuclear materials
    - audit records and reports
    - verification of amounts, incl physical inspection & measurement
    - examination and checks of principal nuclear facilities

Physical protection of a shared waste management system

- Waste acceptance
  - control of waste and SF accepted (category II)
  - non-volatile, robust materials, resistant to dispersal
- Waste transport
  - passive and active security
  - selection of routes and timing
- Encapsulation facilities and repositories
  - passive and active security
- System of measure sufficient to resist the DBT
  - but motives of perpetrators difficult to assess

Assessment of nuclear targets against aims of terrorist or activist groups

Attractiveness or practical potential of nuclear targets to meet possible aims of terrorist or activist groups				
Nuclear reactor	Spent fuel pool storage	Spent fuel cask storage	Spent fuel transport	Encapsulation and repository
Aim 1: to cause destruction and deaths by direct action				
Theoretically possible from uncontrolled fission reaction. Practically impossible due to reactor passive and automatic safety systems	Possibility of widespread contamination following pool draining and zirconium alloy fire. Unlikely and recoverable before overheating.	Negligible potential. Robust containment and limited potential for dispersal.	Negligible potential. Robust containment and limited potential for dispersal.	Negligible potential. Only small amounts of SF uncontained at any one time.
Aim 2: to cause economic damage and/or social disruption, including effects of public fear				
Disruption of power generation possible through damage to reactor and/or control systems. Possible local evacuation and severe fear impacts.	Evacuation and possible fear impacts if facility is damaged.	No objective impact, but possible fear impacts locally.	Minor objective impacts related to disruption of transport routes. Fear impacts locally.	No objective impact, but possible fear impacts locally.
Aim 3: to acquire nuclear material which could then be used in an explosive device				
Radiation hazards make it practically impossible.	Difficult. Insider removal of single rods or part rods has been suggested.	Near impossible. Specialist heavy equipment needed and would take considerable time to take SF from casks.	Near impossible. Specialist heavy equipment needed and would take considerable time to take SF from casks.	Negligible potential. Only small amounts of SF uncontained at any one time.
Aim 4: to gain publicity for the group in question, e.g. causing a Ôspectacular Õevent				
High value target. Perceived very high potential consequence. High media value.	Perceived high potential consequence.	Low potential consequence.	Low potential consequence, but high public concern.	Low potential consequence.

Summary assessment of nuclear targets against possible terrorist aims

- Aim 1 – destruction and deaths by direct action
  - none of the nuclear targets make an objectively attractive target
- Aim 2 – economic damage and/or social disruption
  - all targets have some potential through a fear and social disruption effect; disabling a power station would be a real economic detriment
- Aim 3 – to acquire nuclear material
  - none of the targets seem attractive, both because of the quality of nuclear material and difficulty of reaching or escaping with it
- Aim 4 – to gain publicity - ‘spectacular’ event
  - all the targets offer some possibilities; a nuclear reactor offers most potential as a high value target, but attacks on transport could also be attractive

Nuclear safeguards and non-proliferation

- Not appropriate to assess security risks of state-sponsored diversion of nuclear materials because
  - nuclear safeguards are equally applicable and enforced under the same internationally-supervised arrangements
  - any assessment would need to make judgements about long-term political stability and intentions that are both speculative and political
- In principle, a shared repository programme does offer non-proliferation and nuclear safeguards advantages
  - reduction of the number of sites at which nuclear material is held, so safeguards can be focussed on those fewer locations
  - more rapid progress towards emplacement of their nuclear materials in an underground repository, so that the intrinsic security advantages of geological disposal are realised sooner

Conclusions

Safety and security overview

- Safety and security is achievable for all steps required within a European shared waste management system
  - demonstrated in practice for radioactive waste handling, transport and storage, including for SF
  - appropriate technologies for sealing of SF/HLW into disposal containers has been demonstrated
  - excellent security record including cross-border co-operation
- Licensing and operation of a geological repository for SF/HLW has not been demonstrated, but several countries are working towards that goal
  - security poses no special problems

Key questions

- Are there safety benefits in developing multinational repositories ?
- Are there security benefits in developing multinational repositories ?

Are there safety benefits in developing multinational repositories?

- The assessed radiological safety of shared RWM systems shows a small collective dose reduction relative to national systems of the same capacity
  - this arises from an assumption that timely development would reduce the time that spent fuel is stored
  - the net collective dose reductions (to workers and to members of the public) are very small
- A shared RWM system offers a potential safety advantage over separate smaller national systems
  - primarily as a result of the pooled financial and human resources that can be invested to ensure high quality implementation
  - shared responsibility and multinational oversight should also give greater assurance of regulatory control and adherence to the strict international safety criteria and requirements

Are there security benefits in developing multinational repositories?

- Qualitative assessment of the physical protection of a shared vs national systems shows
  - the security risks are similar, and in both cases less than the risk posed by operating reactors
  - the increased number and distance of shipments increases risk of attacks against SF in transit, but even a successful attack could not produce serious radiological impacts
- A shared RWM system offers potential security advantages as a result of
  - the pooled protection and intelligence resources that can be applied to ensure physical protection during operations
  - reduction in the number of sites at which nuclear material is held
  - prospect of more rapid realisation of geological disposal - offers a high degree of passive security

Co-operation and timely implementation

- A well-focussed, co-operative effort from several countries can lead to a fuller and more critical consideration of safety and security and thus a better quality of implementation may be achieved.
- The combined efforts of several countries may give better prospects for joint realisation of a project at an earlier time
  - a small benefit due to a reduction in the average time that spent fuel is stored at national facilities
  - a less quantifiable benefit of less chance that disposal will be indefinitely delayed in any country
- We fully support the view of the IAEA group on developing multinational radioactive waste repositories
  - "the improvements in safety and security that are expected are at a global scale. It is not intended to imply that a multinational repository will be safer or more secure than a properly implemented national repository. The global benefit results from making a proper disposal facility accessible also to countries that may not be in a position to implement a state of the art national repository."

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