



Selected aspects of the Danish repository program

Views from the outside – potentially (hopefully) helpful to improve the Danish discussion

Gerhard Schmidt

Dialogue Meeting

Copenhagen, March 16, 2014



Index

Themes:

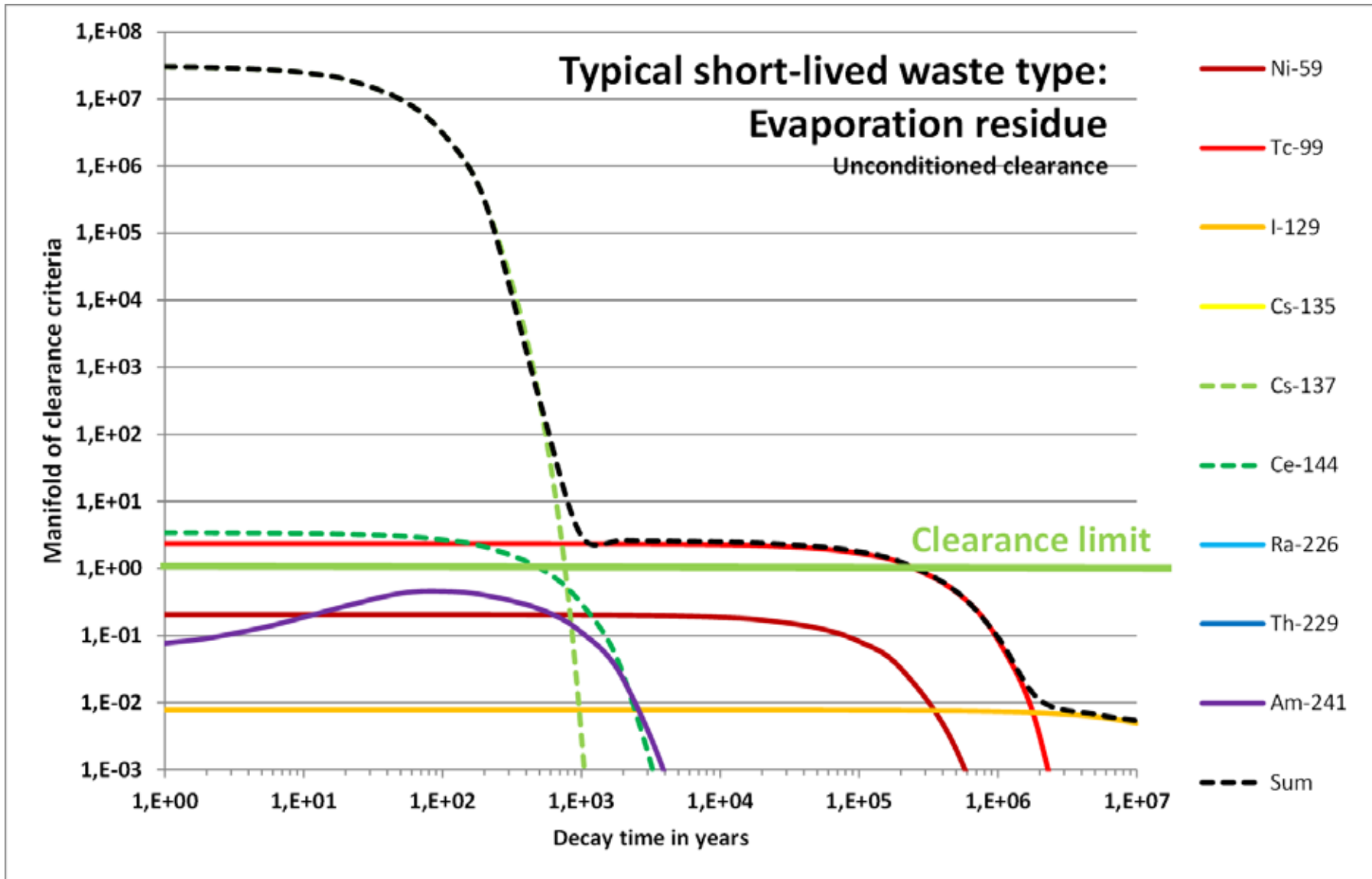
- [Controversial viewpoints of the danish project](#)
- Examples for short-lived wastes, [LWR-NPP](#) resp. [DK-Aluminium](#)
- Decay properties of the [danish inventory](#)
- Cost comparison of [surface-near and deep geologic repository](#)
- [Compliance demonstration](#)
- [Is spent research fuel the problem?](#)
- [IAEA Safety Requirements](#)
- Recommendations and reality: [\(1\)](#), [\(2\)](#), [\(3\)](#), [\(4\)](#) and [\(8\)](#).
- [AkEnd requirements and their applicability](#)



Aspect	Current repository plan	Alternative focus	Potential consequences
Role of repository safety	Compliance driven (dose limit, ...)	Durable enclosure of all wastes; Target: enclose all radioactivity forever!	Set-up safety criteria focussed on enclosure quality (not on repository emissions!)
Role of geological barrier	Only one of many barriers, not in focus, requirements undefined	Central for enclosure quality, all other barriers can only be supportive	Set-up geologic minimum/desirable requirements (layer type and quality, layer thickness, layer age, etc.)
Integrity of the geological layer	(No requirements formulated)	Durability of geological barrier central for enclosure quality	Derive integrity criteria from waste characteristics (e.g. longevity, mobility, gas generation)
Site selection procedure	High priority on naming & selecting sites, (reasons unknown to me)	Which geologic layers in Denmark are best suitable for durable enclosure?	Re-design the whole selection process and base it solely on repository safety criteria; Strive for a broad societal consensus in that risk decision; Strive for voluntariness
Repository depth	Decisive criterion, excluding or beating all other criteria or aspects	Depth selection is a mere sub-function of the integrity criterion (BTW: depth is near to irrelevant for overall costs!)	Repeat the selection process with taking the whole geologic repertoire for enclosure into account and with reliable and carefully & broadly consented enclosure criteria (Selection process V2.0)
Role of economic factors	As cheap as possible and only as safe as unavoidably necessary	Costs are a sub-function of safety; It might be more costly to build a repository at shallow depth due to more severe instability of mine openings	„Safety first!“; It is simply impossible to tailor natural systems to dose criteria, esp. when the integrity of the geologic layer as such is at a high risk; Very different approach necessary than in conventional Civil Engineering!

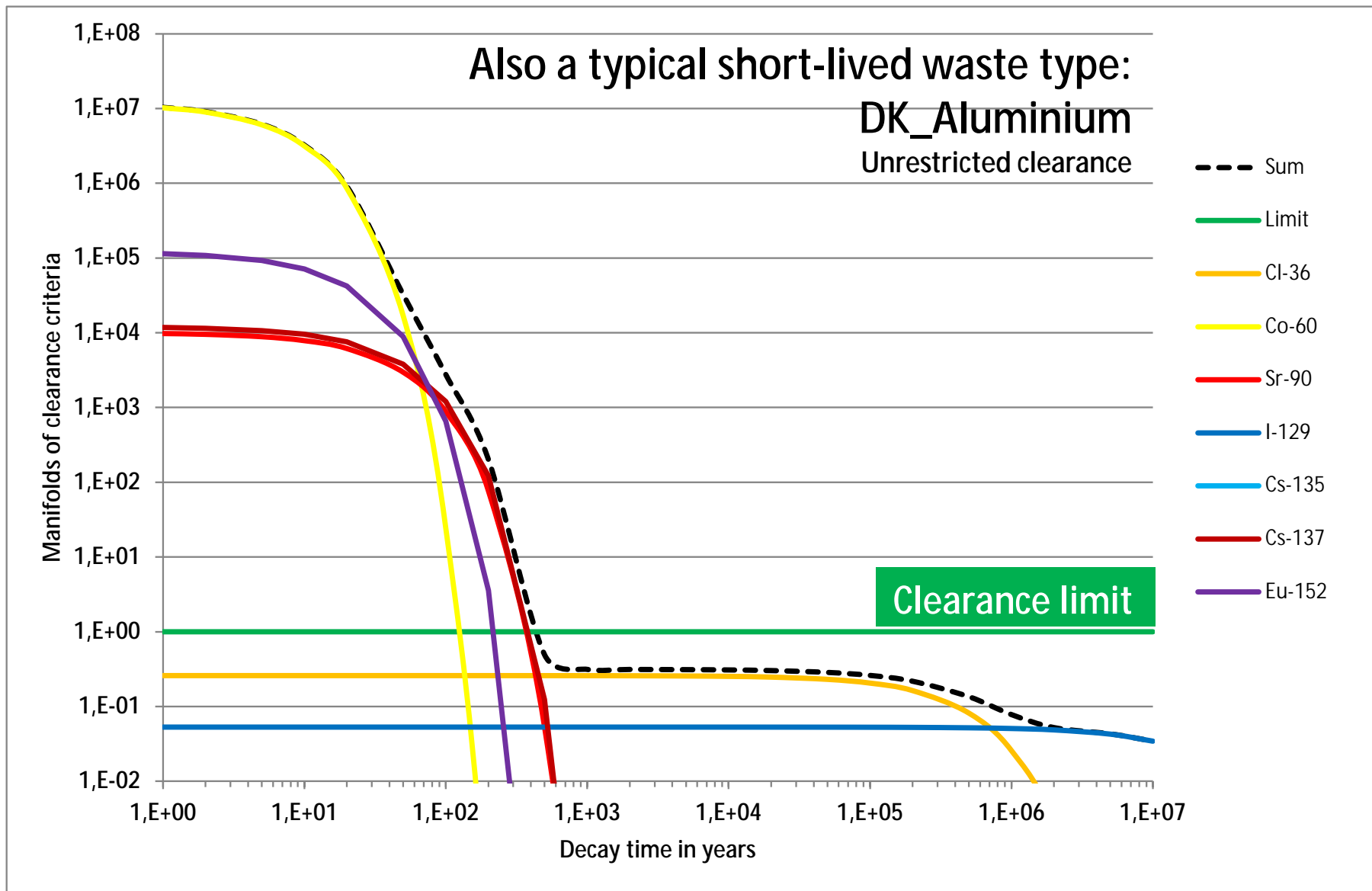


A typical shortlived waste from an NPP



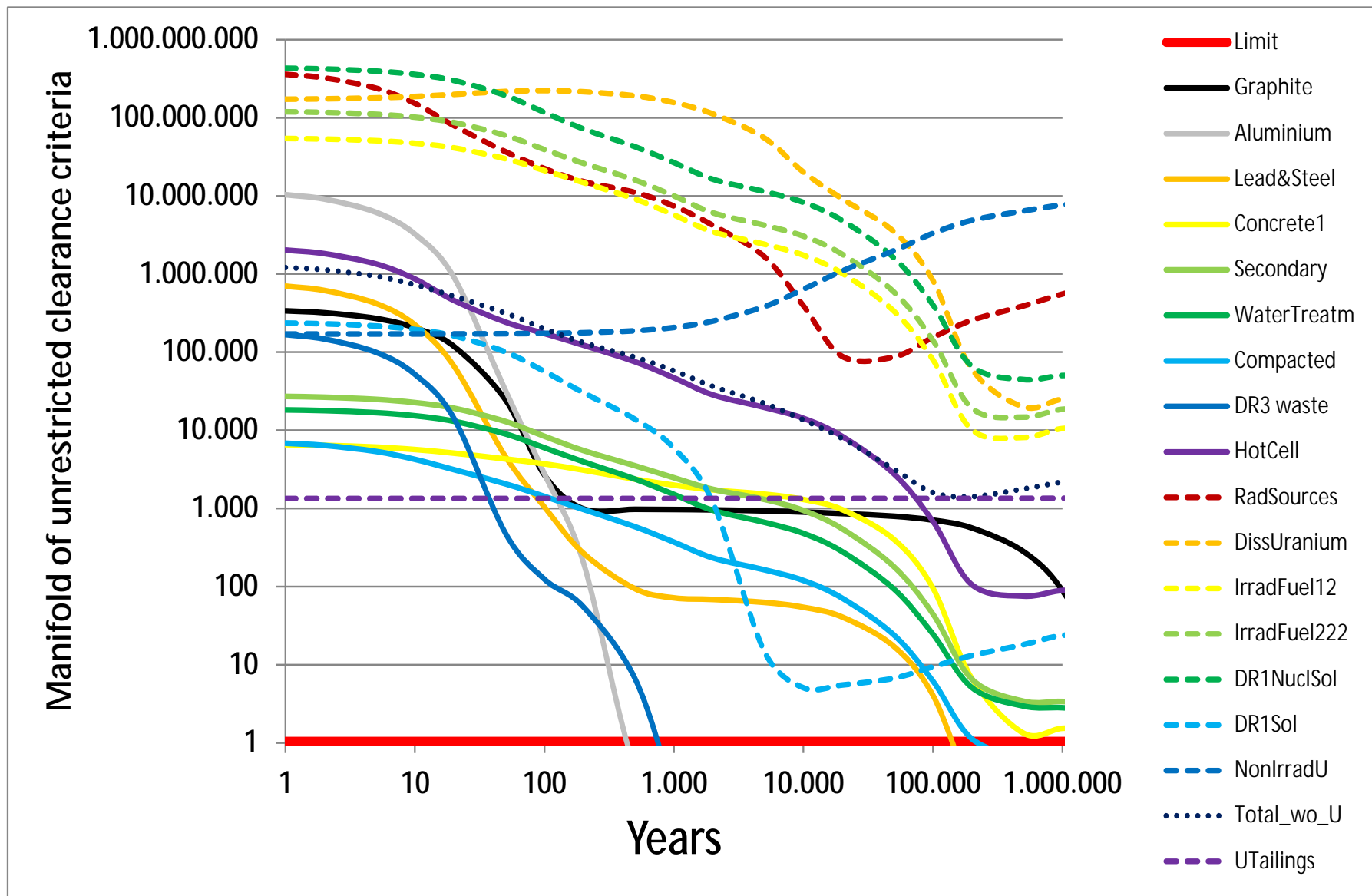


A typical shortlived waste from the Danish inventory



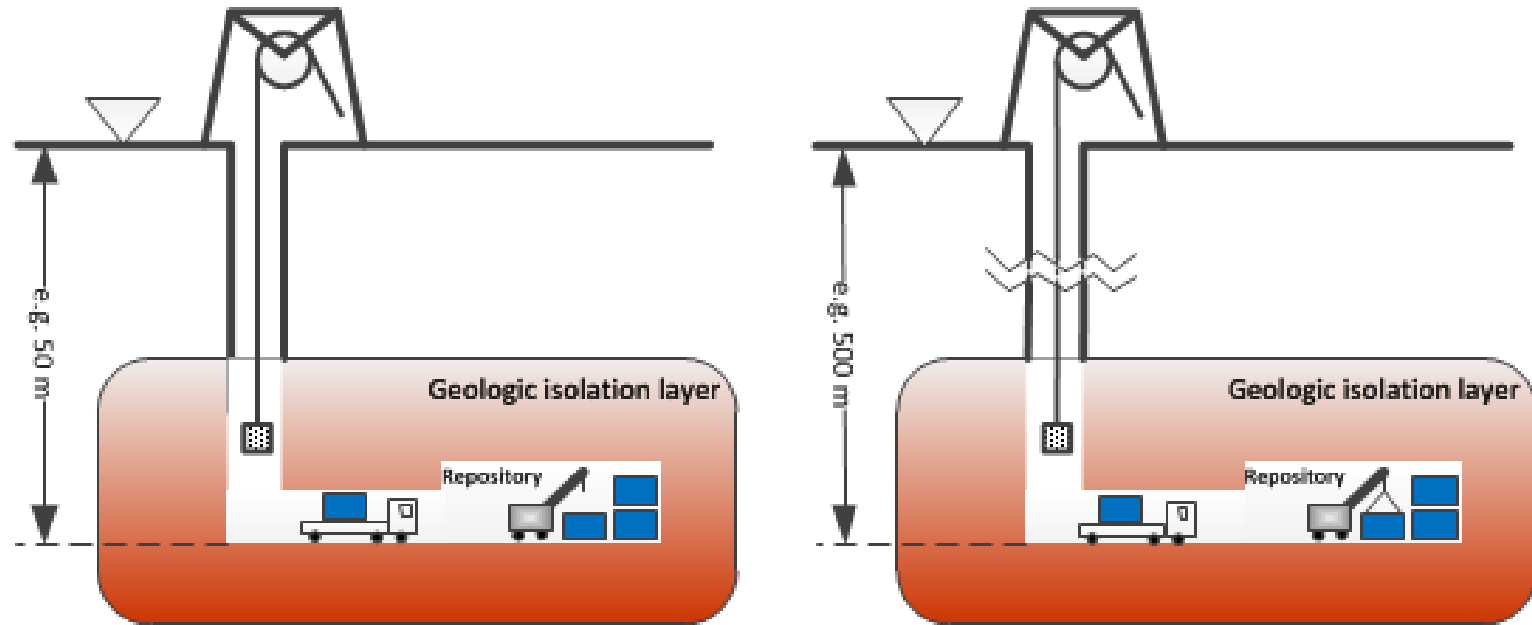


The whole Danish inventory by longevity criteria



Theory: Deep disposal is much more expensive.

- In fact the economic difference between a shallow and a deep repository is in the worst case 450 m additional shaft drilling and 450 m of additional steel cable during shaft operation.

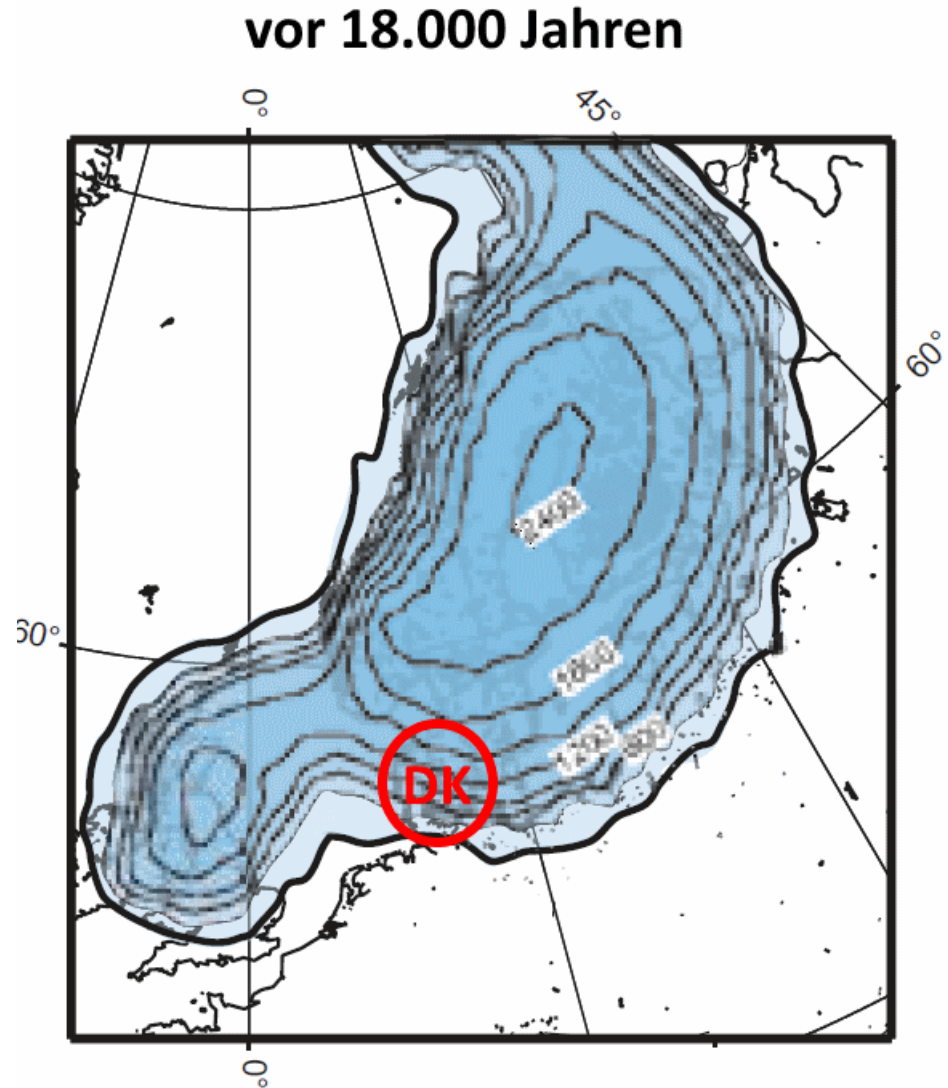


- All other much more relevant cost factors remain merely the same.
- It could as well be that shallow disposal is more expensive because of the less compacted geologic formation (requiring extensive lining of mine openings).



Aspect #2: Compliance demonstration

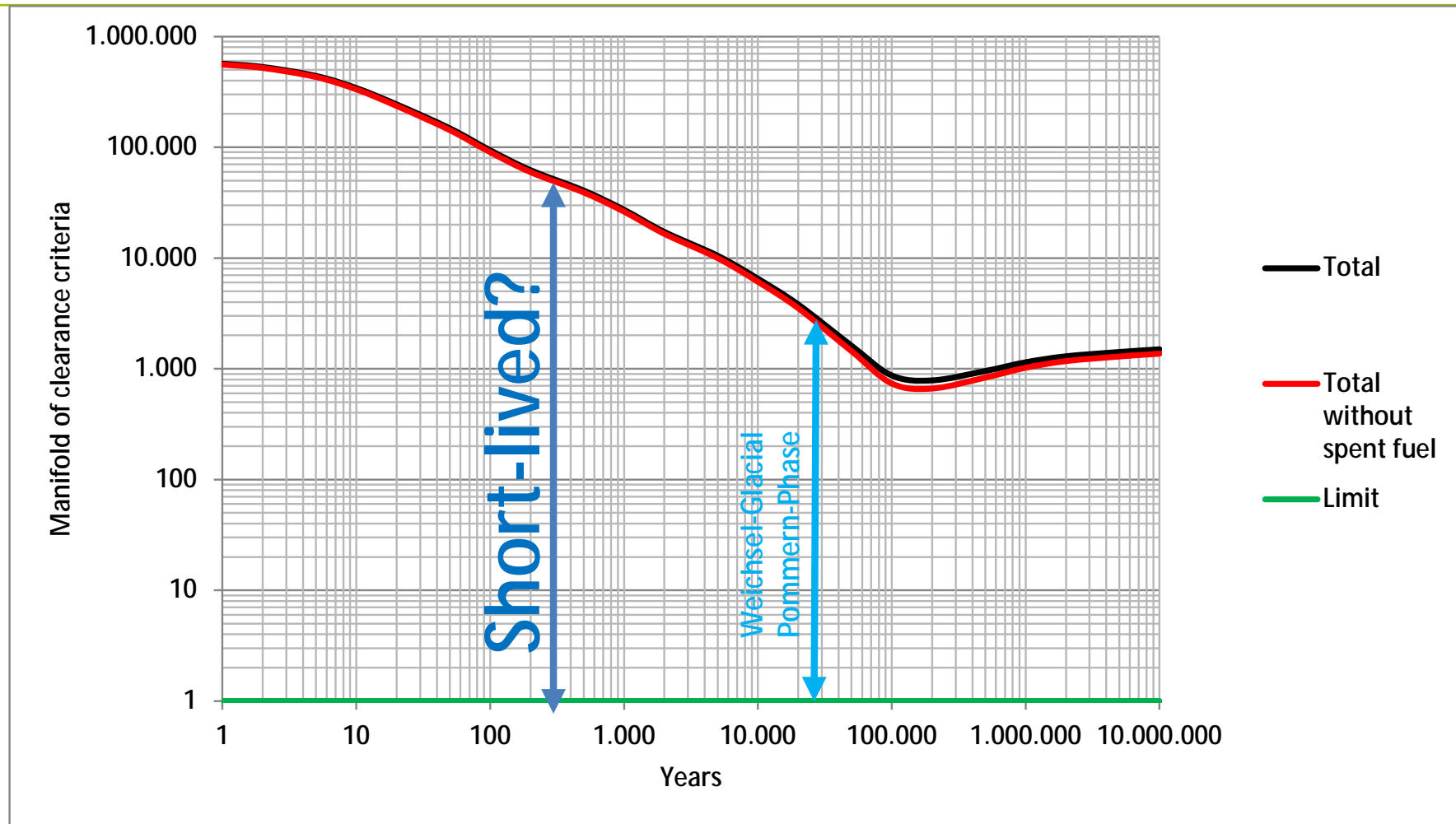
- The integrity of the disposal cell resp. repository has to be guaranteed over very long times.
- For surface-near locations down to 100 m below ground, the integrity proof cannot be demonstrated.
- It is only possible to evaluate long-term safety and regulatory compliance in a reliably functioning isolation system.



Source: modified after SKB: Long-term Safety Analysis Forsmark, 2011



Is the spent research fuel the problem?



- The difference of the Danish inventory with or without the spent fuel is hardly to be seen in the diagram. Removal of the spent fuel and an extra-option for the spent fuel does not change the isolation requirements to a relevant extend.

IAEA Safety Standards say:

„The specific aims of disposal are:

(a) To contain the waste; ← **Containment is the prime target!**

(b) To isolate the waste from the accessible biosphere and to reduce substantially the likelihood of, and all possible **Isolation is the second target!** prevent human intrusion into the waste;

(c) To 1 inhibit, 2 reduce and 3 delay the migration of radionuclides 4 at any time from the waste to the accessible biosphere;

(d) To ensure that the amounts of radionuclides reaching the accessible biosphere due to any migration from the disposal facility are such that possible radiological consequences are acceptably low at all times.”

(Source: Specific Safety Requirements: Disposal of Radioactive Waste, IAEA No. SSR-5, Vienna 2011)



2007 recommendations (1)

1. The disposal should be situated in an area with **homogeneous geological conditions**. It should be demonstrated that these conditions will be found with a high degree of probability at the selected sites. The geology of Denmark is in **many areas relatively heterogeneous**. However, it is the **goal to find continuous and homogeneous sediments or rock layers**.

Compliant with IAEA Safety Standards a)

But why was the depth limited to 0 .. 100 m, where geology in Denmark is well known to be „relatively heterogeneous“?



2007 recommendations (2)

2. The **geological deposits shall contribute to isolation** of the radioactive waste. This is most effective if the disposal is underlain or surrounded by tight layers such as e.g. clays, silts, lime stone or basement rocks.

Compliant with IAEA Safety Standards b)

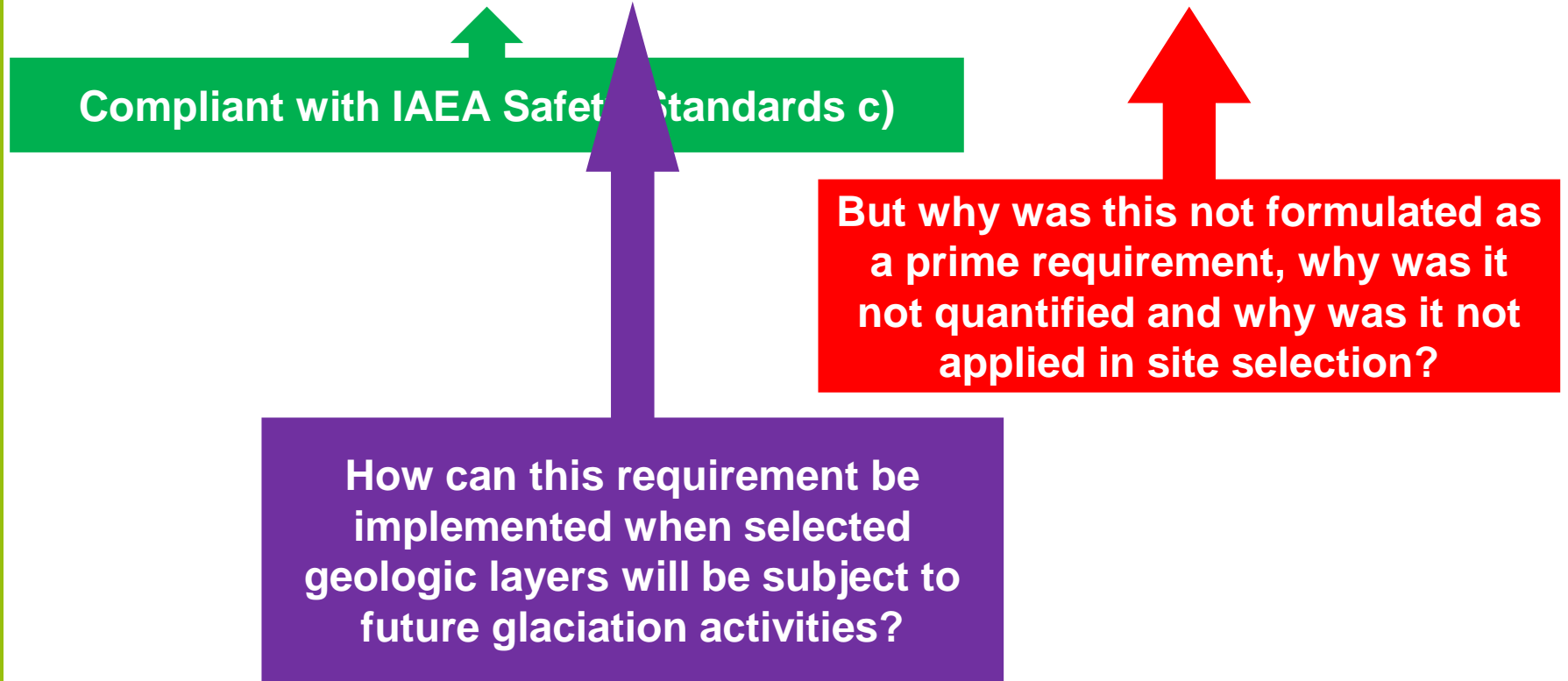
But why was this not formulated as a prime requirement, why was it not quantified and why was it not applied in site selection?

How can this requirement be implemented when selected geologic layers will be subject to future glaciation activities?



2007 recommendations (3)

3. To restrict the water flow from the disposal it will be appropriate if the **disposal is sited in low permeable deposits.**





2007 recommendations (4)

4. The disposal shall be placed at **longest possible distance from groundwater aquifers**. The streaming conditions of the surrounding deposits or rocks must be low.

Compliant with IAEA Safety Standards c)

But why was this not formulated as a prime requirement, why was it not quantified and why was it not applied in site selection?

How can this requirement be implemented when selected geologic layers will be subject to future glaciation activities?



8. Geological processes on the earth surface may not be able to influence on the security of the disposal.

Compliant with IAEA Safety Standard (d)

But why was this not specified further? Why was it not quantified and why was it not applied in site selection?

A view from the far distance (700 km):

- These safety criteria are compliant with international standards.
- They are qualitative only, leaving compliance open for interpretation.
- They seem to be ignored and not at all applied in the site selection phase.
- The reliability and accountability of the process is seriously at stake!



AkEnd requirement	Safety rationale behind the requirement	Applicability in the Danish case
Hydraulic conductivity of rock zone $< 10^{-10}$ m/s	Transport reduction for mobile radionuclides	Yes
Thickness of rock zone > 100 m	Longterm stability of the enclosure zone	Yes
Depth of the top of rock zone > 300 m	Erosion protection + distance to surface activities + probability of unplanned intrusion + continental uplift buffer, + + +	Yes
Repository mine not deeper than 1,500 m	Heat protection of miners	Yes
Areal extension large enough (3 km ² / 10km ²)	Large enough space availability for German waste inventory	No (much smaller)
No rock burst vulnerability	Integrity of isolating rock zone	Yes
Geophysical stability over 1 Million years	Integrity of isolating rock zone	Yes

Vielen Dank für Ihre Aufmerksamkeit!
Thank you for your attention!
Mange tak for opmærksomheden.

Haben Sie noch Fragen?
Do you have any questions?
Har du længere spørgsmål?

