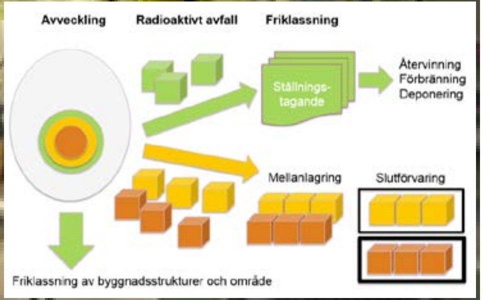
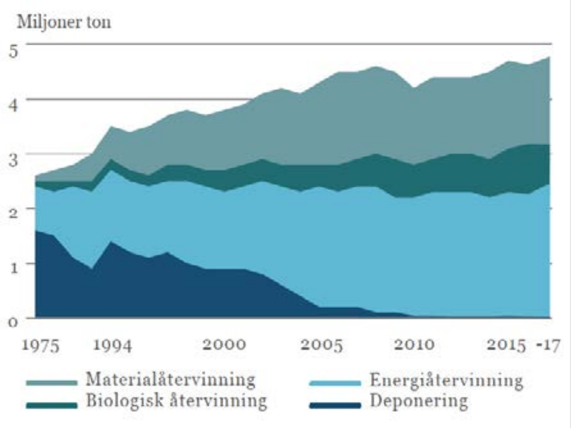


Management of VLLW

Modelling as the support in sustainable clearance decisions

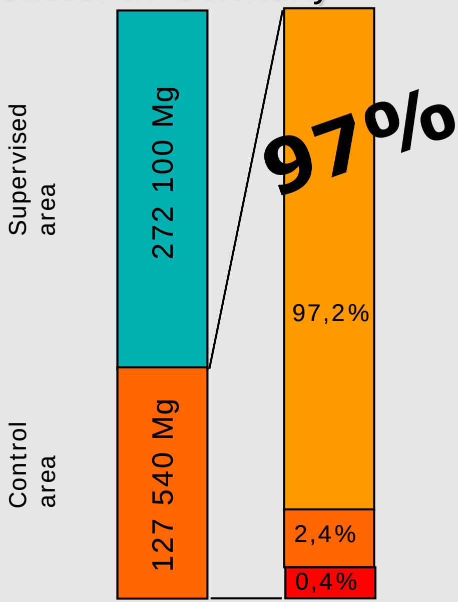
Outlook for wastes in general

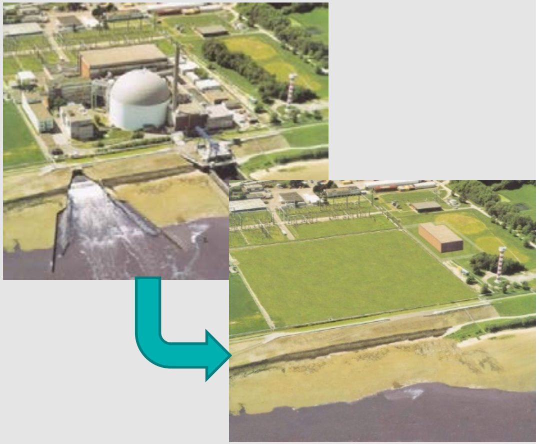
- Reduced waste volumes in society with the vision "There is no waste"
- EU moving towards circular economy concepts and enforcing to target at recycling in new legislations on waste.
- By 2025, at least 55% of waste in the EU will be recycled [NV, AS]
- Decision: Forbidden the disposal of incinerable waste



What is the problem?

Example of masses of waste generated in the D&D of reactor in Germany





Final destinations for VLLW:

• Clearance following SSM FS 2018:3 (unconditioned)

• Recycling (ex. Metal melting), incinerators for energy

• Re-use of construction material and soils

•Disposal in MSW lar

Radioactive was

• Disposal in final
specially engineere

Near surface landfill (MLA)
250 000 tons
Operational costs
25 years: 200M€
Post closure surveillance
30 years: 50M€

VLLW, clearance, decontamination

Some experiences from Germany

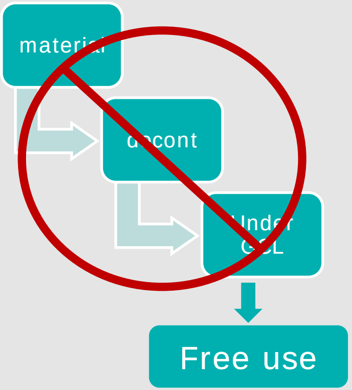
Contaminated areas

Non contaminated areas

Areas with low risk of contamination

Areas with moderate risk of contamination

- Clearable material is dubble as much (or more) than non clearable material
- The final disposal of radioactive waste is coupled to high costs.
- Decontamination to meet clearance levels is an expensive way.
- Clerance levels linked to a specific use for the material (conditional clearance) lead to an alltogether cheaper approach for management of VLLW



Rules for conditioning the clearance?

- Material

Friklassning med särskilda förutsättningar (villkorat till riktad användning)

”En ansökan om friklassning av material som inte kan friklassas enligt 3 §, ska innehålla en analys av olika alternativ till den sökta friklassningen, en beskrivning av de omständigheter som gör att en högre grad av radioaktiv förorening kan accepteras samt beräknade radiologiska konsekvenser”

- Byggnader och mark

”En ansökan om friklassning av byggnadsstruktur eller område ska beskriva hur kvarvarande radioaktiv förorening med hänsyn tagen till ingående osäkerheter förhåller sig till de friklassningsnivåer som gäller enligt dessa föreskrifter eller till friklassningsnivåer som har beslutats av Strålsäkerhetsmyndigheten och i övrigt innehålla de uppgifter som anges i bilaga 7”

SSMFS 2018:3

ÅF tool is IAEAs std method

Clearance tool

Rationale:

Individual effective doses are calculated by evaluating a selected set of scenarios covering all relevant pathways, which lead to the exposure of workers and members of the public from radionuclides in the material to be recycled or disposed of, both on the short-term and the long-term.

- Source term: Waste characterization
- Processer: All treatments to the waste are tracked to characterize the primary and secondary waste
- Scenario: the scenarios (generic or case specific) that cover the range of situations to explore the fate of radionuclides disposed on landfills, possible transfer routes of radionuclides to the atmospheric and aquatic environment, possible exposures to workers and the public arising from the recycling re-use and disposal
- Effective doses are estimated
- Comparison with the limits for general public and workers
- Derivation of the activity concentrations of the radionuclides in the waste linked to the specific destination, that give rise to the accepted dose level => CCL

=> conditioned clearance levels

Key elements of the methodology

- Consistent with the approach used in IAEA Safety Standards Series No. RS-G-1.7:

  Evaluation of a selected set of scenarios covering all relevant pathways leading to an exposure of workers and members of the public (short and long term)

  Determination of activity concentrations such that effective doses

  - for reasonable foreseeable scenarios would not be higher than 10 µSv/a
  - for low probability scenarios not exceed an individual dose of 1 mSv/a

- The derivation CCL takes into consideration:

  The likelihood that a scenario will occur

  The probability of the input parameters used

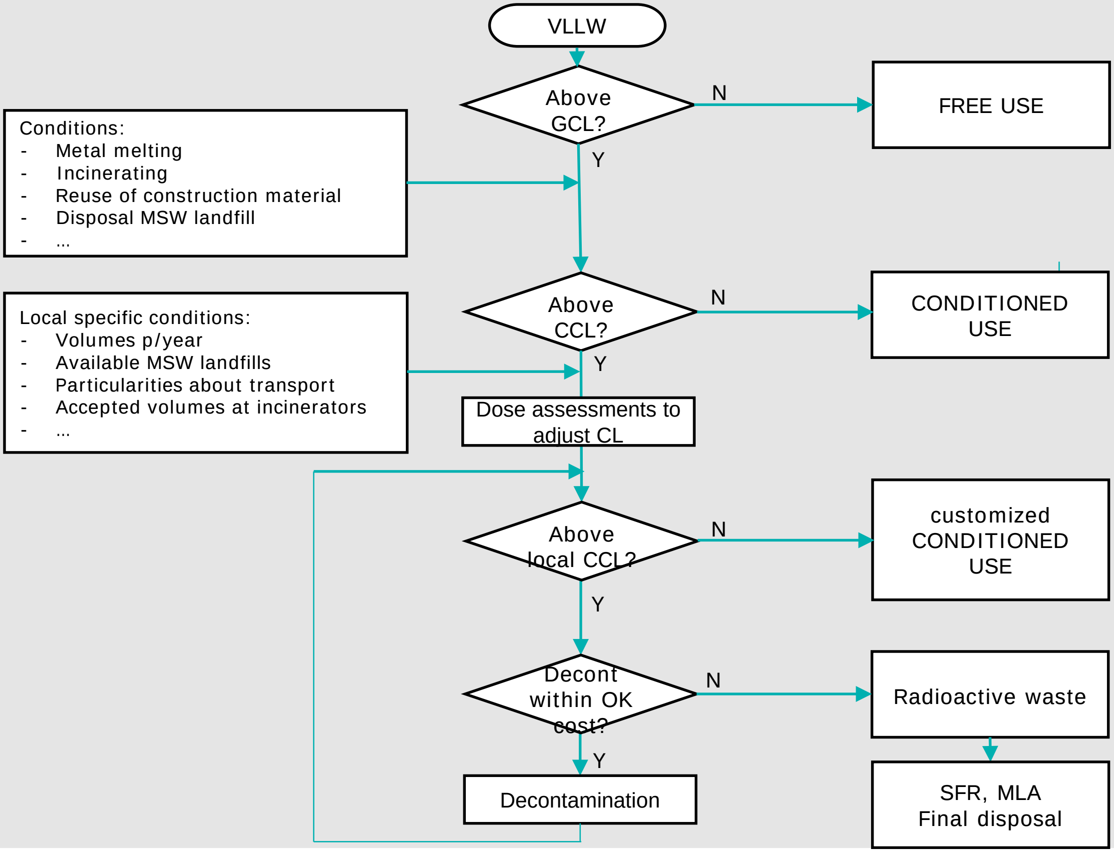
- Deterministic modelling: using realistic and case specific input parameters

- Probabilistic modelling: based on pdf representing the probabilitiy estimates for the different values of the input parameters

Radiological criteria

Group considered	Scenario likely to occur	Scenario unlikely to occur *
Public	Dose less than 10 μSv/a	Dose less than 1 mSv/a
Worker	Dose less than 10 μSv/a	Dose less than 1 mSv/a

Process overview



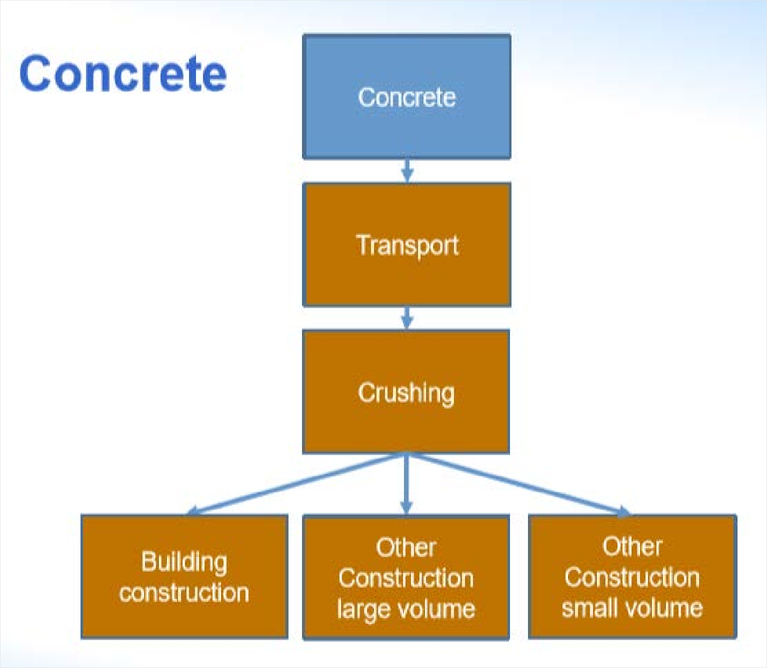
Material types in the waste

- Concrete and other building rubble
- Metals
- Combustible Materials
- Soil
- Secondary materials (e.g. bottom and fly ashes from recycling of metals)
  - Slag and bottom ash from incinerator and smelting furnaces
  - Fly ash from incinerators and dusts from smelting furnaces

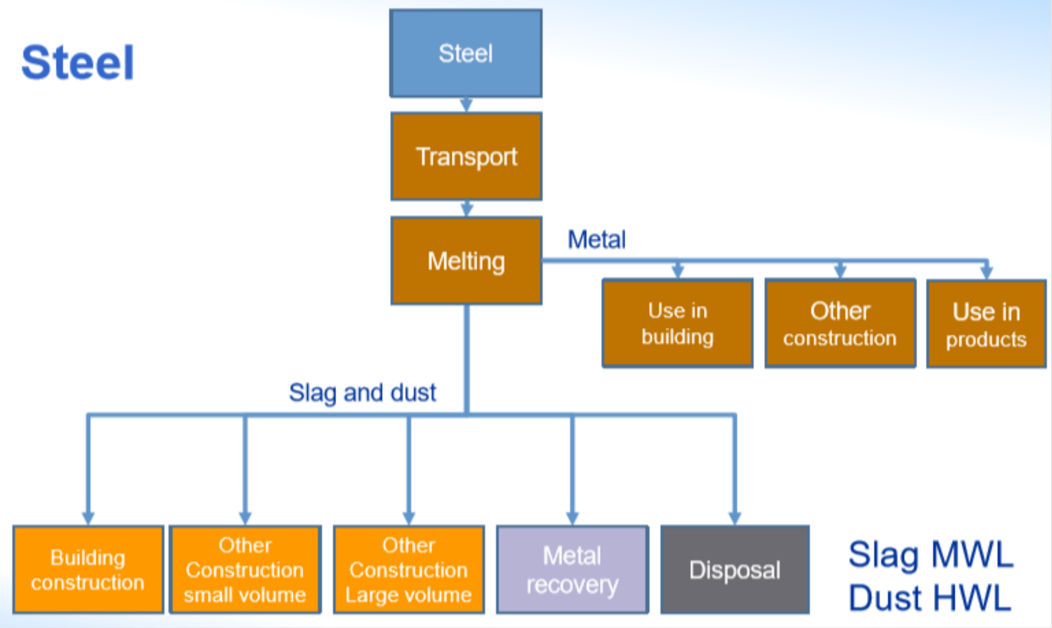
Example of management options

Material type	Management options
Concrete and other building rubble	• Use in building construction after used for making new concrete • Other constructions with small volume and negligible risk of leakage to the water pathways. • Other constructions with large volume and non-negligible risk of leakage to the water pathways. (e.g. as fill material for noise protection walls at streets or for landscaping)
Steel and other metals	• Direct use of metals treated in specialized melting furnaces • Smelting in a foundry and use for new products
Combustible material	• Incineration at a facility for municipal waste • Incineration at a facility for hazardous waste
Soil	• Use in constructions with small volume and negligible risk of leakage to the water pathways. • Use in constructions with large volume and non-negligible risk of leakage to the water pathways. (e.g. as fill material for noise protection walls at streets or for landscaping)

Recycling, re-using



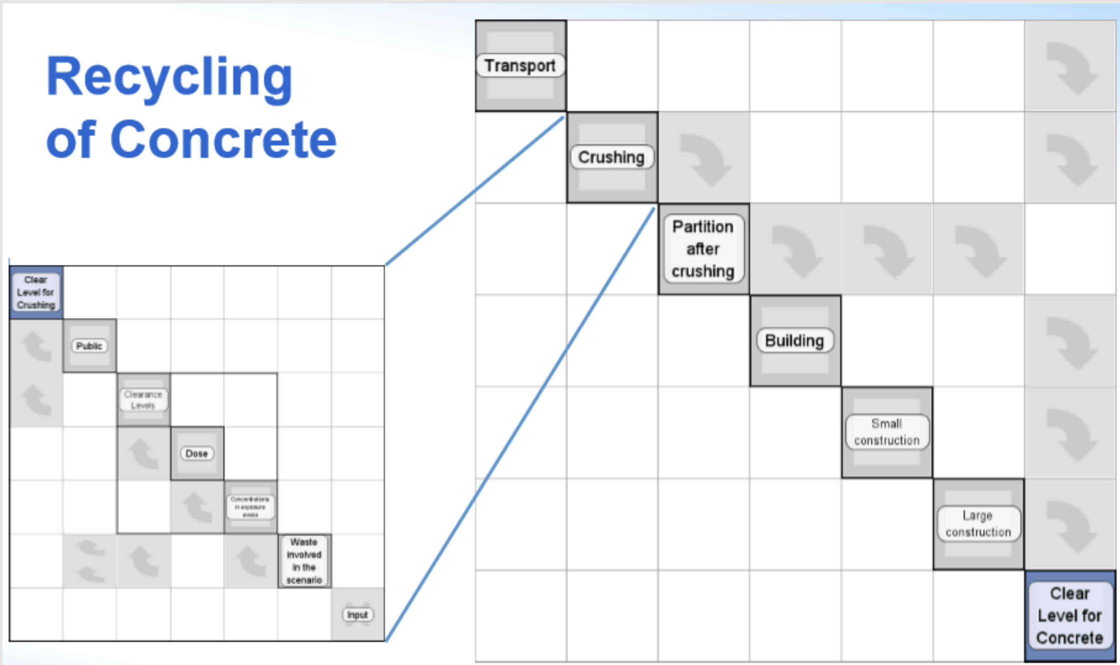
Recycling, re-using



Assumptions for exposure scenarios

Scenarios	Workers	Public
Transport	Transport of material to the recycling facility and unloading: • Exposure of workers from **external irradiation** and **inhalation** of contaminated dust. • Deposition of contaminated dust on uncovered body parts causes **skin exposure**.	Not considered. Less dose than for workers.
Crushing	Concrete is crushed at a special facility: • Exposure of workers from **external irradiation** and **inhalation** of contaminated dust. • Deposition of contaminated dust on uncovered body parts causes **skin exposure**.	Contaminated dust released from crushing facilities may expose nearby residents: • **External irradiation** • **Inhalation** of contaminated dust. • **Ingestion** after deposition on garden crops.
Melting	Metal scrap is handled at a scrap yard and then melted. • Exposure of workers from **external irradiation** and **inhalation** of contaminated dust. • Deposition of contaminated dust on uncovered body parts causes **skin exposure**.	Contaminated dust released from the smelter may expose nearby residents: • **External irradiation** • **Inhalation** of contaminated dust. • **Ingestion** after deposition on garden crops.
Incineration	Combustible waste is incinerated in a waste incinerator facility. • Exposure of workers from **external irradiation** and **inhalation** of contaminated dust. • Deposition of contaminated dust on uncovered body parts causes **skin exposure**.	Contaminated dust released from the incinerator may result is exposure of nearby residents • **External irradiation** • **Inhalation** of contaminated dust. • **Ingestion** after deposition on garden crops.

ECOLEGO - compartmental modelling



Some applications

Derivation of specific CGL (IAEA)

Description: Guidance for application of the CGL. Linkage of the waste types to all generic possible final destinations

Results of project

- Safety report series IAEA std
- Methodology
- Softwares

Post accidental handling of VLLW in Japan - ongoing (Fukushimma prefecture)

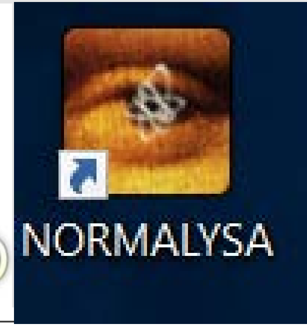
Description: Management of VLLW generated in the aftermath of clean-up operations. Aprox. 1 000 000 m^3 of waste is spread over the territory in 1000 temporary storage facilities

Results of project

- Optimization of the waste storage plans
- Proposal of levels of clearance for disposal in municipal waste landfills

Advantages

- Reduced costs for transport and final disposal of radioactive waste to SFR
- Reduced costs for onsite repository solutions (MLA)
- Decreased decontamination costs
- Possible revenue from the sale of waste
- Proven and implemented IAEA standard method in many countries => facilitates approval process by authorities
- Operators brand strengthened by acting sustainably for society



radionuclide	exemption level			clearance											
				unrestricted clearance of					clearance o[illegible]						
	activity in Bq	specific activity in Bq/g	HASS activity/ 1/100 A_1 in Bq	surface contamination in Bq/cm²	solid substances and liquids in Bq/g	demolition waste, excavated soil of more than 1 000 t/a in Bq/g	soil areas in Bq/g	buildings for reuse and further use in Bq/cm²	solid substances up to 100 t/a to be disposed of on landfills in Bq/g	solid substances and liquids up to 100 t/a to be disposed of in an incineration facility in Bq/g	solid substances up to 1,000 t/a to be disposed of on landfills in Bq/g	solid [illegible] tion facility in Bq/g	[illegible] for demolition in Bq/cm²	debris for recycling in Bq/g	
1	2	3	3a	4	5	6	7	8	9a	9b	9c	9d	10	10a	11
Fe-52	1 E+6	1 E+1	3 E+9	1 E+2	1 E+1	7 E-2		1					2 E+3	1 E+1	8,3 h
Fe-55	1 E+6	1 E+4	4 E+11	1 E+2	2 E+2	2 E+2	6	1 E+3	1 E+4	1 E+4	7 E+3	1 E+4	2 E+4	1 E+4	2,7 a
Fe-59	1 E+6	1 E+1	9 E+9	1	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	4	3 E+1	1 E+1	45,1 d
Fe-60+	1 E+5	1 E+2													1,0 E+5 a
Co-55	1 E+6	1 E+1	5 E+9	1	[illegible]	[illegible]	[illegible]	[illegible]					1 E+3	1 E+1	17,5 h
Co-56	1 E+5	1 E+1		1	[illegible]	[illegible]	[illegible]	1	4	5	1	1	6	0,4	78,8 d
Co-57	1 E+6	1 E+2	1 E+11	1 E+1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5 E+1	1 E+2	2 E+1	271,3 d
Co-58	1 E+6	1 E+1	1 E+10	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5	3 E+1	1	70,8 d
Co-58m	1 E+7	1 E+4	4 E+11	1 E+2	1 E+4	1 E+4		1 E+3					1 E+9	1 E+4	8,9 h
Co-60	1 E+5	1 E+1	4 E+9	1	1 E-1	9 E-2	3 E-2	4 E-1	6	7	2	2	3	0,6	5,3 a
Co-60m	1 E+6	1 E+3		1 E+2	1 E+3	6 E+1		1 E+3					7 E+7	1 E+3	10,5 m

TACK