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Task 3 – NORM Waste Management Cost Assessment

ENVIRONET NORM PROJECT
Working Session During NORM IX Symposium

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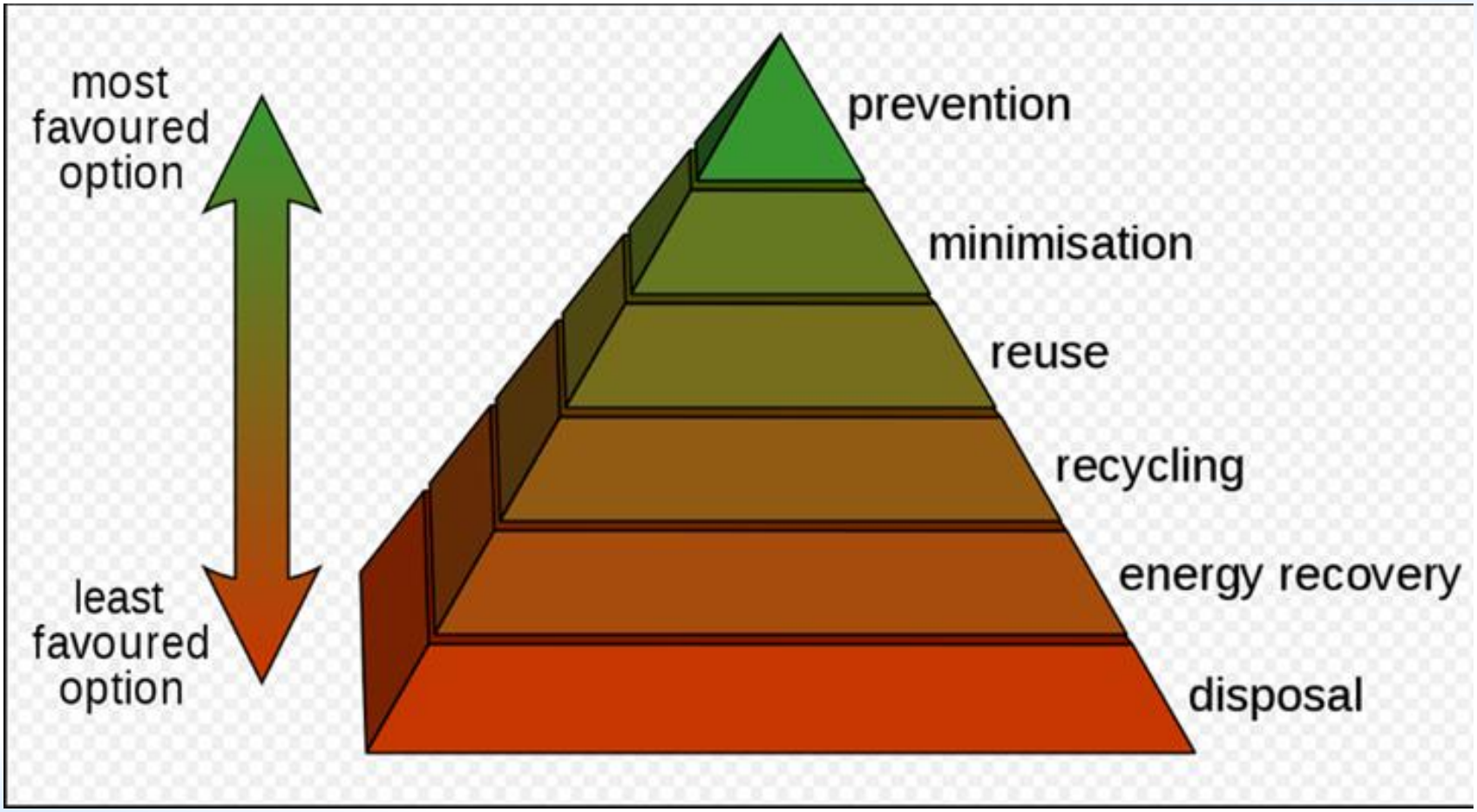
TYPES OF RESIDUES

- Types of NORM Residues
  - Waste rock from mining operations
  - Tailings from the dry separation of heavy minerals
  - Bauxite tailings
  - Tailings and Phosphogypsum from phosphate fertilizers production
  - Scale deposits
  - Sediments and sludge
  - Furnace slag
  - Furnace dust
  - Liquid NORM residues
  - Gaseous NORM residues

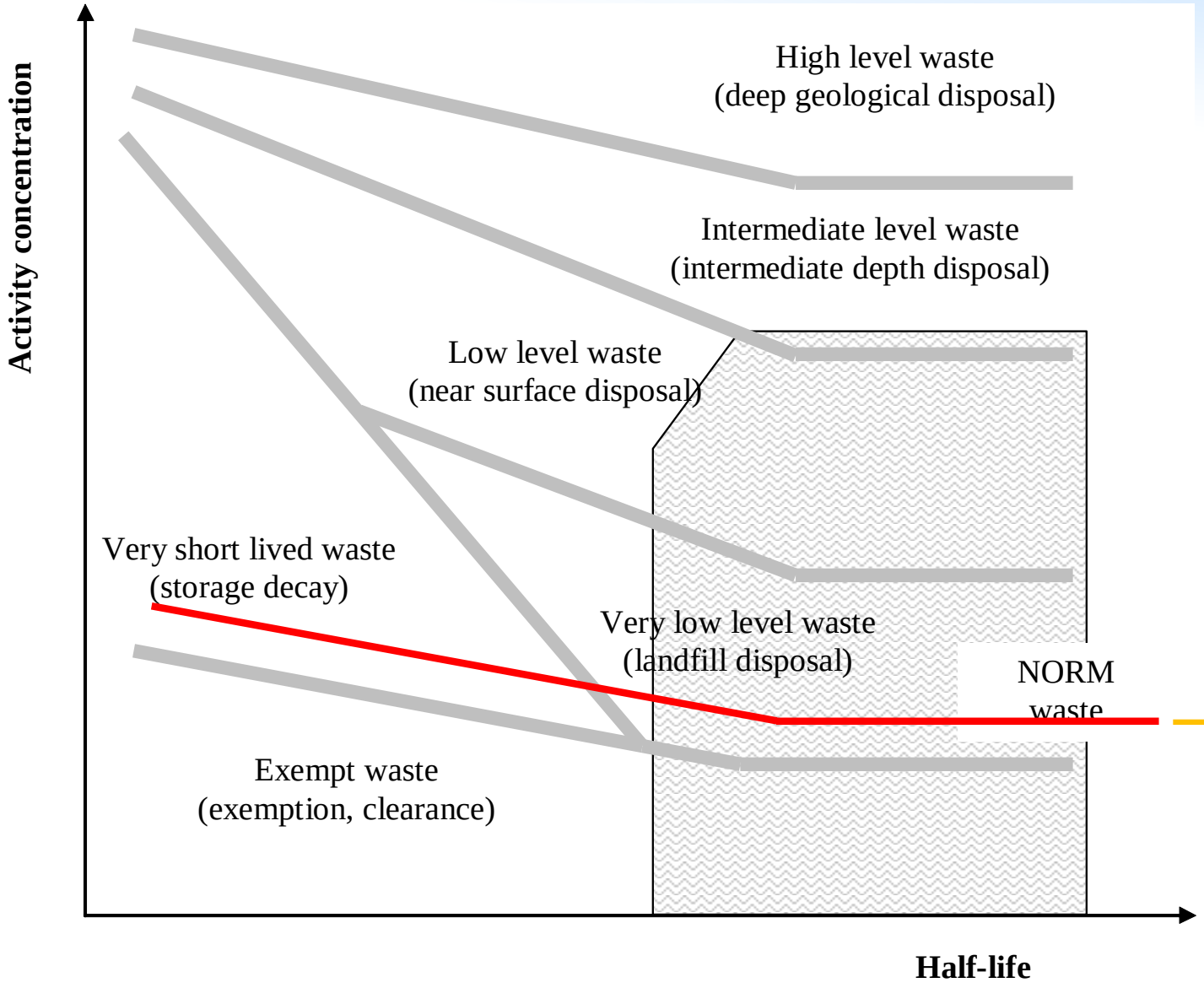
WHAT ARE DIFFERENT COUNTRIES DOING?

- That will depend on a variety of issues:
  - Number of NORM generating industries and amount of residues/wastes being generated;
  - Availability of disposal site(s).
    - Commercial x state owned waste disposal facilities
    - Associate costs: long-term stewardship and institutional controls
    - Geographical characteristics is a point to consider - transportation
  - Public attitude and perception
  - Industry engagement: education
  - Possibility to dilute the waste and use the residue → public acceptance and regulatory requirement
  - Regulatory framework and enforcement

COMMON APPROACHES
APPLICATION OF Waste Hierarchy



Waste Classification Scheme

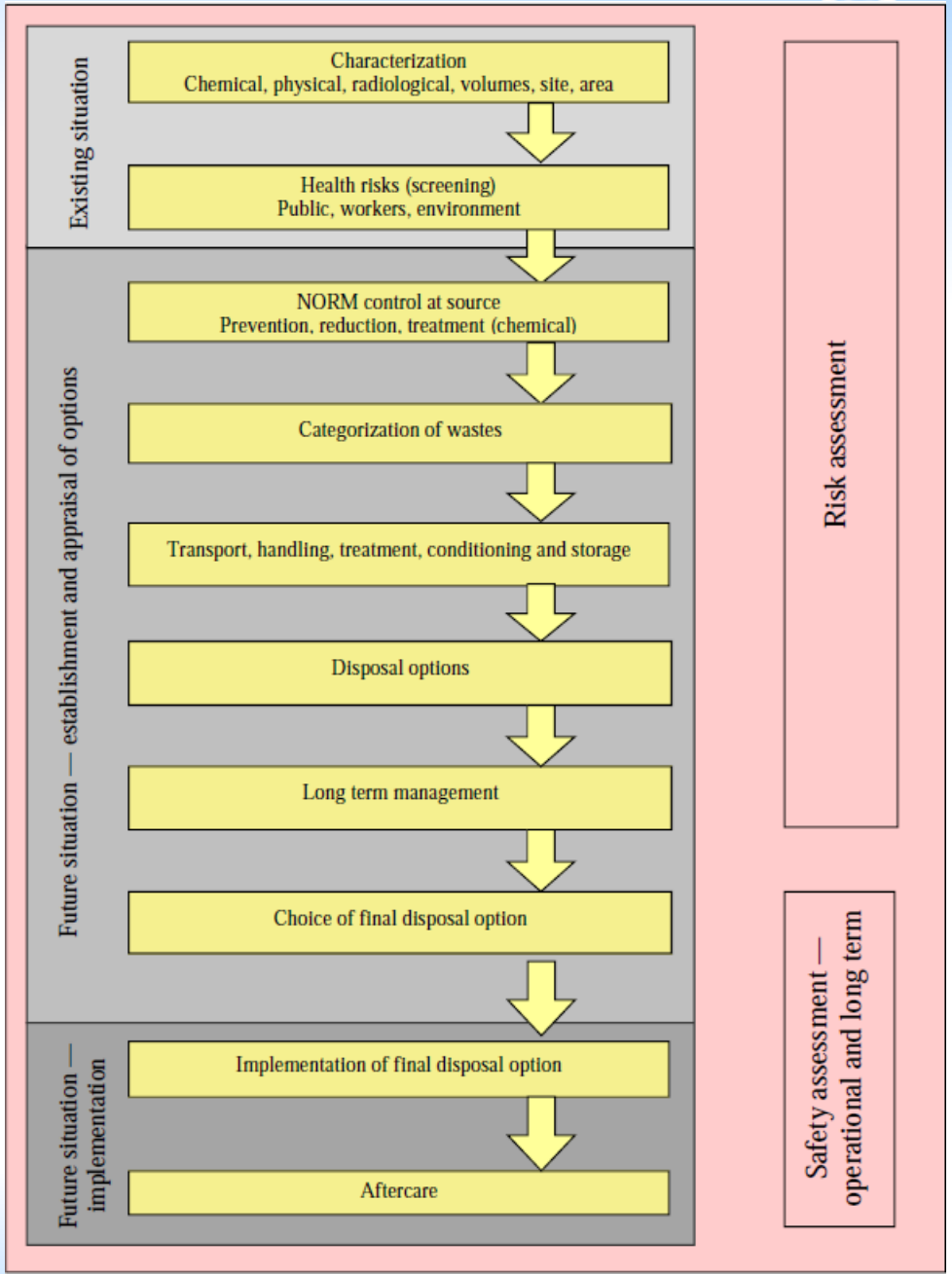


Classification scheme for radioactive waste – application to NORM waste

1 Bq/g

IF NORM RESIDUE IS CONSIDERED WASTE

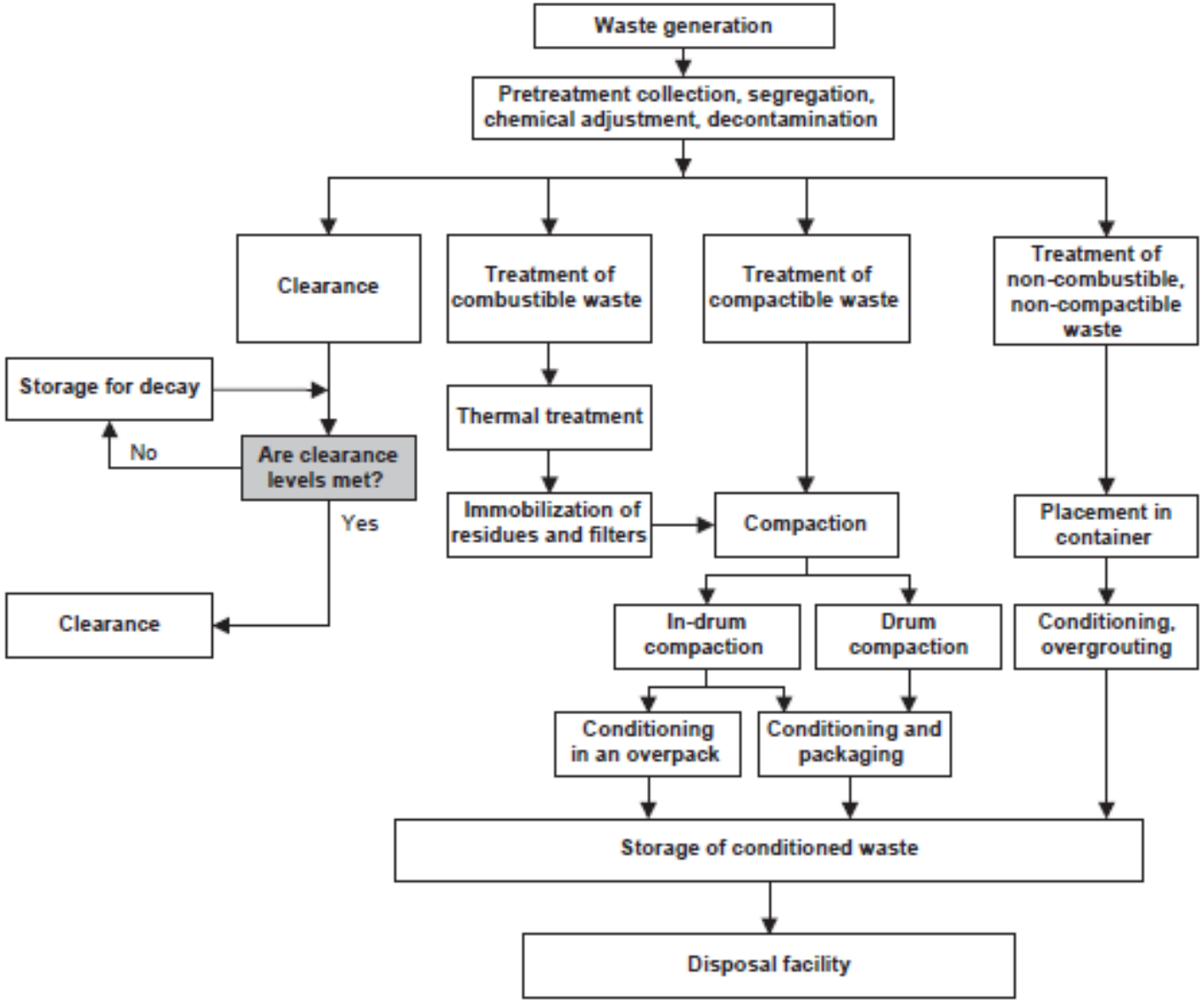
Keeping in Mind the Waste Management Hierarchy

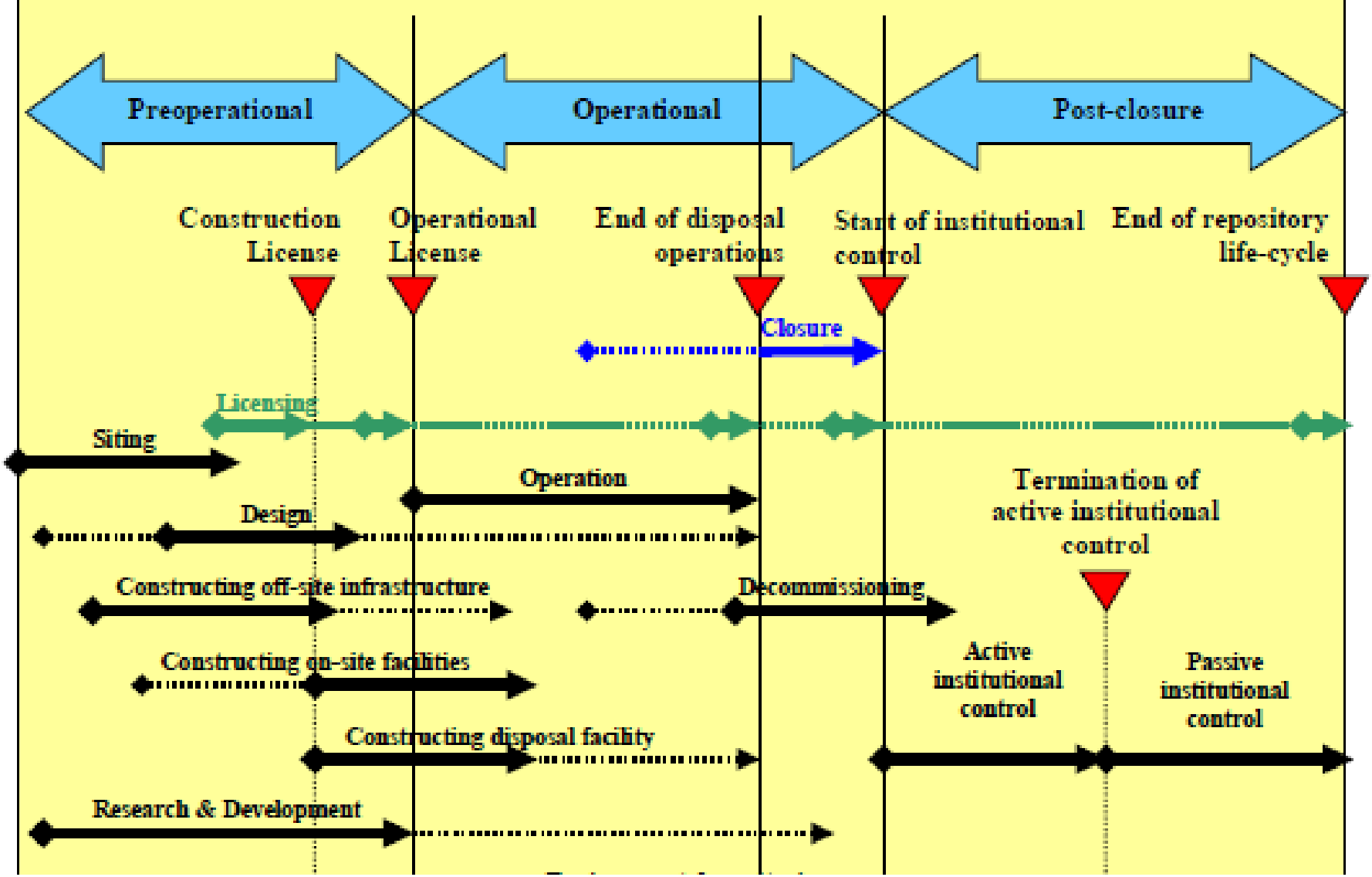


Steps in the Predisposal Management of Radioactive Waste

- Characterization and classification of radioactive waste
  - Physical, mechanical, chemical, radiological and biological properties
  - Waste or waste package will meet the acceptance criteria for processing, storage, transport and disposal of the waste
- Processing of radioactive waste
  - Pre-treatment: waste collection, segregation, chemical adjustment and decontamination
  - Treatment: reduction of volume, removal of radionuclide, change the form of composition of the waste, change of the form or physical properties of the waste
- Storage of radioactive waste
- Waste acceptance criteria

Flow diagram for the management of solid radioactive waste



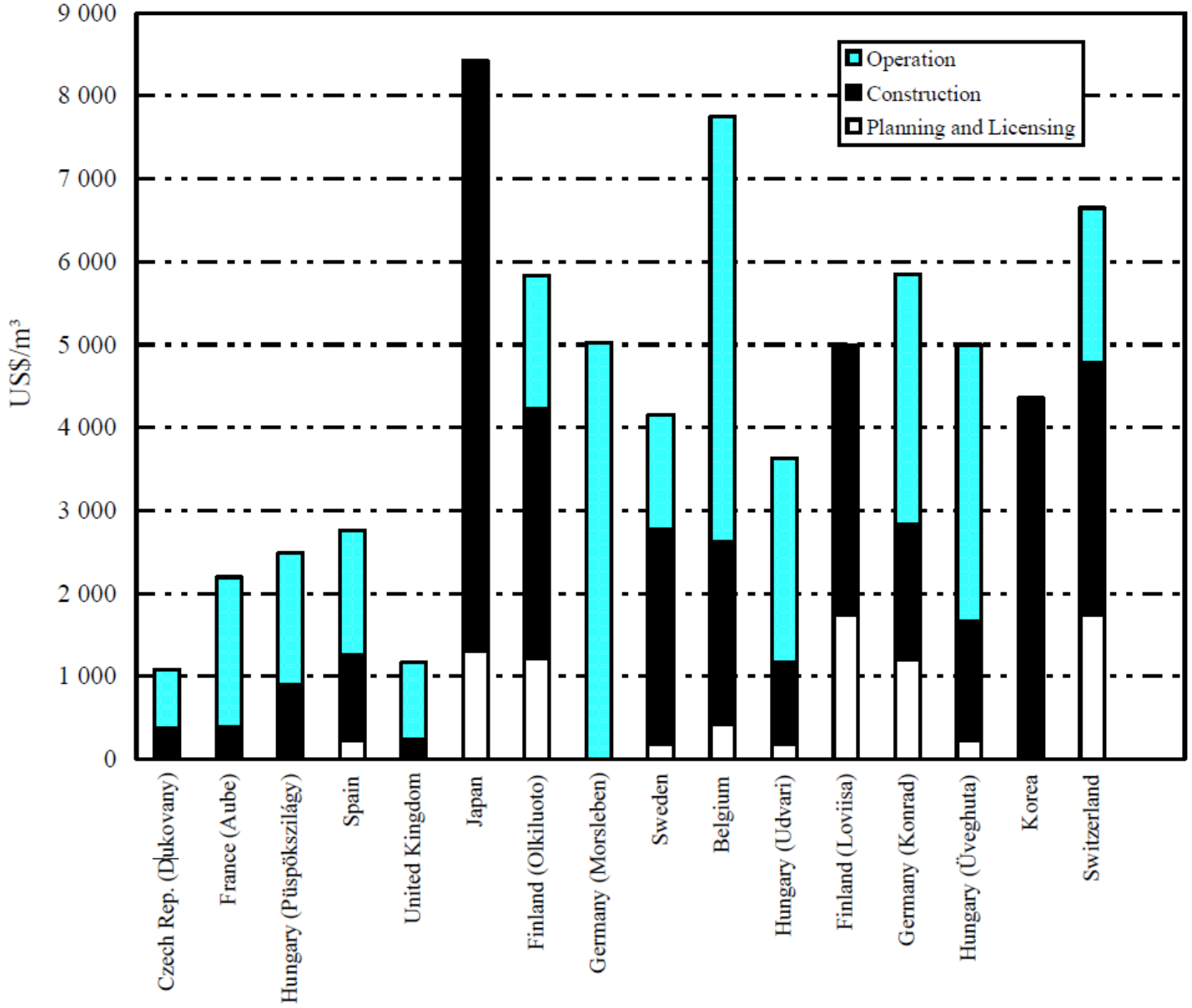


Life cycle of a disposal facility

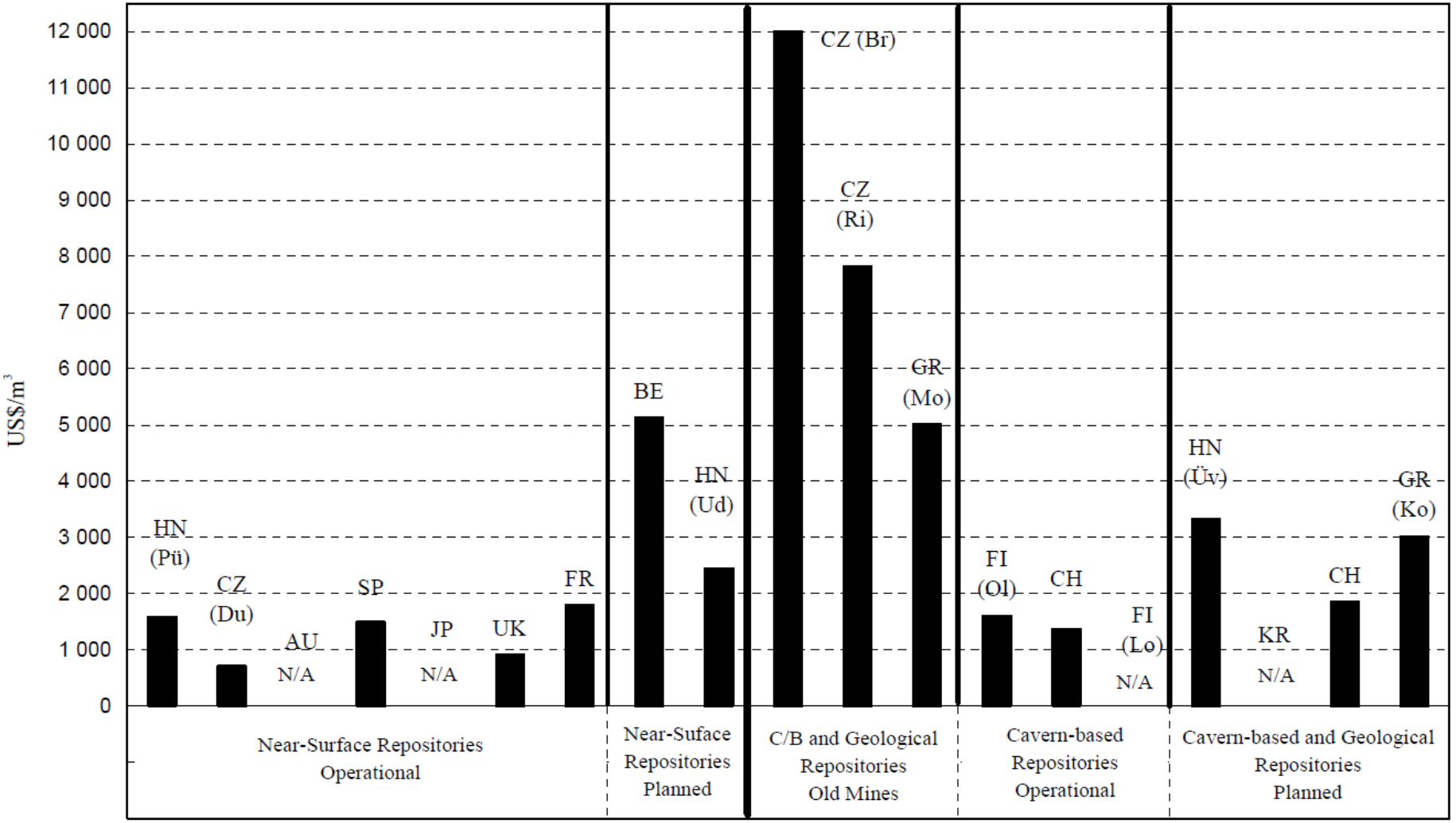
Low-Level Radioactive Waste Repositories: An Analysis of Costs

- Technical factors affecting costs
  - Planning and licensing
  - Construction
  - Operation
  - Decommissioning and closure
  - Post closure activities
- Non-technical factors affecting costs
  - Socio-political factors
  - Regulatory requirements
  - Taxes and insurance
  - Finance
  - Timing
  - Land acquisition and cost of services

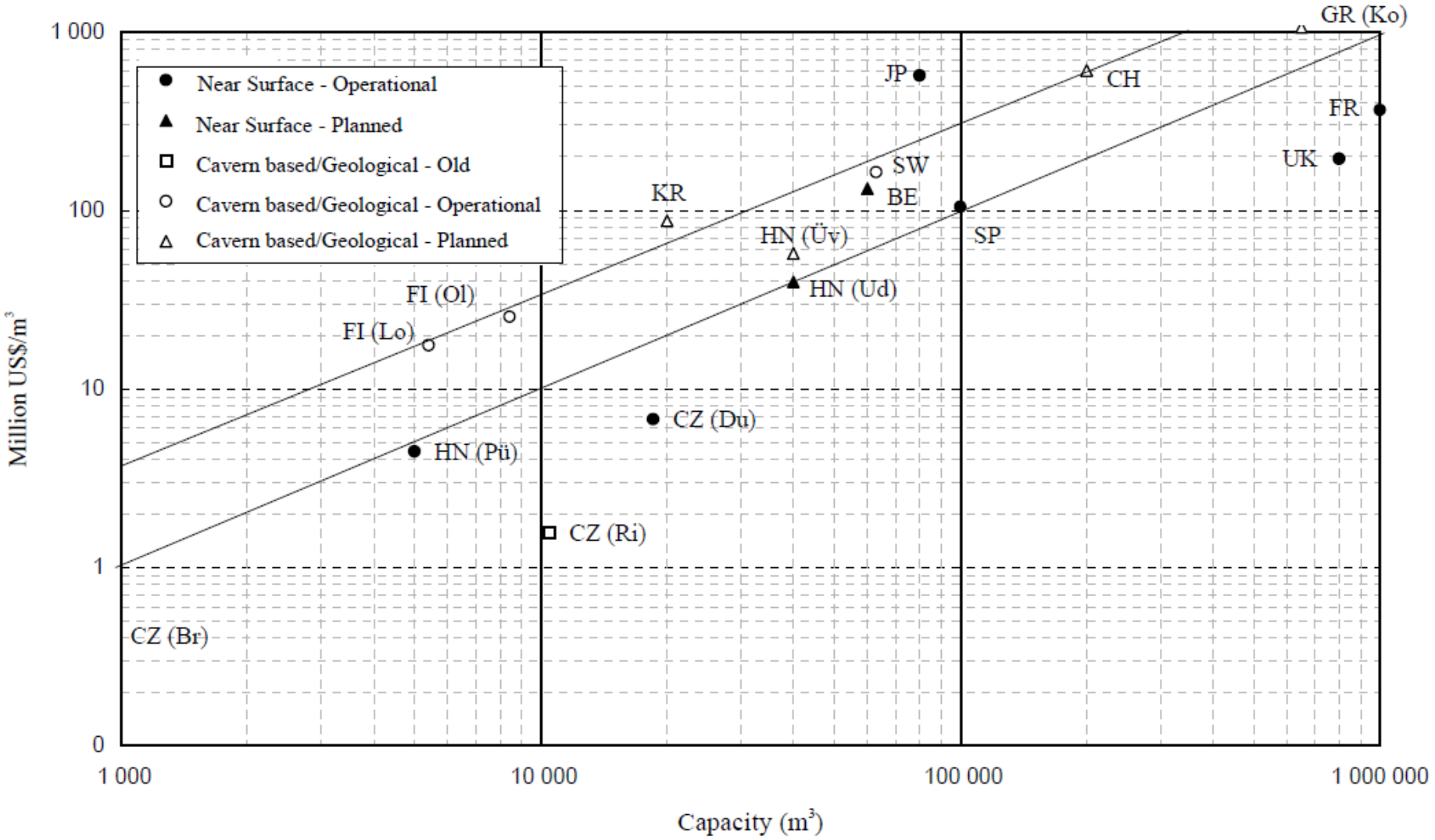
Summation of cost elements (undiscounted)



Operating costs versus repository type



Total construction costs versus capacity



NORM Disposal Costs (55-gal drum)

Disposal Method	Low	Average	High	Additional Costs
Landfill	722	941	1334	None
Landfill	548	914	1280	Radiological and chemical analysis, physical properties check, transportation, waste profile, packing
Surface Treatment	182	384	594	Radiological and chemical analysis, physical properties check, transportation, waste profile, packing
Injection	89.60	376	1828	Radiological and chemical analysis, physical properties check, transportation, waste profile, packing
Recycling steel	Steel purchase price pays for transportation costs			
Encapsulation in Pipes and Disposal in Abandoned Wells	1448	1976	6094	None
Injection into private wells	276	1675	4205	None

Commercial Disposal Costs for NORM

Disposal Method	On-Site/Off-site	Costs ($/bbl) – ($/m³)
Injection	Off-site	236 – 1,484
Injection	Off-site	157 – 1,046
Landfill	Off-site	598 – 661 3,900 – 4,400
Treatment/Injection	On-site	220 – 1,466
Injection	On-site	157 – 300 1046 – 2,000
Injection	On-site	23.6 – 236 157 – 1,573

a) 1 bbl = 42 gal
b) Source: American Petroleum Institute
c) Prices adjusted to 2019

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Thank you!