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Selection and evaluation of decontamination and dismantling techniques for the decommissioning of large NPPs components

Content

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- Generic selection process
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- Conclusion

Motivation

- Wide variety of dismantling and decontamination (D&D) techniques available
- Dismantling tasks of each large NPP component is unique with respect to
  - Technical challenges (space available, radiological conditions at work space)
  - General strategic conditions
- Question:
  What systematics do operators apply to select D&D techniques?

Generic selection process

- List of available techniques
  - Dismantling
    - Mechanical
    - Thermal
  - Decontamination
    - Mechanical
    - Chemical

Available techniques

Generic selection process

Available techniques

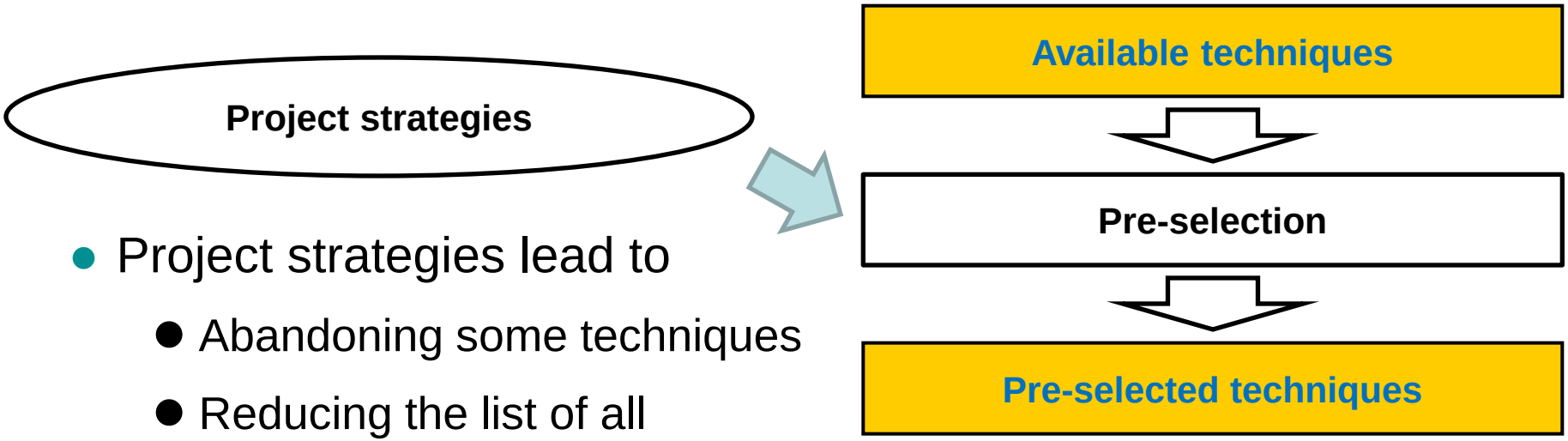
Project strategies

- Project strategies
  - Sum of all considerations influencing the principle proceeding in decommissioning
  - Driven by more strategic factors and considerations
    - Differentiated in general requirements and principles

Generic selection process

- General requirements
  - Technical (not all techniques are suitable to dismantle all types of materials)
  - Regulatory (qualification, i.e. has the technique been demonstrated to be suitable for the foreseen task in former projects, not necessarily at a nuclear installation), and
  - Radiological aspects (use of remote techniques in areas with high dose rates)
- Principles, e.g.
  - Mechanical cutting techniques only
  - To perform a decontamination of the system before dismantling

Generic selection process

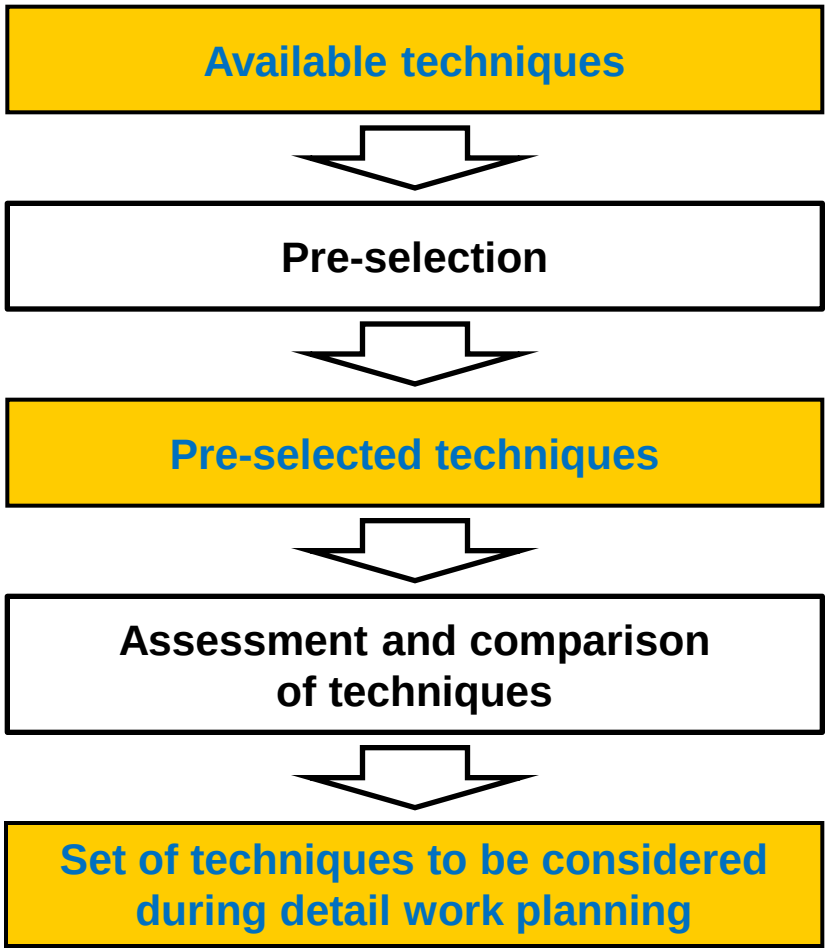


- Project strategies lead to
  - Abandoning some techniques
  - Reducing the list of all available techniques
    - To a list of pre-selected techniques

Generic selection process

Project strategies

- Assessment of pre-selected techniques
  - Qualitative, e.g.
    - Expert judgment
    - Check lists
  - Quantitative, e.g.
    - HAZOP



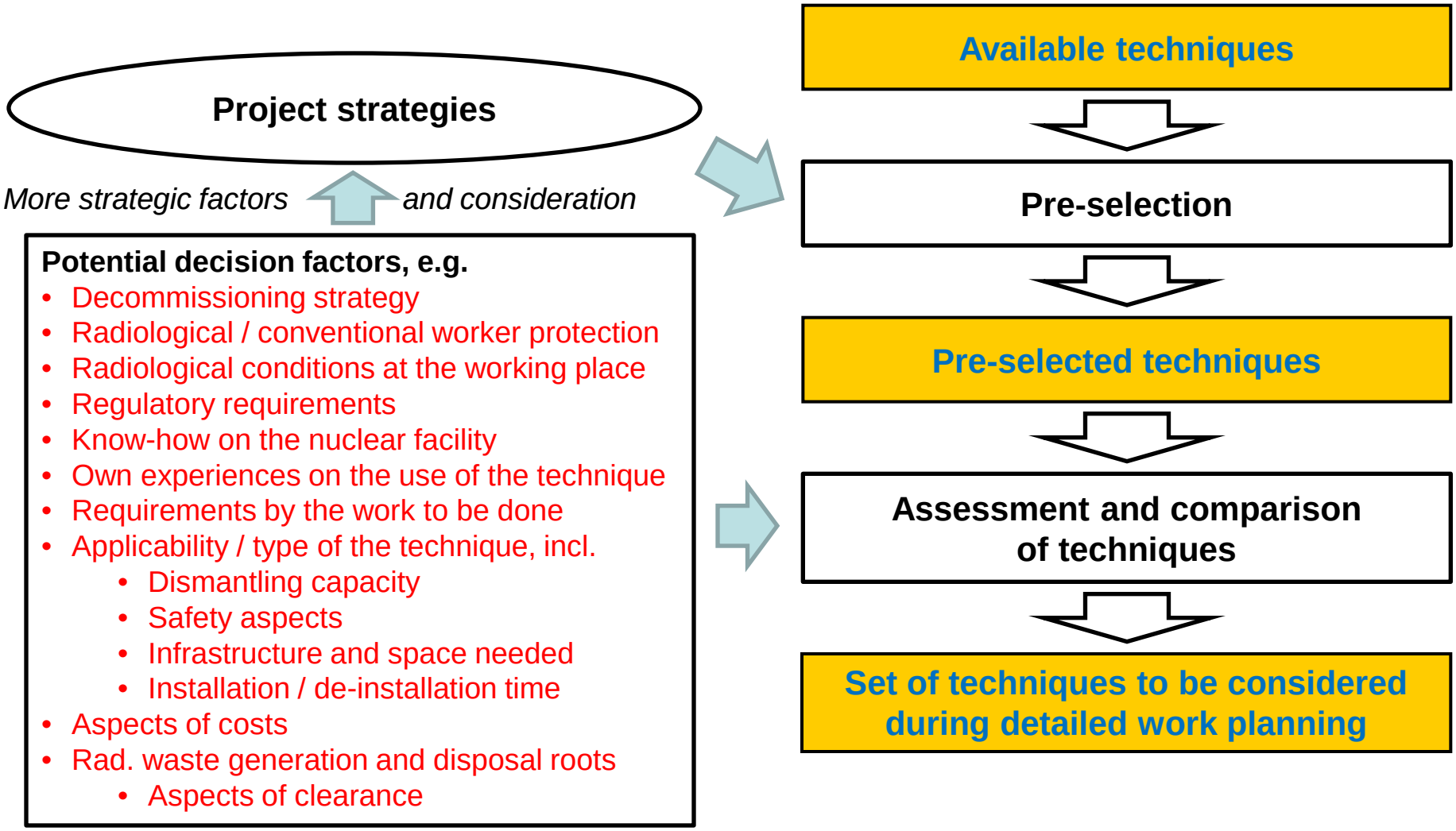
Generic selection process

- Potential decision factors, e.g.
  - Needed infrastructure
  - Needed space to operate the technique
  - Time needed for installation / de-installation of a technique
  - Cutting / decontamination capacity
  - Generation of radioactive waste
  - Radiological conditions at the working place
  - Technical requirements set by the system / component to be decontaminated / cut
  - Aspects of safety
  - Costs

Generic selection process

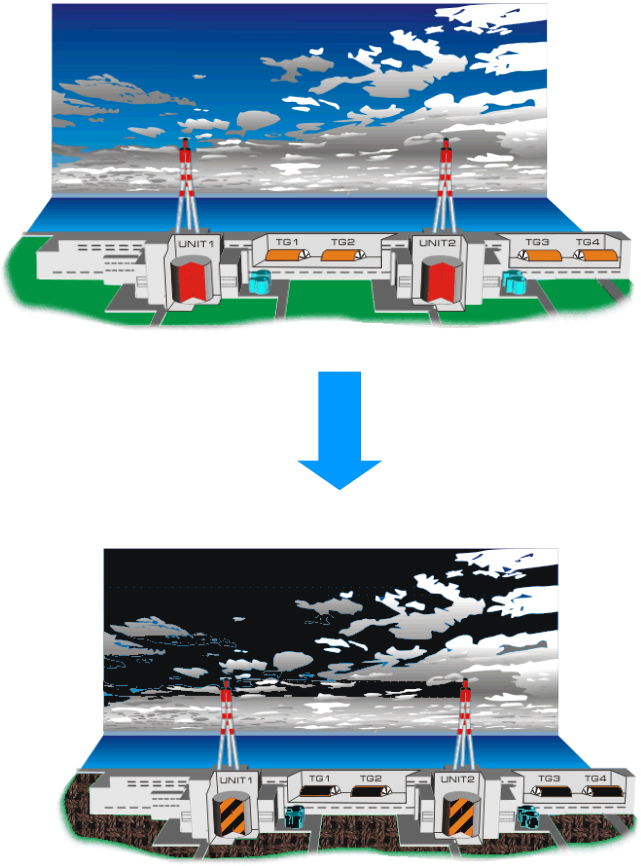
- Technical features, e.g.
  - Technical qualification
  - Quantity and type of waste generated
  - Remote handling
  - Applicability under water
  - Qualification
  - Flexibility
  - Time for set-up and maintenance
  - Cutting or decontamination principle
  - Special features

Generic selection process



Example - INPP

- Ignalina Nuclear Power Plant (INPP)
  - Important part of Lithuania's energy sector since 1983
    (Unit 1: 1983, Unit 2: 1987)
  - Design lifetime was projected until 2013 and 2017 respectively
  - Early decommissioning as a result of the political dialogue leading up to EU enlargement
    - Unit 1 shutdown: 2004
      (~ 9 years loss of operation benefit)
    - Unit 2 shutdown: 2009
      (~ 7.5 years loss of operation benefit)



Example - INPP

INPP Power Operation
(1983 - 2009)

Operational Waste
(stored according old waste classification)

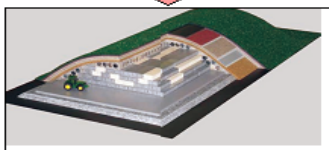
Decommissioning Waste

INPP Decommissioning Activities
According Immediate Dismantling (2000 - 2029)

New radioactive Waste Classification

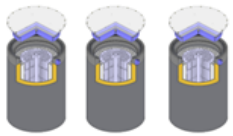
Class 0 | Class A (VLLW-SL) | Class B+C (LILW-SL) | Class D, E, F & Spent Fuel (LL)

Free Release



Landfill
(for 100 years)

Near Surface Repositories
(for 300 years)



Fuel Long Term
Dry Interim Storage
(for 50 years)
LLW Long Term
Interim
Storage

Intermediate Depth/Deep
Geological Repositories
(for ever)

INPP "Brown" field (2030 - 2330)

Example - INPP

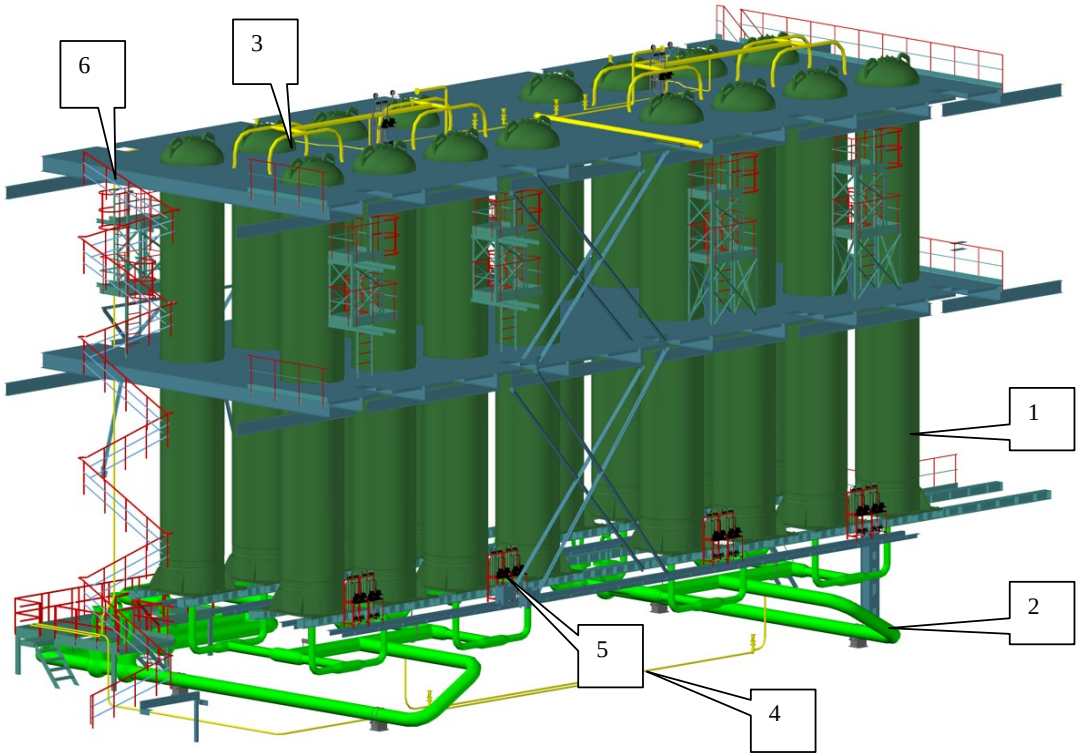
- Projects during decommissioning of INPP
  - INPP Building 117/1 Equipment (Part of the INPP power Unit 1 Emergency Core Cooling System) Decontamination and Dismantling Project - **FINISHED**
  - INPP Building V1 Equipment Dismantling and Decontamination Design Development - **FINISHED**
  - Development of decontamination technology for INPP Unit 1 main circulation circuit, blow down, cooling and bypass purification systems - **ONGOING**

Example - INPP

- Projects during decommissioning of INPP
  - Near Surface Repository (NSR) for Low and Intermediate-Level Short Lived Radioactive Waste (Design) - **ONGOING**
  - Ignalina Interim Spent Fuel Storage Facility - **ONGOING**
  - Ignalina Solid Waste Management and Storage Facilities - **ONGOING**
  - Landfill Facility for Short-Lived Very Low Level Waste - **ONGOING**
  - Free Release Measurement Facility (FRMF) - **FINISHED**

Example - INPP

- INPP Building 117/1 Equipment (Part of the INPP power Unit 1 Emergency Core Cooling System) Decontamination and Dismantling Project



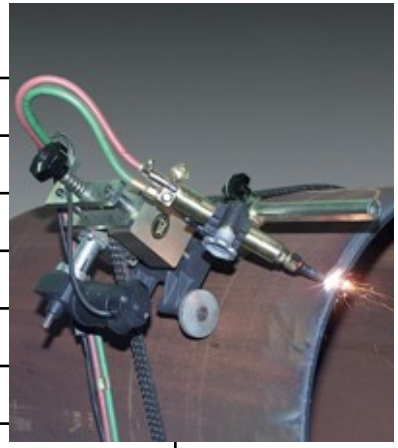
1. Pressurized tanks (PT)
2. Large diameter pipework and fittings
3. Nitrogen pipelines P=100 kgf/cm^2 and fittings
4. Nitrogen pipelines P=6 kgf/cm^2 and fittings
5. C&I frames
6. Steel decks and stairs

Example - INPP

- Dismantling of the Emergency Core Cooling System (ECCS)
  - Characteristics of PTs
    - Height about 14 m
    - Mass (without water) 47650 kg
    - Outside diameter 1760 mm
    - Internal diameter 1600 mm
    - Material carbon steel 16GS-6
  - Radiological conditions
    - <12 μSv/h gamma dose
    - <40 Bq/cm^2 beta surface contamination
    - <4 Bq/cm^2 alpha surface contamination
    - <185 Bq/cm^3 volumetric activity of aerosols

Example - INPP

- List of available dismantling techniques



Flame Cutting
Plasma Cutting
Thermal Lance
Hydraulic Shears
Diamond Wire Saw
Circular Saw
Abrasive Disc Cutting
Band Saw
Reciprocating (Sabre) Saw
UHP Water Jetting
Milling Cutter
Explosives
Vacuum extraction unit

Example - INPP

- Possible D&D strategies

Passive safe storage
Intact disposal of equipment without decontamination
In-situ size reduction and disposal without decontamination
Ex-situ size reduction and decontamination
In-situ size reduction and decontamination

- Decision
  - In-situ size reduction and decontamination

Example - INPP

- Expert judgment to reduce list of available techniques
  - Criteria to abandon techniques
    - Limitation of wall thickness
    - Production of secondary wet waste
    - Low cutting speed
    - Limited effectiveness based on existing trials
    - Significant industrial hazards

Example - INPP

- Weighted Multi Attribute Decision Analysis (MADA) type process for assessment

High Level Criteria	Selected Attributes	Weighted Score	Justification
Safety	Operator Dose and Radiological Hazards	**10**	Low levels of activity associated with each option. None of the proposed options would lead to doses that are unsafe or that exceed legal limits. All of the options would be managed to ensure that operator doses are acceptable, therefore this attribute was allocated the lowest weighting.
	Conventional Safety	**100**	Conventional safety risks were considered to be a significant differentiator between the dismantling techniques. The difference between the techniques in relation to this attribute has the potential to impact the delivery of the project, hence the allocation of the highest weighting.

Example - INPP

- Weighted Multi Attribute Decision Analysis (MADA) type process for assessment

High Level Criteria	Selected Attributes	Weighted Score	Justification
Technical	Process / System Robustness	**50**	Each of the technique assessed involve the application of proven technology. There is some differentiation between the techniques in terms of experience using the equipment, however this was not deemed to have significant implications with regards to the delivery of the project.
	Utilisation of / Compatibility with Existing Plant and Processes	**50**	The technology associated with each of the assessed technique will utilise existing operator skills. Some options will require operator training, however this was not deemed to have significant implications with regards to the delivery of the project.
	Ease of Deployment	**40**	It was agreed that each of the assessed technique adopt simple, proven equipment, therefore technique differentiation with regards to deployment was not considered to be significant.

Example - INPP

- Weighted Multi Attribute Decision Analysis (MADA) type process for assessment

High Level Criteria	Selected Attributes	Weighted Score	Justification
Economic	Lifetime Costs	**100**	The differences between the techniques in terms of cost were deemed to be core project drivers and therefore this attribute was allocated the highest weighting.
	Programme	**100**	The differences between the techniques in relation to project delivery timescales were agreed to be core project drivers and therefore this attribute was allocated the highest weighting.

Example - INPP

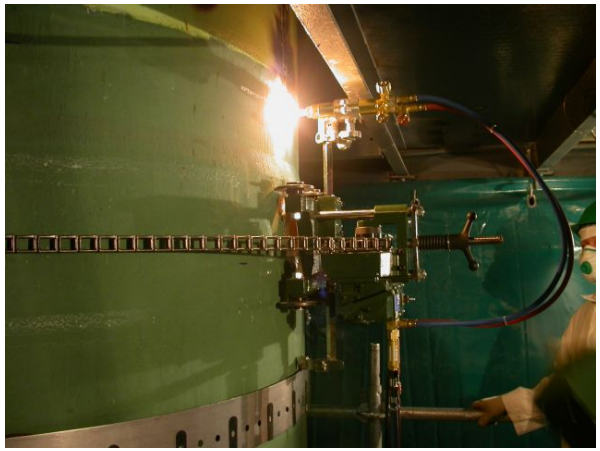
- Result of qualitative assessment
  - 3 possible dismantling techniques
    - Flame cutting
    - Plasma cutting
    - Milling cutting

Example - INPP

- Criteria used for quantitative assessment
  - Cost
  - Waste management
  - Schedule
  - Manpower
  - ALARA
  - Conventional safety

Example - INPP

- Result of quantitative assessment
  - Flame cutting Emergency Core Cooling Tanks







Example - INPP

- “Tool-box” for smaller systems (pipes, valves, etc.), e.g.
  - Hydraulic shears
  - Reciprocating (sabre) saws
  - Adamant twin disc saws
  - Electric nibblers
  - Angle grinders
  - Hacksaws
  - Tube cutters
  - Band saw
  - Diamond wire saw
  - Plasma cutter

Example - INPP

- INPP Building 117/1 Equipment (Part of the INPP power Unit 1 Emergency Core Cooling System) Decontamination and Dismantling Project
  - After project completion about 1000 tons of equipment were decontaminated and dismantled in INPP Building

Conclusion

- Selection of D&D techniques follows a multi-step process
  - Reducing list of available techniques following on basis of
    - General, strategic decisions (technical, regulatory, radiological etc.)
    - Principle decisions (use mechanical cutting only, perform system deco etc.)
  - Qualitative / quantitative analysis during of D&D tasks
    - Leading to „tool-box“ of techniques
    - Allowing flexibility during detailed work planning for optimization of R&P, rad waste, costs etc.