Comparison of standardised decommissioning costing tools on pilot Vienna TRIGA MARK-II research reactor

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Decommissioning costing for research reactors

Typical approach:

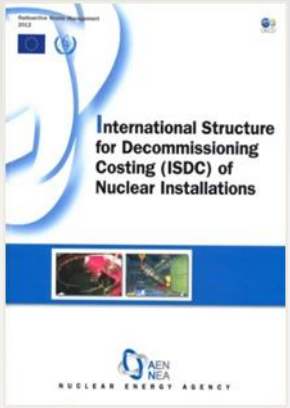
1. IAEA standardised costing platform: International Structure for Decommissioning Costing of Nuclear Installations (ISDC)

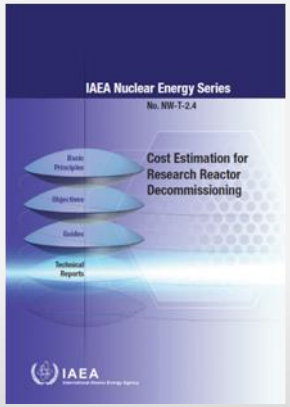
2. IAEA recommended costing methodology: CERREX code (Cost Estimation for Research Reactors in EXcel) developed within IAEA projects – used for preliminary cost estimation

   ↳ Basic CERREX costing case developed for the facility

3. CERREX code calculation results compared with any other calculation costing tool or with estimates on similar facility

4. Sensitivity analyses to identify and analyse the impact of changes of input parameters on the results of decommissioning costing

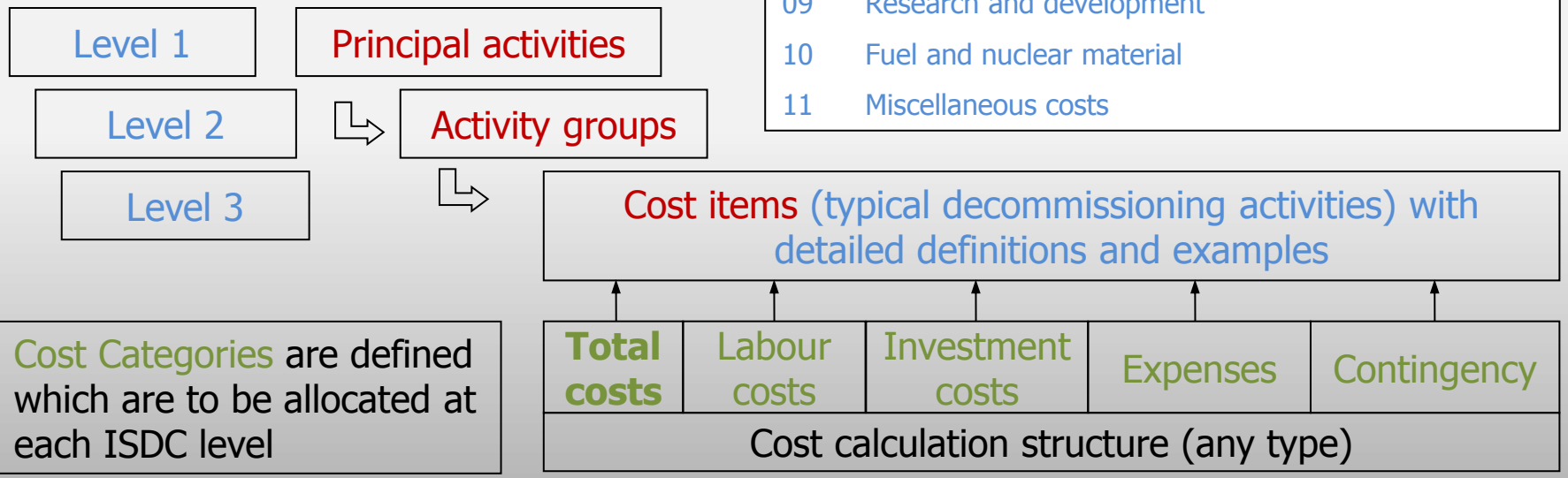




International Structure for Decommissioning Costing

- Numbered matrix of typical decommissioning activities and cost categories
- Common platform for presenting of decommissioning cost of any type of nuclear installation
- Standardized hierarchical structure with three numbered level

01	Pre-decommissioning actions
02	Facility shutdown activities
03	Additional activities for safe enclosure or entombment
04	Dismantling activities within the controlled area
05	Waste processing, storage and disposal
06	Site infrastructure and operation
07	Conventional dismantling and demolition and site restoration
08	Project management, engineering and support
09	Research and development
10	Fuel and nuclear material
11	Miscellaneous costs



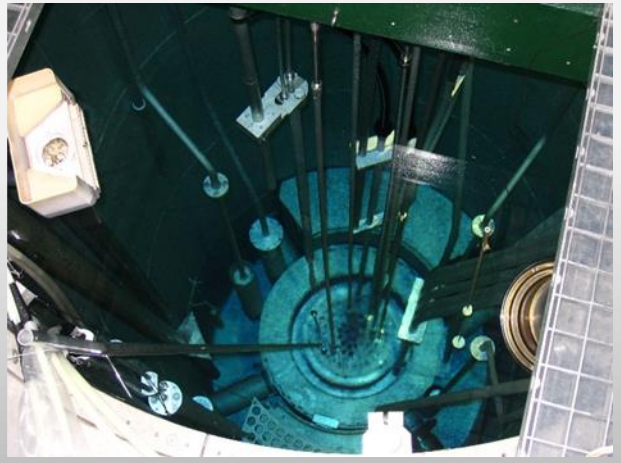
Model ATI costing case calculations objectives

The main purpose:

To compare CERREX decommissioning costing with the advanced - new generation calculation methodology applied in eOMEGA_RR code

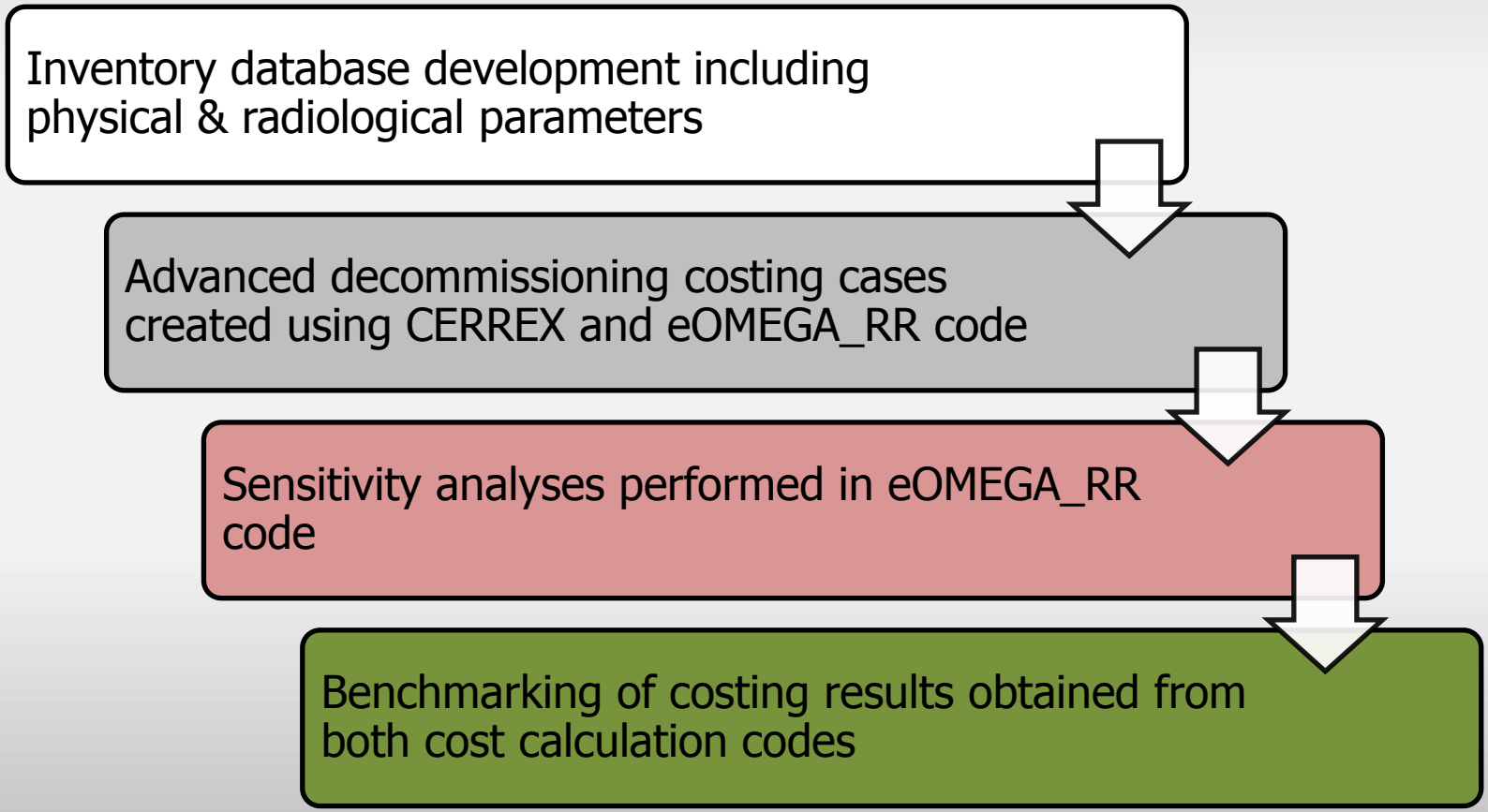
Object of model cost calculations: TRIGA Mark II reactor in Vienna

- Vienna University of Technology, Atominstitute
- Under operation since 1962
- Thermal power output 250 kW



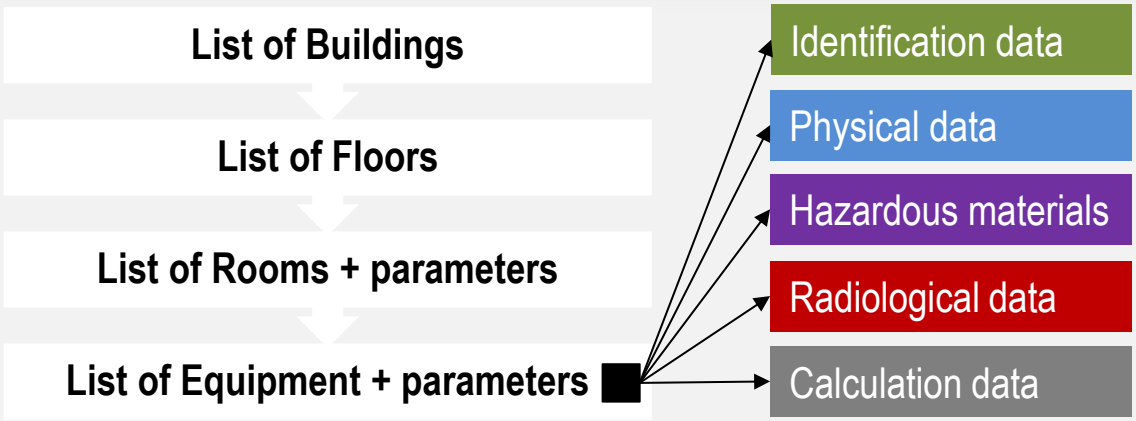
Model ATI costing case calculation methodology

Implemented step-by-step procedures:



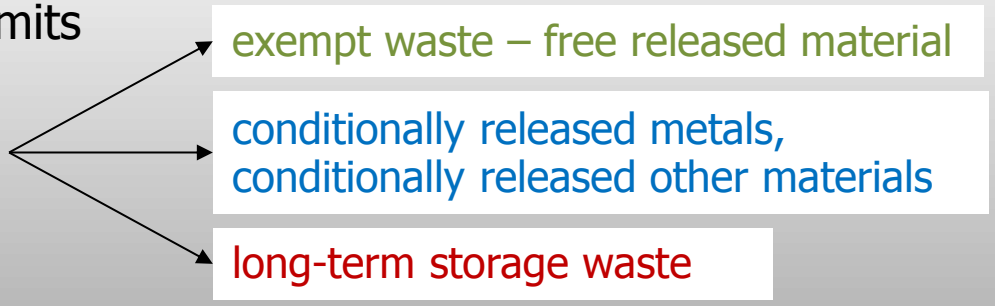
Step 1 - ATI inventory database (1)

1. Database structure corresponds to ISDC costing approach
2. Database template in Excel with hierarchical structure:



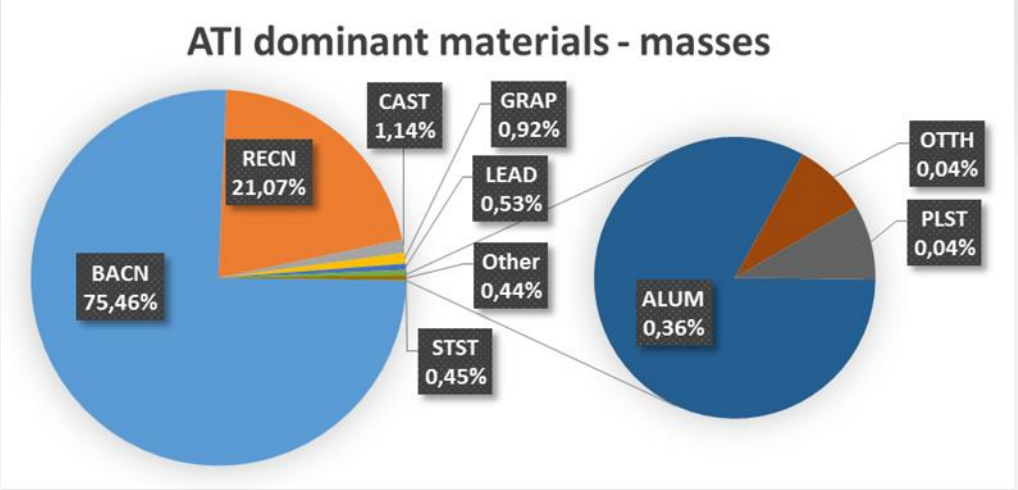
3. Supporting interconnected Excel spreadsheets: ISDC items, technological systems, CERREX inventory categories, materials, radionuclides, radionuclide vectors, RAW limits

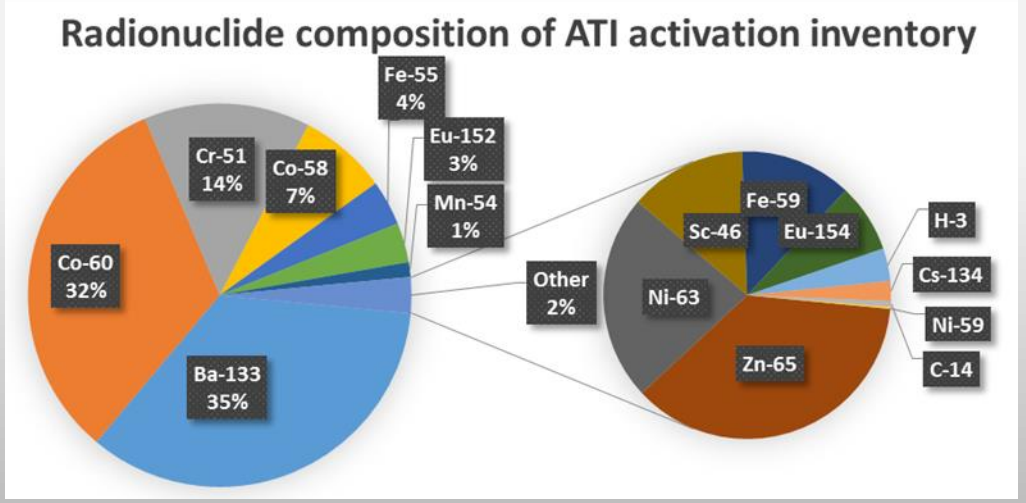
4. Waste streams considered:



Step 1 - ATI inventory database (2)

1. No building structures other than reactor concrete shielding structures are included, since no demolition works are planned
2. 59 technological equipment from the reactor building
3. Material inventory - 532 t (96% concrete shielding)
4. Total radiological inventory of 2.11 E+13 Bq estimated at the end of operation (top activity – stainless steel components)





Step 2.1 - ATI CERREX costing case development

- Inventory database implemented to the CERREX code
- Definition of ISDC items for inventory dependent actions:

04.0502	Dismantling of reactor vessel and core components
04.0503	Dismantling of other primary loop components
04.0506	Dismantling of external thermal/biological shields
04.0601	Dismantling of auxiliary systems
04.0701	Dismantling of embedded elements in building
04.0702	Removal of contaminated structures
04.0703	Decontamination of buildings
05.0900	Management of decommissioning LLW
05.1200	Management of decommissioning EW and materials

- Definition of input parameters (unit factors, waste distribution coefficients, work difficulty factors) for inventory dependent activities e.g. dismantling, decontamination, waste management activities
- Definition of input parameters (duration, workgroup composition, expenses, investments) for period dependent activities and collateral costs e.g. management of project, maintenance, surveillance, procurement, taxes
- Definition of general calculation parameters e.g. labour rates for basic professions;
- Analysis of the obtained results for basic calculation case (costs and manpower in ISDC format)

Step 2.2 - ATI eOMEGA_RR pilot costing case

- eOMEGA_RR - a version of the code eOMEGA focused on the decommissioning costing of research reactors with some limited functionalities
- eOMEGA = Connection of two existing and matured solutions:
  1. OMEGA decommissioning software fully implementing ISDC and unique tool for simulation the material and radioactivity flow in the decommissioning process
  2. Flexible and user-friendly web-based platform ADIOS

- ATI eOMEGA_RR costing case - a pilot demonstration of the code
- The same input data as for CERREX costing case were used

Step 2.3 - ATI eOMEGA_RR costing case results

- Calculated results in ISDC structure case – immediate dismantling

ISDC No.	Name of ISDC item	Workforce (manhour)	Total costs (EUR)	Labour costs (EUR)	Investments (EUR)	Expenses (EUR)	Contingency (EUR)
	Total	**157 000**	**13 446 900**	**7 590 600**	**940 700**	**2 986 000**	**1 929 500**
01	Pre-decommissioning actions	7 000	562 000	386 400	0	92 300	83 300
02	Facility shutdown activities	2 900	250 400	132 200	0	76 400	41 700
04	Dismantling activities within the controlled area	37 700	3 692 500	1 693 800	765 700	458 600	774 400
05	Waste processing, storage and disposal	17 100	2 420 300	709 400	150 000	1 157 500	403 400
06	Site infrastructure and operation	31 500	1 945 900	1 361 300	25 000	339 800	219 800
08	Project management, engineering and support	60 800	4 365 900	3 307 500	0	661 500	396 900
11	Miscellaneous expenditures	0	209 900	0	0	199 900	10 000

- Quantities of waste streams – immediate dismantling

Type of material	Quantity	Unit	Activity [Bq]
Material released to environment (unconditionally)	473.26	t	1.82E+05
Material released to environment (conditionally)	1.37	t	1.59E+06
Radioactive waste	57.29	t	1.38E+13

Step 3.1 - Sensitivity analyses

Objective: To identify and analyse the impact of input data uncertainties on the resulting costs, workforce and waste quantities from decommissioning process

ATI calculation case – sensitivity analyses in eOMEGA_RR code:

1. Effect of deferred dismantling – 50 years safe enclosure

2. Higher level of activation – 10 times

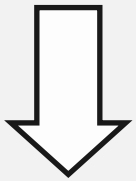
3. Extended duration of the project – 1 year extension

Step 3.2 – Results from sensitivity analyses (1)

Analysis No.1 - Effect of deferred dismantling – 50 y:

1. Radioactive decay of nuclides ⇒ reclassification of some materials from radioactive waste to materials to be released to environment

2. Additional operational costs (mainly site operation, site security or taxes and insurances)



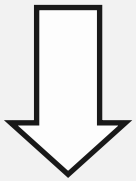
Results:

- Reduced costs for waste management (almost 50%)
- Increase of operational costs
- The **total costs** – **about 15% higher** compared with immediate dismantling

Step 3.2 - Results from sensitivity analyses (2)

Analysis No.2 - Effect of higher level of activation – 10-times:

1. Inaccuracy of the radiological inventory input data
2. Investigation of impact on decommissioning costs



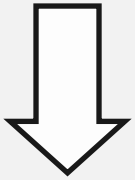
Results:

- Only **small increase** of **radioactive waste quantities** (**about 2%**)
- **Small increase** of the **total costs** (**about 1%**)
- Inventory dependent activities do not represent majority of costs as for bigger facilities
- Suitable more detailed analysis with different levels of activation

Step 3.2 - Results from sensitivity analyses (3)

Analysis No.3 - Extended duration - from 5 to 6 years:

- Expected increase of costs for period dependent activities

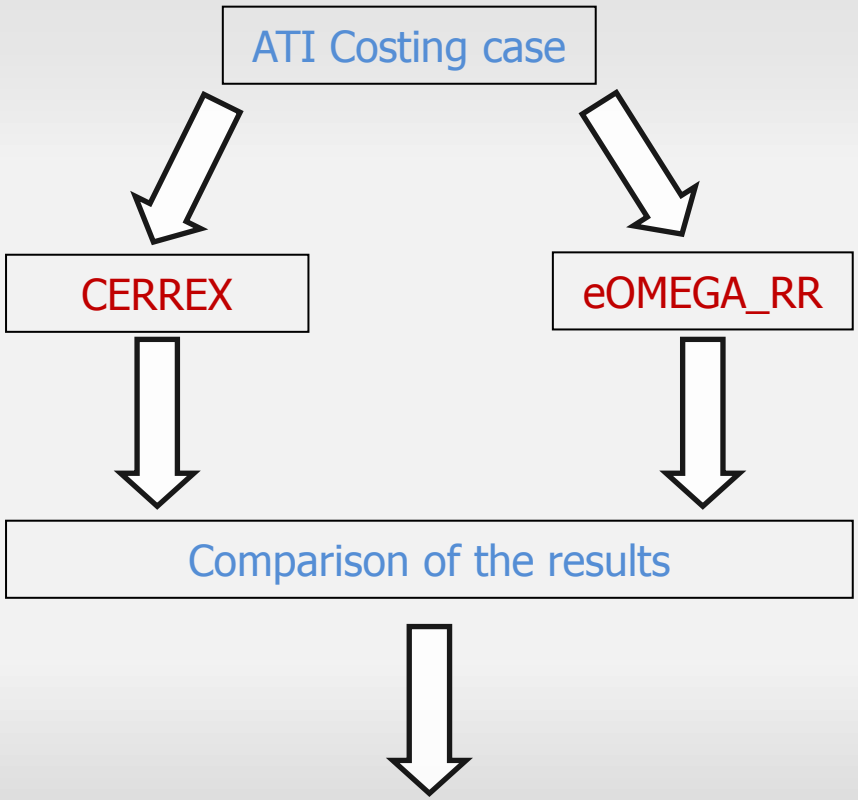


Results:

- **Increase** of mainly **labour costs** (**about 12%**)
- **Increase** of the **total costs** (**about 10%**)

Step 4.1 - Benchmarking of eOMEGA_RR with CERREX

Basic scheme:



Difference of total costs – **about 2%**

Step 4.2 - Benchmarking results (1)

- Period dependent activities:
  - CERREX – period specific data introduced as €/year (exact values)
  - eOMEGA_RR – period specific data introduced as €/hour (rounded values)
- Different considerations for working groups:
  - CERREX – simplified working groups („average worker" – one labour rate)
  - eOMEGA_RR – working group with several professions (specific labour rates)
- Different ways for calculation parameters of remote dismantling:
  - CERREX – separate dismantling category with unit factors for remote dismantling
  - eOMEGA_RR – remote dismantling based on the input radiological parameters or by using the specific work difficulty factors defined by the user

Step 4.2 - Benchmarking results (2)

- Different ways for application of work difficulty factors (WDFs):
  - CERREX – all the WDFs defined manually by the user
  - eOMEGA_RR – some of WDFs calculated automatically by the code algorithm based on the specific input parameters
- Decomposition of inventory items:
  - CERREX – tool for decomposition of materials not available
  - eOMEGA_RR – all the inventory items decomposed on the one-materials components
- Different algorithm for calculation of waste and material quantities:
  - CERREX – quantities based on the user's defined partitioning for individual inventory items into waste types
  - eOMEGA_RR – unique tool for simulation the materials and radioactivity flow

Conclusions

- ATI model costing case – a successful demonstration of eOMEGA_RR code on research facility
- CERREX as well as eOMEGA_RR codes have fully implemented ISDC structure and methodology and meet the actual international requirements, trends and best practices in the decommissioning costing
- Major advantages of eOMEGA_RR vs. CERREX:

1. More detailed cost calculations of inventory dependent activities
2. Automatic sorting of material due to incorporated unique tool for simulation the material and radioactivity flow
3. Sensitivity analysis tool allowing to compare automatically multiple costing cases
4. User-friendly environment and online access

- Presented ATI model costing case can be easily modified for other TRIGA reactors

Thank you for your attention !

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