New advances in AquilaCosting decommissioning and waste management cost estimation software

Workshop on advanced methods for knowledge management, training and education for nuclear decommissioning (DigiDecom2019)
Halden, Norway, June 19-21, 2019

Author: Dušan Daniška, dusan.daniska@aquilacosting.com, WAI Ltd., www.aquilacosting.com
Co-authors:
Vladimír Daniška, vladimir.daniska@gmail.com, consultant
Najah Fajurally, Najah.FAJURALLY@kinectrics.com, Kinectrics Inc., Toronto, Ontario, Canada
Peter Zubčák, peter.zubcak@aquilacosting.com, WAI Ltd.

What is AquilaCosting?

- Software for estimating costs for decommissioning of nuclear installations
  - Of any type, size or in any radiological situation
- Based on IAEA's recommended methodology – ISDC – International Structure for Decommissioning Costing
- Simplifies creating, optimization, reviewing, benchmarking and sharing of cost estimates
- Suitable both for cost estimators and regulatory bodies
- Waste management cost estimations included

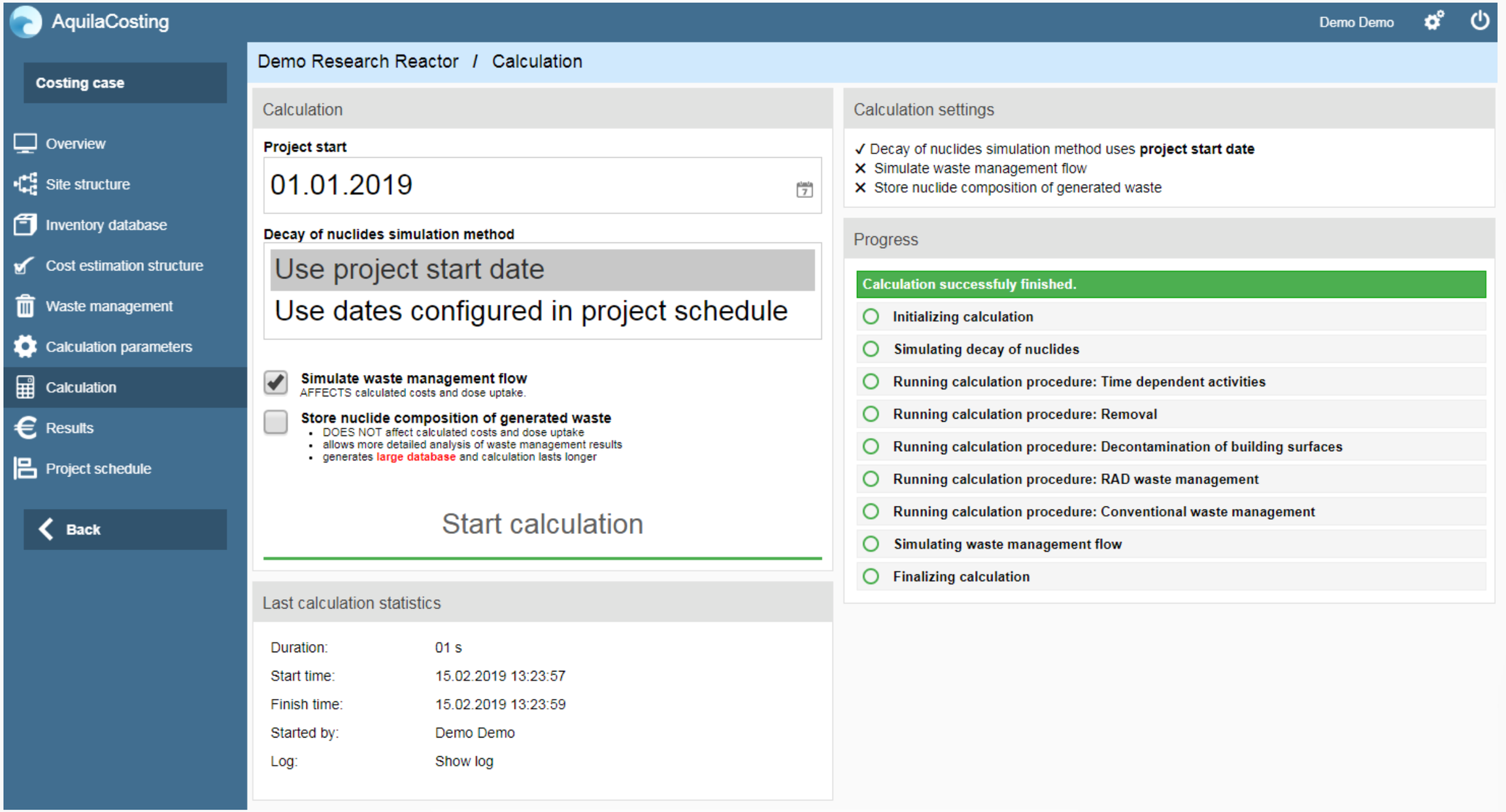
Why ISDC?

- ISDC – International Structure for Decommissioning Costing of Nuclear Installations
- Issued by OECD/NEA/IAEA/EC in 2012, as the joint publication
- Enables transparent benchmarking of costing cases
- Covers all activities during the decommissioning project
- International decommissioning cost practice is implemented as presented in “The practice for cost estimation of nuclear facilities”, OECD/NEA 2015, No. 7237

Basic AquilaCosting's features

- Tree-view based site structure
- Tree-view based inventory database
- Versatile cost estimation structure
- Configurable waste management
- Benchmarking and sensitivity analysis
- Comprehensive set of unit factors
- Work difficulty factors
- Simulation of decay of nuclides
- Dose uptake calculations
- Project gantt chart & schedule
- 16 types of cost activities
- Work groups and work professions
- Intuitive multi-user interface
- Very fast cost estimate calculations
- Secure client/server architecture
- Very large cost estimates
- Save to file & open from file
- Monte Carlo based cost uncertainty analysis

Sample screenshots



Calculation screen of a sample small-sized cost estimate

AquilaCosting

Demo Demo

Costing case

- Overview
- Site structure
- Inventory database
- Cost estimation structure
- Waste management
- Calculation parameters
- Calculation
- Results
- Contingency uncertainity a...
- Project schedule

Back

Demo Research Reactor / Contingency uncertainity analysis

General configuration

Number of iterations: 200 *How many iterations will be used to calculate the contingency?*

Number of samples: 50 *How many sampling points will be used to split the distribution function?*

Confidency interval: P 90 *What is your most preffered confidency interval?*

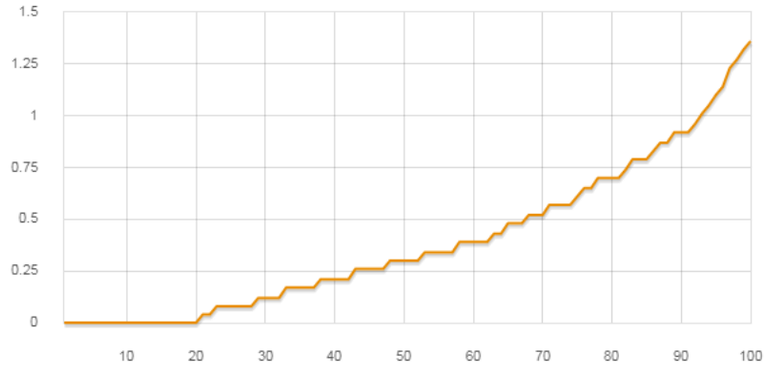
Per-activity configuration

Activity	Calculated activity costs	Distribution function	MIN -	MAX +
01 Pre-decommissioning actions				
01.0100 Decommissioning planning	141 750,00 €	Triangle	20.00 %	35.00 %
01.0200 Facility characterisation	235 850,00 €	Triangle	20.00 %	35.00 %
01.0300 Safety-, security- and environmental studies	54 000,00 €	Triangle	20.00 %	35.00 %
01.0400 Waste management planning	33 750,00 €	Triangle	20.00 %	35.00 %
01.0500 Authorisation	13 375,00 €	Triangle	20.00 %	35.00 %
01.0600 Preparing management group and contracting	0,00 €	Triangle	20.00 %	35.00 %
02 Facility shutdown activities				
02.0100 Plant shutdown and inspection	148 550,00 €	Triangle	20.00 %	35.00 %
02.0200 Drainage and drying of systems	60 075,00 €	Triangle	20.00 %	35.00 %
02.0300 Decontamination of closed systems for dose reduction	0,00 €	Triangle	20.00 %	35.00 %
02.0400 Radiological inventory characterisation to support detailed ...	0,00 €	Triangle	20.00 %	35.00 %
02.0500 Removal of system fluids, operational waste and redundant ...	0,00 €	Triangle	20.00 %	35.00 %
03 Additional activities for safe enclosure or entombment				
03.0100 Preparation for safe enclosure	0,00 €	Triangle	20.00 %	35.00 %
03.0200 Site boundary reconfiguration, isolating and securing ...	0,00 €	Triangle	20.00 %	35.00 %
03.0300 Facility entombment	0,00 €	Triangle	20.00 %	35.00 %
04 Dismantling activities within the controlled area				
04.0100 Procurement of equipment for decontamination and	750 000,00 €	Triangle	20.00 %	35.00 %

Results

Within a confidency interval of **P90**
will the contingency not exceed
919 191,82 €.

Maximum contingency per confidency interval

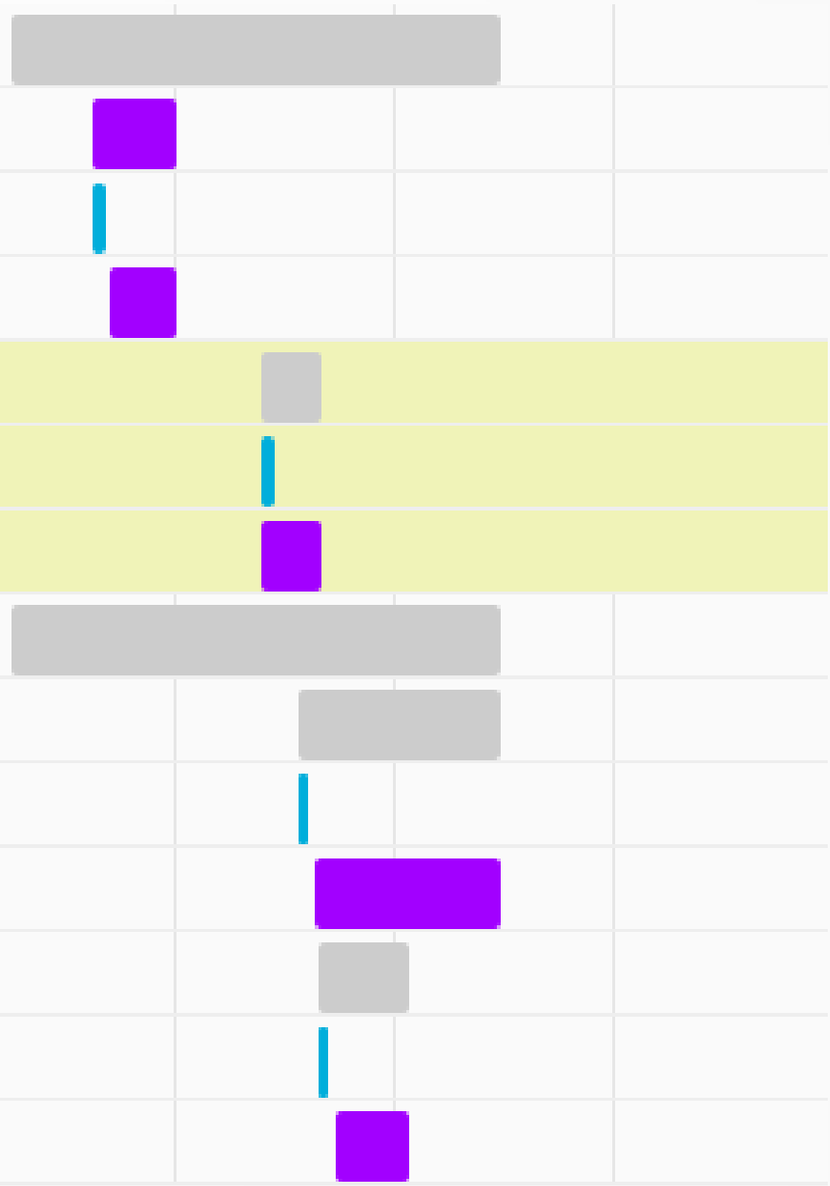


X-axis = Confidency interval, Y-axis = Maximum contingency in milions

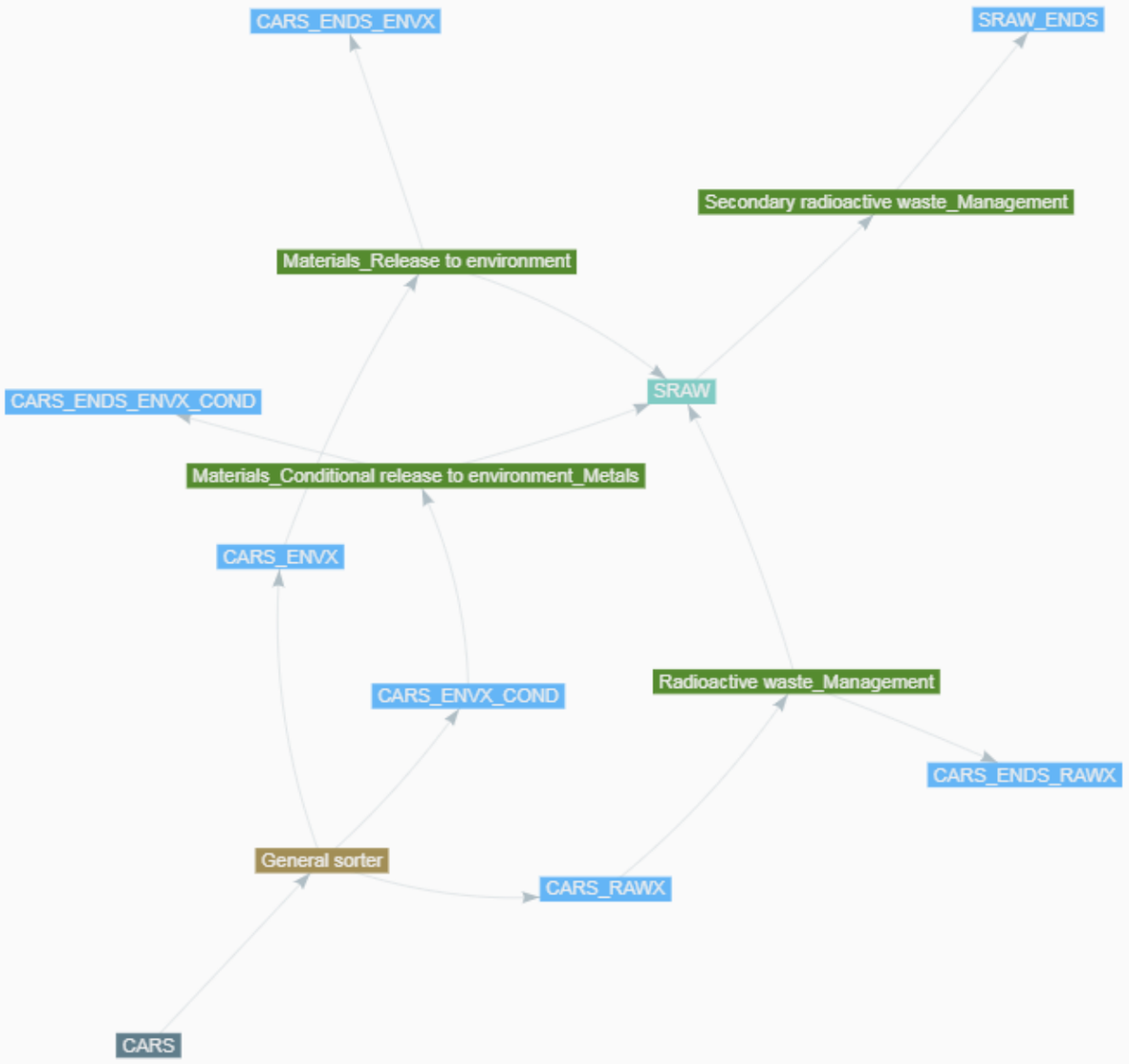
Number of occurrences of random calculated costs

Sample uncertainty calculations and analysis (small amount of iterations)

07.04.2073	30.06.2075
21.08.2073	11.01.2074
21.08.2073	14.09.2073
18.09.2073	11.01.2074
28.05.2074	07.09.2074
28.05.2074	21.06.2074
28.05.2074	07.09.2074
08.04.2073	02.07.2075
30.07.2074	01.07.2075
30.07.2074	19.08.2074
27.08.2074	02.07.2075
01.09.2074	02.02.2075
02.09.2074	14.09.2074
30.09.2074	01.02.2075



Decommissioning project gantt chart



Visualization of a sample carbon steel waste management process

Most recent features

- Intuitive waste management scenario configuration
  - E.g. from stainless steel through melting, transport up to disposal
  - Configurable national limits for disposal & release
- Batch automation (beta version)
  - Create several cost estimations at once, varying selected parameter
  - Very good for further sensitivity analysis
- Uncertainty calculations based on Monte-Carlo for in-scope and out-of-scope uncertainties
  - As presented in “Addressing Uncertainties in Cost Estimates for Decommissioning Nuclear Facilities”, OECD/NEA -IAEA 2017, OECD/NEA No. 7344
- Gantt chart & nuclide decay simulations
  - Plan your decommissioning activities with drag&drop
  - Recalculate cost estimation with nuclide decay simulation
- Optimisation for large inventory database and speed
  - 10.000 items in inventory database and very detailed WM scenario = cca 2-3 minutes on mid-low server

WM scenario configuration

- Inventory database item → Breakdown to “one-material components” → Waste ready for treatment
- Input Waste → Sorter → Technology → Output Waste + Secondary Waste + Effluent → Repeat
  - **Sorter** reads input waste’s nuclide composition and compares it to limits (disposal limits, technology limits); based on the comparison **decides** which technology to use (configurable)
  - **Technology** takes input waste and processes it; **generates** output waste, secondary waste and effluents are generated and then processed by a next WM iteration
- WM management iterations repeat until an end state (e.g. disposal or release) is achieved
- Sorter does not cost anything, Technology uses unit factors (costs something)

Waste management

Materials | Primary | Secondary | Effluents

- Aluminium
- Asbestos
- Building surface (chemical decontamination)
- Building surface (mechanical decontamination)
- Carbon steel
- Contaminated soil
- Contaminated/Activated Concrete
- Copper
- Electric cable
- Graphite
- Hazardous material
- Lead

[#1] ALUM

1 **First sorted by a following sorter:**
General sorter

IF NO LIMIT CAN BE APPLIED

If one of following limits can be applied:

Release to environment [further processing is not defined]
Conditional release to environment [further processing is not defined]
Disposal in VLLW repository [further processing is not defined]

[+ Manage limits in this sorter]

[#2] ALUM_ENVX

2 **and then processed by a following technology:**
Materials_Release to environment

Primary output waste [?]
Aluminium_End state_Release to environment

Secondary output waste [?]
Secondary radioactive waste

Effluents [?]
No effluents

[= Configure output waste]

[#3] ALUM_ENDS_ENVX

No treatment plan defined for this type of waste. If this is NOT the final step

configure the next step of waste management stream.

Batch automation

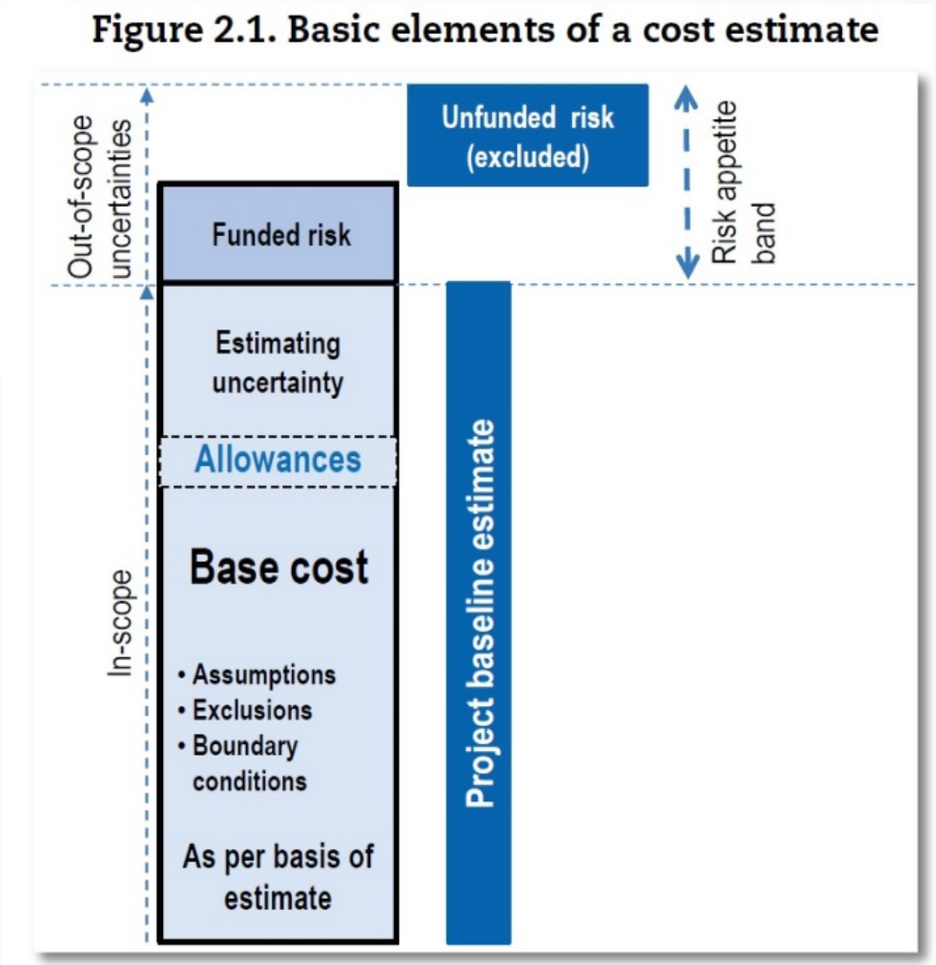
- Very handy tool for sensitivity analysis
- How to use:
  - Create a costing case (a “source” costing case)
  - Select which parameter to vary
  - Configure variation parameters (from / to / step)
  - Run the batch automation
- Result:
  - Set of costing cases based on the “source”
  - Each CC in the set has varied a specified parameters
  - Cost estimation calculated
  - Compare the results in an ISDC format and learn which parameter contributes to the costs the most

Project gantt & nuclide decay simulation

- Run the cost estimation calculation for the 1st time
  - Output: each decommissioning activity gets the duration calculated (based e.g. on work groups and work shifts configuration)
  - Starting date of each activity is set to decommissioning project start
- Re-plan the decommissioning project
  - Each activity is represented by a single line in a gantt chart
  - Set new starting date for each activity
- Re-run the calculation
  - Nuclide decay for the inventory processed by an activity is simulated
  - Affects the nuclide composition of a waste processed by a WM scenario
  - WM may be easier and with lower costs

Cost risk estimation based on Monte-Carlo

- Alternative probabilistic estimation of ISDC contingency; as the input data are used the sums of labour cost, investment cost and expenses at the ISDC Level 2
- Estimation of funded out-of-scope risks based risk register with user's pre-estimated cost data;
- User defines probabilistic distribution functions, settings for Monte Carlo method and the confidentiality intervals (100 % for alternative ISDC contingency and e.g. 60 % for funded risks;
- Follows recommendations from the document "Addressing Uncertainties in Cost Estimates for Decommissioning Nuclear Facilities", OECD/NEA -IAEA 2017, OECD/NEA No. 7344;



Thank you

Thank you for your attention

Dusan Daniska

dusan.daniska@aquilacosting.com
www.aquilacosting.com