EcoSMR webinar 24.11.2021

Investment modelling

Design-to-cost in SMR DH

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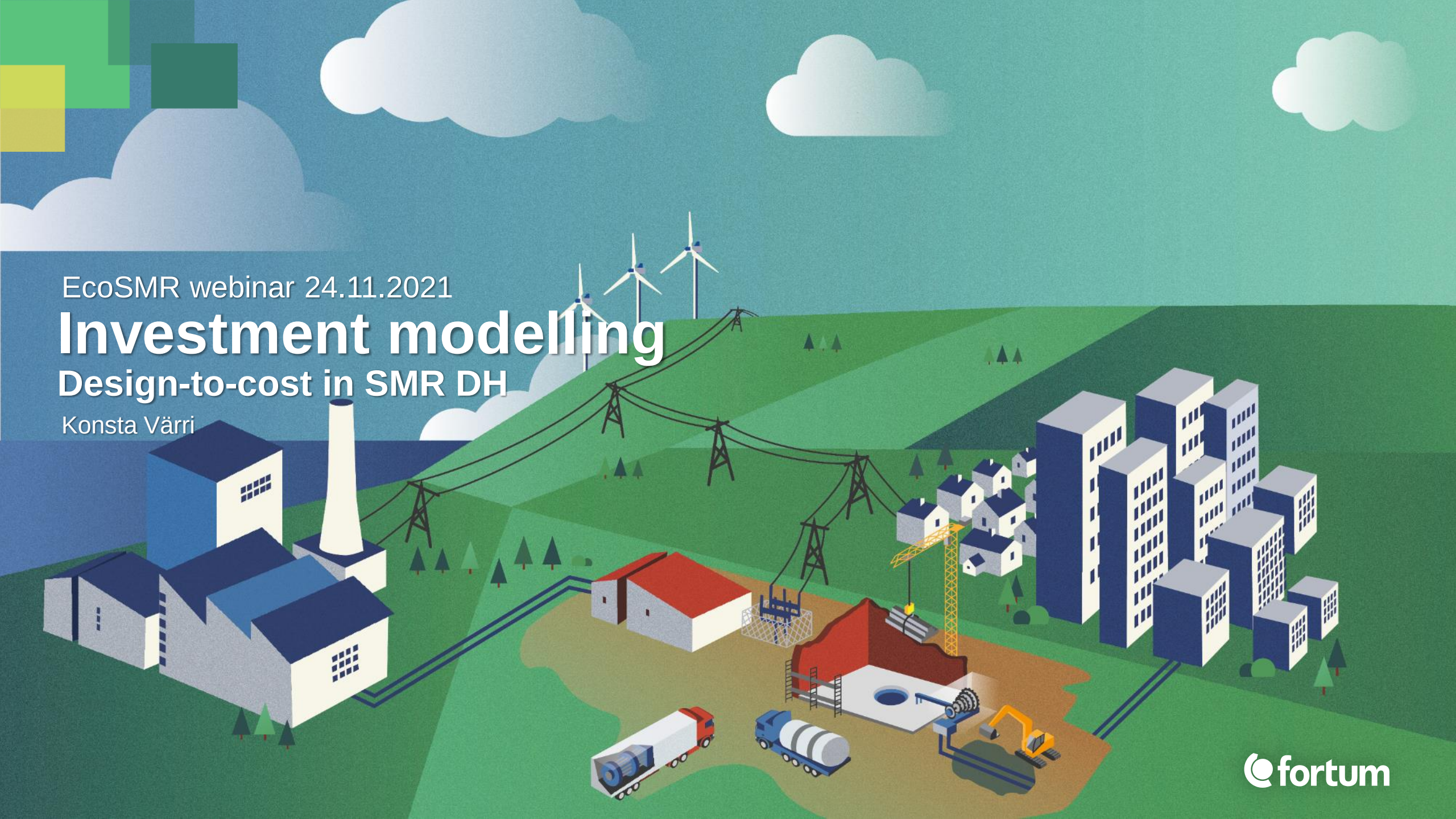

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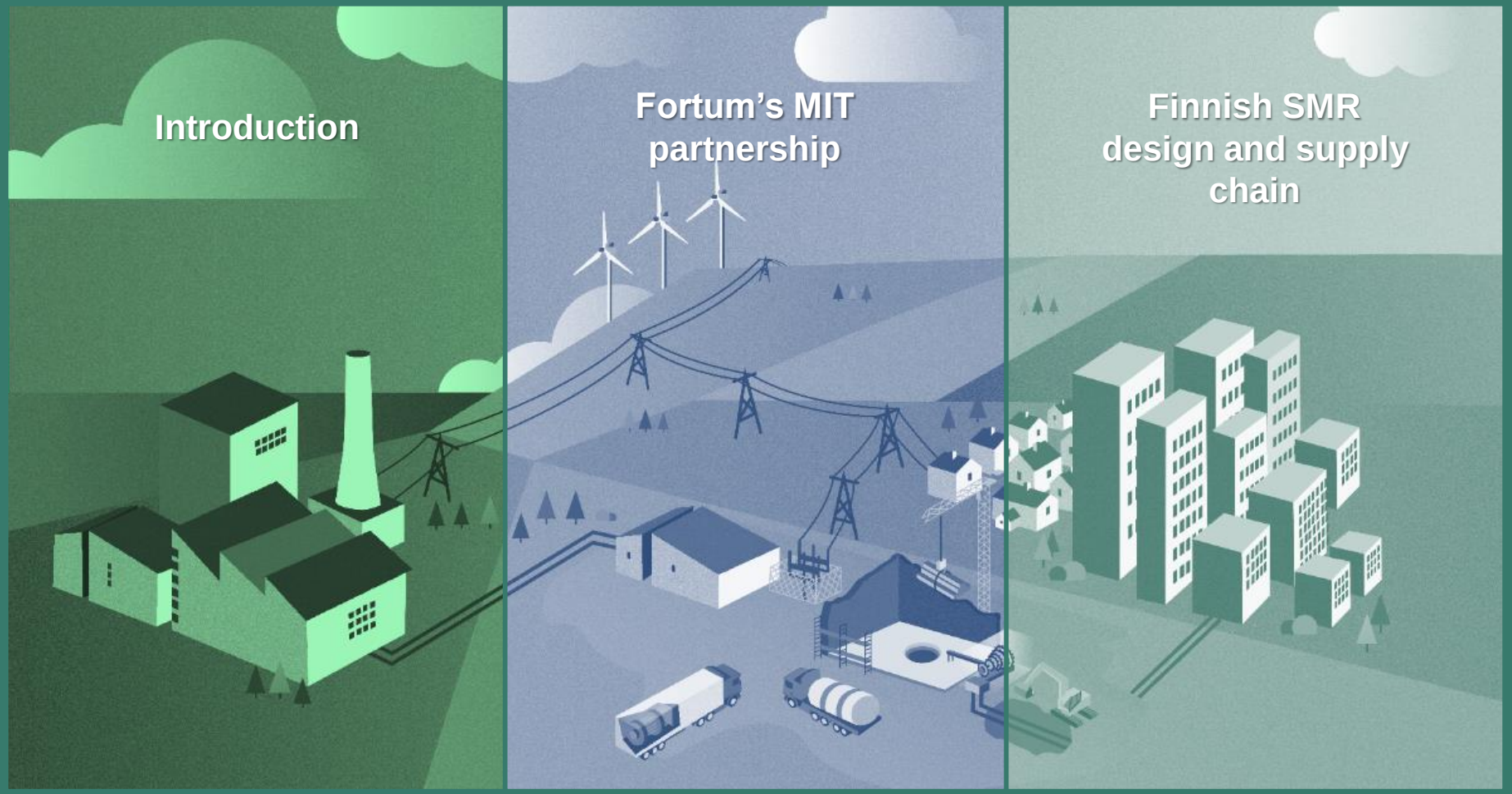
Outline



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Introduction

- Importance of design-to-cost when enabling Finnish SMR DH
  - To put it bluntly, safety design is important but futile if the plant is never built due to the cost of the plant
  - Competitiveness is critical if the aim is a fleet of Finnish SMR designs producing district heating
  - This approach cannot be only limited to the CAPEX of the plant but should include the operational costs
- There is quite the hype around SMR DH in Finland at the moment and no designs that could readily answer that
  - Perfect opportunity for a Finnish design, but only if the design is attractive to local power utilities
  - Political/societal goodwill can only go so far

Fortum’s co-operation with MIT

- Objective: Build an open-source tool for assessing the economic risks and uncertainties related to the construction of SMRs
  - Capable of assessing vendor promises of a price level, but also functioning as a tool for design-to-cost and optimising a potential plant.
- In practice this means understanding and modelling:
  - The cost and complexity of the design
  - The cost assessment of civils structures
  - The labor cost and uncertainties in plant construction
  - O&M costs
  - How learning works in nuclear

General learnings from the cooperation so far

Key factor(s) driving SMR costs

- **Economy of scale**
  - Still the primary cost driver
  - Low power density will still drive up the price, significant amount of concrete translates to a higher price per MW produced
  - If the aim is to produce small DH plants, it's critical that we're aware of this.
  - Learning from FOAK to NOAK is critical to succeed
- Passive safety
  - Not as significant as perhaps presumed, but cutting active systems from a design will still cut down costs
- Modularisation
  - Does not necessarily cut costs, but can drive down construction time
  - Potentially allows for a higher learning rate in a factory environment
- Cost of capital
  - As with all capital intensive projects, the cost of the capital will have a significant effect on the total capital costs

Design-to-cost of an Finnish SMR DH design – Current understanding and the potential of the tool

The cost and complexity of the design

- Evaluating the cost of components and labour required for installation is fairly straightforward based on existing databases
  - But the complexity increases as we move towards scaling different costs, taking into account new approaches to systems and factors like learning and modularisation
- Nevertheless the more simplified the plant is, the more economic it will be to design and build.

The cost assessment of civils structures

- As noted, a significant section of the building cost will be from the civil structures of the nuclear plant, namely concrete and steel.
- To understand this, the modelling tool will be able to evaluate either the cost of a readily available vendor design, or an unfinished design
  - Input either as a readily mapped out design or as an iterative process that runs through the loads inflicted on the structure etc. to produce suitable civil design
- Ability to assess different civil codes
- Enabling an iterative process to find a balance between cost and function

Design-to-cost of an Finnish SMR DH design – Current understanding and the potential of the tool

The labor cost and uncertainties in plant construction

- The model takes a task based approach mapping out a flowchart structure
  - Limited by total staff and how much staff can fit into a single building at once
  - Allows for mapping out delays and their effects to measure uncertainty
- Potentially able to support the design when it comes to mapping out constructability and potentially moving work offsite

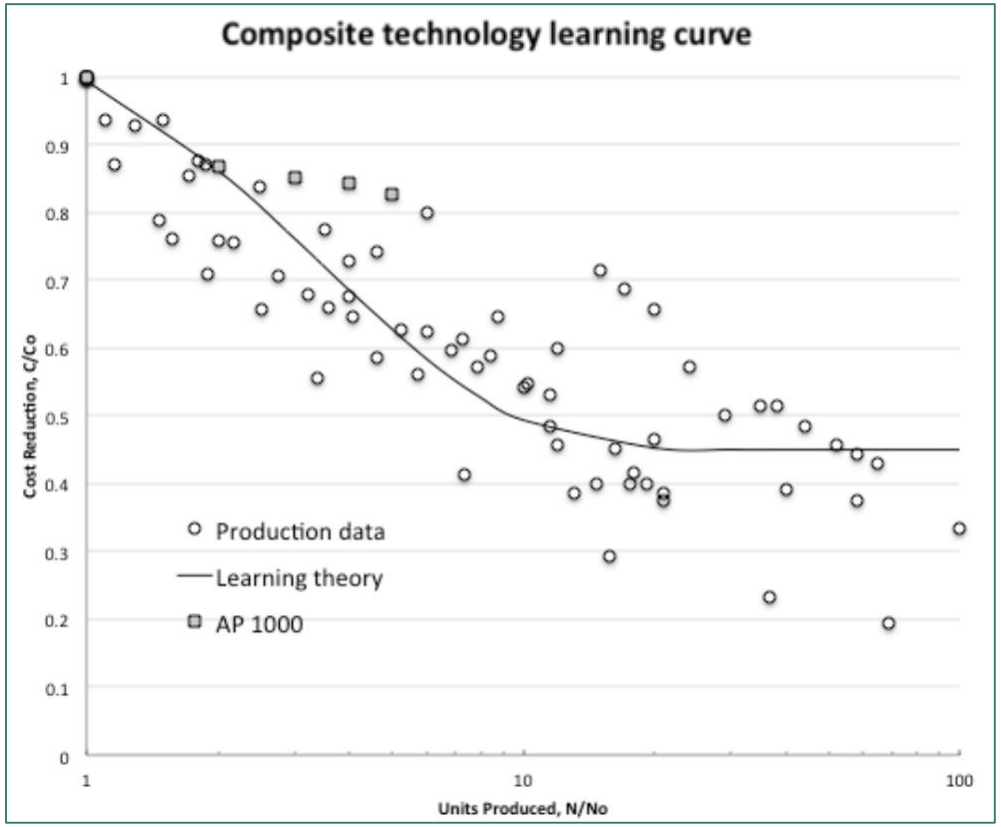
O&M costs

- The smaller the plant, the more critical the O&M costs become.
- Designing for a limited staffing, limited online maintenance etc. will be valuable to keep these costs low
- In general, so far with SMRs the presumed difference from traditional nuclear has not necessarily been that significant
  - This will require a change for smaller plants, questions like required security personnel becomes a critical one and should be considered in the design

Design-to-cost of an Finnish SMR DH design – Current understanding and the potential of the tool

How learning works in nuclear

- Learning in nuclear should be no different from other industries, but the potential increased offsite manufacturing for SMRs should be able to increase the learning
- A rough assumption of 10% learning rate for onsite work, 15% for offsite
- Work planned for better understanding the effects of factory manufacturing, this also reflects on the scheduling and hopefully reduces delay-based risks



World data trend for cost reduction by learning from [1]

[1] Duffey, Romney. (2018). Size and Cost Optimization of Nuclear Reactors in Energy Markets: The Need for New Approaches and Advances.

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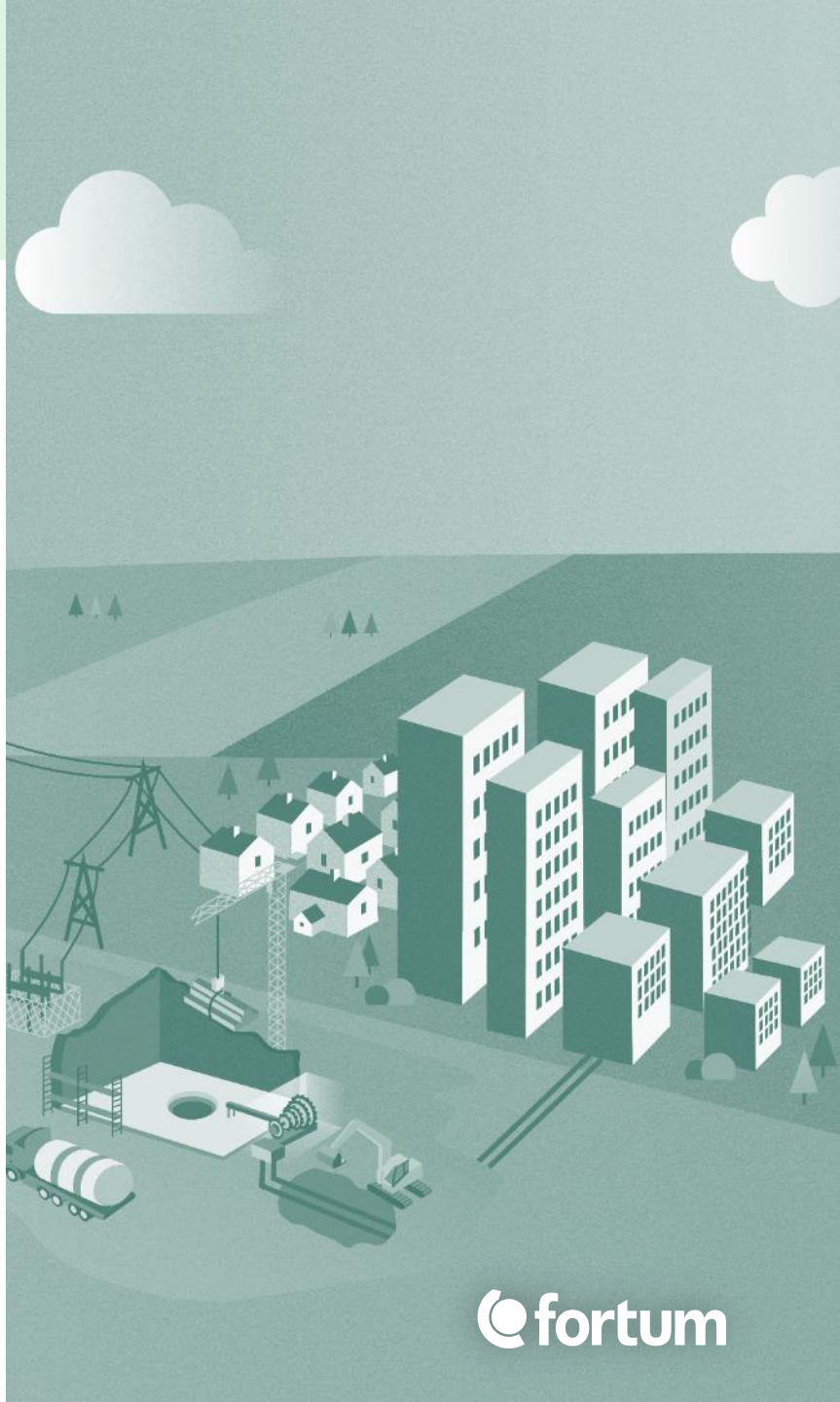
What this all adds up to

- The tool as said was originally conceived for understanding risks, costs and uncertainties of SMR projects
- But just as well, it could be utilised for iterative design process of an SMR plant to keep the design-to-cost philosophy at the forefront
- The work on the model is still ongoing, but we will hopefully start our forays into expanding the modelling tool from larger electricity based SMRs into more simplified reactor types in early 2022

Finnish SMR design and supply chain

- As noted, there is a clear place for SMR DH in Finland
  - This potential is by no means stopped along the border, but especially Eastern Europe struggling to get rid of coal could be an attractive market → potential for an export industry
- Some early studies performed reflect that the Finnish supply chain could potentially produce up to 70 – 80 % of a Finnish DH SMR
- Primarily the Finnish expertise is limited to safety class 2 and 3 components
  - This currently leaves out primary circuit, automation and fuel production to be exported
  - The classification of the lower pressure primary circuit brings some additional uncertainty, could potentially mean higher percentage of lower safety grade components



Finnish SMR design and supply chain

- If the potential is deemed great enough, there are no hard stops for expanding the know-how to safety class 1, but it does also include risks
- Otherwise the knowledge and manufacturing potential either exists, or could be attained with a reasonable effort
- Hopefully some of the experience attained from the KELPO project would also support this work
- There are still a number of unanswered questions in this area, but further study alongside the industry would be critical for moving forward

Thank you!

For questions, please contact konsta.varri@fortum.com