Finnish trend-setters in SMR development

Fortum SMR research and development

Eero Vesaoja, 17 November, 2019

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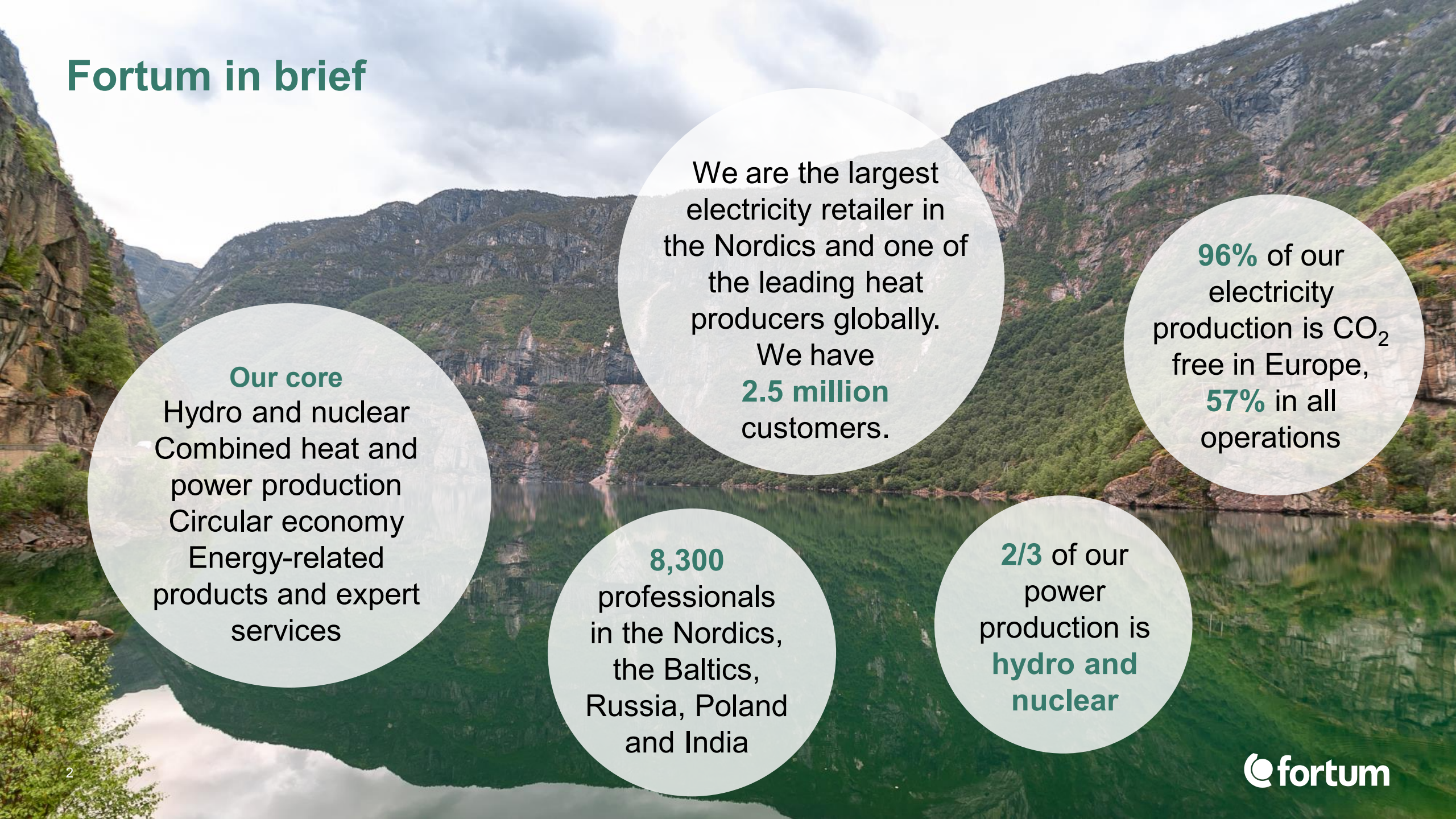
Fortum in brief



Our core
Hydro and nuclear
Combined heat and power production
Circular economy
Energy-related products and expert services

We are the largest electricity retailer in the Nordics and one of the leading heat producers globally. We have **2.5 million** customers.

96% of our electricity production is CO_2 free in Europe, **57%** in all operations

8,300 professionals in the Nordics, the Baltics, Russia, Poland and India

2/3 of our power production is **hydro and nuclear**

Contents

- Work done at Fortum
- Challenges
- Opportunities
- What is Fortum going to do with SMRs and District Heating?

Work done at Fortum on SMR's

Select published work from Fortum on SMRs:

- Doctoral Dissertation on Licensing of SMR (2013)
  - New model of licensing in Finland suggested
- Simulation and safety features of NuScale SMR (2017)
- Master's Thesis on Safety Classification of SMR (2018)
- Market Potential of Small Modular Nuclear Reactors in District Heating (2018)

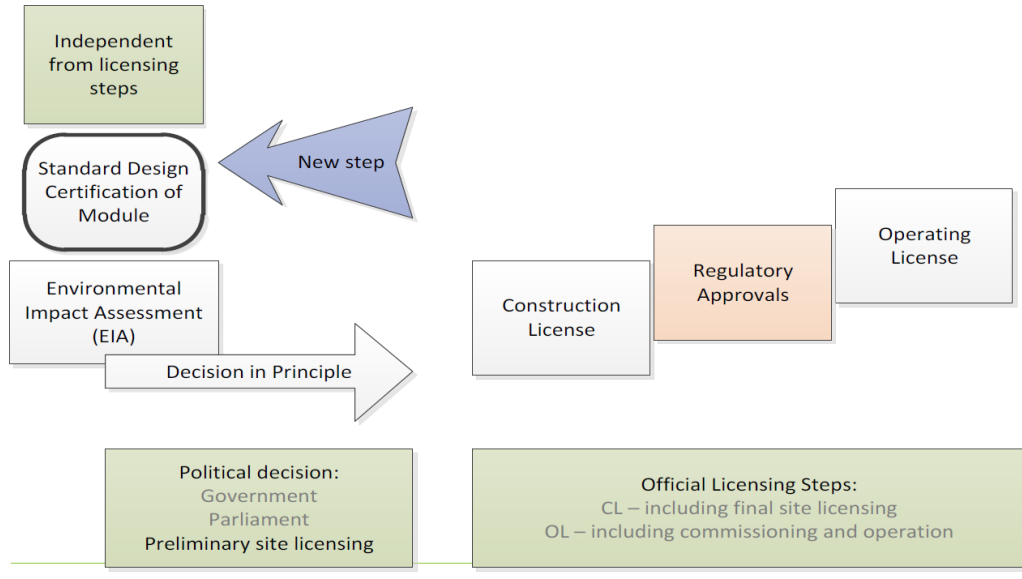
Select internal work:

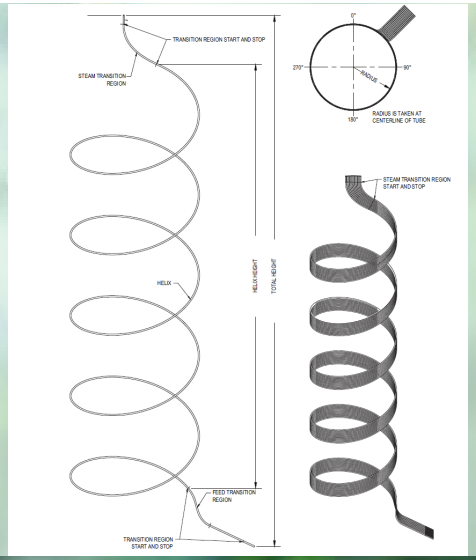
- APROS development for helical SG analysis (2017)
- SMR world status report (2018)
- APROS development of HOB and CHP SMR models (2018)
- SMR District heat business opportunity study (2019)

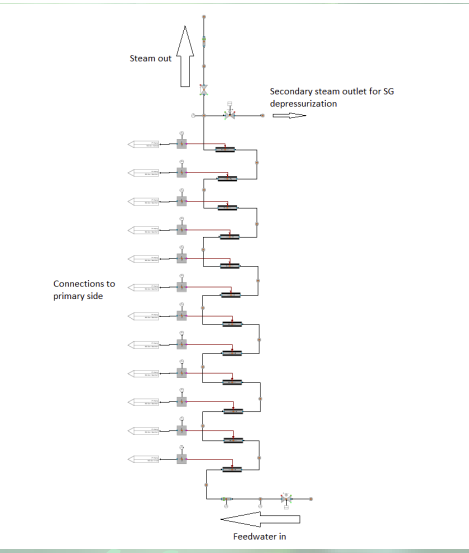
Ongoing collaborations

- ELSMOR, WP leader
- EcoSMR

Suggested modifications to Finnish licensing process







R&D Work planned, not confirmed

- Supply Chain evaluation, what are the vendor plans, how many alternatives are there, localization
- DHR simulation development, passive components, large pools, district heating connection
- Understanding source term, different levels of PRA, siting criteria and site evaluation
- Design evaluation method development and collaboration in select cases
- Three doctoral theses under preparation

Challenges for SMR DH

An industry in transition:

- Huge reduction in prices for Wind, Solar, Batteries, Heat pumps
- Some new options for CO2 free DH: Deep geothermal, Data centers
- What is the competitiveness of SMR DH for 60 years?

New design

- Completely new design first time built, don't start with half complete design
- Who will be the first-of-a-kind builders?
- Cost escalations in earlier new designs lead to skepticism w.r.t. vendor estimates

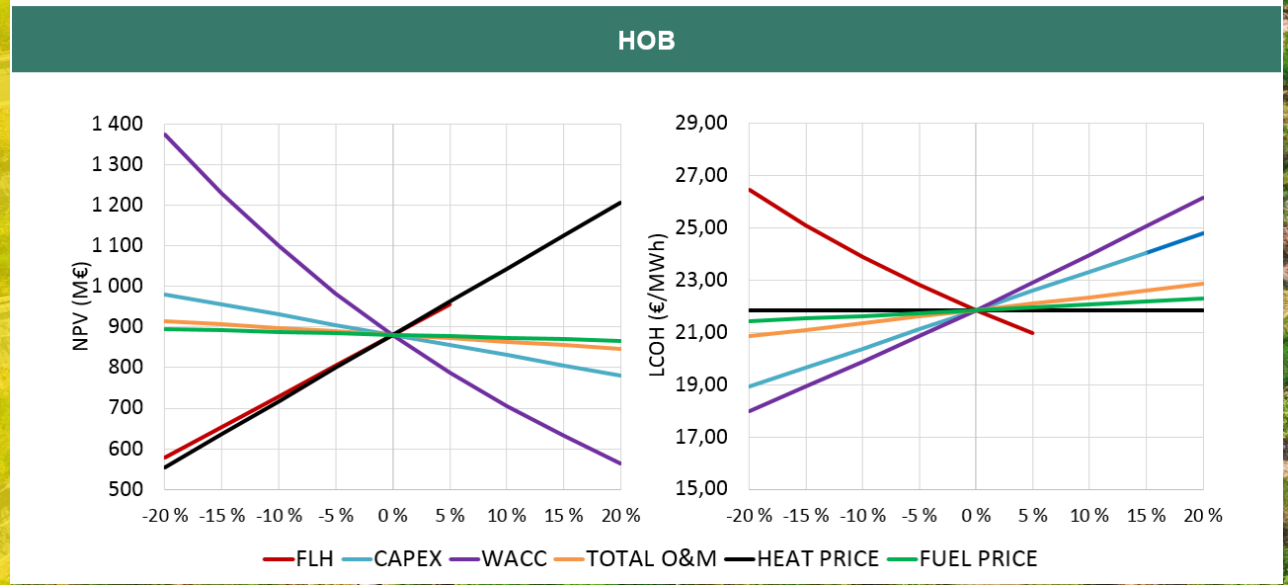
FOAK vs NOAK

- How many designs will reach NOAK?
- What will the N be for those, is it enough?

Design purpose

- Most designs are for electricity, many have CHP option

Sensitivity analysis of the SMR



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Opportunities for SMR DH

The big driver: Climate Change

”Massive actions that affect every sector. It requires large investments in emission free electricity and heat production as well as transformation to CO2-free energy in practically all areas of the society”
– Pekka Lundmark, IS, 21.11.2018 (translation mine)

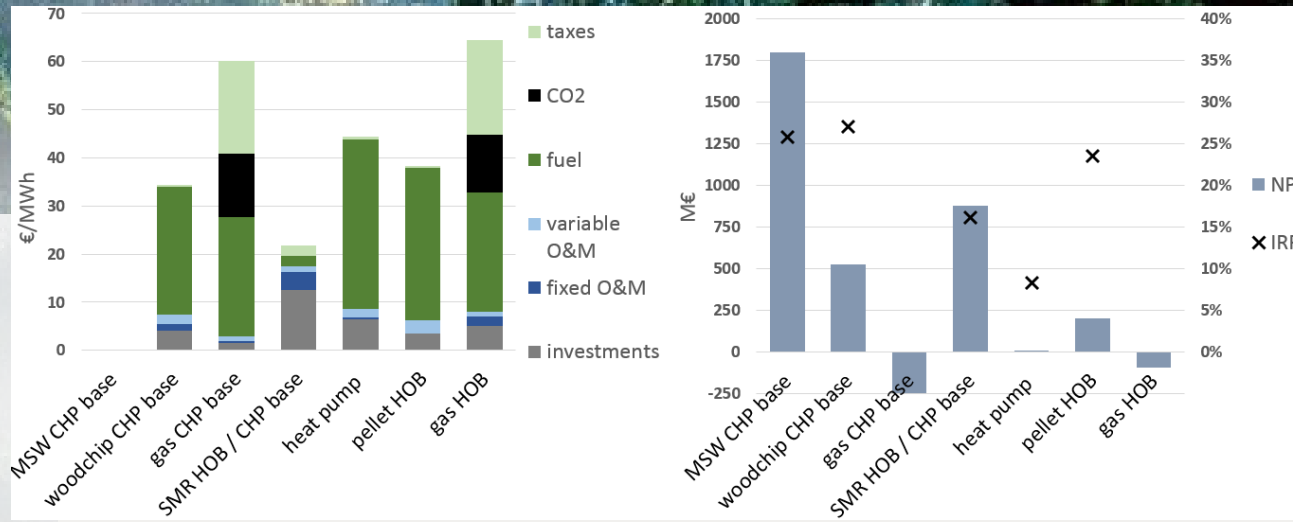
”Even though the change will be challenging to all of us, it provides Finland and Finnish companies huge opportunities in offering globally clean innovations and solutions”
- Pekka Lundmark, Kauppalehti, 21.11.2018
(translation mine)

Why nuclear?

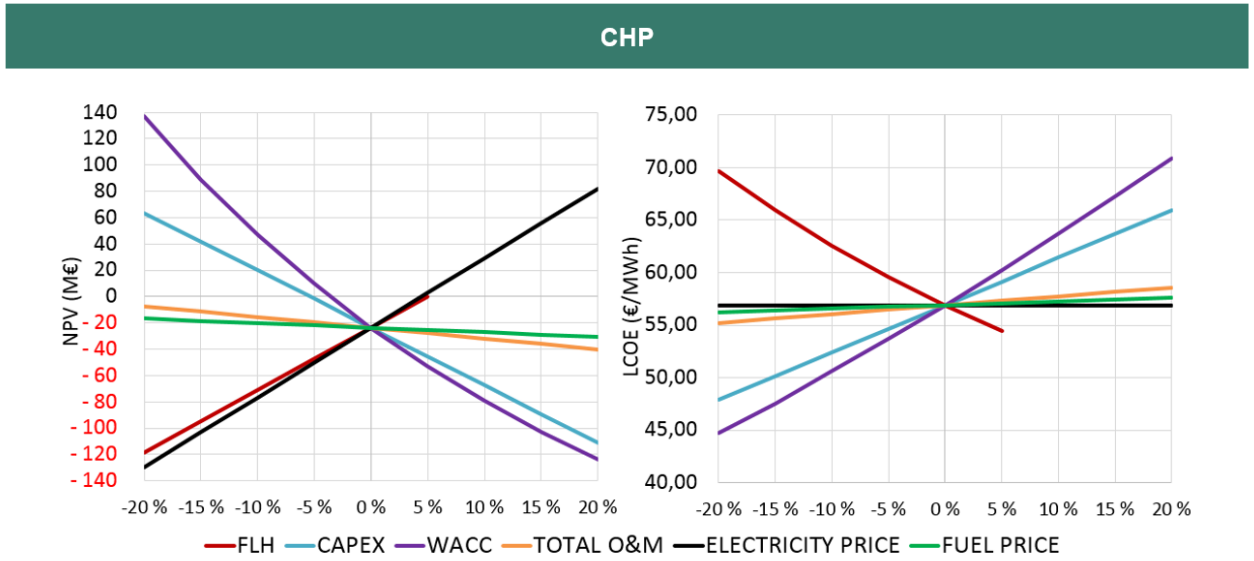
- Unique proven history of scalable decarbonization
  - Most of electricity in France and much of Sweden in the 1980s
  - While without, even the strongest efforts have been in difficulties, Germany
- We must evaluate and utilize all the tools we have
- Finland is a player bigger than its size in nuclear with two new build projects

More opportunities

- Higher value biomass industry in strong tail wind
- Higher share of waste recycled
- Higher efficiency reduces waste heat sources for heat pumps
- Although CHP LCOE doesn't look good, maybe achieved prices will?



Sensitivity analysis of the SMR



What is Fortum going to do with SMRs?

- Currently we have no investment plans in SMRs or commitments with any SMR vendors
- SMRs and recently especially in SMRs in DH are important part of our Nuclear R&D
- We are working on a suite of business options for Fortum in SMRs
- We have a wide array of expertise in nuclear in all stages of the life cycle and offer services

Thank you!

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