



Industry nuclear R&D comments on

Clean District Heating with Small Nuclear Reactors

Eero Vesaoja / March 29th

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Fortum in brief

<p>For a cleaner world</p>			<p>8,000+ energy professionals</p> <p>Nordic and Baltic countries, Russia, Poland</p>
	<p>61% of power generation CO₂-free - in EU 97%</p>		
		<p>Core competences in hydro and nuclear power, combined heat and power production and in operating on energy markets, circular economy</p>	<p>Energy-related products and expert services</p> <p>2.4 million electricity sales customers</p>

Figures: 2017

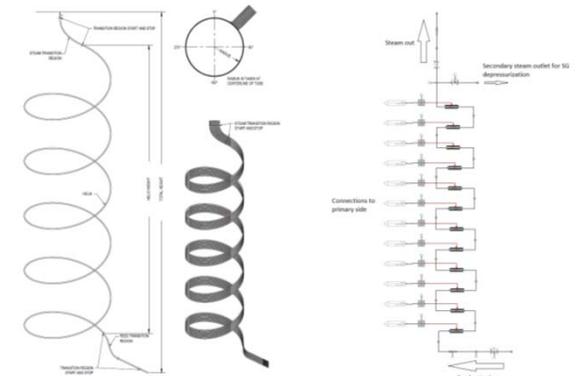
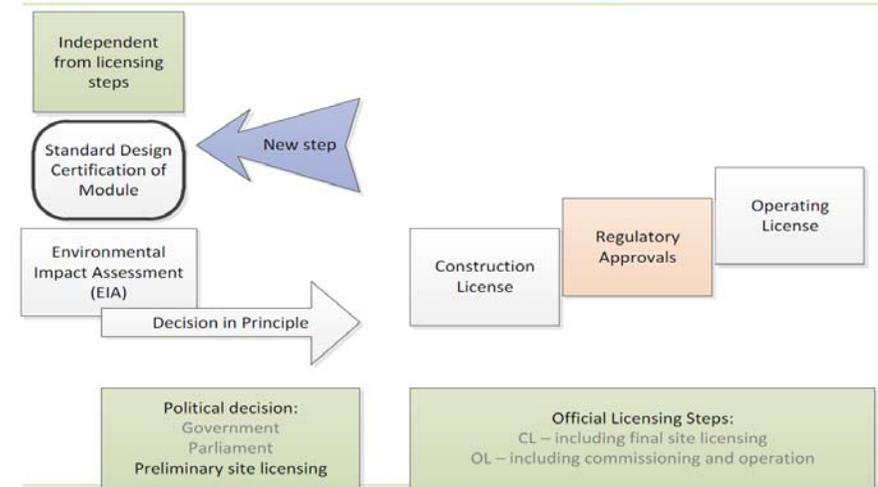
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Work done at Fortum on SMRs

- 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

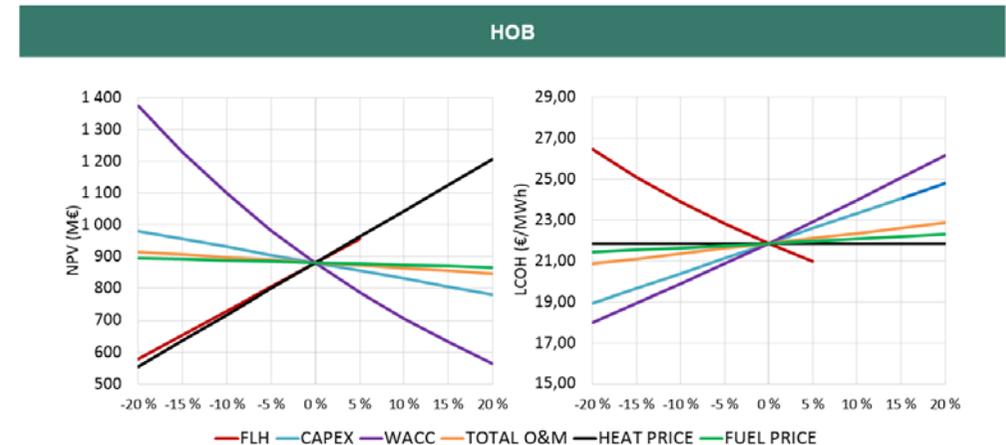
Suggested modifications to Finnish licensing process



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

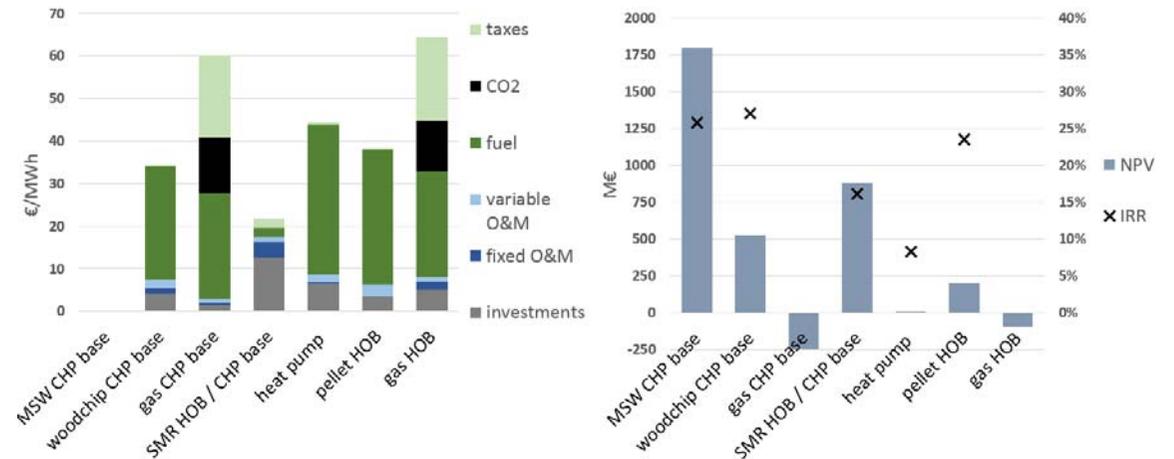


Opportunities for SMR DH

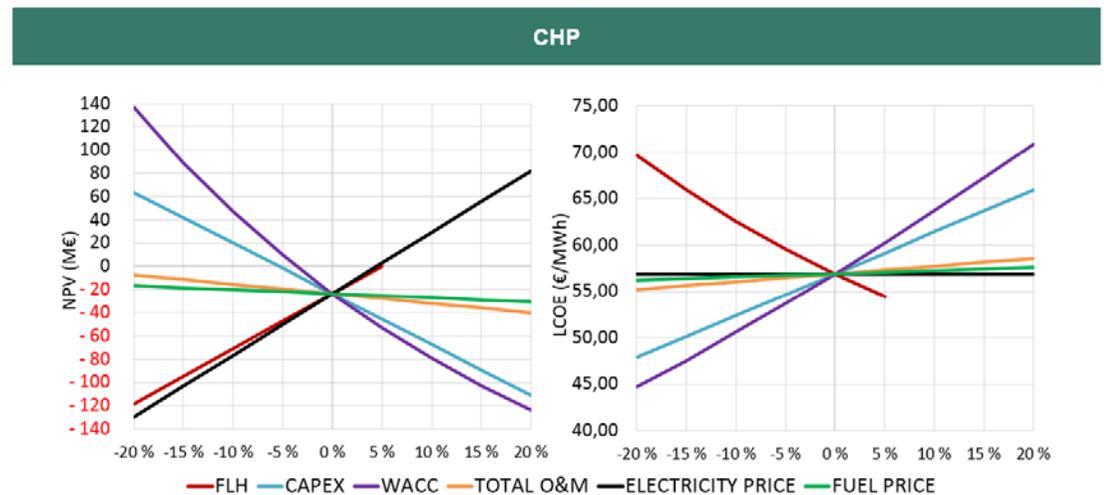
- The big driver: Climate Change
 - "Massive actions that affect every sector. It requires large investments in emission free electricity and heat production as well as transformation to CO2-free energy in practically all areas of the society" –Pekka Lundmark, IS, 21.11.2018 (translation mine)
 - "Even 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 in District Heating?

- 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