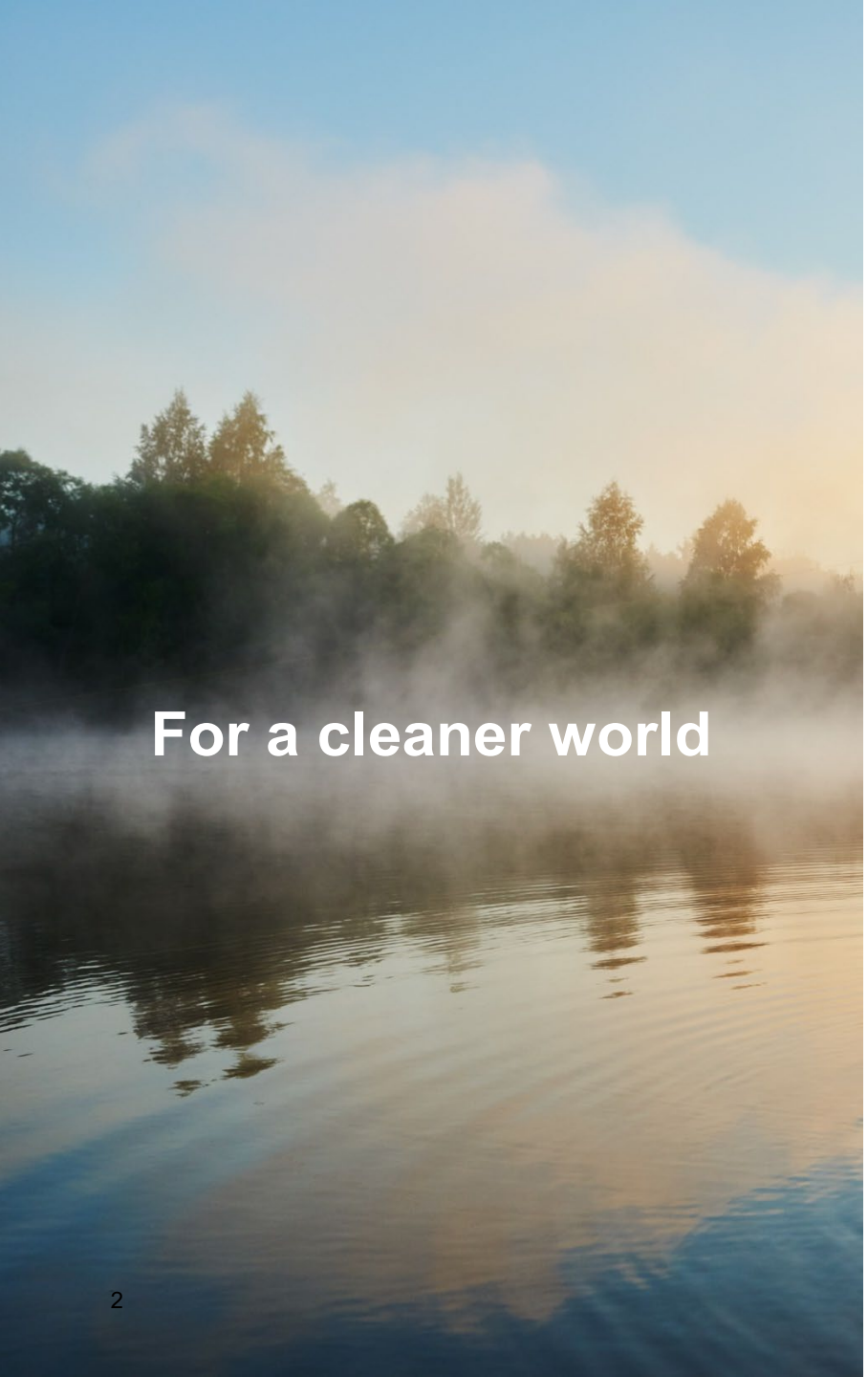
Potential of SMR technology as part of future power and heat production mix

Energiforsk Nuclear Seminar 2021

Olli Kymäläinen, 21 January, 2020

fortum
For a cleaner world

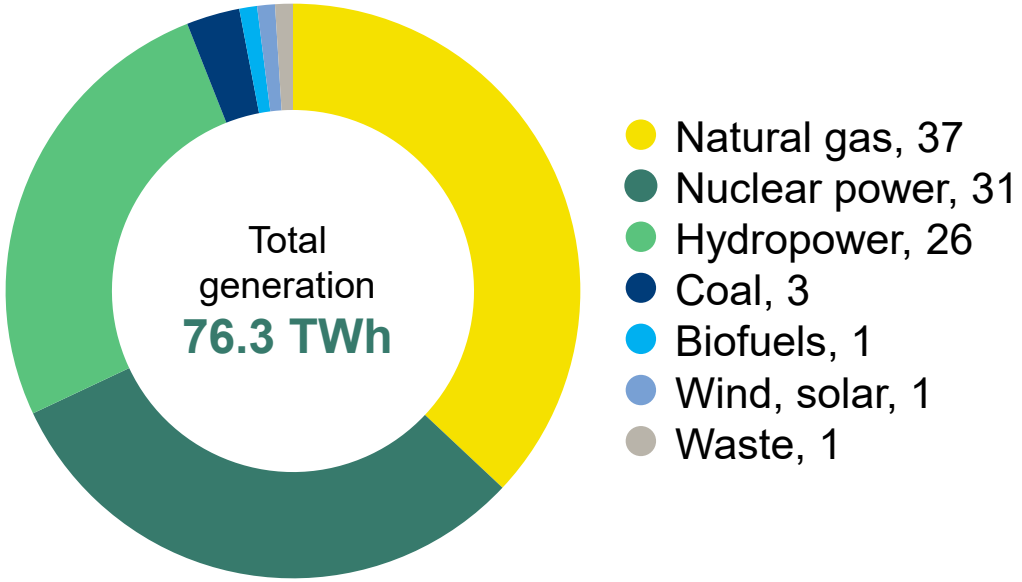


Outline

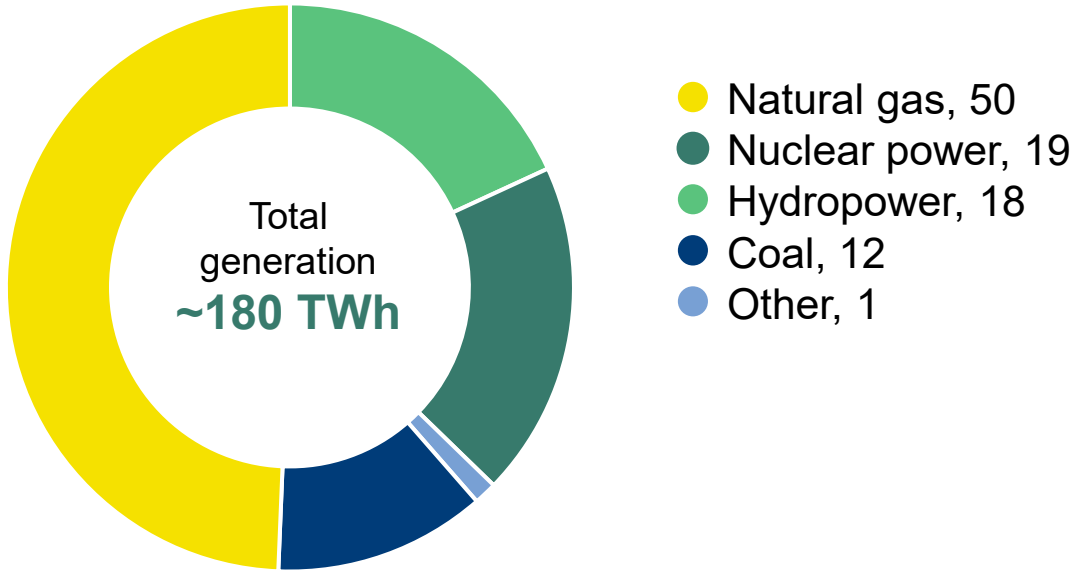
- Introduction
  - About Fortum and our activities regarding SMRs
  - Rationale for growth in nuclear power
- Future technology options for nuclear growth
- Selected preconditions for SMR deployment
  - Managing licensing risks
  - Standardization and serial production
  - Efficient supply chain
  - Learning the lessons from the current Gen III FOAK projects
- Conclusions

Fortum’s power production

Fortum power generation by energy source 2019 (excluding Uniper)



Fortum and Uniper combined power generation 2019

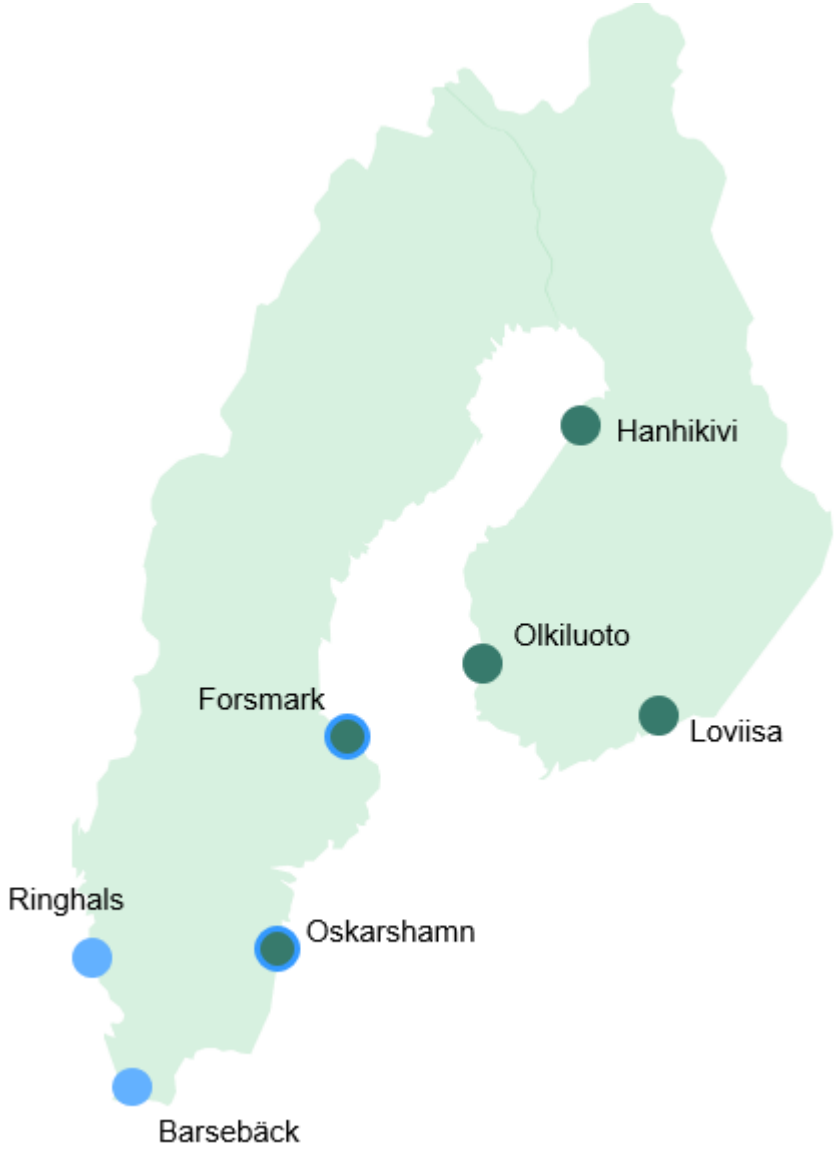


Note: Fortum’s power generation capacity 14,230 MW (hydro 4,677, nuclear 2,821, CHP 5,689, condensing 565, wind 194 and solar 285) and heat production capacity 13,249 MW at the end of 2019

fortum
For a cleaner world

Fortum’s and Uniper´s nuclear fleet

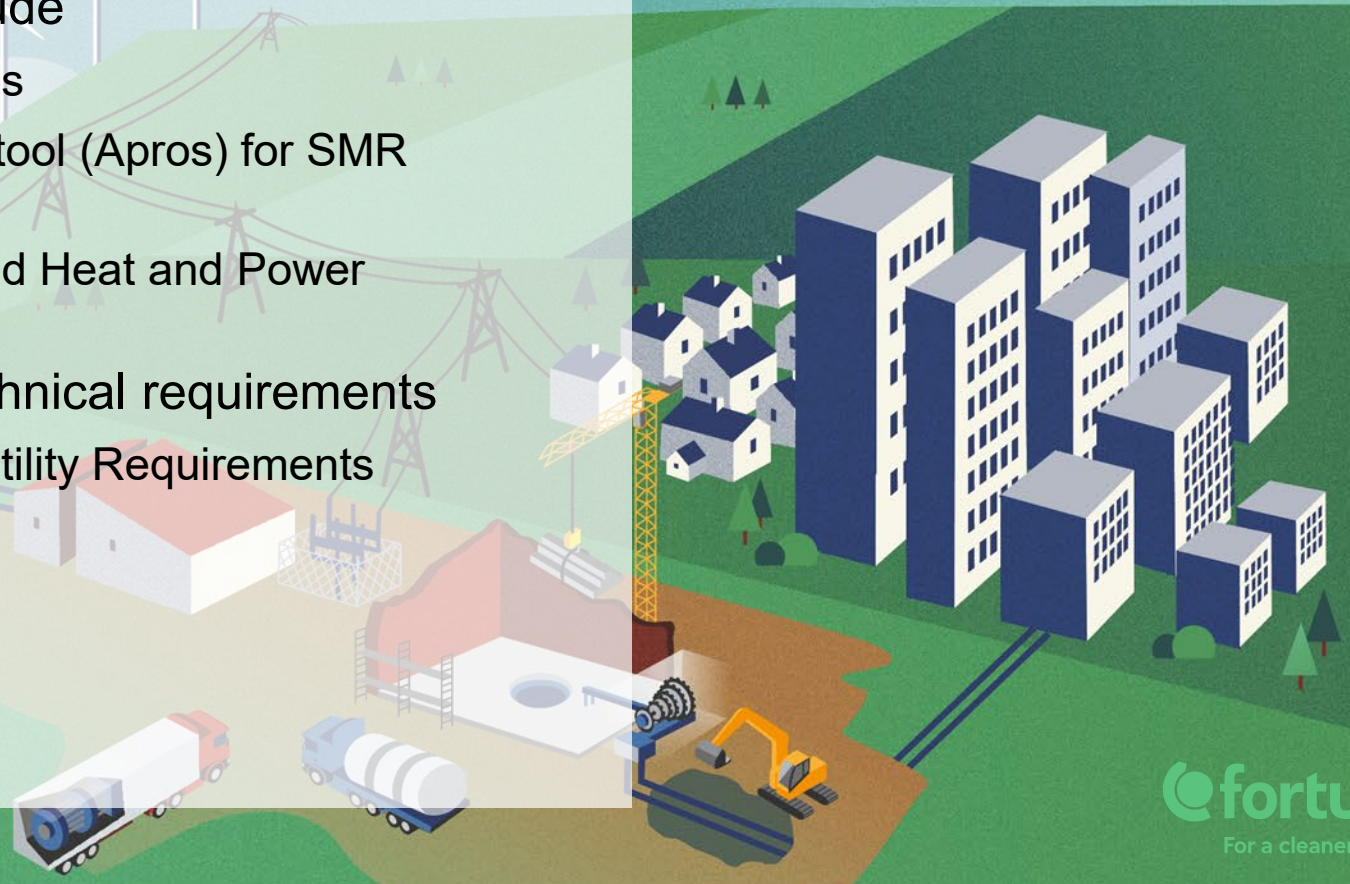
Unit	Mwe (net)	Fortum Share %	Uniper Share %
Loviisa 1 Loviisa 2	507 507	100 100	
Olkiluoto 1 Olkiluoto 2 Olkiluoto 3 (newb)	890 890 1600	26,6 26,6 25	
Hanhikivi 1 (newb)	1200	6,6	
Forsmark 1 Forsmark 2 Forsmark 3	988 1120 1172	23,4 23,4 20,1	9,3 9,3 10,8
Oskarshamn 1 Oskarshamn 2 Oskarshamn 3	decom decom 1400	43,4 43,4 43,4	54,5 54,5 54,5
Ringhals 1 Ringhals 2 Ringhals 3 Ringhals 4	881 decom 1063 1103		29,6 29,6 29,6 29,6
Barsebäck 1 Barsebäck 2	decom decom		100 100



fortum
For a cleaner world

SMR activities at Fortum

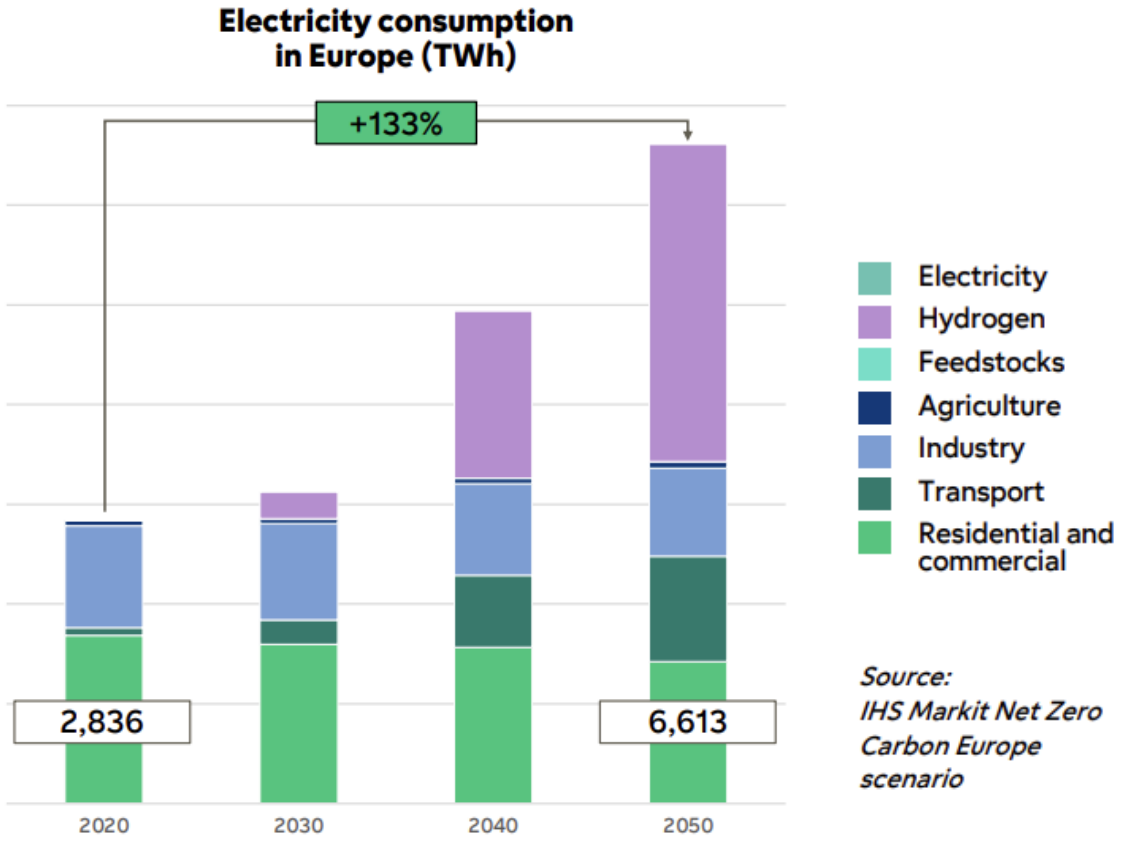
- SMR related R&D program has been ongoing for several years at Fortum
- We actively monitor international activities and development of SMR technologies
- Our R&D focus areas related to SMRs include
  - Possible licensing issues, safety design issues
  - Development of thermal hydraulic simulation tool (Apros) for SMR applications
  - Studies on applications of SMRs for Combined Heat and Power (CHP) and District Heating (DH)
- We pursue harmonization of safety and technical requirements
  - Fortum is actively participating in European Utility Requirements (EUR) SMR working group
- We support and cooperate with
  - Fermi Energia Oü, Estonia
  - Synthos Green Energy, Poland



fortum
For a cleaner world

Rationale for SMRs

- Large part of the current power generation capacity in Europe will be phased out in order to reach the decarbonization targets
- At the same time, the demand for electricity is expected to significantly increase
- According to several studies, maintaining nuclear power in the energy mix would bring significant savings in the cost of deep decarbonization



Presented in Fortum Capital Market's Day on 3 Dec, 2020

fortum
For a cleaner world

Rationale for SMRs

- Today, investments in newbuild nuclear do not seem realistic in the current market situation
- However, due to the aggressive **decarbonization targets**:
  - Demand for dispatchable and reliable carbon-free power generation to supplement intermittent renewables is expected to increase as the degree decarbonization increases

    → New nuclear may become one of the key technologies
  - Nuclear power has the potential to significantly reduce the cost of deep decarbonization
- In addition to base load power production, SMRs are expected to have
  - Flexible operation / load following capabilities
  - capabilities for cogeneration or heat only production
- SMRs need to be economically viable considering
  - Technology
  - Project implementation and project risks (incl. licensing risks)
  - Financing

fortum
For a cleaner world

Future technology options for nuclear growth

Several alternative or parallel technology paths

1. **Large light water reactors of Gen III/III+**
   - Track record for recent newbuid projects in Europe is not encouraging
   - However, situation may be improving through the experience and lessons learned from the currently ongoing projects
2. **Light-water, small modular reactors (SMR) for power production or for CHP**
   - The losses in economy of scale compensated through other means such as simplification and maximized standardization
   - Smaller upfront investment may ease funding
   - How to speed-up start of construction of FOAK units?
3. **SMRs for heat-only production for district heating**
   - Potential in countries with developed district heating infrastructure as combustion based technologies will gradually give way to other technologies
   - Heat-only design district heating purposes allows significant simplification of the technology
   - Near-term deployment in China?
   - In Finland, VTT and LUT are developing concepts
4. **Advanced reactors other than light-water technology**
   - Option for high-temperature process heat
   - How to speed-up the development and pilot projects?
   - For longer-term perspective

Selected preconditions for SMR deployment

Managing licensing risks (1/2)

- Essential to:
  - avoid unnecessary, country-specific design modifications or unnecessary changes in design processes or documentation
  - ensure stability and predictability of licensing requirements

- An SMR cannot be afforded to be redesigned for each country
  - International harmonization of licensing requirements needs to be deepened

Selected preconditions for SMR deployment

Managing licensing risks (2/2)

- Fortum has studied, together with Fermi Energia, possible licensing model for a newcomer country such as Estonia
  - Many of the issues identified are valid also for experienced countries – not only newcomers
- Some considerations for licensing an SMR first-in-a-country unit (but not FOAK):
  - Creating a framework for international or European design certification would be an optimal way, but cannot be realistically expected soon
  - The safety case (and PSAR) for non-FOAK units (even if first-in-a-country) should utilize to a maximum extent the safety case of a standard design or reference plant
  - The licensee always needs to demonstrate intelligent customer capability and carry out its own safety assessment
  - The safety authority of the host country shall do its own safety assessment but with maximum utilization of an earlier safety assessment of an earlier safety assessment and licensing process (e.g. from the country-of-origin)
    - Avoid detailed, prescriptive country specific requirements
    - Deep cooperation agreed between the two safety authorities
    - Transparent access to the earlier safety assessment and analyses
  - Utilization of the foreign safety assessment should be based on **graded approach** prioritizing deviations from the standard or reference plant design and safety significant items as well as site and licence applicant-specific matters
  - Enhance predictability of construction license process through e.g. by using of topical pre-approval

Further considerations for making SMRs affordable

Simplification, standardization and serial production

- The smaller power output of SMRs allows to increase the use of passive safety systems and to significantly simplify the design
- Increased use of use automated controls should allow an optimization of the operating staff
  - Consideration of human factors during the design phase

Efficient supply chain

- Harmonization of the qualification requirements
- Use of high-quality industrial grade items (commercial grade dedication)
  - Due to the smaller size, SMRs may have the potential to benefit even more from utilizing components already proven in other industries requiring high quality

Lessons learned from the current Gen III FOAK projects

- The track record of recent newbuild nuclear projects in Europe has been poor
- On the other hand, experience is being gained and lessons can be taken
  - See e.g. recent OECD/NEA report: *Unlocking Reductions in the Construction Costs of Nuclear: A Practical Guide for Stakeholders* .
- Cost escalations in the recent projects due to indirect costs such as design, planning, support service and installation expenses rather than from components and materials
  - The potential for improvements is there, as evidenced also by some Far East countries with experienced organizations and supply chains
  - Focus on project governance

Conclusions

- The potential to make SMRs affordable and a real contributor for deep decarbonization is there
- Standard designs with minimum country specific tailoring
  - Harmonized and stable requirements
  - International cooperation in licensing
- Take the lessons learned from current newbuild projects to minimize escalation of indirect costs

Thank you

For more information, please visit www.fortum.com/nuclearservices

Follow us on:

www.twitter.com/FortumNuclear
www.twitter.com/Fortum

www.linkedin.com/company/fortum

www.youtube.com/user/fortum

Fortum ForEnergy blog at
fortumforenergyblog.wordpress.com

fortum
For a cleaner world