LDR-kaukolämpöreaktori: kohti puhdasta kaukolämpöä

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Challenge

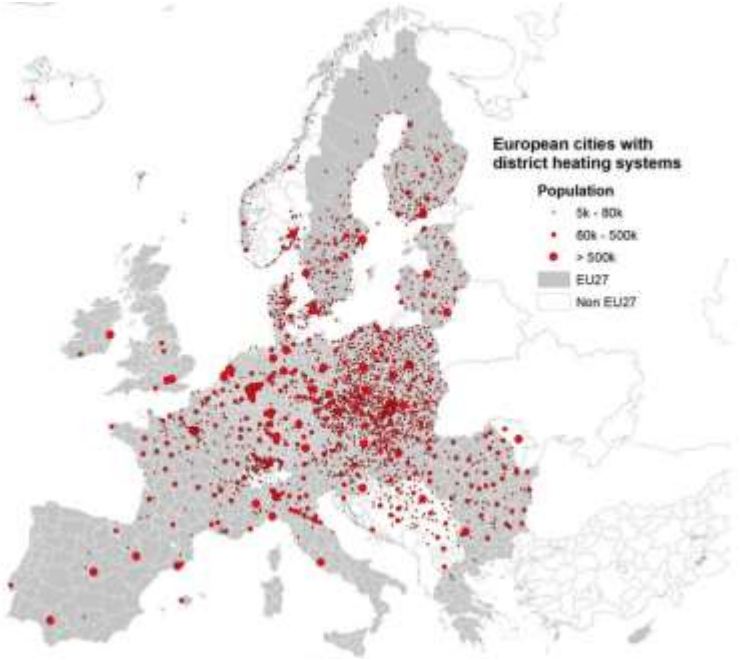
Heating and cooling accounts for circa 50% of the energy consumption in the EU

District heating represents circa 12% of the heat energy consumed in the EU at present

Circa **3500 district heating systems** in EU, serving **circa 60M people, 75% powered by fossil-fuel** based Combined Heat and Power (CHP) **plants**.

Decentralized supply close to municipalities.

Required replacement investment in next few decades in tens to hundreds of billions euros



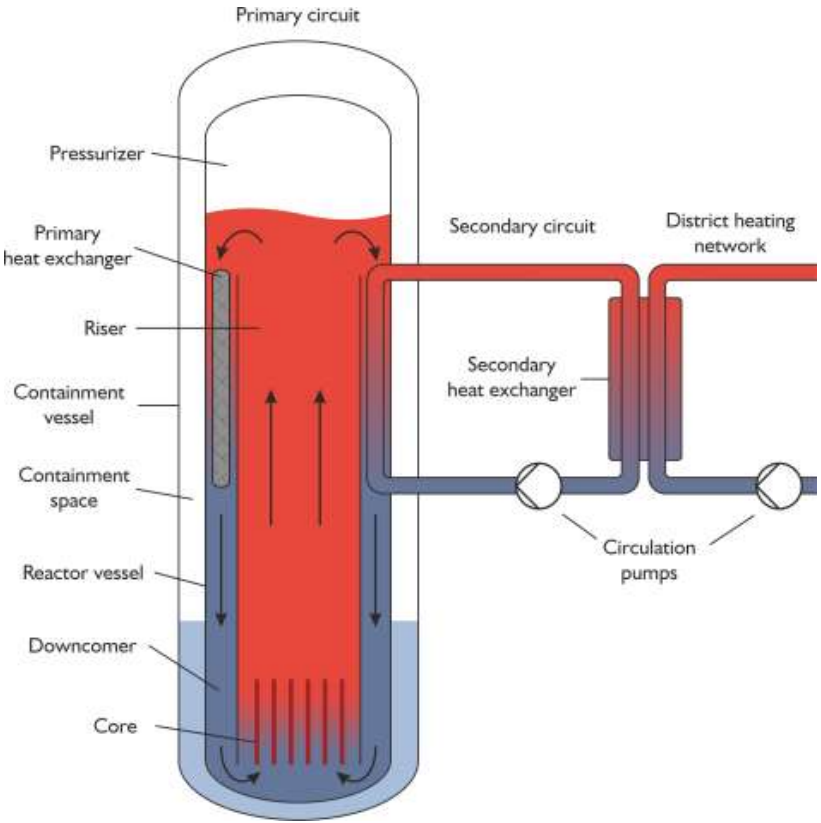
Source: JRC Technical Report *Decarbonising the EU heating sector* (European Commission, 2019)

VTT Solution

LDR–50

- **L**ow-Temperature **D**istrict Heating and Desalination **R**eactor (LDR)
  - For centralized production of heat at 80–120 C temperature
  - For clean potable water and farming

- System level innovation using proven technology – to solve challenges
  - Clean heat sufficiency
  - Drinking water sufficiency

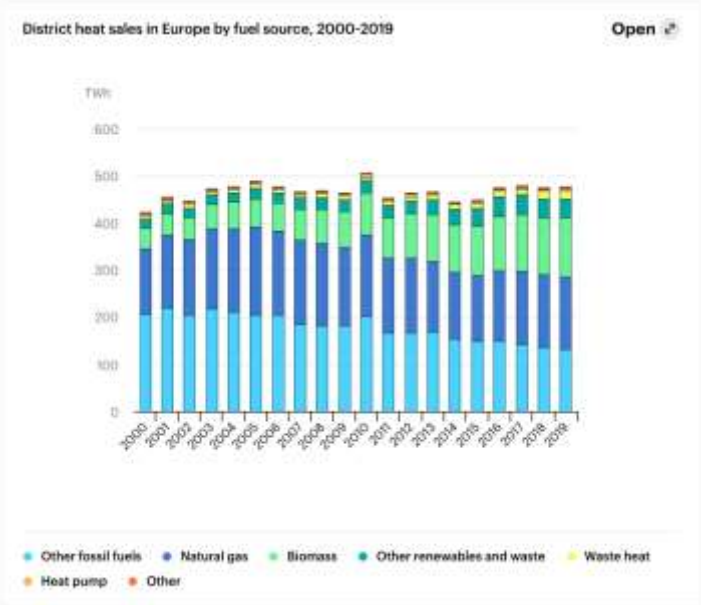


District Heating Small Modular Reactors

- Designing for production of district heating only requires lower temperature, lower pressure
  - Increased potential for Finnish manufacturing of critical components
- Modularity to lead to economies of scale plus speed / flexibility when building capacity
- Passive / Intrinsic safety – potential to situate at existing CHP plant sites or near population and use

- Ultimate target:
  - Commercialization of serialized nuclear district heating facility
  - 100 MW production; <150 M€ construction cost;

Rough estimate of the market



- In EU ~300 TWh/a of district heat is produced with fossil fuels, ~100 TWh/a with biomass
  - Most of this needs to be replaced
- Approx 2/3 of energy is being produced with 1/3 of capacity – which is 200 – 300 TWh/a
  - ”Baseload” suitable for nuclear energy
- 100 MW reference plant produces 0.5—0.6 TWh/a
  - Technoeconomic potential for ~500 plants in EU alone in the next decades
  - 15% market share represents ~10 B€ investment
- District heating networks being expanded
- Half a billion people in China in heating region

Finnish first market

For end user:

Dispatchable source of low-carbon heat

- Does not depend on electricity prices
- Low fuel costs, limited fuel transportation needs
- Economic alternative for heat supply

Potential number of District Heating Reactors in **Finland**

Käyttöaika-vaatimus / laitoskoko	4000 h	5000 h	6000 h	7000 h	8000 h
400 MW_DH	4	3	1	1	1
200 MW_DH	7	7	4	1	1
100 MW_DH	19	14	9	6	3
50 MW_DH	26	23	19	12	7
25 MW_DH	47	41	31	23	15

Short term potential considering current investments

Käyttöaika-vaatimus / laitoskoko	4000 h	5000 h	6000 h	7000 h	8000 h
400 MW_DH	1	1	1	0	0
200 MW_DH	4	3	1	1	0
100 MW_DH	8	6	2	1	1
50 MW_DH	14	11	5	2	1
25 MW_DH	21	17	8	3	1

VTT’s district heating reactor project

Goals of the project – first phase


Fossiilisille kyytiä! VTT kehittää pienreaktoria kaukolämpökäyttöön

The project was started in February 2020

The goal was to create a pre-conceptual design of a small nuclear reactor module for district heating applications:

- Design covers the reactor unit and main components of the heating pant
- Supplied temperature high enough for most of the year
- Pre-conceptual design by the end of 2020

- 2021 looking at system integration, component optimization
- 2022 consortium building

Design boundary conditions 1/2

- Based on existing technology:
  - No unconventional features, materials or manufacturing techniques
  - Design using VTT's in-house computational tools
  - No additional effort or new expertise required from the regulator*
  - Compatible with the Finnish final disposal concept

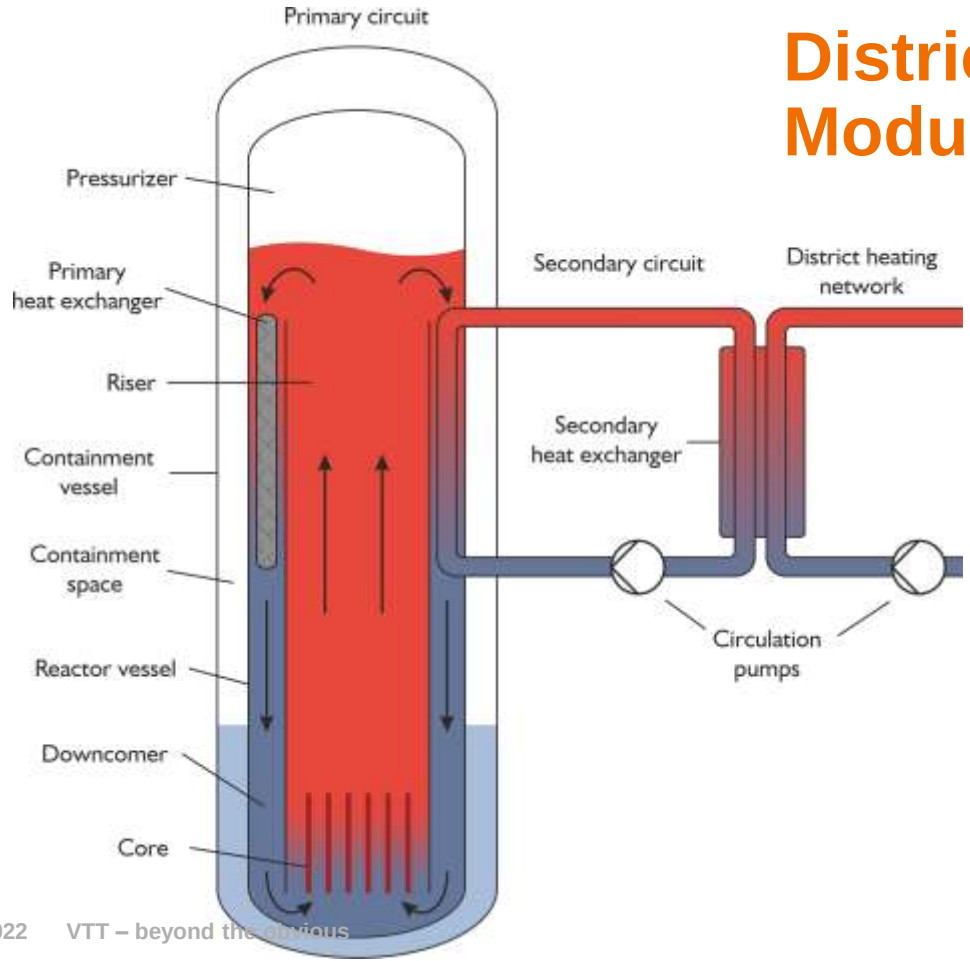
Mitigation of technology risks related to later stages of the project by relying on well-established solutions.

* Apart from common SMR challenges related to urban siting, EPZs, etc.

Design boundary conditions 2/2

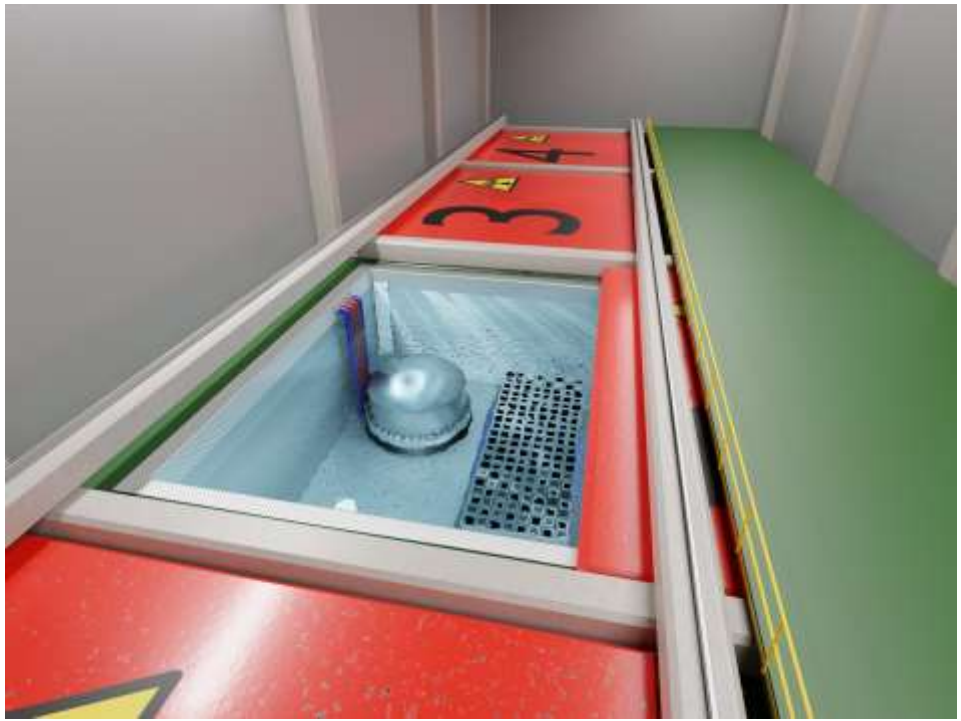
- Passive safety:
  - High level of safety achieved without complicated active multiply-redundant systems
  - Simple operating principle, in which safety relies on physical phenomena (gravity, buoyancy, etc.)
- Business opportunities for the Finnish industry:
  - Apart from fuel, all key components can be manufactured in Finland
  - Design work relies on Finnish experience and expertise
- Parallel in-house tools and competence development

District Heating Small Modular Reactors

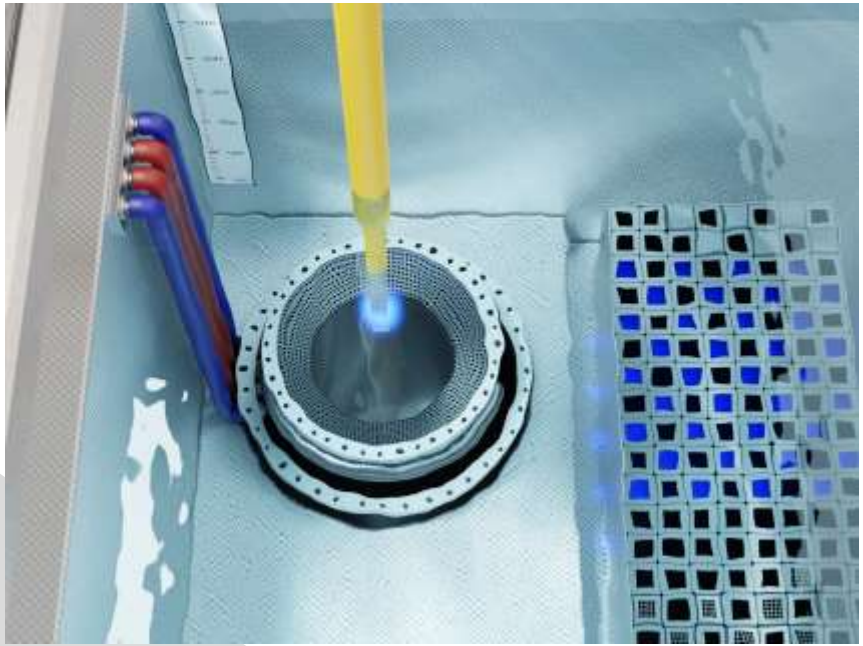


LDR-50 facility

LDR-50 reactor hall



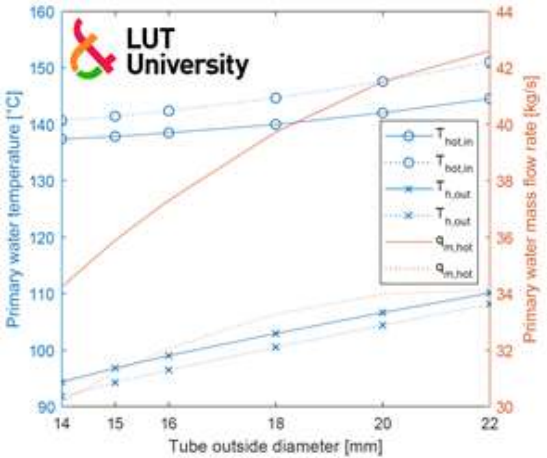
LDR-50 reactor module



Current status

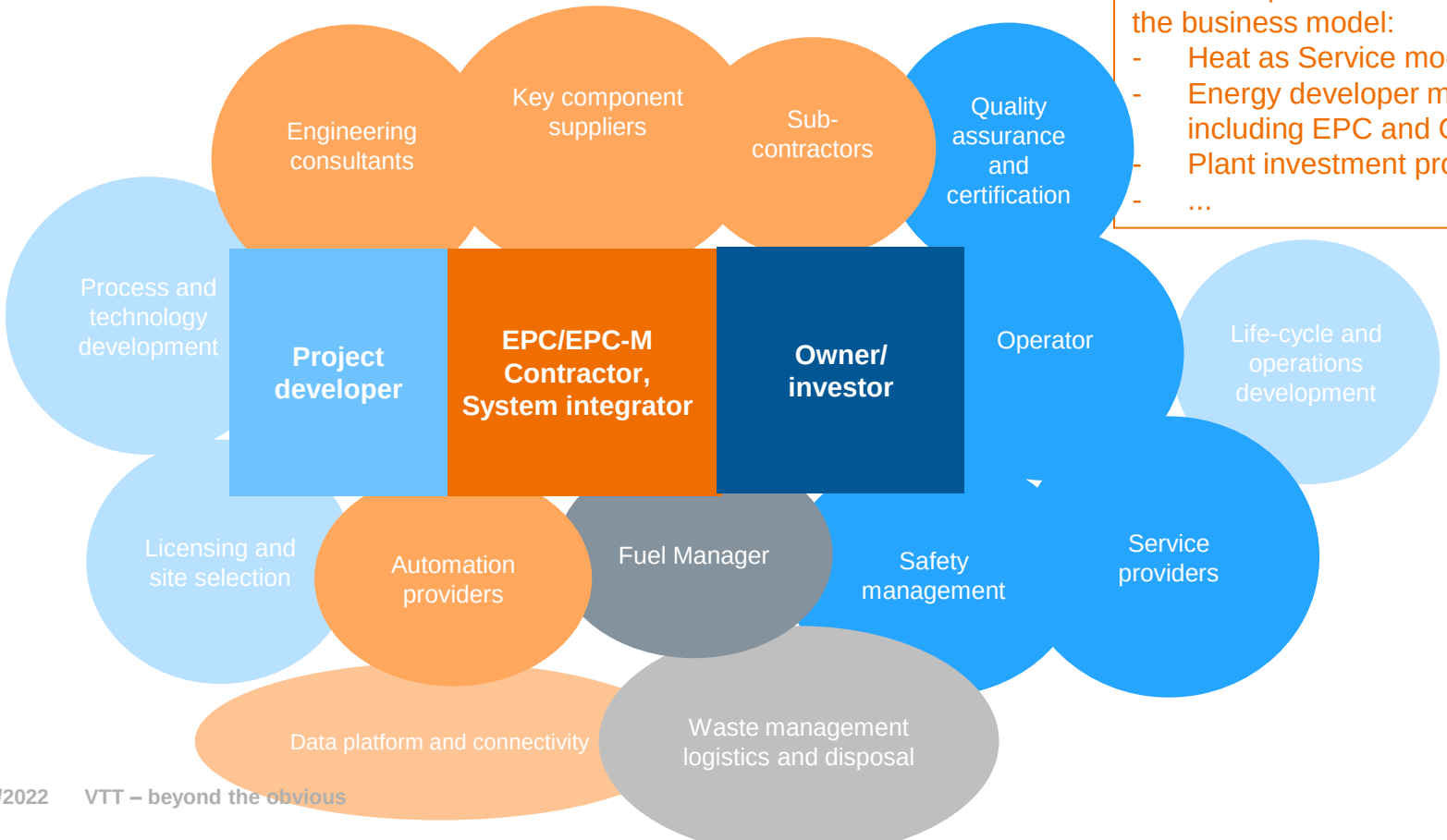
- Moving from conceptual to engineering design phase:
  - Basic functionality established, while keeping conservative margins and multiple design routes to reduce technology risk
  - Nuclear design based on traditional LWR technology with few unconventional features

- On-going work:
  - Modeling of realistic operating scenarios
  - Design of primary heat exchangers in collaboration with LUT University



Building a network

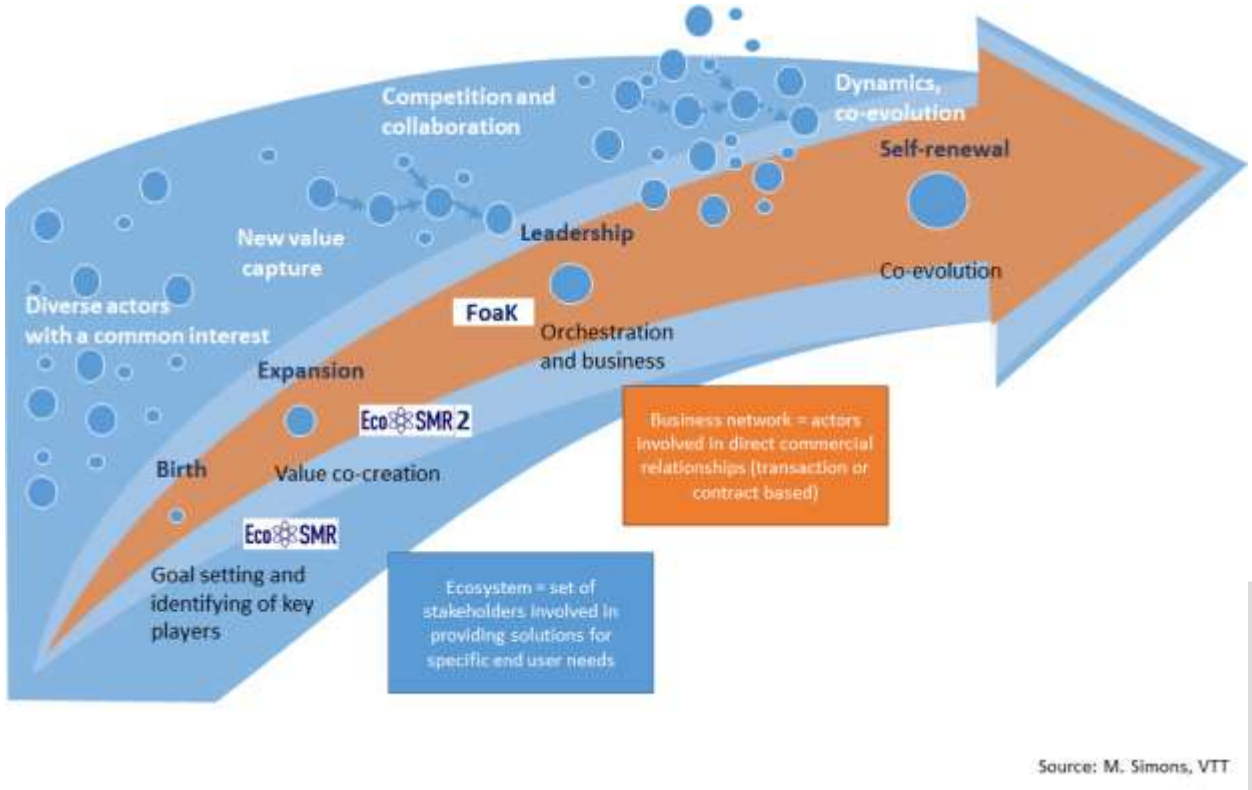
Final product needs a whole village



Different options for the business model:

- Heat as Service model
- Energy developer model, including EPC and O&M
- Plant investment project
- ...

Ecosystem building from small to big



Source: M. Simons, VTT

Mailstones:
1. Generic approval and interest
2. Key partners' commitment
3. FoaK, Production chain
4. Sustainable business network established


Seminar 3.-4.5.2022
Helsinki, Finland
Nuclear Energy Ecosystems -
Open Business Day 2022
- Building nuclear energy future together
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