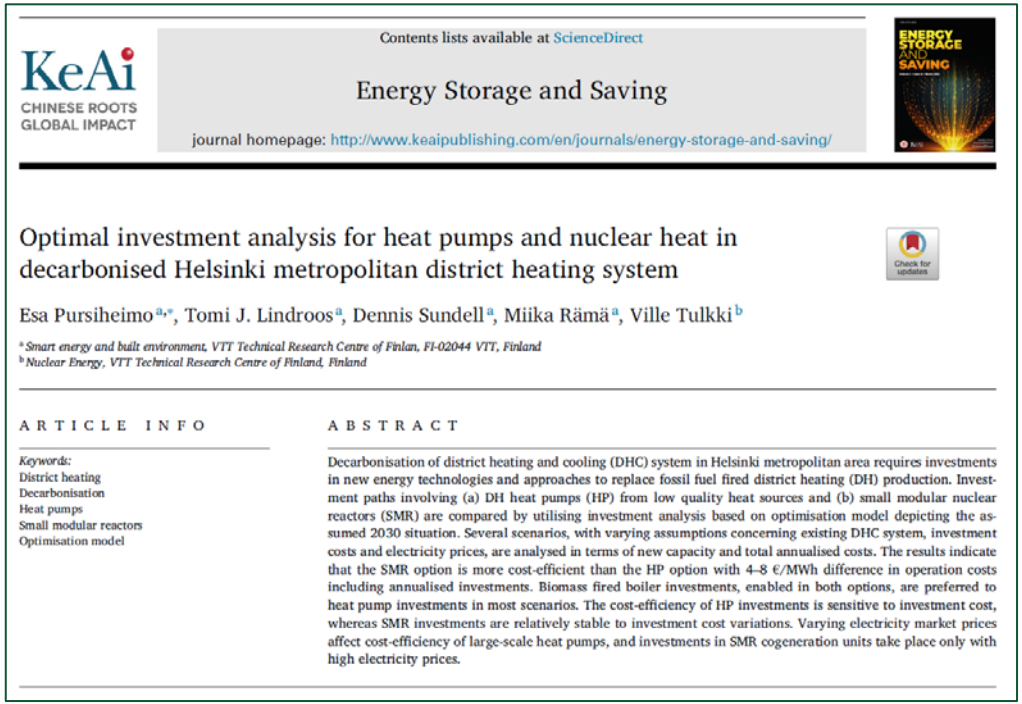
Investments in Nuclear Heating in Helsinki Metropolitan Area During Volatile Energy Markets

Esa Pursiheimo, Tomi J. Lindroos, Ville Tulkki

Basis for the analysis

- Previous SMR related DH system study concerned SMRs vs large scale heat pumps
- We use the energy system model and techno-economic parameters from this study
- Our analysis concerns the Helsinki + Espoo + Vantaa DH system in year 2030
- Work done under EcoSMR project



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Optimal investment analysis for heat pumps and nuclear heat in decarbonised Helsinki metropolitan district heating system

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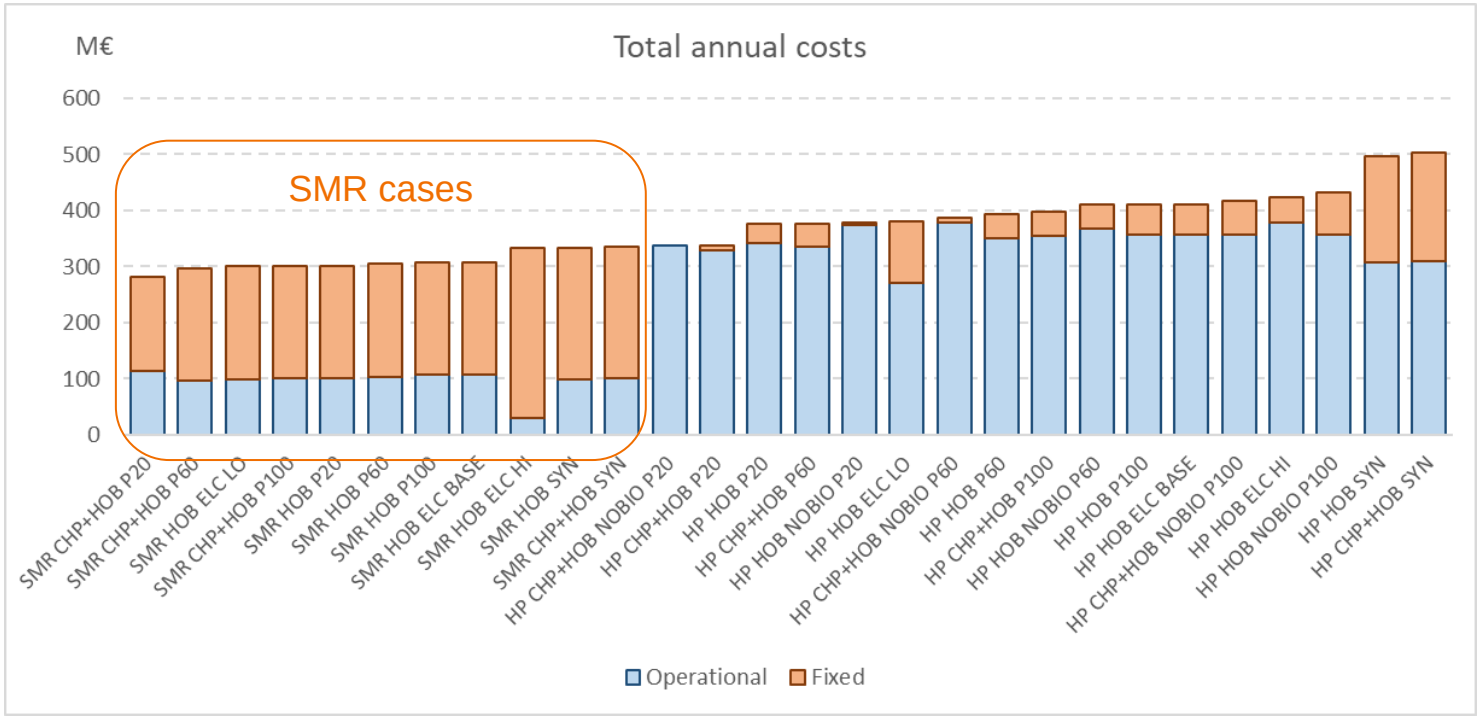
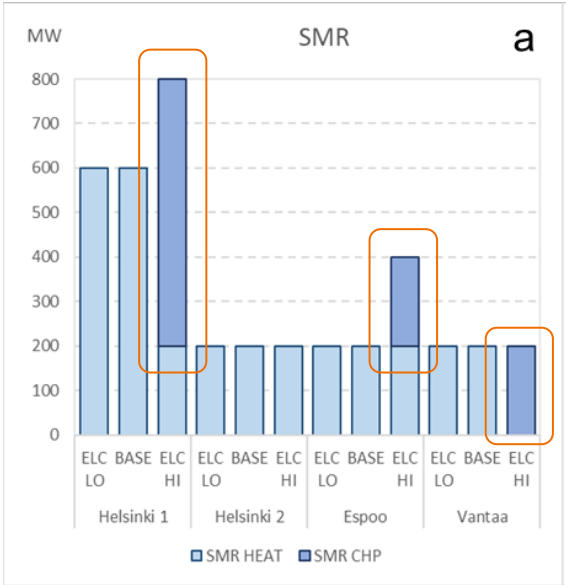
ABSTRACT

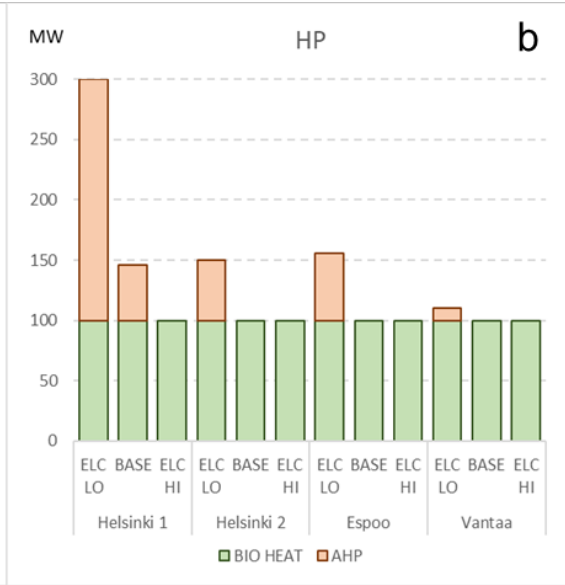
Decarbonisation of district heating and cooling (DHC) system in Helsinki metropolitan area requires investments in new energy technologies and approaches to replace fossil fuel fired district heating (DH) production. Investment paths involving (a) DH heat pumps (HP) from low quality heat sources and (b) small modular nuclear reactors (SMR) are compared by utilising investment analysis based on optimisation model depicting the assumed 2030 situation. Several scenarios, with varying assumptions concerning existing DHC system, investment costs and electricity prices, are analysed in terms of new capacity and total annualised costs. The results indicate that the SMR option is more cost-efficient than the HP option with 4–8 €/MWh difference in operation costs including annualised investments. Biomass fired boiler investments, enabled in both options, are preferred to heat pump investments in most scenarios. The cost-efficiency of HP investments is sensitive to investment cost, whereas SMR investments are relatively stable to investment cost variations. Varying electricity market prices affect cost-efficiency of large-scale heat pumps, and investments in SMR cogeneration units take place only with high electricity prices.

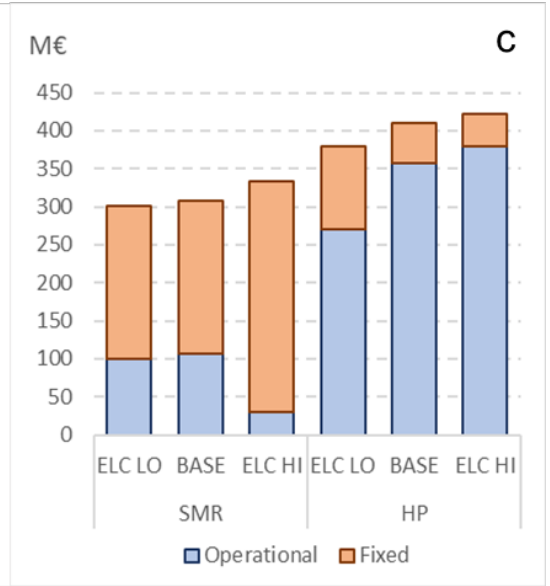
Results from the SMR vs HP scenarios



Results from the SMR vs HP scenarios

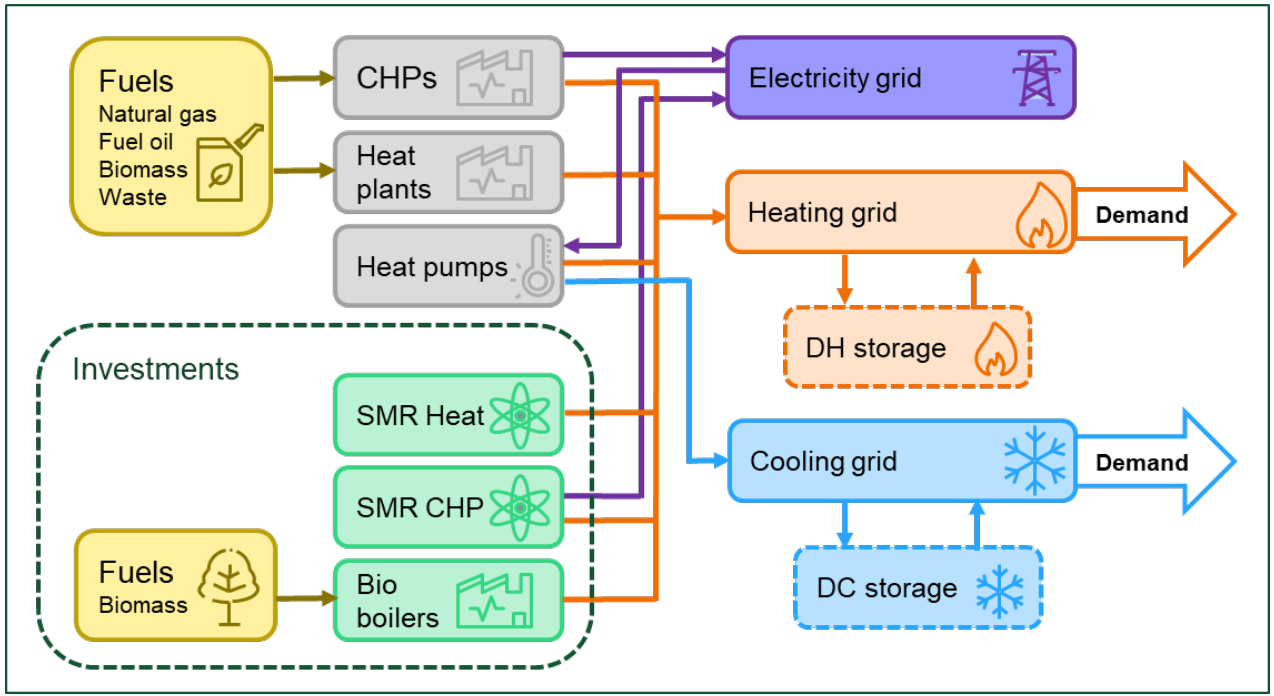






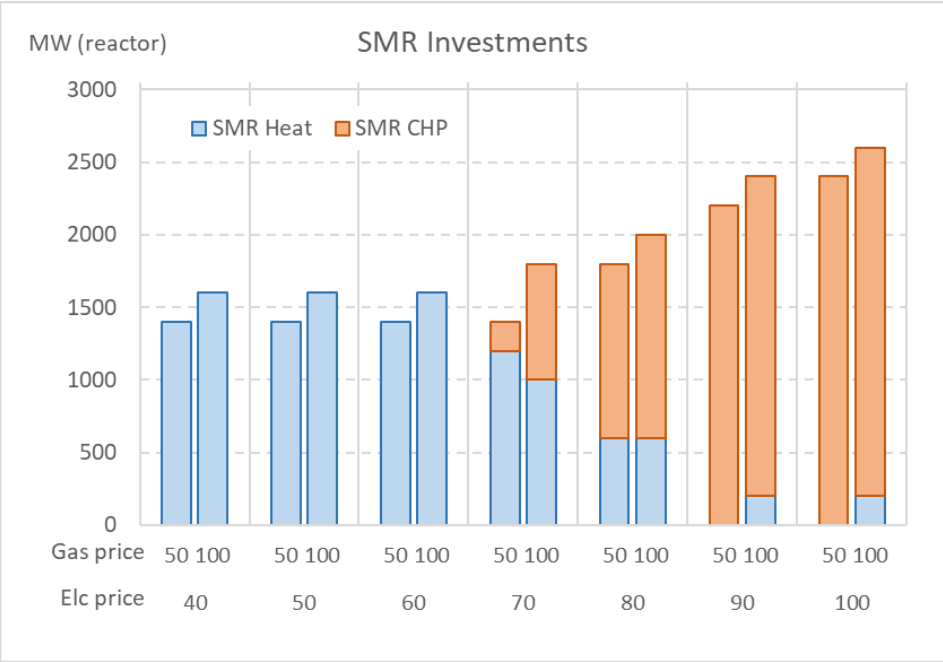
Energy system model structure

- Investment model
  - uses hourly data from sample weeks from analysed year and finds optimal investments
- Schedule model
  - optimises the entire year with fixed production capacity values



Phase #1: Heat-only-SMR vs CHP-SMR

- Investment model is run with varying gas (50/100 €/MWh) and electricity prices (40→100 €/MWh)
- Investments in CHP units start with 70+ €/MW electricity prices
- Effect of natural gas price on investments is relatively small
- 12 new units of SMR-CHPs add 600 MW in power generation capacity → affects market prices?



Phase #2: Price scenario combinations

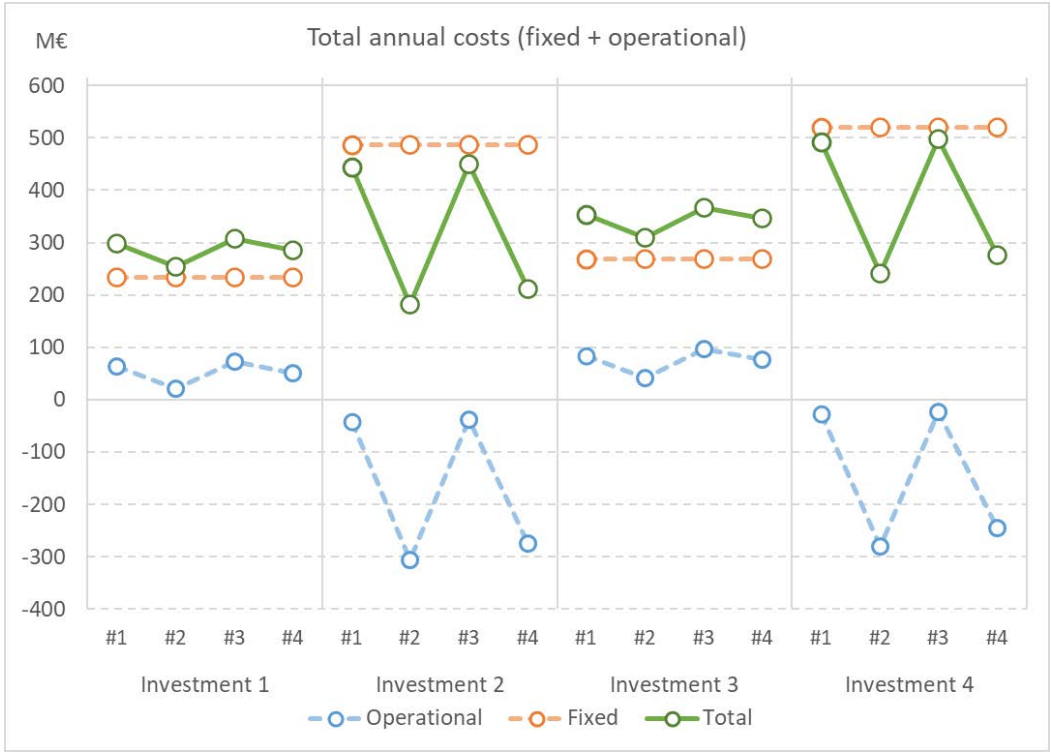
- Investment scenario #1 = capacity investments with price scenario #1
- Robustness to prices is tested by running investment scenarios with different price scenarios by using schedule model
- Total annual costs = annual system operation costs + annualised investment costs

Investment case / price case	Natural gas price	Electricity average market price
Case 1	50 €/MWh	40 €/MWh
Case 2	50 €/MWh	100 €/MWh
Case 3	100 €/MWh	40 €/MWh
Case 4	100 €/MWh	100 €/MWh

Phase #2: Results

- Total annual costs vary more with CHP investments (24 €/MWh) than with heat-only investments (5 €/MWh)
- On average heat-only investments have marginally lower total costs
- Flexibility of SMR-CHP enables high utilisation rates

Technology	Case 1-1	Case 4-4
SMR Heat	72 %	61 %
SMR CHP	-	99 %
Heat Pumps	28 %	3 %
Bio CHP	12 %	48 %
Bio Heat	10 %	28 %



Conclusions

- Investment scenarios were examined with varying energy prices
- SMR CHP units require 70+ €/MWh average market prices for investments to occur in our case
- Under varying energy prices CHP unit based DH system has significantly more fluctuation in terms of total annual costs when compared to heat-only unit based system
- Flexibility of CHP units materialise with higher utilisation rates

beyond

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