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Transitioning remote arctic settlements to renewable energy systems

- a modelling study of Longyearbyen, Svalbard

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The Independent Barents Observer

The port facilities for coal shipments in Van Mijenfjord. Photo: Thomas Nilsen

End comes to 100 years of Norwegian coal mining at Svalbard


ENERGIVERKET

Longyearbyen

- Norway's only coal-fired power plant
- Ageing infrastructure
  - Recent upgrades extended lifetime for another 20 years
- 70 GWh district heat and 40 GWh electricity per year
- About 60 000 ton CO_2 emitted per year
- Coal supply for ten more years

Longyearbyen needs a new energy supply!

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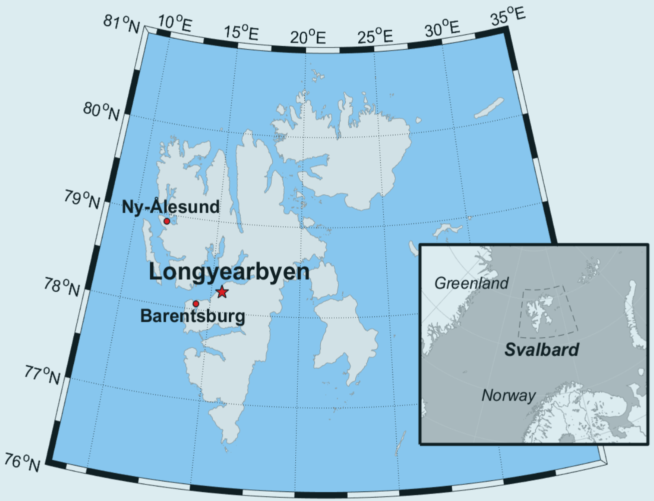
How can we transition the energy system in Longyearbyen to one based on renewable energy sources?

Modelling Approach

- Long-term energy model
  - TIMES-Longyearbyen
- Horizon: 2050
- Techno-economic linear optimisation tool
- Provides energy services at the lowest cost possible
  - Models investments in infrastructure, operation of the system and imports of energy carriers

- **Stochastic model version**
  - Takes into account the uncertainty of wind and solar availability
  - 60 operational scenarios modelled

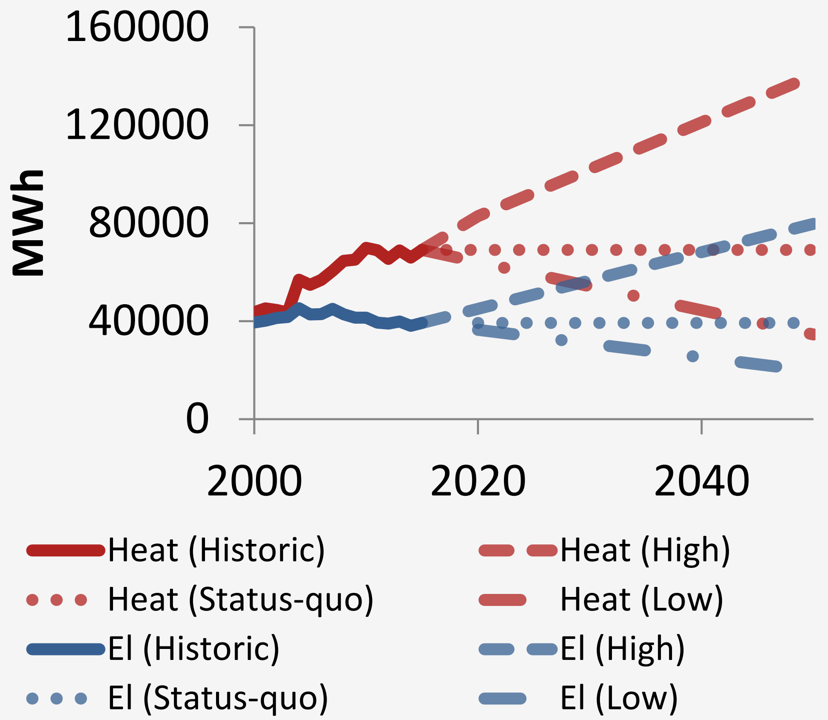


- Longyearbyen (78.2° N)
- Largest settlement on Svalbard
- About 2100 year-round residents

Demand Projections

- Model results are largely driven by the demand of energy services

- Three demand projections:
  - **Low** (Energy efficiency measures, lower population, reduced tourism etc.)
  - **Status-quo** (Same situation as today)
  - **High** (Doubled population, increased tourism etc.)



Model cases

ISO

- Isolated system with local renewable energy production

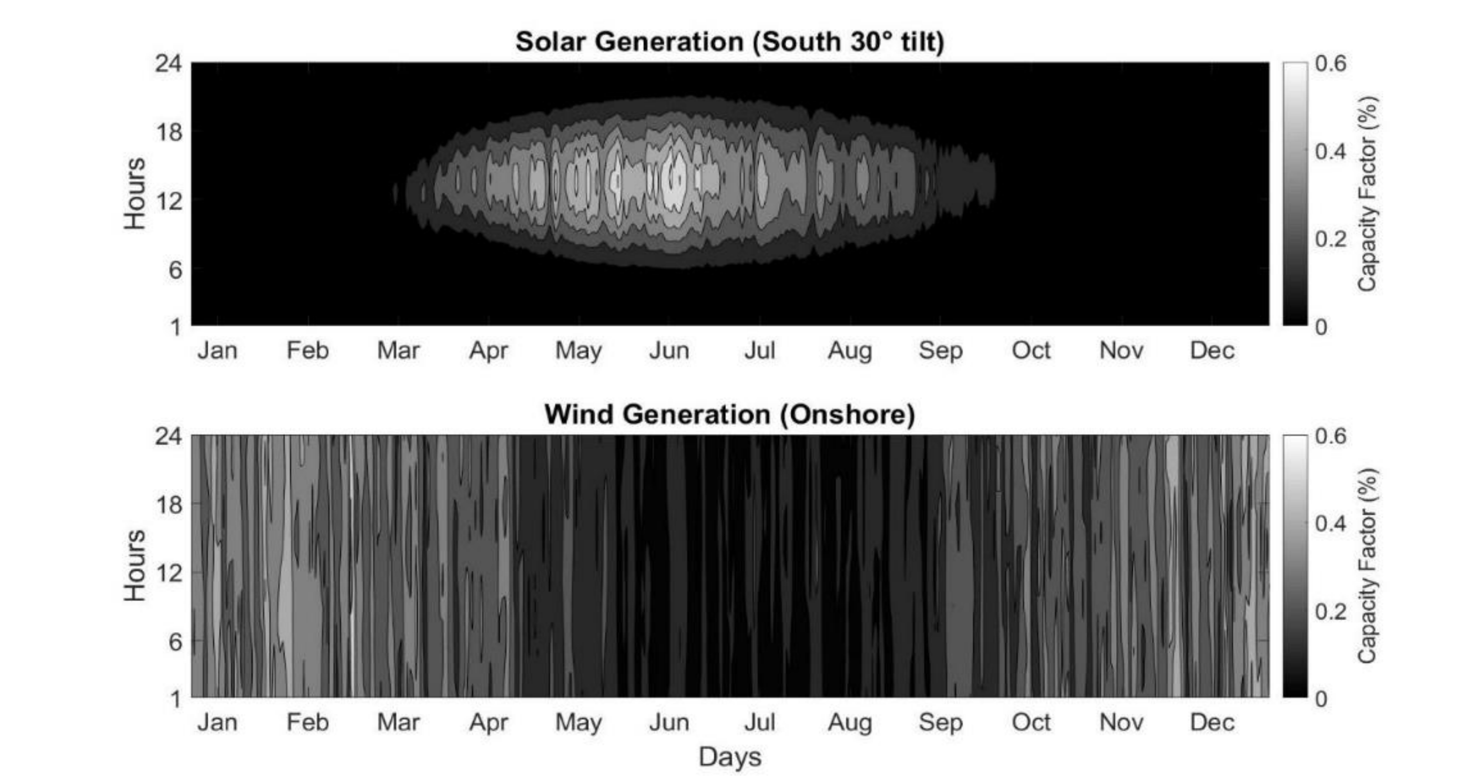
HYD

- Imports of hydrogen from mainland Norway

FOS

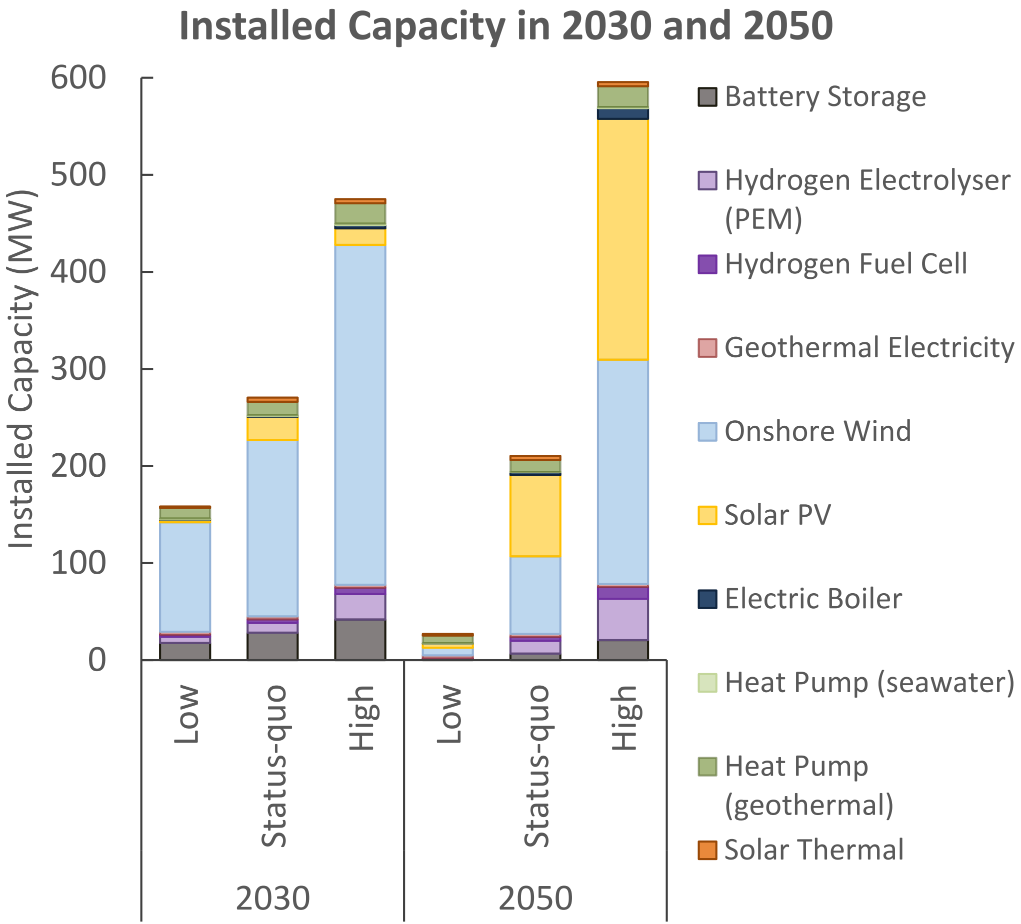
- No constraints, i.e. imports of both fossil fuels and hydrogen permitted

Solar and wind resources



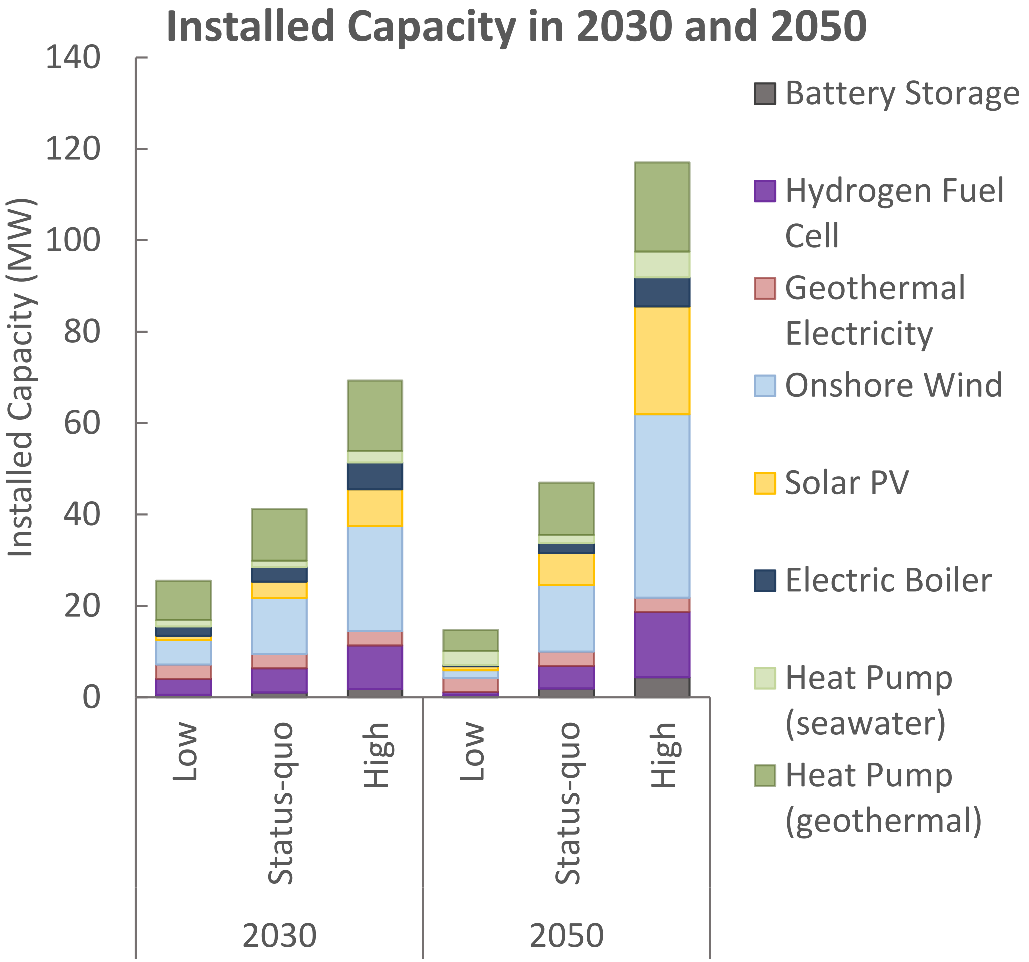
An isolated system

- High investments in infrastructure needed
- Full hydrogen value chain
- Large amounts of energy storage



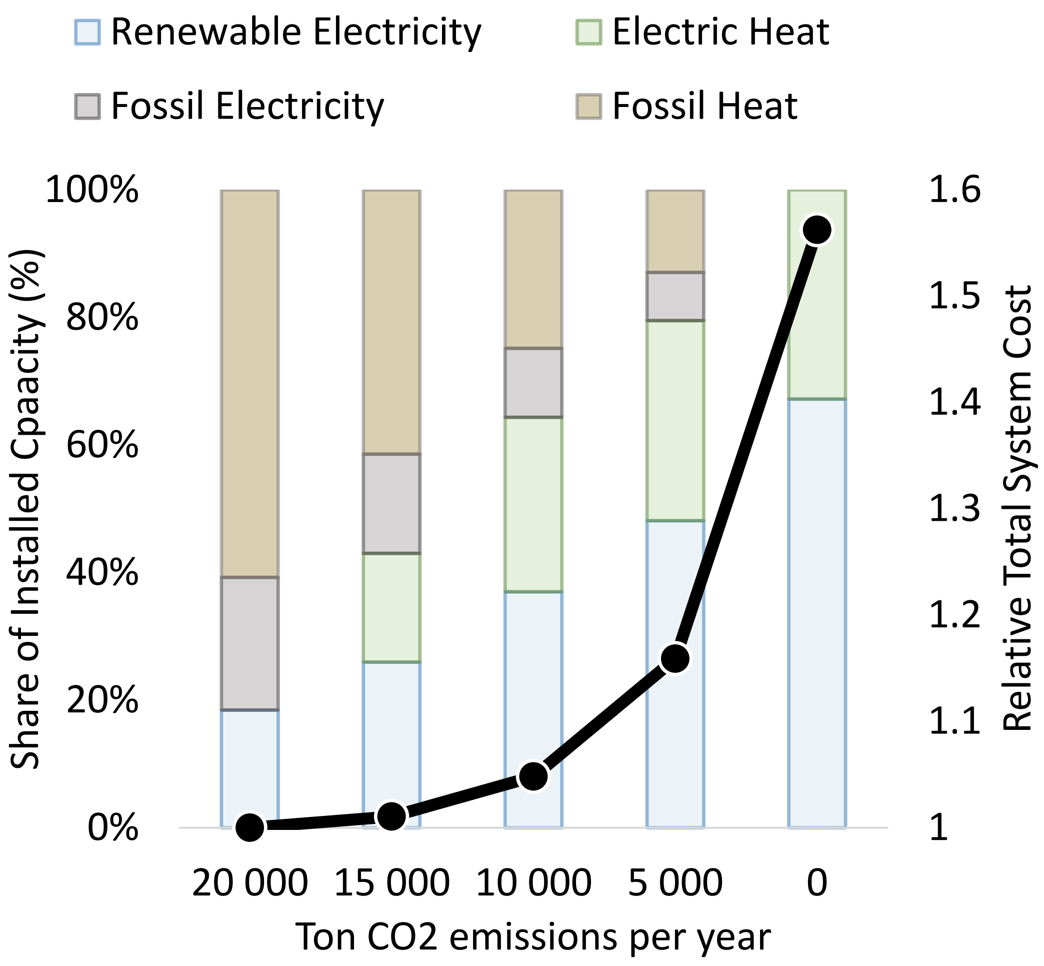
Hydrogen import

- Importing H_2 drastically reduces investments
- Reduces total costs by a factor 2 to 3
- 35 NOK per kg H_2



Import of fossil fuels

- Natural gas is preferred
- Reduces emissions by about a third
- System cost increases exponentially as emissions are further reduced



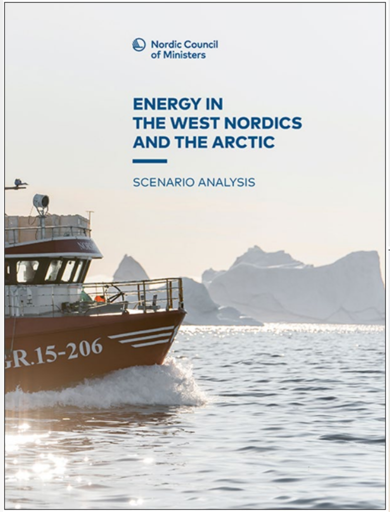
Overall results

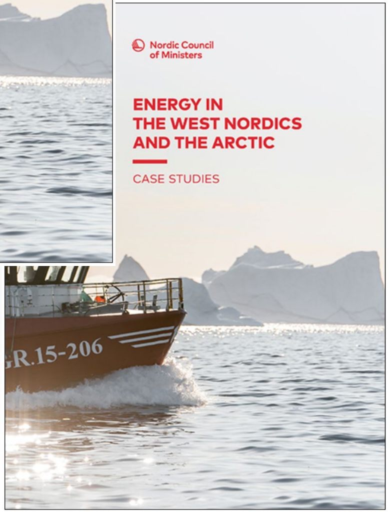
- All model cases lead to feasible solutions
- Allowing for minor emissions could be an effective way to reduce costs and increase system reliability
  - Reducing emissions to 5000 ton CO_2 per year could give a Cost of Energy of 1.76 NOK/kWh for the Status-quo demand projection

Model Cases	Total System Cost (bNOK)			Cost of Energy (NOK/kWh)		
	Low	Status-quo	High	Low	Status-quo	High
ISO	3.63	6.17	11.32	5.15	6.33	8.54
HYD	1.67	2.36	3.52	2.37	2.42	2.66
FOS	1.31	1.51	1.97	1.86	1.55	1.49

Comparison with EVA

- The results are in good agreement with the recommendations from EVA
- Solar and wind shows potential
- Smart energy use and energy efficiency
- Electrification of heating is required





Summary

- A renewable-based energy system is feasible for Longyearbyen
- Importing hydrogen is cheaper than an isolated system
- Fossil fuel reserve generators can be a good option to bring down costs with limited emissions

Transferable Outcomes

- The potential of solar energy use in the Arctic is underrated
- The combination of various resources and technologies is key
- In systems based on variable renewables, a small fossil fuel reserve is likely to reduce costs while only leading to limited emissions
- Renewable Arctic energy systems are possible **today!**

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