The future energy system in Longyearbyen

- A modelling study

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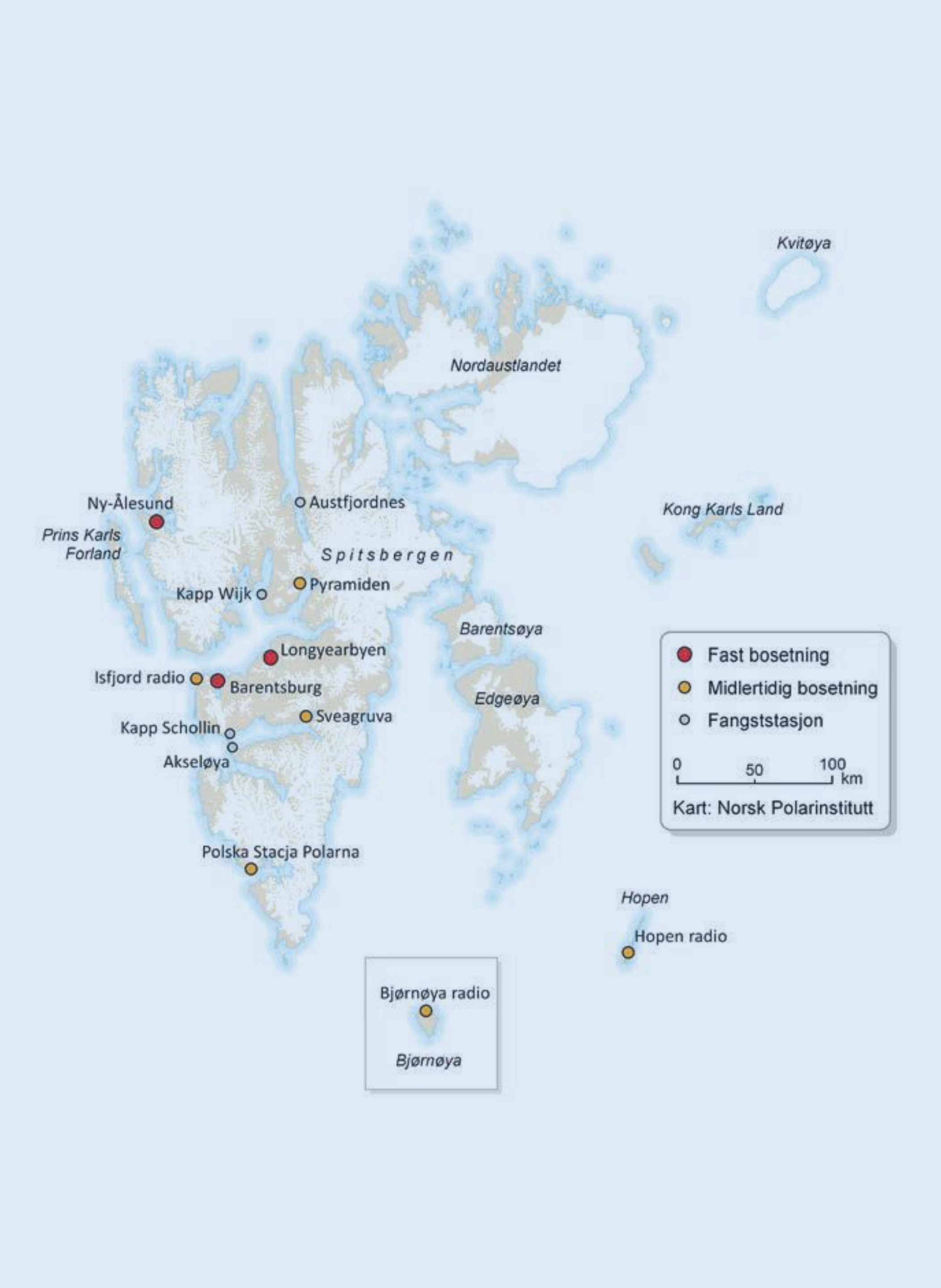
Illustration: www.colourbox.com

Longyearbyen

- Arctic climate (78.2° N)
- Largest settlement on Svalbard
- About 2100 year-round residents
- Heavily influenced by the coal industry



The energy system on Longyearbyen

- Only coal-fired power plant in Norway
- Built in 1982
- Electricity and heat
    - About 70 GWh district heat per year
    - About 40 GWh electricity
- 25 000 tonnes of coal
- Reserve diesel generators and oil boilers

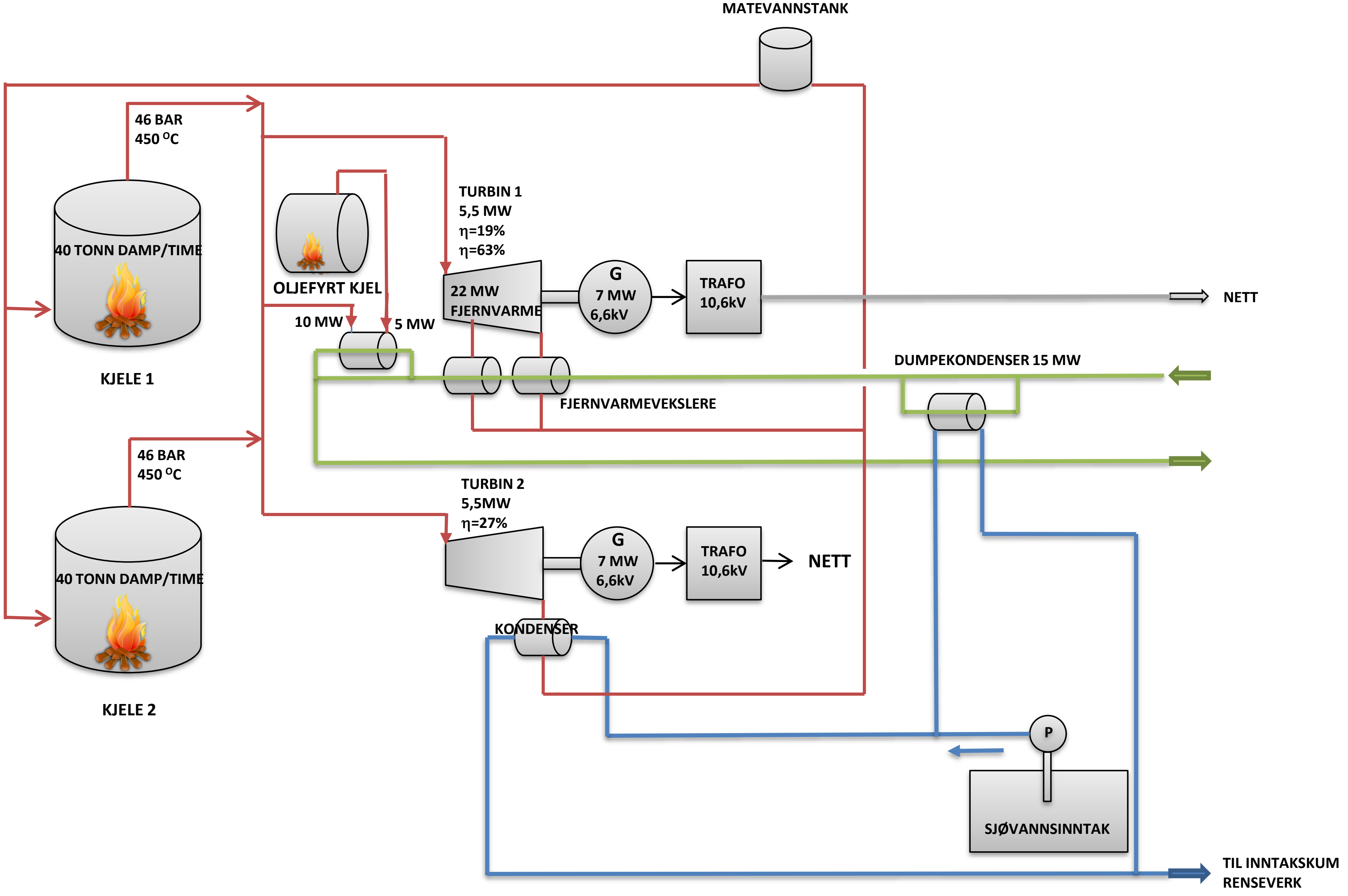


Figure: **Longyearbyens energisituasjon i dag og i fremtiden**, Kim Rune Røknes (Longyearbyen Lokalstyre)

Current situation

- Ageing infrastructure
    - Recent upgrades extends lifetime for about another 20 years
- Emissions
- Coal supply for ten more years?

Svea- og Lunckefjell-gruvene på Svalbard har fått nådestøtet av regjeringen. Her fra Svea. Foto: Tor Richardsen / NTB scanpix

Nyheter Industri

Stenger mesteparten av kulldriften på Svalbard

Regjeringen vil legge ned to av de tre kullgruvene Store Norske driver på Svalbard. Nå skal det ryddes opp mens den siste gruven drives i ti år til.

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

Motivation

- AGF 353/853 Sustainable Arctic Energy Exploration and Development
- Developed a very simple model of the energy system in Longyearbyen
- Obtained promising and interesting results

Excursion in the Russian settlement Barentsburg. Photo: Lars Henrik Smedsrud/UNIS.

Modelling approach

- TIMES-Longyearbyen
- Built from the TIMES (The Integrated MARKAL-EFOM System) framework
- The model aims to provide energy services at the lowest cost possible
  - Makes optimal decision regarding investments in infrastructure, operation of the system and imports of energy carriers
- Linear program (**deterministic,** i.e. only one operational scenario):

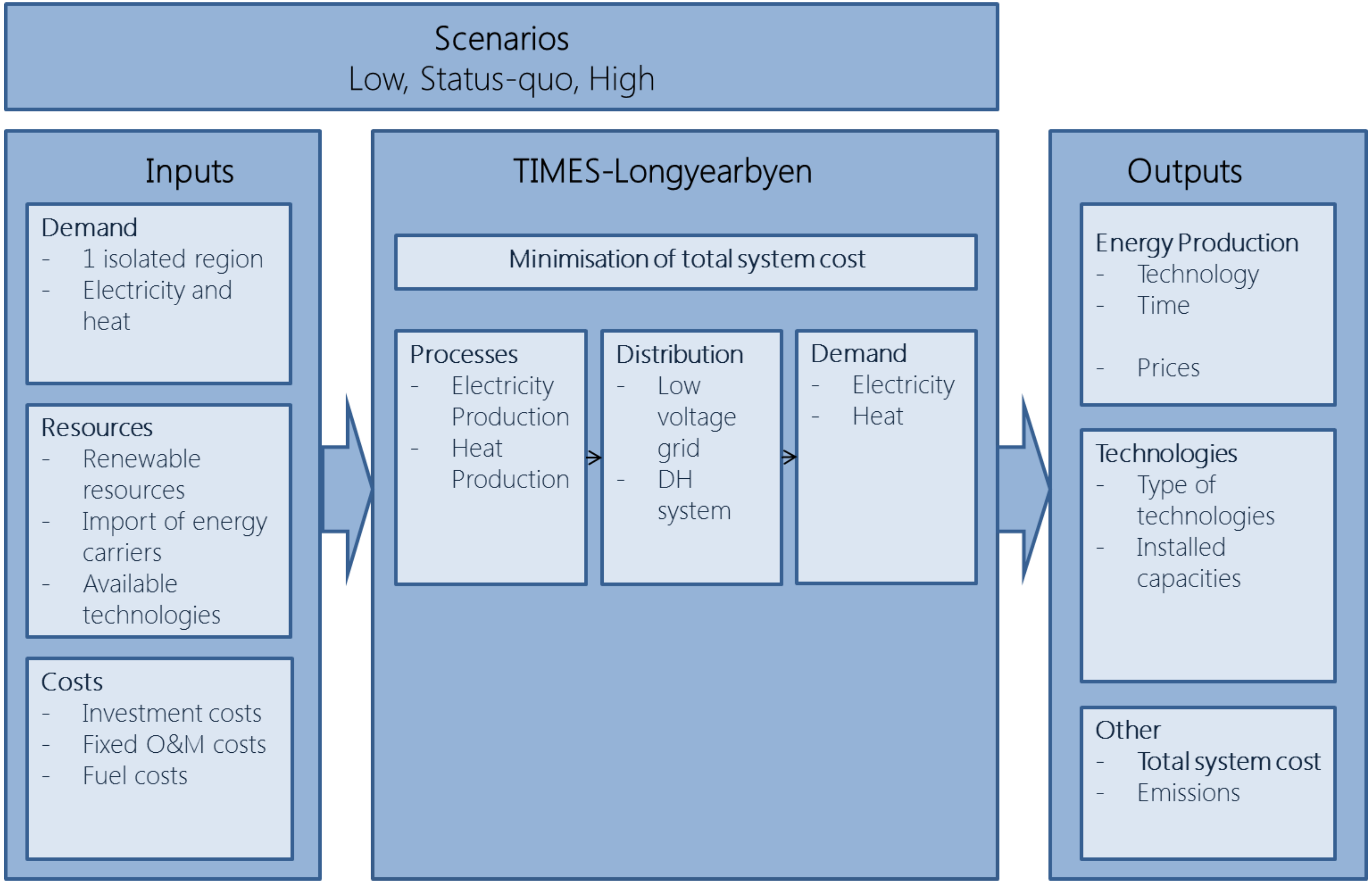
$$\min(c * X)$$

$$s.t. \quad \sum_k A_{k,i}(t) \geq D_i(t) \quad i = 1,2,\ldots,I; t = 1,\ldots,T$$

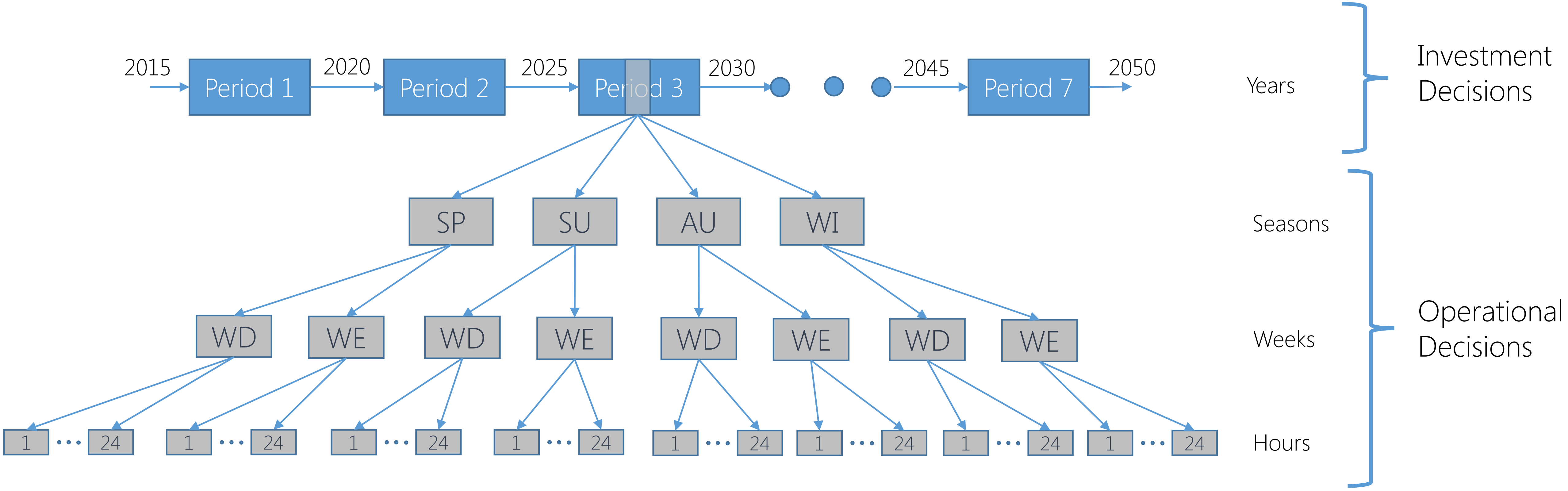
$$and \quad B * X \geq b$$

Model structure

- Model horizon: 2050
- Base-year: 2015
- Currency: NOK
- Discount rate: 4 %

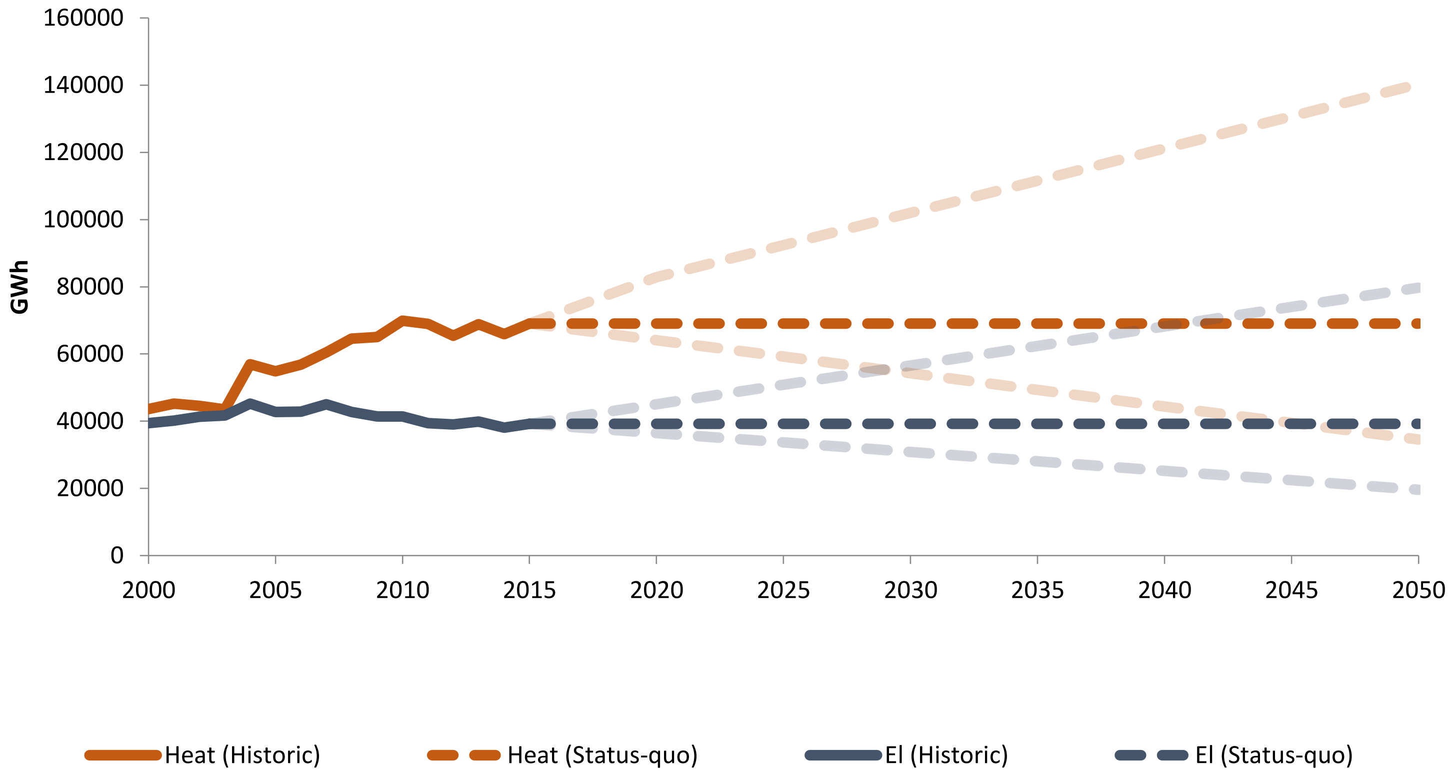


Temporal Resolution



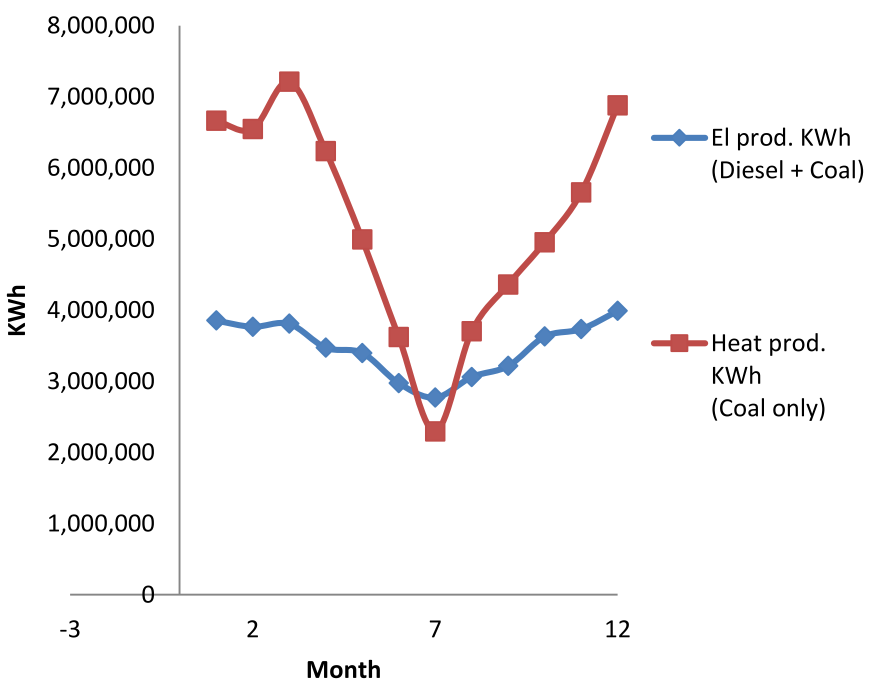
Demand projection scenarios

- High, low and status-quo scenario
- Results from the status-quo scenario will be presented

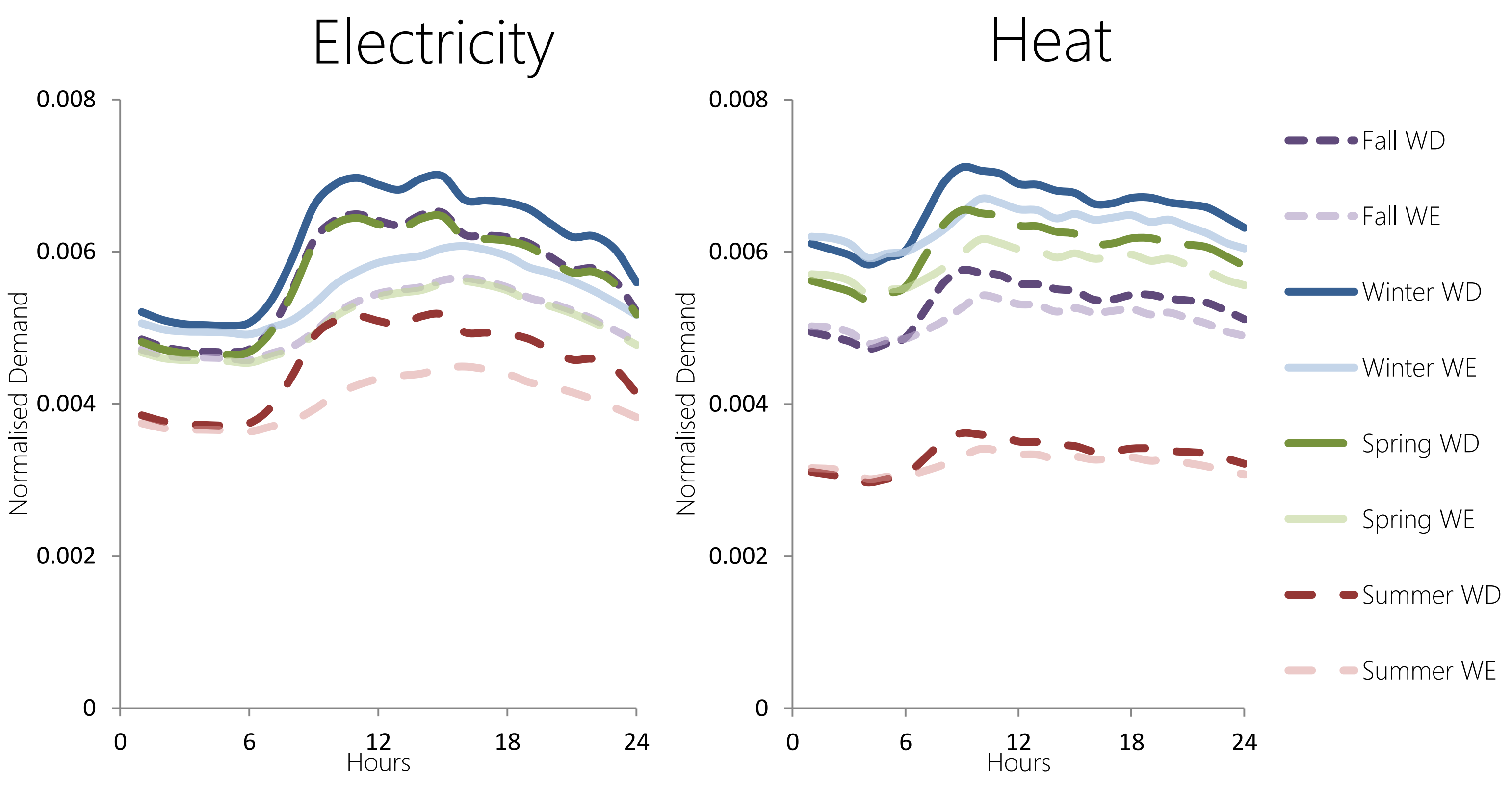


Demand for electricity and heat

Seasonal cycle



Daily profiles



Wind and Solar Resources

- 17 years of hourly data (01.01.2000 – 31.12.2016)
- Based on MERRA reanalysis data run through the GSEE (Global Solar Energy Estimator) model and the VWF model (Virtual Wind Farm) – Web application renewables.ninja

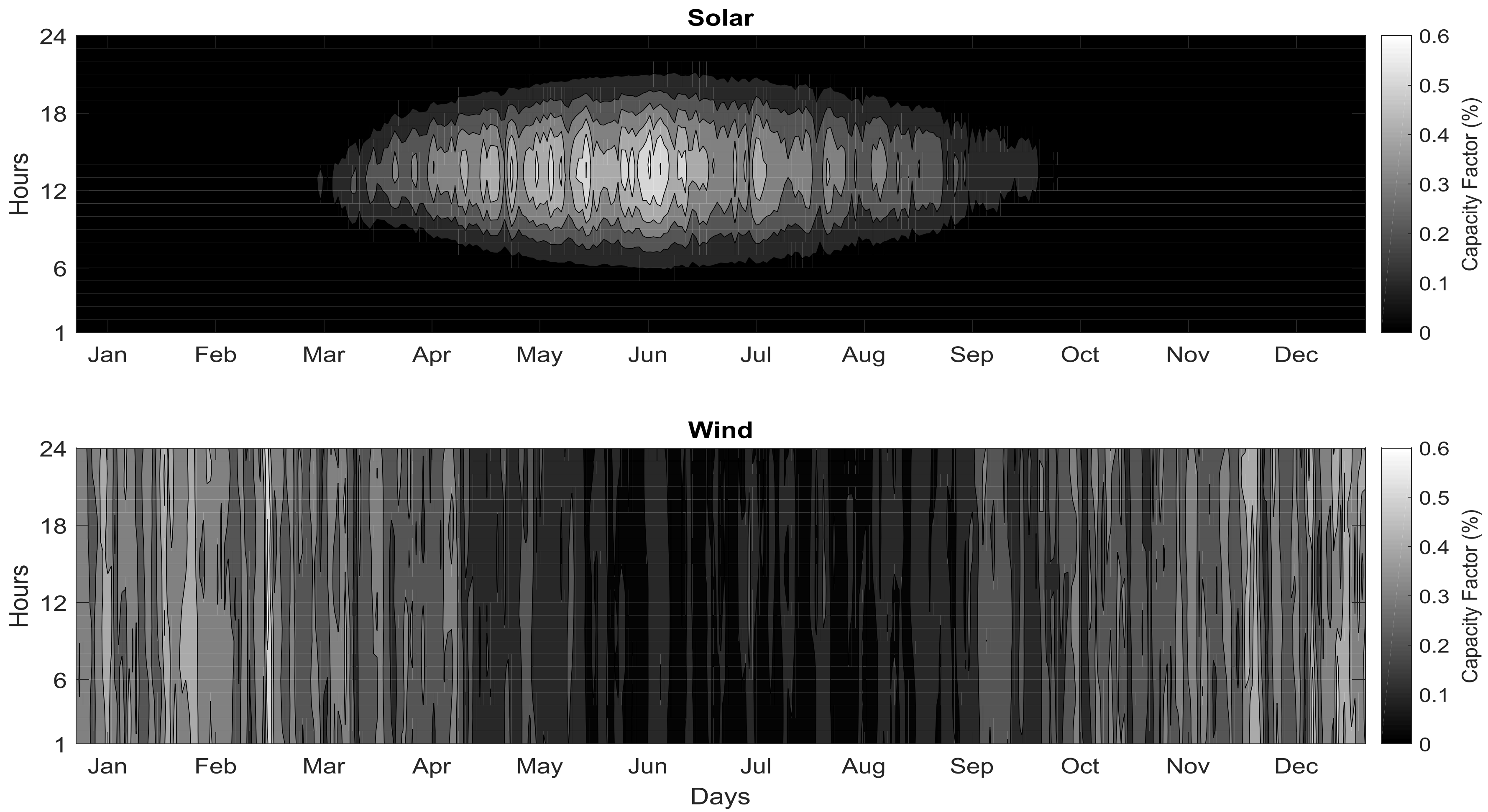
Table 2: Wind data specifications

Type	Location	Hub height (m)	Wind turbine model
Onshore	78.222 °N, 15.422 °E	80	Vestas V90 3000
Offshore	78.359 °N, 14.724 °E	80	Vestas V90 3000

Table 3: Solar data specifications

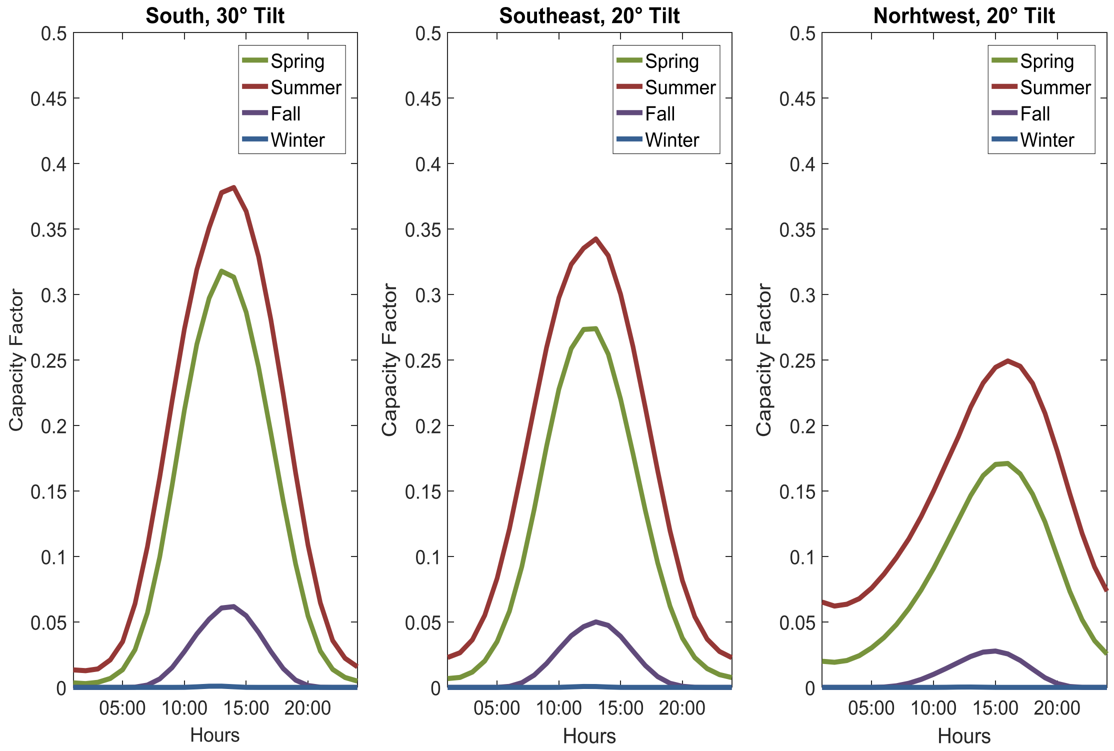
Type	Location	Orientation (Azimuth)	Tilt
Ground	78.222 °N, 15.422 °E	180° (South)	30°
Rooftop	78.201 °N, 15.837 °E	315° (Northwest)	20°
Rooftop	78.201 °N, 15.837 °E	135° (Southeast)	20°

Wind and Solar Resources

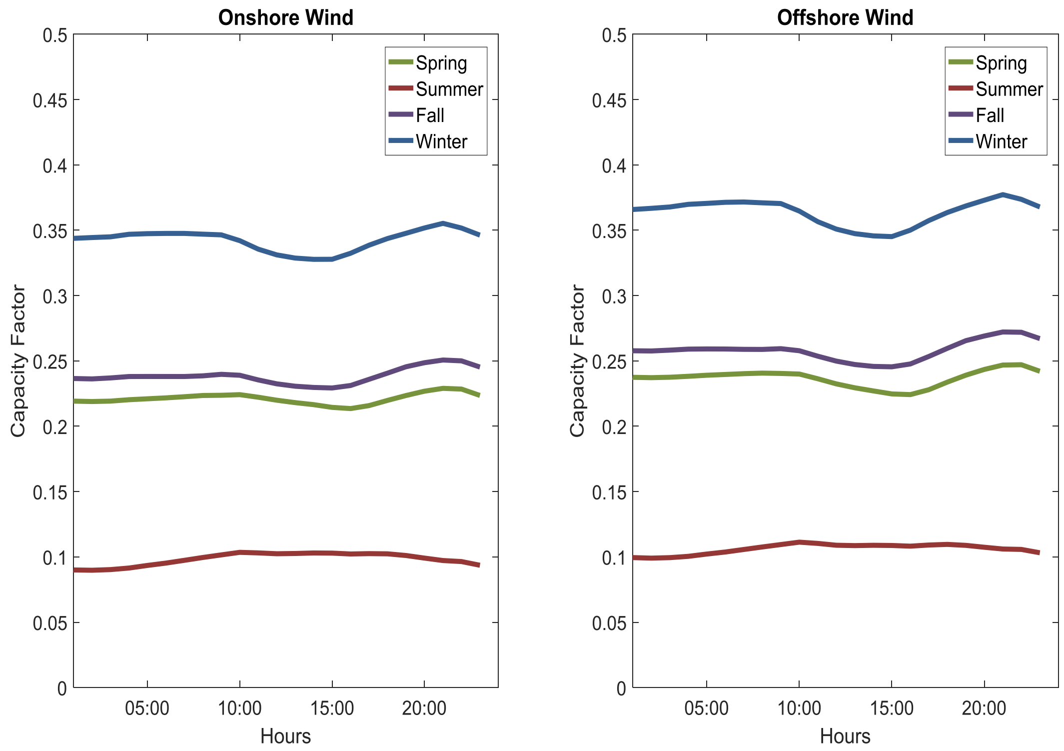


Solar and wind input profiles

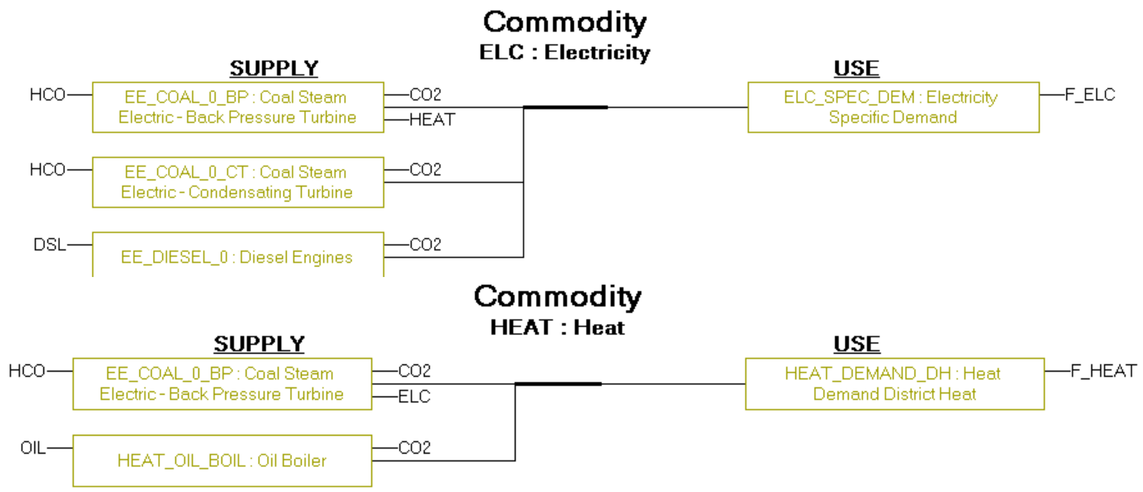
Solar

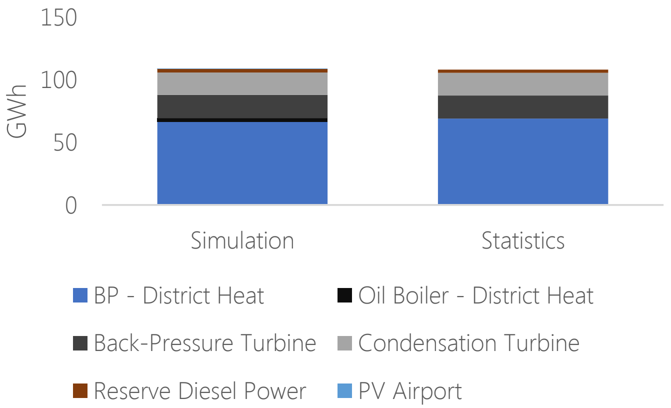


Wind

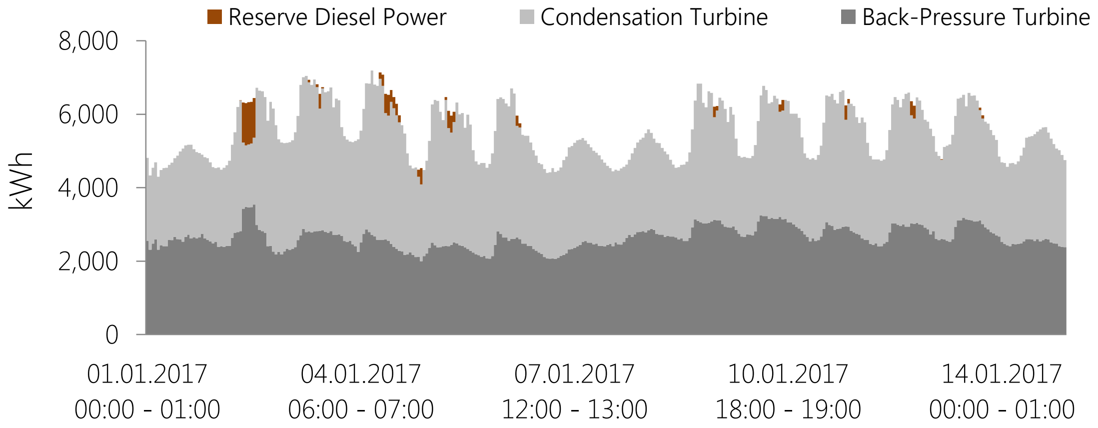


Calibration of existing system

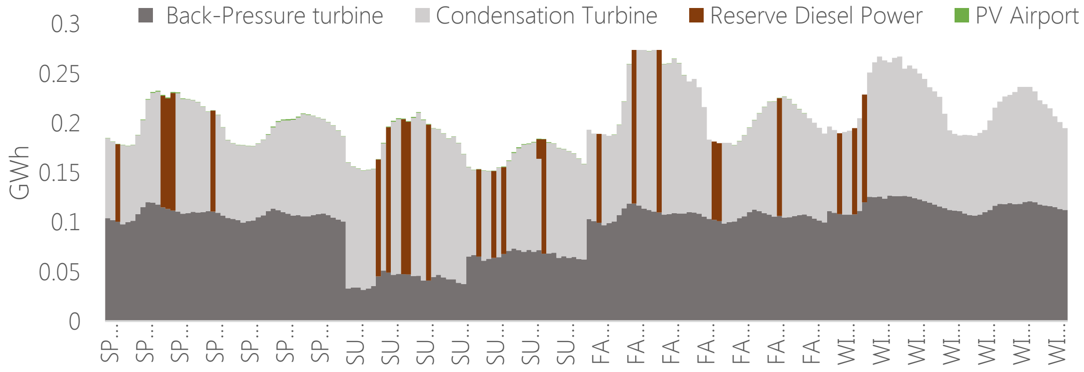




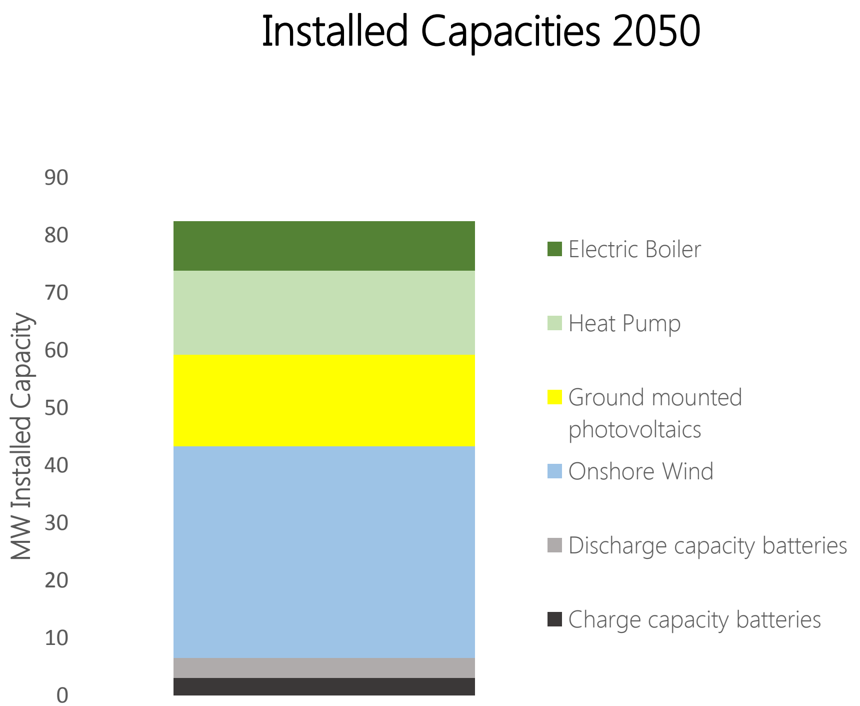
Statistics 01.-14.01 2017

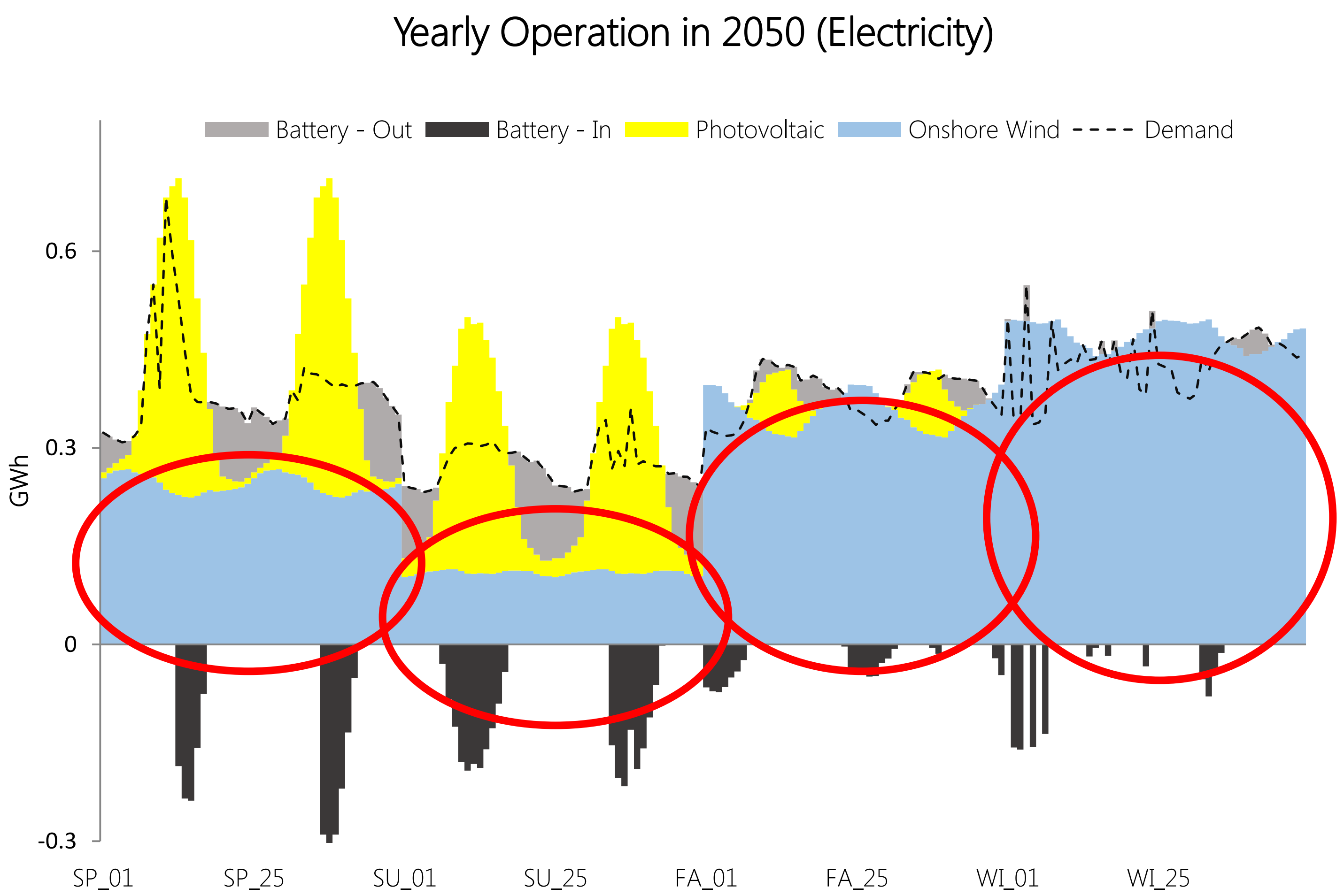


Model simulation of 2015



Deterministic Model Results 2050

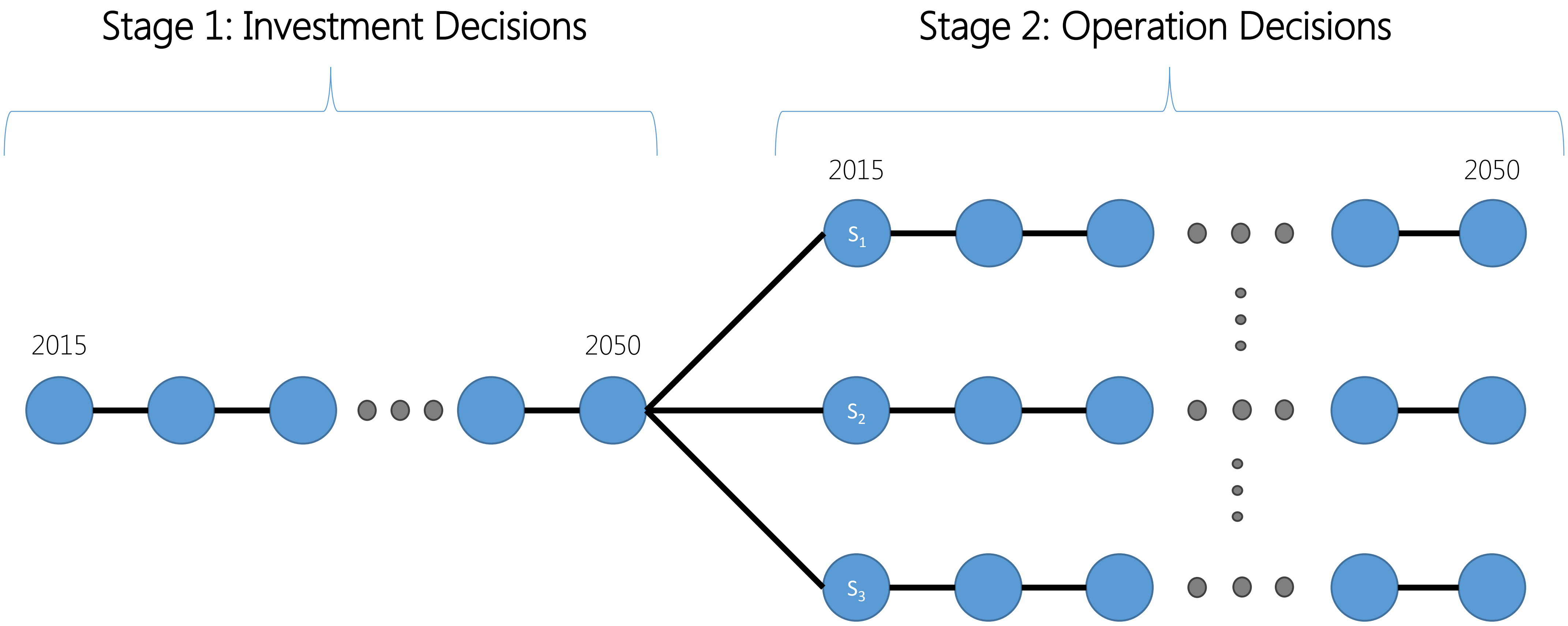




Stochastic Modelling Approach

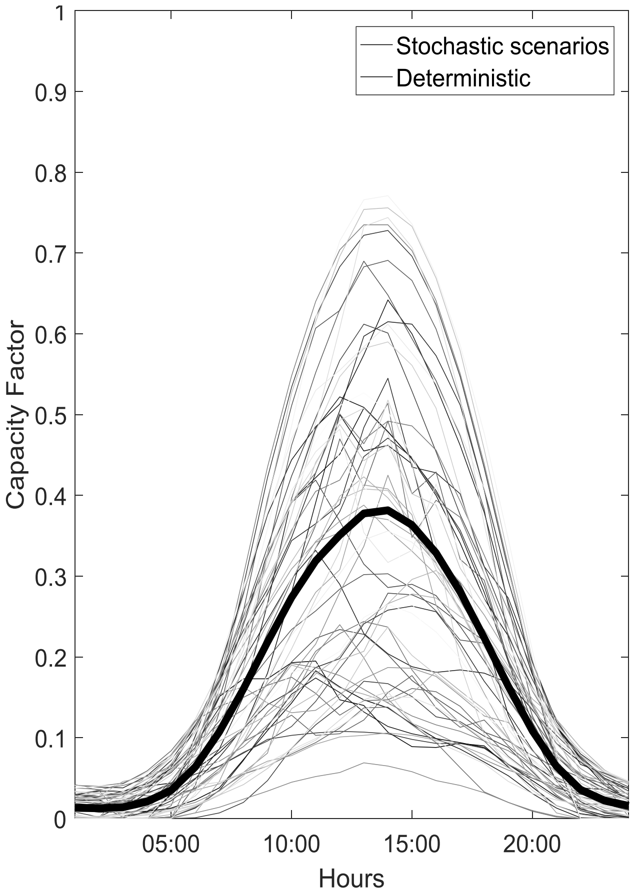
- The deterministic model treats wind power as a base-load generator
- A better representation of solar and wind variability is needed
- Treat solar and wind inputs as uncertain parameters, described by 60 operational scenarios
- Apply a two-stage stochastic model:
  - First stage involves investment decisions
  - Second stage deals with the operation of the system
  - Investments are feasible for all operational scenarios (Important for security of supply)

Stochastic Modelling Approach

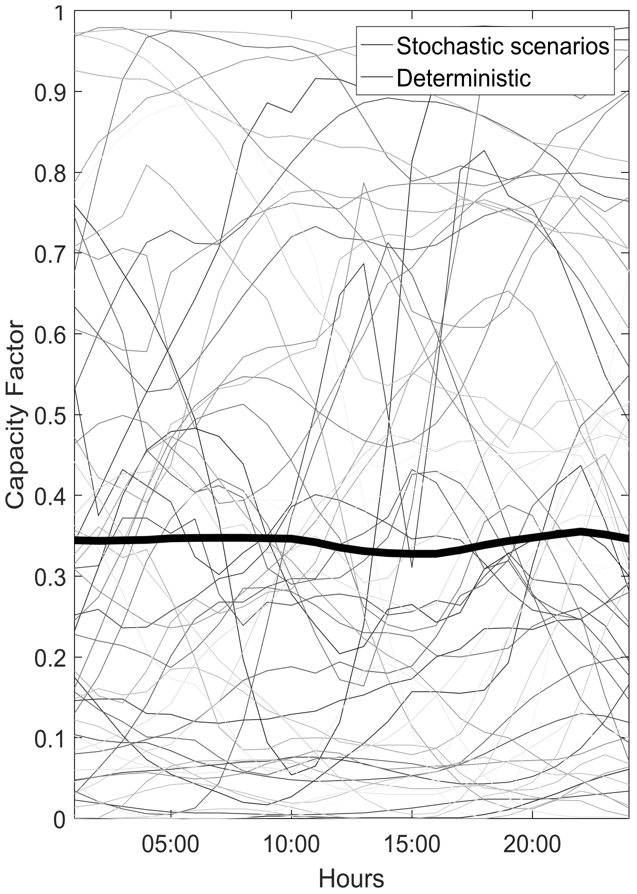


Solar and wind scenarios

Solar

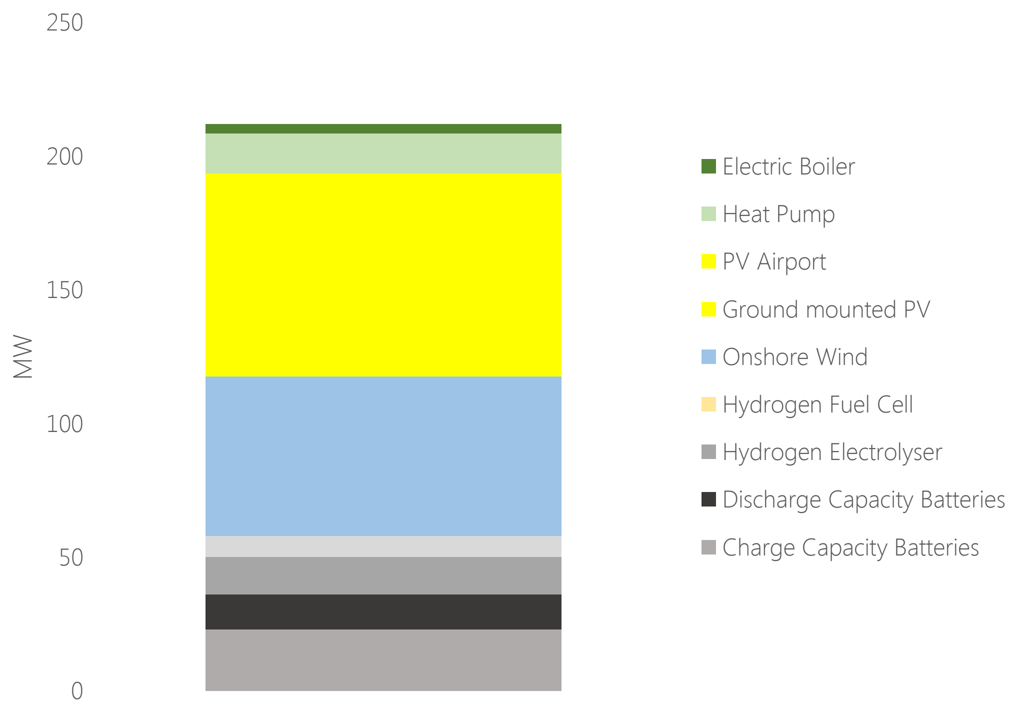


Wind



Stochastic modelling results

- Some modelling challenges that needs to be solved will change these results dramatically



Discussion

- A combination of solar and wind with energy storage shows promise for Longyearbyen
- Results still need to be solidified through the stochastic modelling approach
- There are a lot of technologies not included that should be discussed (Geothermal, CCS, hydropower, tidal, other storage options etc.)
- Future work can expand to look at the whole energy system
    - Decarbonisation of the transport sector (snowmobiles on hydrogen, emission-free tourism)

Thank you for your attention!