Research Centre on ZERO EMISSION NEIGHBOURHOODS IN SMART CITIES

The Research Council of Norway

NTNU

SINTEF

Investment analysis of a local energy system with seasonal thermal energy storage

Smart Energy Systems, Copenhagen 21.9.2021

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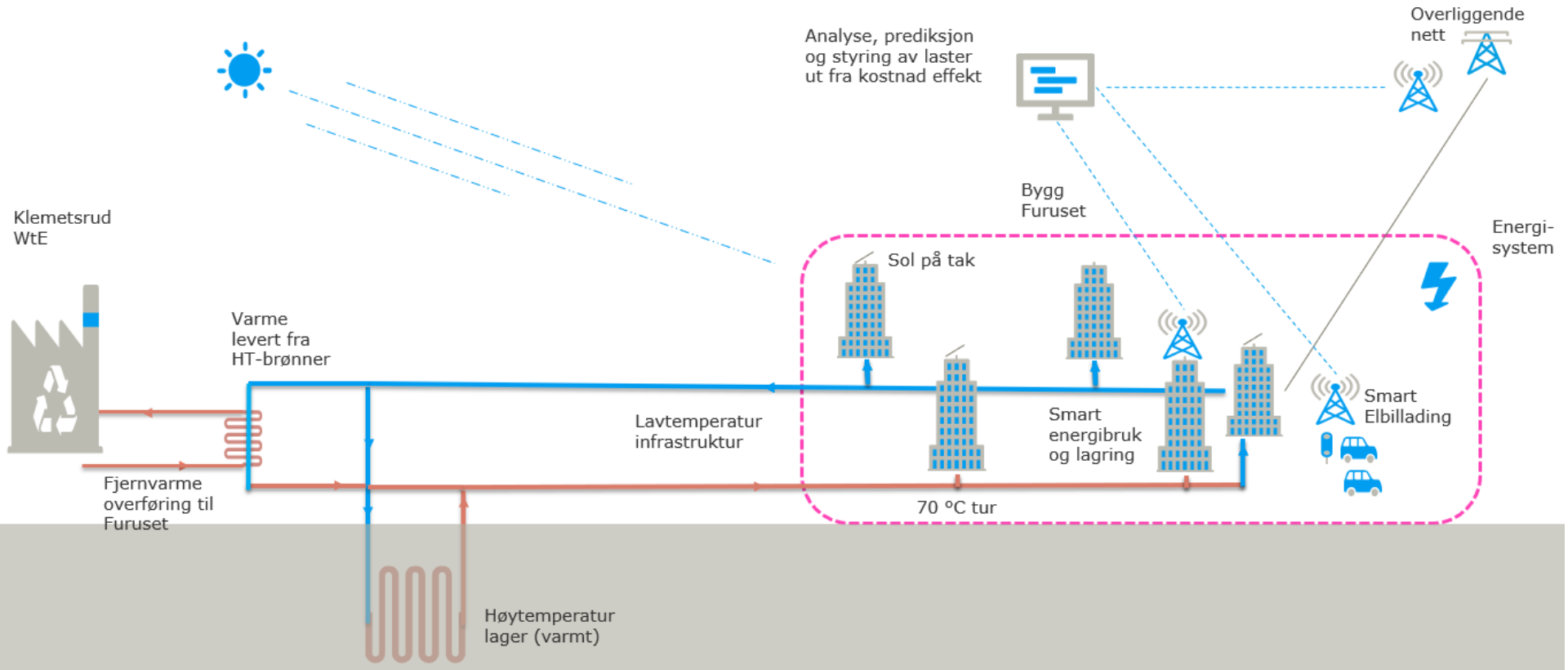
SINTEF Energy Research

The micro energy system of Furuset



Goal with the analysis

Main objective:
Demonstrate the benefits with district heating and seasonal thermal energy storage.

Techno-economic evaluation of three cases:

1. Direct electric heating
2. Conventional high-temperature DH
3. Low-temperature DH with seasonal thermal energy storage (STES)

	Energy demand [GWh/year]
Electricity specific	32.4
Electric vehicles	5.7
Total heating demand	31.9
Heating demand to be covered by DH	16.9
Heating demand to be covered by electricity	14.7

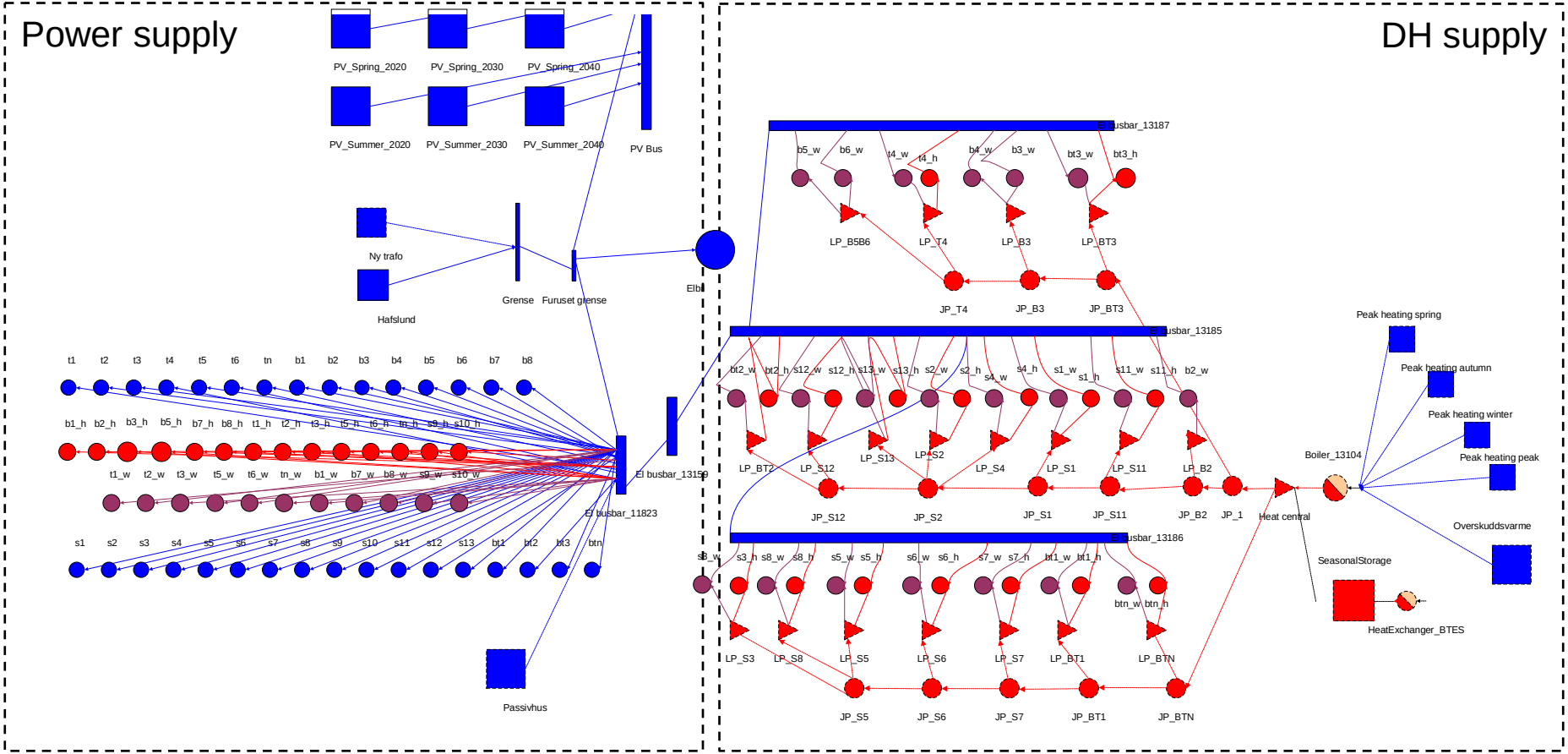
Methodology

Integrate – optimization of integrated energy systems

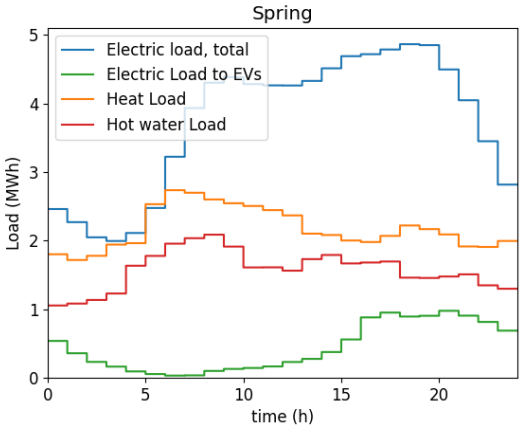
- Software for planning of local energy systems
- Multiple energy carriers: electricity, district heating, hydrogen, ..
- Optimization of
  - **Operation:** within 24 hours for a selected number of representative days
  - **Investments:** over a given planning period (e.g. 30 years)

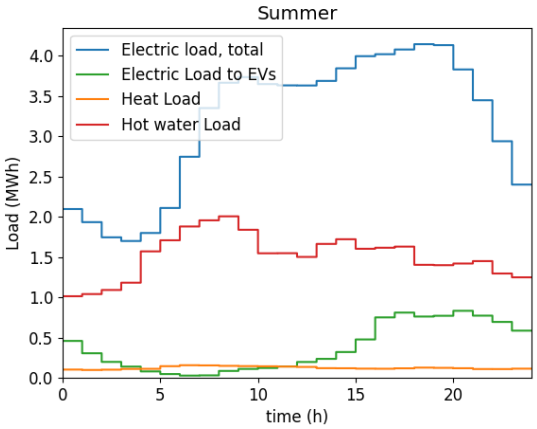
INTEGRATE

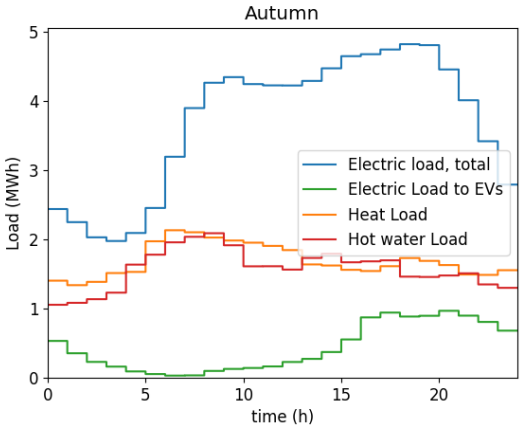
https://www.sintef.no/en/software/integrate/

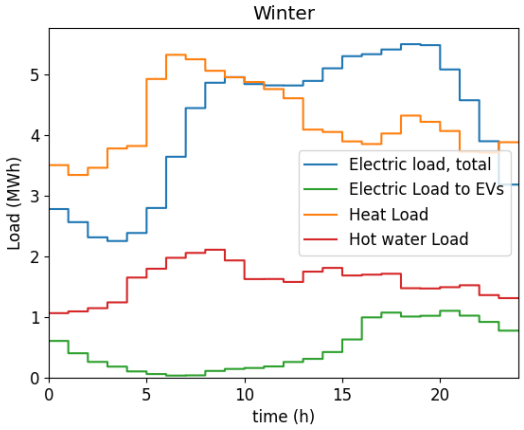

Power supply
DH supply
PV_Spring_2020
PV_Spring_2030
PV_Spring_2040
PV_Summer_2020
PV_Summer_2030
PV_Summer_2040
PV Bus
Ny trafo
Hafslund
Grense
Furuset grense
Elbil
El busbar_13159
El busbar_11823
Passivhus
El busbar_13187
El busbar_13185
El busbar_13186
LP_B5B6
LP_T4
LP_B3
LP_BT3
JP_T4
JP_B3
JP_BT3
LP_BT2
LP_S12
LP_S13
LP_S2
LP_S4
LP_S1
LP_S11
LP_B2
JP_S12
JP_S2
JP_S1
JP_S11
JP_B2
JP_1
Heat central
Boiler_13104
Peak heating spring
Peak heating autumn
Peak heating winter
Peak heating peak
Overskuddsvarme
SeasonalStorage
HeatExchanger_BTES
LP_S3
LP_S8
LP_S5
LP_S6
LP_S7
LP_BT1
LP_BTN
JP_S5
JP_S6
JP_S7
JP_BT1
JP_BTN

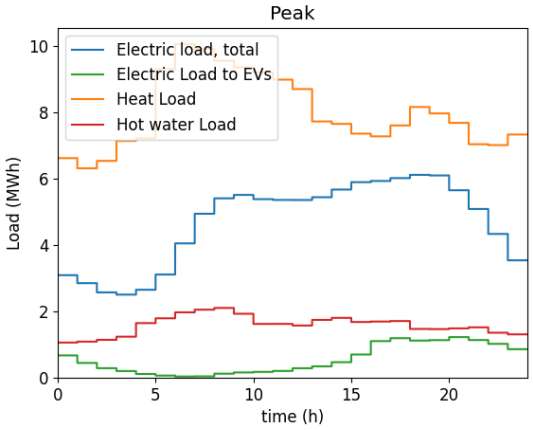
Daily load profiles









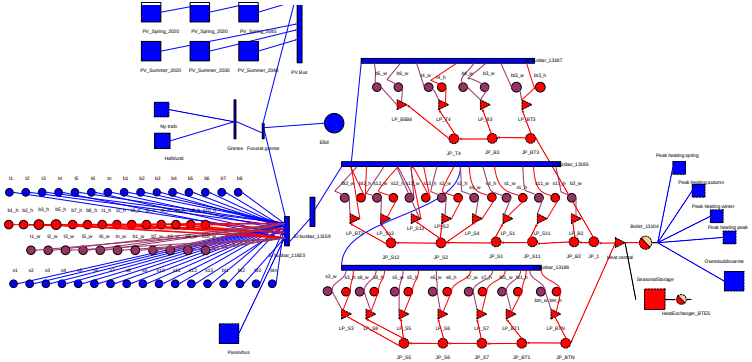


Seasonal Thermal Energy Storage – STES

- Capacity: **13 GWh**
- Annual heat loss: **5 GWh (38 %)**
- Max heat flow rate for charging/discharging: **4.27 / 4 MW**

	Number of days	Charge / discharge per season [MWh]
Peak	1	-50
Summer	127	13 000
Winter	123	-6 050
Autumn	62	-1 400
Spring	52	-500
Heat loss		-5 000
SUM	365	0

Investment analysis



Three alternatives:

1. Direct electric heating to all buidlings: no investment
2. High-temperature DH: total investment 6 M€
3. Low-temperature DH: total investment 13 M€

Evaluated period: 2020-2049, divided into three planning periods of 10 year each.

Technology	Must (can) be a part of	Cost [M€]	Lifetime [years]
New trafo	(1), (2), (3)	1.0	40
Heating network	2, 3	1.9	30
Seasonal thermal energy storage	3	6.8	60
Connection to HT DH	2,3	3.9	60
Upgrading the existing building mass	(1), (2), (3)	97.0	30

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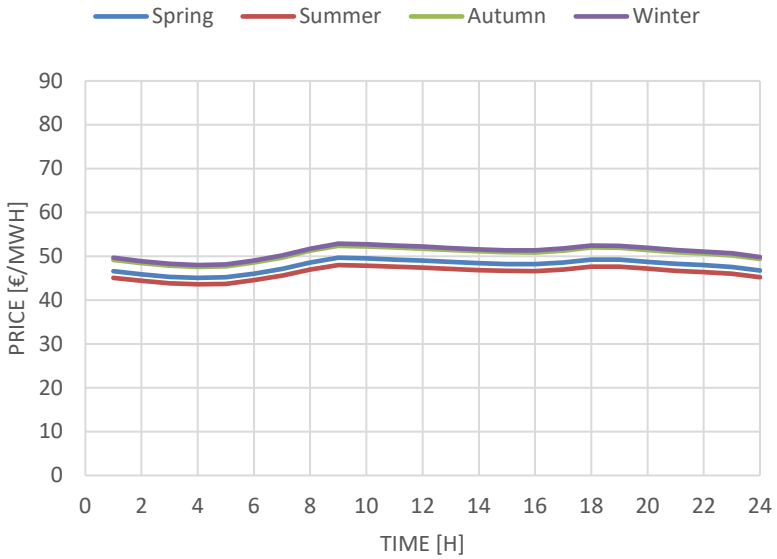
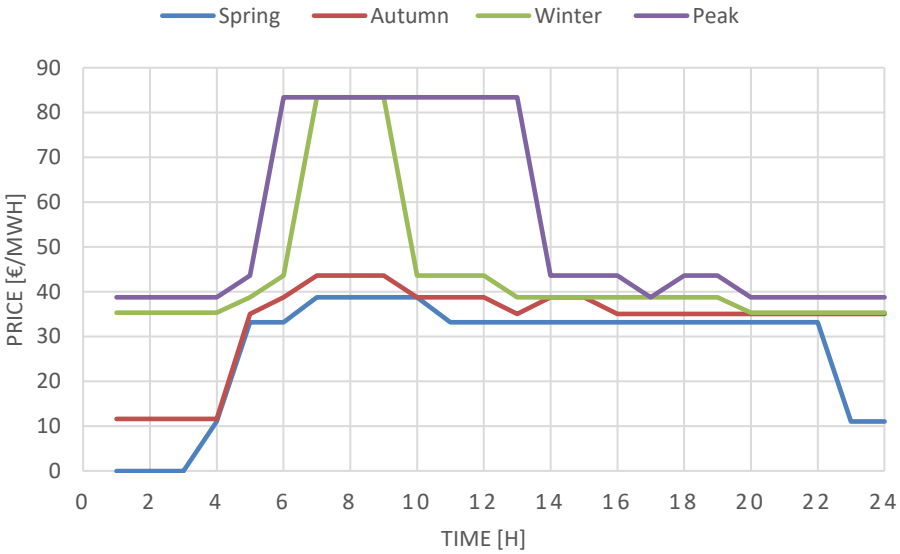
Energy costs

Electicity

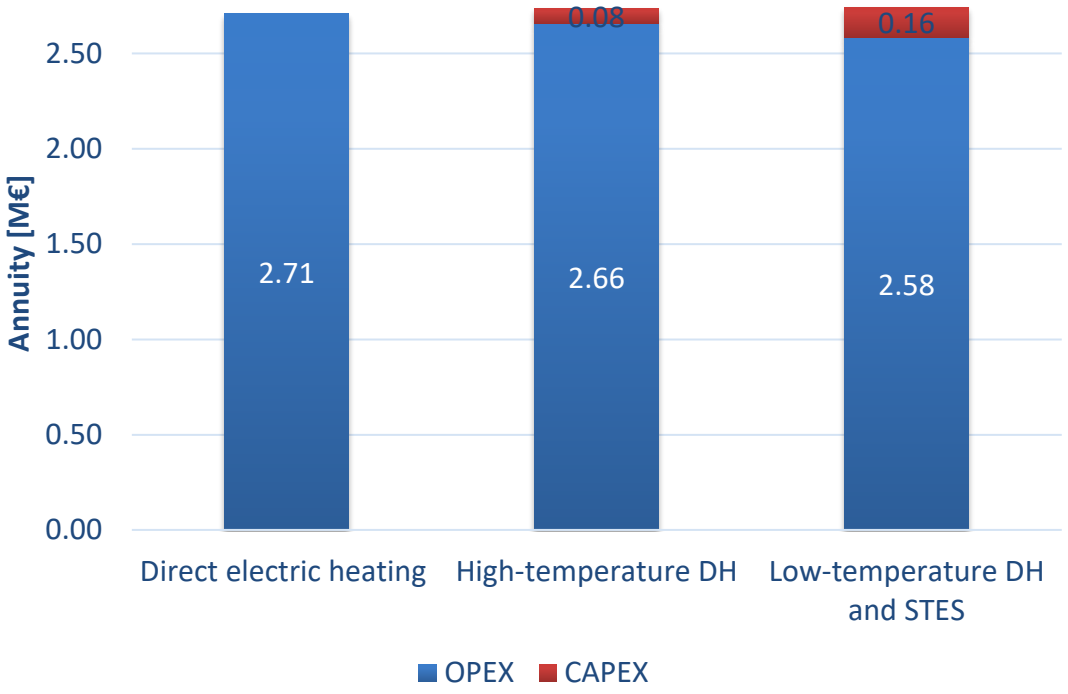


District heating



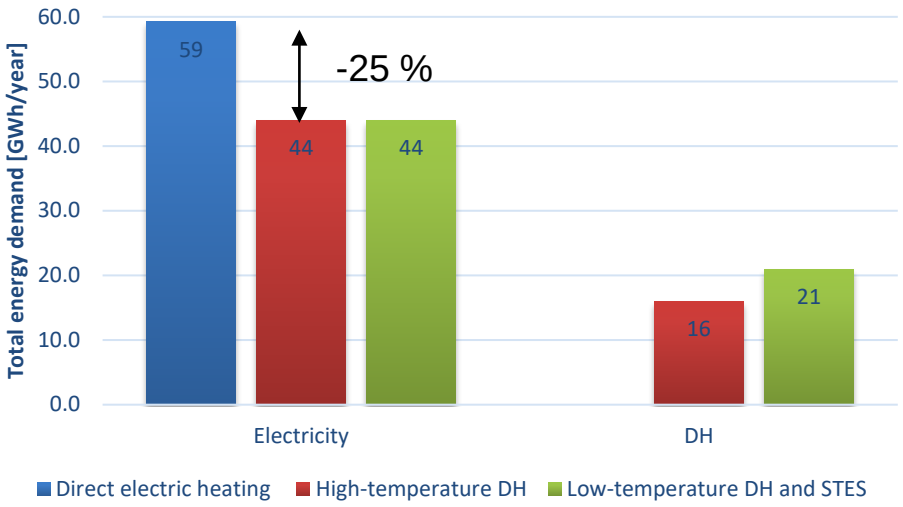
Results

Investment analysis - annuity

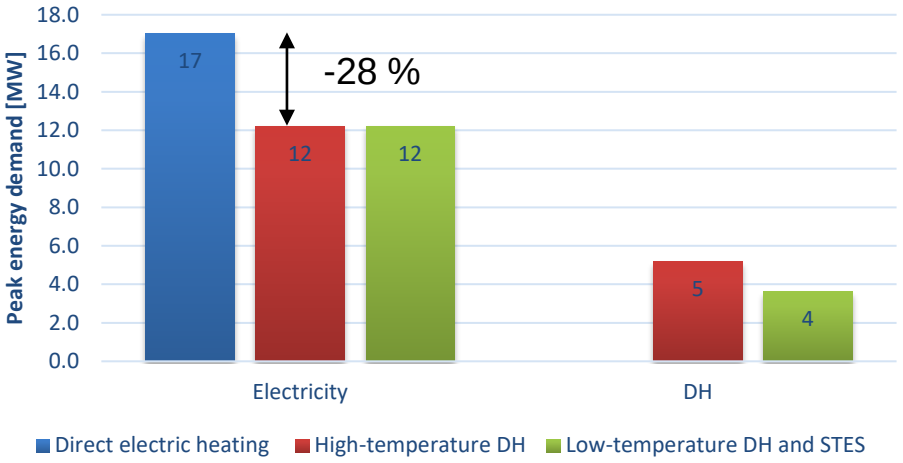


Annual supplied energy and peak energy demand

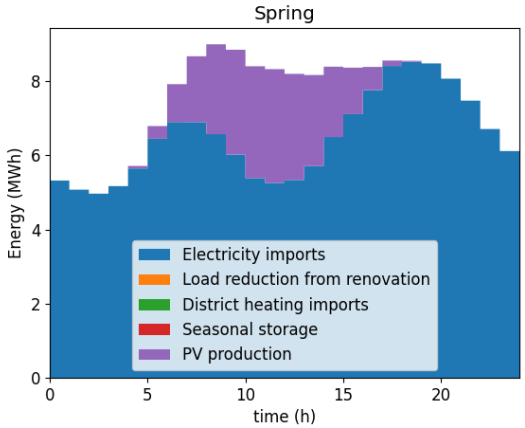
Annual demand for electricity and DH

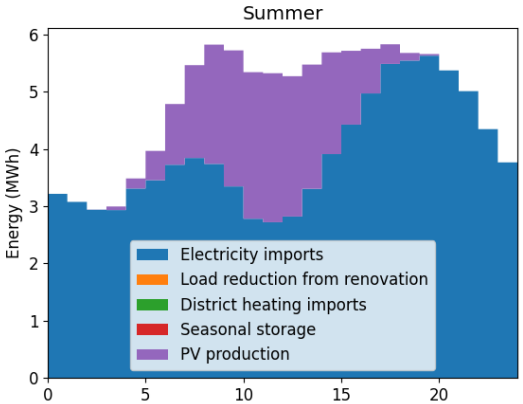


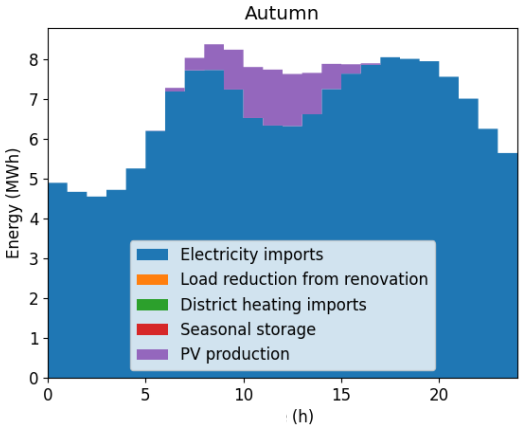
Peak energy demands

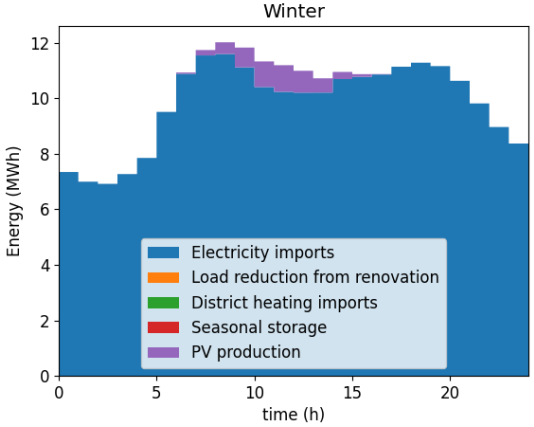


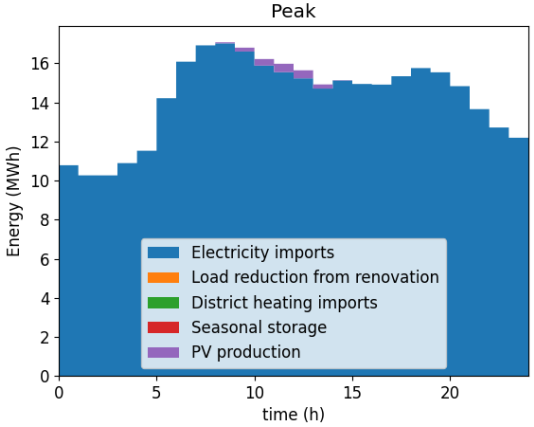
Aggregated energy breakdown - Direct electric supply



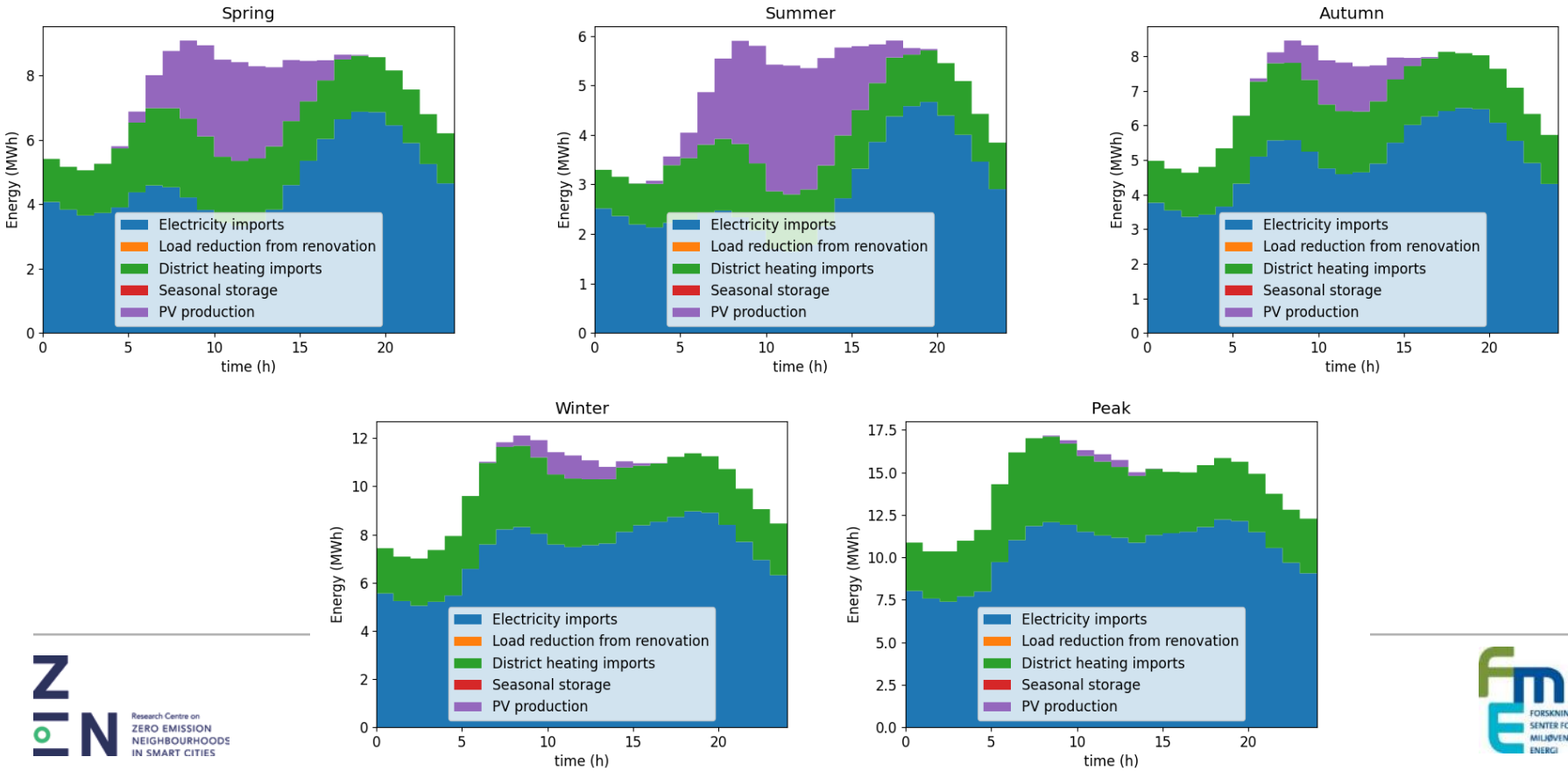








Aggregated energy breakdown - High-temperature DH



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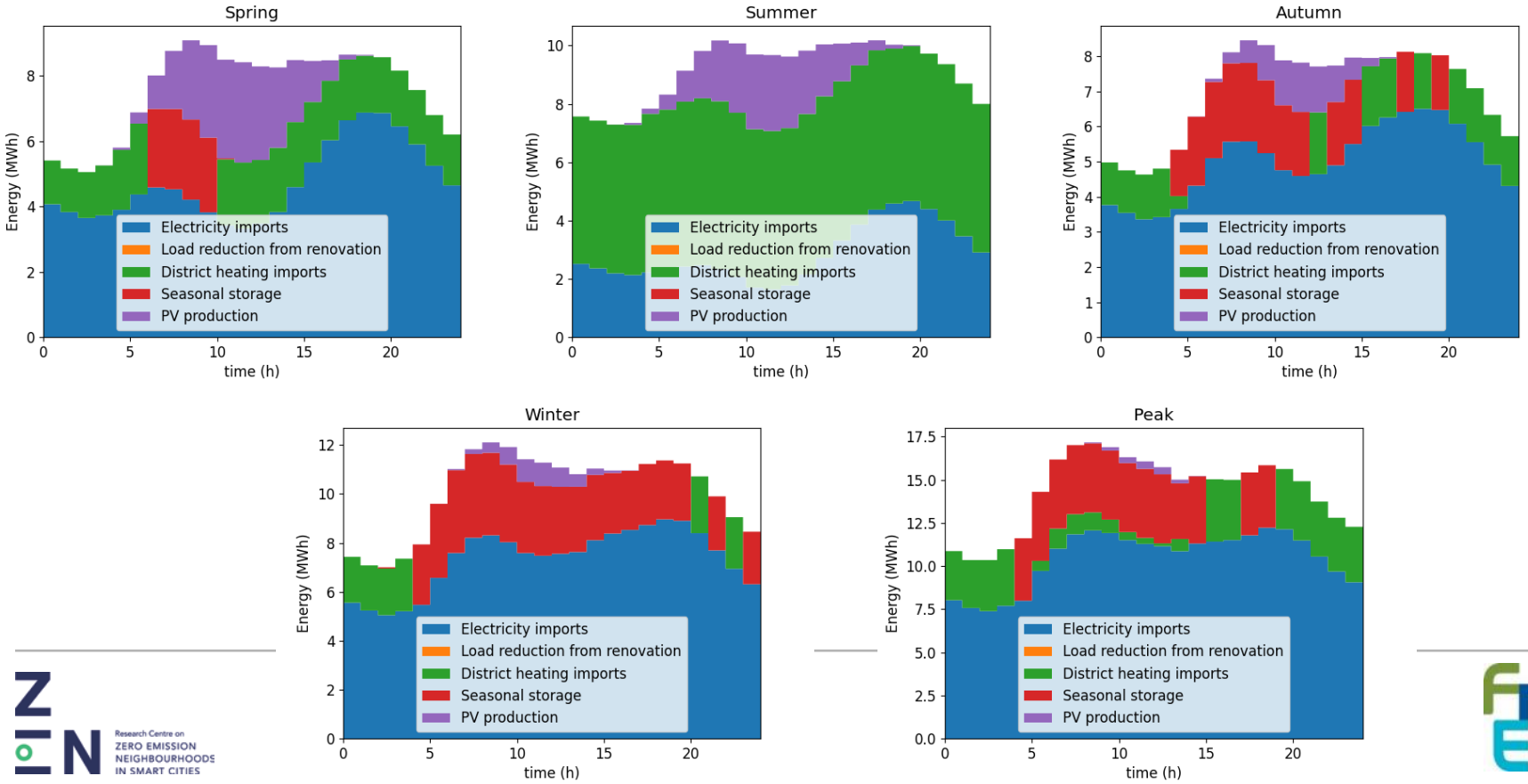
Aggregated energy breakdown - Low-temperature DH & seasonal storage



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Conclusions

- District heating is effective in lowering the pressure on the power grid
  - Peak power and total yearly power demand reduced by 28 / 25 %, respectively

- District heating is capital intensive, however it is difficult to put a price for the actual costs for required investments in grid expansion and renewable power production by continued use of direct electric heating for new developments.

- Seasonal thermal energy storage is an important technology in enabling increased utilization of excess heat, and reducing the demand for peak heating sources.
  - Temperature not considered in the model
  - The study should be combined with more detaile physical modeling of the STES for more realistic estimation of heat available in different seasons

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Any questions?

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