The Potential for Power-to-Heat in the Swedish District Heating Systems

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Context

- Limited interest for power-to-heat in Sweden so far
- Sweden has good conditions for integration of variable electricity production due to large capacity of storage hydropower
- Growing concern over future reliability of the electricity system
- Considerable expansion of wind power (almost fivefold increase since 2010)
- Possibly very high proportion of variable electricity in the future

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The purpose

…was to estimate the future (~2050) technical potential of power-to-heat as a flexibility measure in Swedish district heating systems for different power scenarios and conditions.

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Overview of method

- Design power scenarios
- Calculate the hourly power production and consumption for the scenarios
- Calculate hourly negative power residual (”surplus” electricity)
- Calculate hourly district heat load
- Calculate the power-to-heat potential by comparing the negative power residual and district heat load
- Repeat for different scenarios and restrictions

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Important assumptions

- Unlimited electricity transmission
- We disregard other flexibility measures and export & import of electricity
- Electric boilers
- Installed capacity equal to 30% of the design heat load in each DH system
- District heating demand assumed to remain at level of 2014 (57 TWh)

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Power scenarios ~2050

Electricity production and consumption	2015	Scenarios		
		Conservative	High Wind	High Wind & Solar
Nuclear power	54	55	0	0
Hydropower	74	65	65	65
Other thermal power (CHP, gas turbines)	13.5	15	15	15
Wind power	16.6	30	70	70
Solar power	0.1	5	5	20
Total production	158	170	155	170
Total consumption, including losses	136	140	140	140

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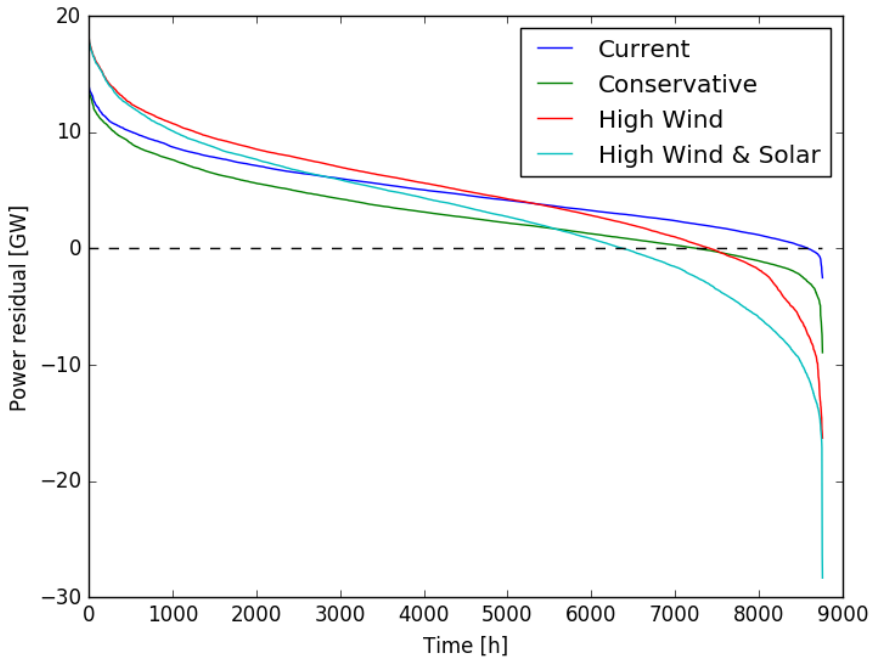
Calculation of power residual

$$P_{res} = P_{cons} - (P_{wind} + P_{sol} + P_{nucl} + 0.5 \cdot P_{th} + P_{hyd\_min})$$



Annual negative power residual for the different scenarios [TWh]	
Current	0.1
Conservative	2.1
High Wind	4.7
High Wind & Solar	11.1

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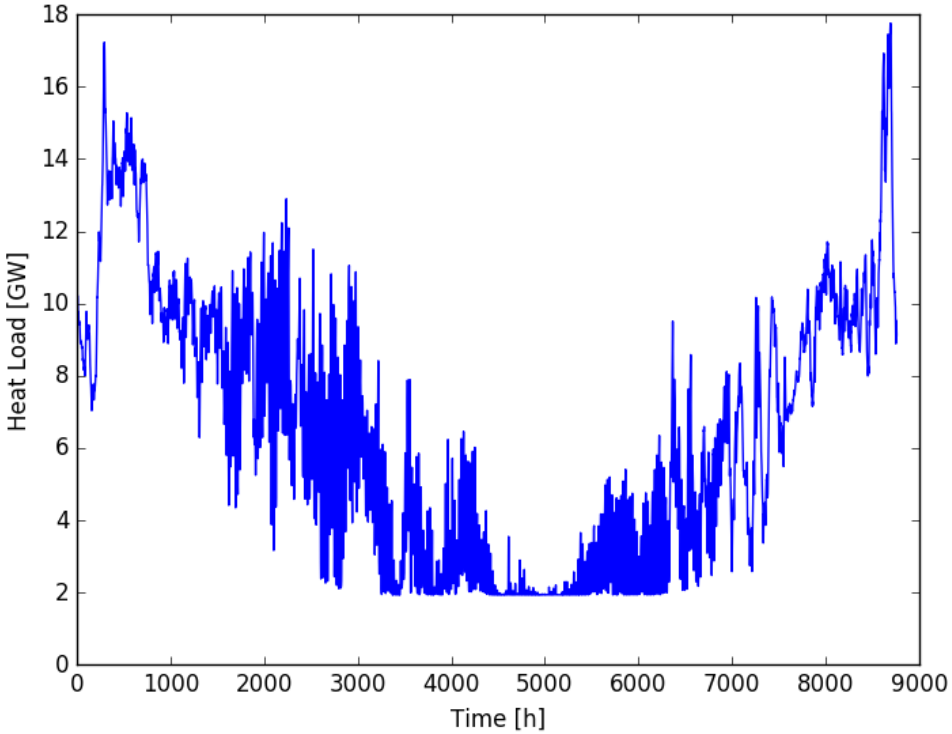
Swedish hourly district heat load



- Aggregation of regional heat loads
- The hourly district heat load was calculated for different regions using linear correlation with outdoor temperature.

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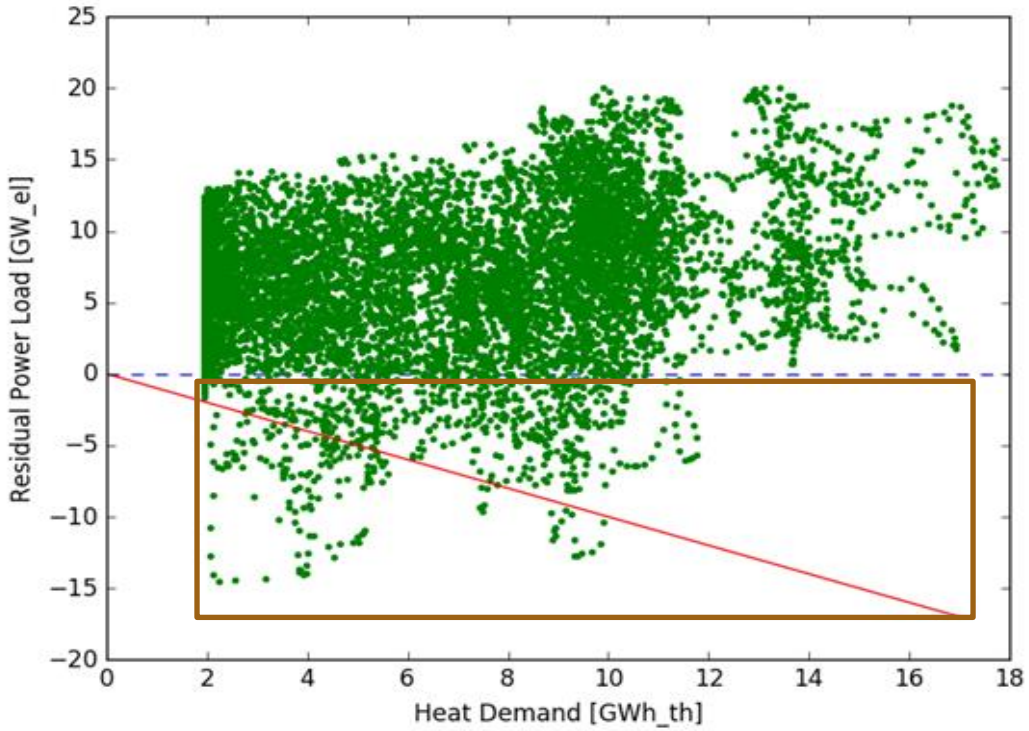
Power residual versus heat demand



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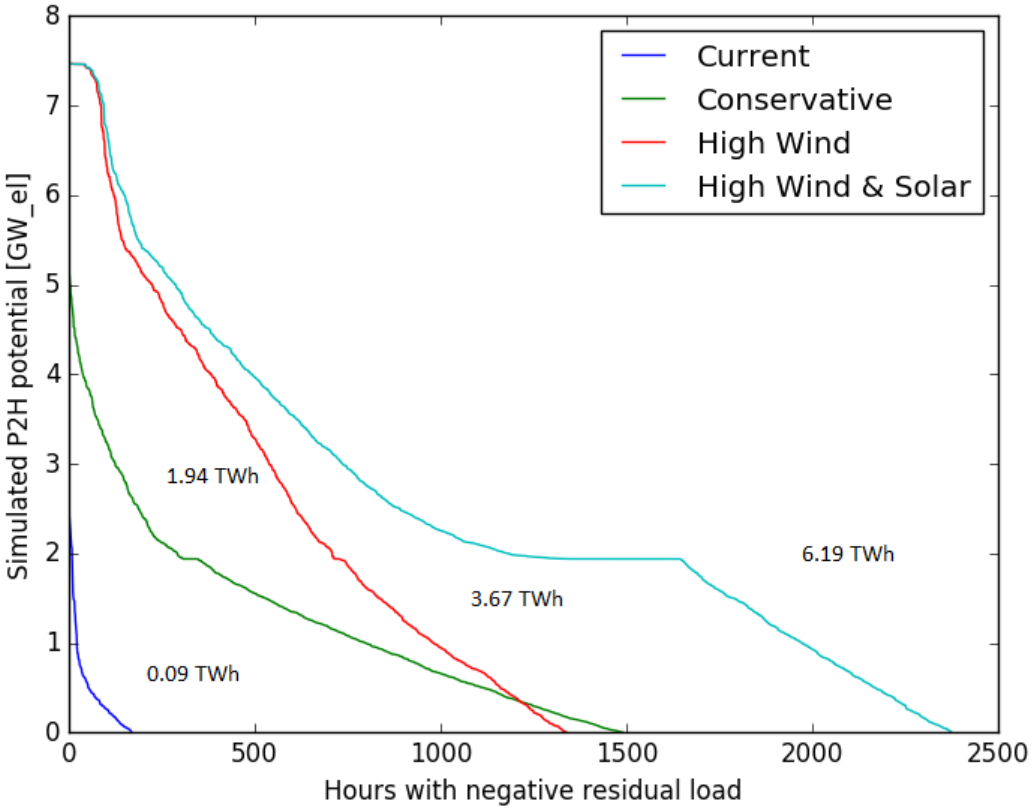
Power-to-heat potential



About 60-90% of the power residuals.

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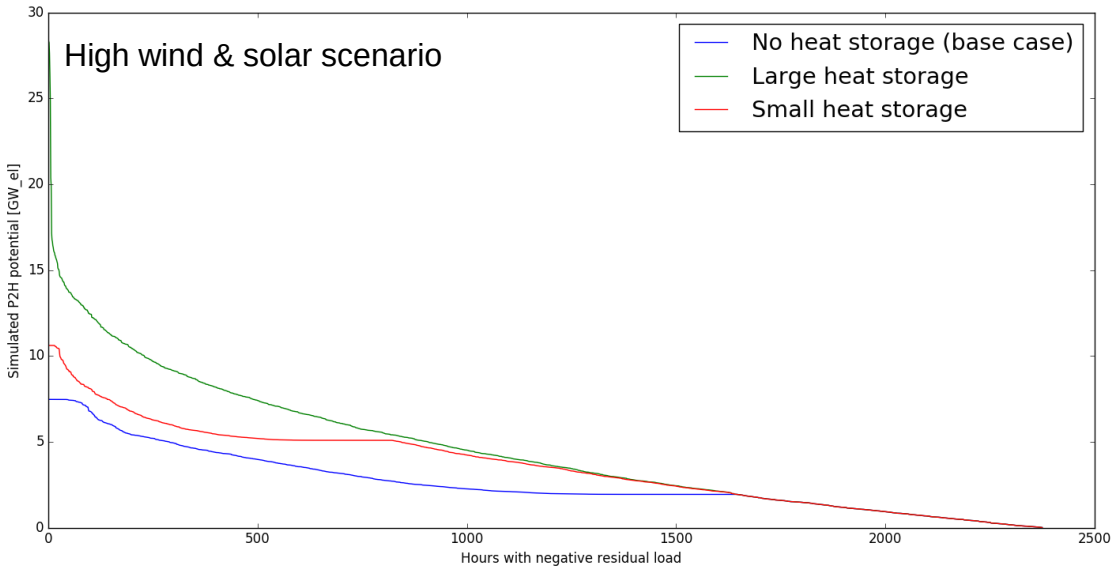
Impact of access to heat storage (accumulation tanks)



- Accumulator with the capacity to store 25-250% of its mean daily demand
- Transfer capacity corresponding to 2.5-25% of its mean daily demand

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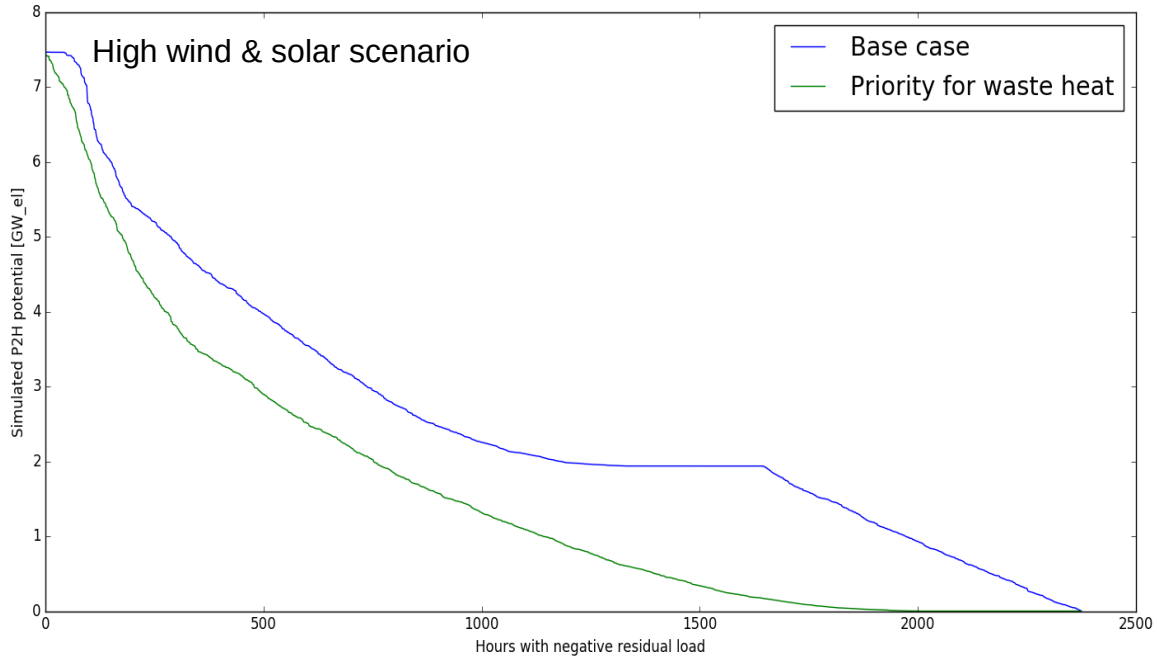
Impact of priority to waste heat in the district heating supply



Priority to industrial waste heat and heat from waste incineration (27% of current production)

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Conclusions

- Technical potential for power-to-heat was estimated to 3-8.5 TWh for scenarios with high proportion of wind and solar power production (75-90 TWh in total).
- Limited need and potential for power-to-heat in the conservative scenario.
- DH load is mainly a restriction in the High wind & solar scenario and especially if assuming priority for waste heat.

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Reflections

- Simplified assumptions
- An opportunity that should be explored further.
- No business case for power to heat in Sweden today
- Future viability depends on how electricity prices and policies develop.
- Implement with care! The shutdown of CHP plants would be problematic at times with low variable electricity production.

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Thank you!

Questions and feedback?

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