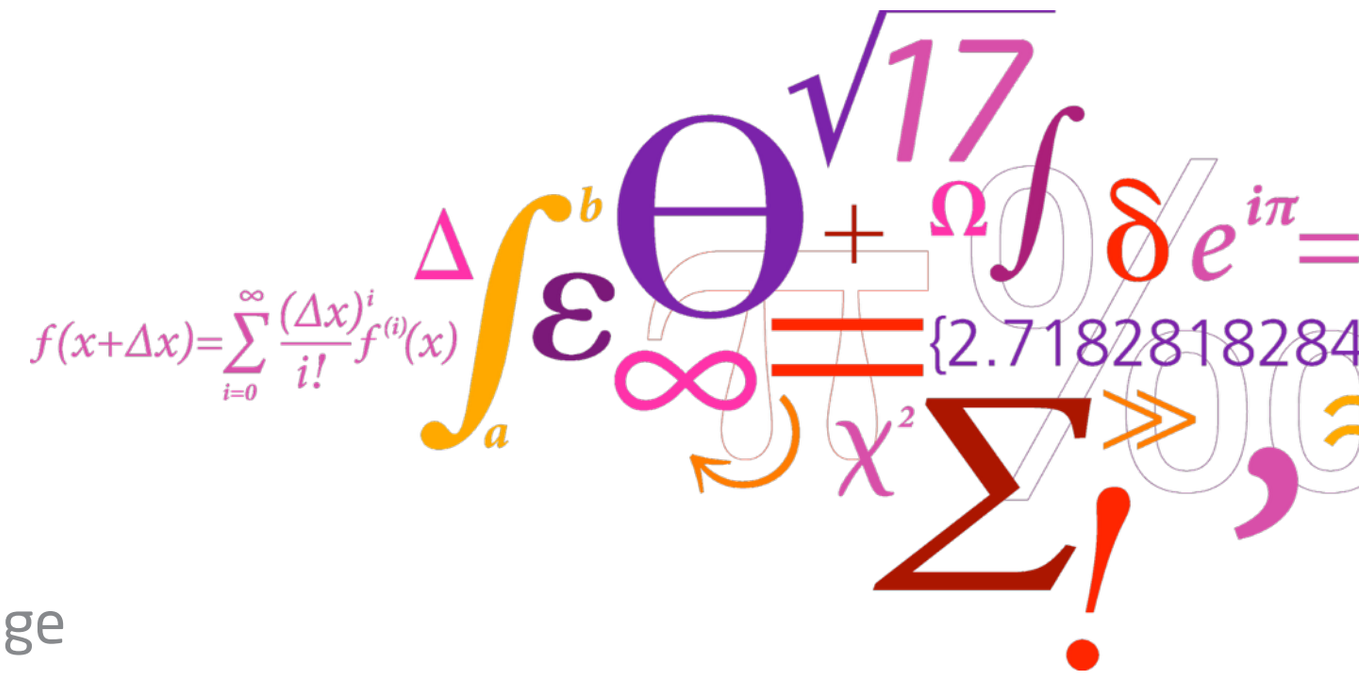
Technical University of Denmark

Energy System Modelling in Cities

Illustrated Using Data from the Case of Sønderborg

Nordic Cities Workshop, 01.09.2015

Daði Þ. Sveinbjörnsson



DTU Energy
Department of Energy Conversion and Storage

Centre for IT-Intelligent Energy Systems in Cities

The Aims of CITIES Work Package 2:

- To characterize and model the energy production, transmission, storage and conversion resources required to meet the future demand for energy services in cities.
- To identify opportunities for increased energy system efficiency, flexibility and integration.

Sønderborg as a case study for modelling energy supply in CITIES

Population

- Sønderborg municipality: 27'500
- Sønderborg area: 75'000

Why Sønderborg?

Sønderborg's energy system is sufficiently complex for a realistic case study, but simple enough to make detailed modelling of the system possible.

Sønderborg municipality has the goal of becoming CO_2-neutral by 2029.

Bright Green Business
ProjectZero

Sønderborg as a case study for modelling energy supply in CITIES

- ProjectZero and PlanEnergi have published a strategic energy plan for Sønderborg in 2029, which we use as a starting point for the modelling work.

- We want to model alternative scenarios and see how new energy technologies could increase the efficiency and integration of Sønderborg's energy system.

- The experience from the Sønderborg case will be used for more general energy system models on a city level.

Bright Green Business
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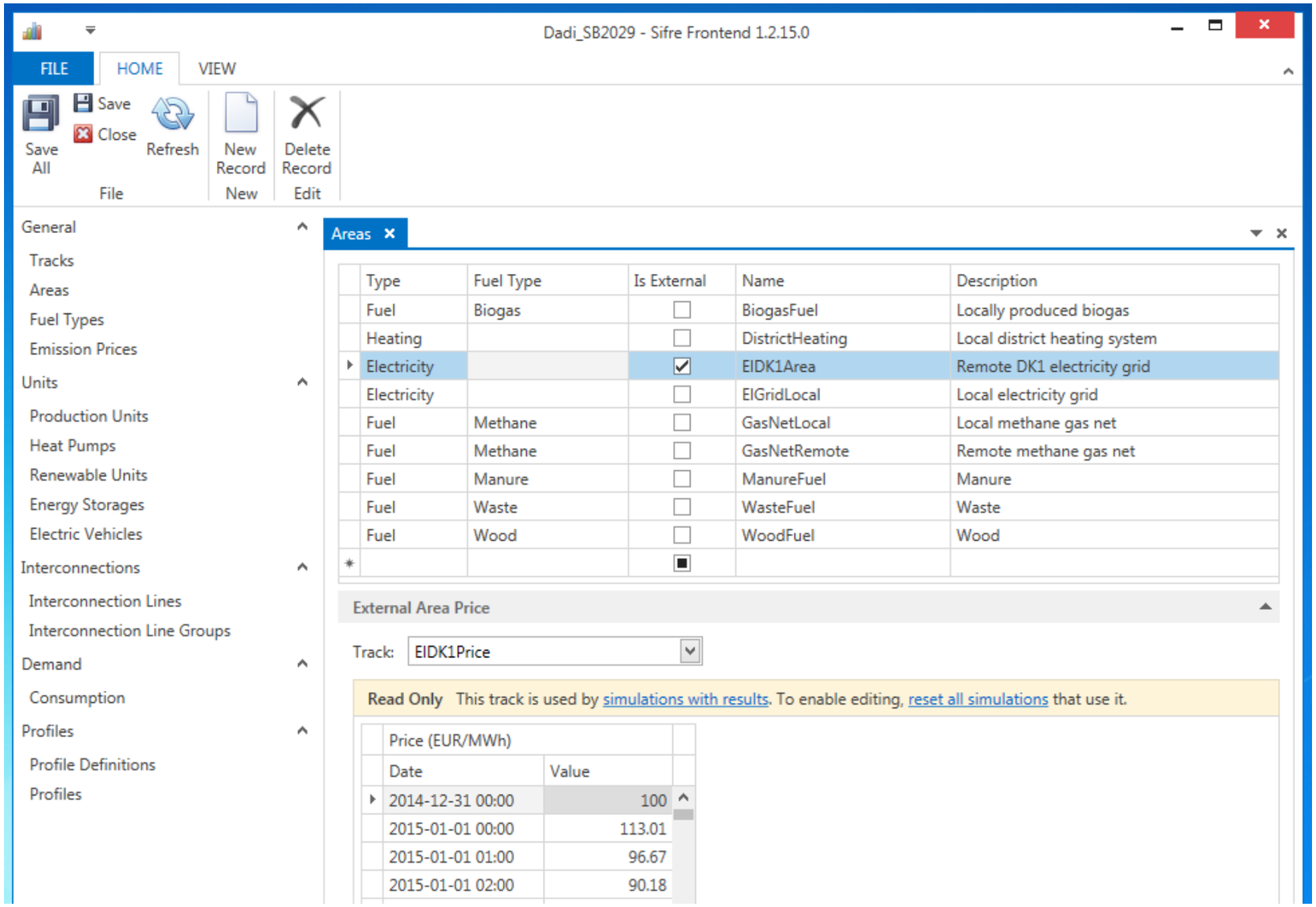
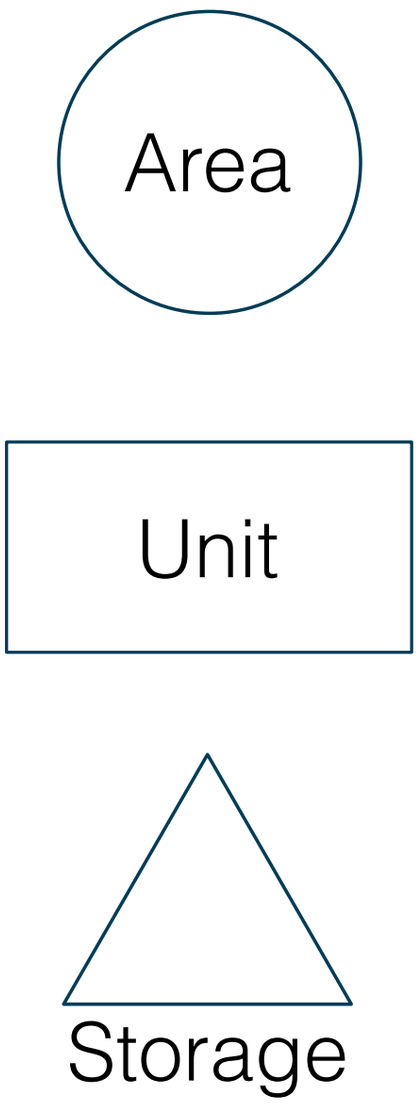
The techno-economic energy systems modeling tool *Sifre*

- *Sifre* is a new linear optimization modelling tool developed by Energinet.dk
- A local front end with a remote back-end optimization solver and SQL server.



ENERGINET.DK

The modular layout of the *Sifre* model



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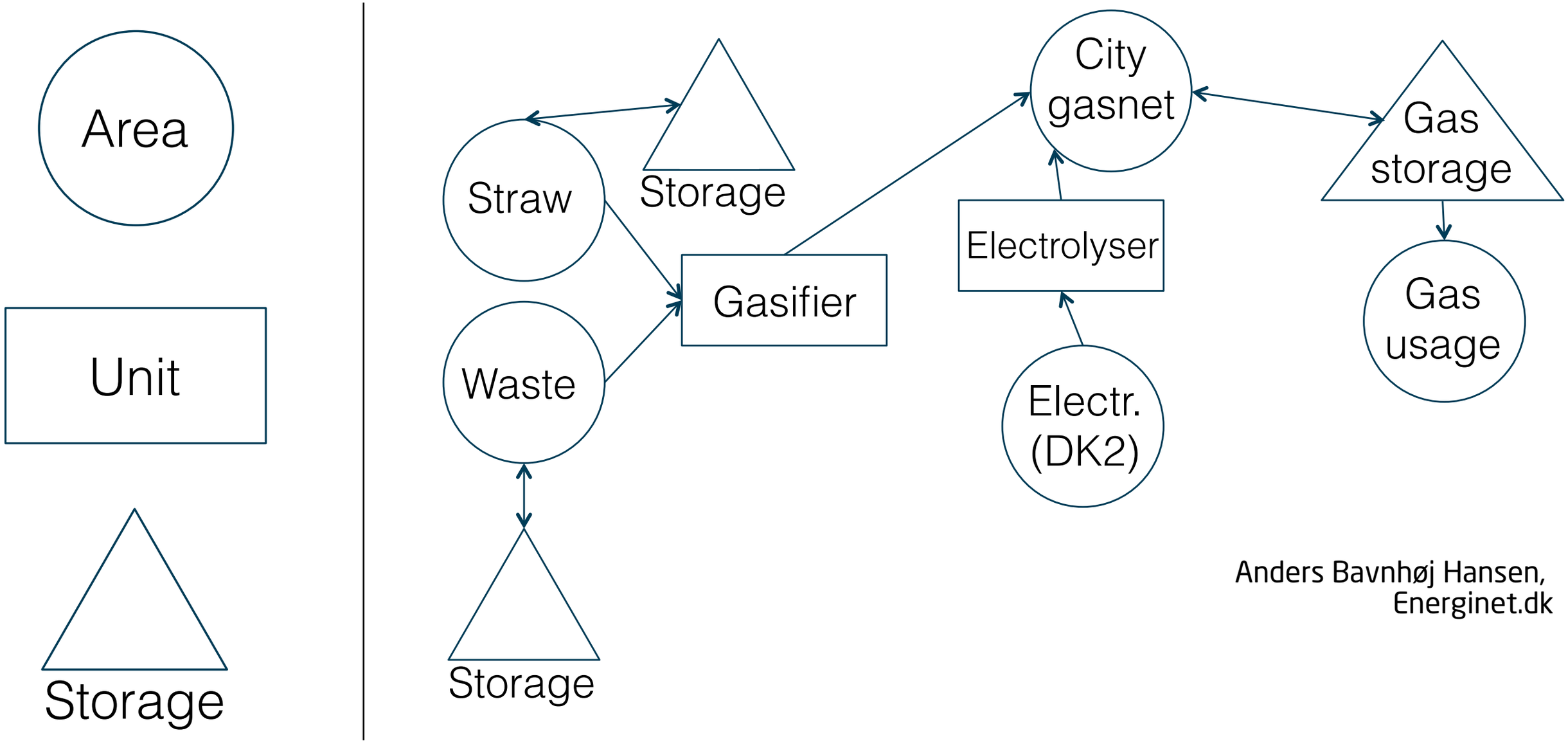
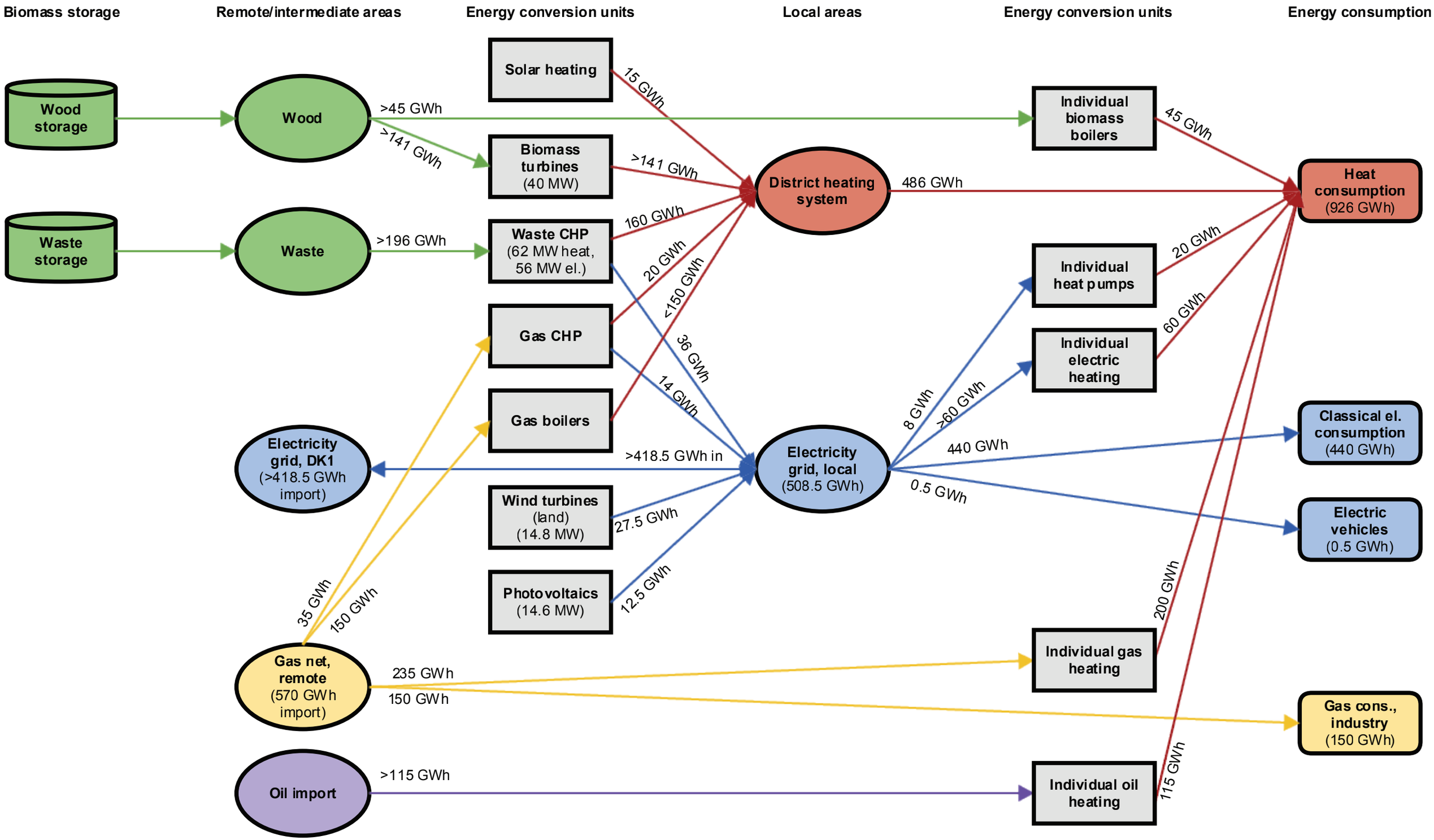


Anders Bavnhøj Hansen,
Energinet.dk

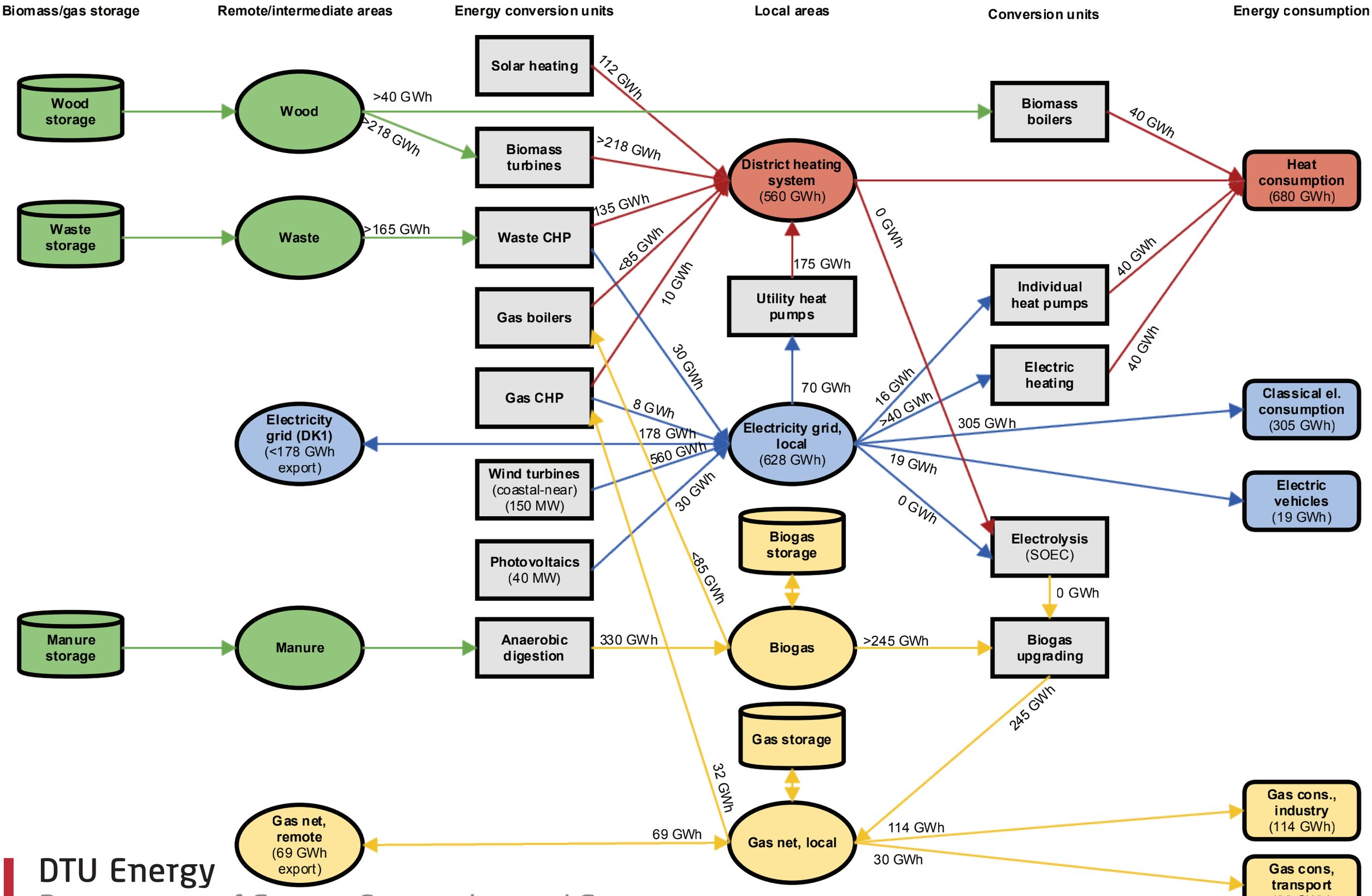
Main model outputs

- The optimized hour-by-hour system operation and energy flows.
- Model-generated market prices for energy within the system.

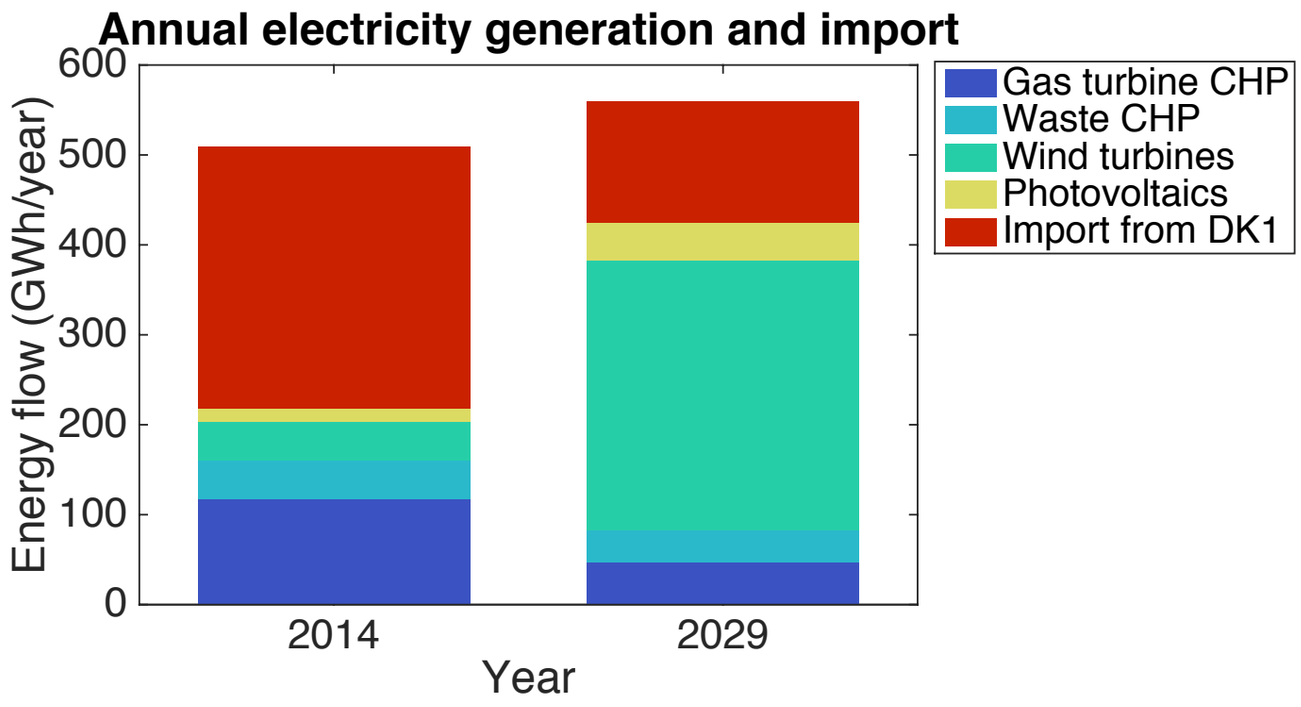
Model layout: Sønderborg's energy system in 2013



Model layout: Sønderborg's energy system in 2029



Examples of results: Annual electricity generation and consumption



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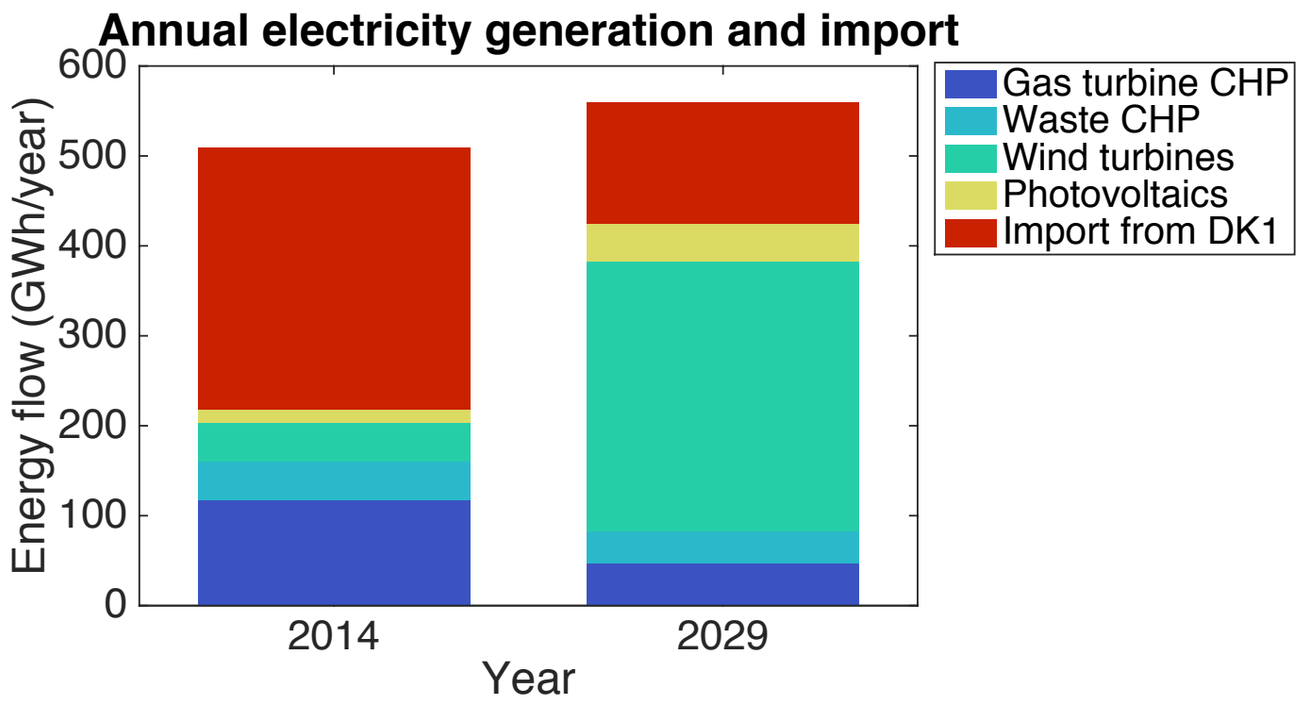
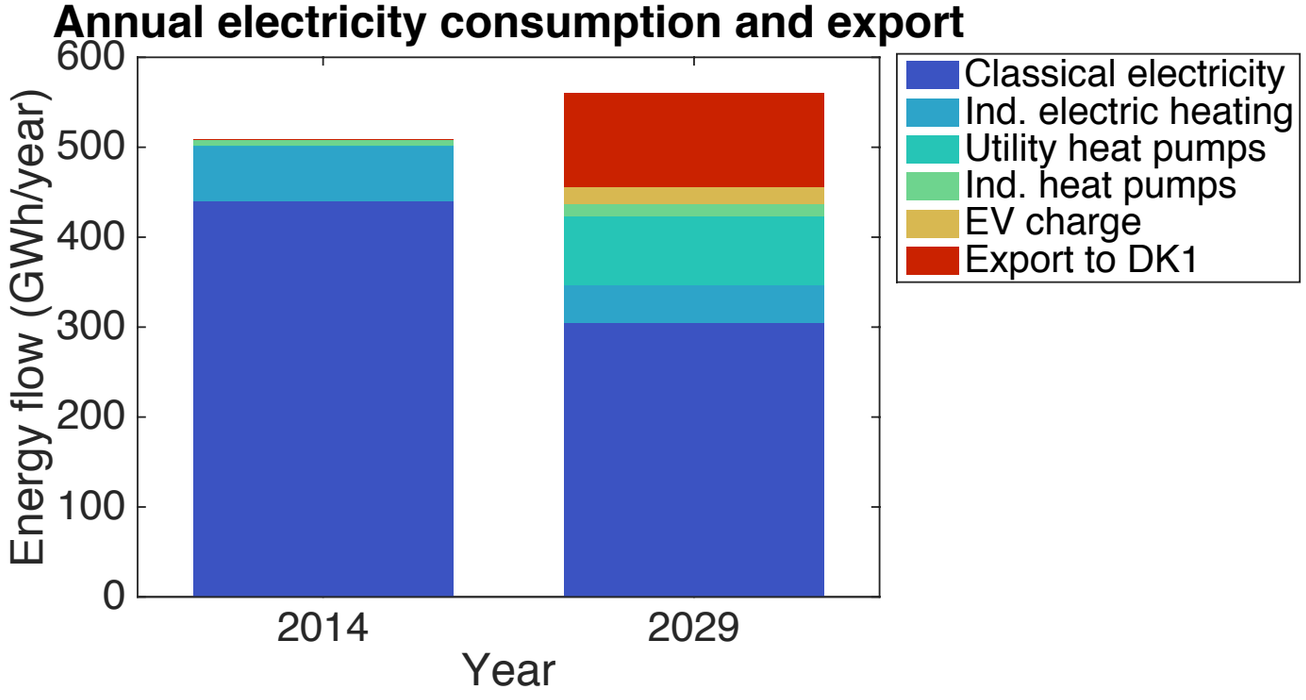
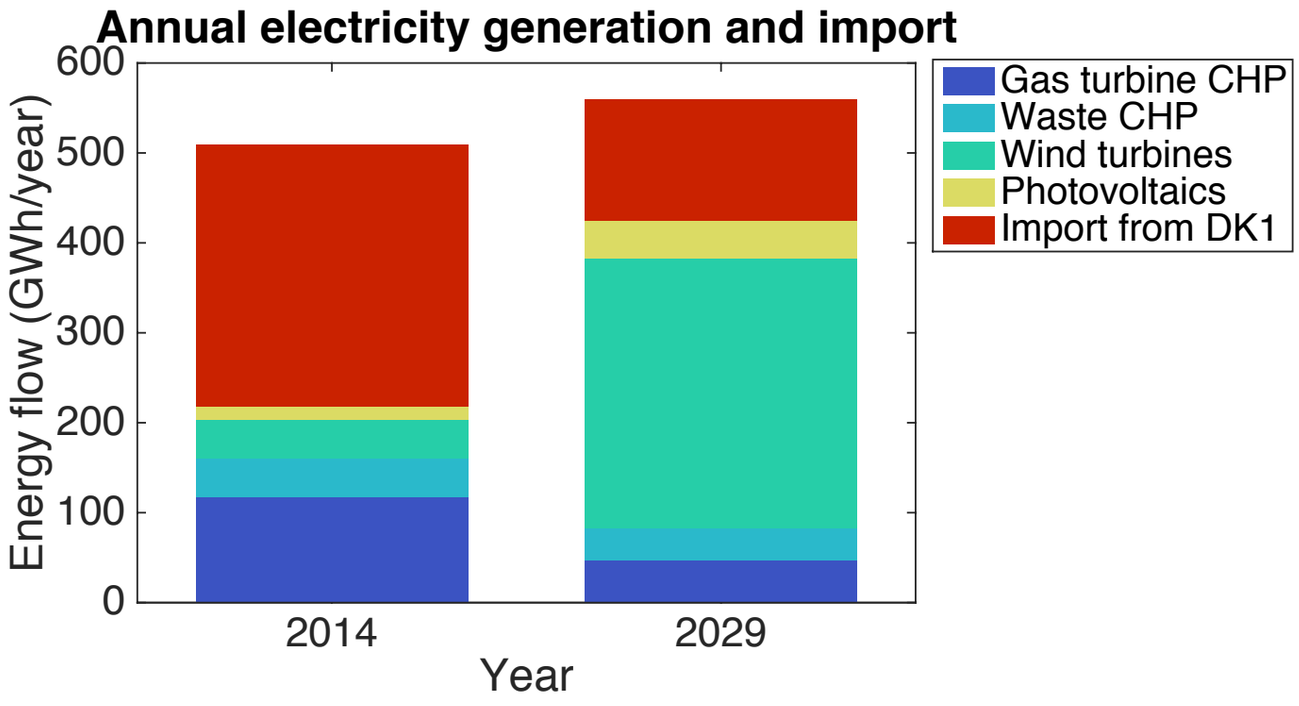




Examples of results: Annual electricity generation and consumption

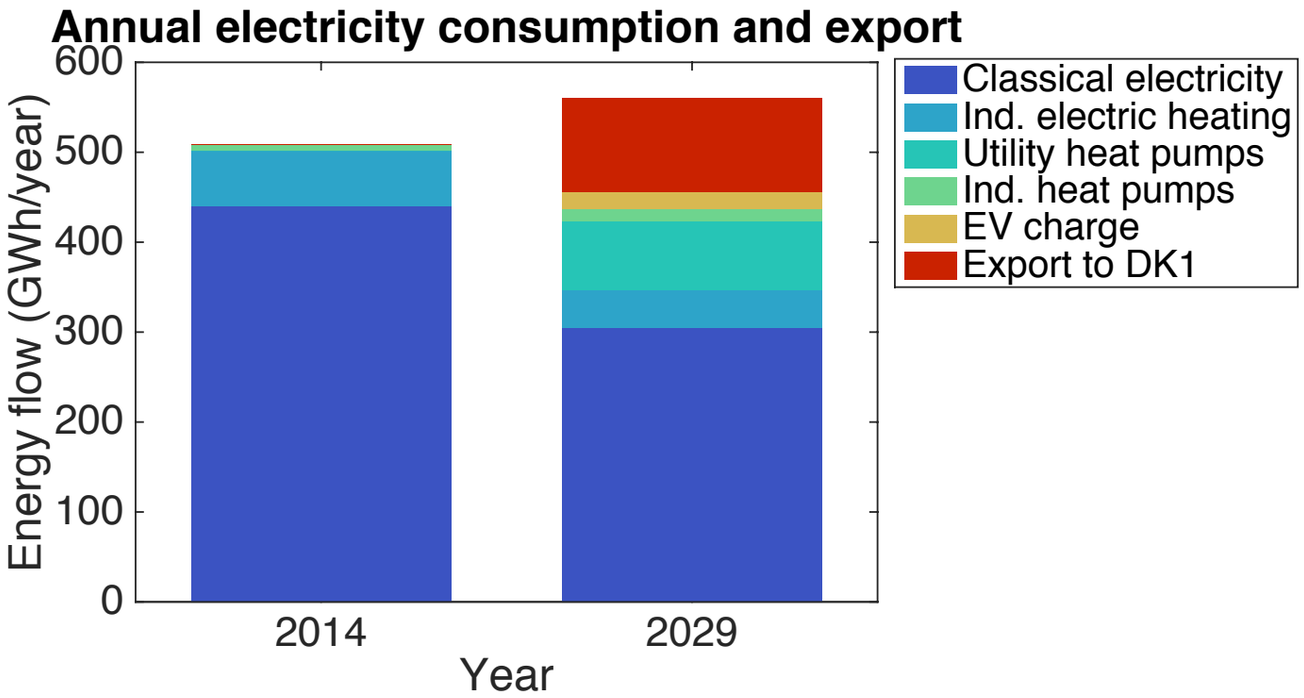
A CO_2 neutral electricity system in 2029 (Project Zero & PlanEnergi):

- A vast increase of Sønderborg's wind turbine and photovoltaic capacities replaces gas CHP.

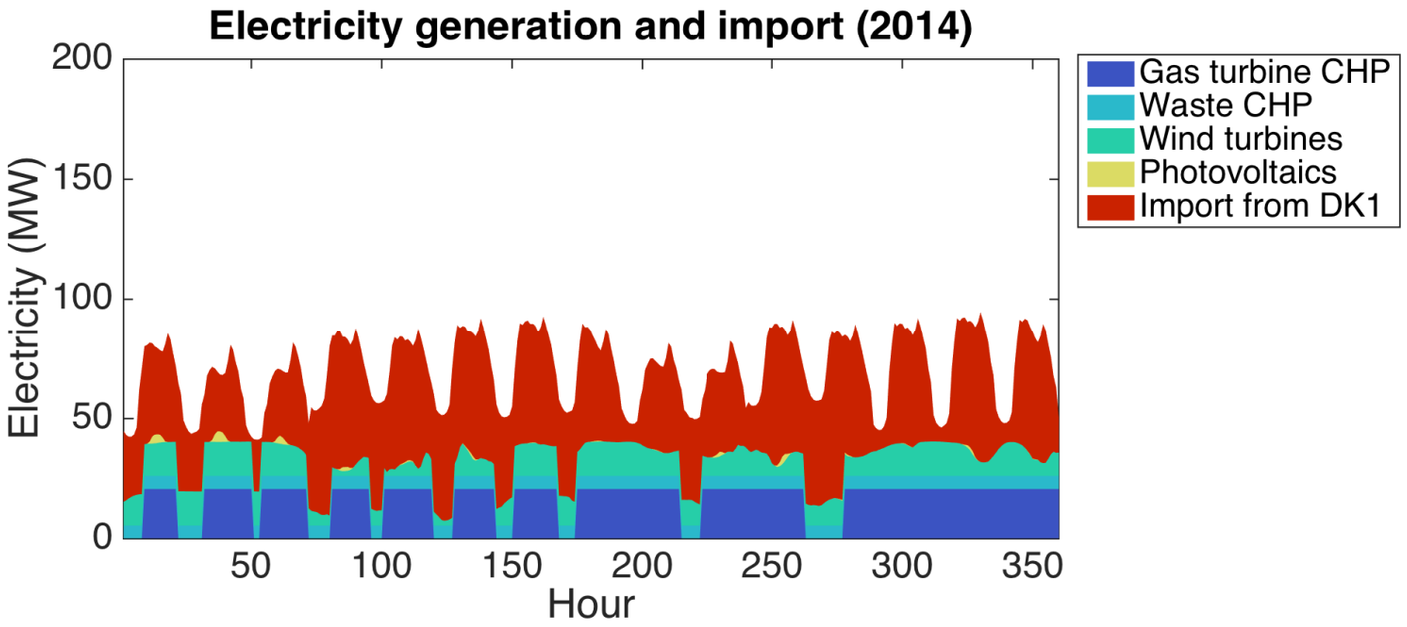


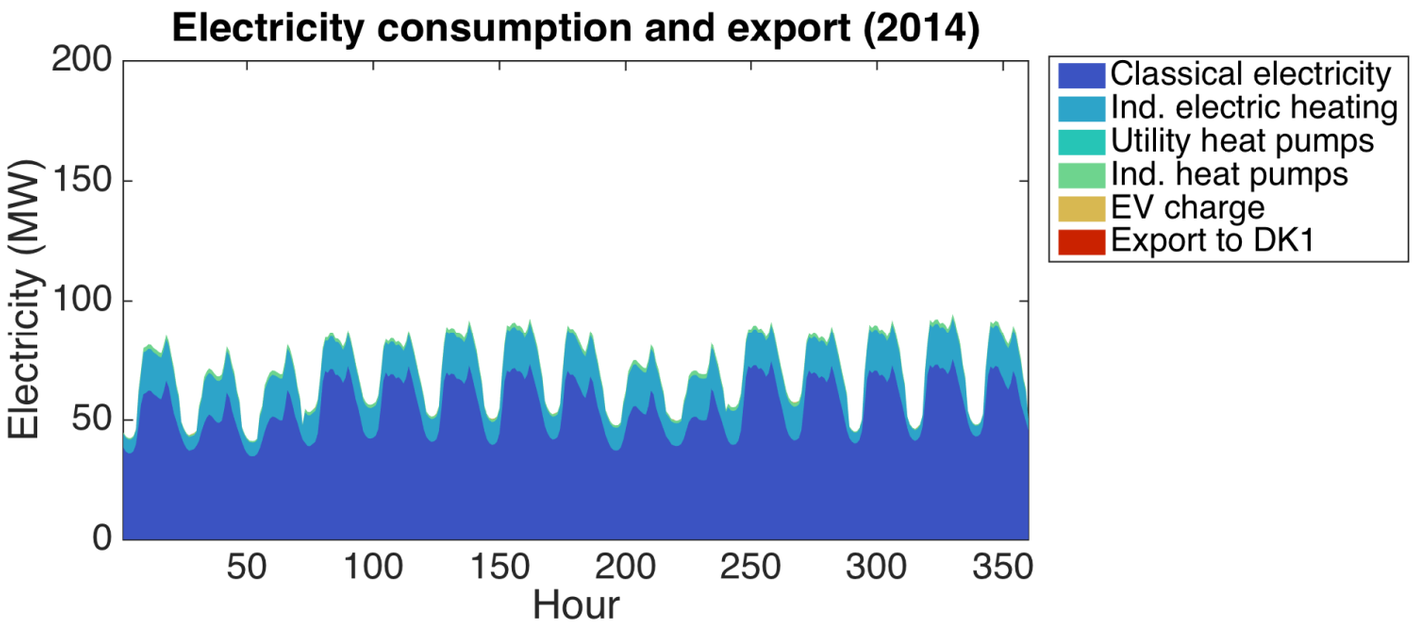
- Decreased classical electricity demand due to e.g. increased efficiency.

- Sønderborg goes from importing most of its electricity to being a net exporter of electricity.



Examples of results: Electricity time series for 2 weeks in January





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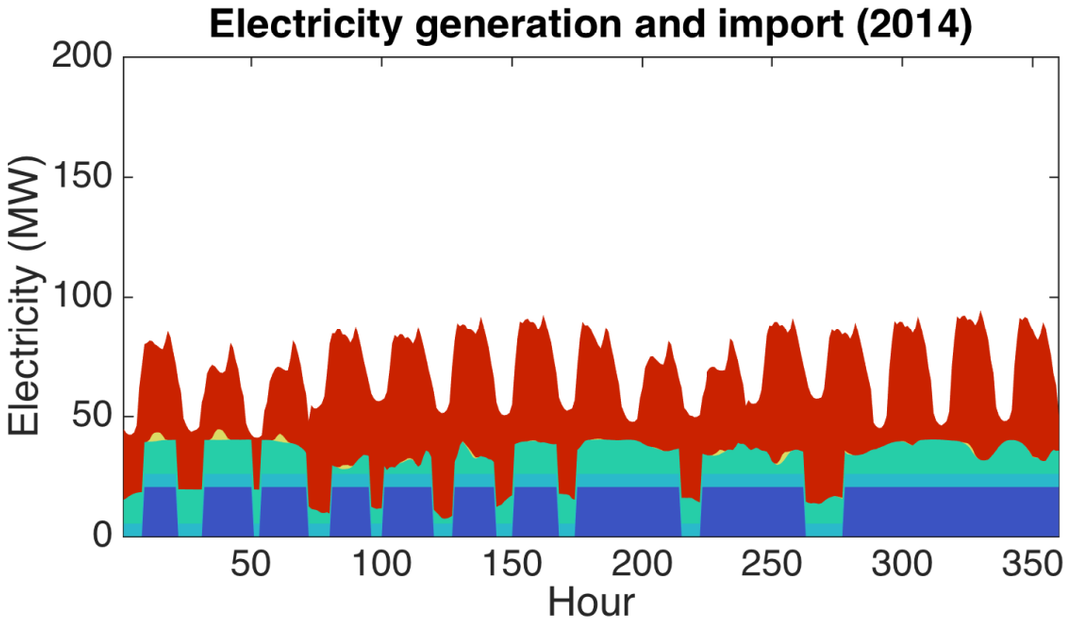

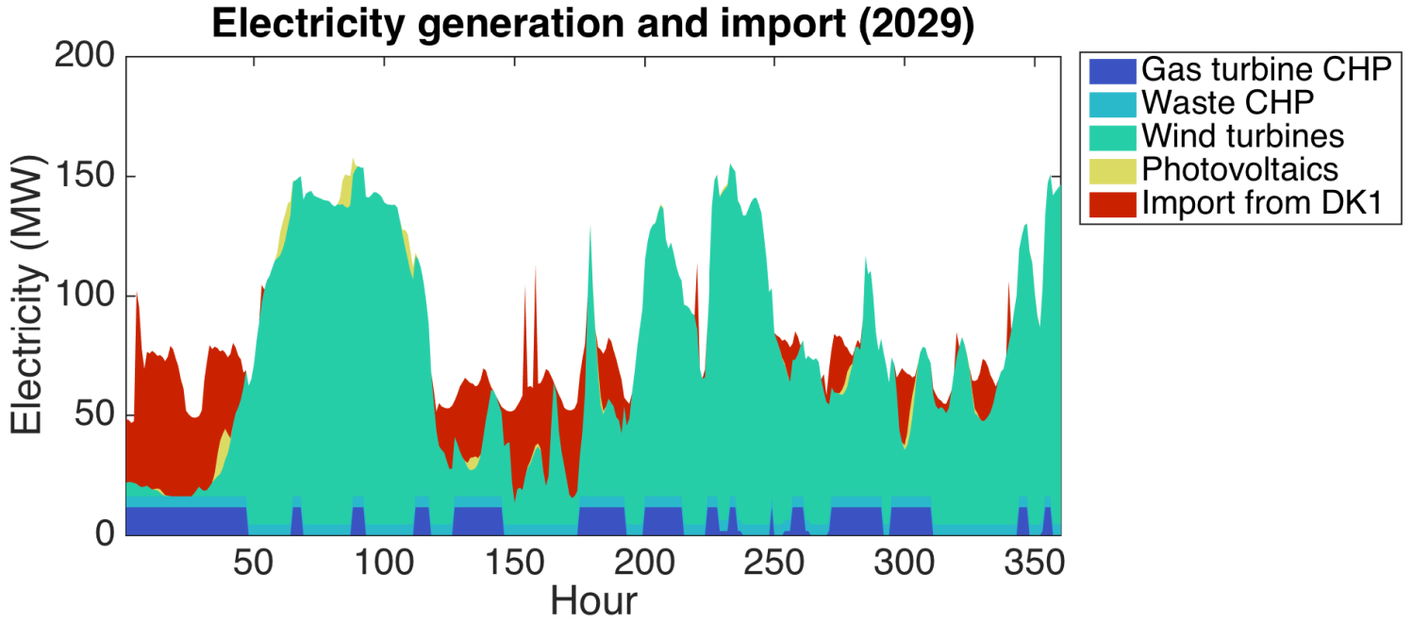

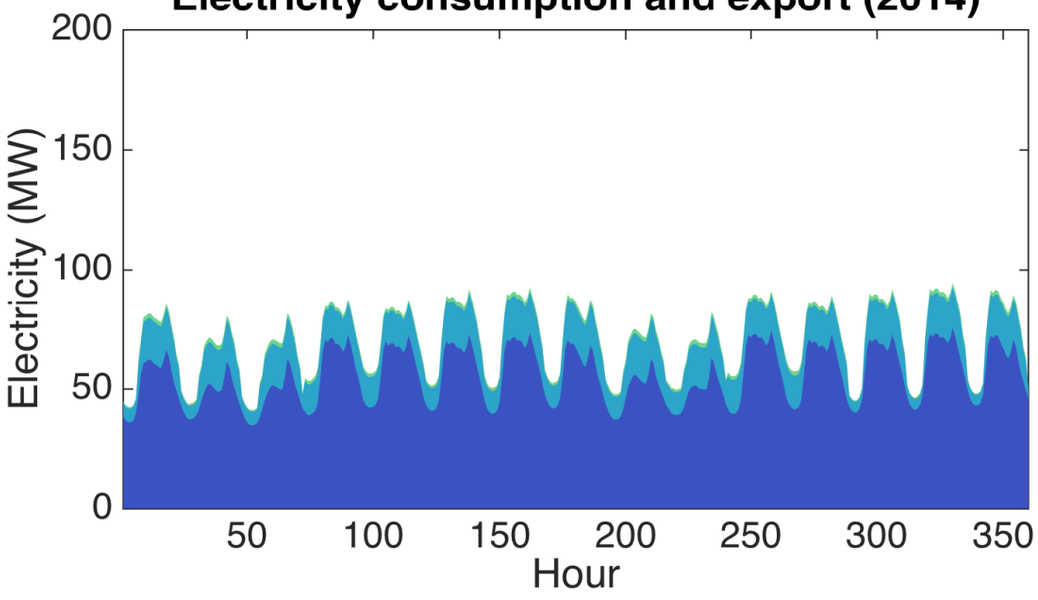

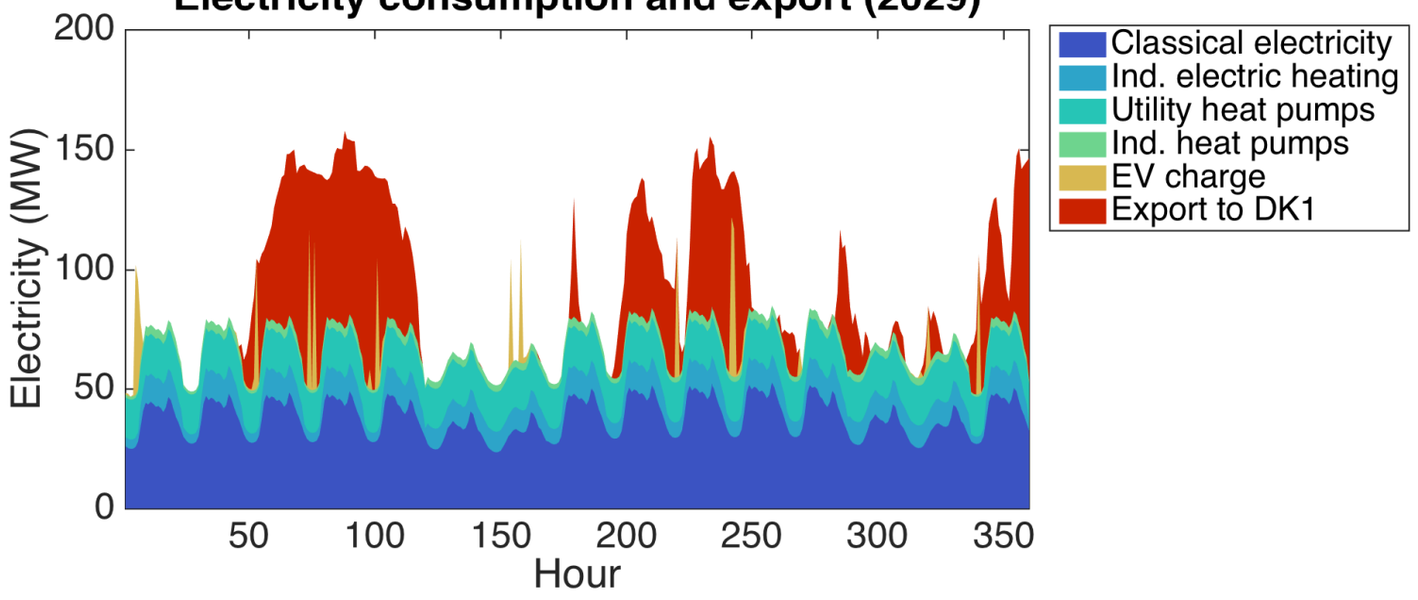

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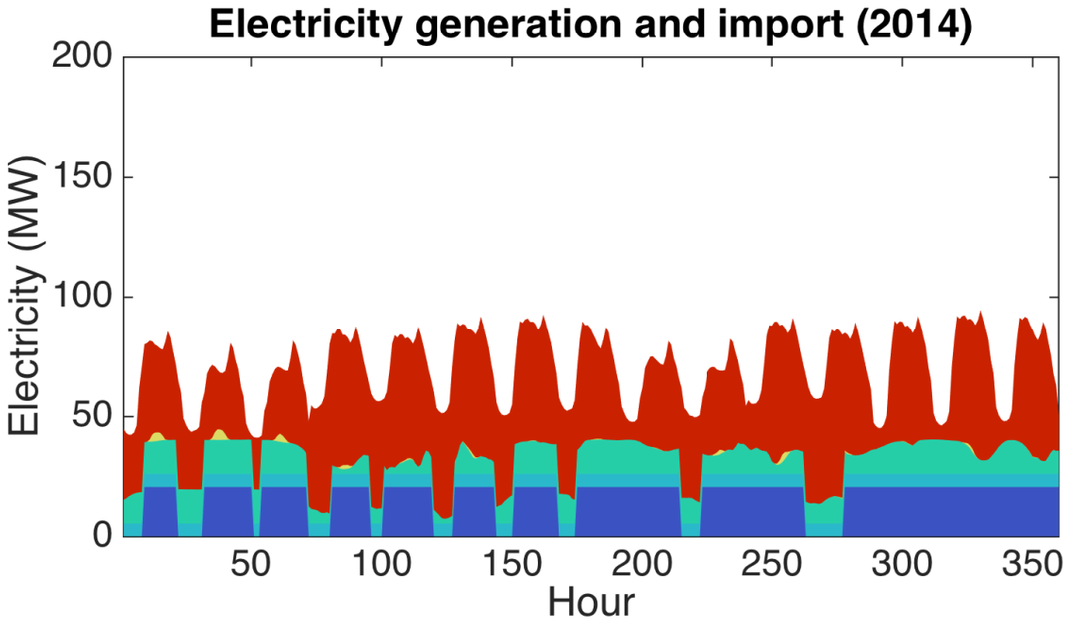
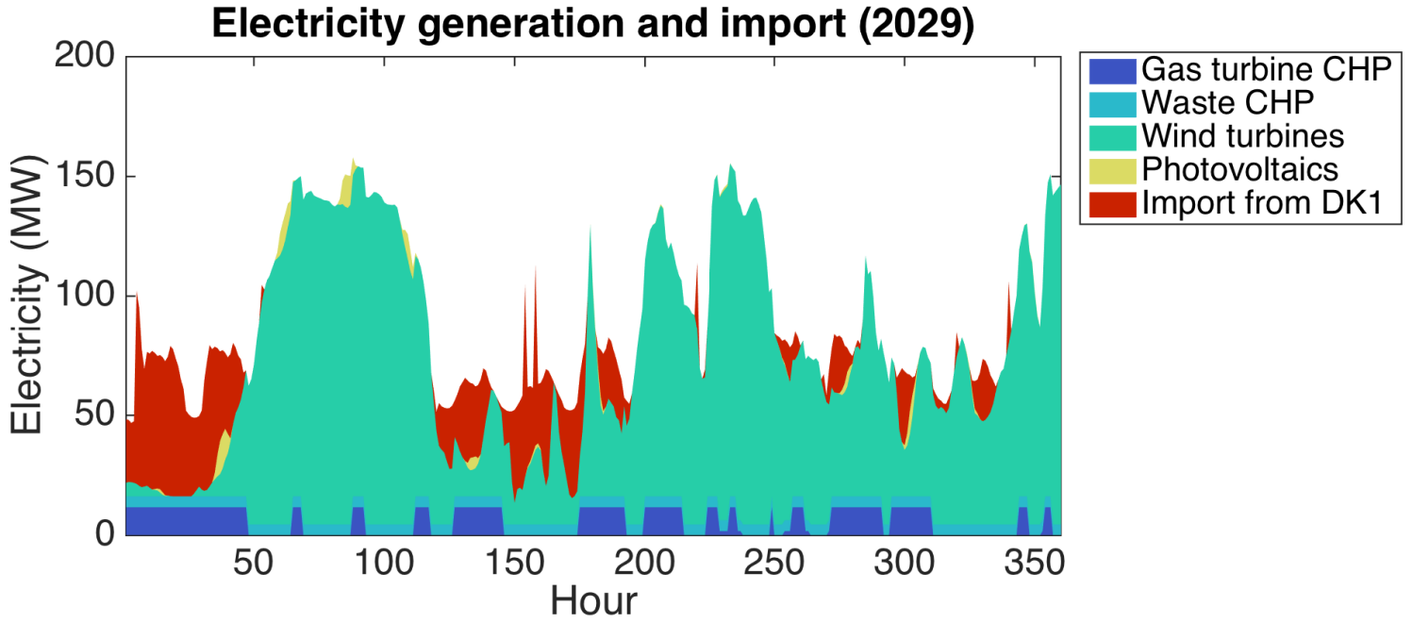
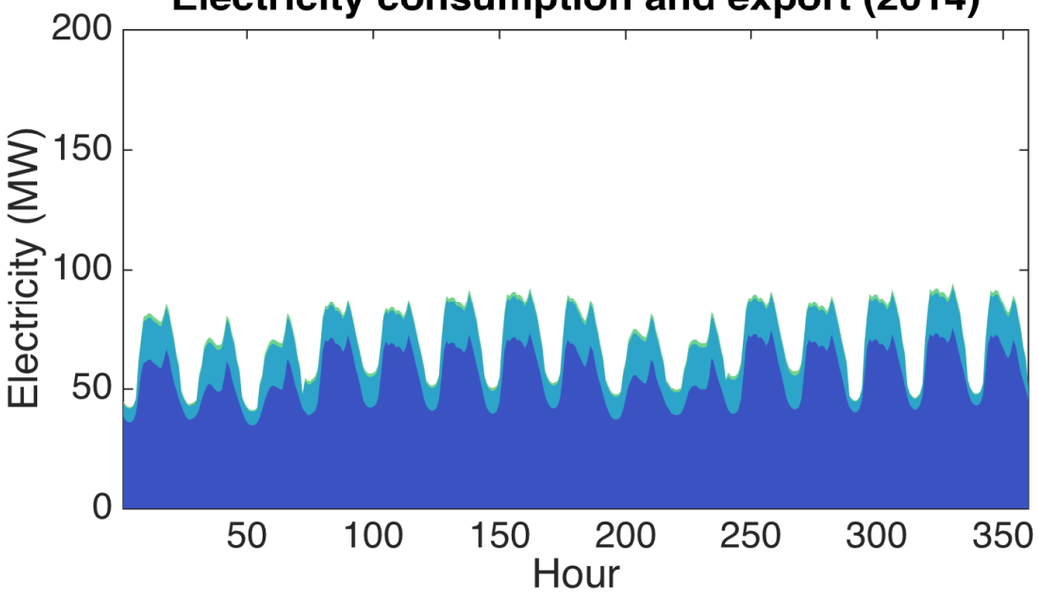
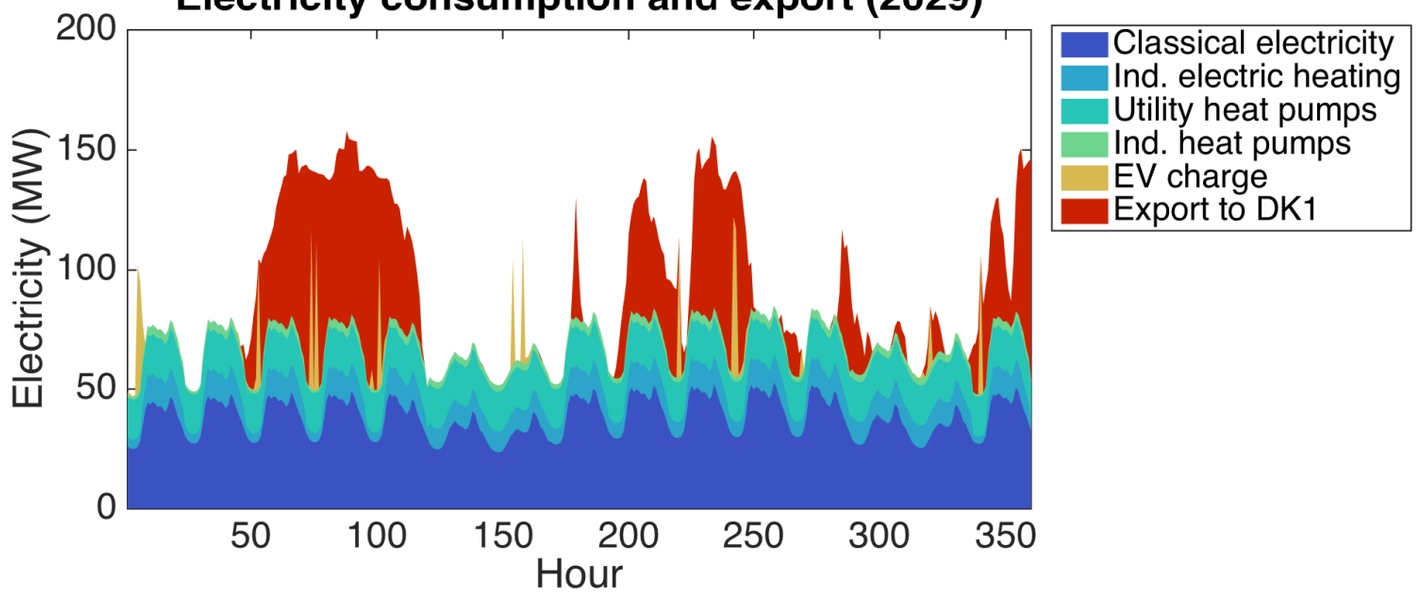






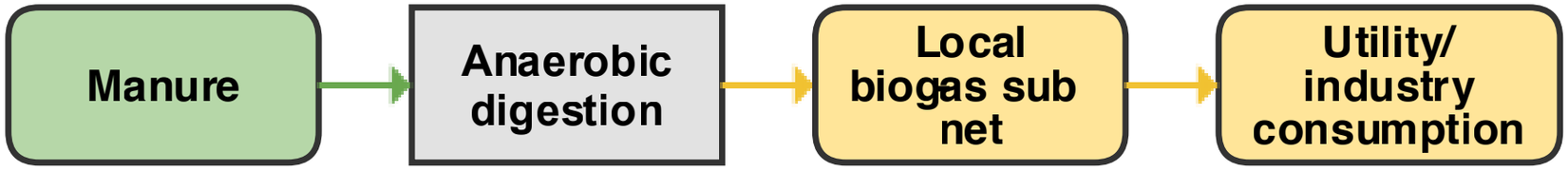


Much larger wind and photovoltaic capacities in 2029 will result in very large fluctuations, some way of balancing the system will be required.

Examples of alternative scenarios for Sønderborg in 2030

Biogas production and local biogas sub-net

- Is it necessary to upgrade all biogas, or can it be used directly by some local utilities and industries?



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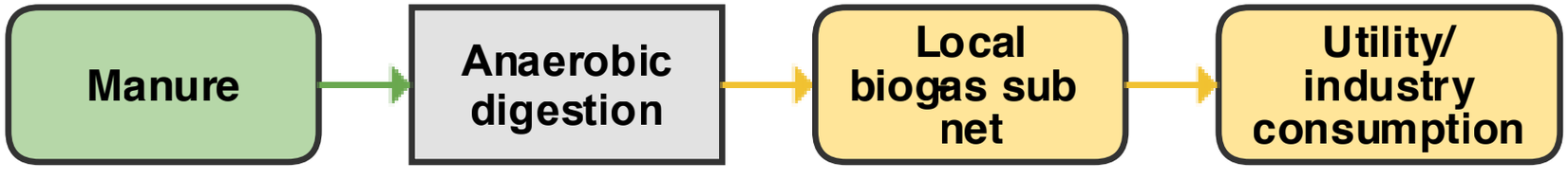
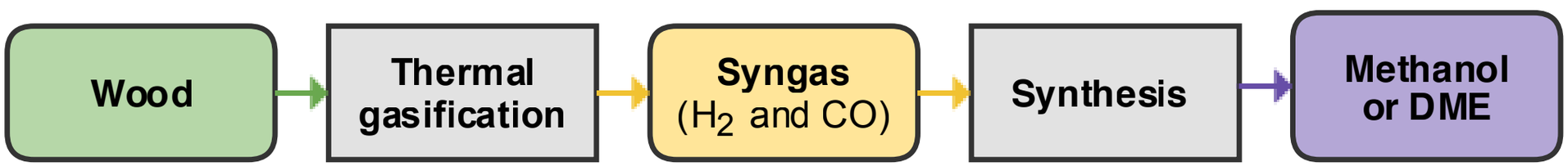


Thermal gasification and transport fuel production

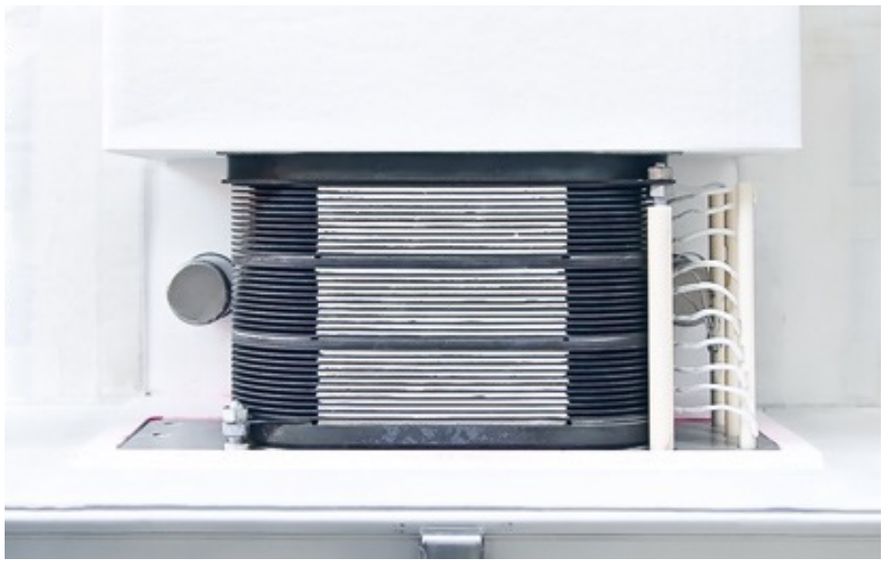
- How would a thermal gasifier and a methanol/DME synthesis plant fit into the system?
- Are there good possibilities for heat integration here?

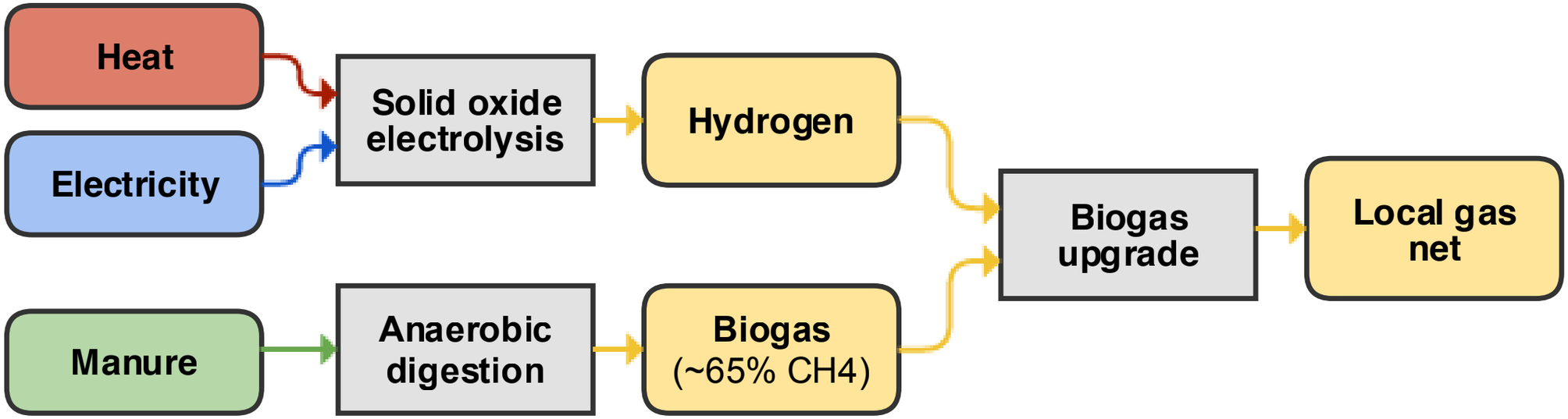


More efficient usage of biomass with hydrogen addition

- The energy contents of biomass can be utilized more efficiently by adding hydrogen to the biomass-derived gas.

- How would hydrogen production from electrolysis fit in Sønderborg's energy system?





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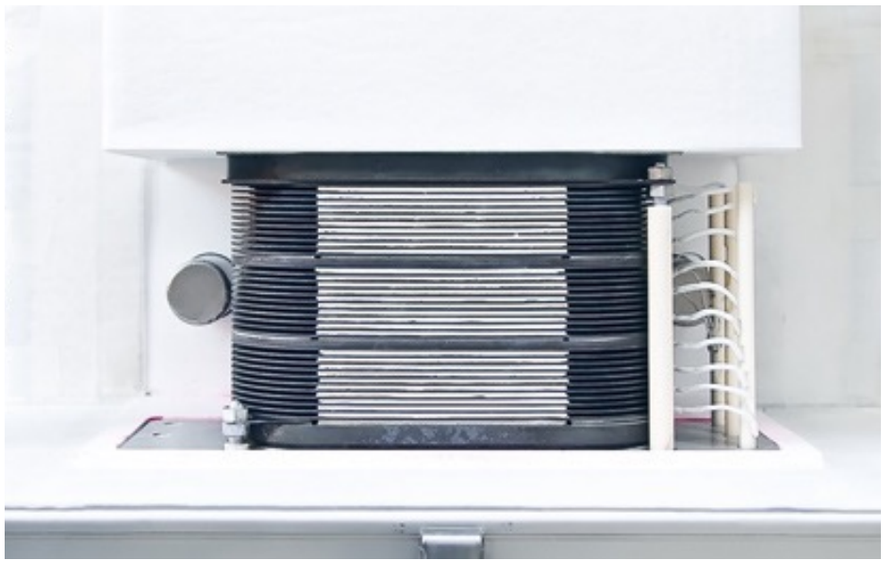
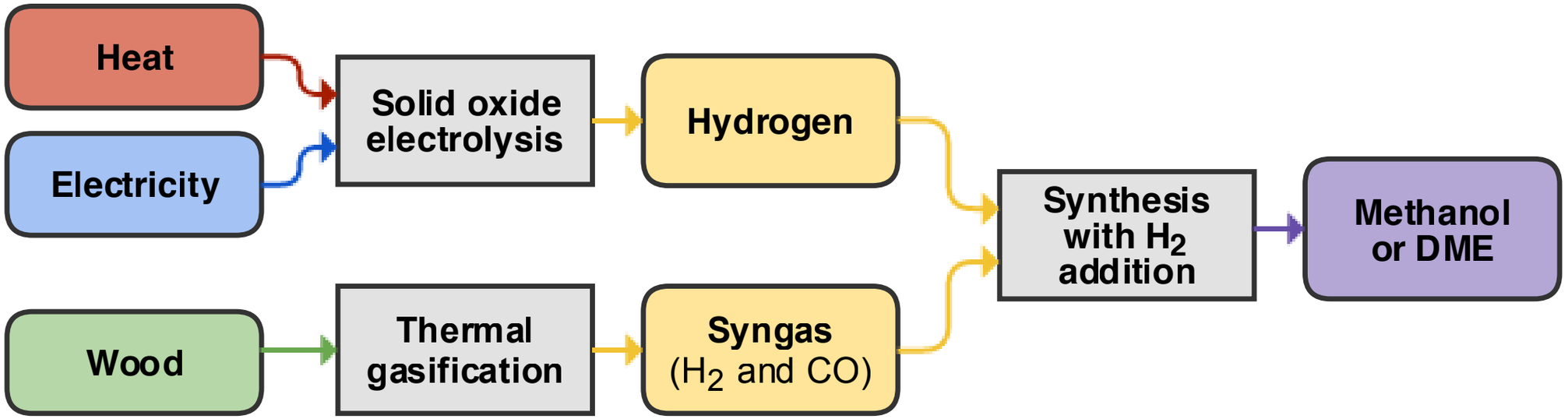
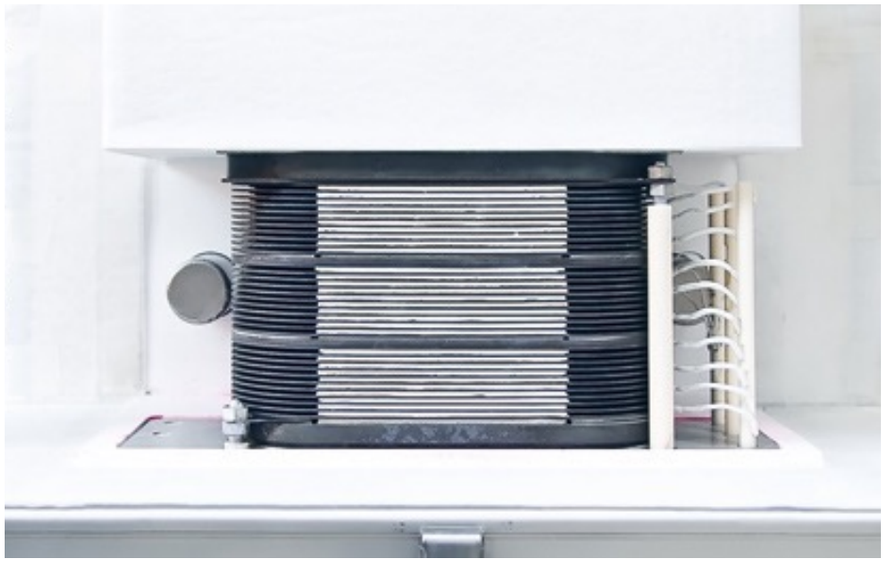




Reversible operation of solid oxide cells for peak load generation

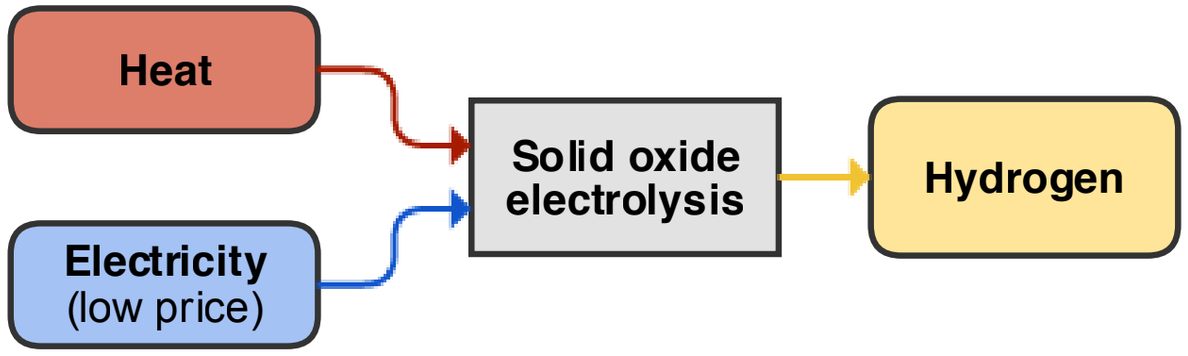
- Sønderborg will rely heavily on electricity from wind, and may need gas turbines on standby for peak load electricity generation.

- Using SOEC for hydrogen production opens up the possibility of running the cells reversibly for peak load generation.



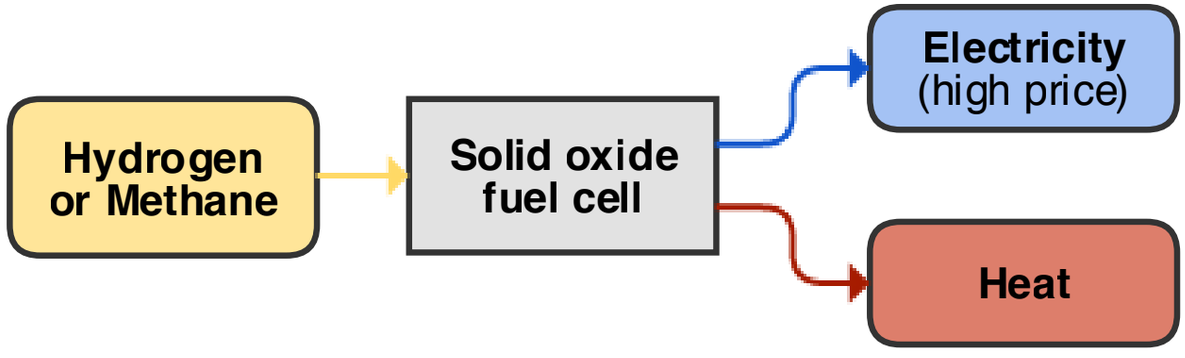
Most of the time: Electrolysis

Hydrogen production to boost biomass



Occasionally: Peak load generation

Could displace reserve gas power plants



Summary

- We are working with data from Sønderborg as a case study for modelling energy supply in cities.

- The objective of the work is to analyze and identify opportunities for increased energy system efficiency and integration across the sectors of the system.

- We will model and analyze different scenarios, including e.g. biogas production with hydrogen addition and electrolysers capable of reversible operation.

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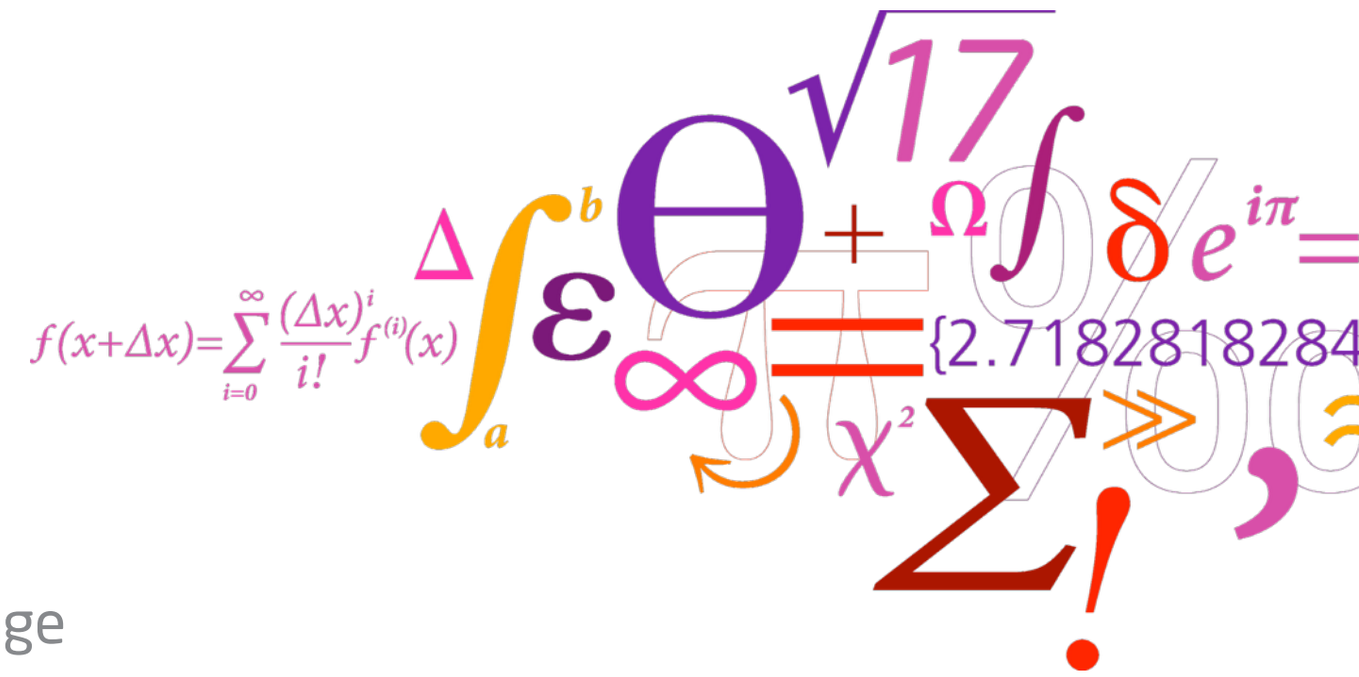
Thanks for your attention!

Questions?



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