

Status and Results of Energy Supply Modelling in CITIES

Illustrated Using Data from the Case of Sønderborg

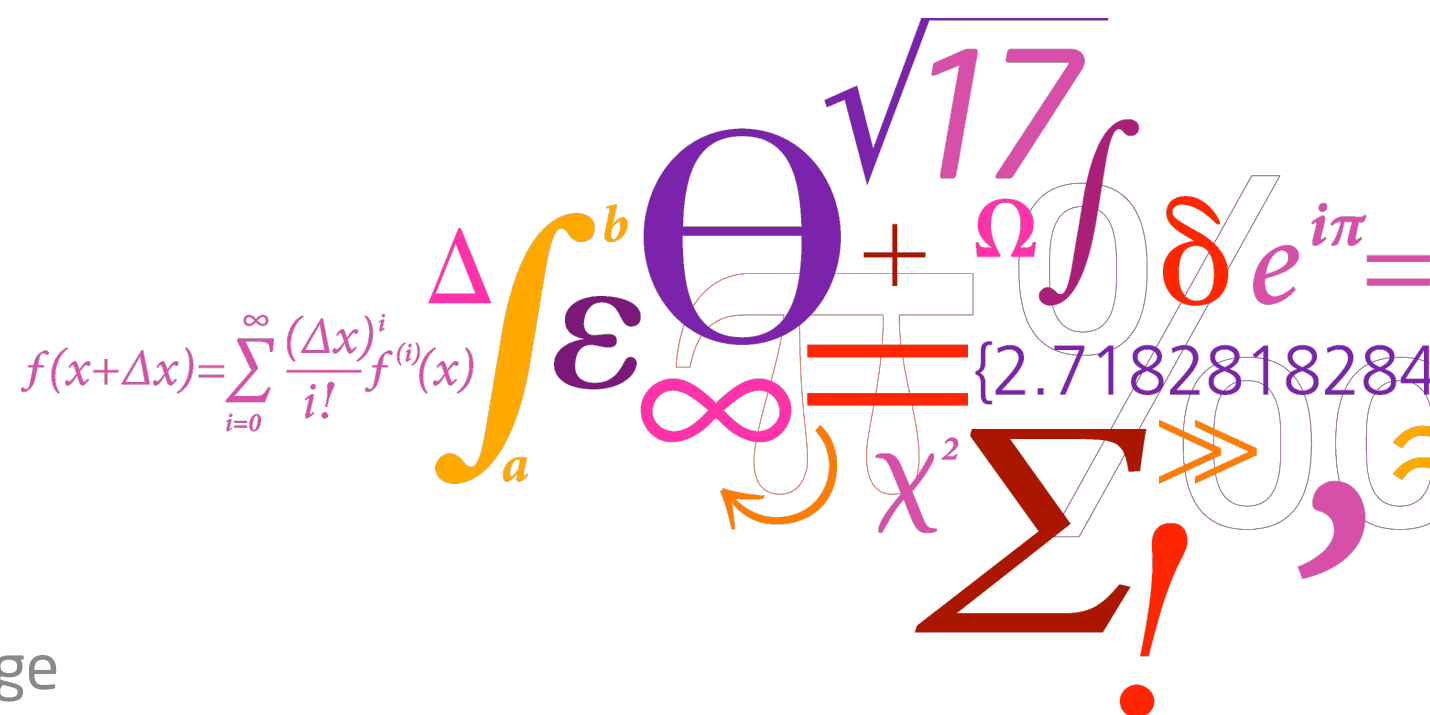
WP2 presentation

CITIES Consortium Meeting, 26.05.2015

Daði P. Sveinbjörnsson

DTU Energy

Department of Energy Conversion and Storage



CITIES Work Package 2

Aims:

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

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Sønderborg as a case study for modelling energy supply in CITIES

Population

- Sønderborg municipality: 27'500
- Sønderborg area: 75'300

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.



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Sønderborg municipality has the goal of becoming CO₂-neutral by 2029.

The collaboration with ProjectZero is essential for the case study.



Bright Green Business

ProjectZero

DTU Energy

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The case of Sønderborg as a CITIES demo-project

Demo-project proposal:

“2030 scenarios for energy supply in Sønderborg”

Participants:

- CITIES WP1 & WP2
 - Energinet
 - Project Zero
 - (Possibly: A local industrial gas consumer)
-
- ProjectZero and PlanEnergi have made a strategic energy plan for Sønderborg in 2029.
 - We want to model alternative scenarios and see if new energy technologies could increase the efficiency and integration of Sønderborg's energy system.



The techno-economic energy systems modeling tool *Sifre*

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

The screenshot displays the Sifre Frontend 1.2.15.0 interface. The main window is titled 'Dadi_SB2029 - Sifre Frontend 1.2.15.0'. It features a ribbon menu with 'FILE', 'HOME', and 'VIEW' tabs. The 'HOME' tab is active, showing icons for 'Save All', 'Close', 'Refresh', 'New Record', and 'Delete Record'. The left sidebar contains a tree view with categories: General, Tracks, Areas, Fuel Types, Emission Prices, Units, Production Units, Heat Pumps, Renewable Units, Energy Storages, Electric Vehicles, Interconnections, Demand, and Profiles. The 'Areas' category is selected, and the 'Areas' window is open. This window contains a table with the following data:

Type	Fuel Type	Is External	Name	Description
Fuel	Biogas	<input type="checkbox"/>	BiogasFuel	Locally produced biogas
Heating		<input type="checkbox"/>	DistrictHeating	Local district heating system
Electricity		<input checked="" type="checkbox"/>	EIDK1Area	Remote DK1 electricity grid
Electricity		<input type="checkbox"/>	ElGridLocal	Local electricity grid
Fuel	Methane	<input type="checkbox"/>	GasNetLocal	Local methane gas net
Fuel	Methane	<input type="checkbox"/>	GasNetRemote	Remote methane gas net
Fuel	Manure	<input type="checkbox"/>	ManureFuel	Manure
Fuel	Waste	<input type="checkbox"/>	WasteFuel	Waste
Fuel	Wood	<input type="checkbox"/>	WoodFuel	Wood
*		<input checked="" type="checkbox"/>		

Below the table, there is a section for 'External Area Price'. It includes a 'Track' dropdown menu set to 'EIDK1Price'. A yellow warning box states: 'Read Only This track is used by [simulations with results](#). To enable editing, [reset all simulations](#) that use it.' Below this, a table shows price data:

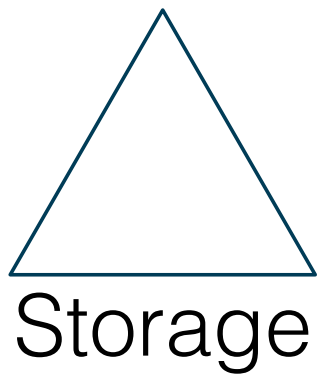
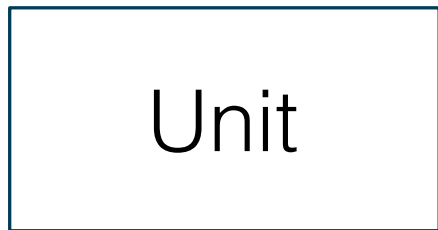
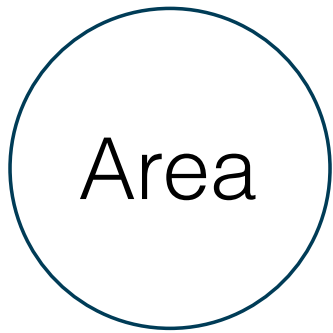
Date	Value
2014-12-31 00:00	100
2015-01-01 00:00	113.01
2015-01-01 01:00	96.67
2015-01-01 02:00	90.18

Energinet.dk

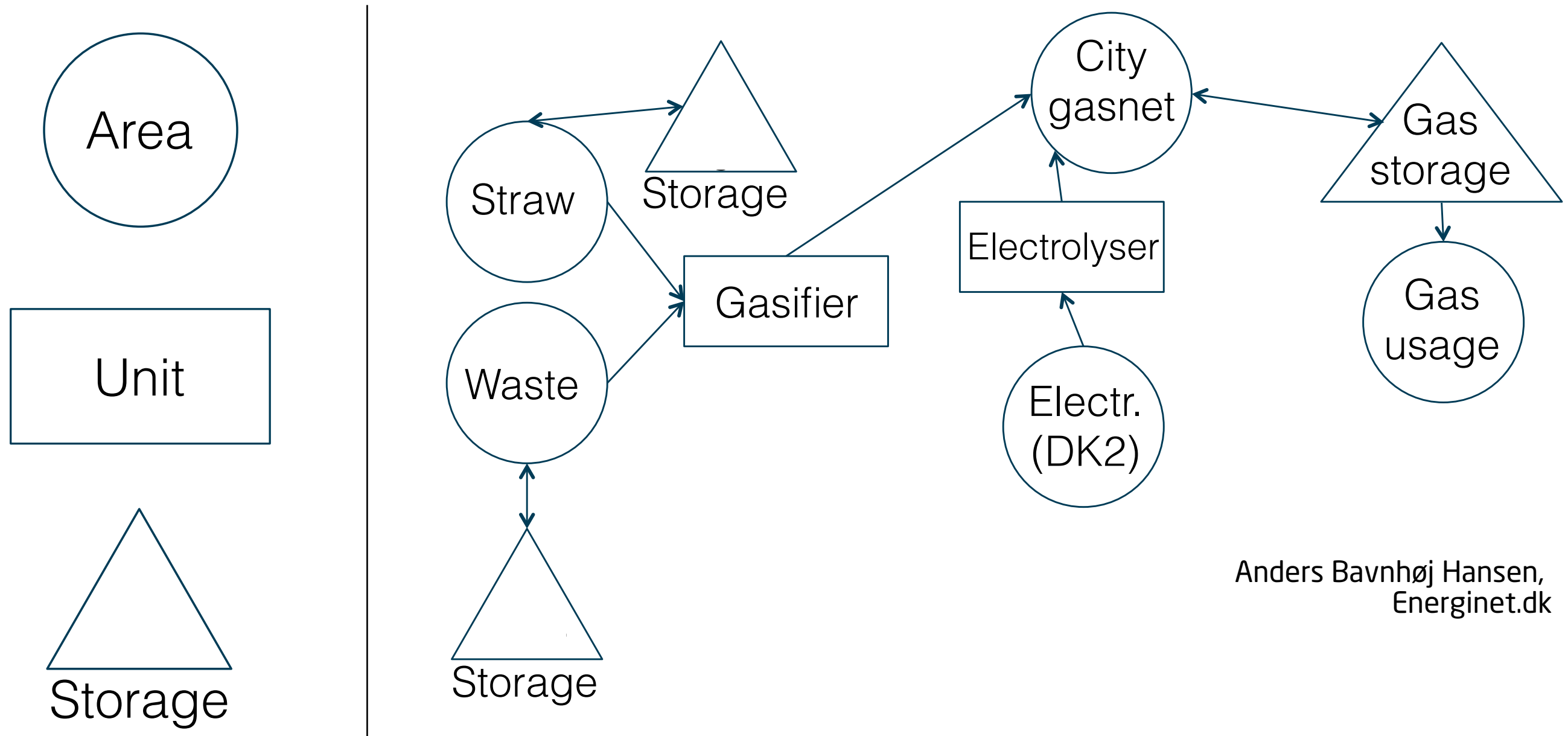
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The general layout of the *Sifre* model



The general layout of the *Sifre* model



Anders Bavnhøj Hansen,
Energinet.dk

Main model outputs

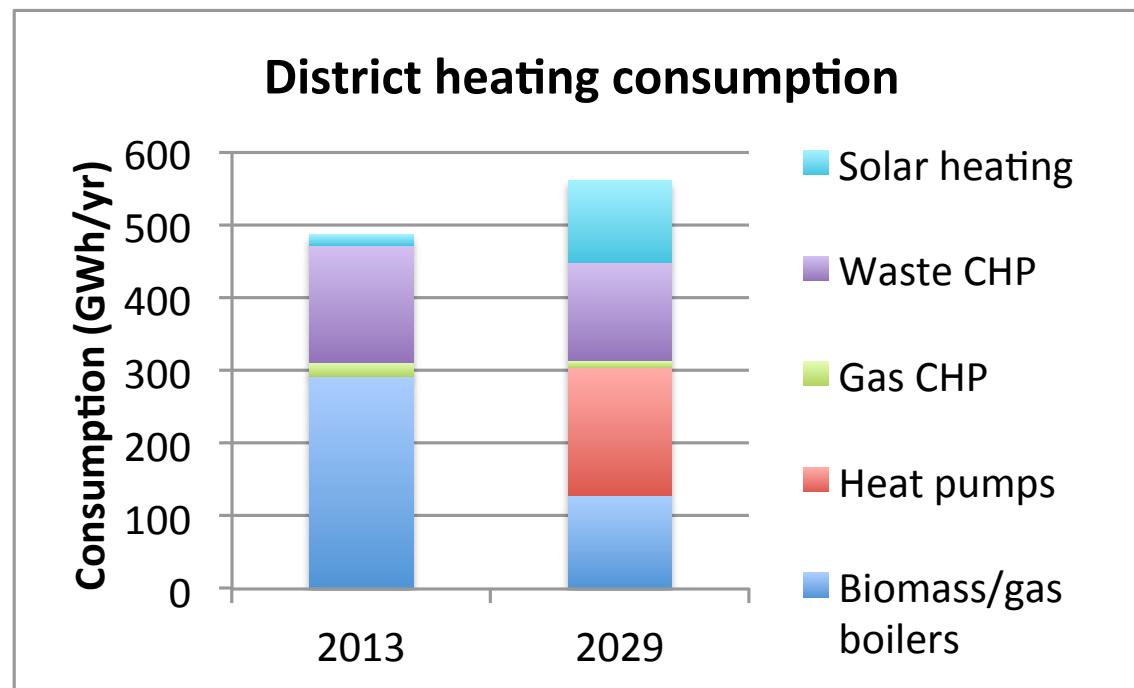
- The optimized hour-by-hour system operation and energy flows.
- Model-generated market prices for energy within the system.

Sønderborg's energy consumption in 2013 and 2029

We use Sønderborg's strategic energy plan by Project Zero and PlanEnergi as the benchmark case for our model.

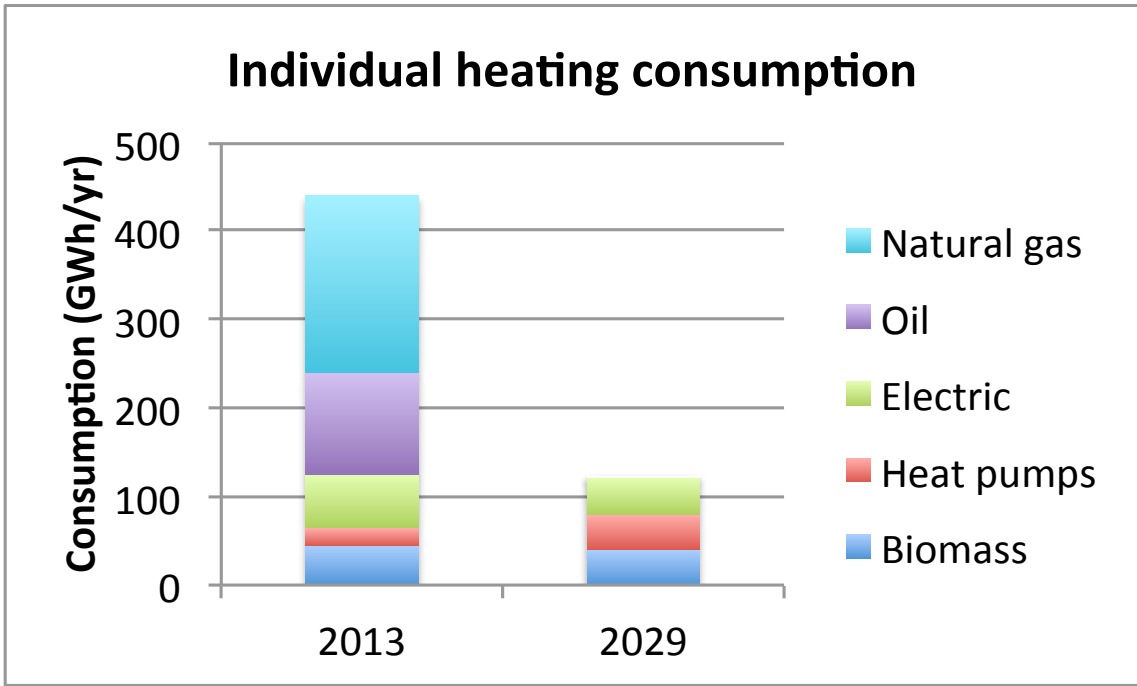
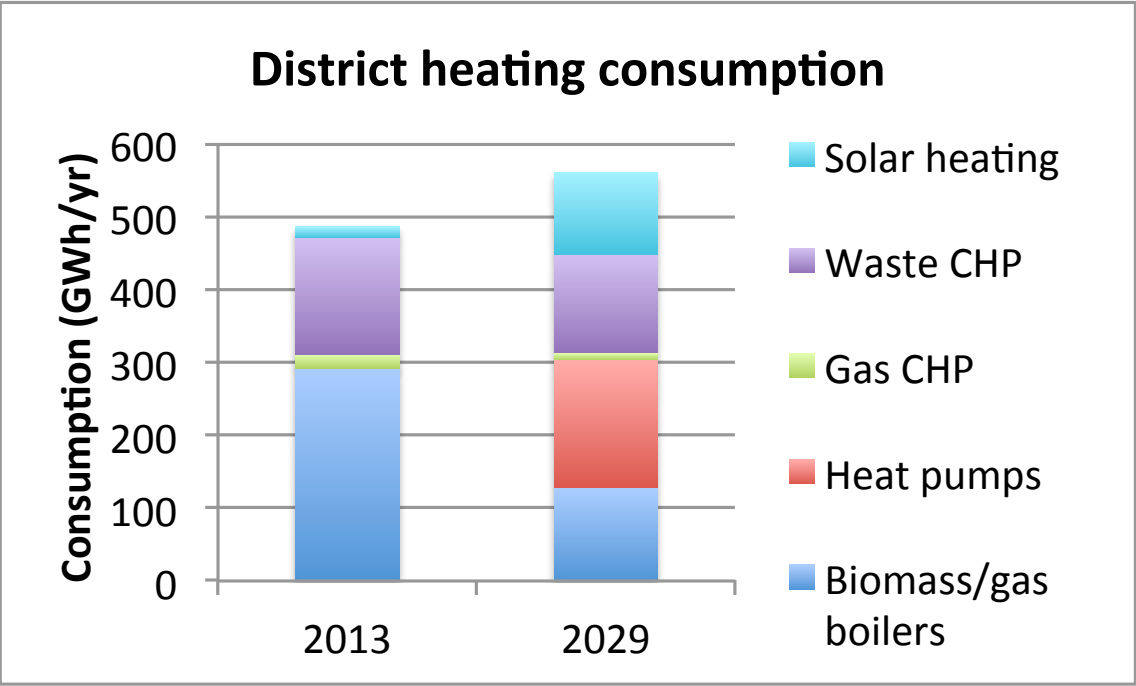
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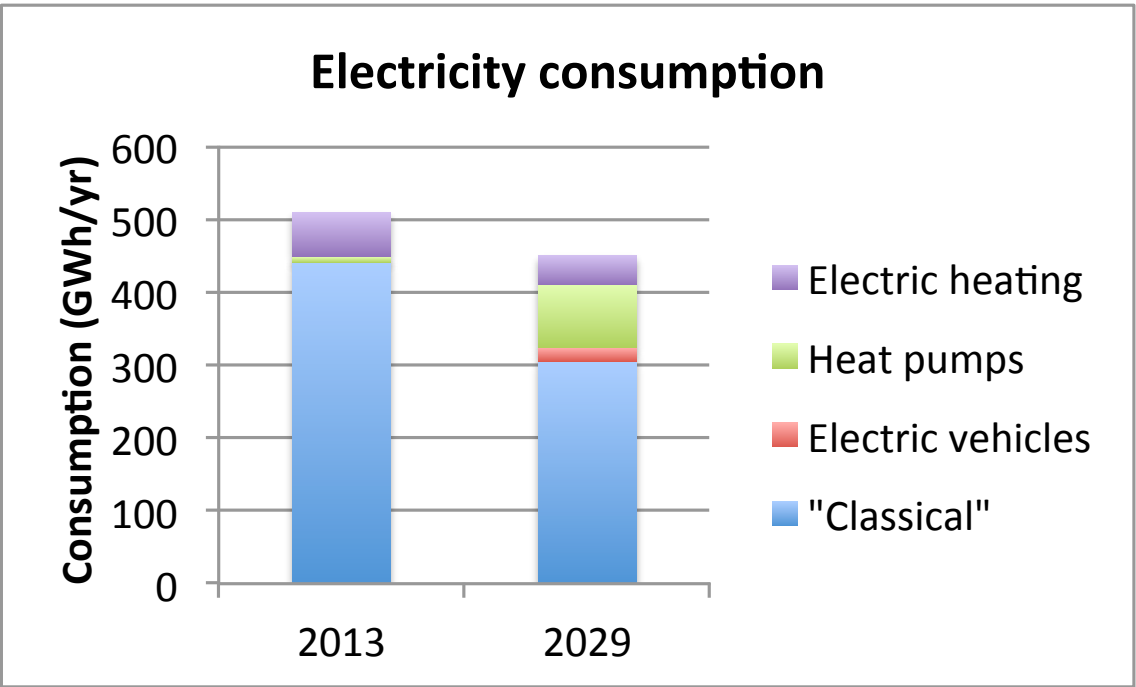
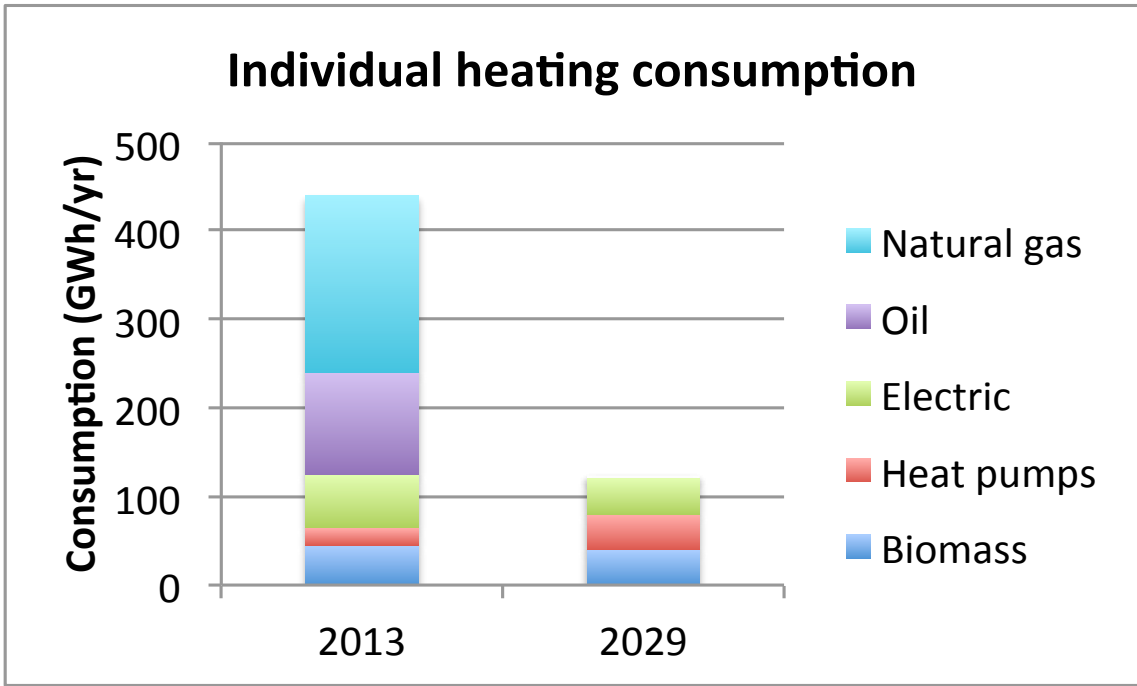
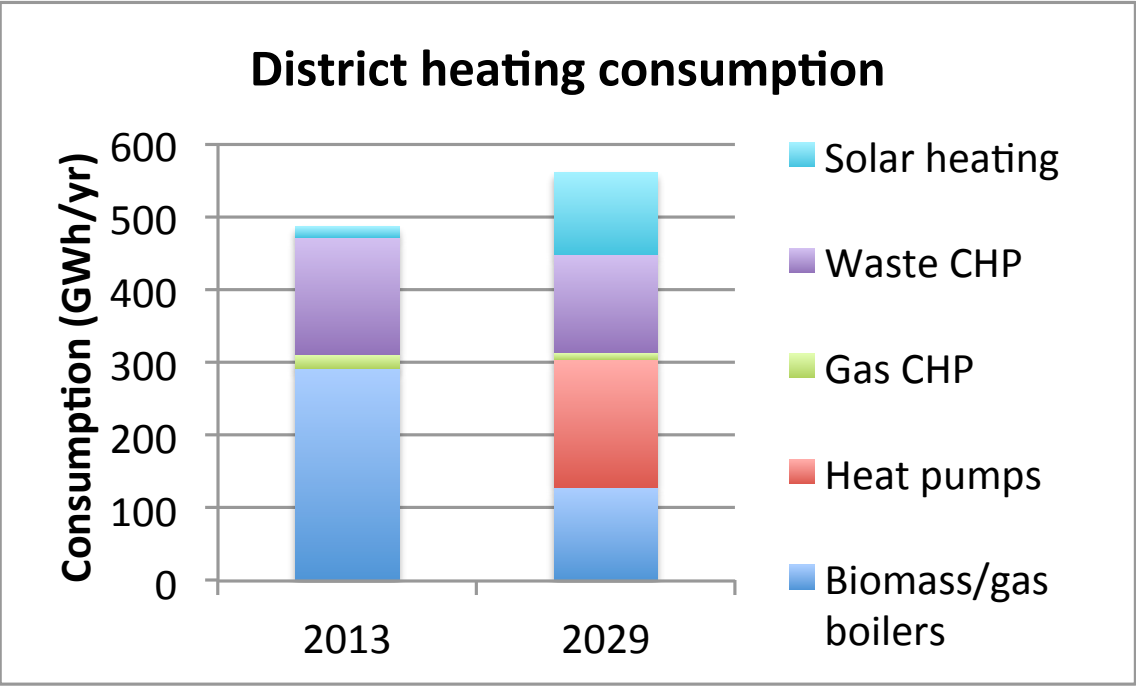
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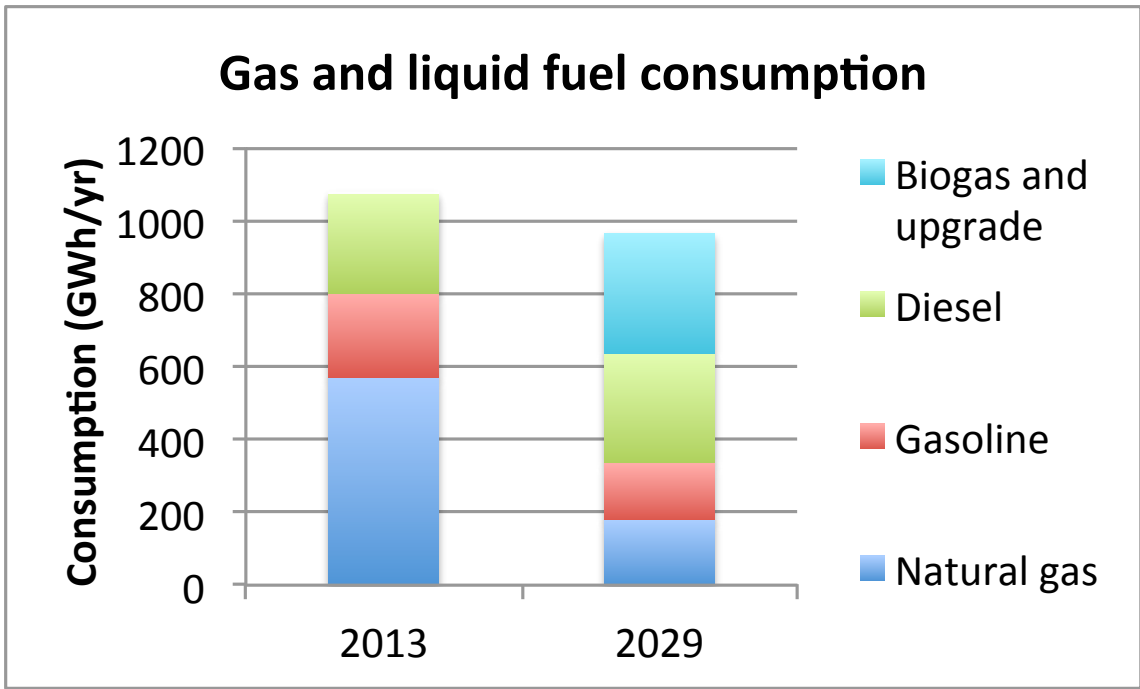
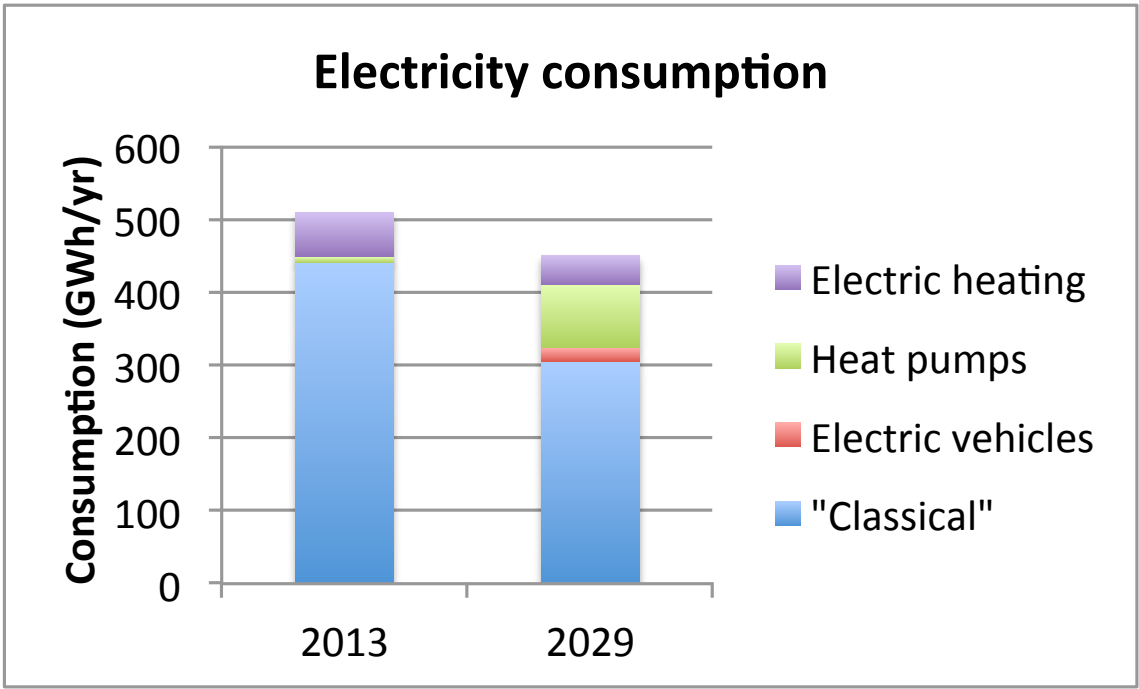
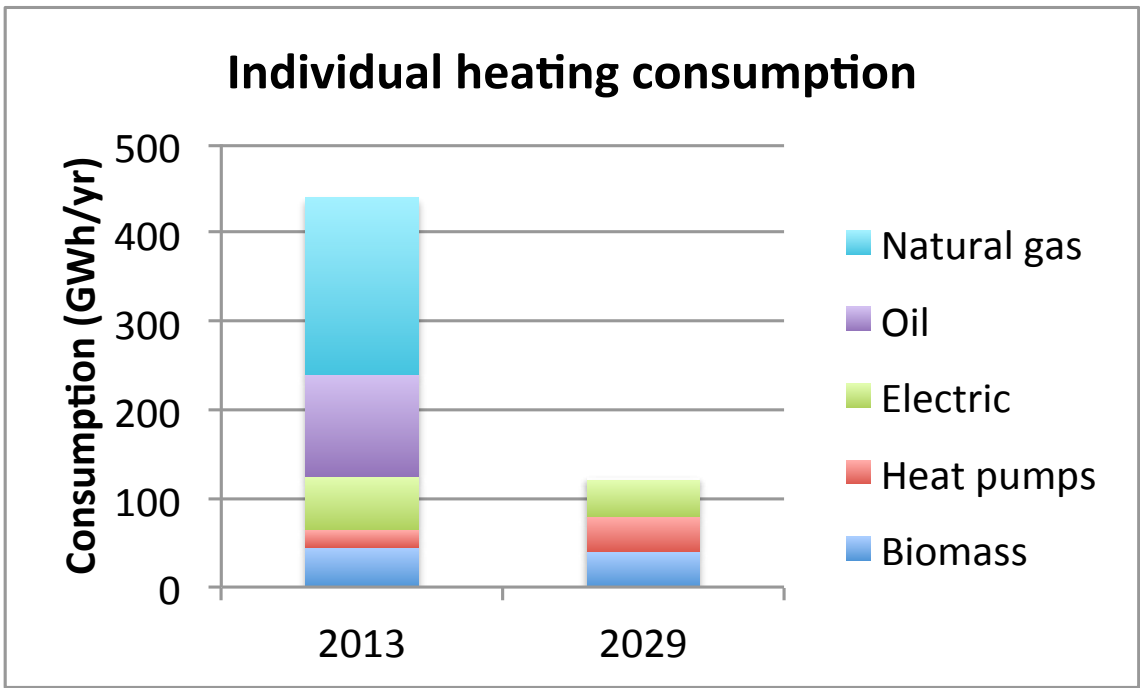
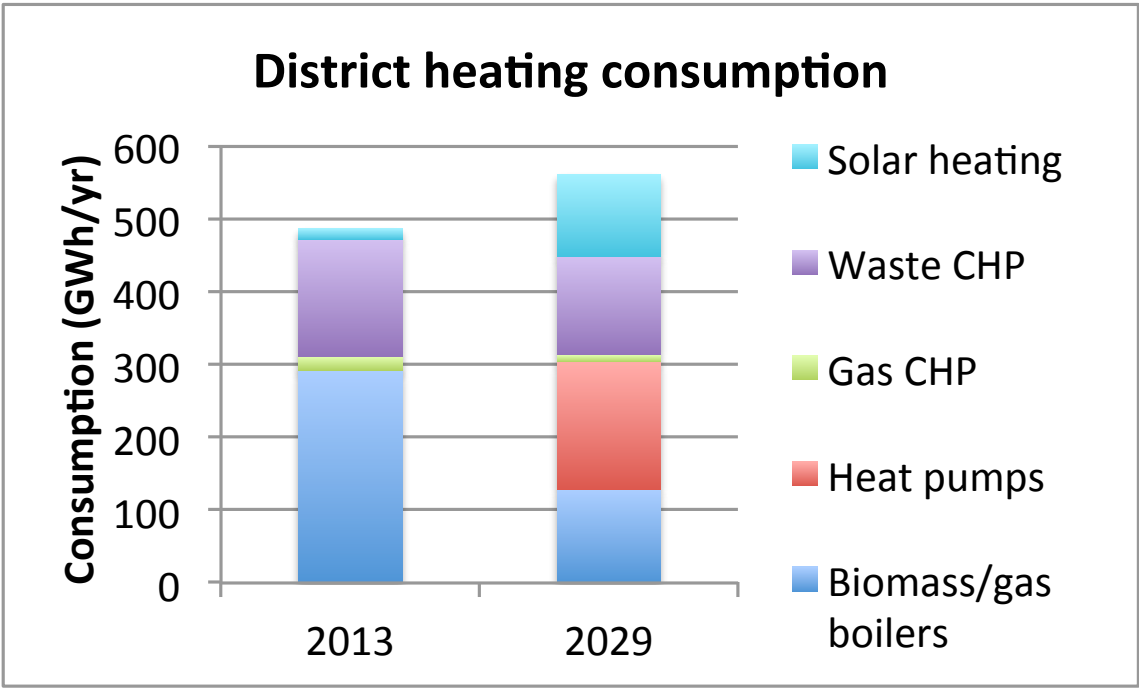
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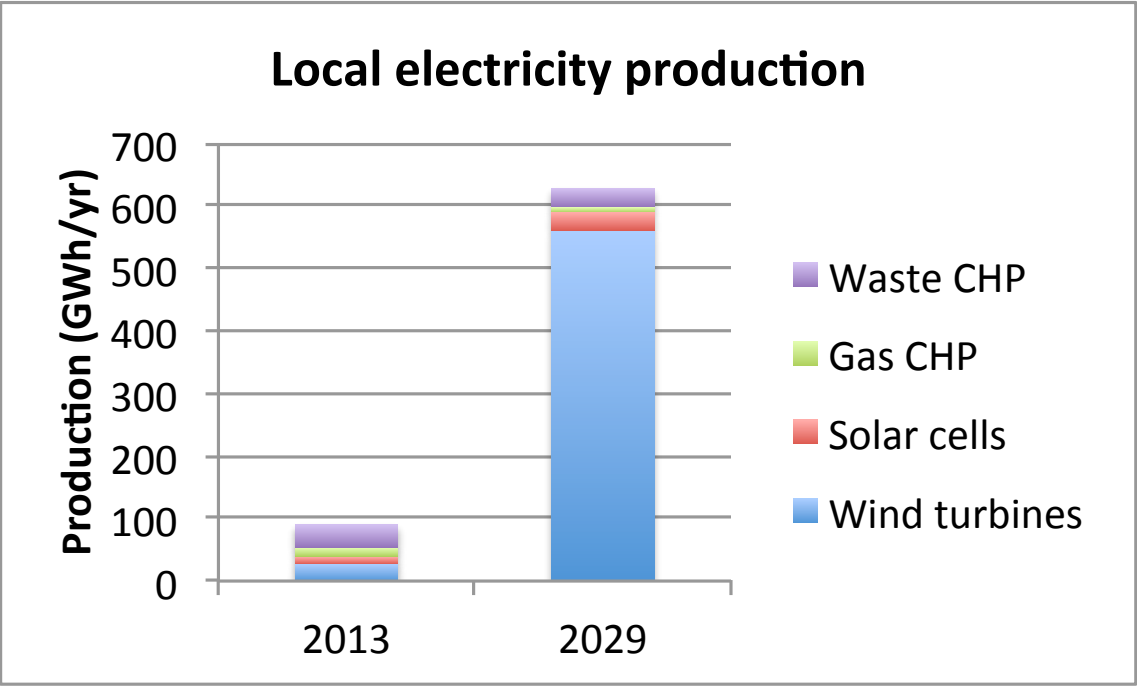


Sønderborg's energy consumption in 2013 and 2029

Sønderborg aims at being self-sufficient with electricity and gas production in 2029.

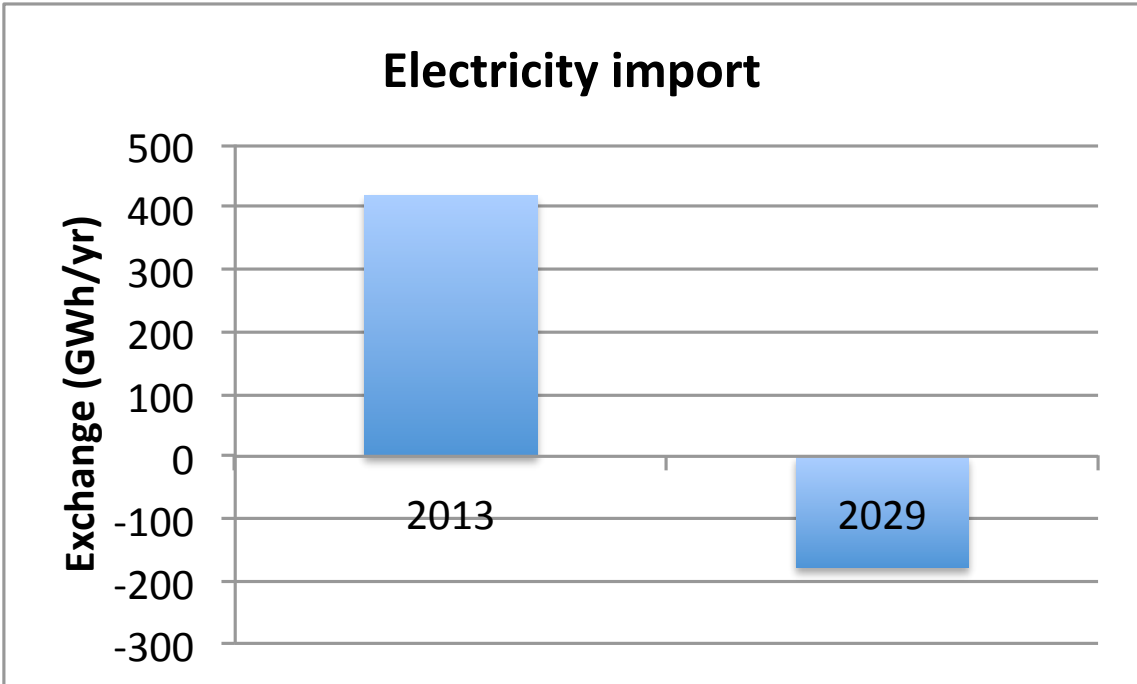
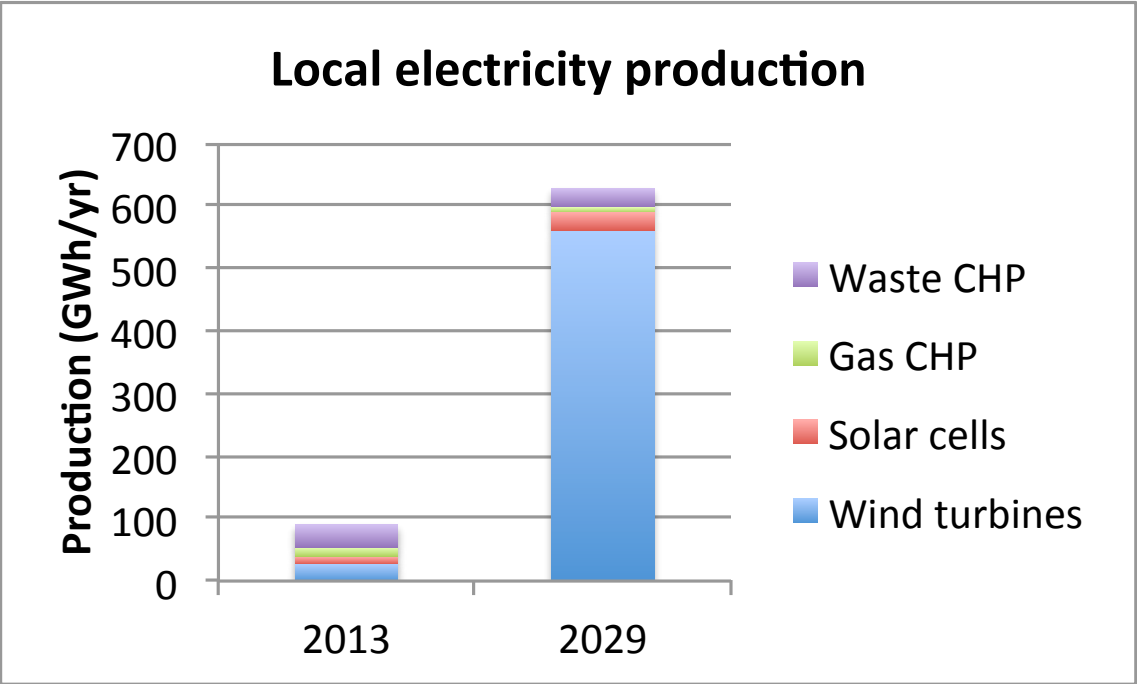
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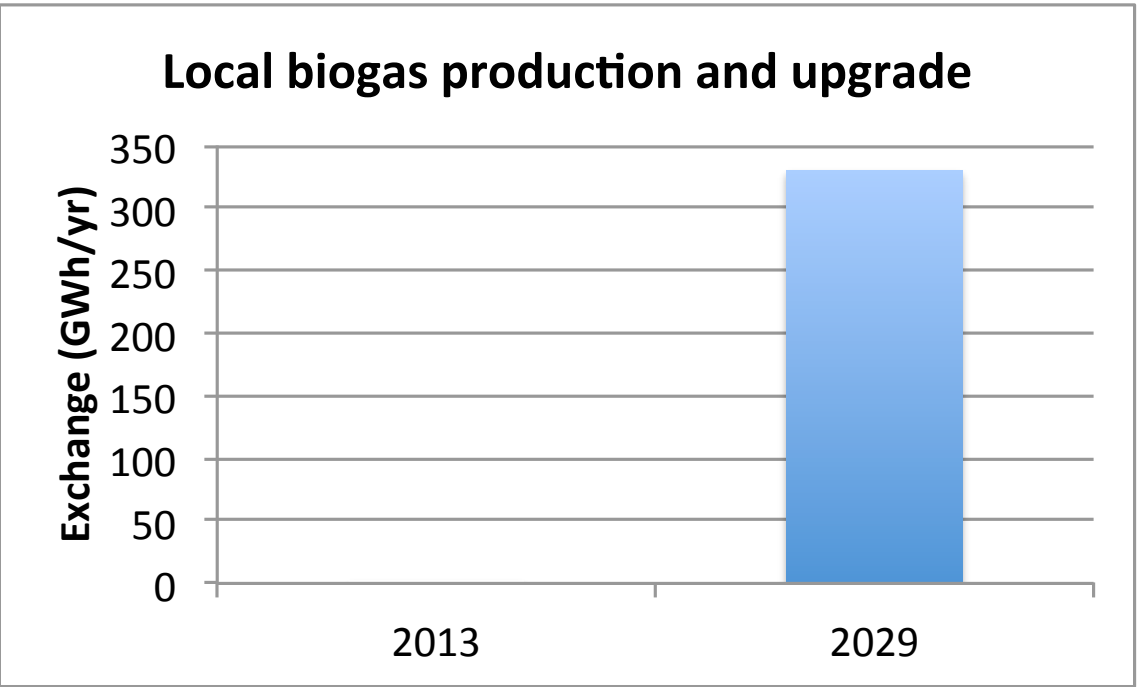
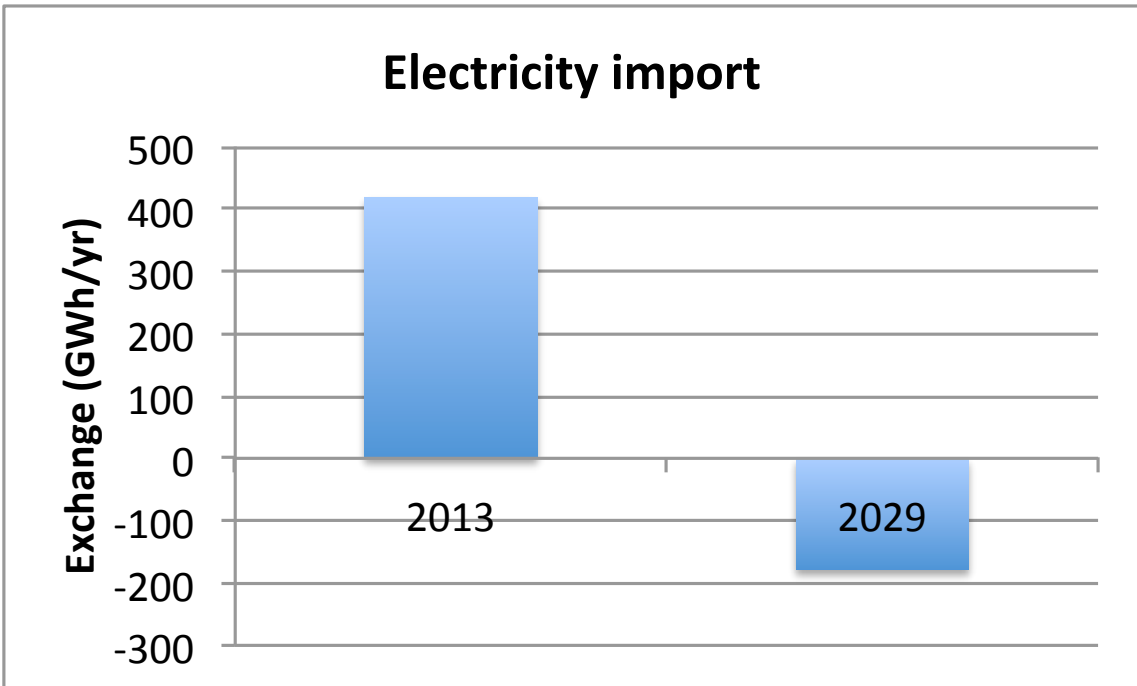
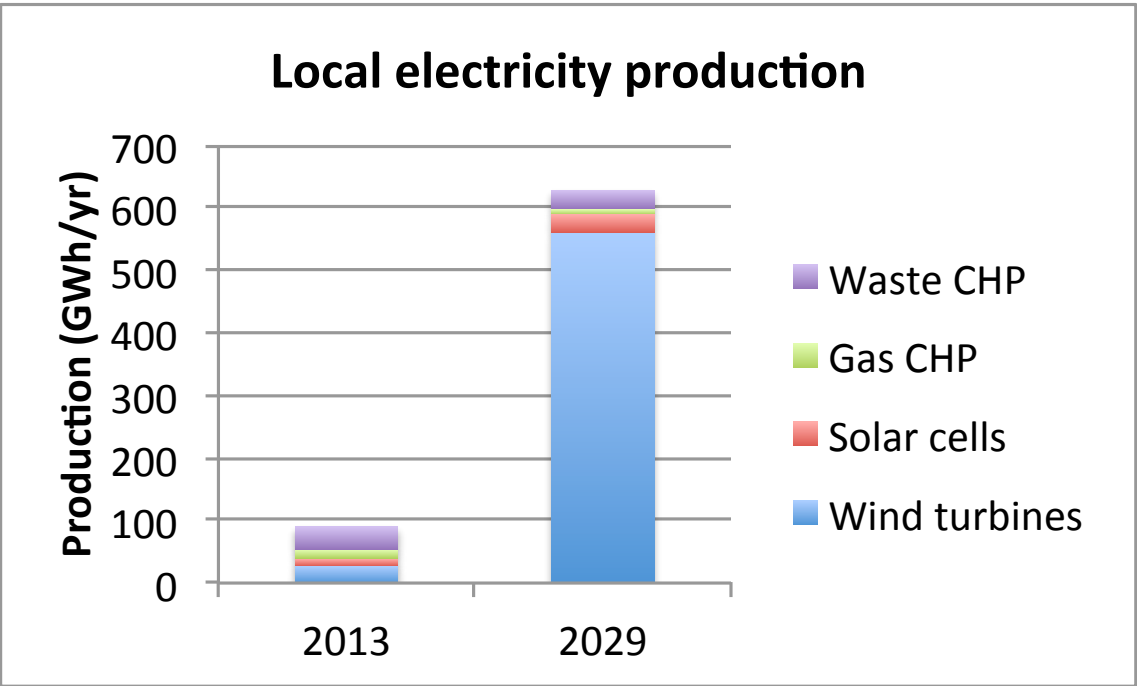
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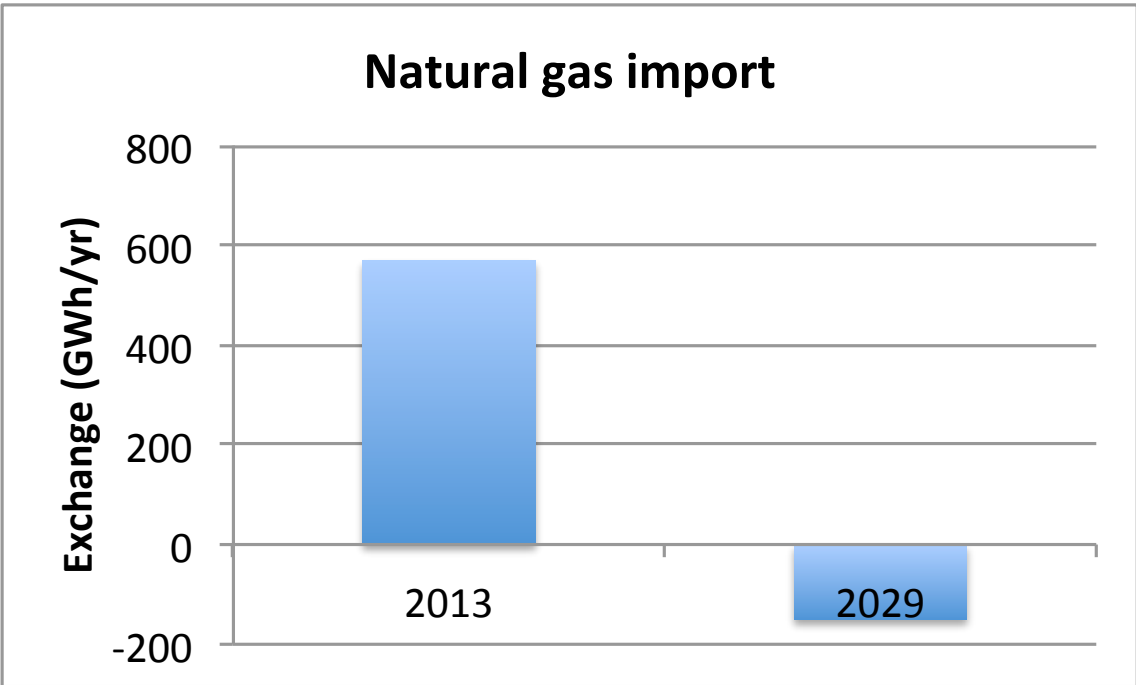
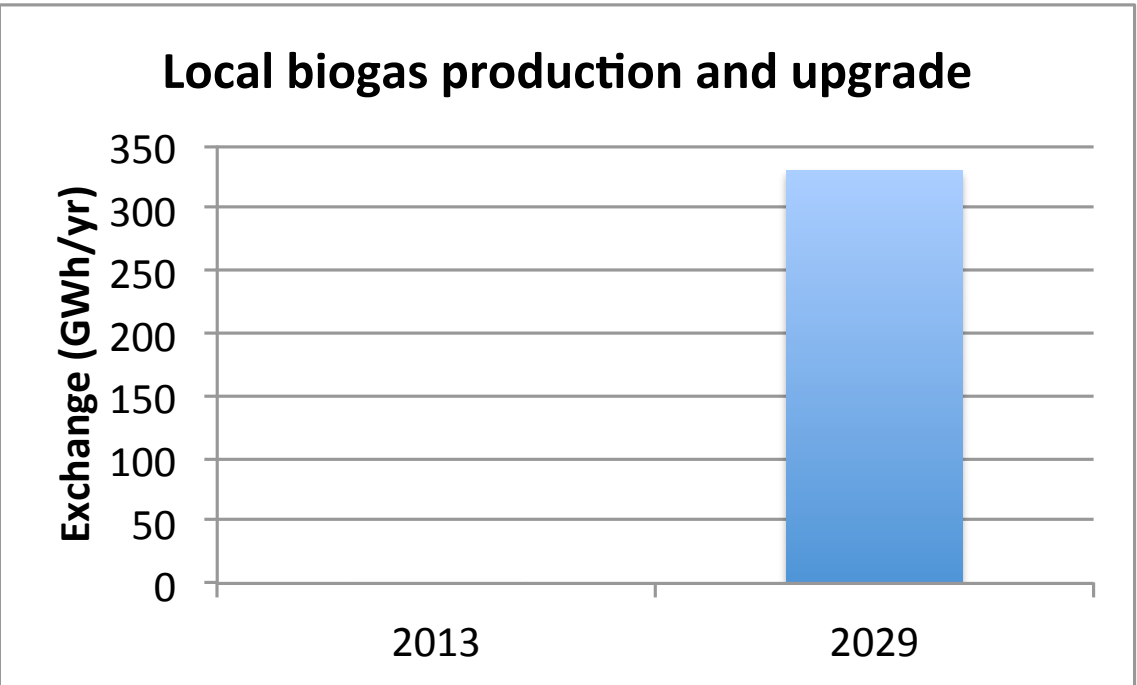
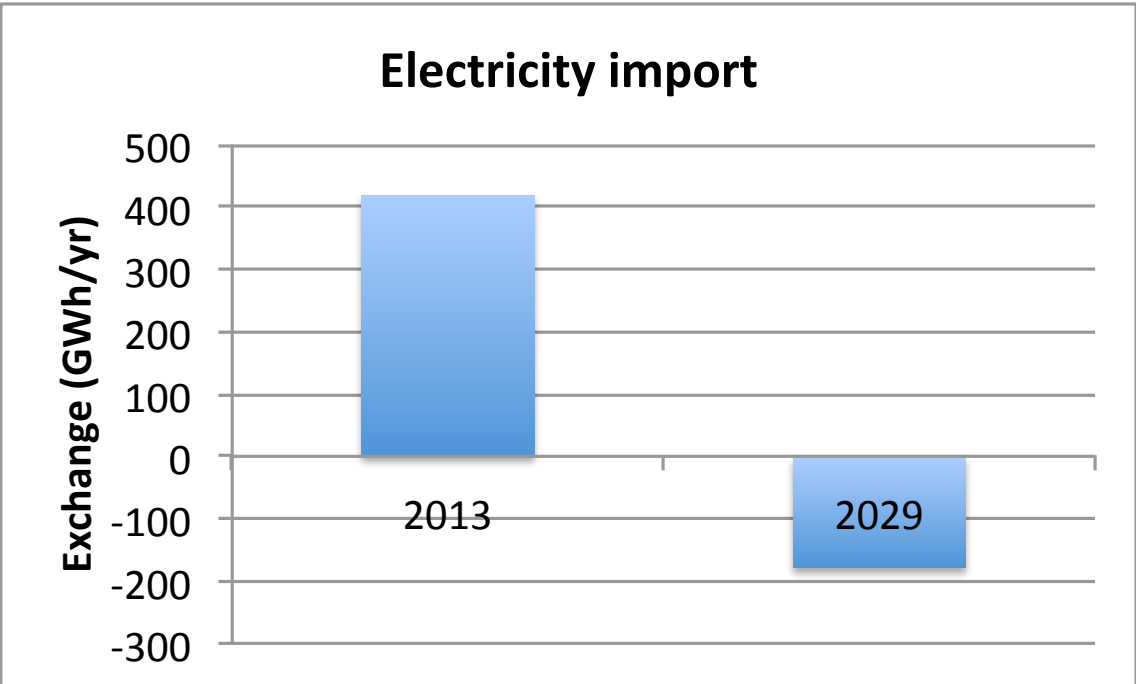
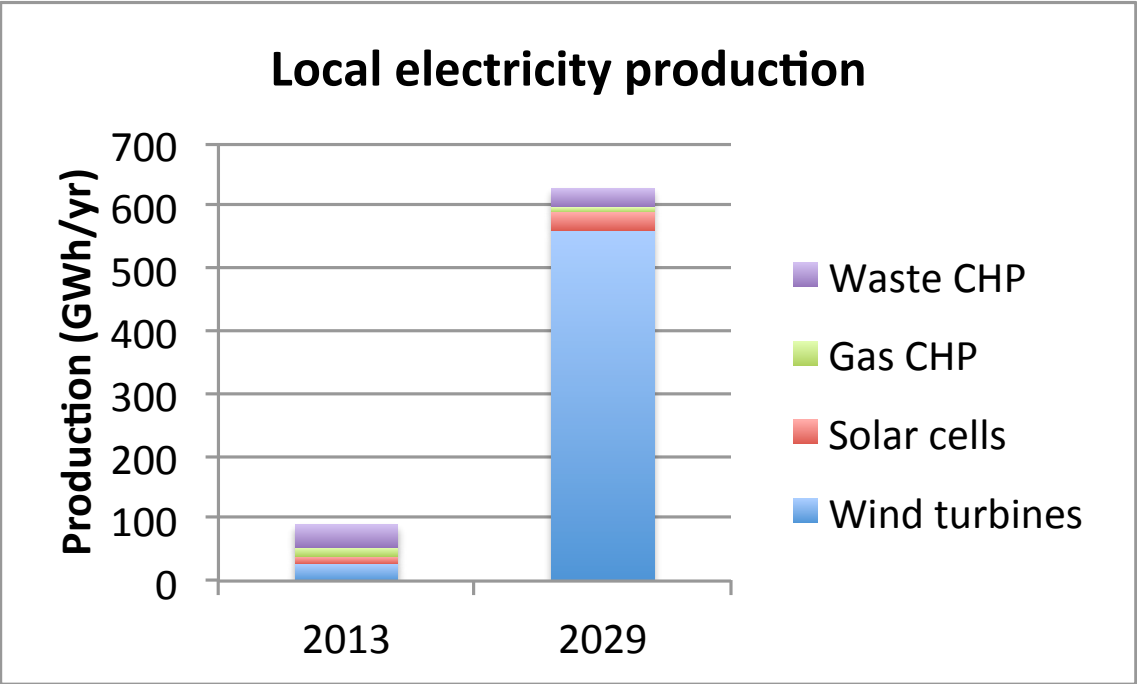
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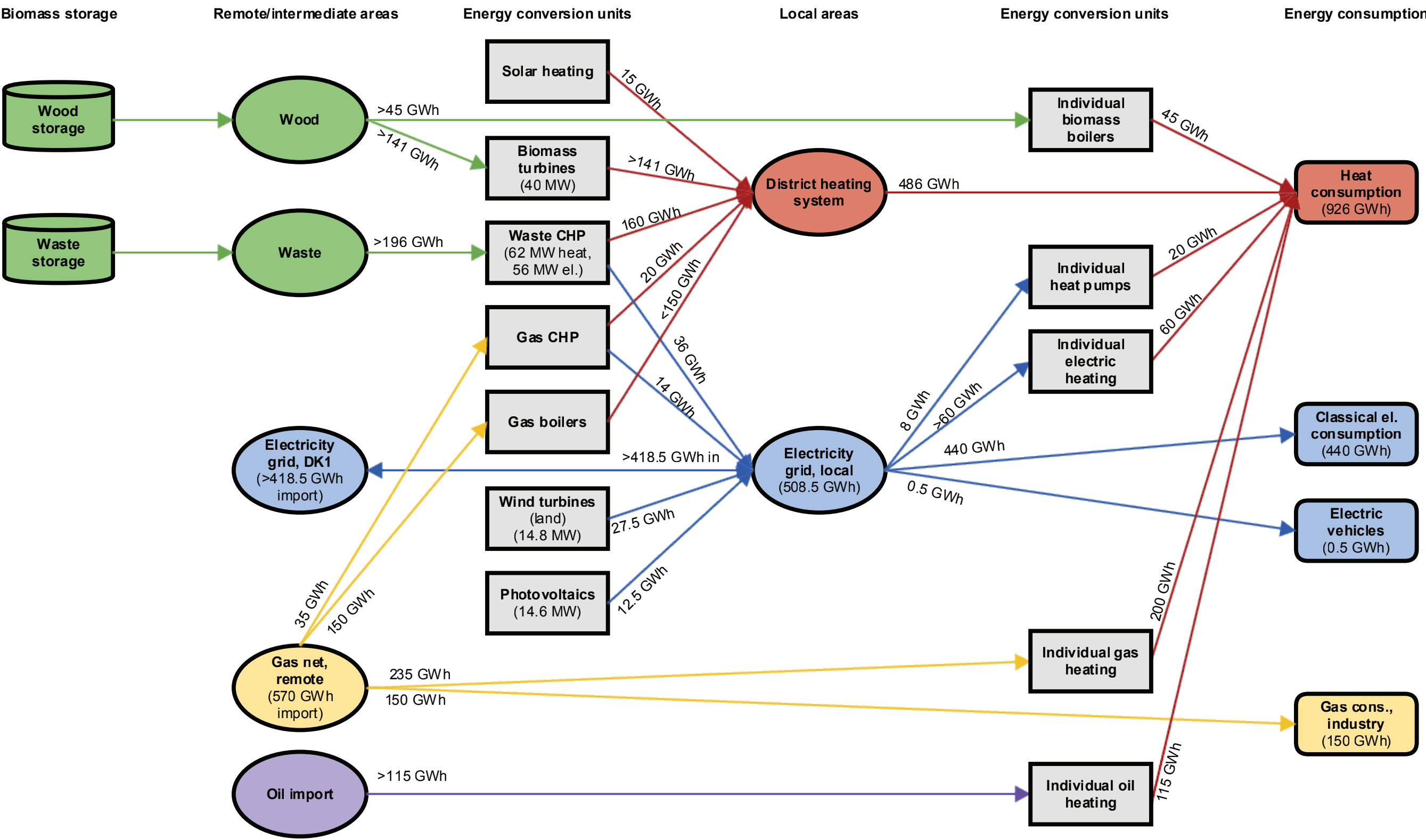


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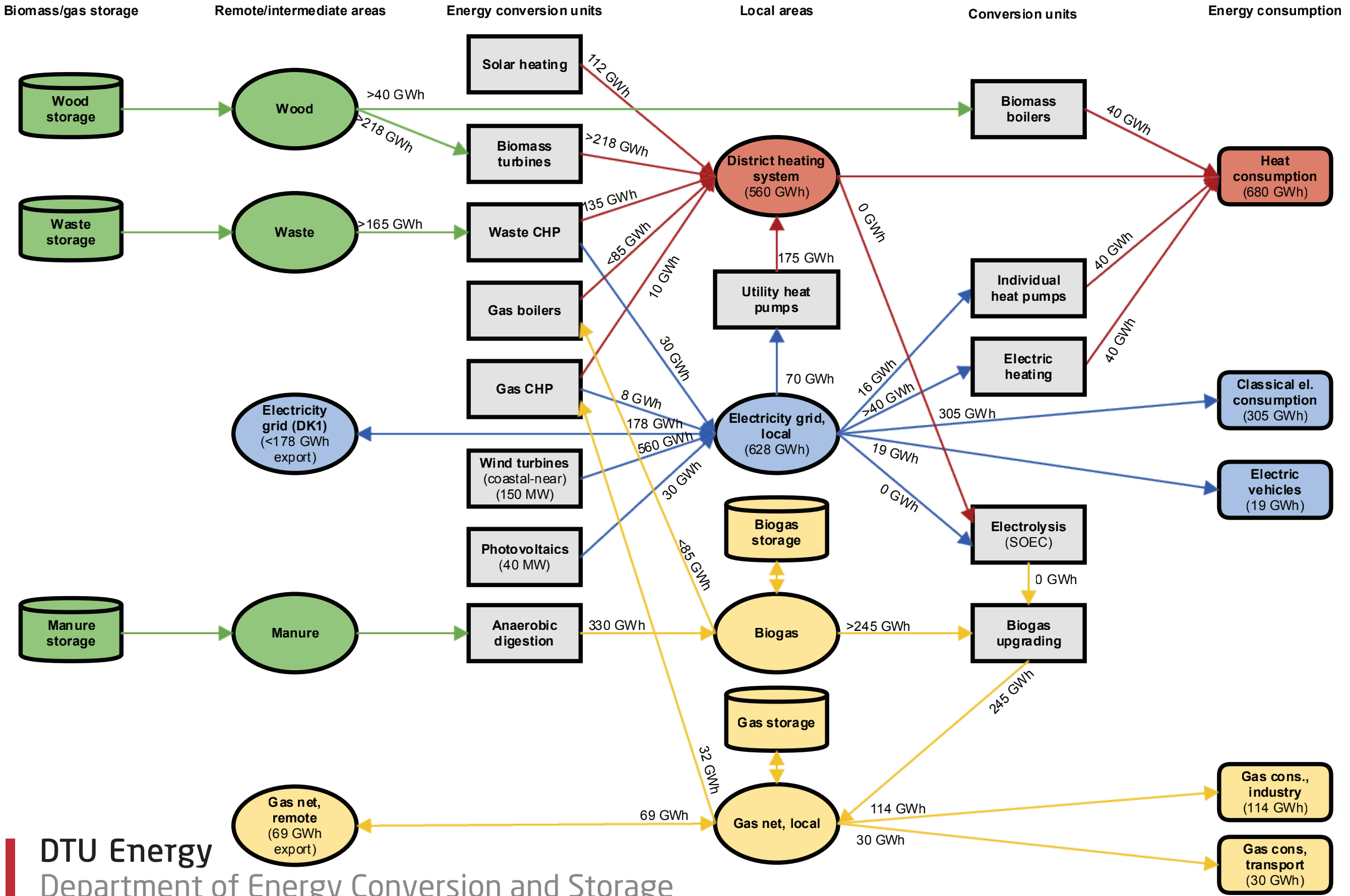
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Model layout: Sønderborg's energy system in 2013

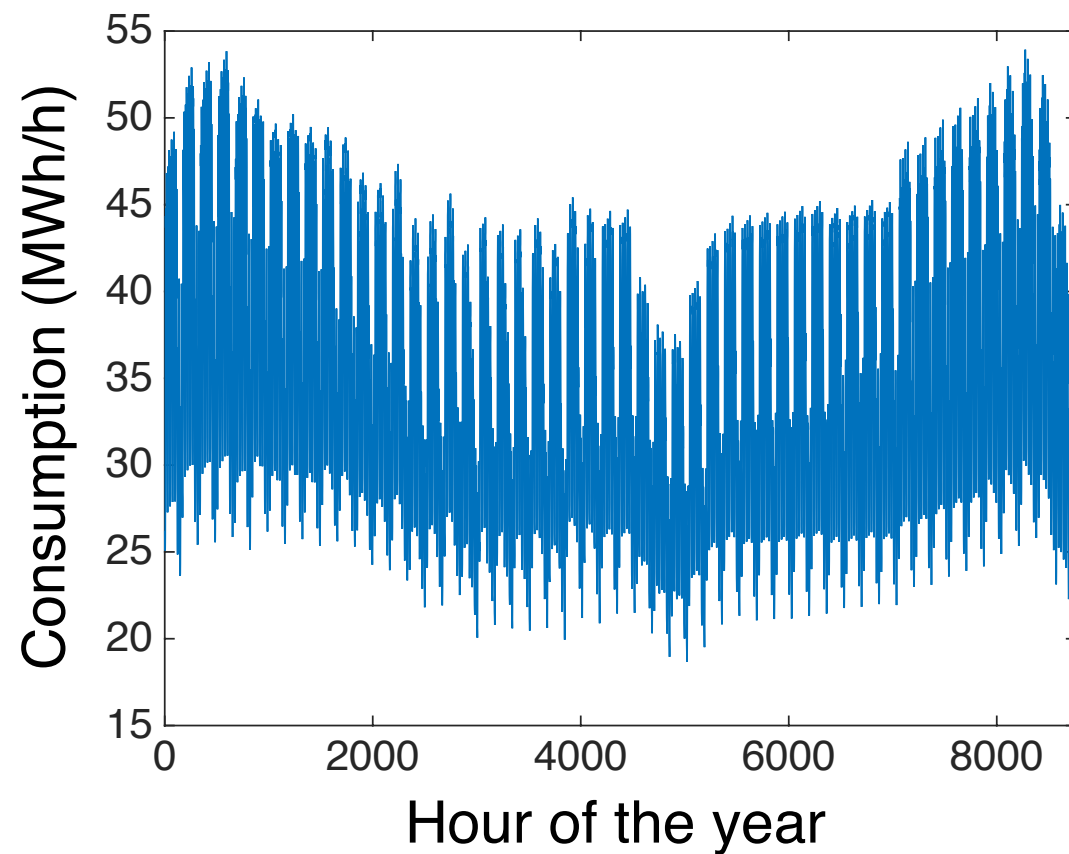


Model layout: Sønderborg's energy system in 2029

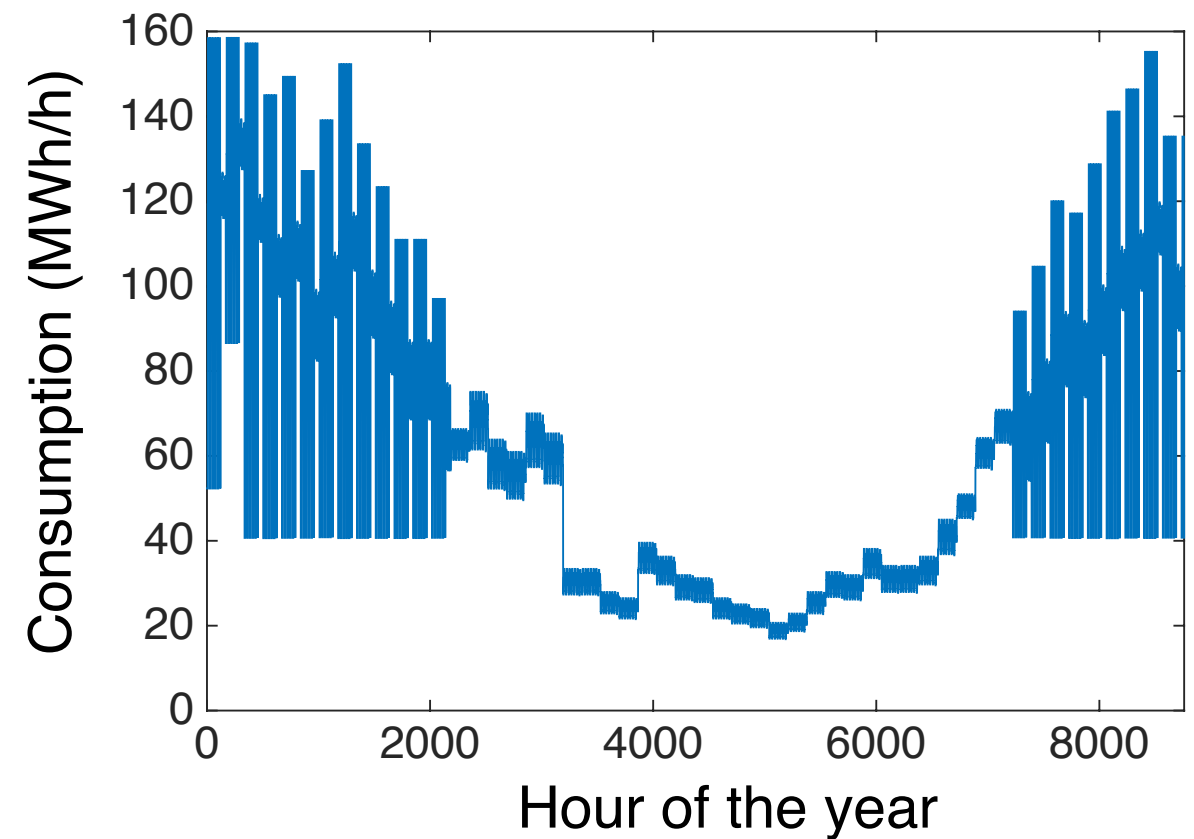


Status of the Sønderborg modelling work and examples of results

Electricity consumption



District heating consumption

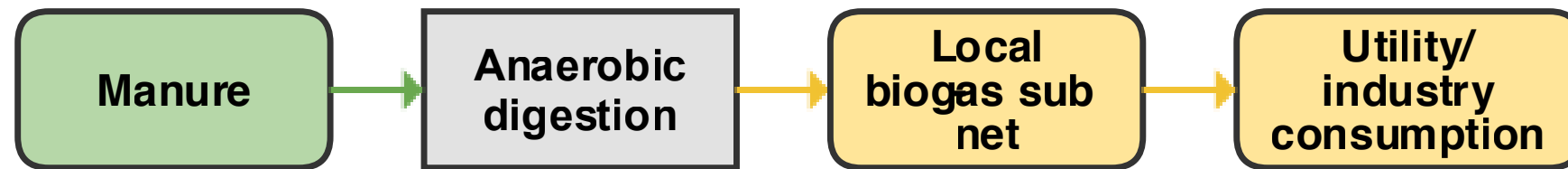


- The model yields results in the form of hour-by-hour time series, optimized for pre-defined consumption profiles.
- The modelling work is on-going and not all system components have been accurately modelled. Therefore no detailed results are available yet.

Examples of alternative scenarios for Sønderborg in 2030

Local biogas sub-net

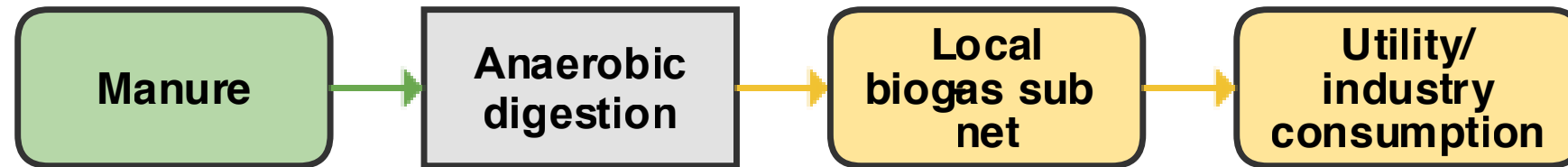
- Is it necessary to upgrade all biogas, or can it be used directly by some local utilities and industries?



Examples of alternative scenarios for Sønderborg in 2030

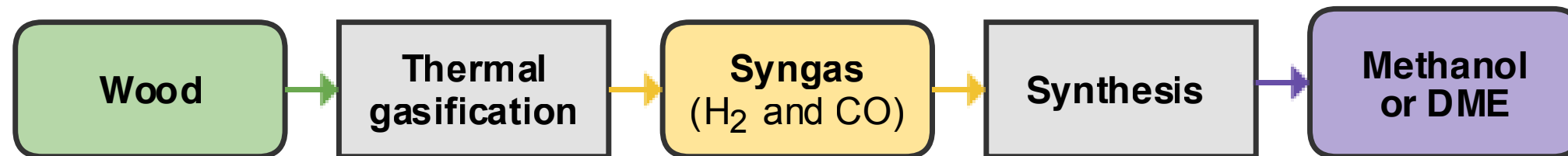
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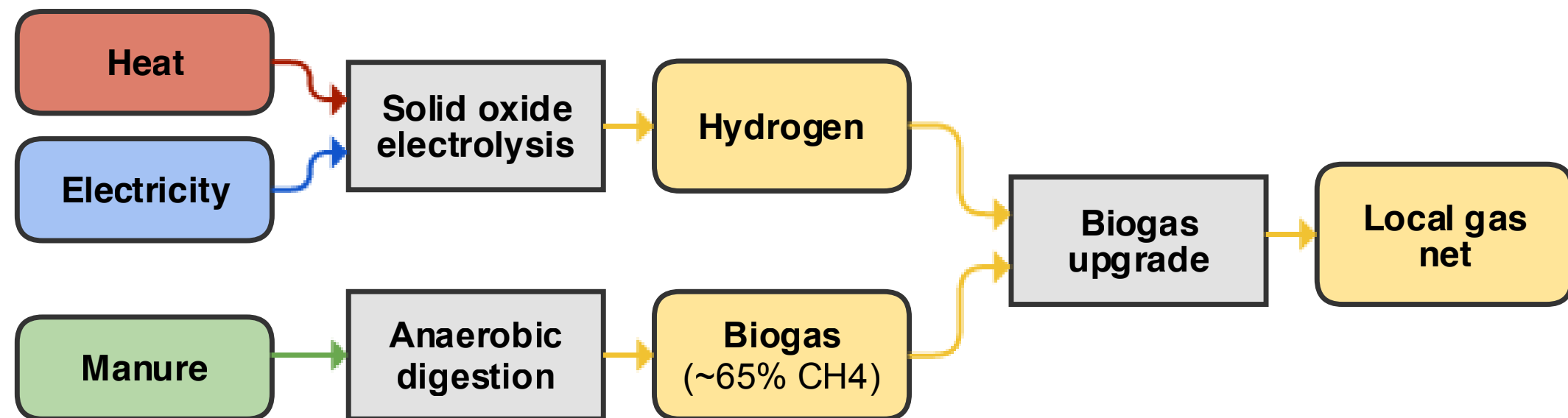
Transport fuel production from thermal gasification

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



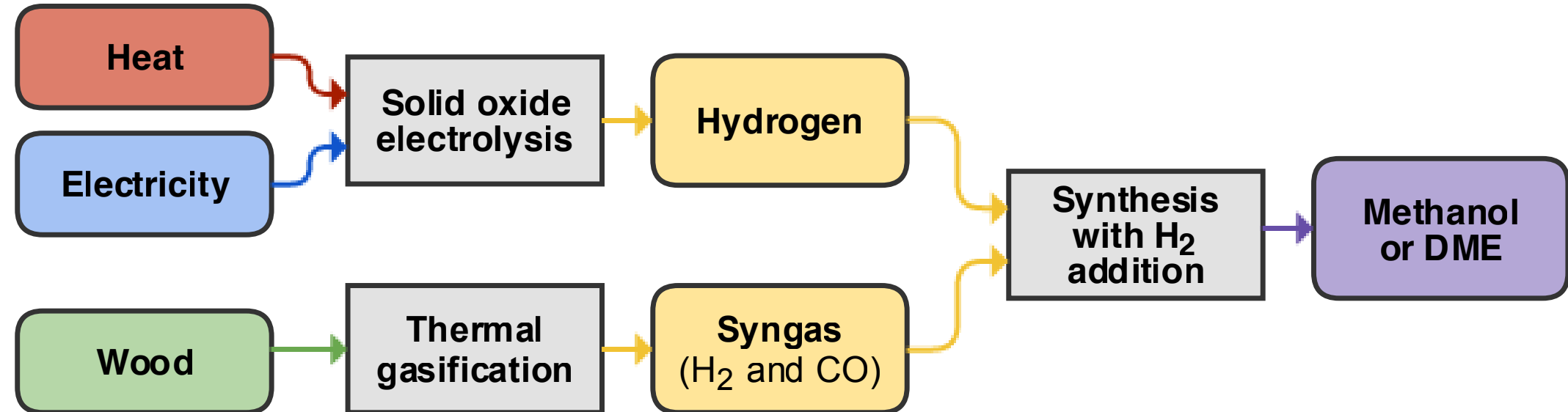
More efficient usage of biomass with hydrogen addition

- 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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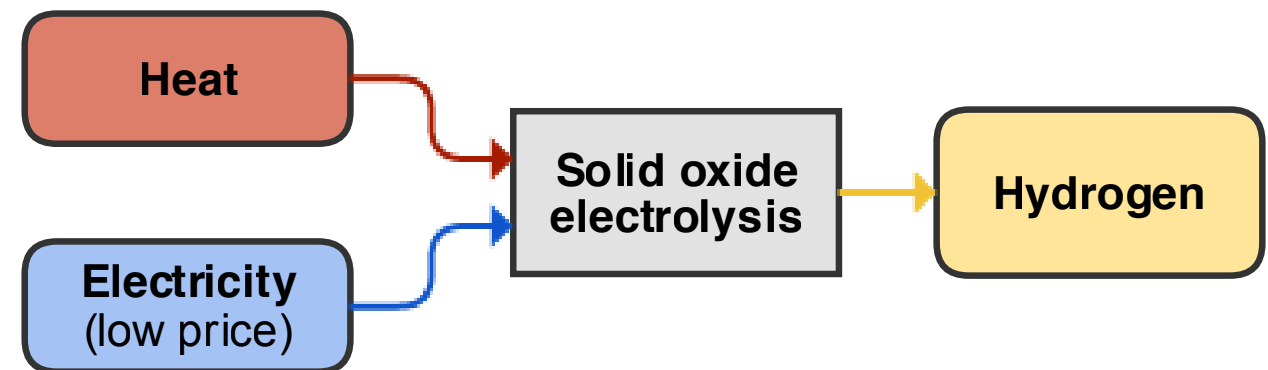
Reversible operation of solid oxide cells for peak load generation

- 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.



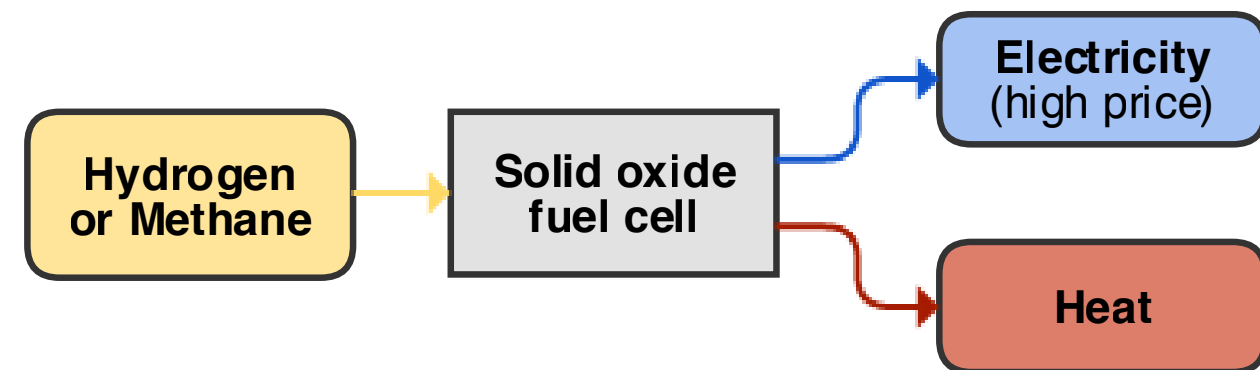
Most of the time: Electrolysis

Hydrogen production to boost biomass



Occasionally: Peak load generation

Could displace reserve gas power plants



Summary

- In WP2 we are working with the case of Sønderborg as a CITIES demo project for modelling energy supply.
- The purpose 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 scenarios containing e.g. biogas production with hydrogen addition and electrolyzers capable of reversible operation.
- The modelling work is on-going and we look forward to presenting the results at next year's CITIES consortium meeting.



Thanks for your attention!

Questions?

