Future sources of district heating – results from energy systems analysis

District heating in decarbonising economies.
Climate Recon 2050 Webinar

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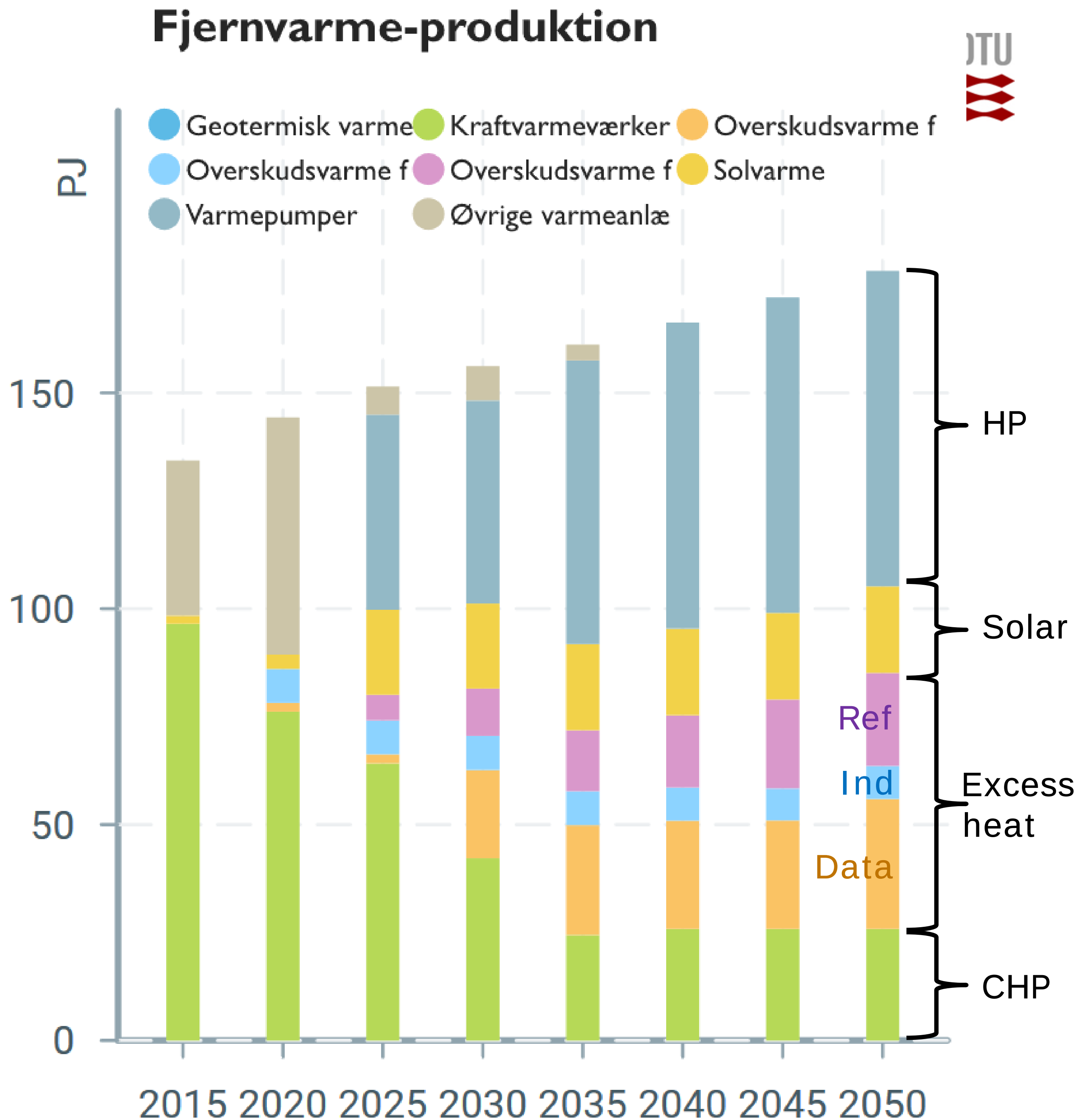
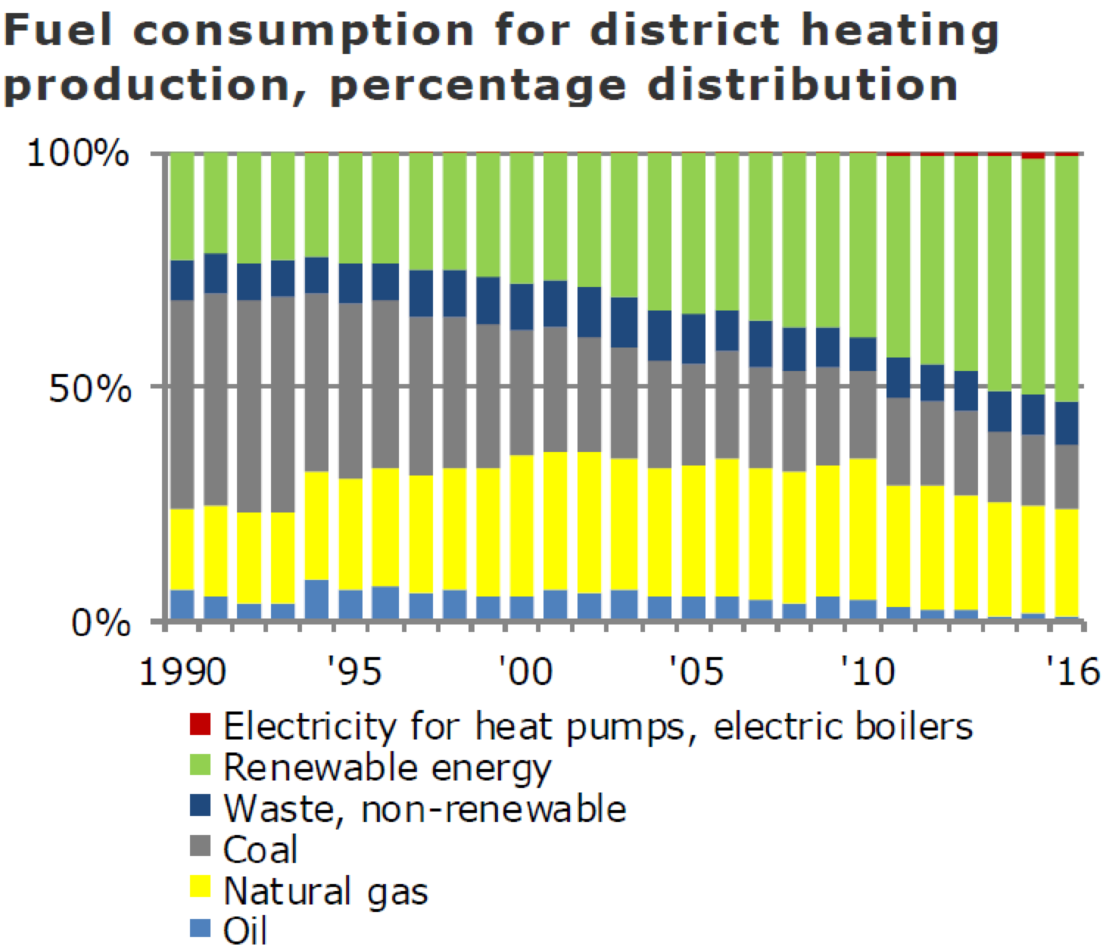
District heating production

(TIMES-DK Energy agreement 2018)



https://energiaftalen.tokni.co

District heating (DH) in Denmark



>50% of heat demand covered with district heating

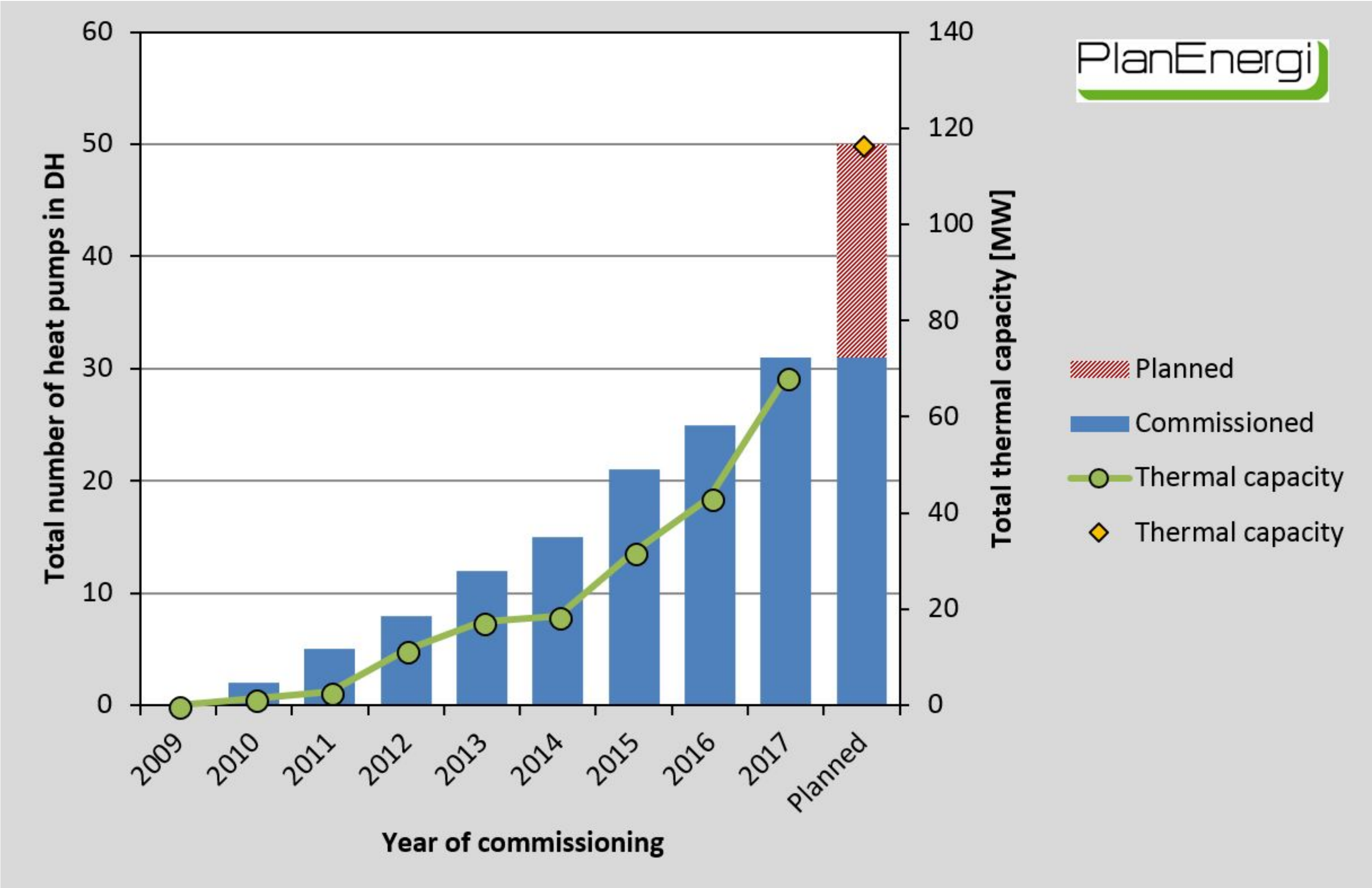
>50% from renewable energy

>50% decentral production

66% of DH from CHP

Danish Energy Agency. Energy Statistics 2016

Development in heat pumps for DH



Bjarke Lava Paaske. PlanEnergi. Februar 2018 update

Development in solar heating for DH

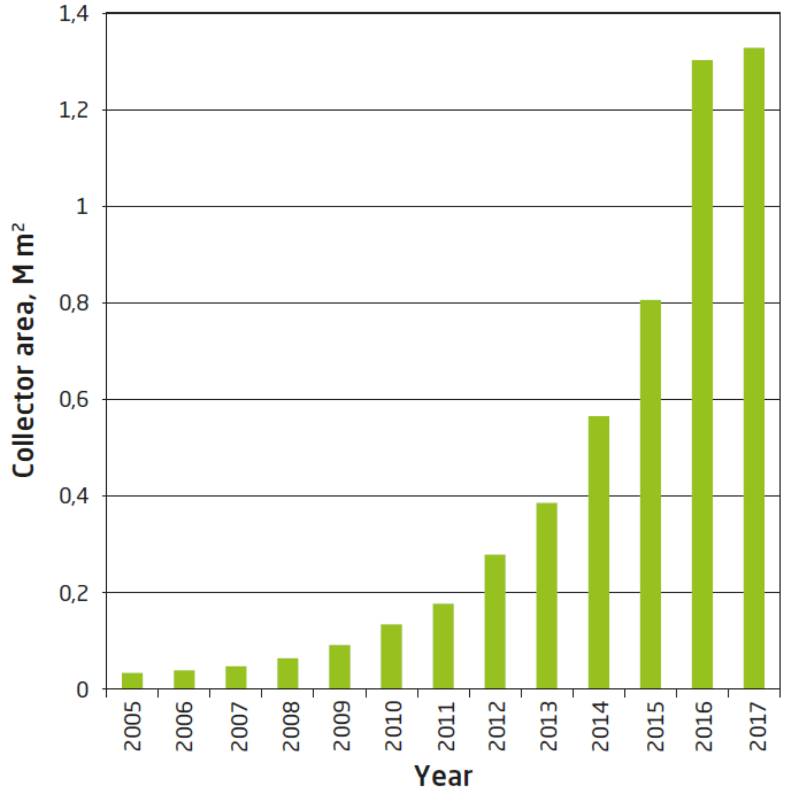


Figure 3. Solar collector area of Danish solar heating plants for district heating.

Accelerating the clean energy revolution - perspectives on innovation challenges: DTU International Energy Report 2018

Examples

Solar heating

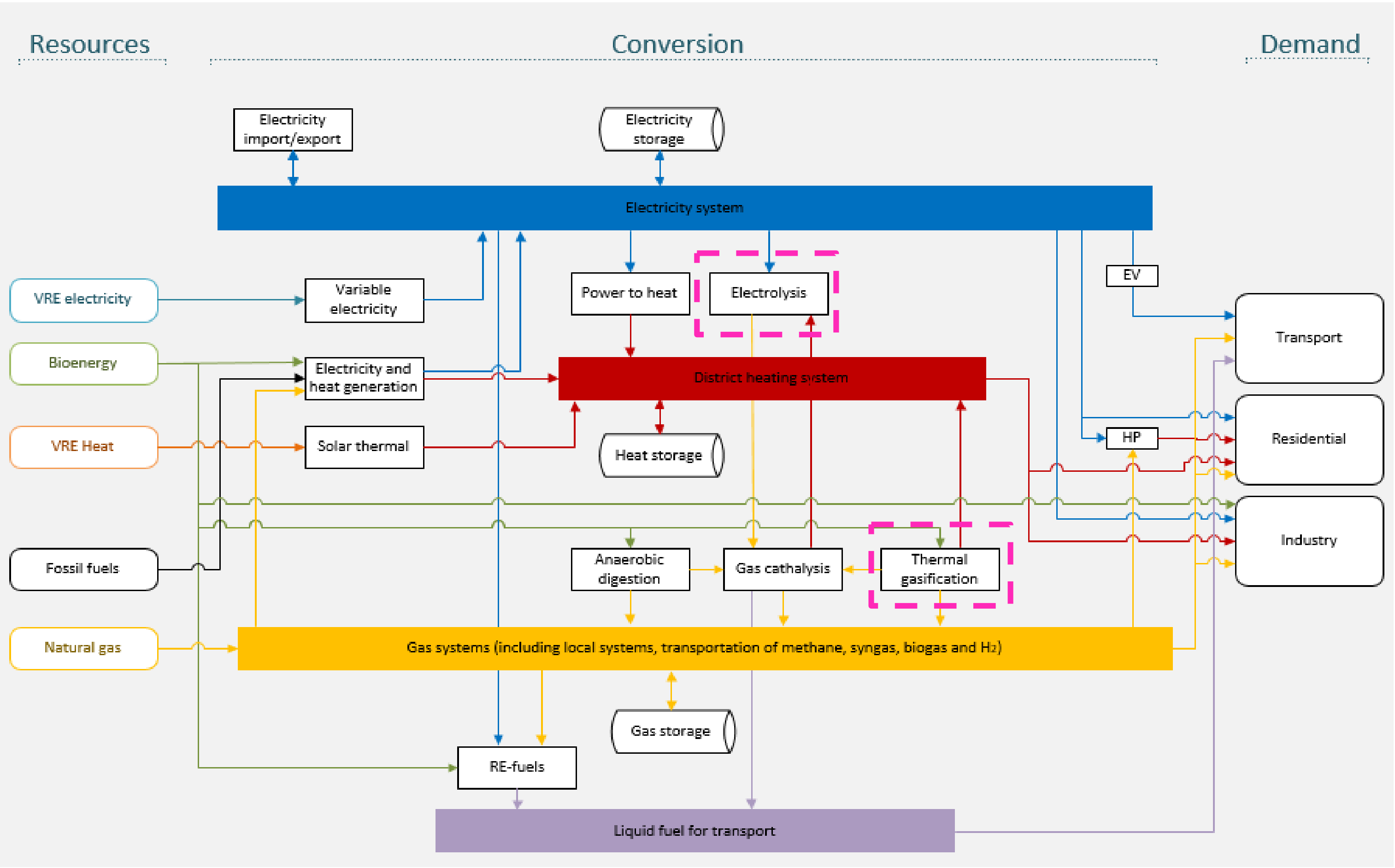
Silkeborg 156,694 m²

Pit storage

Vojens 200,000 m^3

Photos from Simon Furbo

Integrated energy systems



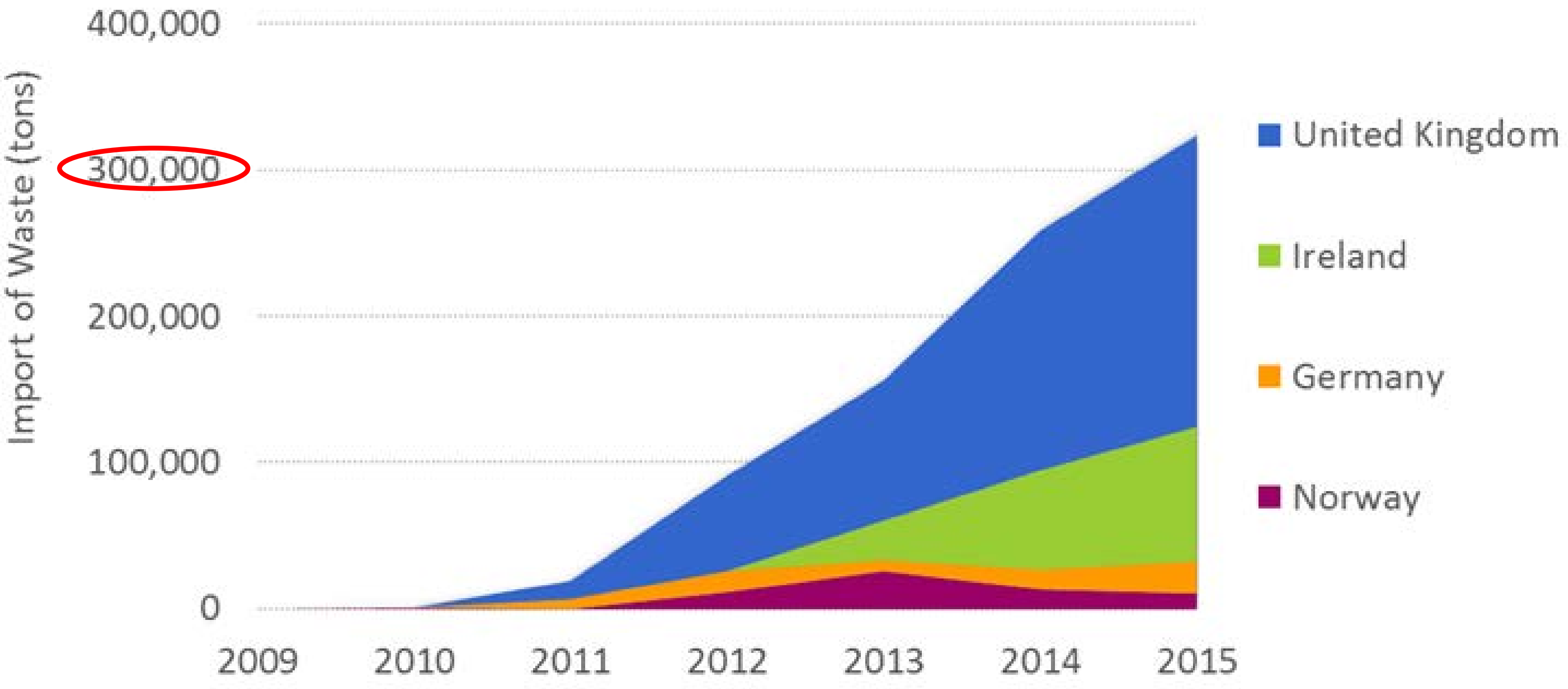
Example 1) Waste incineration

Amalia Pizarro

- ***The economic value of imports of combustible waste in systems with high shares of district heating and variable renewable energy****. / Pizarro Alonso, Amalia Rosa; Cimpan, Ciprian; Ljunggren Söderman, Maria; Ravn, Hans V.; Münster, Marie. Waste Management, Vol. 79, 2018, p. 324-338.*
- ***The climate footprint of imports of combustible waste in systems with high shares of district heating and variable renewable energy****. / Pizarro Alonso, Amalia Rosa; Cimpan, Ciprian; Münster, Marie. Waste Management, 2018*

Import of waste

1. Is there a raw socioeconomic benefit of importing combustible waste to Denmark?
2. Is there a climate benefit of importing waste?



Waste generation DK (2014-2035)

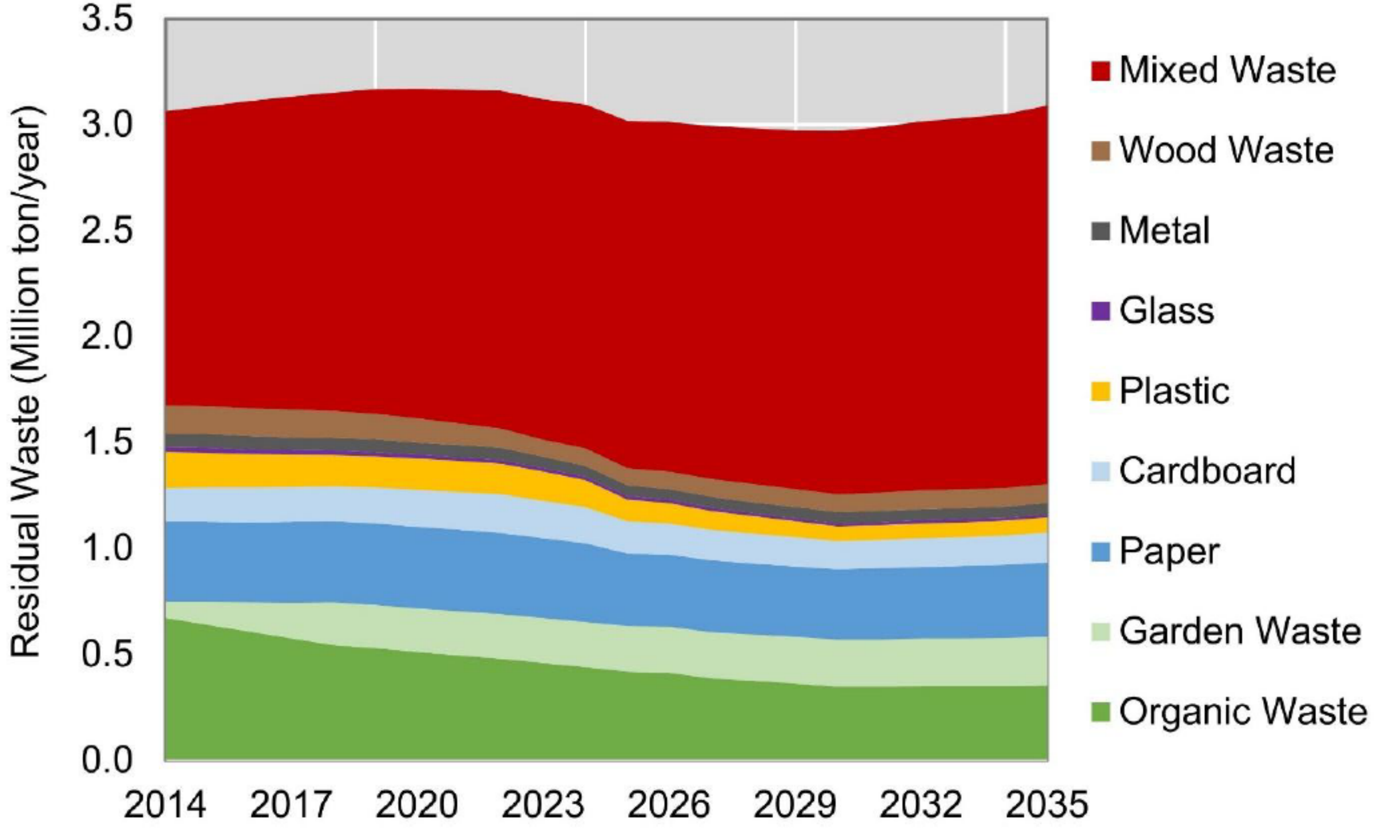


Figure 5. Forecast of household and industrial waste available for incineration in Denmark

Electricity consumption
DK 2014 & 2035 (LowElec & HighElec)

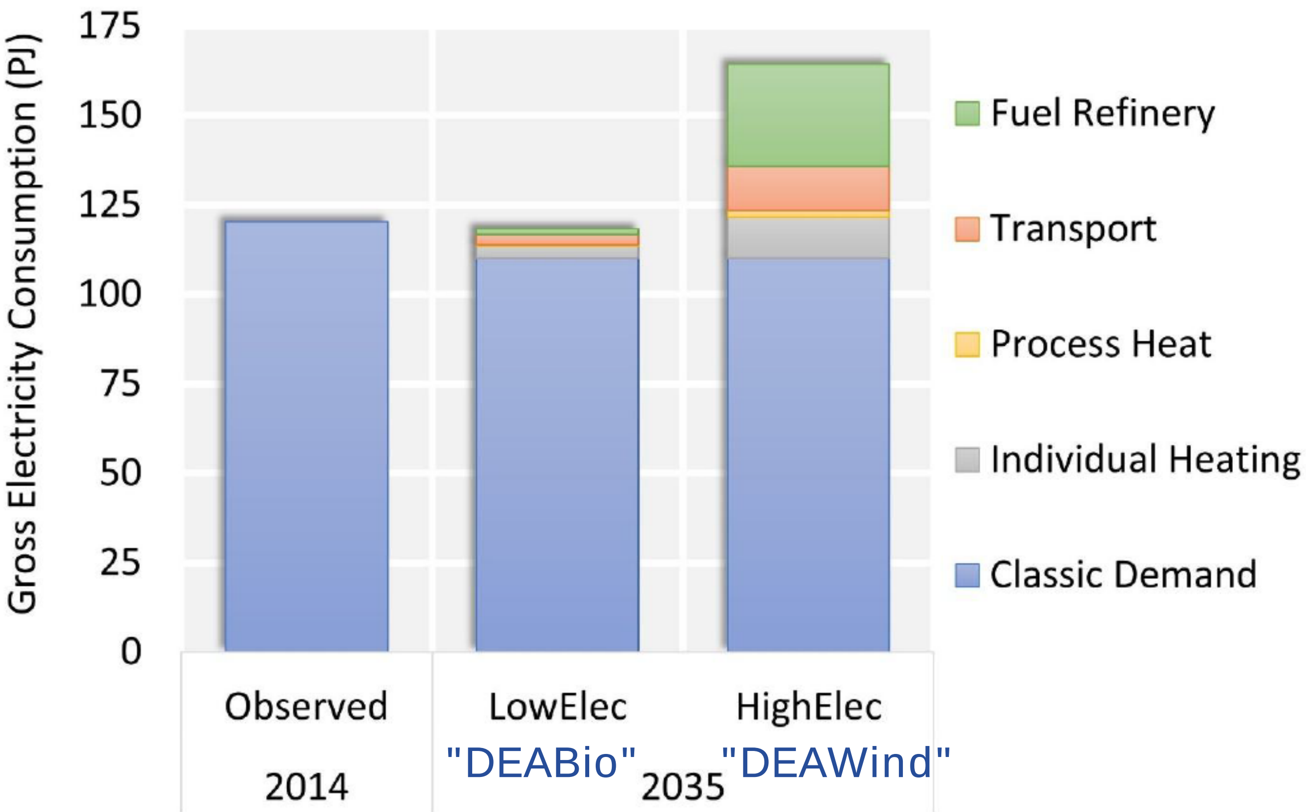


Figure 8. Gross Electricity Consumption in the Danish scenarios until 2035 (Danish Energy Agency, 2015)

Value of waste import (DK 2014)

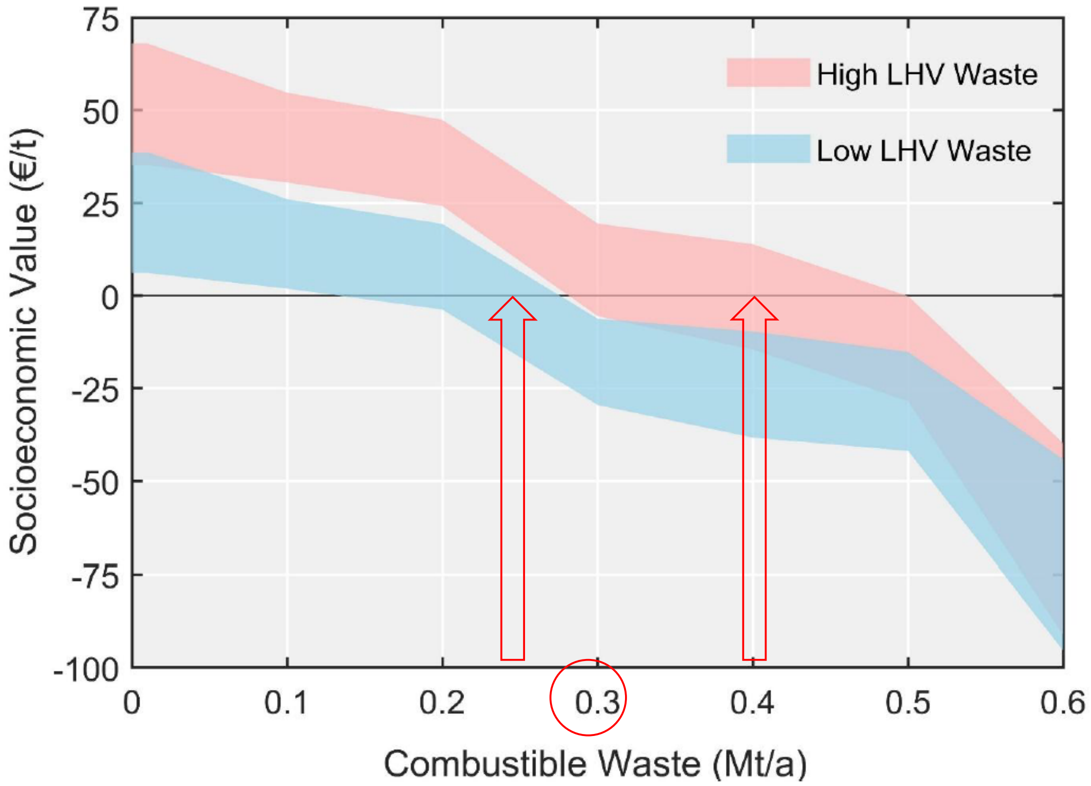
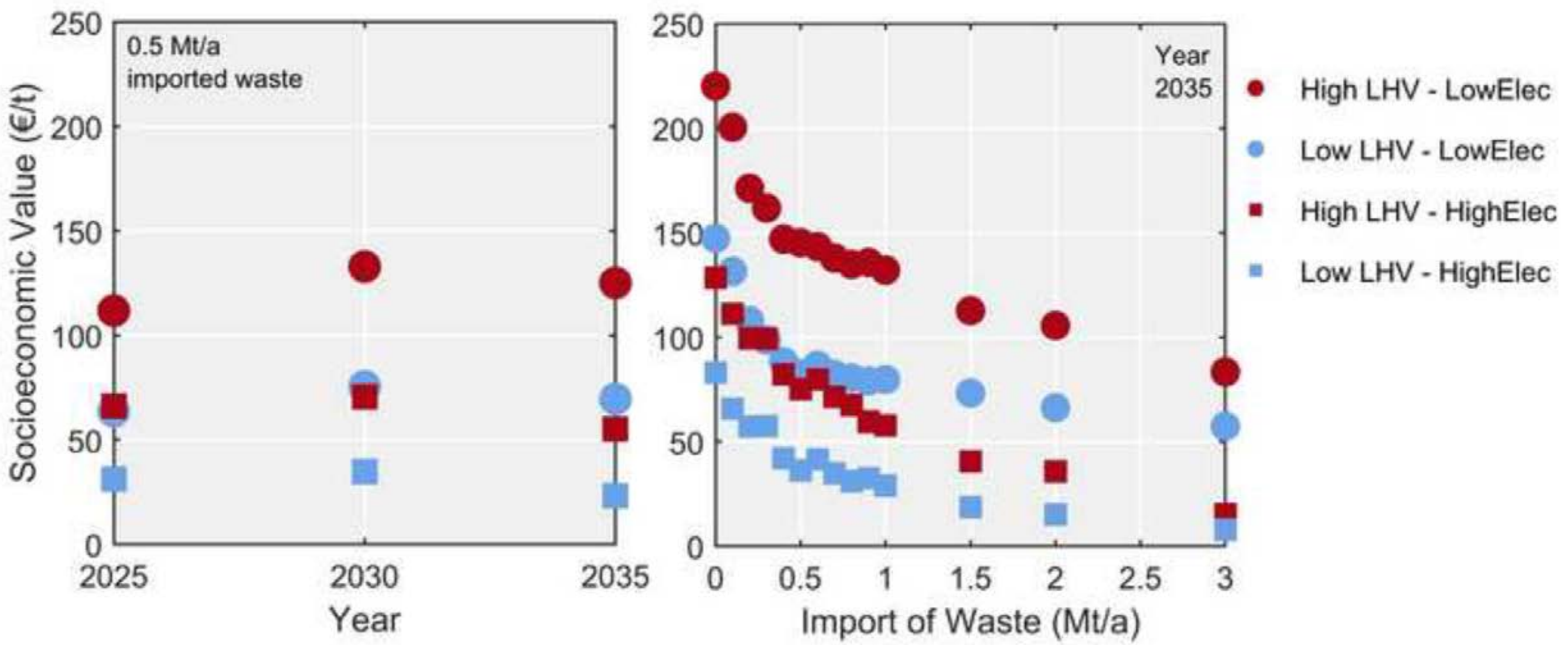


Figure 14. Uncertainty Range of the socioeconomic value from importing waste depending on the ratio between fix operational costs and variable operational costs: upper range corresponds to 35% of the waste treatment costs as variable costs and lower range corresponds to 65%

Value of waste import (DK 2025-2035)



Environmental system scope

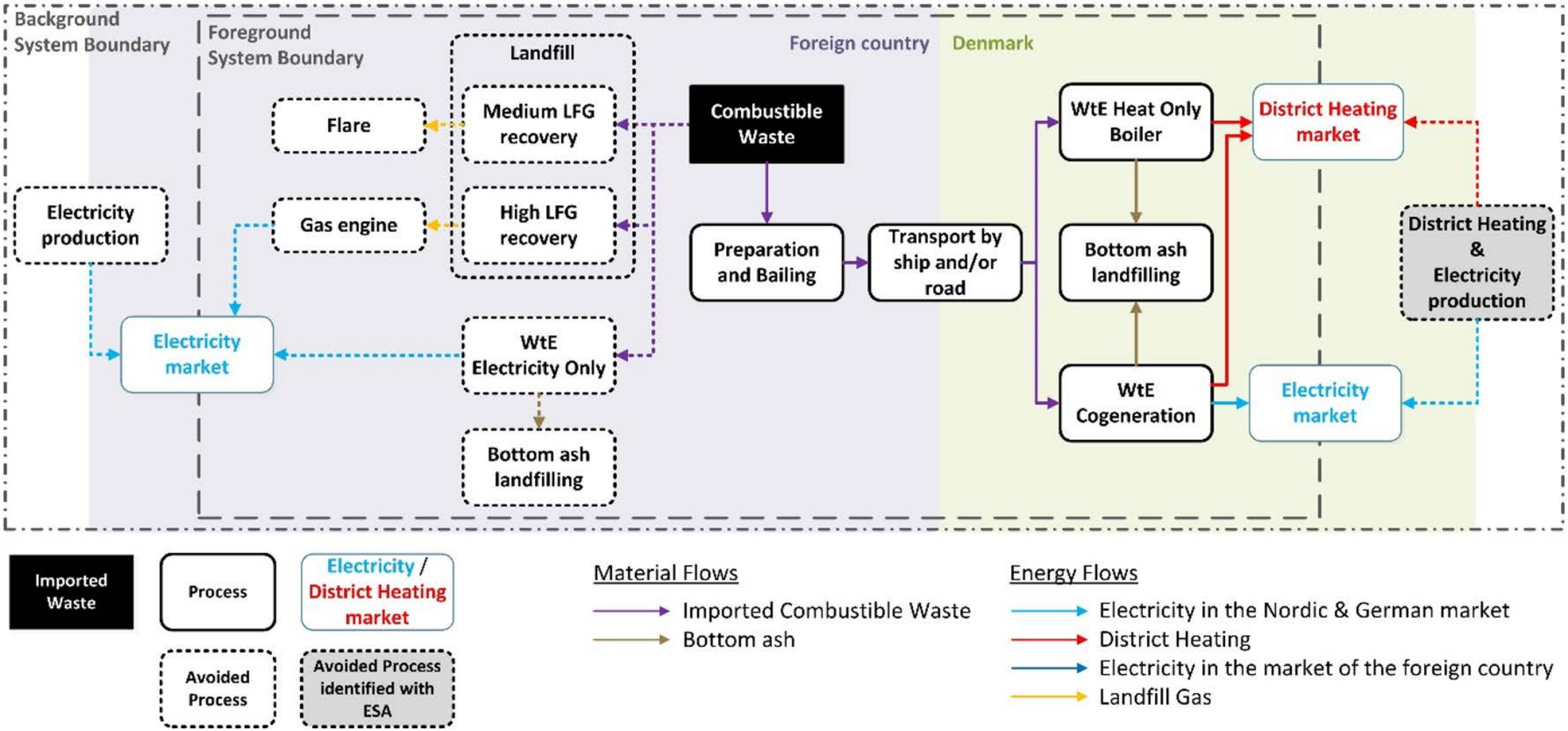


Figure 1. System boundaries, induced and avoided processes associated with import of combustible waste. The background system sitting outside a country boundary, reflect that electricity markets are international.

Scenarios

Dk energy system

Waste quality

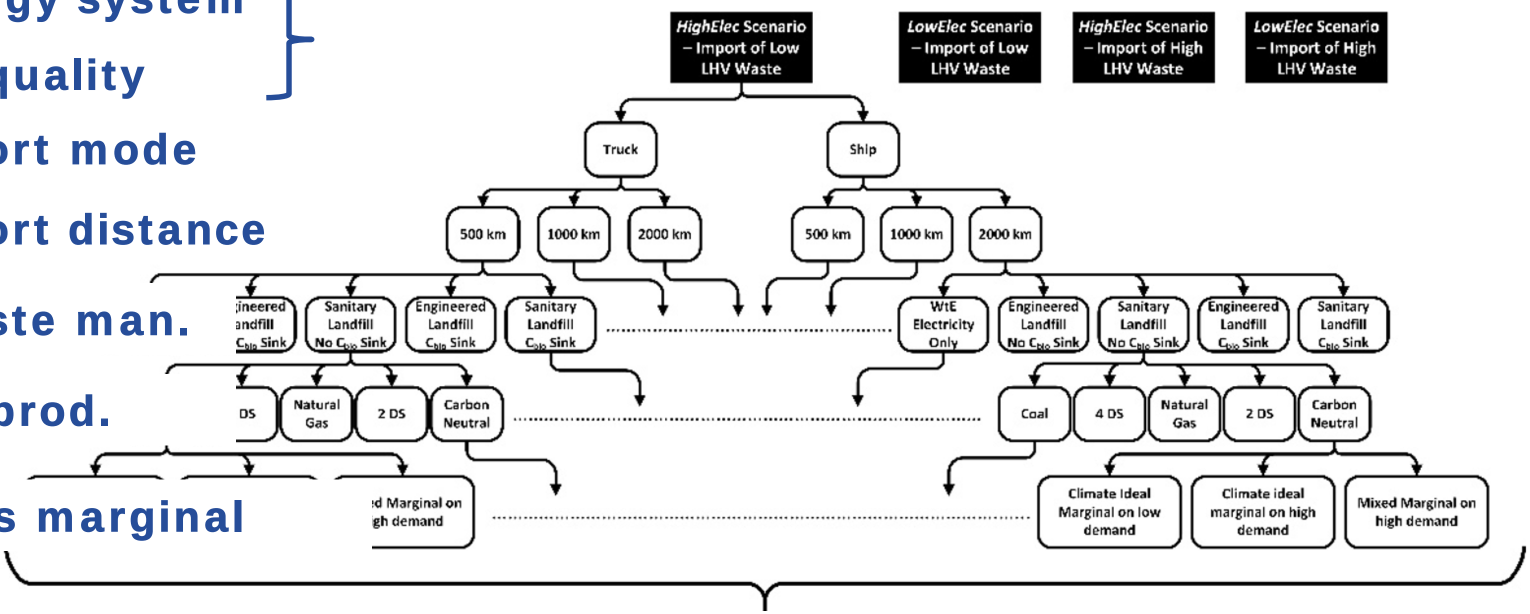
Transport mode

Transport distance

Alt. waste man.

Alt. el. prod.

Biomass marginal



450 x 4 scenarios

Figure 3. Overview of scenarios for assessing the climate footprint from waste imports (for each milestone year and quantity imported)

Average net GHG balance

Importing 0.3 Mt/a (2014)

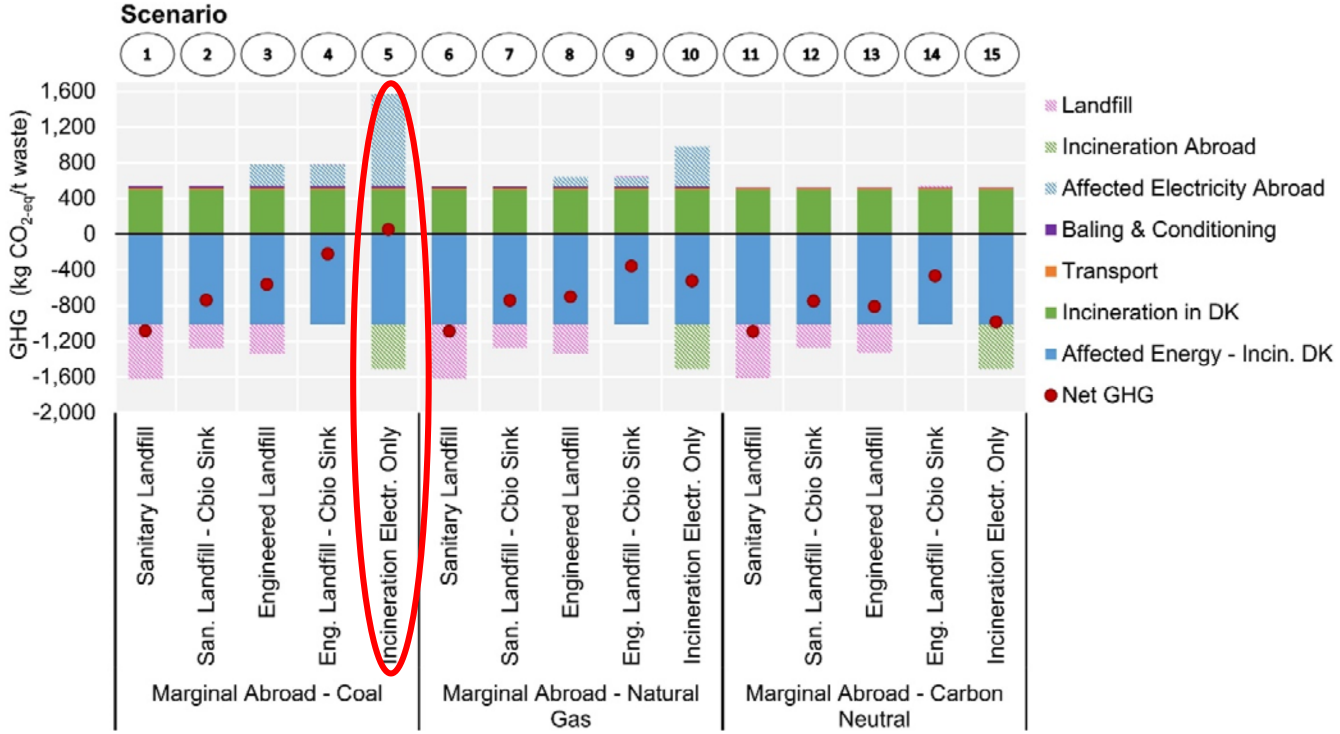


Figure 8. Year 2014 - Average net GHG balance when importing 0.3 Mt/a (Functional Unit) of low LHV waste transported 1000 km by ship: Negative values represent avoided $CO_{2\text{-}eq}$ emissions, and positive values, induced emissions (coloured bars represent the foreground systems and dashed bars the background systems; vertical names in the x-axis label represent avoided waste management process and horizontal labels the affected fuel for electricity generation in the exporting country)

Average net GHG emissions

2035 HighElec, importing 0.5 Mt/a (Marginal el. abroad - biomass marginal)

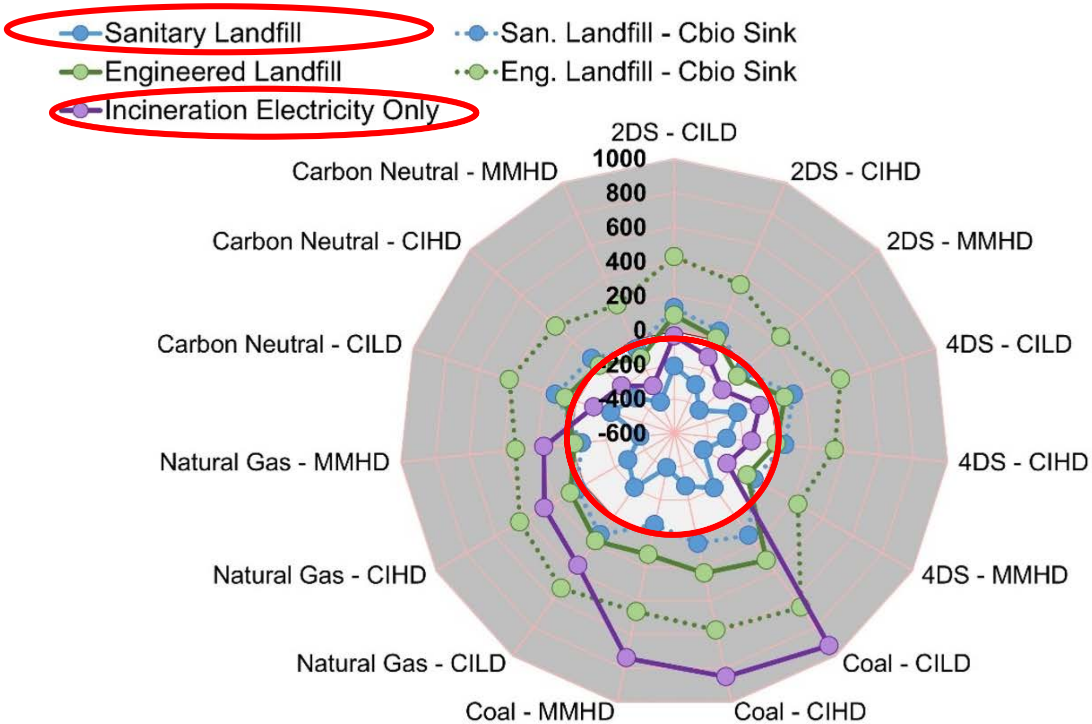


Figure 11.Year 2035 - Average net GHG Emissions (kg CO_{2-eq}/t waste) in the HighElec scenario when importing 0.5 Mt/a of Low LHV waste by ship 1000 km – each label represents the Marginal Electricity Abroad (section 4.6) and the biomass marginal (see Table 1, CID: climate ideal marginal in low demand, CIHD: climate ideal marginal in high demand and MMHD: mixed marginal in high demand)

Conclusion - environmental impact

- From a raw socio-economic perspective it pays to import waste to DK
- But mixed combustible waste may pollute future clean energy systems (better use with CHP)
- Leaving the waste at engineered landfills may be the best option (counting Cbio sink)
- Other environmental impacts should also be analysed

- So, only import waste if
  - 1) the alternative waste management will be at a sanitary landfill or if
  - 2) local incineration in exporting country would displace green electricity

Example 2: Biorefineries

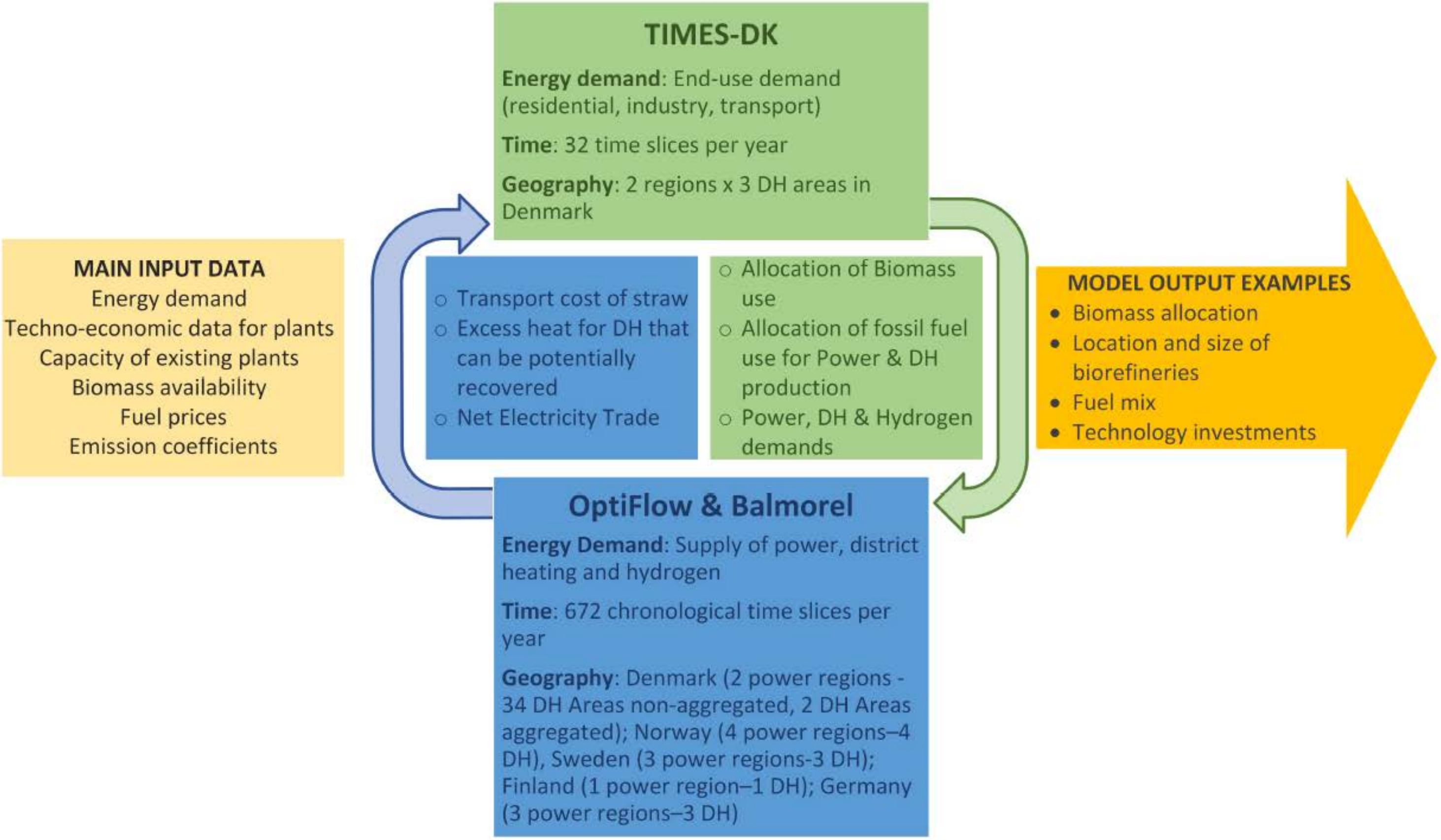


Figure 3: Model linking between TIMES-DK and Balmorel-OptiFlow

Venturini, G. Pizarro-Alonso, A. Münster, M. How to maximise the value of residual biomass resources? The case of straw in Denmark. PhD thesis

Scenarios focussing on bio-refineries (TIMES-DK and OptiFlow)

Scenario	Description	Straw use	CO_2 target	Biomass imports	Biofuels imports
BAU	Business as Usual	Heat&Power 23% Left on field 50% Fodder&bedding 27%		Allowed	Allowed
CO2	Carbon-constrained	Fodder&bedding 27% Energy system 73%	Fossil fuels phase-out 2050	Allowed	Allowed
NO-IMP	No bioenergy imports	Fodder&bedding 27% Energy system 73%	Fossil fuels phase-out 2050	Not allowed	Not allowed

Straw use

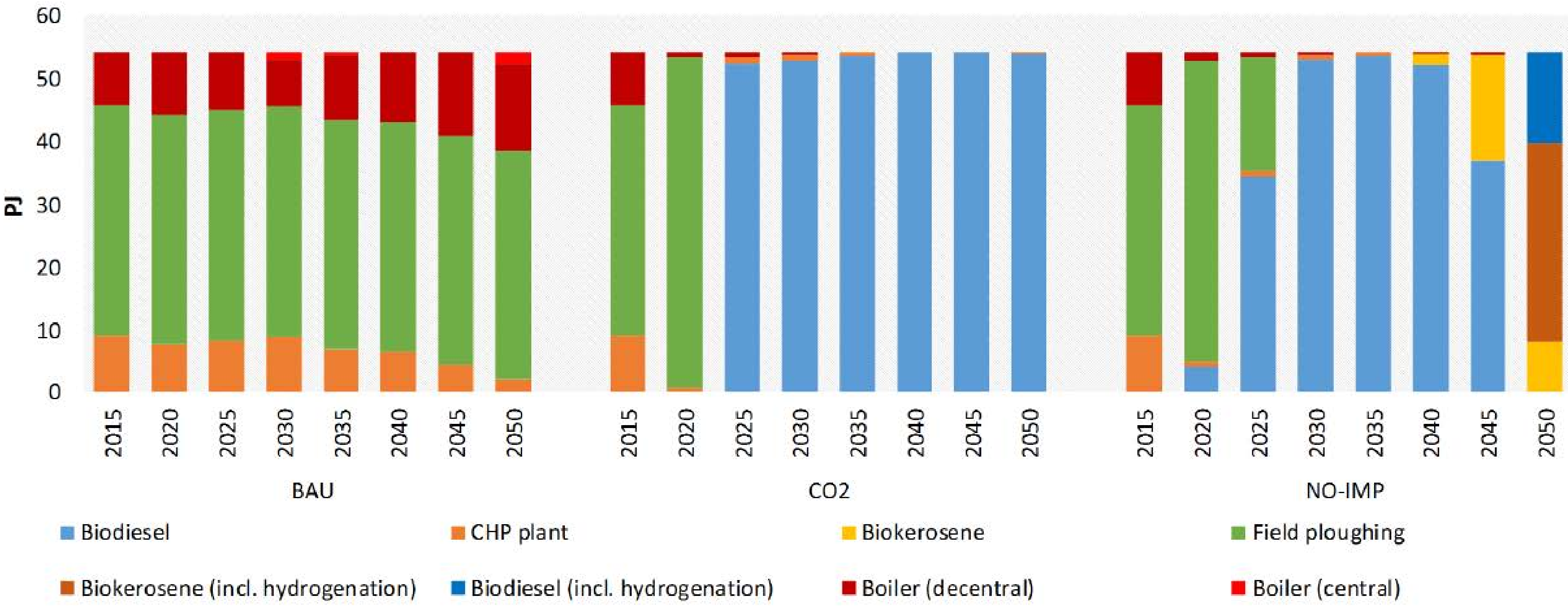
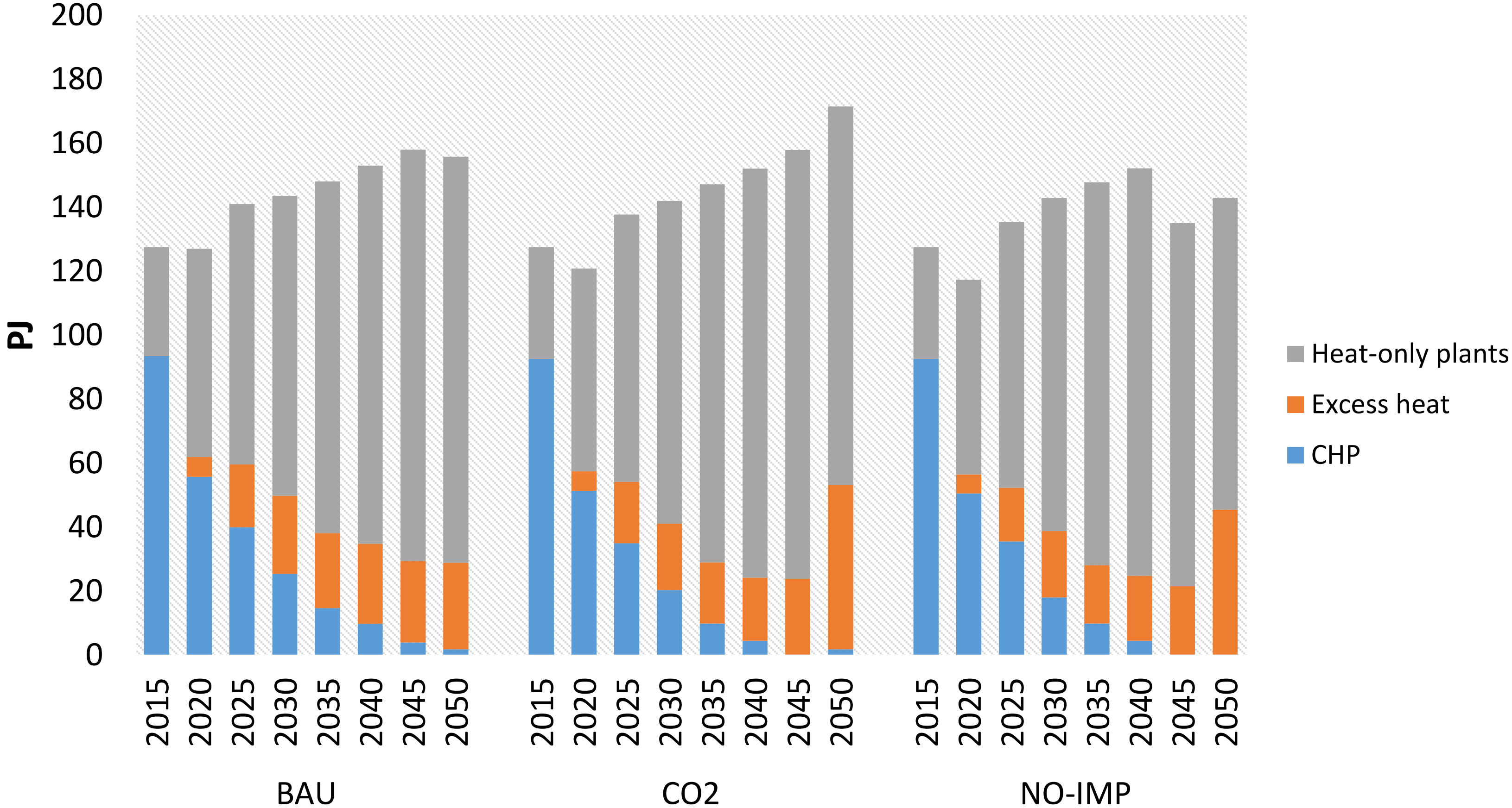
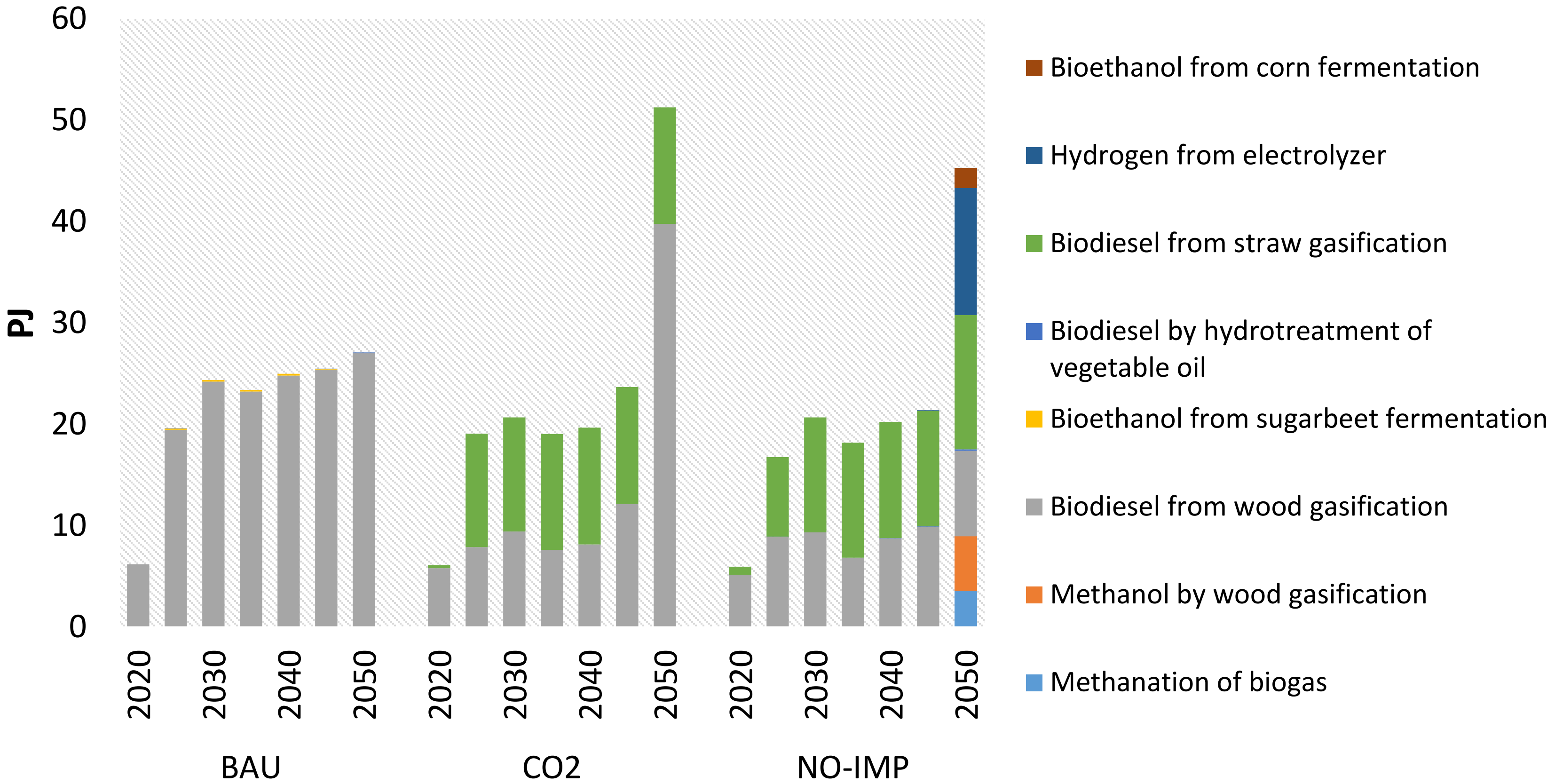


Figure 11: Use of straw across years in the analysed scenarios

District heating generation



Excess heat by origin plant



Conclusion

- Danish biorefineries could contribute substantially to future district heating - particularly from thermal gasification
- There is not enough domestic biomass with current production to fuel both land-, sea- and air based transport

Summary

- Sources for heat may change in the future
- We need smart planning (and modeling) to utilise new sources
- Some technologies are well on the way
- Others may need some initial help

The End

- Questions and comments?

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