DTU

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What is the benefit of sector coupling?

FutureGas

The aim of the FutureGas project is twofold:

1) *In an energy system context to facilitate the integration of the gas system with the power system, the district heating system and the transportation sector taking into account possible synergies*

2) *To facilitate a cost-efficient uptake of renewable gases, hereby in the longer term substituting natural gas and fossil fuels*

Period: 2016-2020

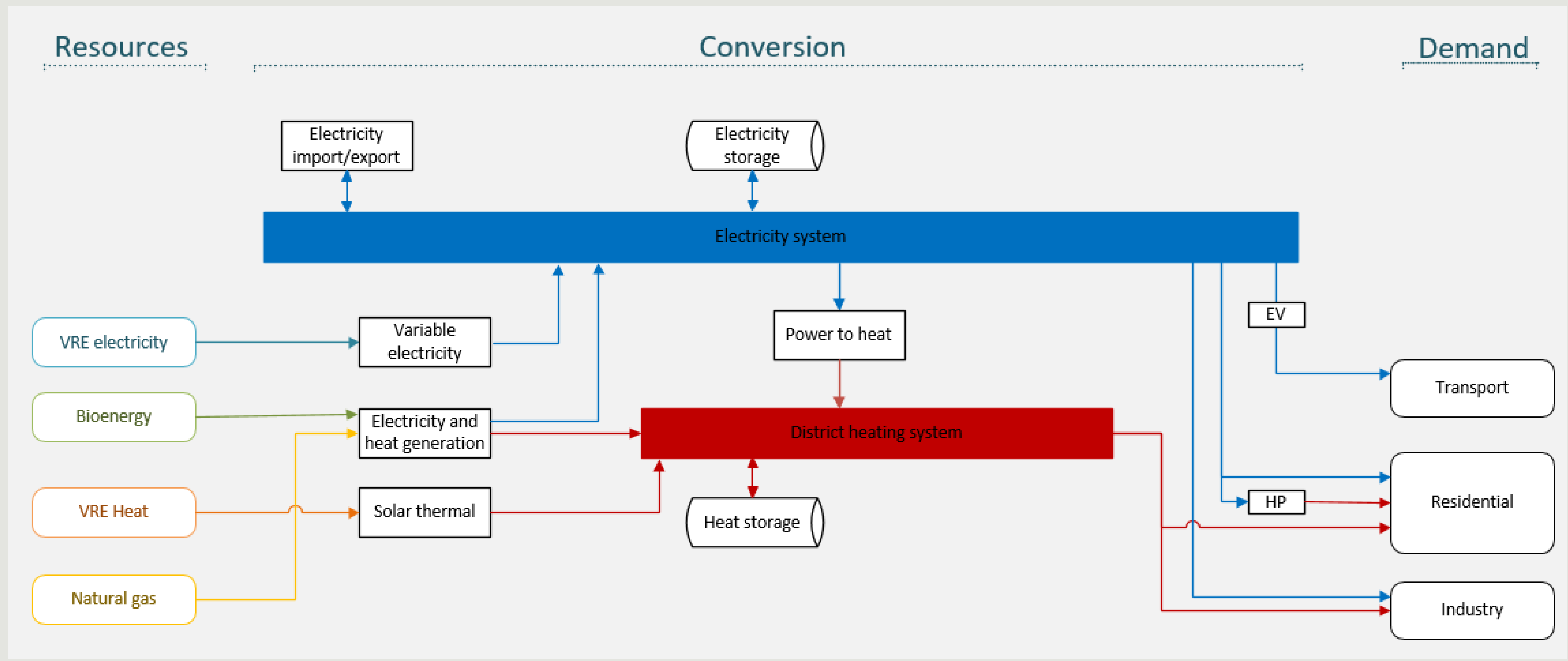
www.futuregas.dk

Creds to Mason Lester for model runs

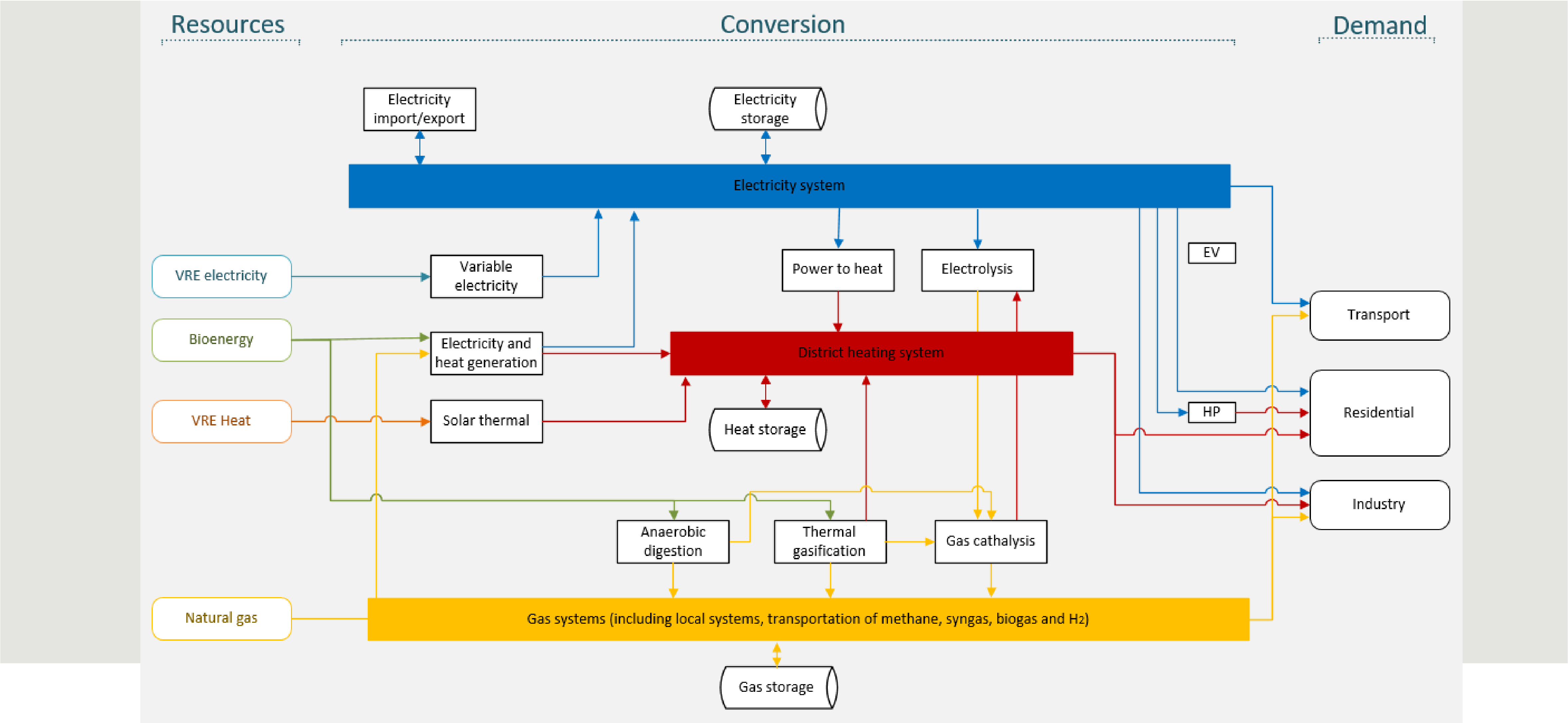
Potential benefits

- Using variable renewable power sources to decarbonise other sectors
- Providing stability and storage to the power grid
- Utilising excess heat

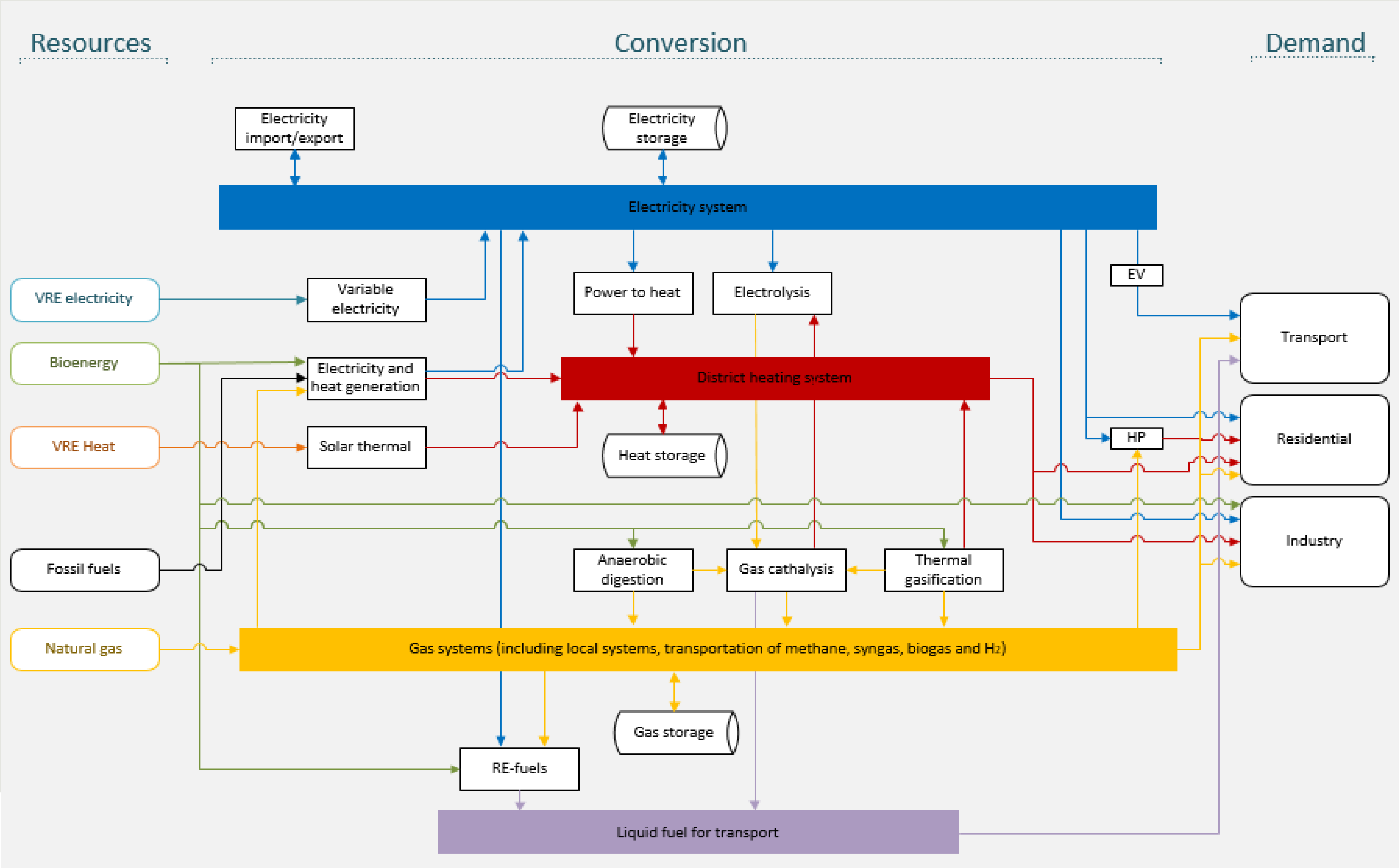
Integrated energy systems



Integrated energy systems



Integrated energy systems



Part I
– What is the value of the gas grid and Power to heat?

Balmorel

Input

Heat and electricity demand
Fuel prices and emissions
Efficiencies and costs
Hourly distribution of demands
and production from RE sources
Capacities of existing plants and transmission
Time aggregation

Output

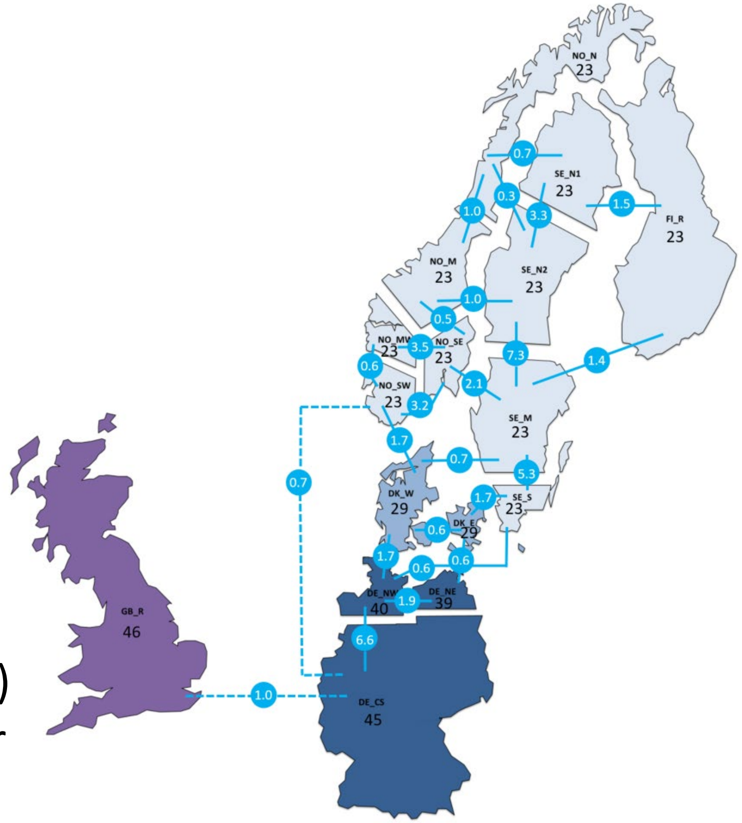
Energy conversion
Fuel consumption
Electricity import/export
Emissions
Investments in plants
and transmission lines
Prices on traded energy
Total costs

Modes

LP or MIP
(e.g. economy of scale)
Myopic investments or
Rolling horizon

Assumptions

Economic rationality
Perfect markets
Perfect foresight within a year



Wiese, F. et. al. Balmorel open source energy system model. Energy Strategy Reviews, Vol. 20, 2018, p. 26-34.

Scenarios

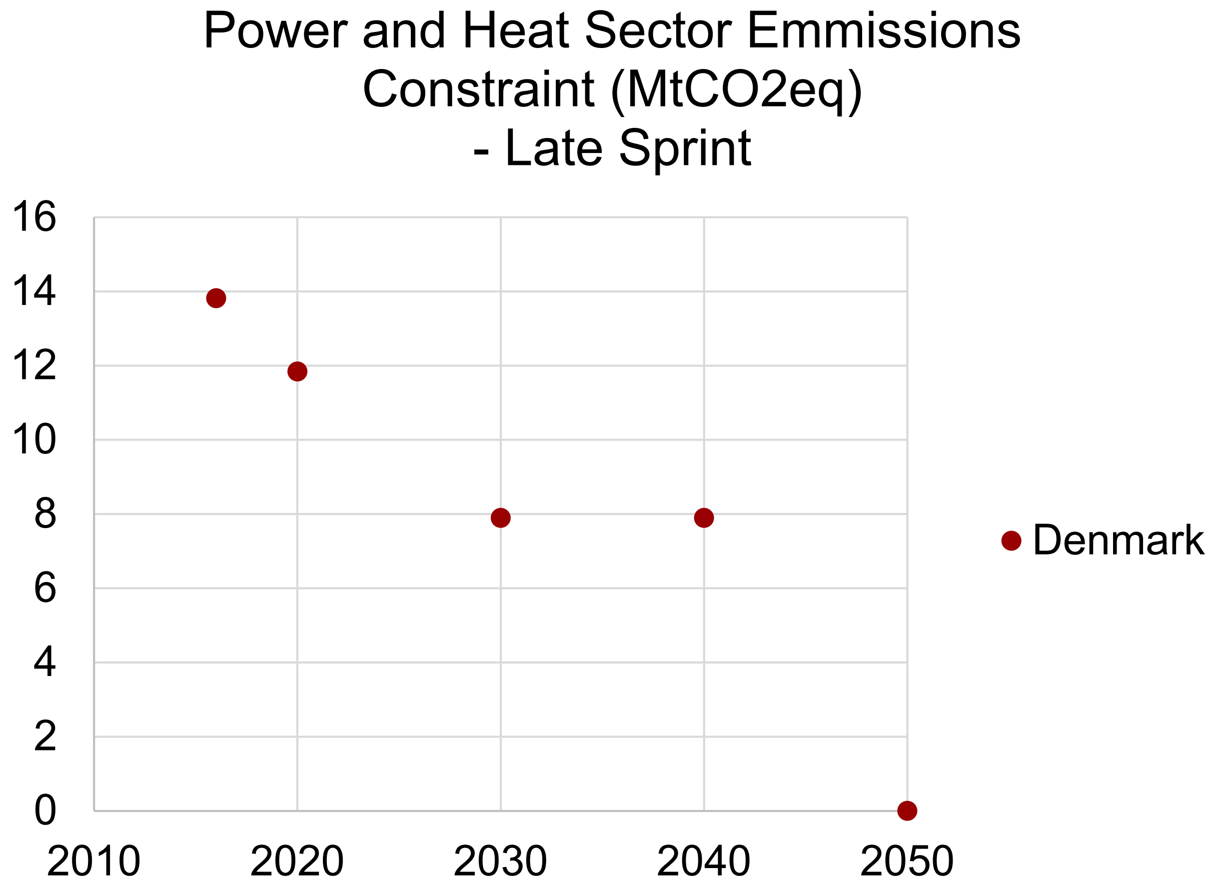
- **Model**
  – Denmark, Germany, Sweden, and Norway
  – Includes individual heating and industry
  – Does not include transport sector

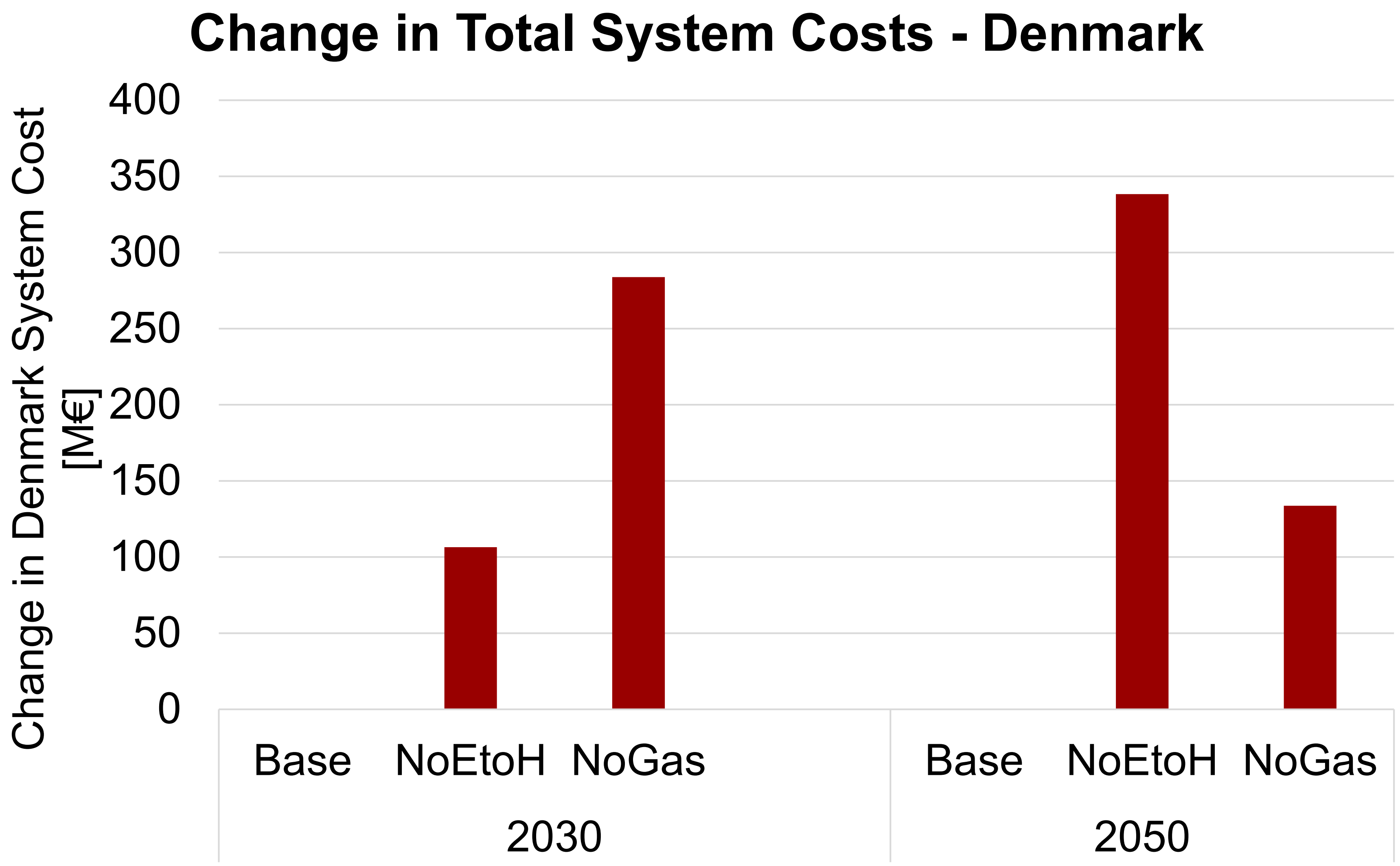
- **Scenarios**
  – **Base - Balmorel**
  – **No gas - BALMOREL**
    - No natural gas or biogas
  – **No E to H - BALMOREL**
    - No electricity to heat i.e. no HP or ELC boilers

Biomass Costs and CO2 Constraint – Late Sprint

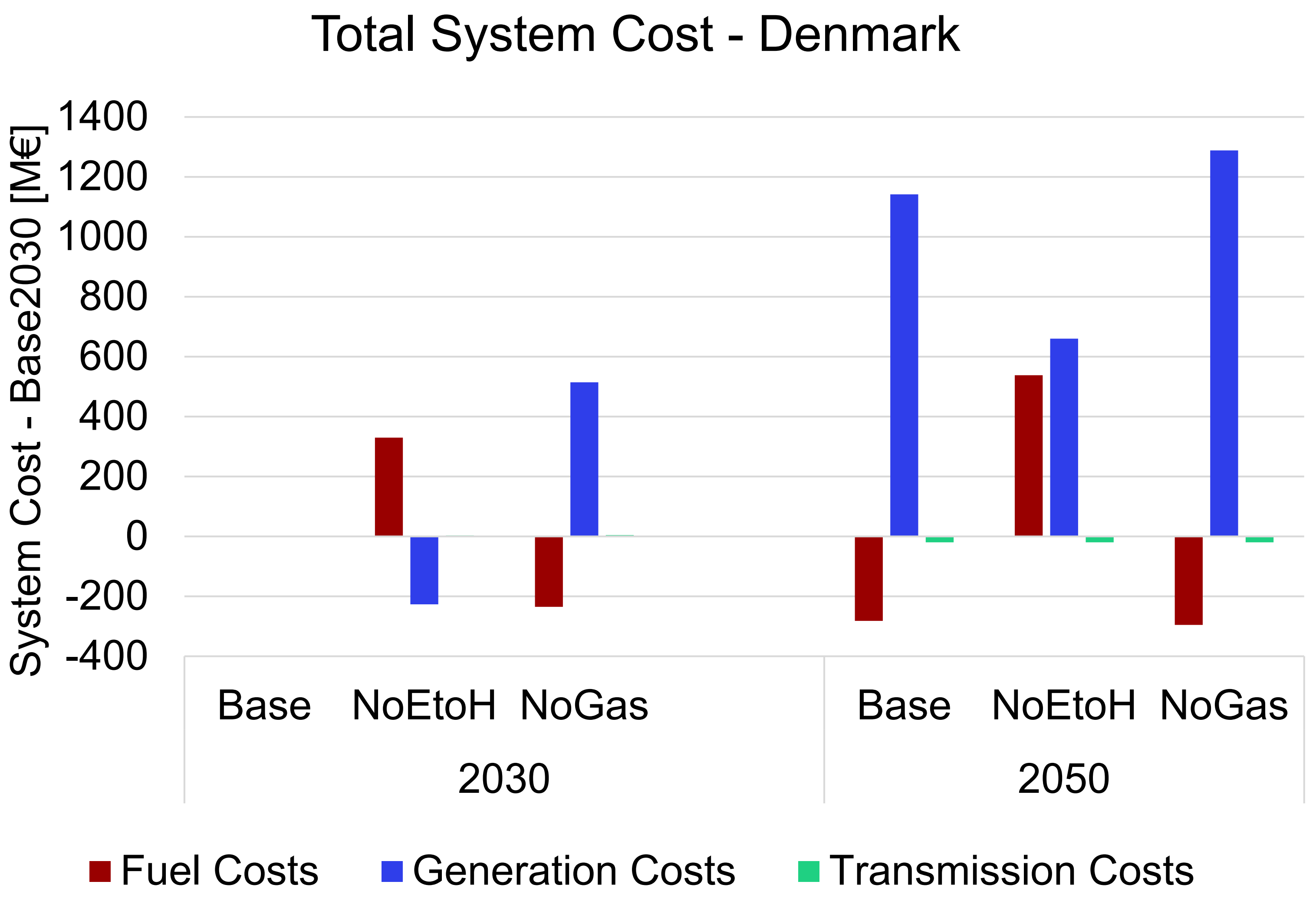
[€/GJ]	2030	2050
Straw	5.95	6.14
Wood chips	6.96	7.28
Wood pellets	9.03	9.26

DEA, Analyseforudsætninger

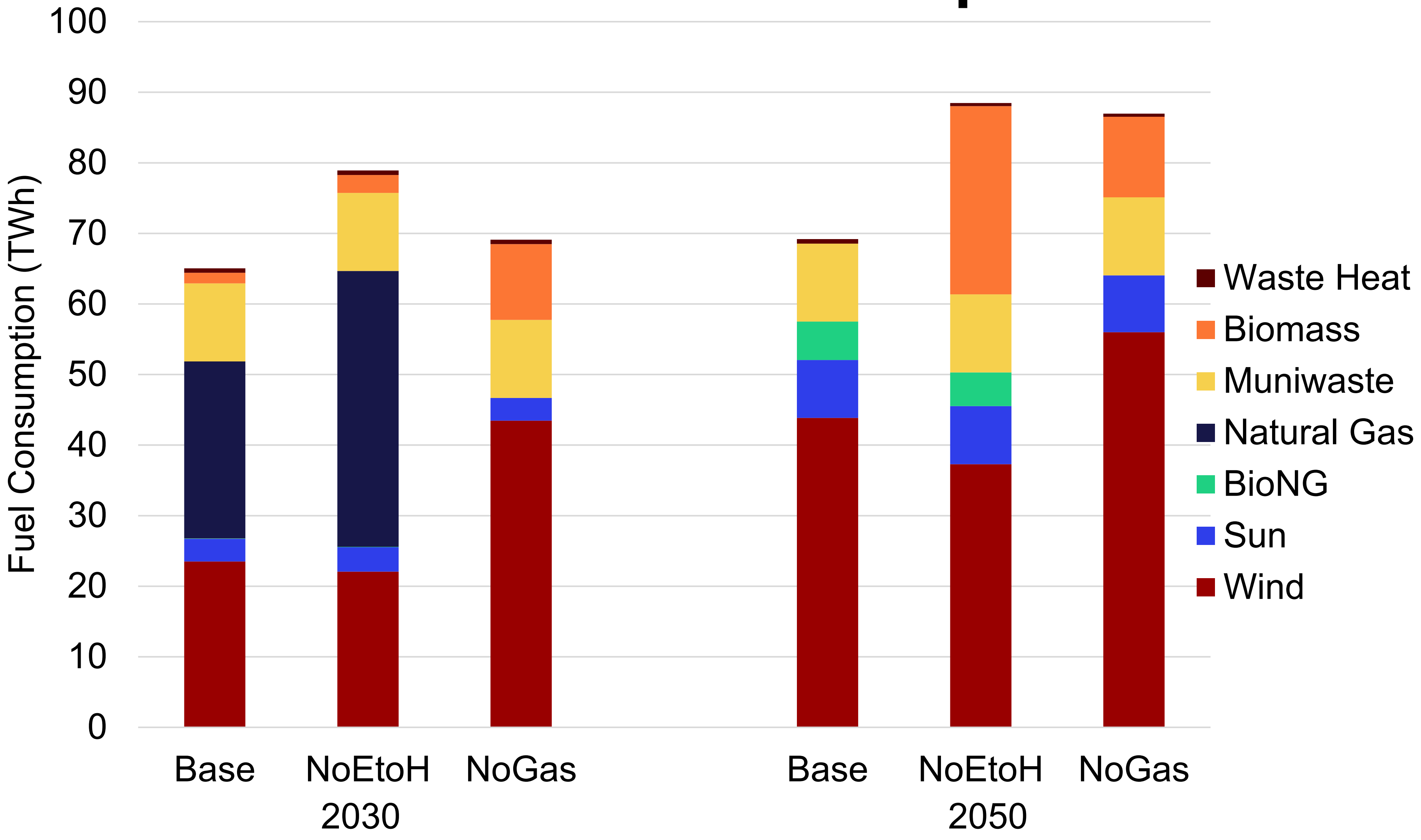



Change in Total System Costs - Denmark
Change in Denmark System Cost [M€]
400
350
300
250
200
150
100
50
0
Base
NoEtoH
NoGas
2030
Base
NoEtoH
NoGas
2050

Normalized


Total System Cost - Denmark
System Cost - Base2030 [M€]
1400
1200
1000
800
600
400
200
0
-200
-400
Base
NoEtoH
NoGas
2030
Base
NoEtoH
NoGas
2050
Fuel Costs
Generation Costs
Transmission Costs

Danish Fuel Consumption



Conclusion

- Both PtH and the gas grid will add value to future energy systems of up to 340 MEUR/yr
- The gas grid provides the highest value in the short term
- PtH provides the highest value in the longer term
- With no PtH, we need more natural gas in 2030 and more biomass both in the short and the long term
- With no gas grid, we require more biomass and wind

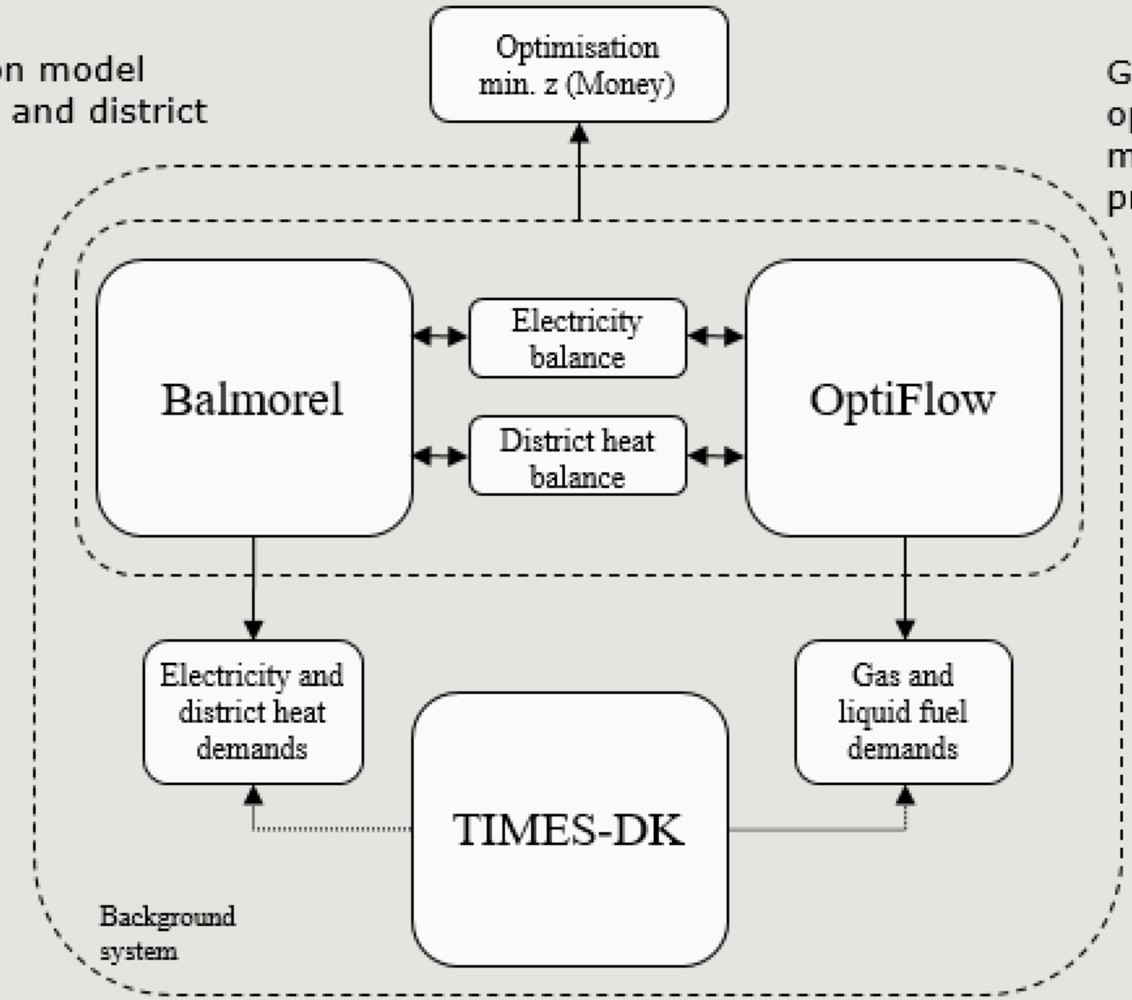
Part II
– What is the value of power to fuels, hydrogen, and EVs?

Balmorel

Energy system optimization model covering the Nordic power and district heating sectors.

OptiFlow

Generalized spatiotemporal network optimization model which facilitates modelling of renewable gas and fuel production.



Least-cost power and district heating system

Hourly district heating prices

Hourly electricity prices

Optimisation of RE gas and fuel production

Power and DH production from RE-gas

Excess heat from thermal gasification

Electricity consumption in electrolysis

Model characteristics

- Year 2050
- Fossil independent energy system
- High biomass costs
- Denmark, Germany, Sweden, and Norway
- Includes standard electricity and district heating demands (not other industry or individual heat)
- Includes projected transport energy demands
  - Adapted from TIMES-DK results
- Based on Mason Lesters Masters Thesis Balmorel-Optiflow model

Scenarios

- **Base**
- **No P to X**
  - No P to X transport fuel technologies (electrofuels)
- **No hydrogen**
  - No direct use of hydrogen for transport
- **No EVs**
  - No electric vehicles

- **Limitations**
  - Only changes to transport sector i.e. no analysis in the use of hydrogen for industry, nor analysis of hydrogen for electricity storage
  - Includes hydrogen storage technology for transport use only
  - Hydrogen can be produced variably according to price signals and demands
  - Fuel demands are assumed constant over the year

Energy Demands

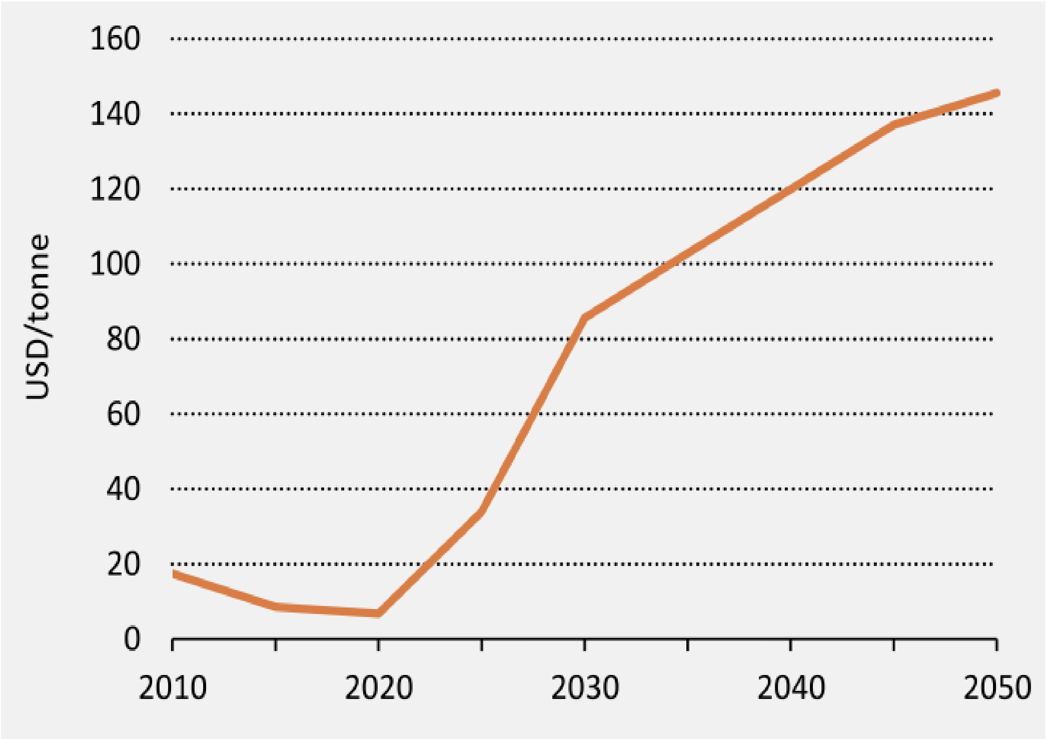
- Electricity and District Heating Demands
  - 2050 Nordic Energy Technology Perspective
- Transport Fuel Demand
  - TIMES-DK results

Transport Fuel Demands

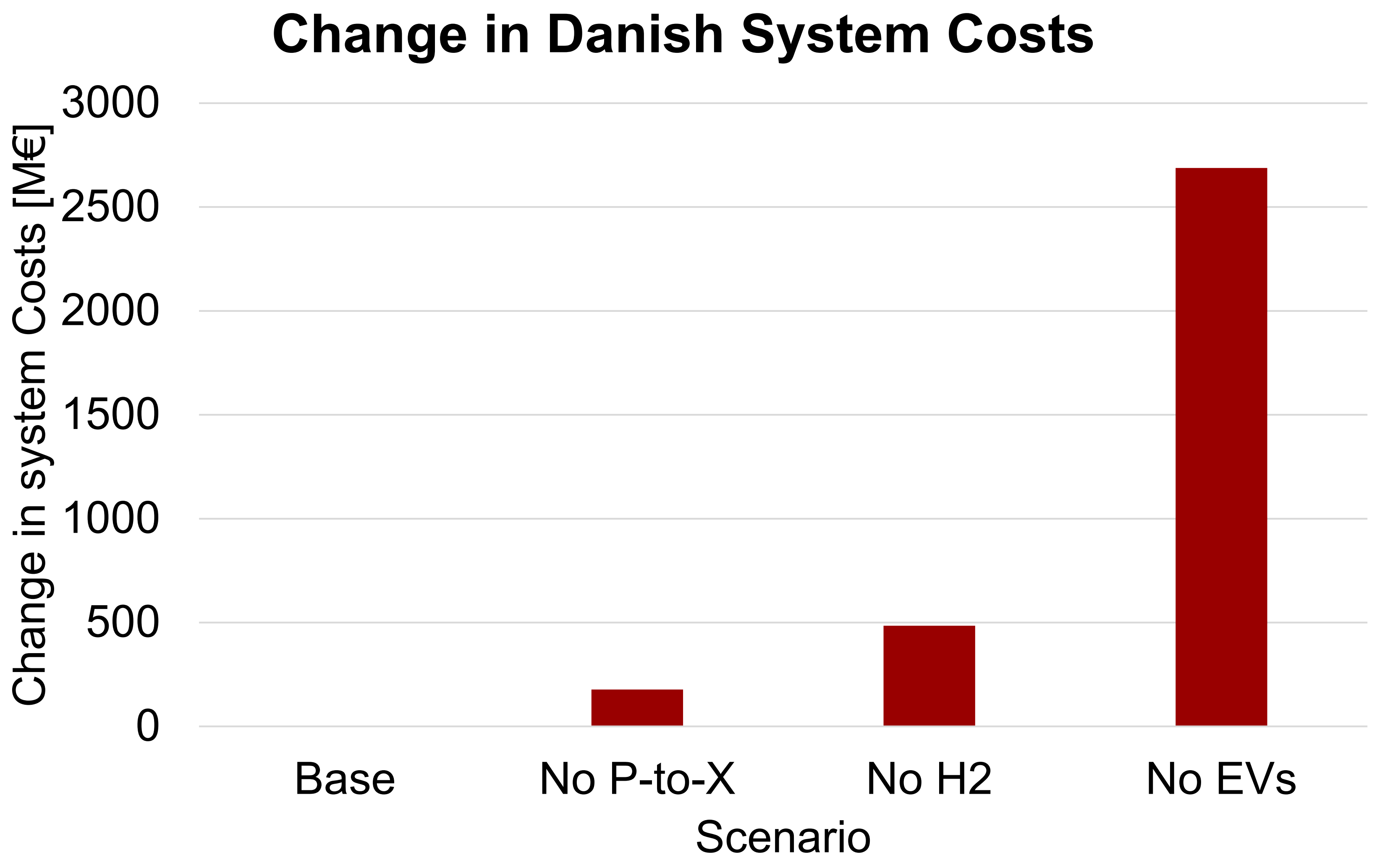
[PJ]	Base	No PtX	No H2	No EVs
Aviation Fuel	58	58	58	58
Maritime Fuel	10	10	10	10
Road Fuel	60	60	80	274
EV demand	56	56	56	0
H2 demand	10	10	0	15

Fuel Price, Potentials and CO2 cost

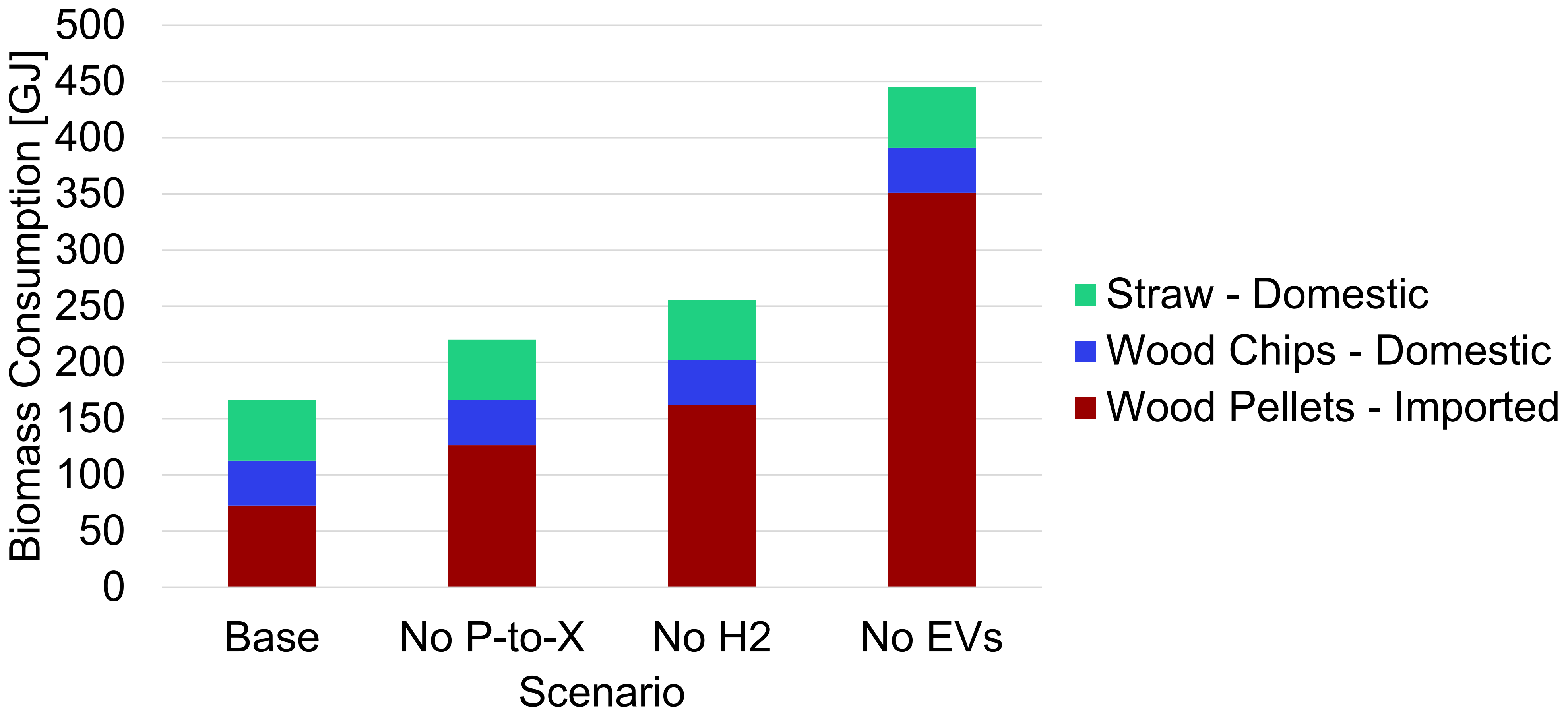
	Price [€/GJ]	Potential [PJ]
Natural Gas	4.89	∞
Coal	1.05	∞
Straw	6.8	54
Wood chips	7.9	41
Wood pellets	9.8	∞

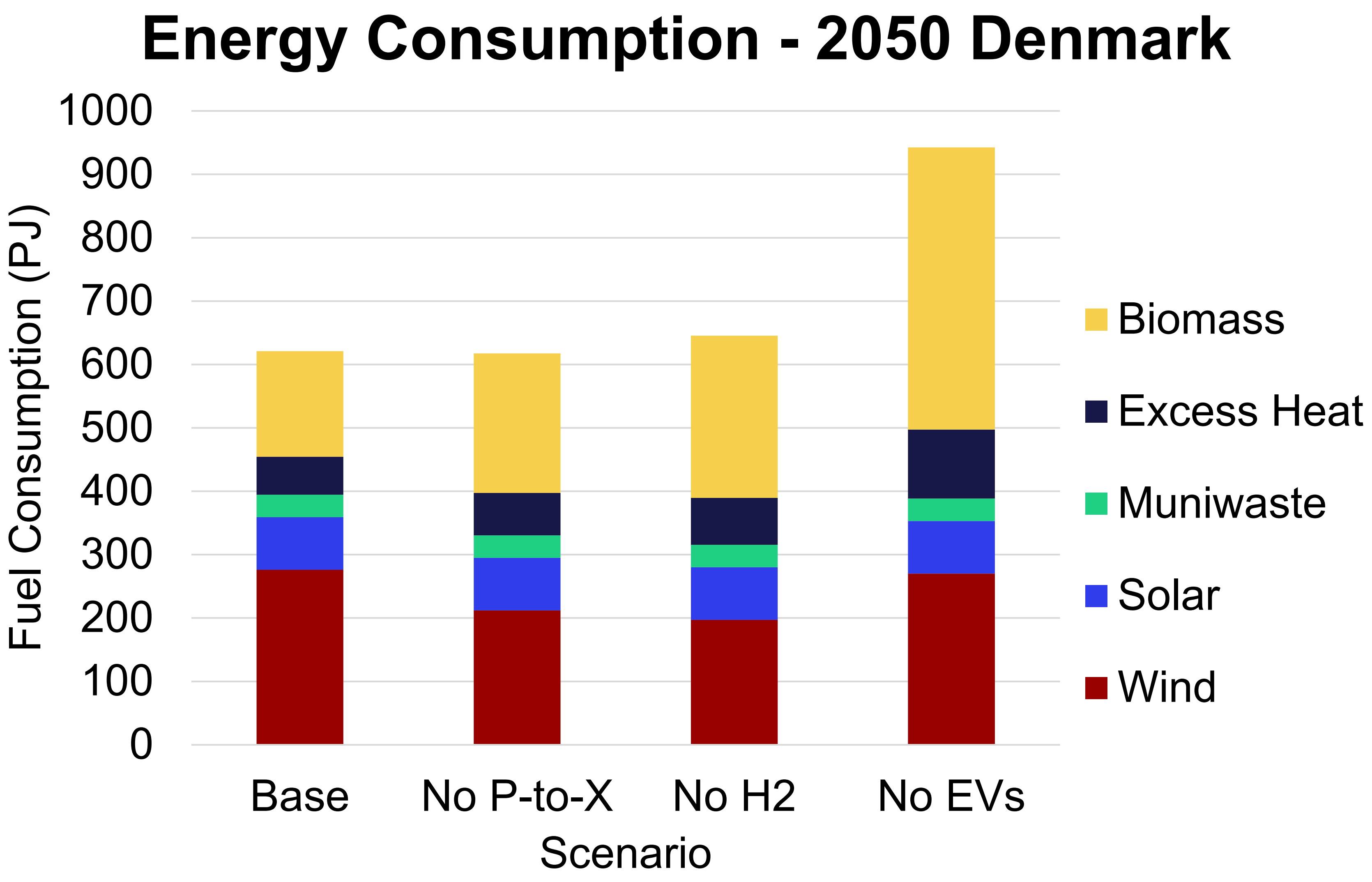


Nordic Energy Technology Perspective 2016, IEA


Change in Danish System Costs
Change in system Costs [M€]
3000
2500
2000
1500
1000
500
0
Base
No P-to-X
No H2
No EVs
Scenario

Biomass Consumption - 2050




Energy Consumption - 2050 Denmark
Fuel Consumption (PJ)
1000
900
800
700
600
500
400
300
200
100
0
Base
No P-to-X
No H2
No EVs
Scenario
Biomass
Excess Heat
Muniwaste
Solar
Wind

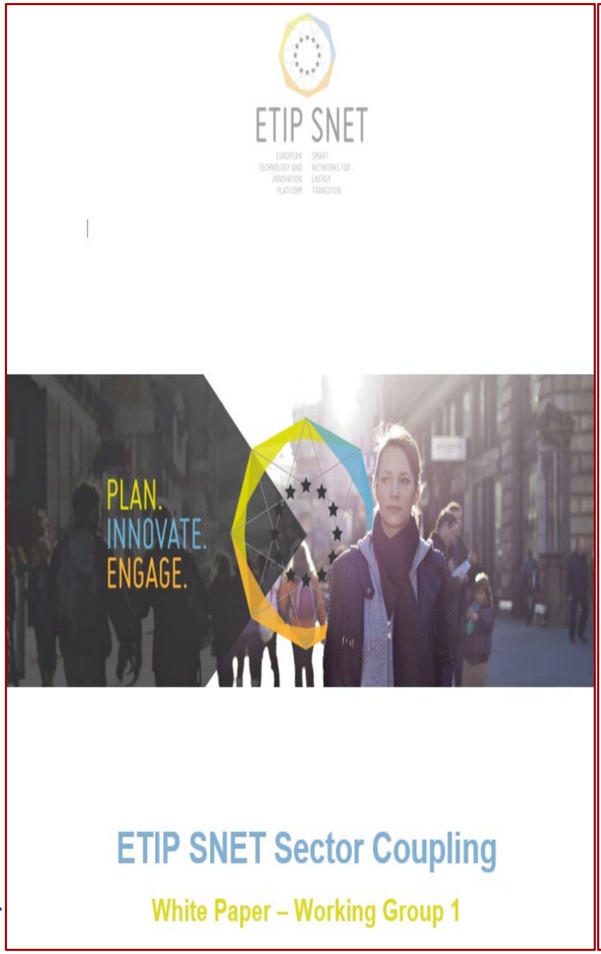
Conclusion

- EVs have the greatest value to the Danish energy system
- PtX and H2 have value but not as much since best e-fuels are using biomass for their carbon source
- Wood pellets are imported if no EVs are available and - to a lesser extent - with no PtX and no H2

Coming up: ETIP SNET WG1 White paper on sector coupling

- The white paper addresses the potential benefits of energy sector coupling: PtH, PtG, PtX, and EV's
- Work in progress:
  - Coordinated by DTU
  - International collaboration between leading researchers, industry and institutions in the field of energy sector coupling

https://www.etip-snet.eu/about/working-groups/wg-1/



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The End

Questions or comments?

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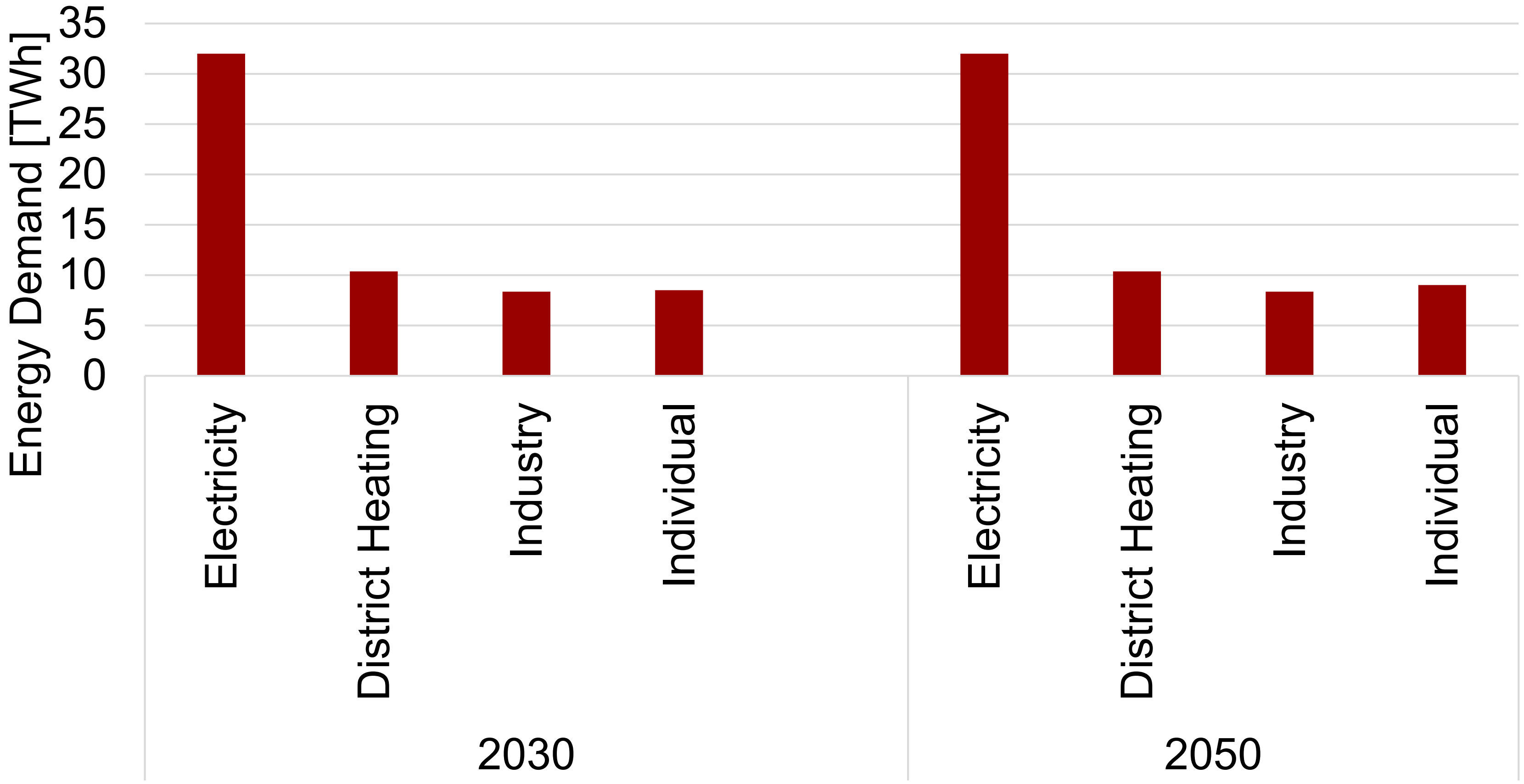
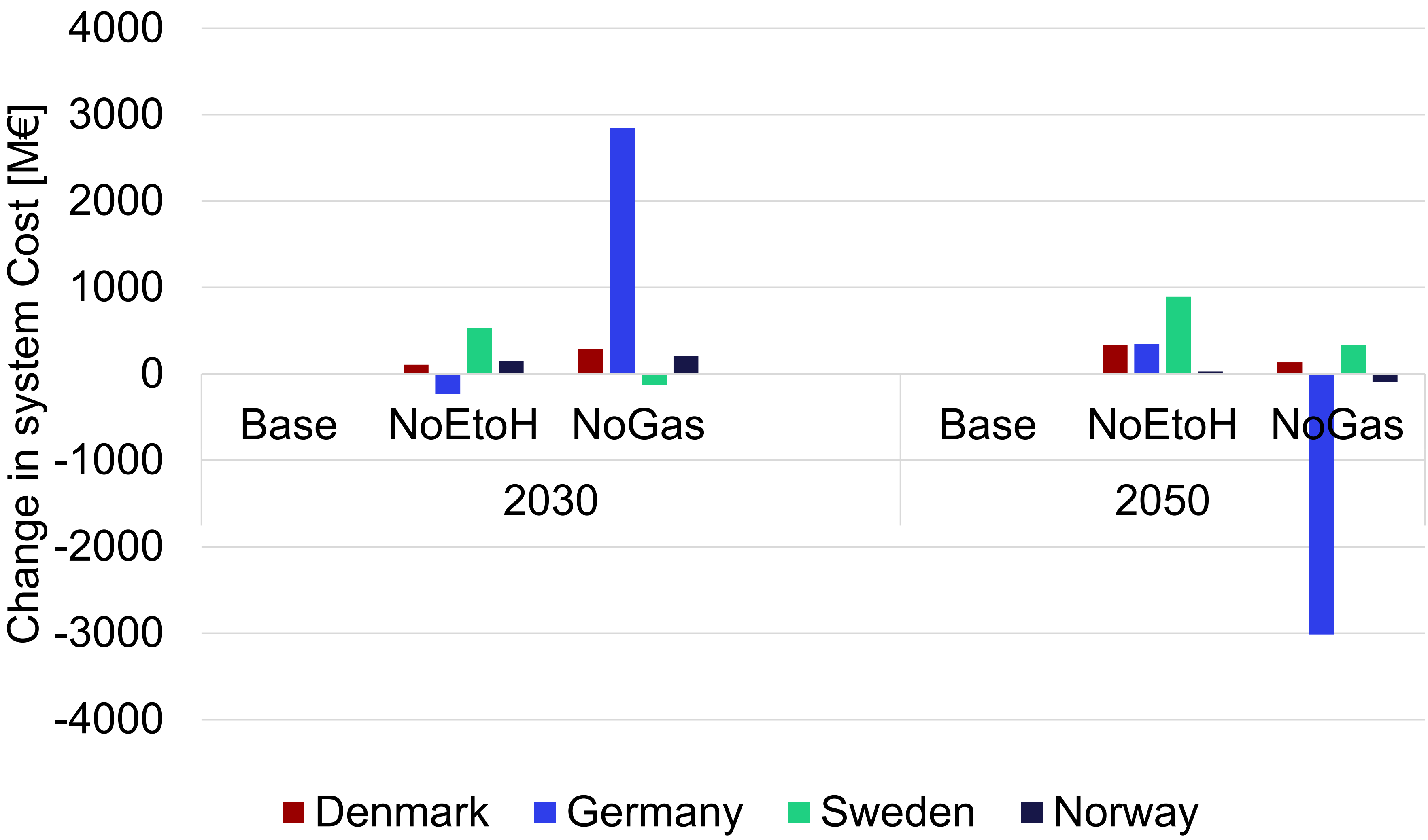
https://orbit.dtu.dk/en/persons/marie-munster(48791cb0-5c40-4de1-8659-e6cfb586f16a).html

Extras

Energy Demand - Denmark



Change in Total System Costs



Normalized Total Danish Energy System Costs