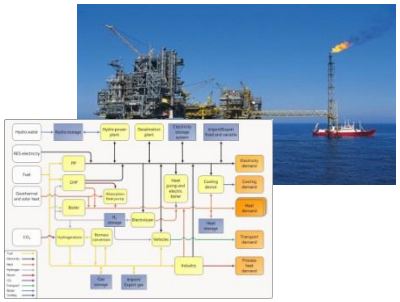
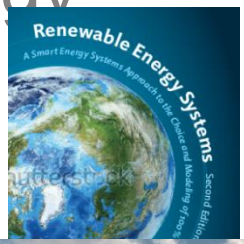
RENEWABLE ENERGY – NOW MORE THAN EVER !

REScoop.eu INTERREGIONAL CONFERENCE, EUPEN (BELGIUM), Tuesday 17 January 2017



Smart Energy Europe

Technological & Economic Status: A Scenario of 100% Renewable Energy



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AALBORG UNIVERSITY
DENMARK

Smart Energy Europe

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journal homepage: www.elsevier.com/locate/rser

Smart Energy Europe: The technical and economic impact of one potential 100% renewable energy scenario for the European Union

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ARTICLE INFO

ABSTRACT

Article history:
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This study p
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www.EnergyPLAN.eu/SmartEnergyEurope

- Report Online
- Paper Published

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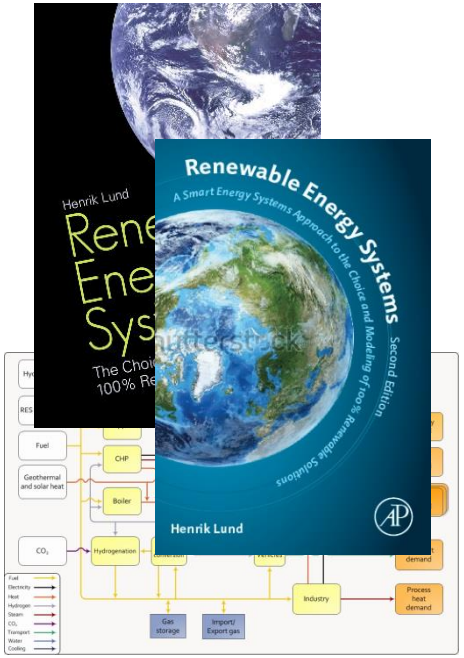
Smart Energy Systems

The key to cost-efficient 100% Renewable Energy

- A sole focus on renewable **electricity (smart grid)** production leads to electricity storage and flexible demand solutions!

- Looking at renewable electricity as a part **smart energy systems** including heating, industry, gas and transportation opens for cheaper and better solutions…



Power-to-Heat

Power-to-Gas
Power-to-Transport

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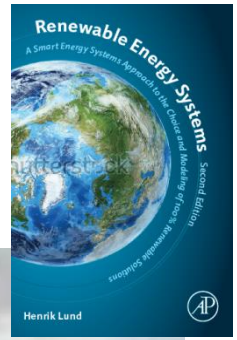
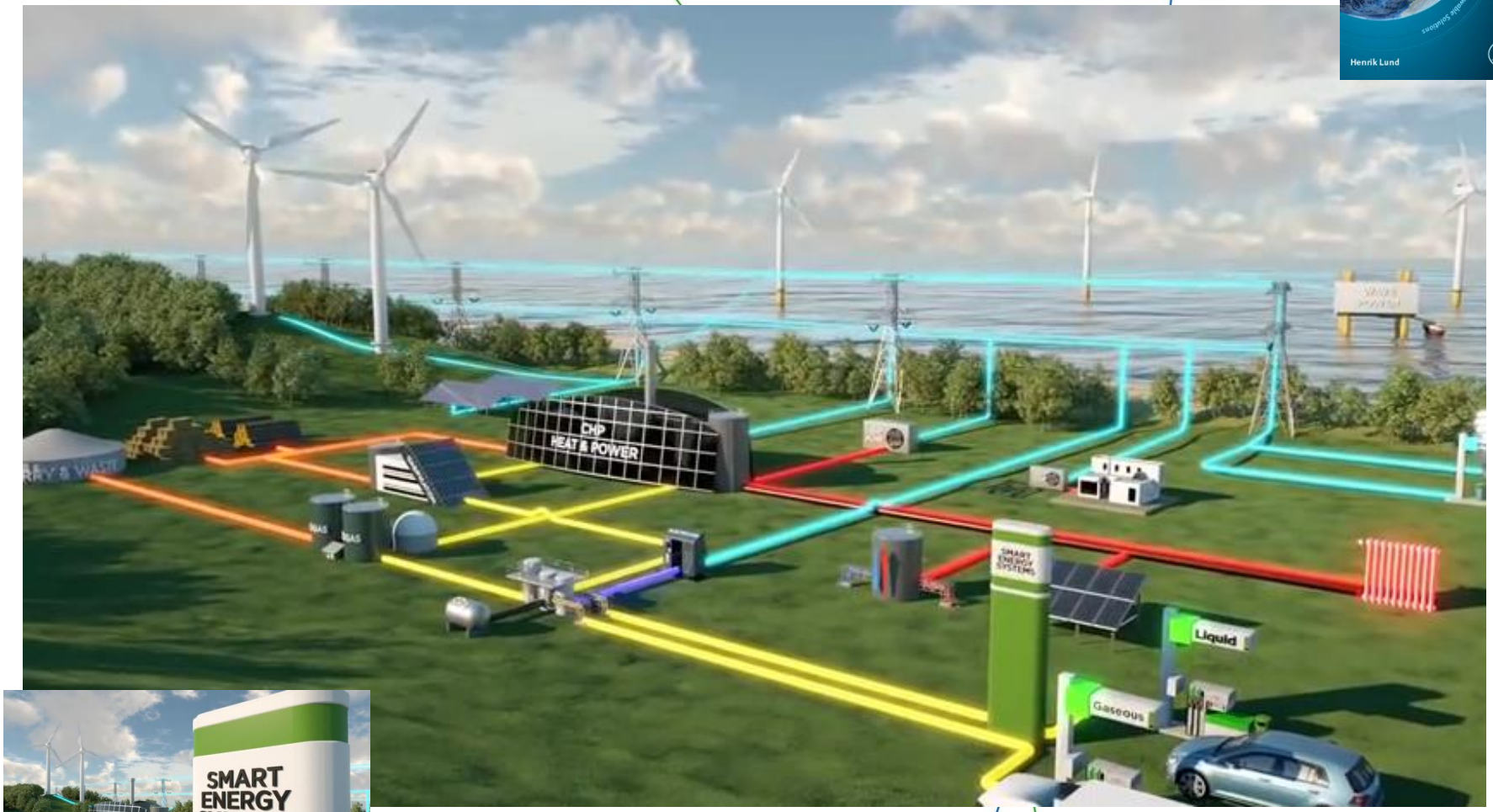
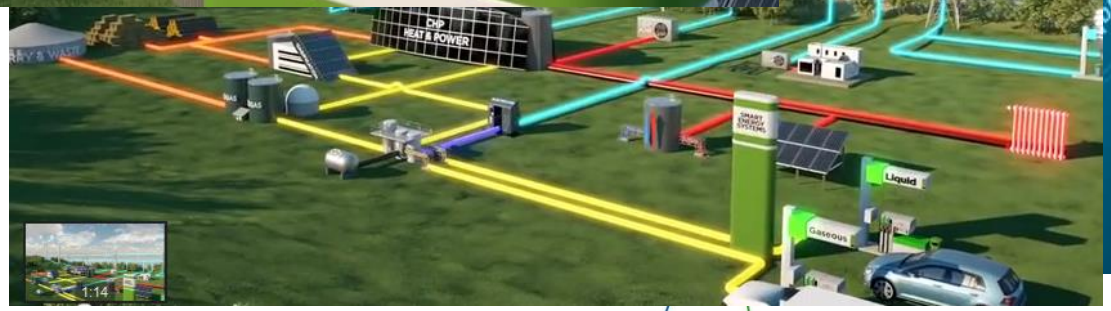
Smart Energy Systems





Smart Energy Systems

www.energyplan.eu/smartenergysystems/



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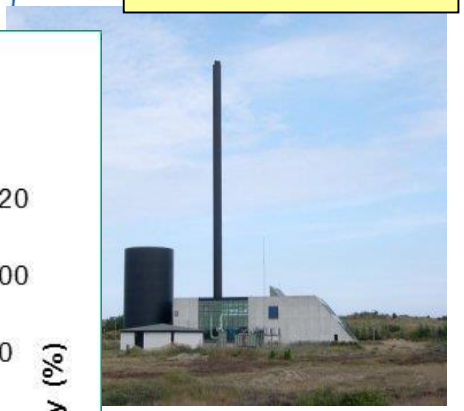
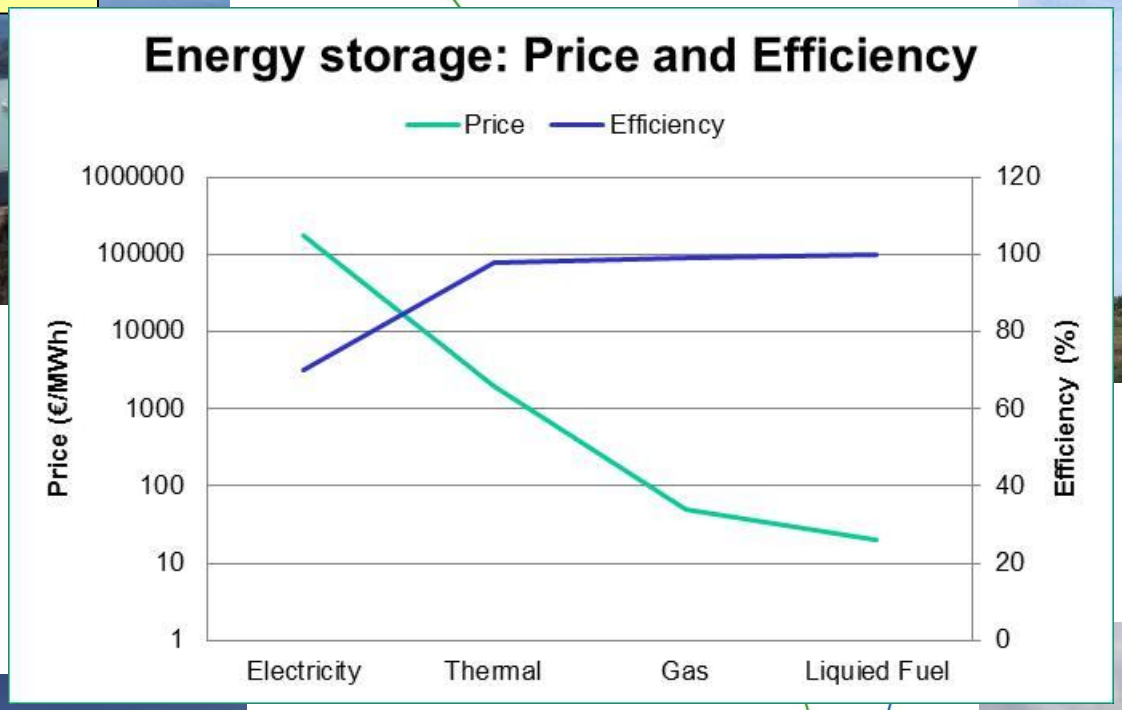
Energy Storage

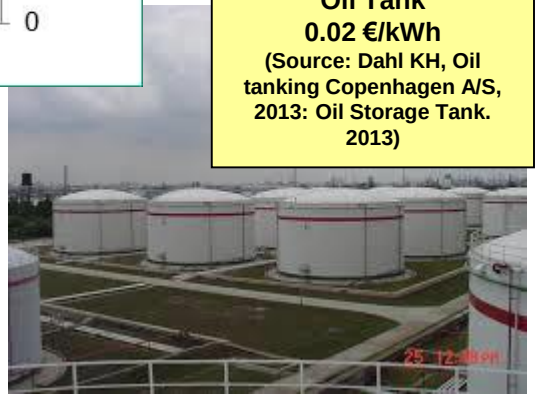
Pump Hydro Storage
175 €/kWh
(Source: Electricity Energy Storage Technology Options: A White Paper Primer on Applications, Costs, and Benefits. Electric Power Research Institute, 2010)

Thermal Storage
1-4 €/kWh
(Source: Danish Technology Catalogue, 2012)





Oil Tank
0.02 €/kWh
(Source: Dahl KH, Oil tanking Copenhagen A/S, 2013: Oil Storage Tank. 2013)

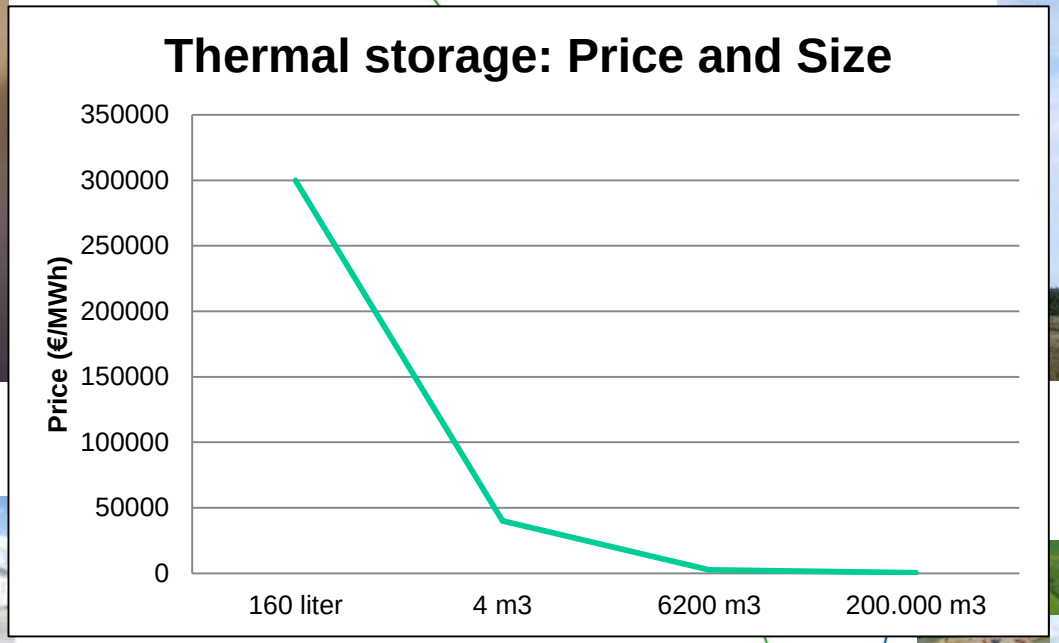


Natural Gas Underground Storage
0.05 €/kWh
(Source: Current State Of and Issues Concerning Underground Natural Gas Storage. Federal Energy Regulatory Commission, 2004)

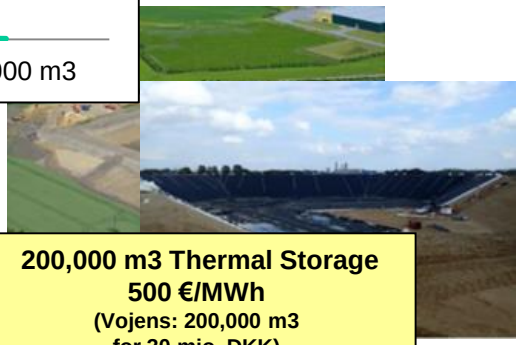
Thermal Storage

0.16 m3 Thermal Storage
300.000 €/MWh
(Private house: 160 liter for 15000 DKK)

6200 m3 Thermal Storage
2500 €/MWh
(Skagen: 6200 m3 for 5.4 mio. DKK)



4 m3 Thermal Storage
40,000 €/MWh
(Private outdoor: 4000 m3 for 50,000 DKK)



200,000 m3 Thermal Storage
500 €/MWh
(Vojens: 200,000 m3 for 30 mio. DKK)

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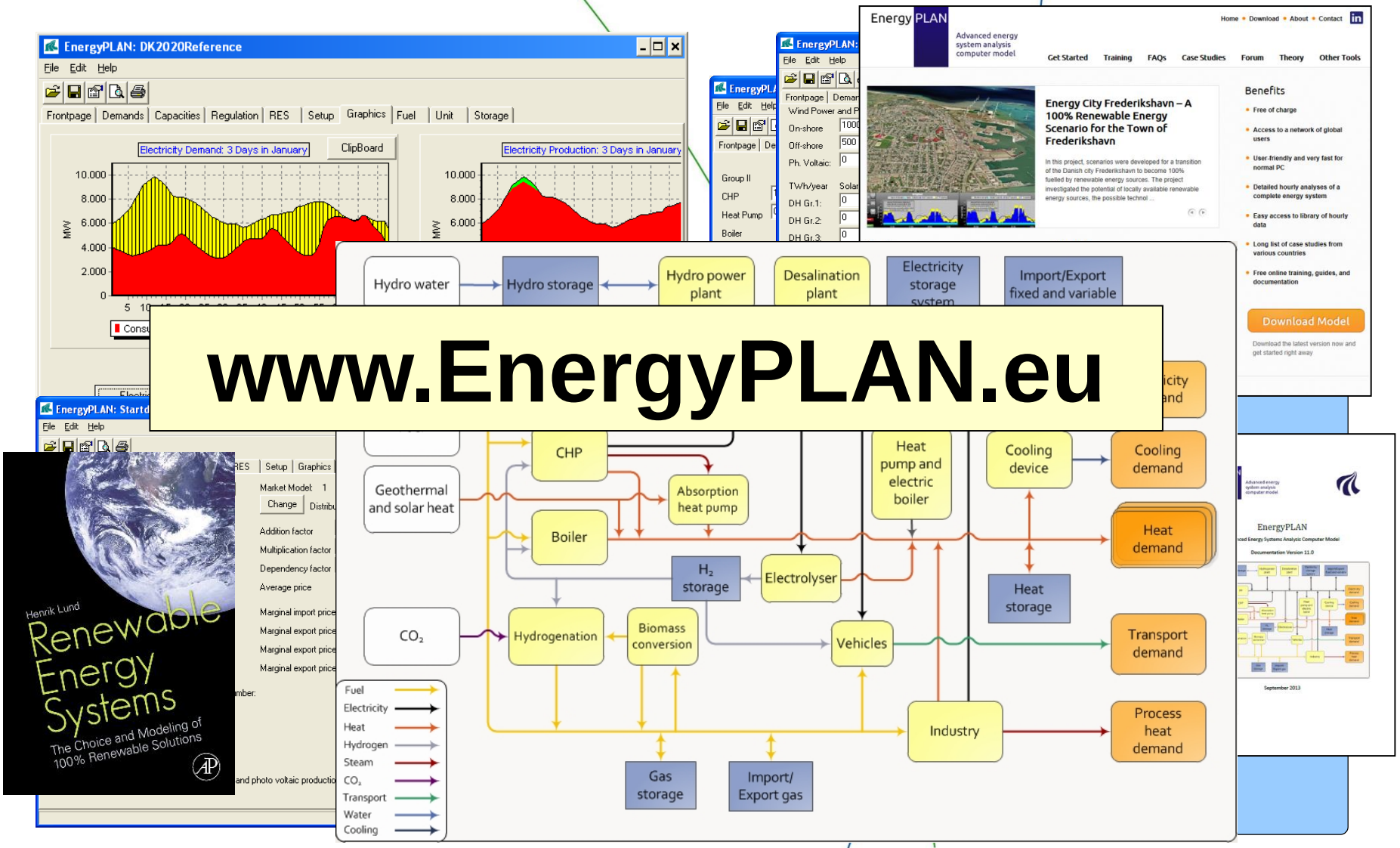
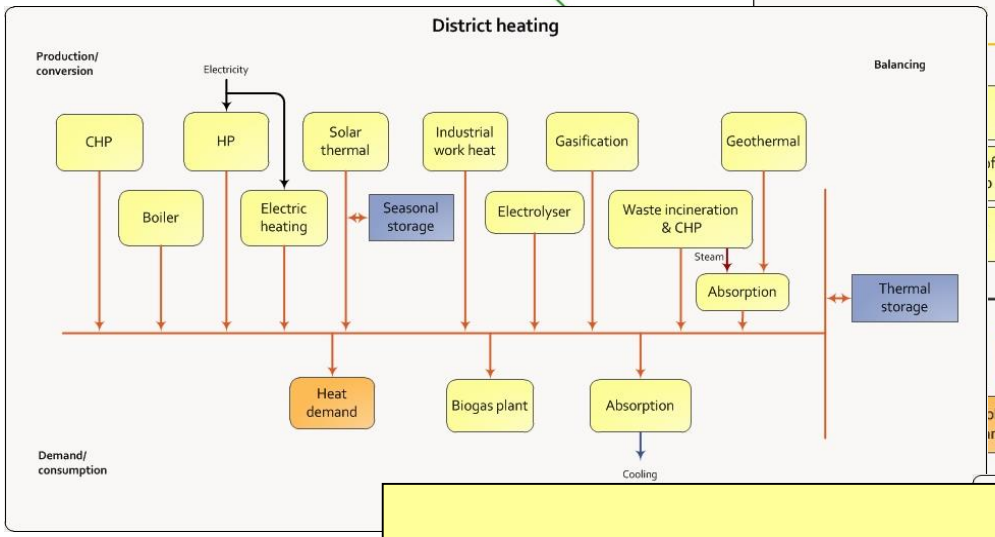
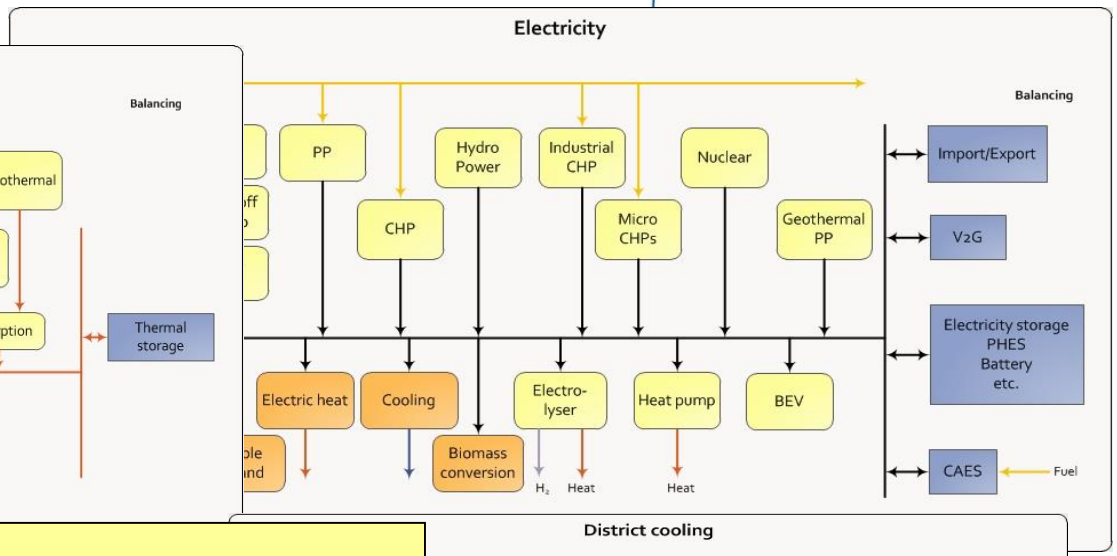
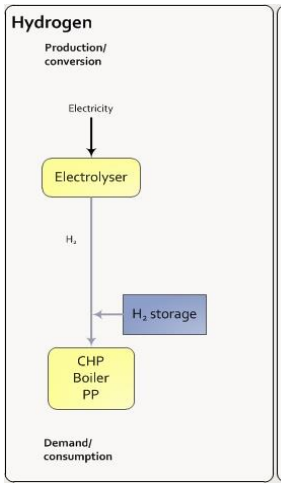
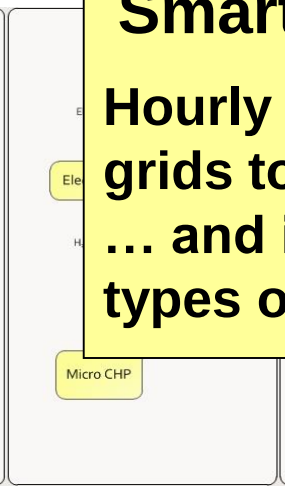
Energy System Analysis Model

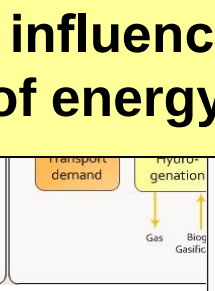


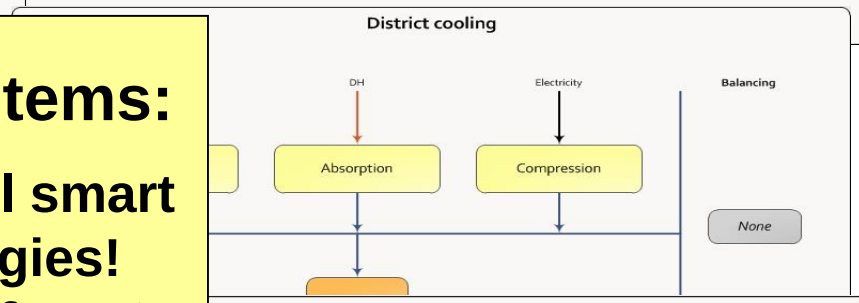


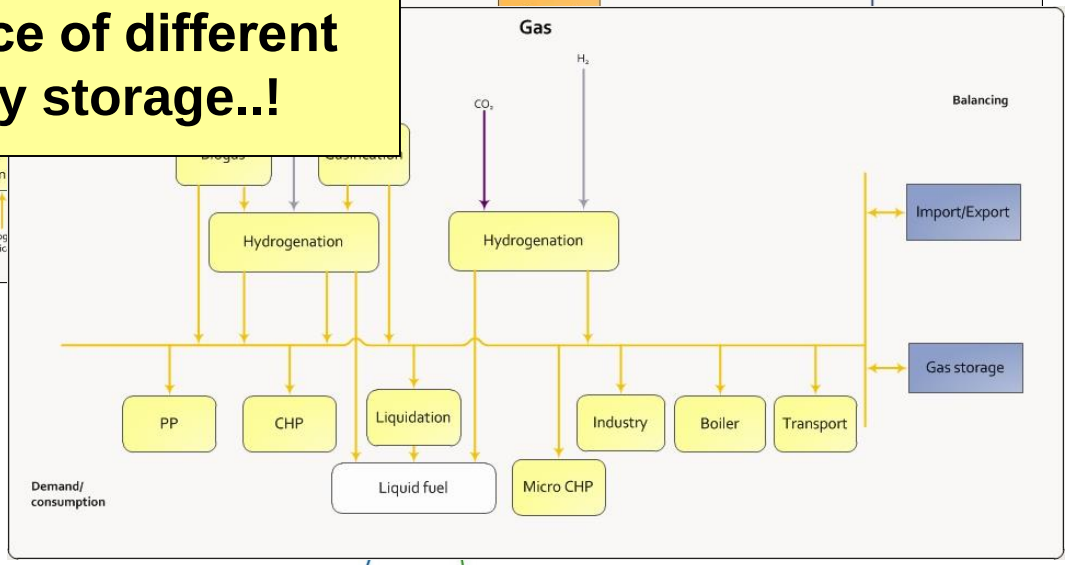












Smart Energy Systems:

Hourly modelling of all smart grids to identify synergies!
… and influence of different types of energy storage..!

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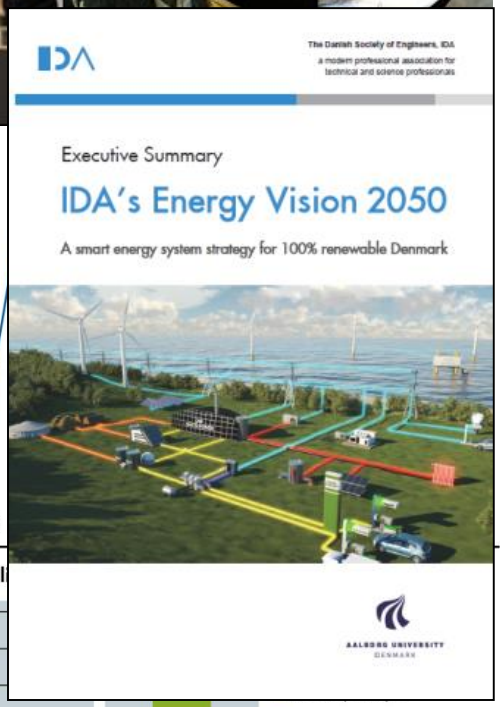
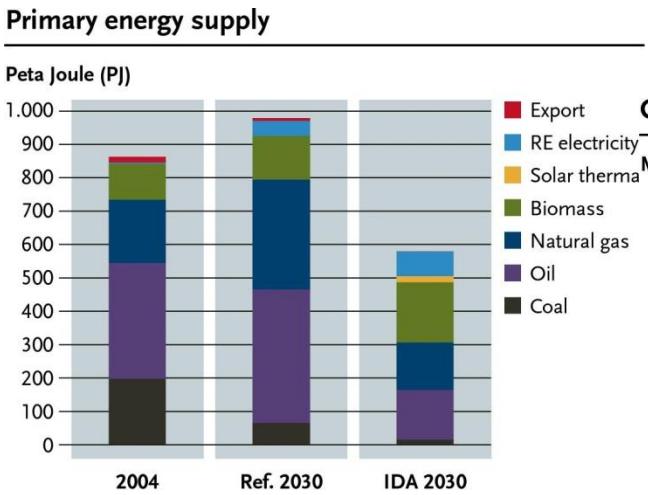
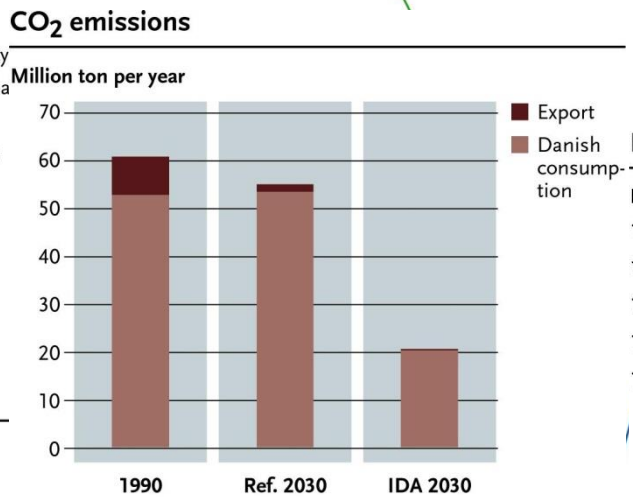
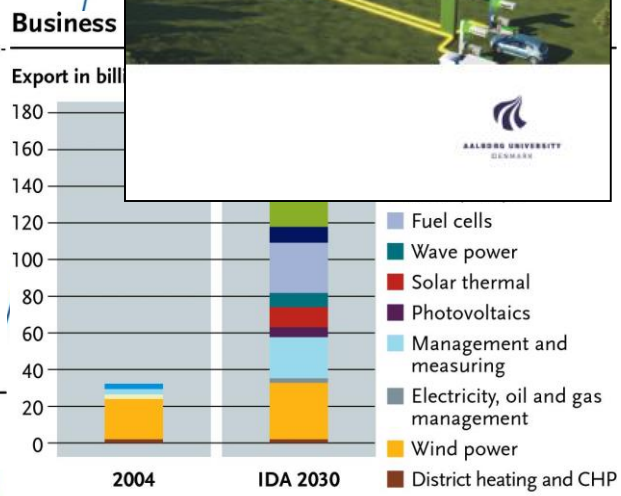
IDA Energiplan 2030









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DTU Danmarks Tekniske Universitet

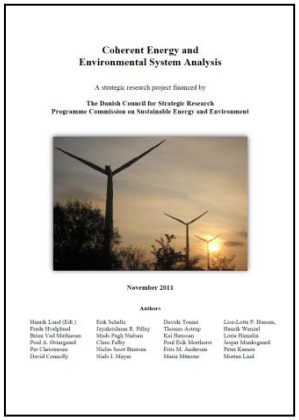
CBS COPENHAGEN BUSINESS SCHOOL HANDELSHØJSKOLEN

AALBORG UNIVERSITY DENMARK

KØBENHAVNS UNIVERSITET

SYDDANSK UNIVERSITET

CEESA Project 2011/2012

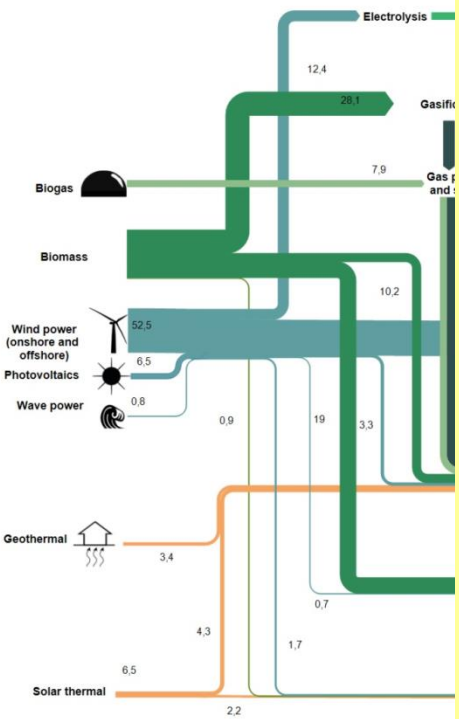

Coherent Energy and Environmental System Analysis

A strategic research project financed by

The Danish Council for Strategic Research
Programme Commission on Sustainable Energy and Environment

November 2011

Authors



Transport:

Electric vehicles is best from an energy efficient point of view. But gas and/or liquid fuels is needed to transform to 100%.

Biomass:

.. is a limited resource and can not satisfy all the transportation needs.

Consequence

… Electricity from Wind (and similar resources) needs to be converted to gas and liquied fuels in the long-term perspective…

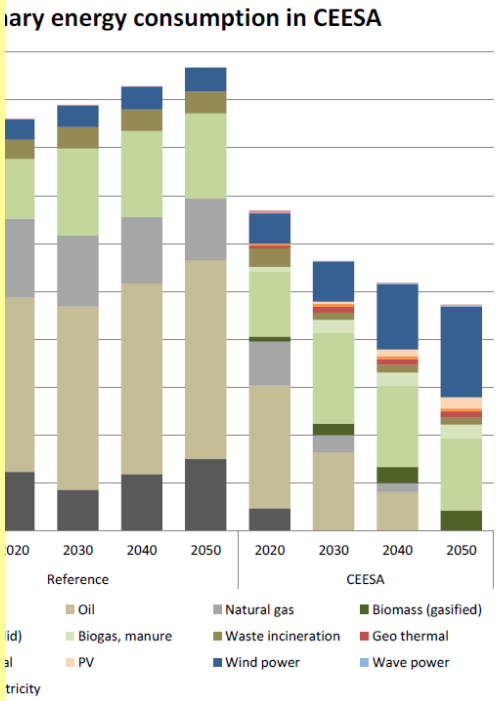


Figure 2: Primary Energy Supply in CEESA.

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Electro-fuels

100% Renewable Energy 2050

Power-to-Transportation

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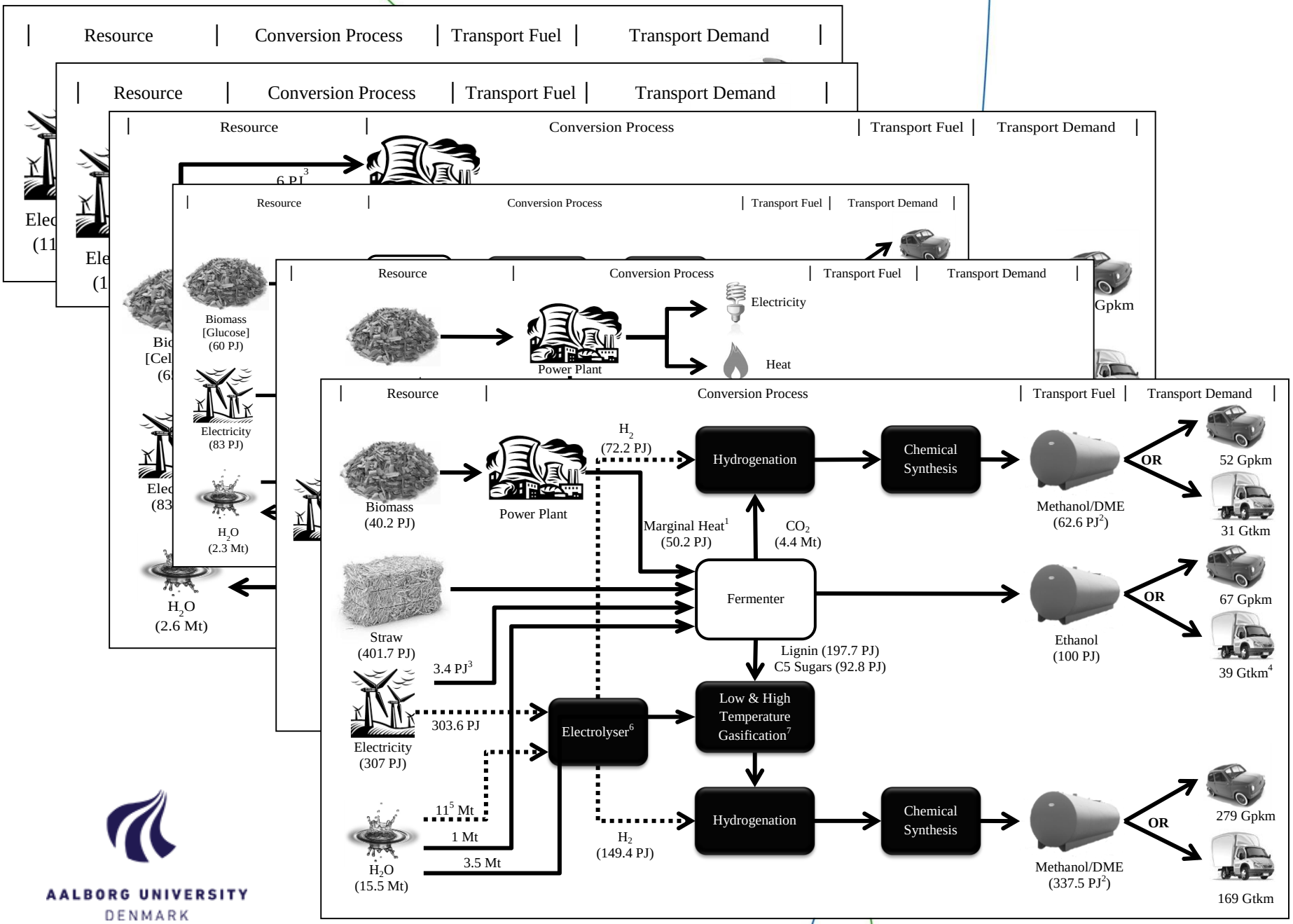

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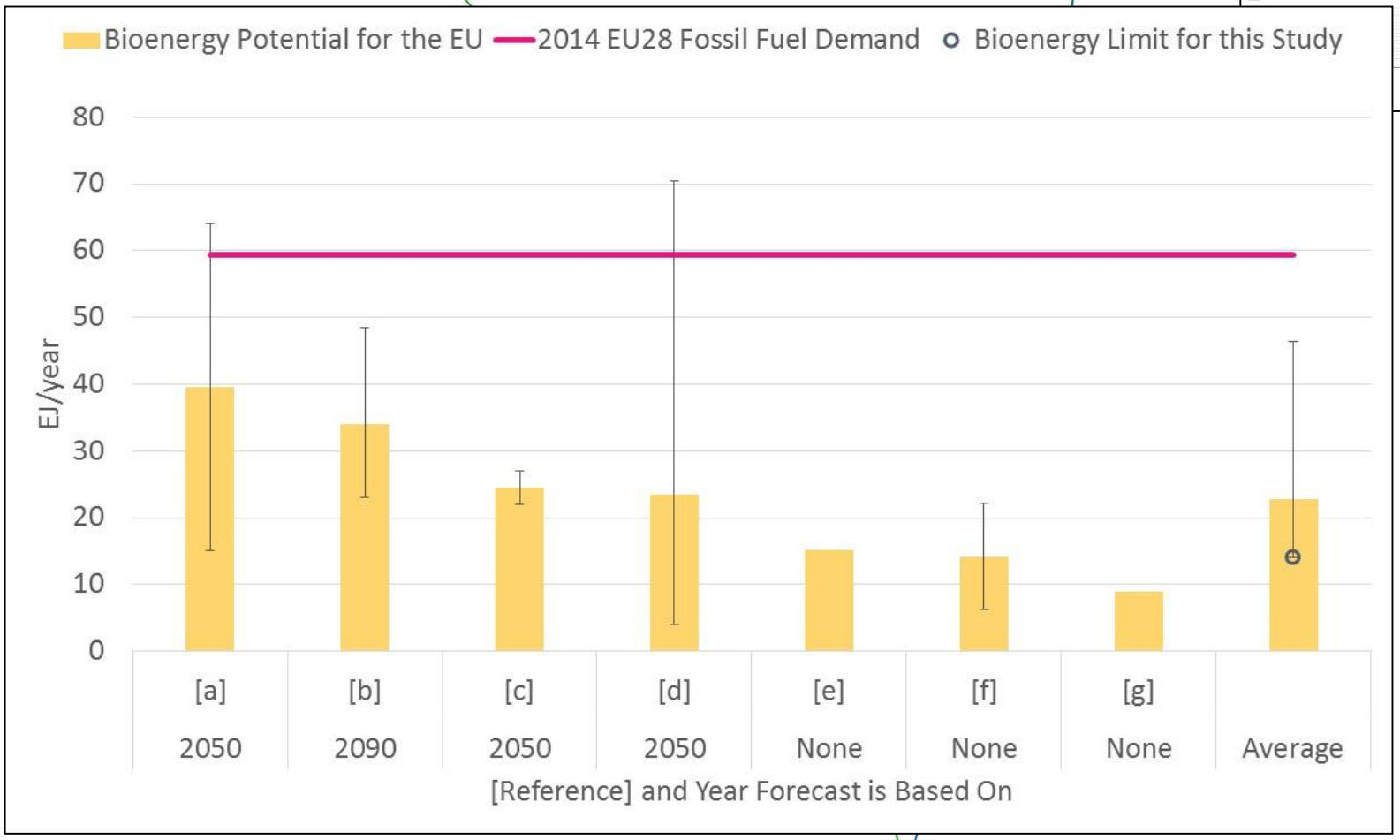
Bioenergy Is Limited



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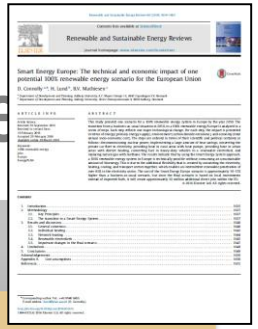
10 Steps to Smart Energy Europe



Starting Point

1. EU28 CPI 2050

General Consensus

2. No Nuclear
3. Heat Savings
4. Electric Ca

Maximise Wind in All Scenarios

Heating

5. Heat Pumps
6. District He

2050 Heat Roadmap Europe
A low-carbon heating and cooling strategy

Transport / Fuels

7. Electrofuels
8. Replacing Coal & Oil
9. Replacing Natural Gas

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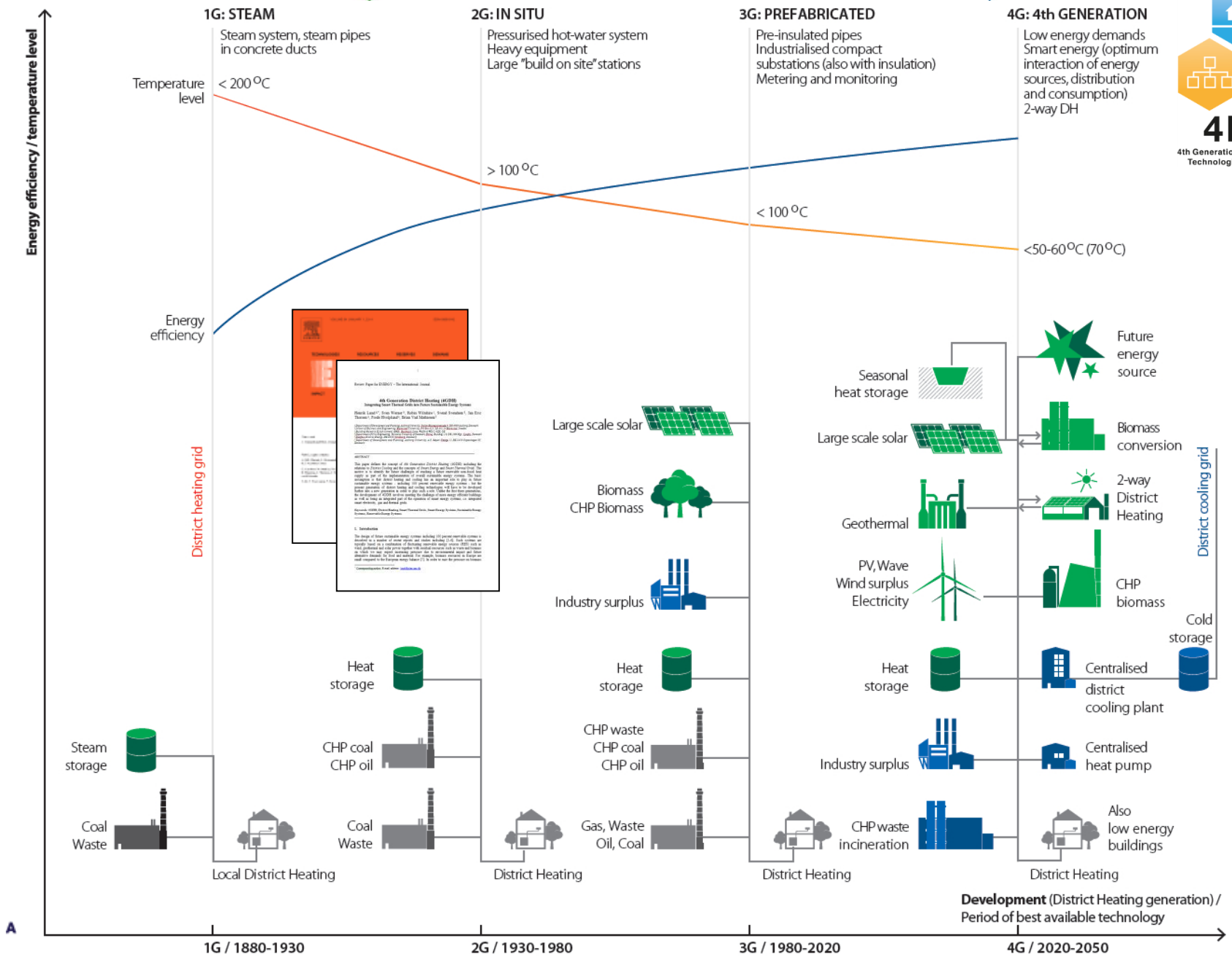
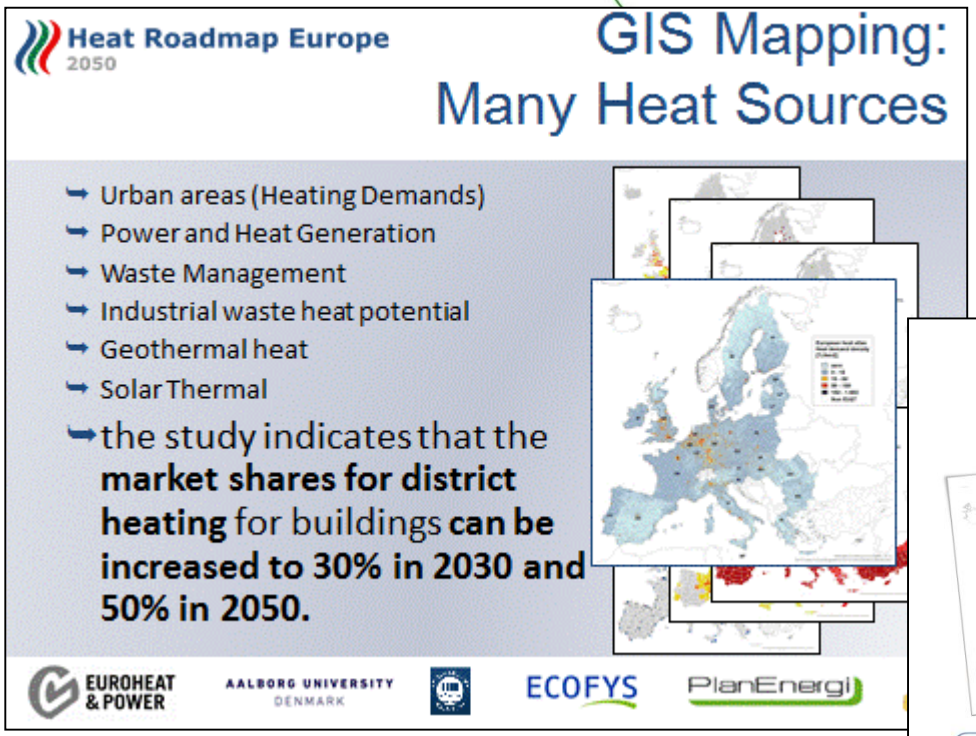


4DH
4th Generation District Heating Technologies and Systems

Heat Roadmap Europe



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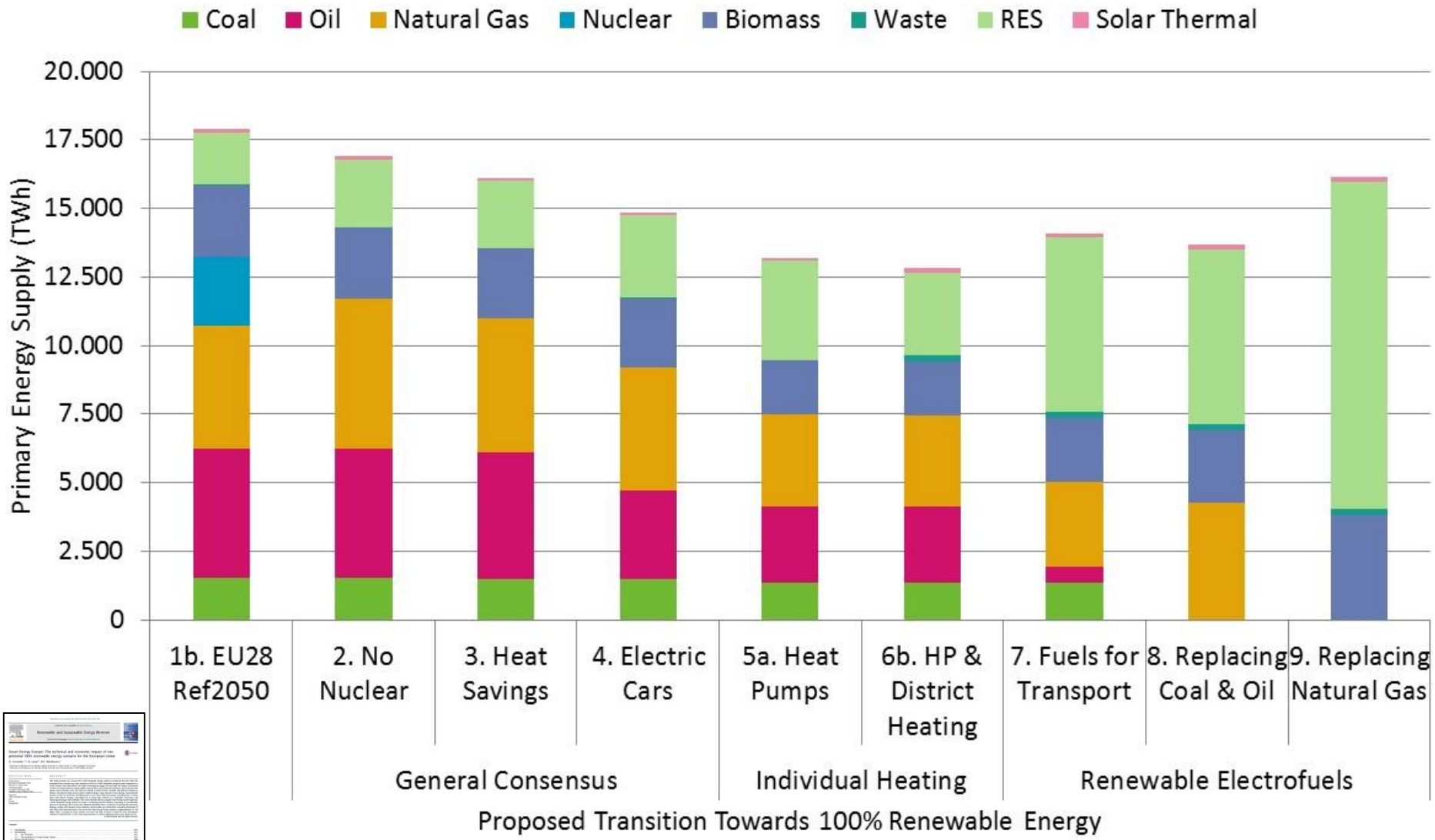
ECOFYS
sustainable energy for everyone

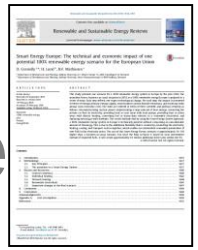
PlanEnergi

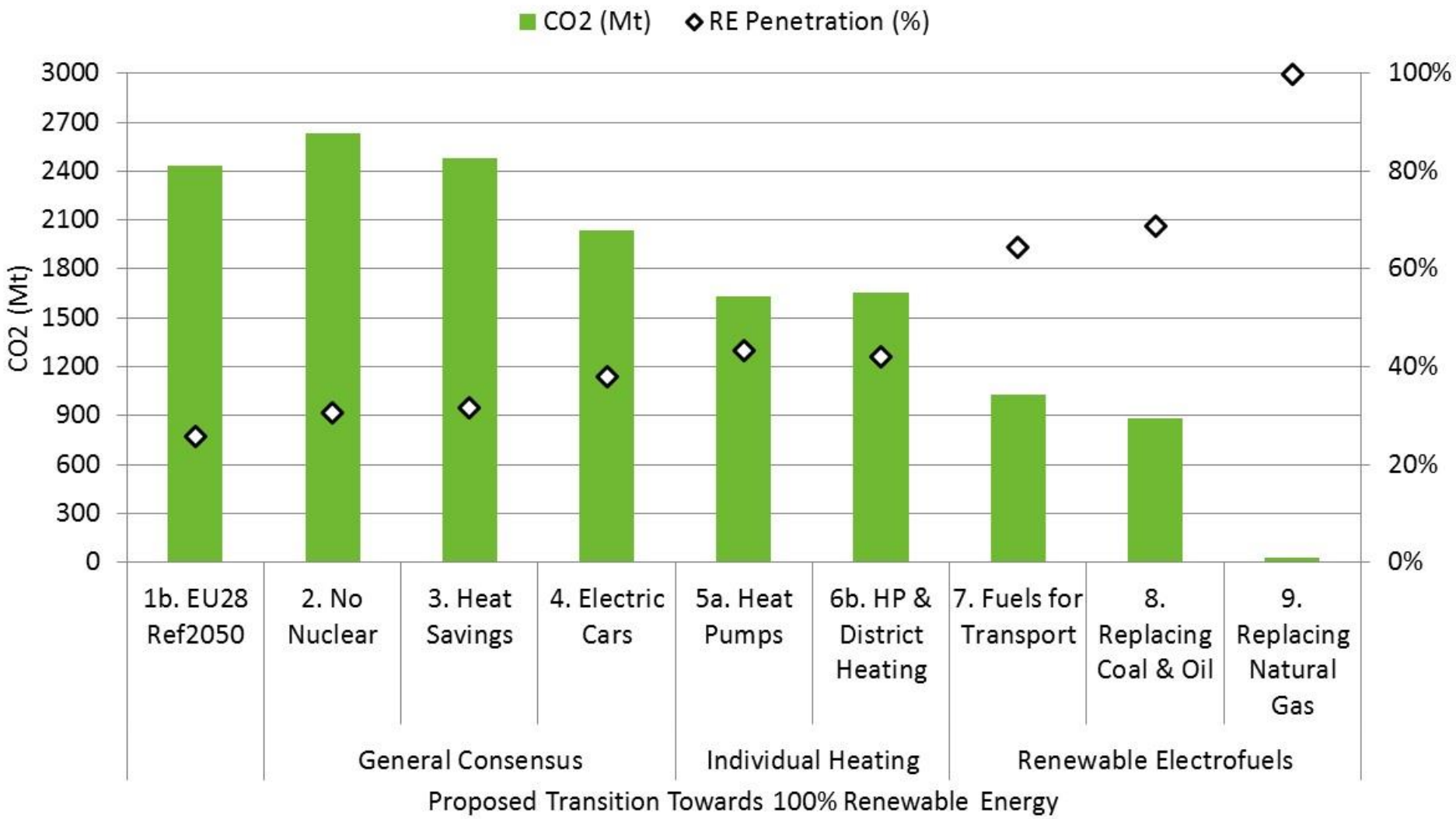
HÖGSKOLAN HALMSTAD

Smart Energy Europe: Primary Energy Supply

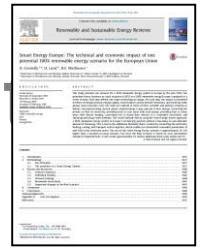


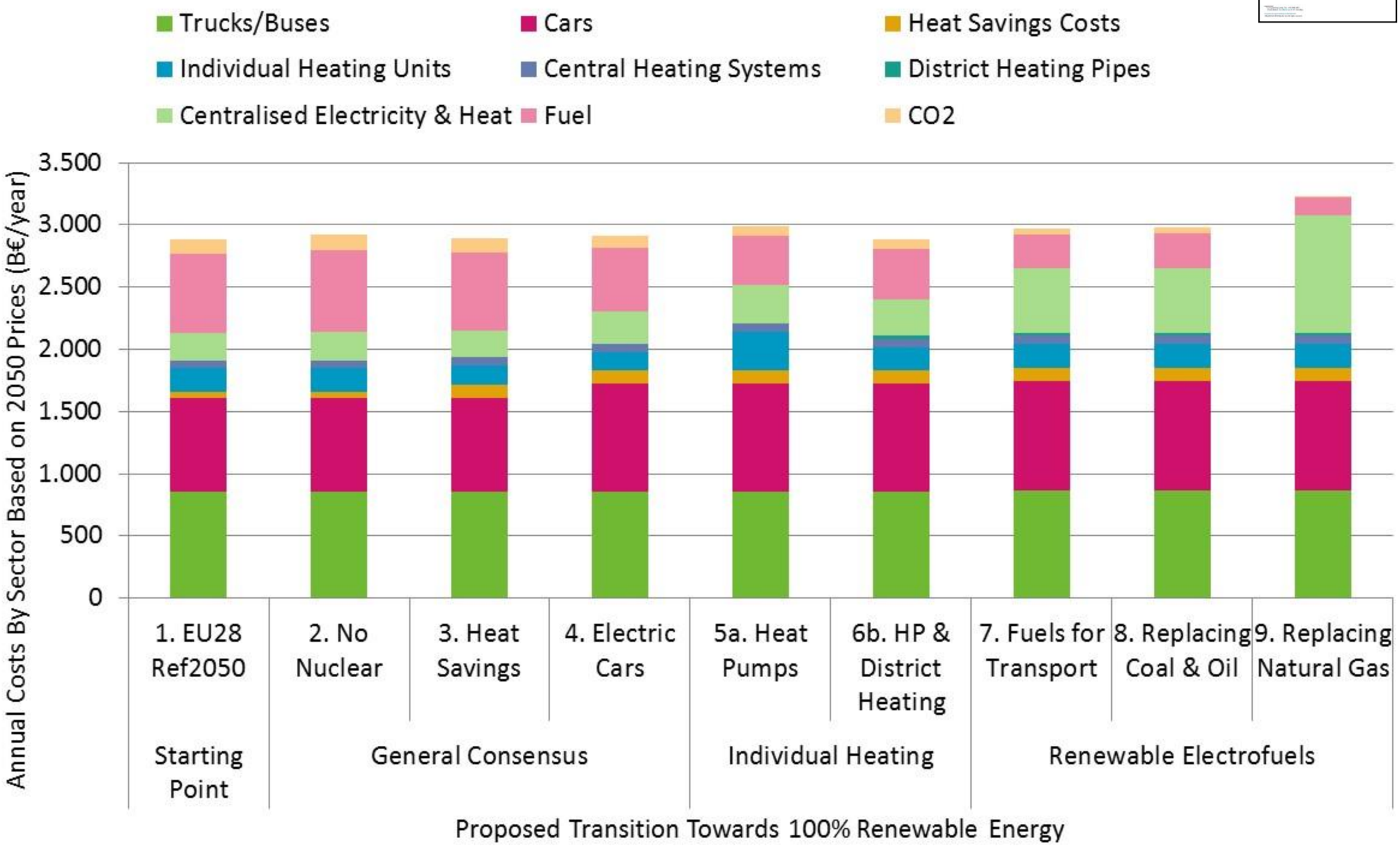
Smart Energy Europe: CO2 emission and Renewable Share





Smart Energy Europe: Annualized Cost



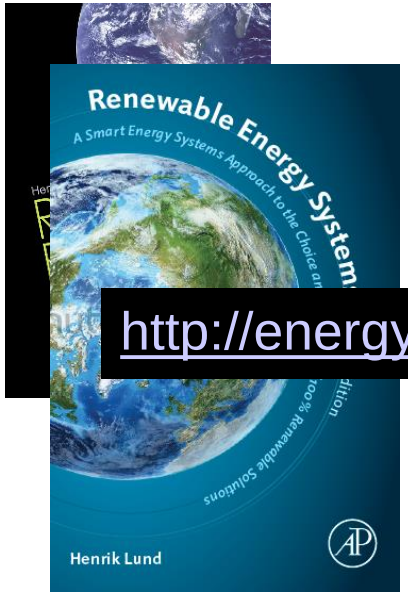


More information:

www.henriklund.eu

www.4DH.dk

4DH
4th Generation District Heating Technologies and Systems



http://energy.plan.aau.dk/book.php

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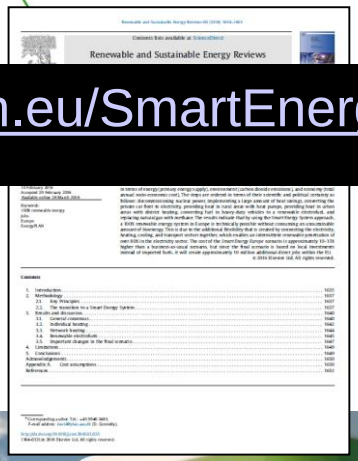

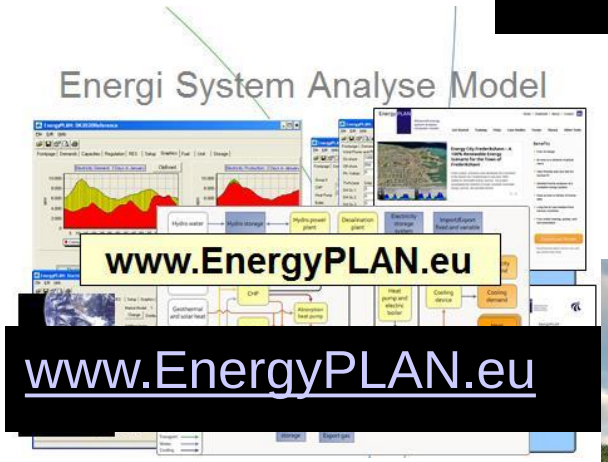

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