»Nahwärme kompakt«

Kongress und Workshop
8. und 9. Oktober 2018
in Karlsruhe

DEUTSCH-DÄNISCHER
DIALOG WÄRMENETZE
BADEN-WÜRTTEMBERG

EMBASSY OF DENMARK
Berlin

Danish Energy Agency

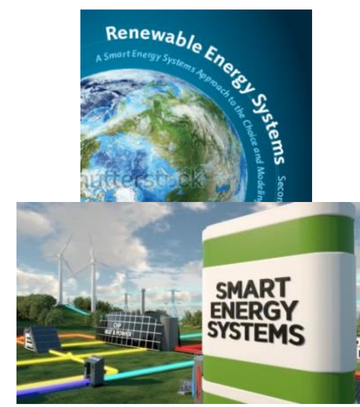
DBDH

4DH
4th Generation District Heating Technologies and Systems

4th Generation District Heating and Smart Energy Systems

Insights from the 4DH Research Centre

Henrik Lund
Professor in Energy Planning
Aalborg Universitet



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CITIES
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Smart Energy Europe

Renewable and Sustainable Energy Reviews 60 (2016) 1634–1653

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Renewable and Sustainable Energy Reviews

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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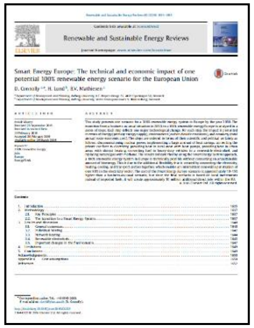
ABSTRACT



www.EnergyPLAN.eu/SmartEnergyEurope

- Report Online
- Paper Published

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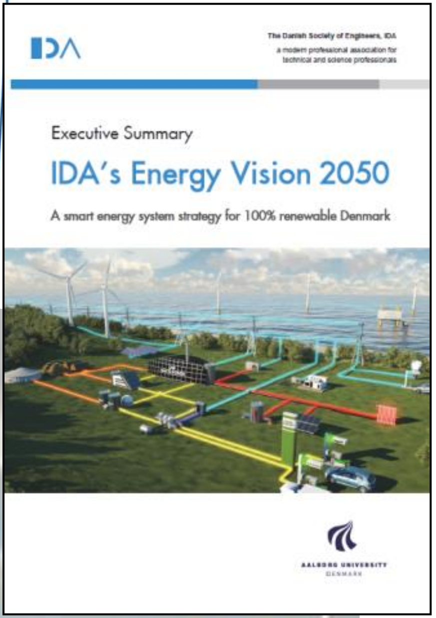
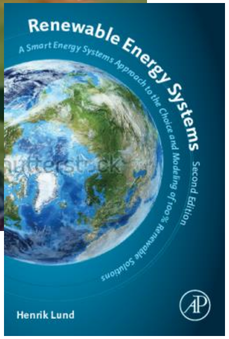
Smart Energy Systems





Smart Energy Systems

www.energyplan.eu/smartenergysystems/

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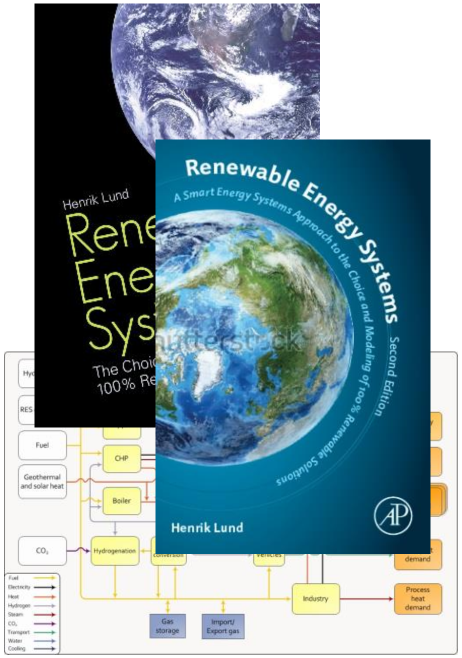
Smart Energy Systems

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…



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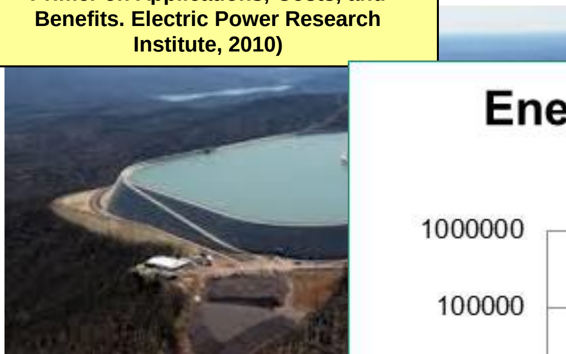
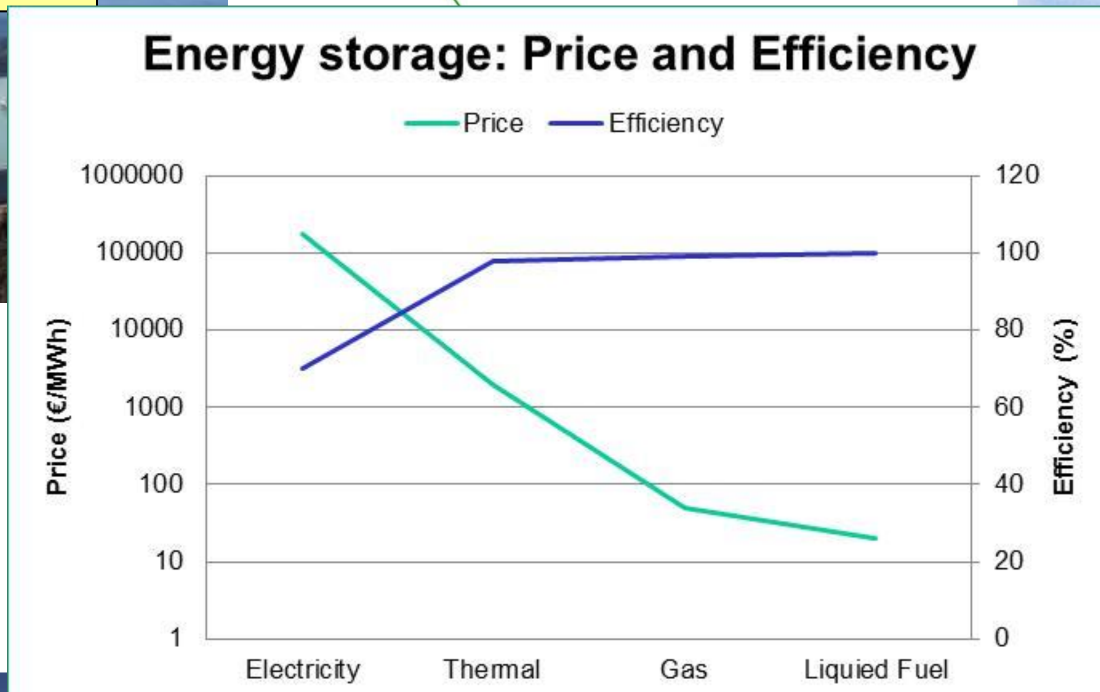
Power-to-Heat

Power-to-Gas
Power-to-Transport

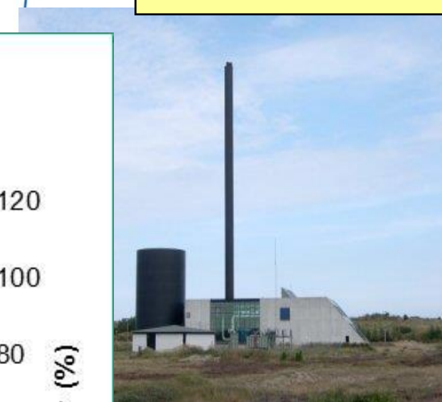
Energy Storage

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)



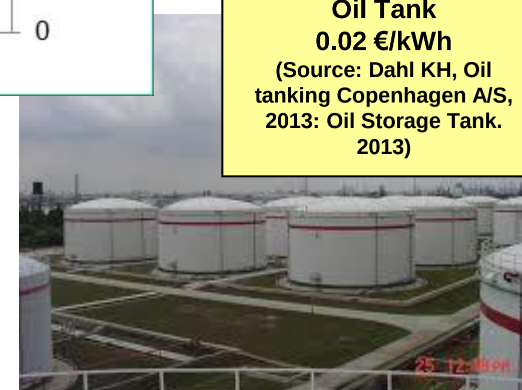


Thermal Storage
1-4 €/kWh
(Source: Danish Technology Catalogue, 2012)



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

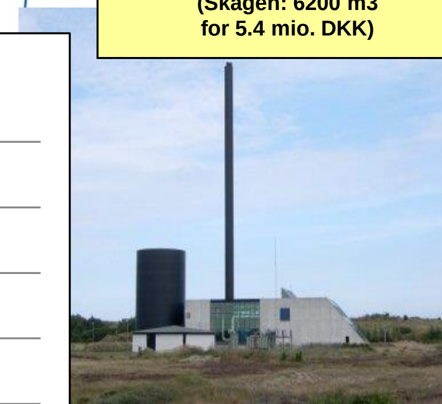
Oil Tank
0.02 €/kWh
(Source: Dahl KH, Oil tanking Copenhagen A/S, 2013: Oil Storage Tank. 2013)

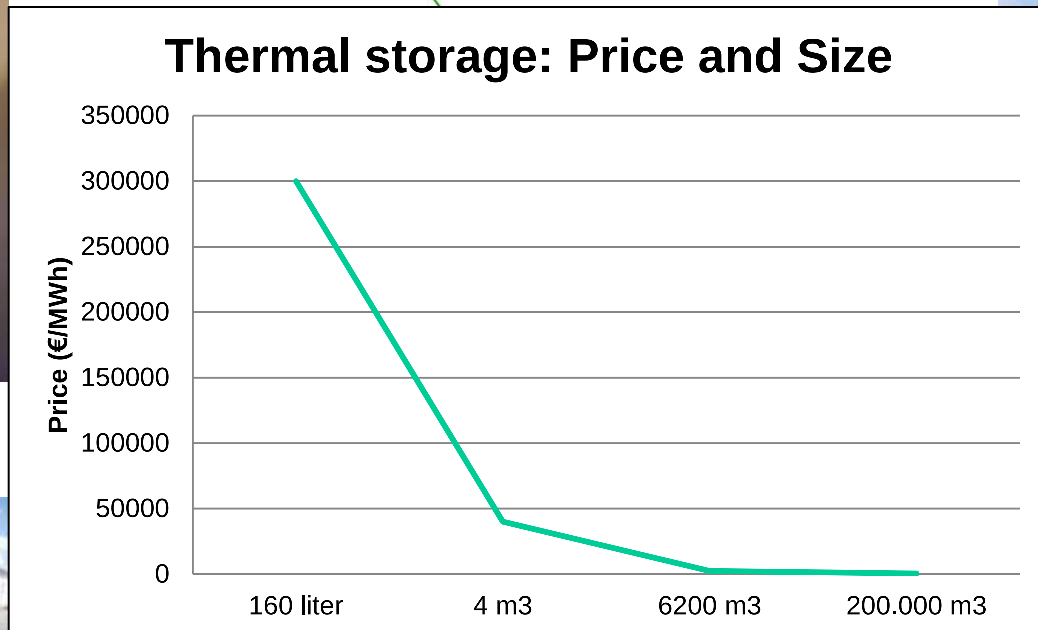


Thermal Storage

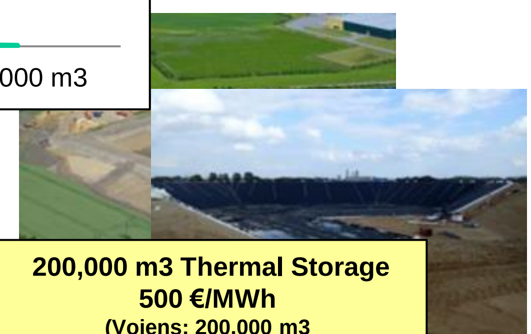
0.16 m3 Thermal Storage
300.000 €/MWh
(Private house: 160 liter for 15000 DKK)

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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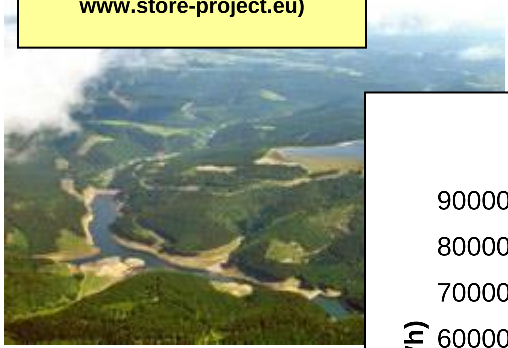
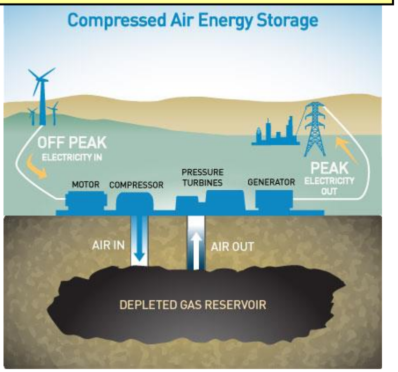
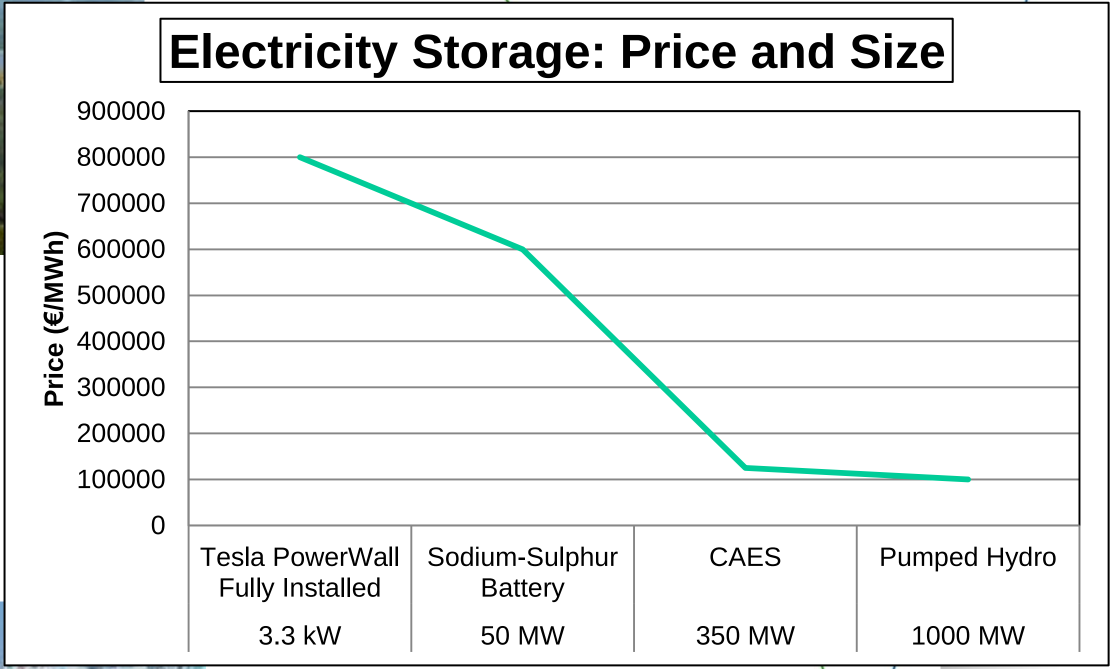
Electricity Storage

Pump Hydro Storage
100 €/kWh
(Source: Goldisthal Pumped Storage Station, Germany, www.store-project.eu)



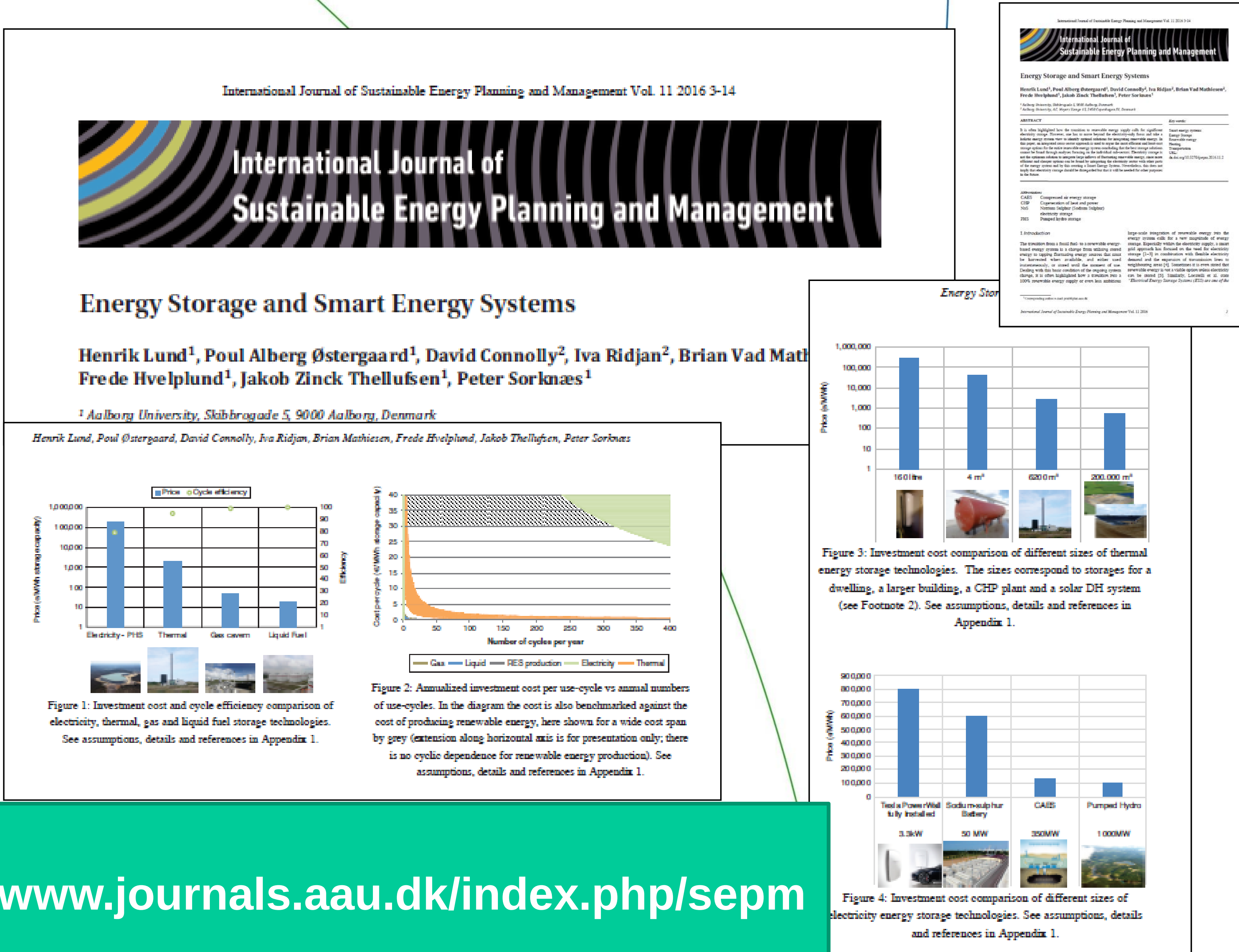
Compressed Air Energy Storage
125 €/kWh
(Source: http://www.sciencedirect.com/science/article/pii/S0196890409000429)





Sodium-Sulphur Battery
600 €/kWh
(Source: Table 4: http://large.stanford.edu/courses/2012/ph240/doshay1/docs/EPRI.pdf)

Tesla PowerWall
800 €/kWh
(Source: Dahl KH, Oil tanking Copenhagen A/S, 2013: Oil Storage Tank. 2013)



International Journal of Sustainable Energy Planning and Management Vol. 11 2016 3-14

International Journal of
Sustainable Energy Planning and Management

Energy Storage and Smart Energy Systems

Henrik Lund[1], Poul Alberg Østergaard[1], David Connolly[2], Iva Ridjan[2], Brian Vad Math
Frede Hvelplund[1], Jakob Zinck Thellufsen[1], Peter Sorknæs[1]

[1] Aalborg University, Skibbrogade 5, 9000 Aalborg, Denmark

Figure 1: Investment cost and cycle efficiency comparison of electricity, thermal, gas and liquid fuel storage technologies. See assumptions, details and references in Appendix 1.

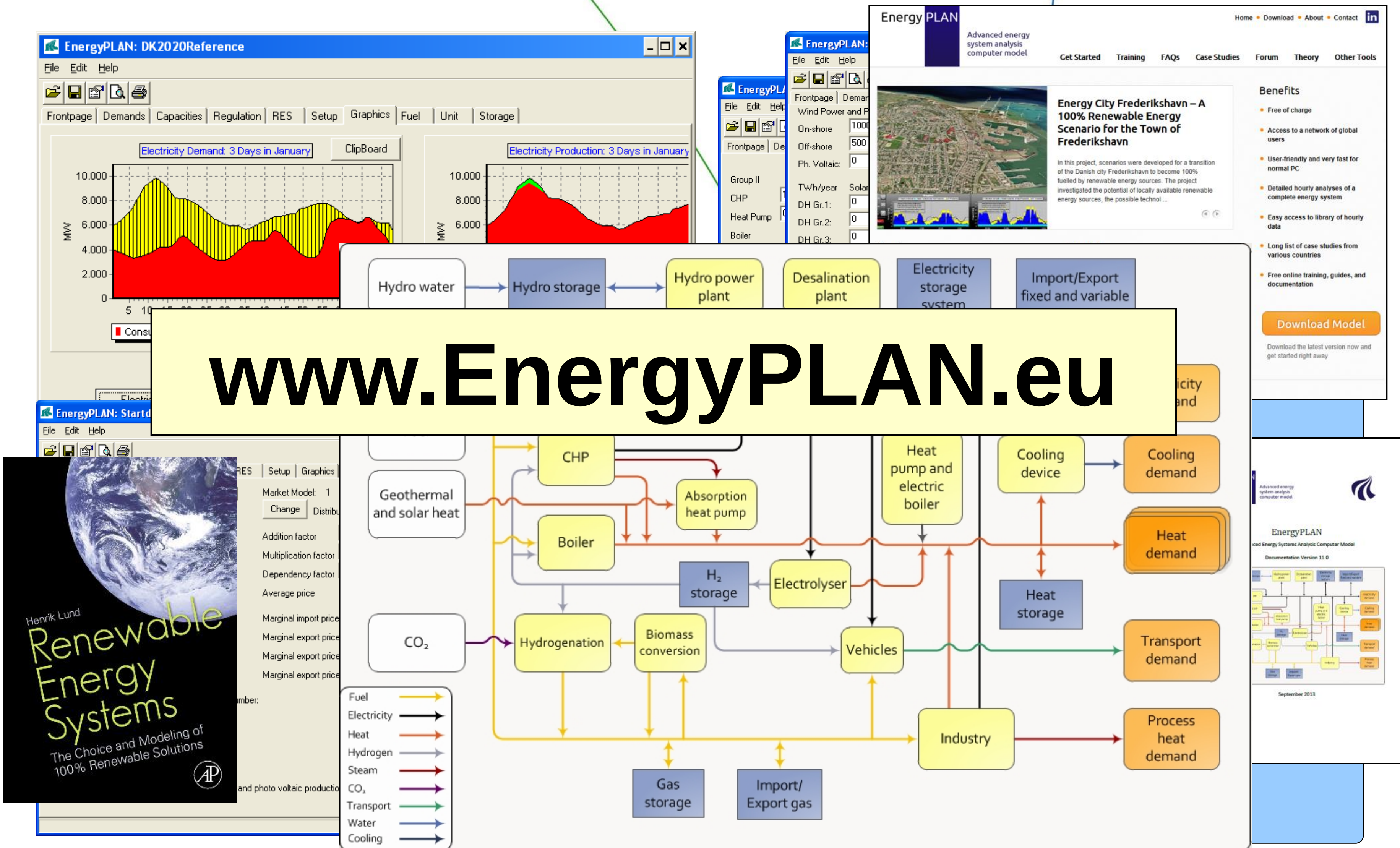
Figure 2: Annualized investment cost per use-cycle vs annual numbers of use-cycles. In the diagram the cost is also benchmarked against the cost of producing renewable energy, here shown for a wide cost span by grey (extension along horizontal axis is for presentation only; there is no cyclic dependence for renewable energy production). See assumptions, details and references in Appendix 1.

Figure 3: Investment cost comparison of different sizes of thermal energy storage technologies. The sizes correspond to storages for a dwelling, a larger building, a CHP plant and a solar DH system (see Footnote 2). See assumptions, details and references in Appendix 1.

Figure 4: Investment cost comparison of different sizes of lectricity energy storage technologies. See assumptions, details and references in Appendix 1.

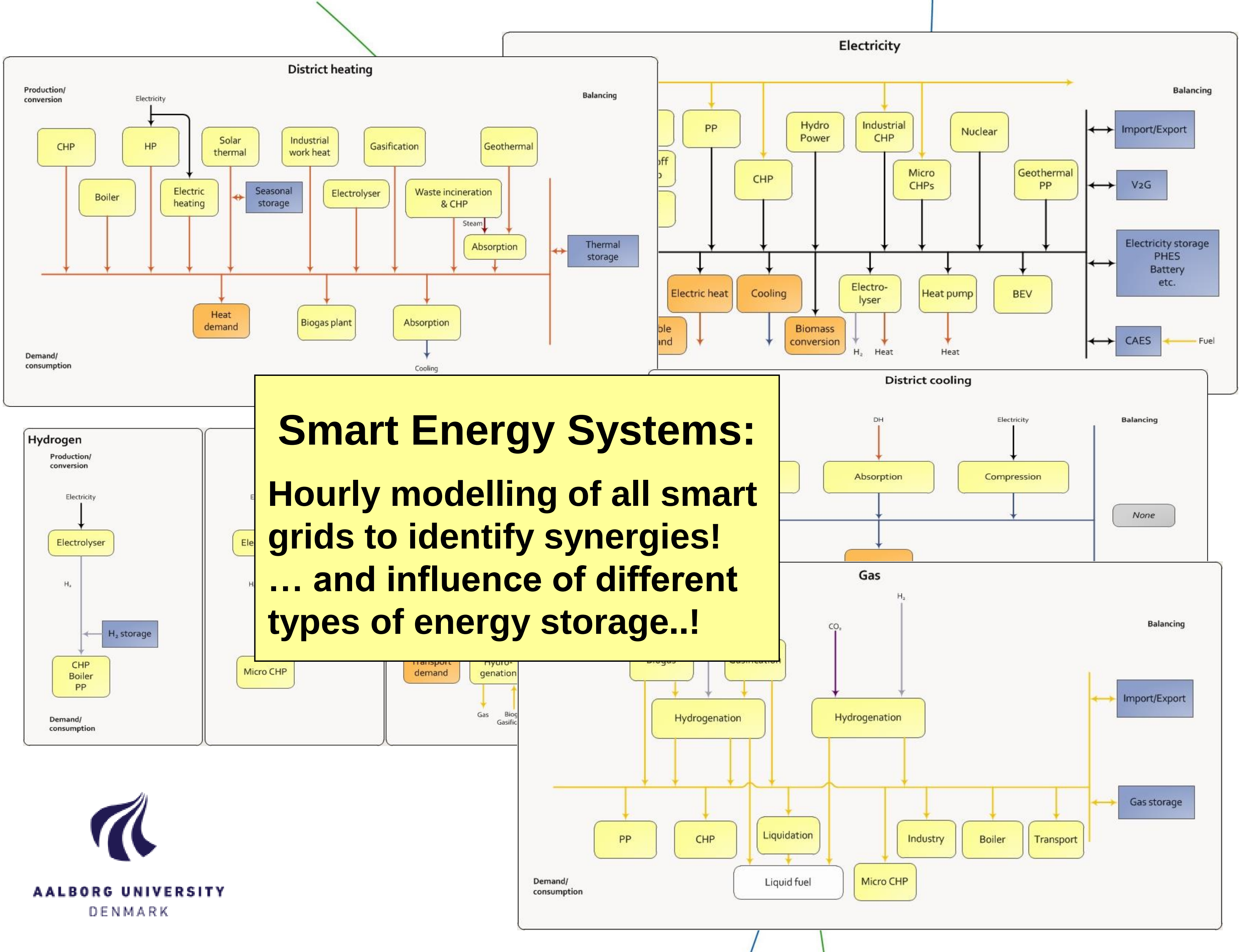
www.journals.aau.dk/index.php/sepm

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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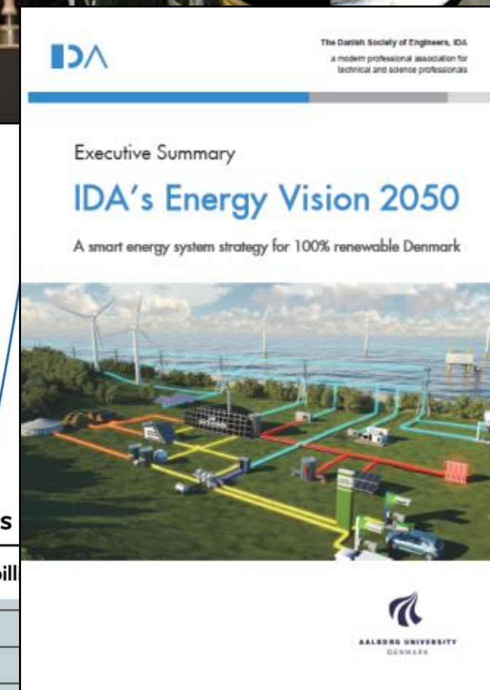
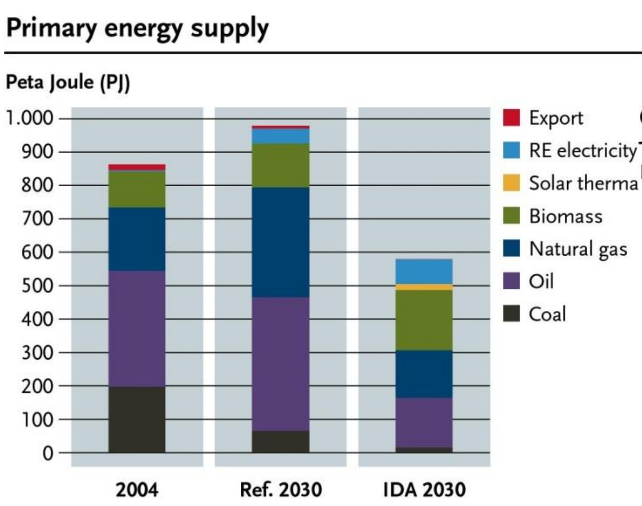
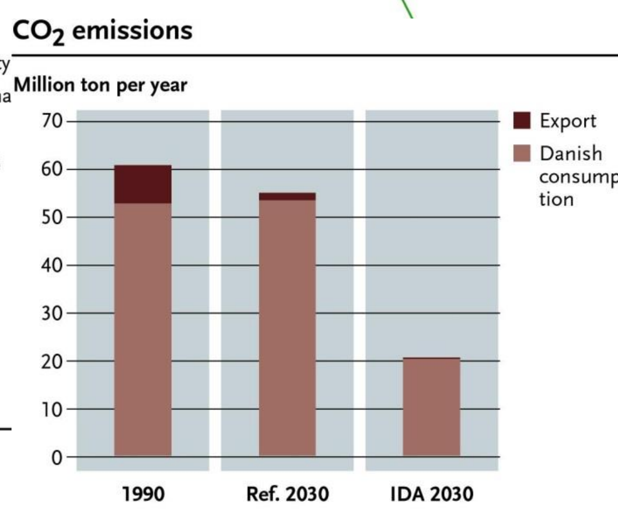
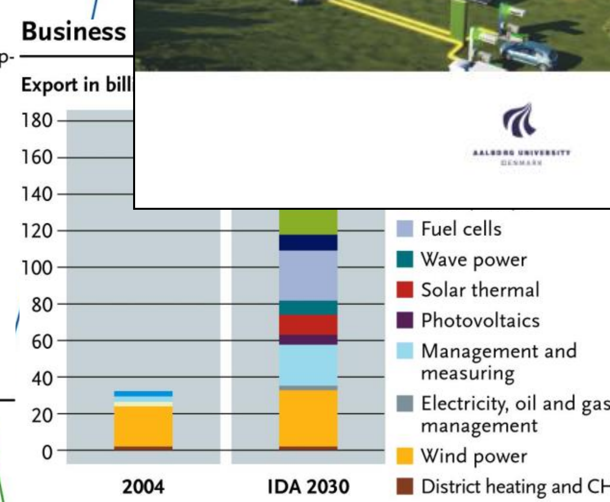


IDA Energiplan 2030







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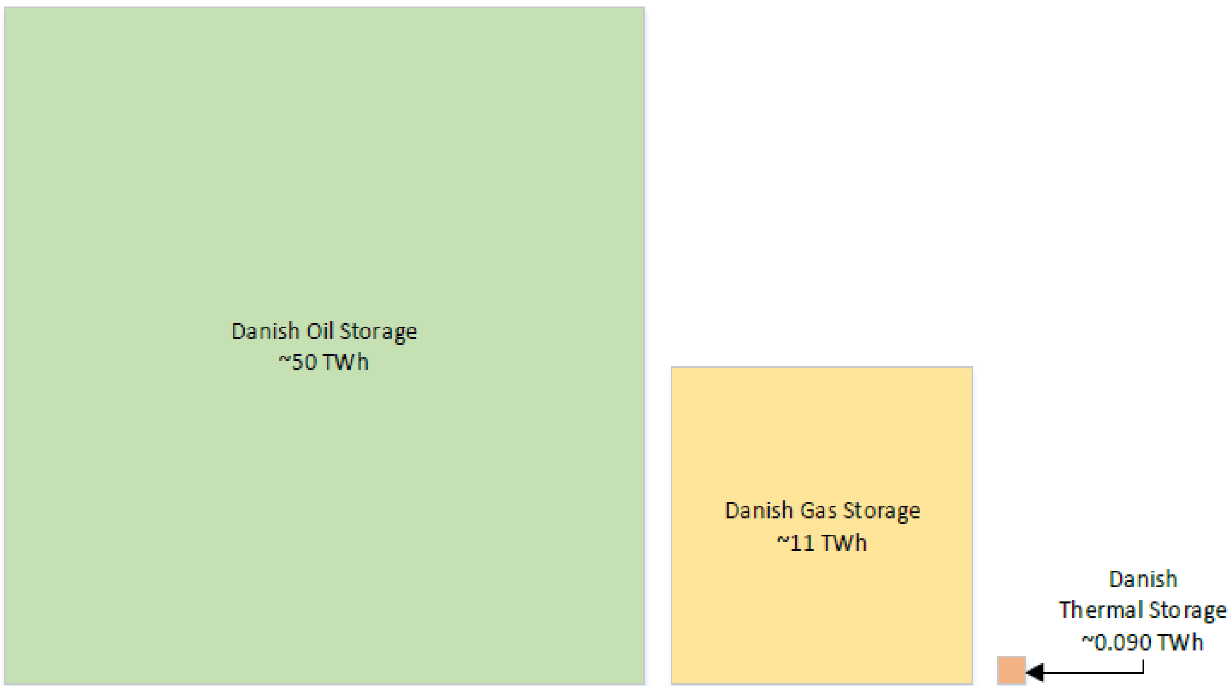
Energy Storage Capacities in Denmark



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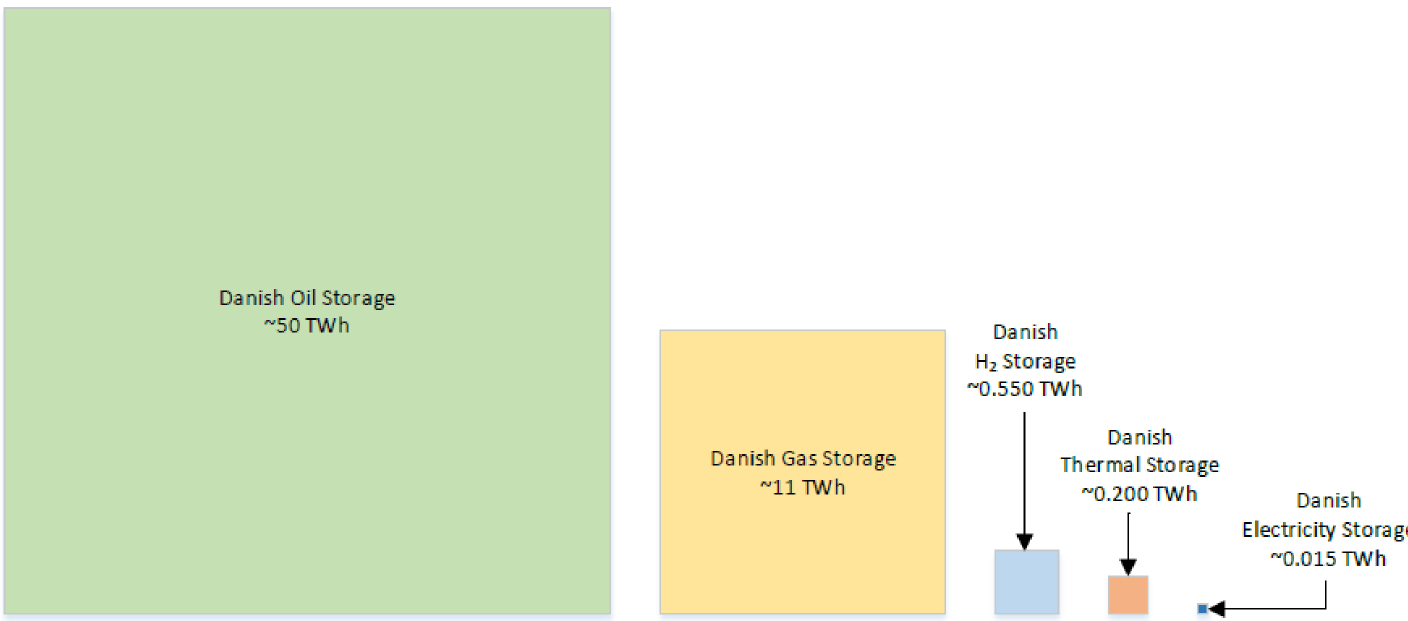
Innovation Fund Denmark

Energy Storage Capacities in 100 % RES Denmark 2050 (IDA)



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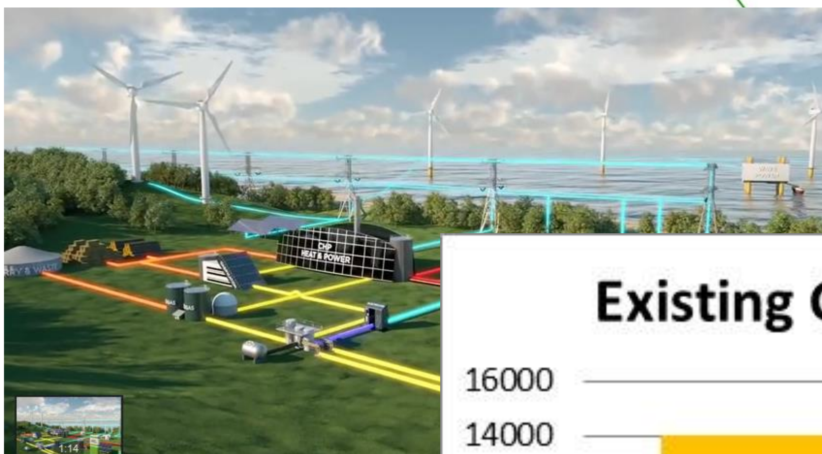
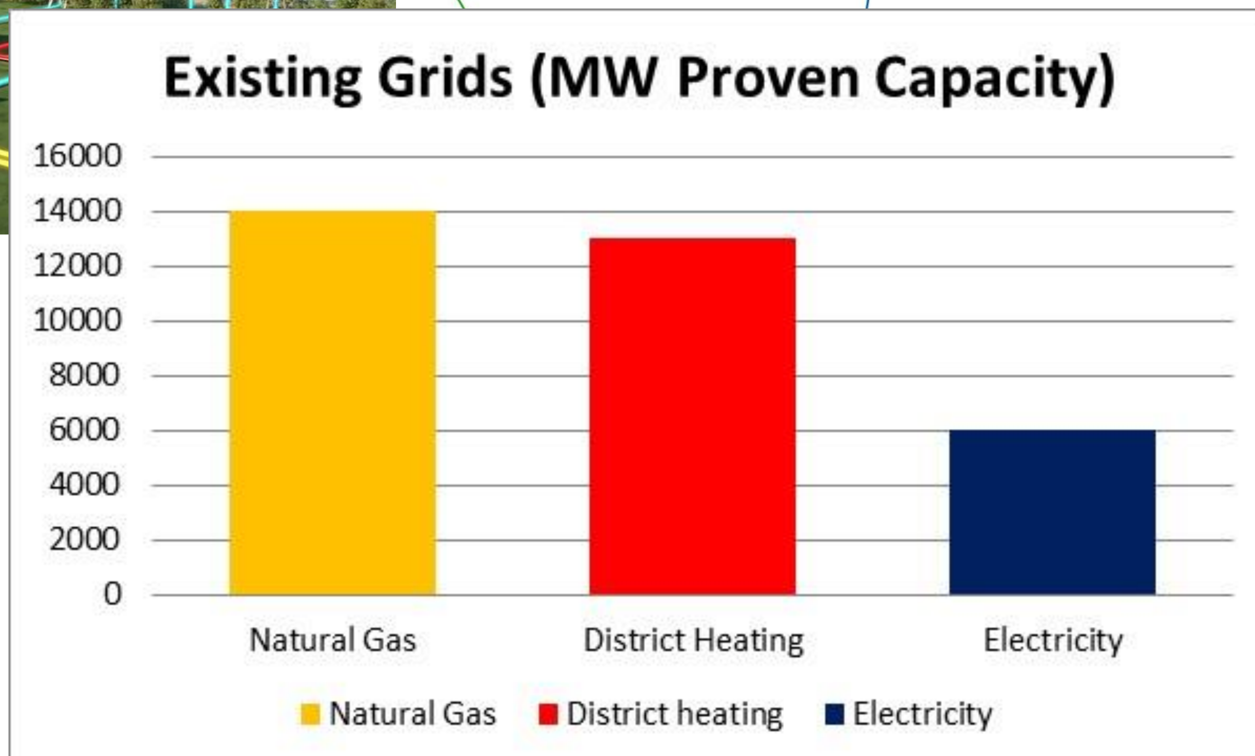
Eksisterende distributionsnet





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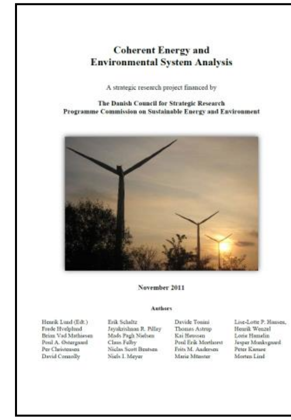
CEESA Project 2011/2012


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

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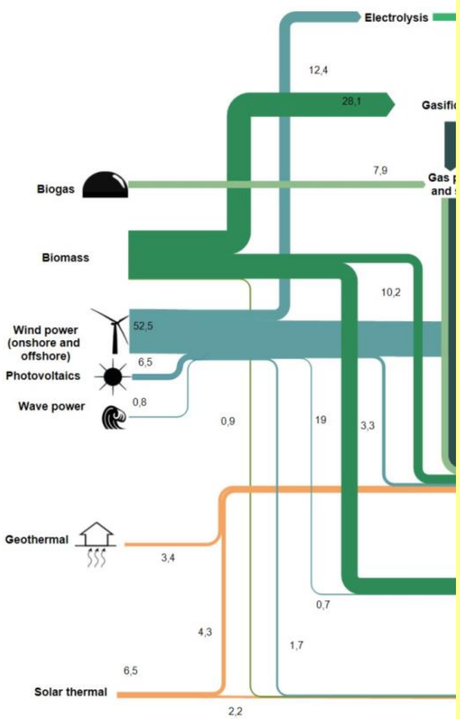

Transport:
Electric vehicles is best from an energy efficient point of view. But gas and/or liquid fuels is needed to transform to 100%.

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…

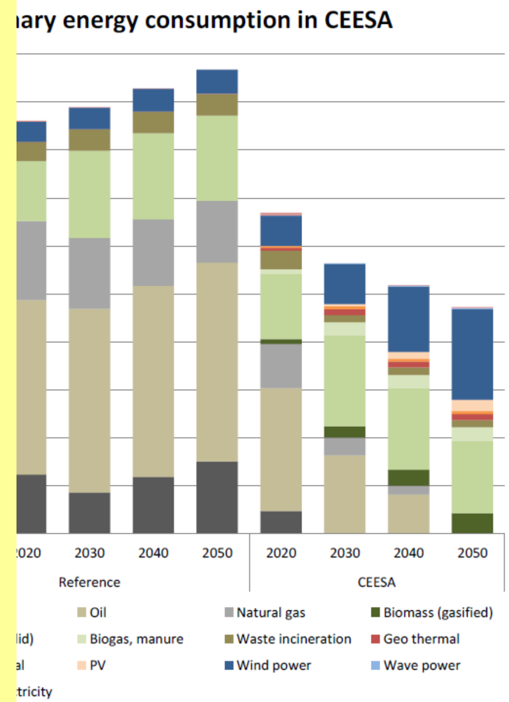

Figure 2: Primary Energy Supply in CEESA.

Electro-fuels
100% Renewable Energy 2050
Power-to-Transportation

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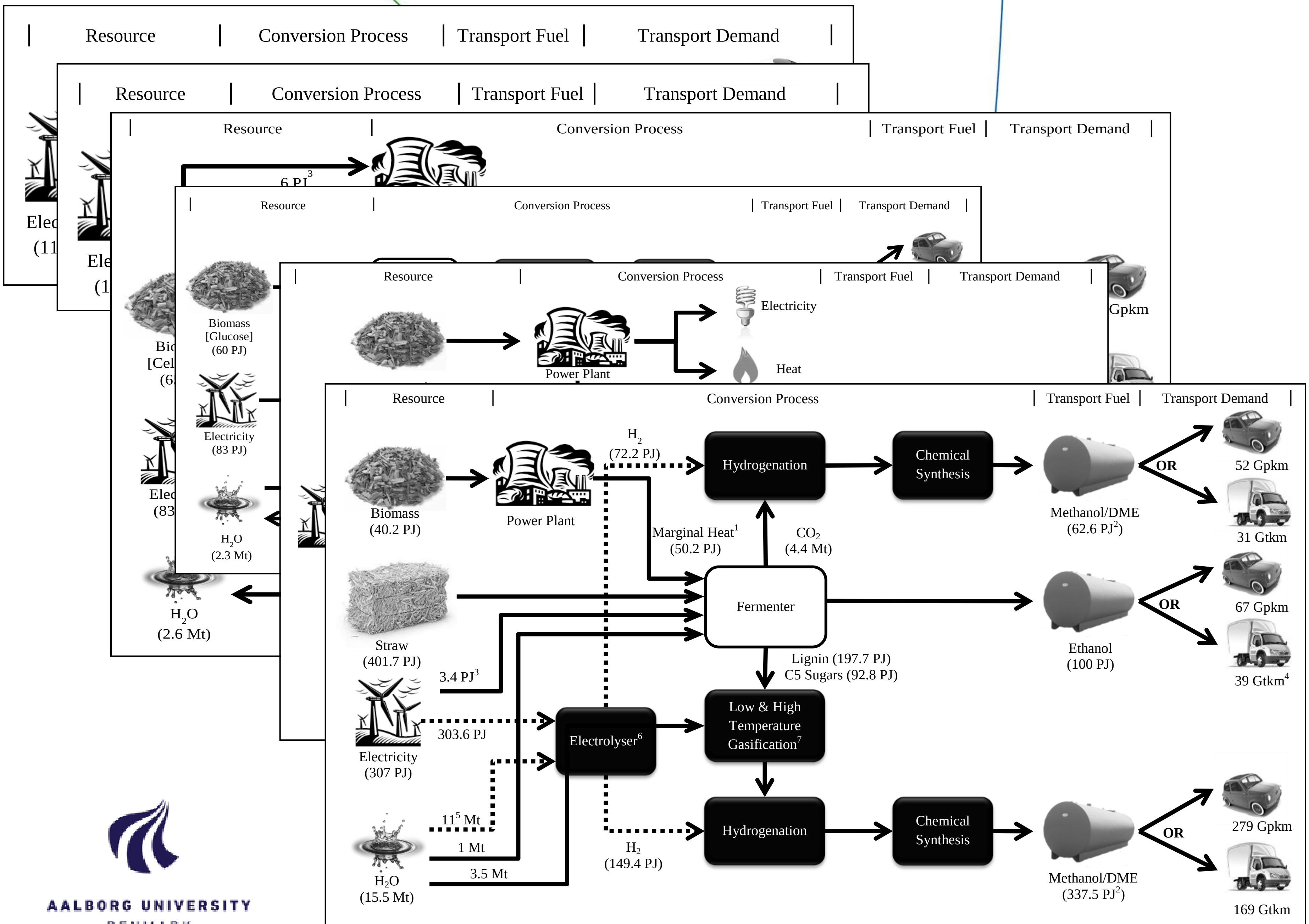

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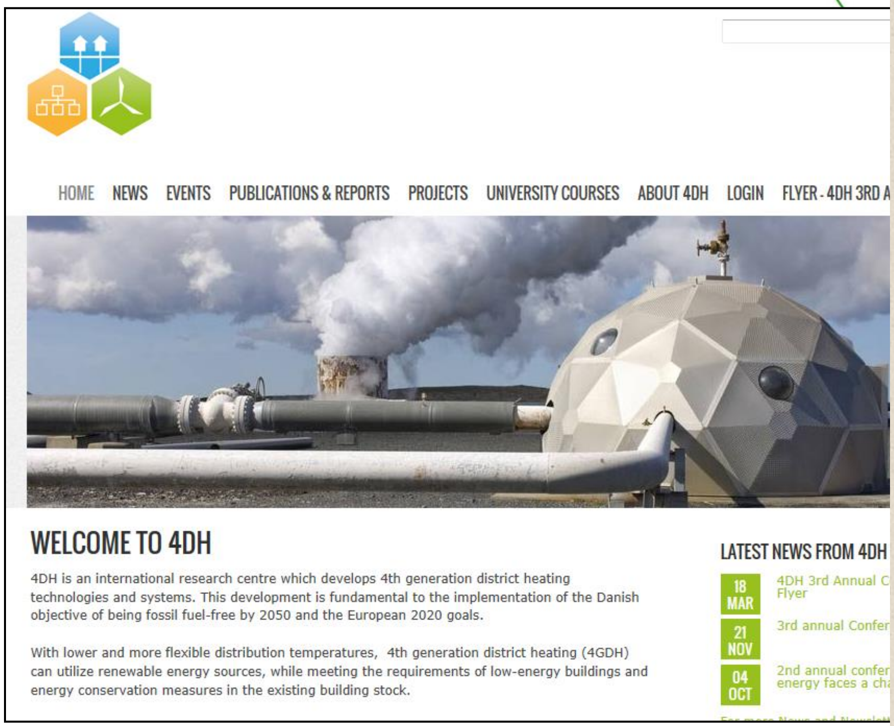
www.4DH.dk

4DH
4th Generation District Heating Technologies and Systems



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#SmartEnergySystems & #4DH

4DH
4th Generation District Heating Technologies and Systems

Three pillars

Supply:
Low temperature District heating

Production:
Renewable Systems Integration

Organisation:
Planning and Implementation

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#SmartEnergySystems & #4DH

Supply:

Low temperature District heating

4th Generation District Heating
Technologies and Systems

Grids and components:

- low-temperature district heating systems based on renewable energy.
- new knowledge of the hardware and software technologies of the new generation of district heating systems
- existing energy renovated buildings and new low-energy buildings.





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4DH
4th Generation District Heating Technologies and Systems

Production:
Renewable Systems Integration

Production and system integration:

- the development of energy systems analysis tools, methodologies and theories
- scenario building of future sustainable energy systems.
- The aim is to identify the role of district heating systems and technologies in various countries

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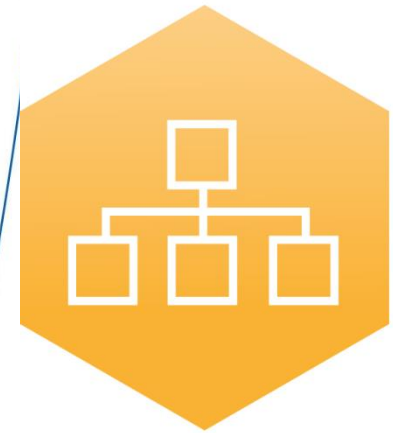
4DH

4th Generation District Heating Technologies and Systems

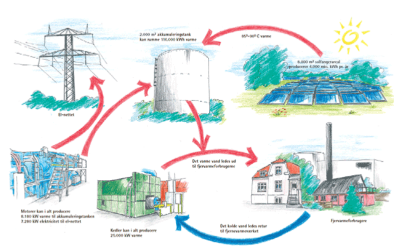
Organisation:

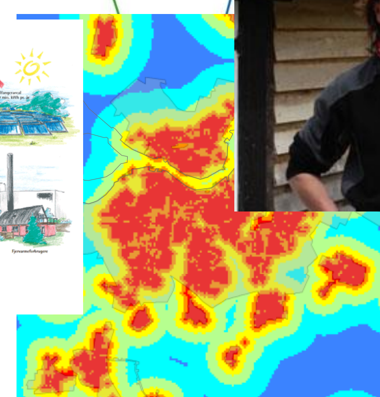
Planning and Implementation



Planning and implementation:

- further development of the planning and management systems
- spatial analysis and geographical information systems (GIS) as a tool for planners and decision-makers.
- organisation and design of specific public regulation measures including ownership, tariffs, reforms etc.





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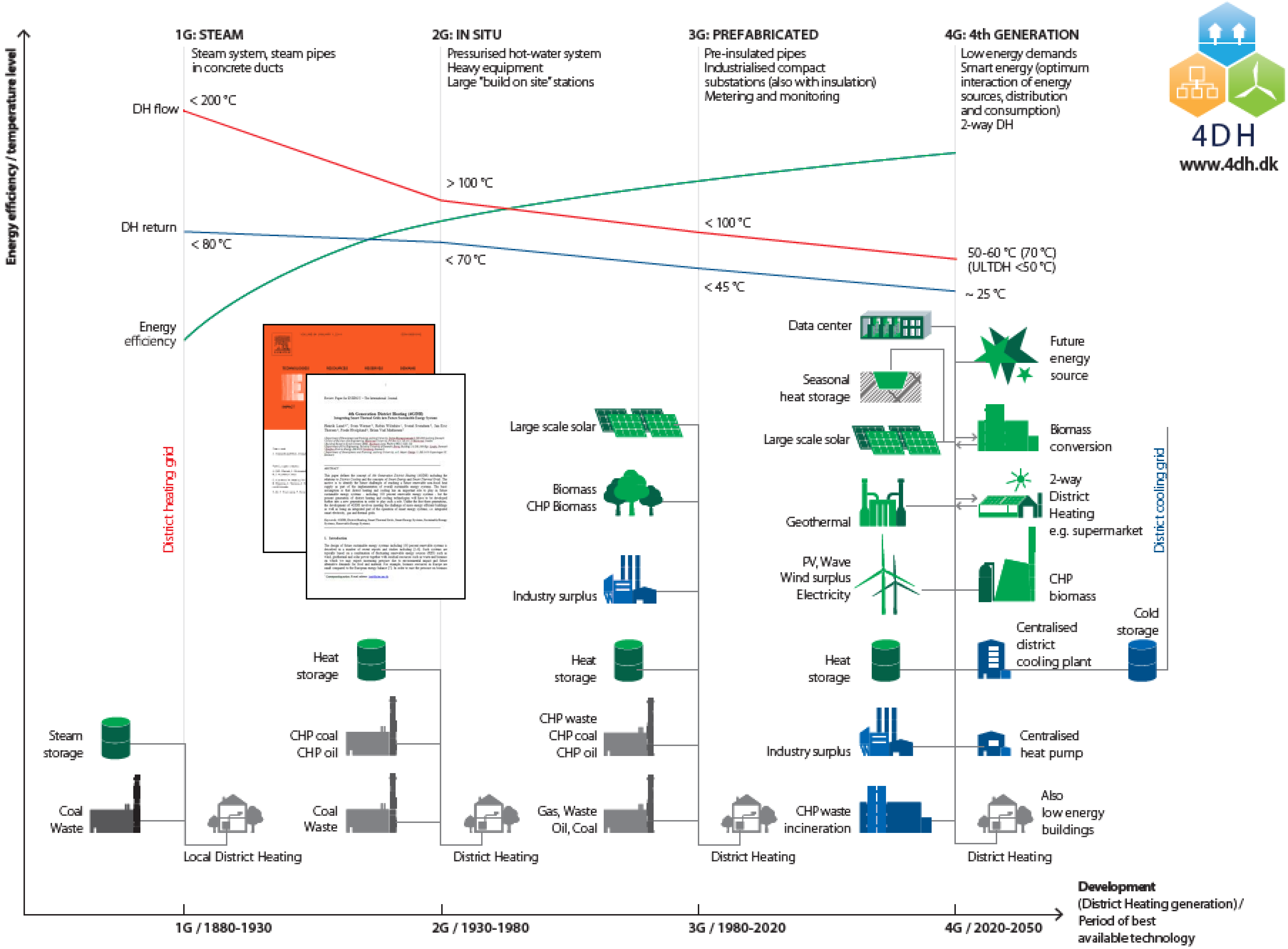
1G: STEAM
Steam system, steam pipes in concrete ducts
2G: IN SITU
Pressurised hot-water system
Heavy equipment
Large "build on site" stations
3G: PREFABRICATED
Pre-insulated pipes
Industrialised compact substations (also with insulation)
Metering and monitoring
4G: 4th GENERATION
Low energy demands
Smart energy (optimum interaction of energy sources, distribution and consumption)
2-way DH
4DH
www.4dh.dk
Energy efficiency / temperature level
DH flow
< 200 °C
> 100 °C
< 100 °C
50-60 °C (70 °C)
(ULTDH <50 °C)
DH return
< 80 °C
< 70 °C
< 45 °C
~ 25 °C
Energy efficiency
District heating grid
District cooling grid
Data center
Future energy source
Seasonal heat storage
Large scale solar
Biomass conversion
Biomass CHP Biomass
2-way District Heating e.g. supermarket
Geothermal
PV, Wave Wind surplus Electricity
CHP biomass
Industry surplus
Cold storage
Centralised district cooling plant
Heat storage
Steam storage
CHP coal CHP oil
CHP waste CHP coal CHP oil
Centralised heat pump
Coal Waste
Gas, Waste Oil, Coal
CHP waste incineration
Also low energy buildings
Local District Heating
District Heating
1G / 1880-1930
2G / 1930-1980
3G / 1980-2020
4G / 2020-2050
Development
(District Heating generation) / Period of best available technology

EUROHEAT & POWER

Heat Roadmap Europe

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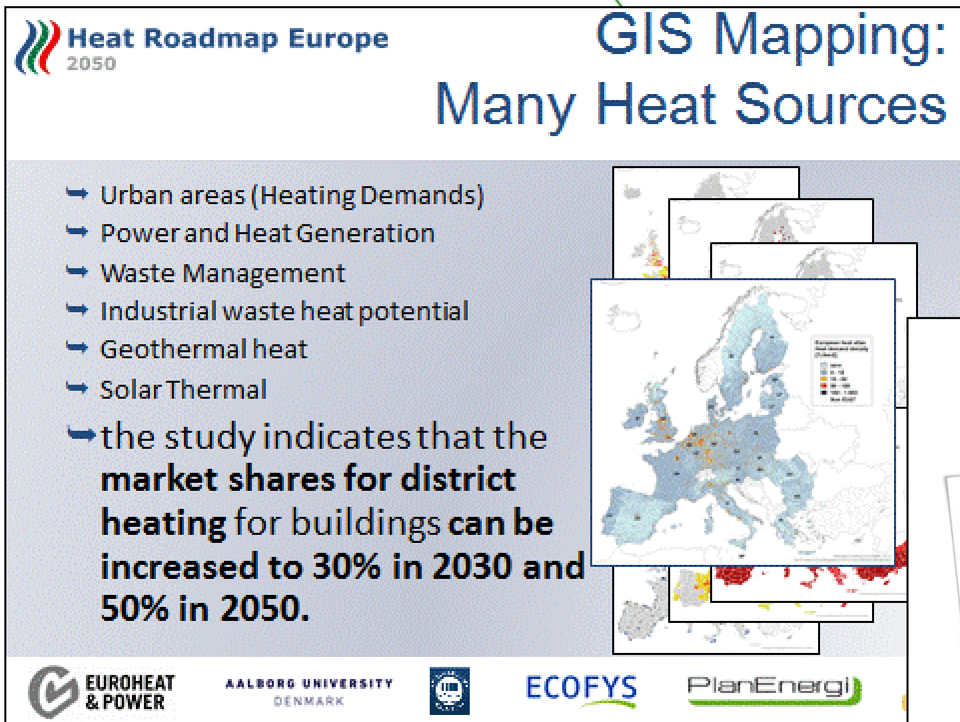
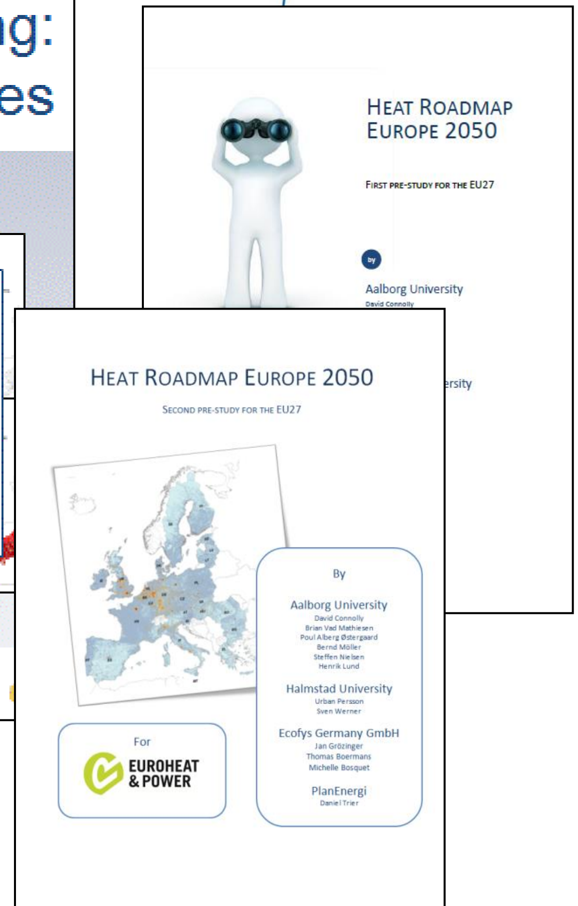
4th Generation District Heating Technologies and Systems





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ECOFYS sustainable energy for everyone

PlanEnergi

HÖGSKOLAN HALMSTAD

Stratego

4DH
4th Generation District Heating Technologies and Systems

STRATEGO WP2

Enhanced National Heating and Cooling Strategies

Co-funded by the Intelligent Energy Europe
Programme of the European Union

Heat Roadmap Europe
2050

HRE4 Countries: 14 Largest EU Countries by Heat Demand = 90% of EU Heat

- Belgium (BE)
- Czech Republic (CZ)
- Germany (DE)
- Spain (ES)
- France (FR)
- Italy (IT)
- Hungary (HU)
- Netherlands (NL)
- Austria (AT)
- Poland (PL)
- Romania (RO)
- Finland (FI)
- Sweden (SE)
- United Kingdom (UK)

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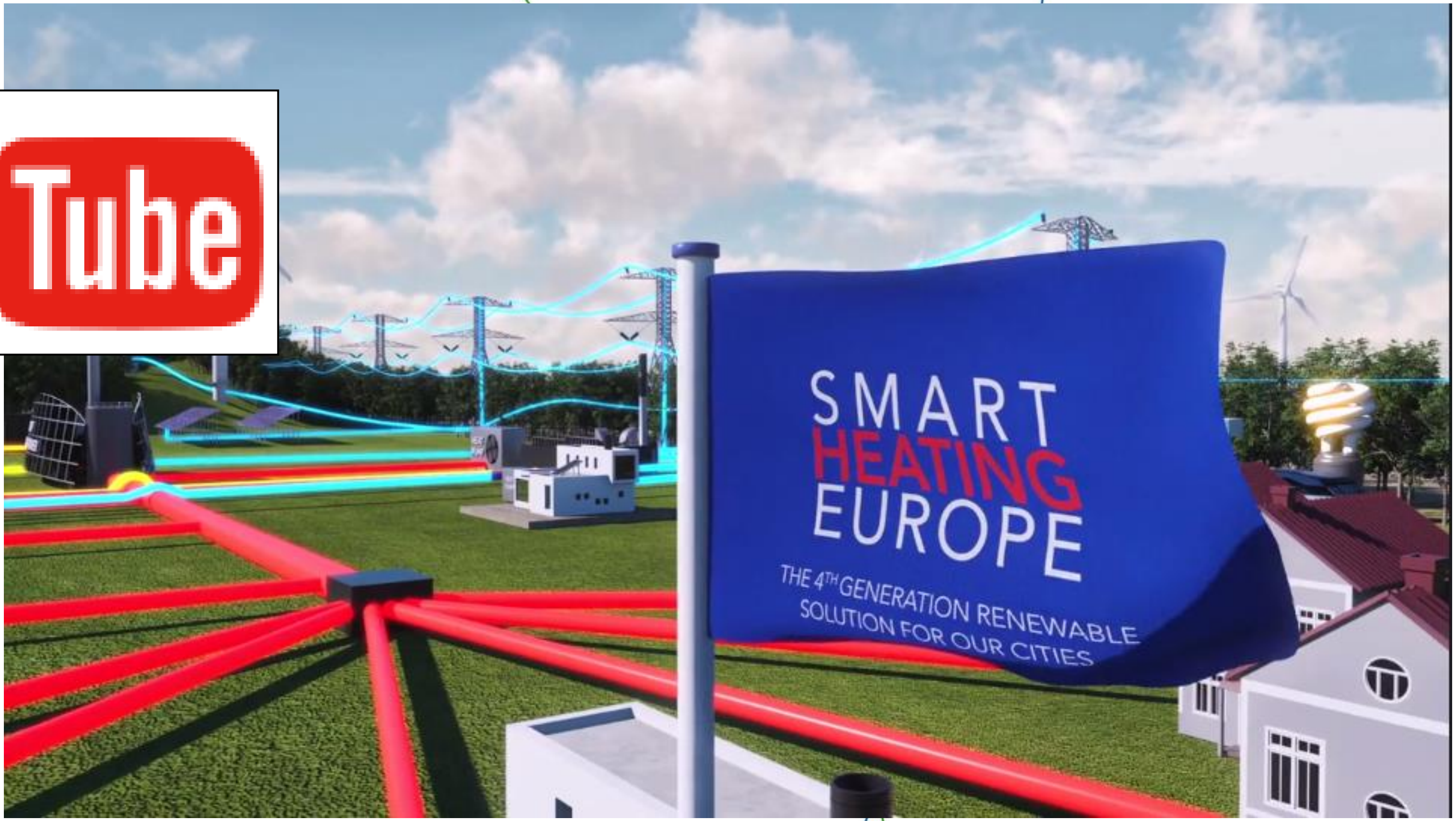
Smart Heating Europe



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Technologies and Systems

4th International Conference on

Smart Energy Systems and 4th Generation District Heating

13-14 November 2018 · Aalborg

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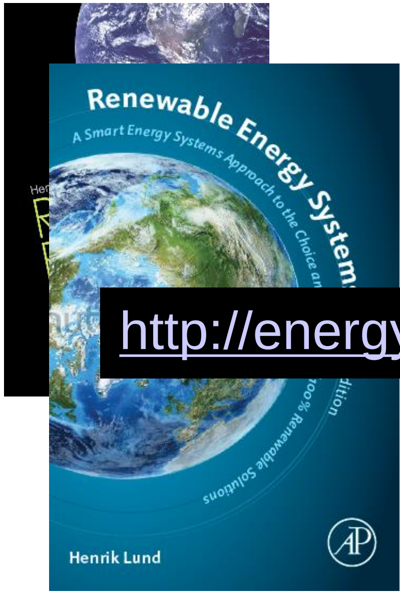

http://energy.plan.aau.dk/book.php

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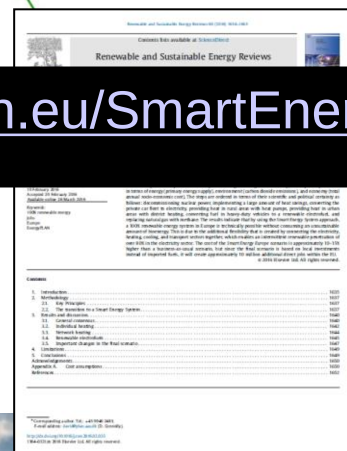
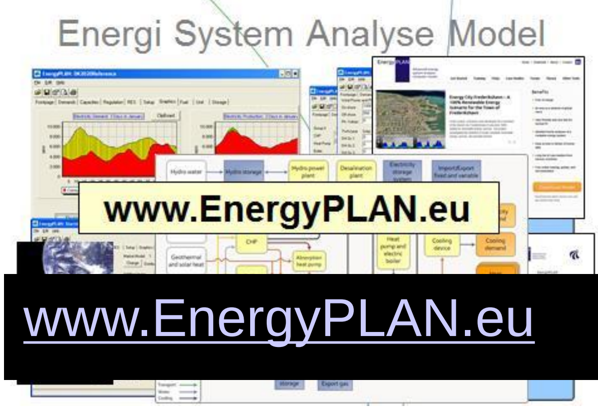


www.energyplan.eu/SmartEnergyEurope



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