State-of-the-art of designing future sustainable energy systems

– and the role of district heating

4DH
4th Generation District Heating Technologies and Systems

4th Generation District Heating Technologies and Systems,
First Annual Conference 3-4 October 2012

Utzon Center, Aalborg
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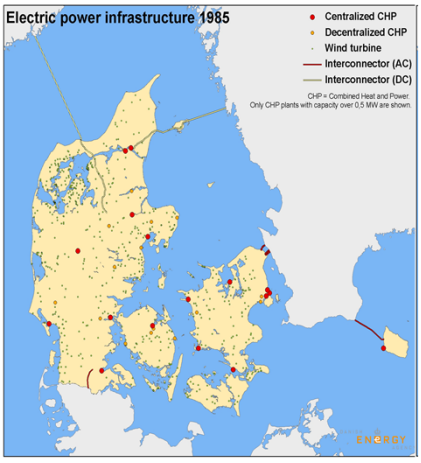
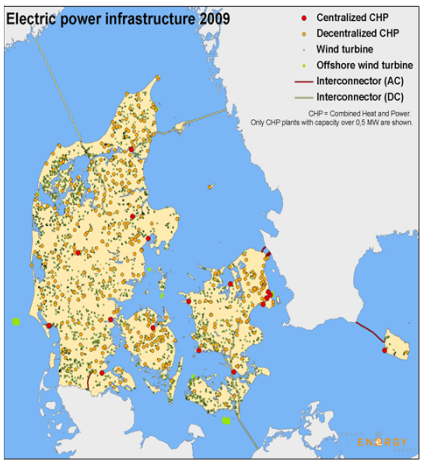
Energy research in a real life experiment



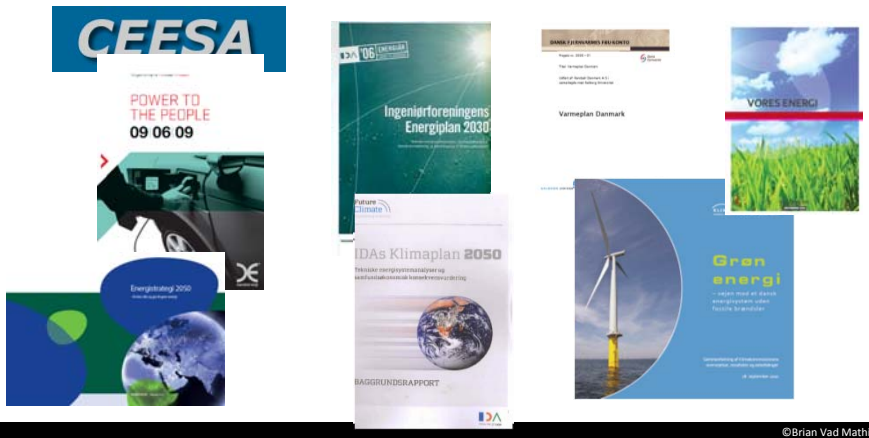


The long-term Objective of Danish Energy Policy

Expressed by former Prime Minister Anders Fogh Rasmussen in his opening speech to the Parliament in **2006** and in several political agreements since then:

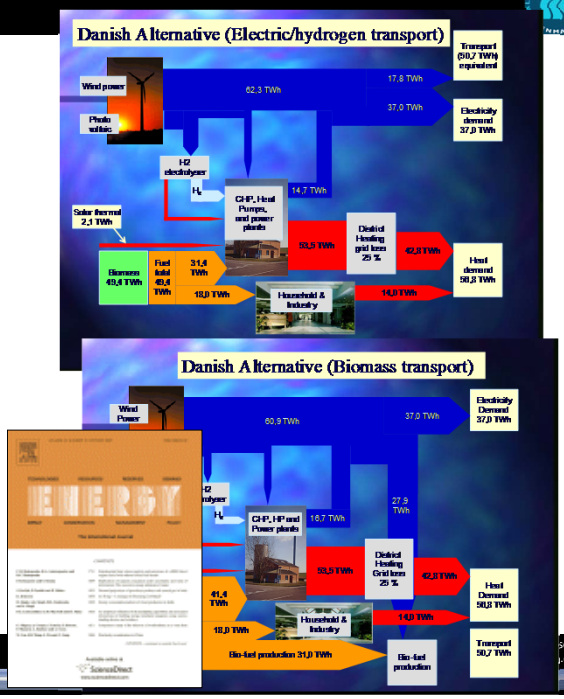
To convert to 100% Renewable Energy

100% Renewable Energy Systems - developments



2005-06

Electricity is important in the transport sector to meet the demand with limited biomass ressources



IDA Energy Year 2006

- To maintain security of energy supply
- To cut CO_2 emissions by 50 % by year 2030 compared to the 1990 level
- To create employment and to quadruple the export in the energy industry

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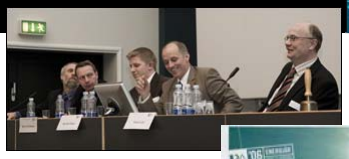
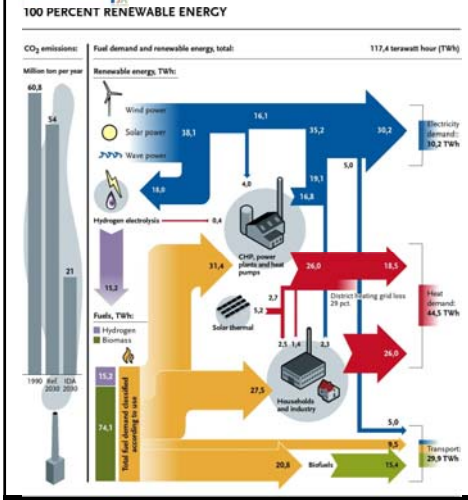
2006
Conclusions

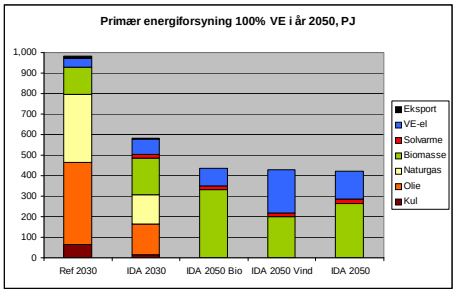


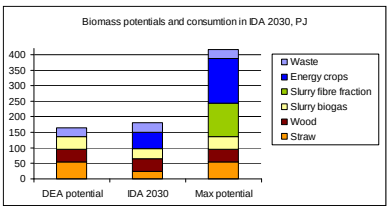
- 100 Per cent Renewable energy is **physically possible** and the first step in 2030 is **feasible** to the Danish Society.

- The methodology of the design is a very complex process, i.e. a
  - **creative phase** involving many single experts and
  - **detailed system analyses** of **different transition years** and
  - **different technologies** and **sectors**.

Scenario with 100% Renewable Energy in 2050







2008
Heat Plan Denmark

2008: Technical and economic analyses
2010: Implementation and Public Regulation

- How should we heat the houses in Denmark ??
  - What to do in a **short-term** perspective in which we want to decrease CO2-emissions and energy consumptions.
  - And what to do in a **long-term** perspective in which we want to convert to a 100% Renewable Energy System.

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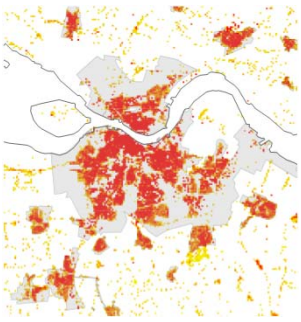
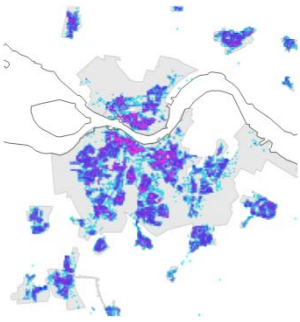
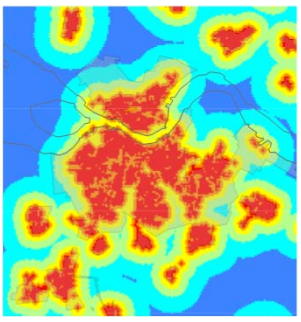
Calculations based on GIS Heat atlas



Heating demands



Posible connections



Distance to district heating

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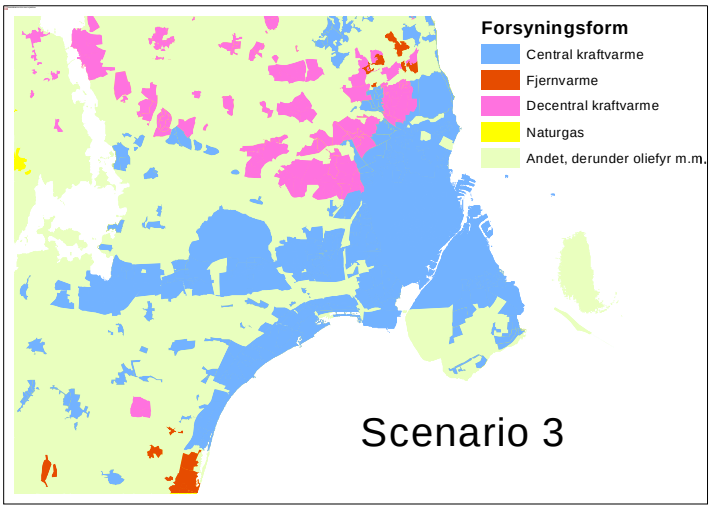
Scenarios - example (GIS)



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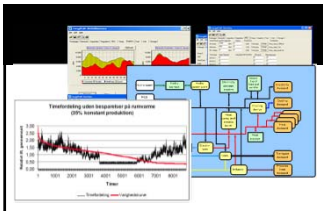

Conclusions

The reasonable solutions seems to be to combine:

- Gradually increasing District Heating from now 46% to somewhere in between 53% and 70%
- Individual Heat Pumps in the rest of the buildings
- Focus on synergies with regards to increasing the efficiencies of district heating networks (essential)
- District heating can integrate more renewable energy sources

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2009
IDA's Climate Plan 2050

The Danish Society of Engineers has suggested that Denmark is totally independent of fossil fuels in 2050 in the IDA Climate Plan 2050

4 targets:

- To reduce the emission of green house gasses by 90% in 2050 (including farming)
- To maintain security of energy supply
- To expand Denmark's position within energy and climate technologies
- To improve the Danish economy and prosperity

Future Climate
Engineering Solutions

Conclusions:

- It is technically possible to reduce the green house gas emissions by 90% in 2050 and have 100% renewable energy
- Going towards such an energy system is socio-economically feasible.
- Energy savings and improved efficiencies are main measures for achieving the targets
- Renewable energy systems create jobs and business potentials.
- Reduces health costs related to the energy system

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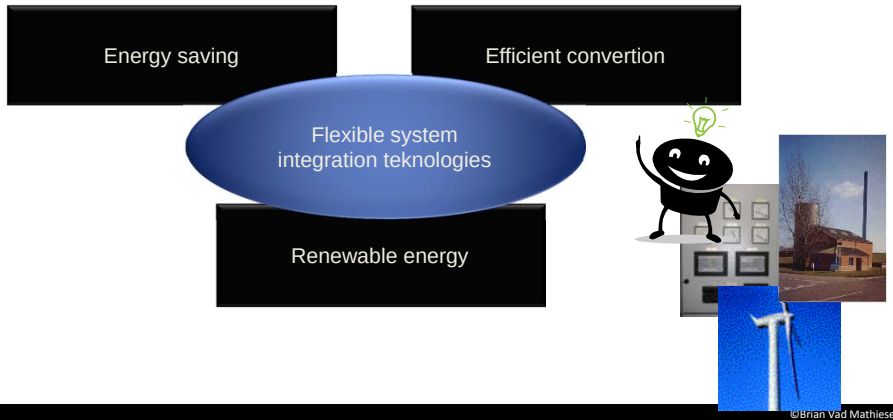
System integration



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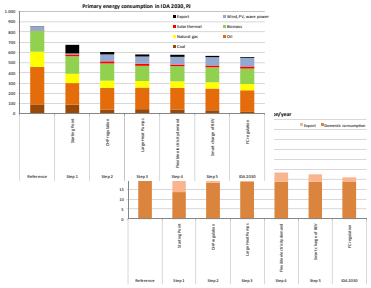
Technical energy system analyses from 2009 with 50% renewable energy

(Example for IDA 2030 from IDAs Climate Plan 2050)

- Objectives:
  - Reduce excess electricity
  - Decrease fuel demand



	Excess electricity	Boiler share
Step 1: Starting Point	44%	10%
Step 2: CHP regulation	17%	36%
Step 3: Large Heat Pumps	16%	15%
Step 4: Flexible electricity demand	14%	16%
Step 5: Smart charge of battery electric vehicles	10%	20%
Step 6: FC regulation	5%	23%

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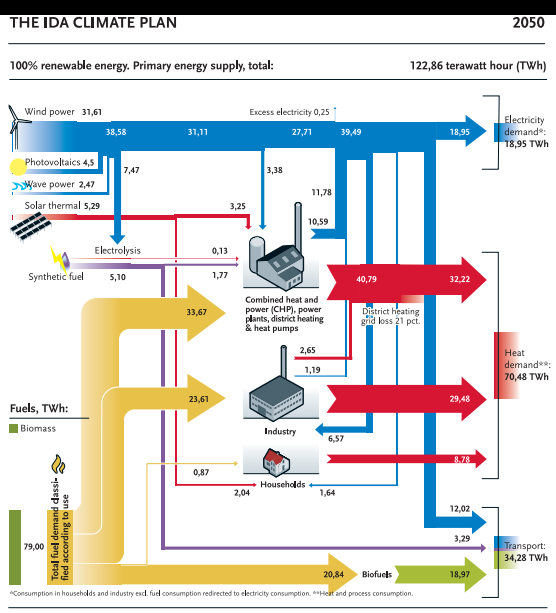

Technical comparison 2050

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2011-12
CEESA

Smart energy systems are crucial in 100% renewable energy systems

Electricity smart grids are only one part of this system. The scenarios rely on a holistic *smart energy system* including the use of:

- ***Heat storages*** *and district heating with CHP plants and large heat pumps.*
- ***New electricity*** *demands from large heat pumps and electric vehicles as storage options.*
- ***Electrolysers and synthetic liquid fuel*** for the transport sector, enabling energy storage in a dense liquid form;
- ***The use of gas storage and gas grids*** for biogas and syngas/methane

Flexible integration of electricity, heat, gas and transport

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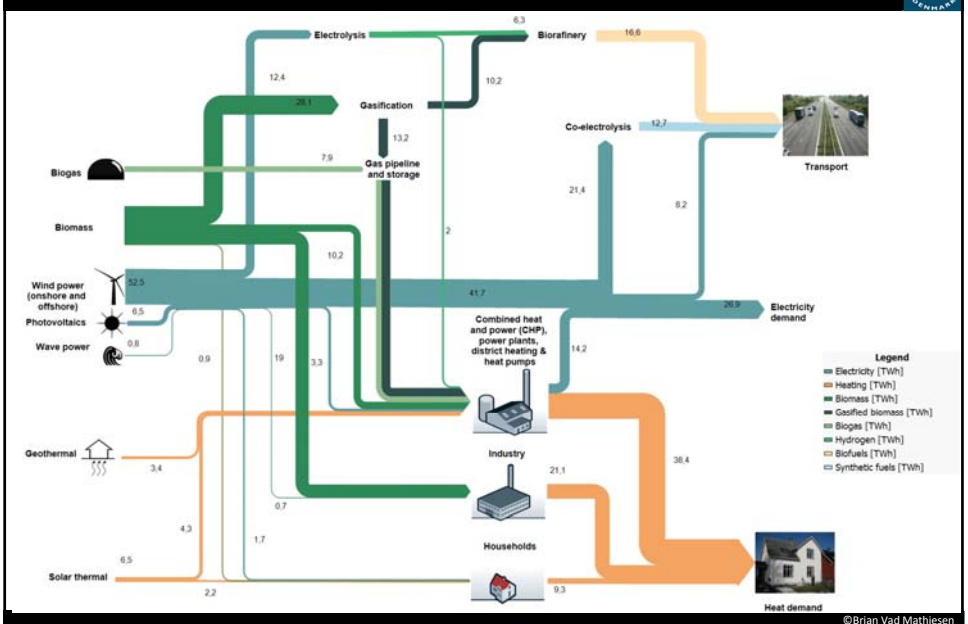


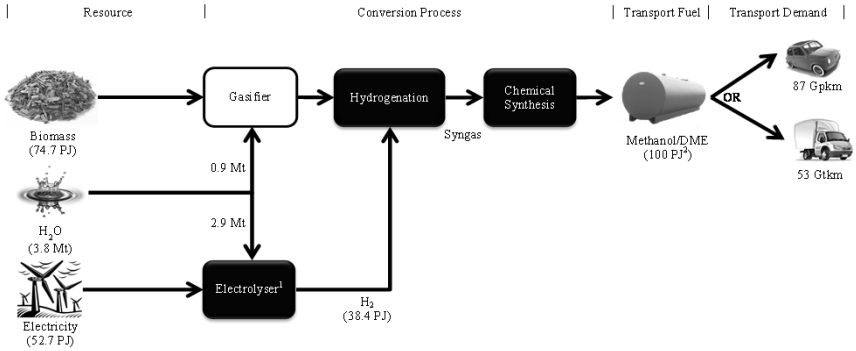
Creating Liquid Fuels for Transport

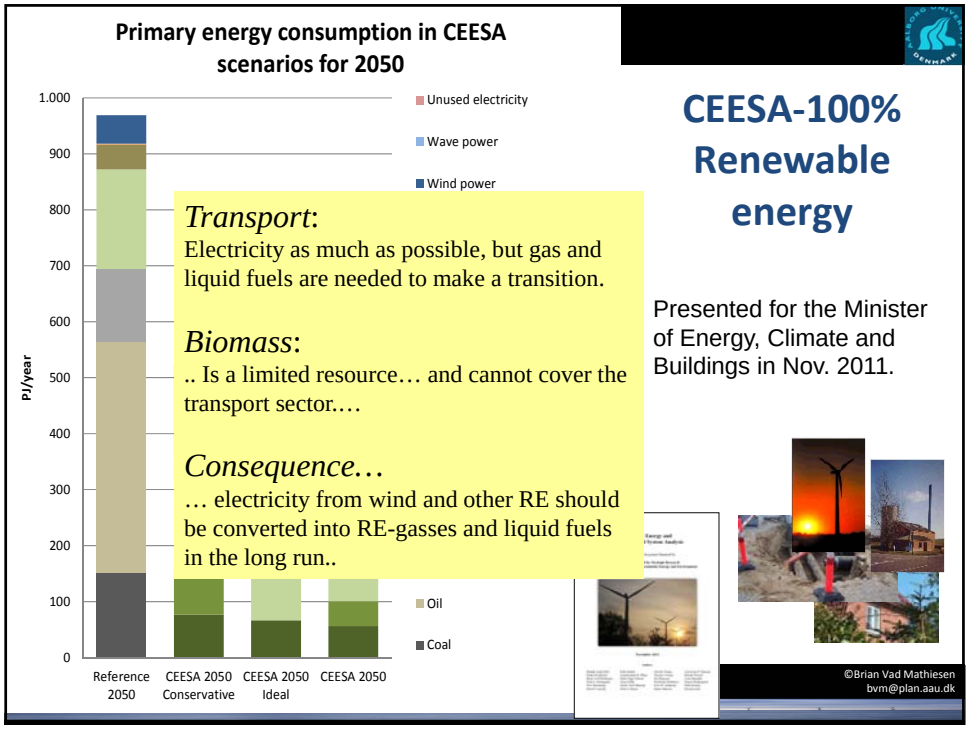
4 Principal Options:

1. Fermentation
2. Gasification
3. Hydrogenation
4. CO2 electrolysis

These pathways were assessed to quantify how much biomass and electricity are required to supply the same transport demand using these pathways

Example:
Hydrogenation of gasified biomass




Primary energy consumption in CEESA scenarios for 2050
PJ/year
1.000
900
800
700
600
500
400
300
200
100
0
Unused electricity
Wave power
Wind power
Oil
Coal
Reference 2050
CEESA 2050 Conservative
CEESA 2050 Ideal
CEESA 2050
Transport:
Electricity as much as possible, but gas and liquid fuels are needed to make a transition.
Biomass:
.. Is a limited resource… and cannot cover the transport sector.…
Consequence…
… electricity from wind and other RE should be converted into RE-gasses and liquid fuels in the long run..
CEESA-100% Renewable energy
Presented for the Minister of Energy, Climate and Buildings in Nov. 2011.
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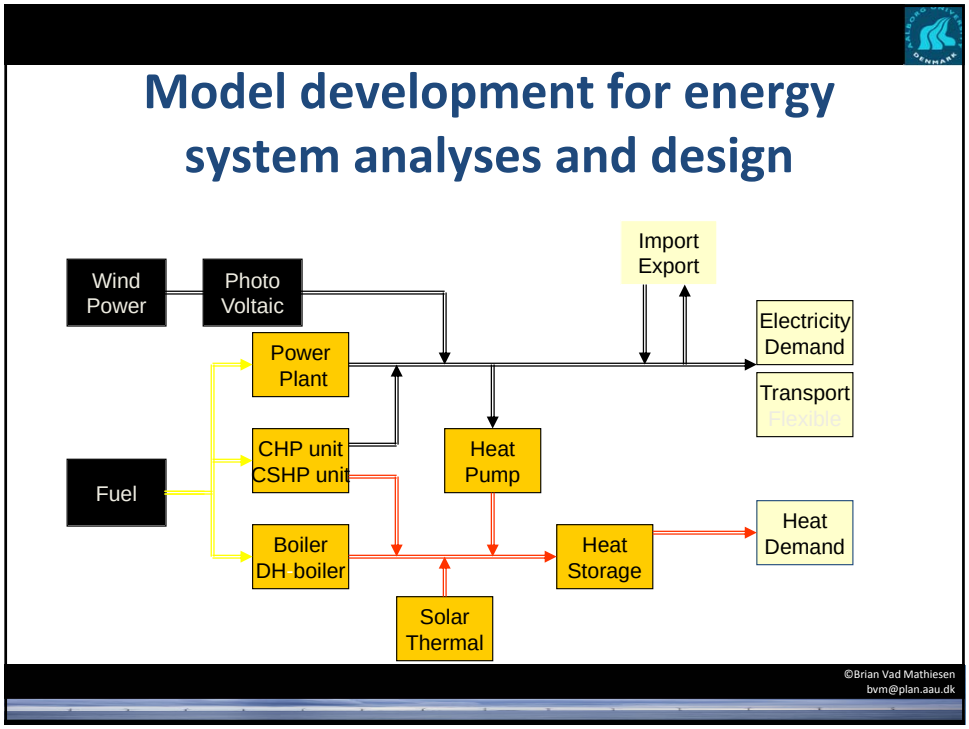
Model development for energy system analyses and design
Wind Power
Photo Voltaic
Import
Export
Power Plant
Electricity Demand
Transport
Flexible
CHP unit
CSHP unit
Heat Pump
Fuel
Boiler
DH boiler
Heat Storage
Heat Demand
Solar Thermal
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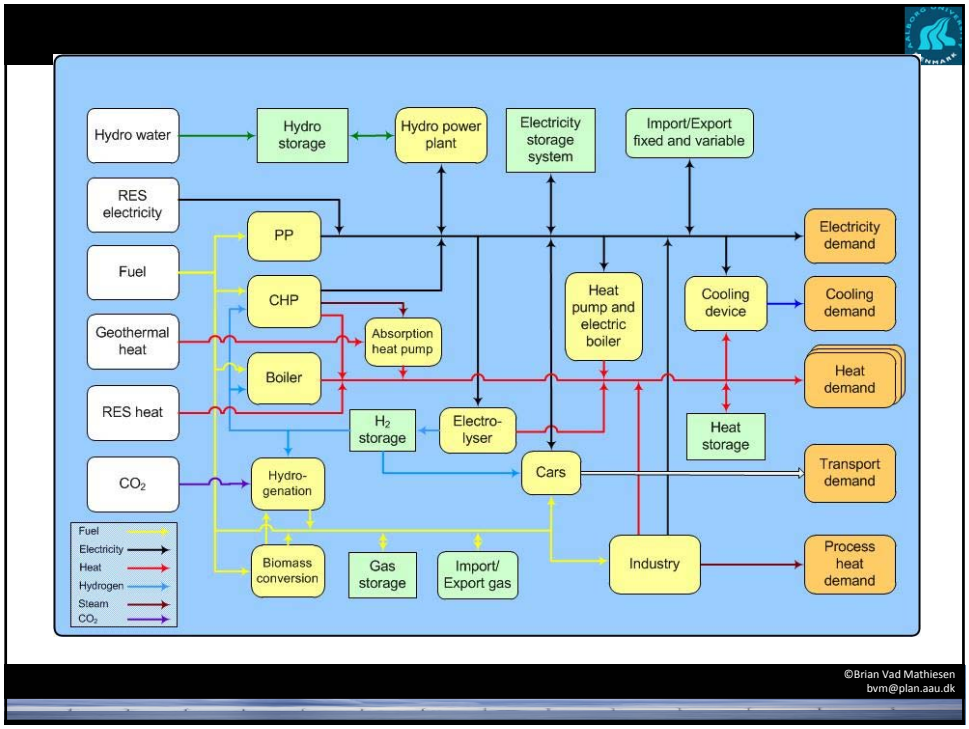

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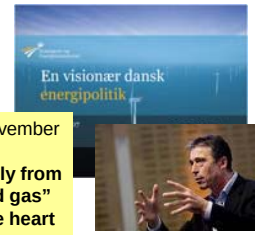

Former Prime Minister 16 November 2008:
"We will free Denmark totally from fossil fuels like oil, coal and gas"
"… position Denmark in the heart of green growth"

New broad agreement in March 2012 with 2020 targets on energy savings and 50% wind power + 2050 100% RE target

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Thank you for your attention!

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