


## The design of Smart Energy Systems for 100% renewable energy and transport solutions

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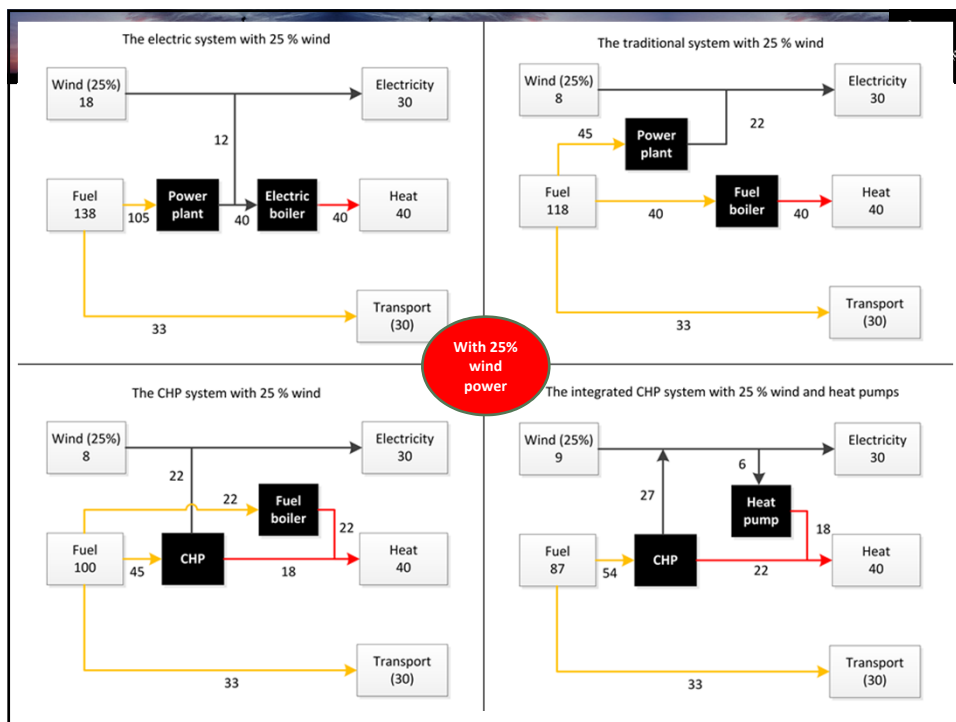
SPECIAL SESSION AT THE 8TH CONFERENCE ON SUSTAINABLE DEVELOPMENT OF ENERGY, WATER AND ENVIRONMENT SYSTEMS – SDEWES

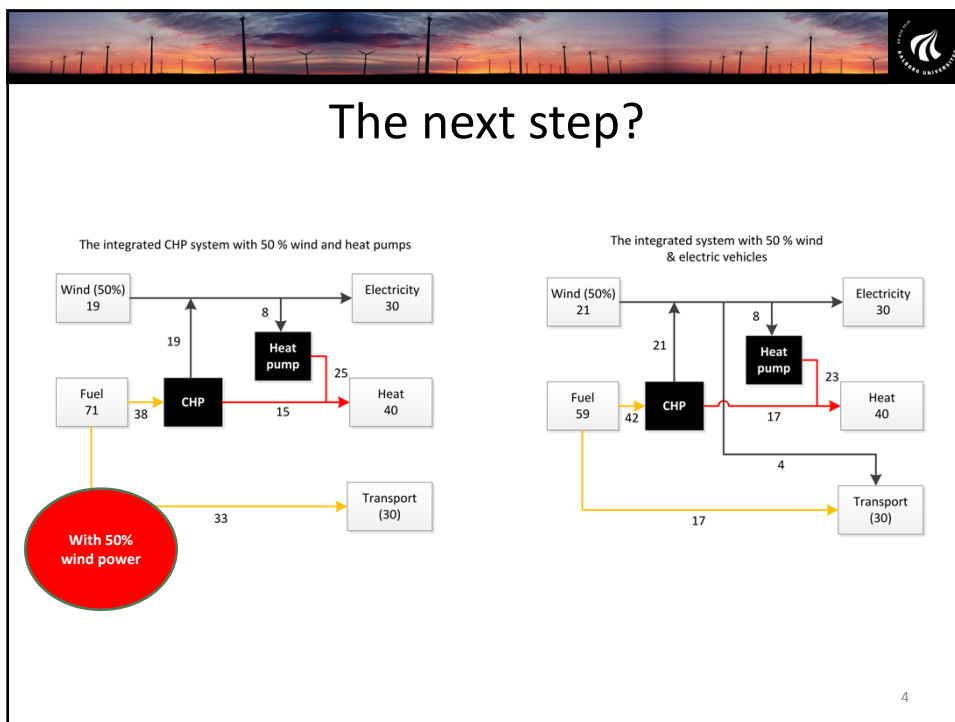
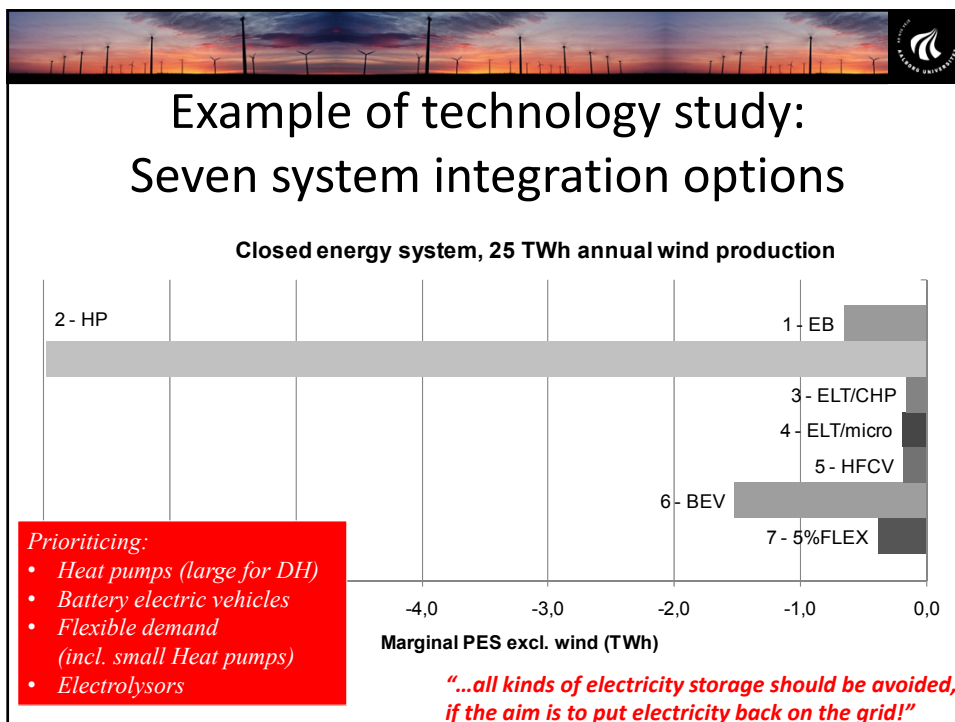
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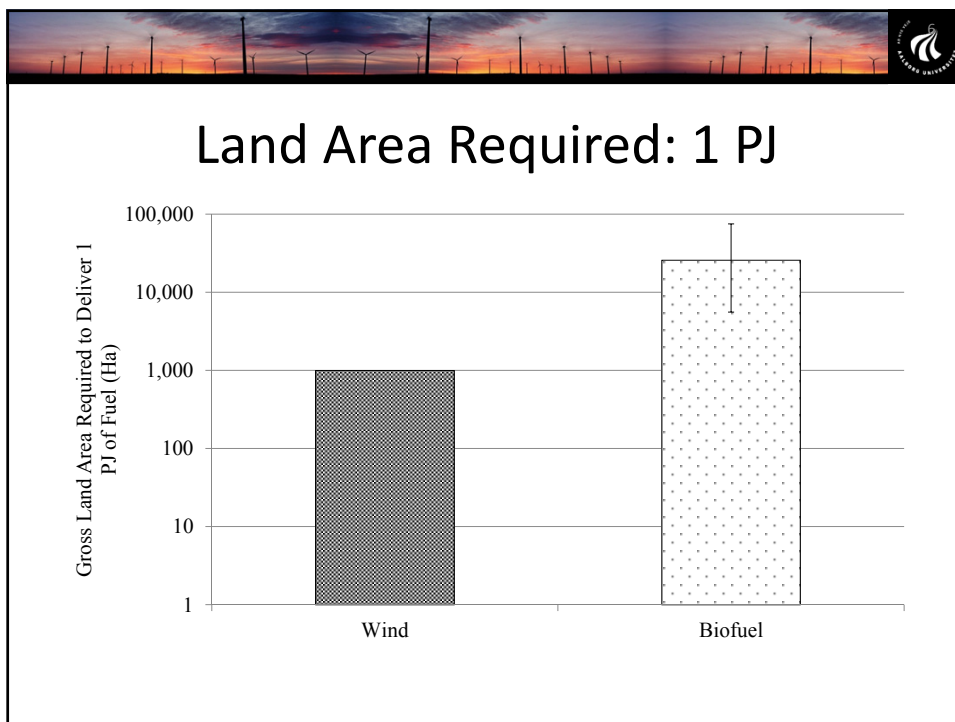
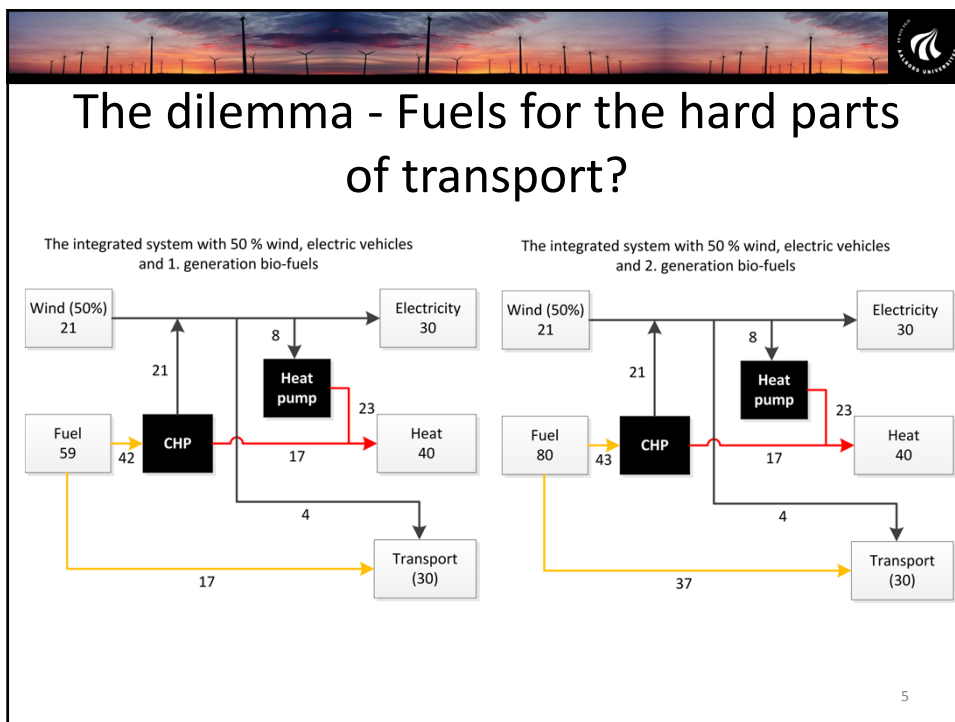
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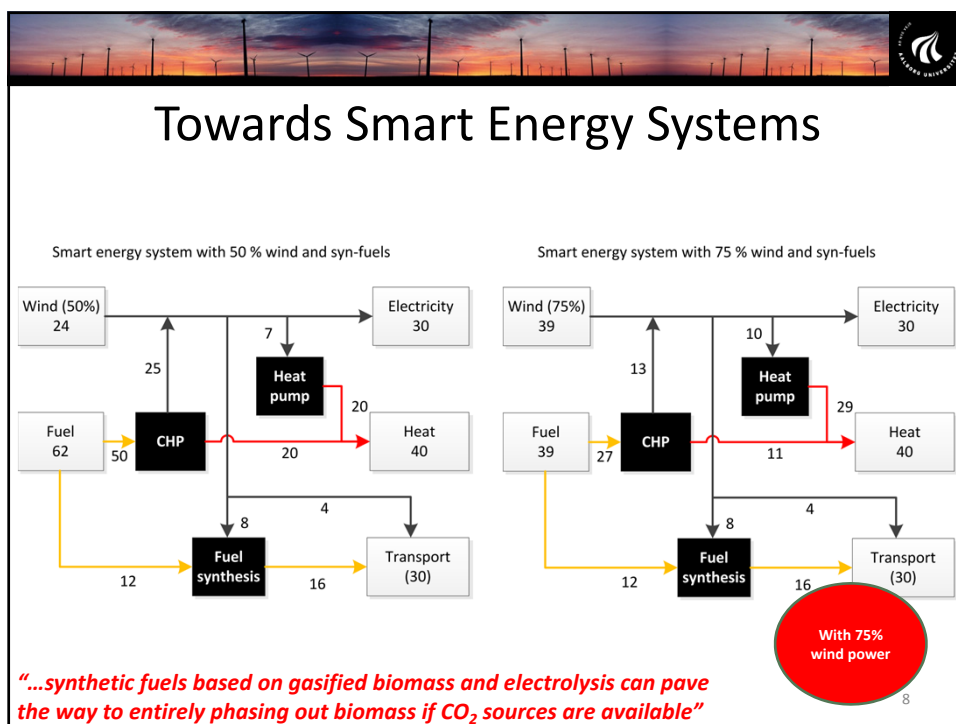
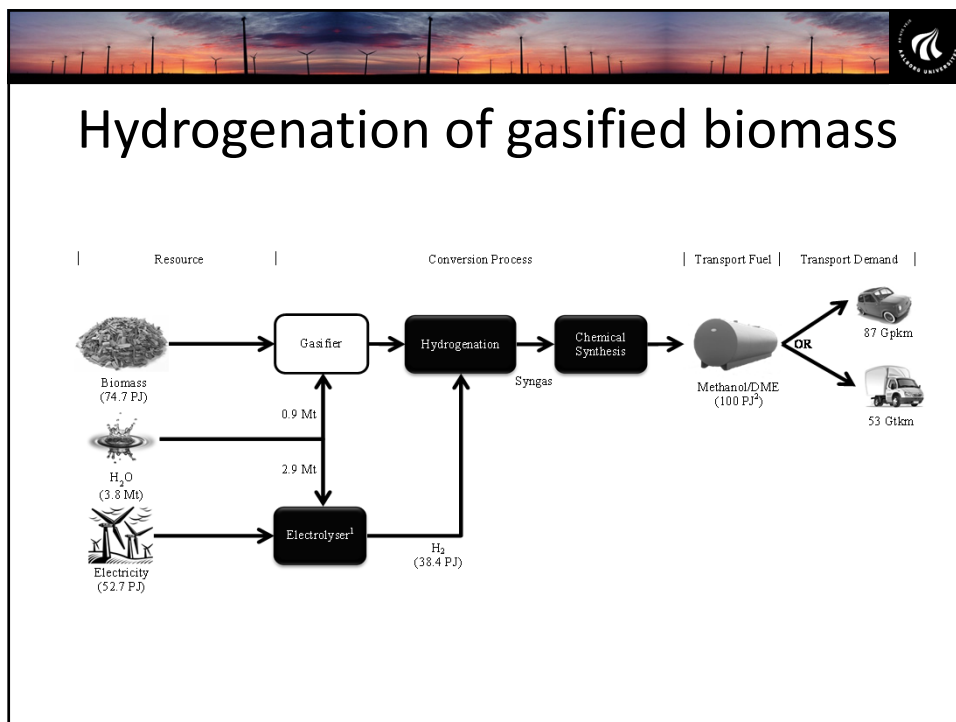


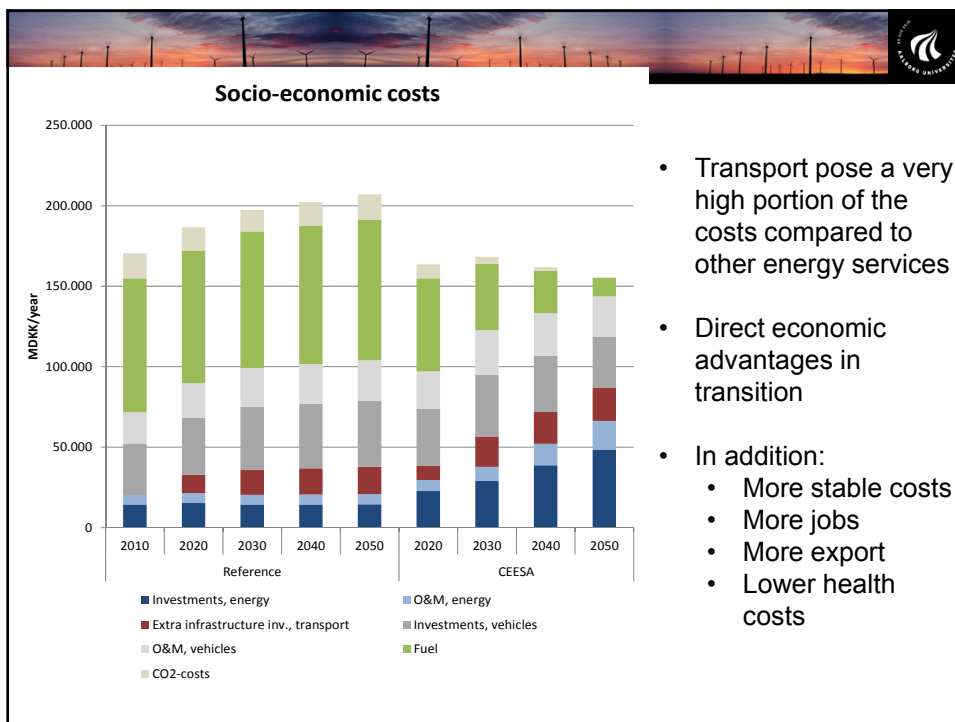
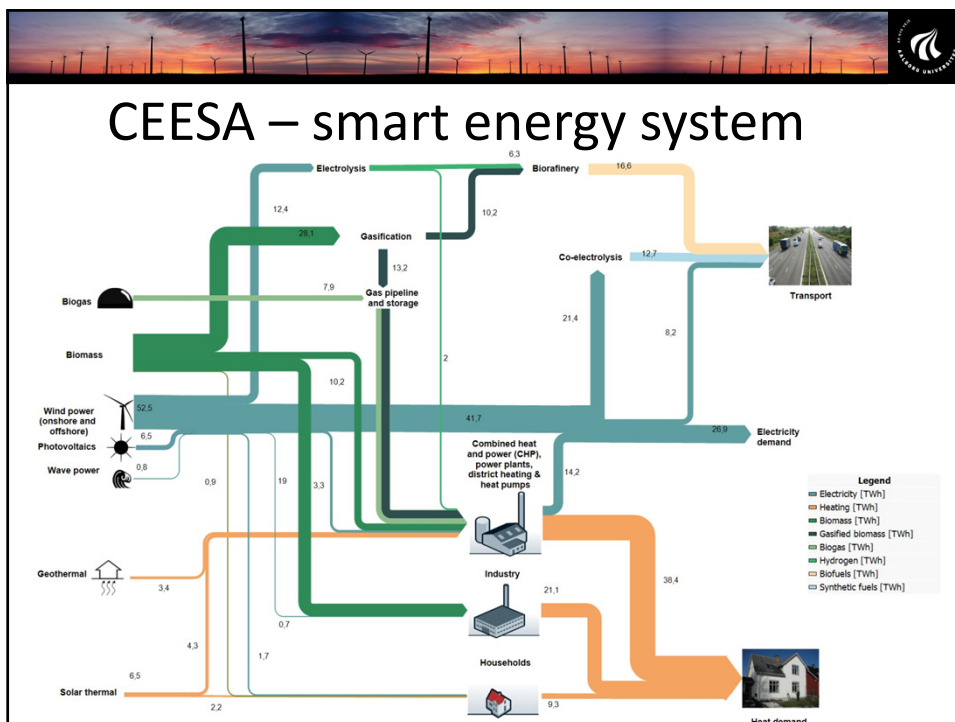
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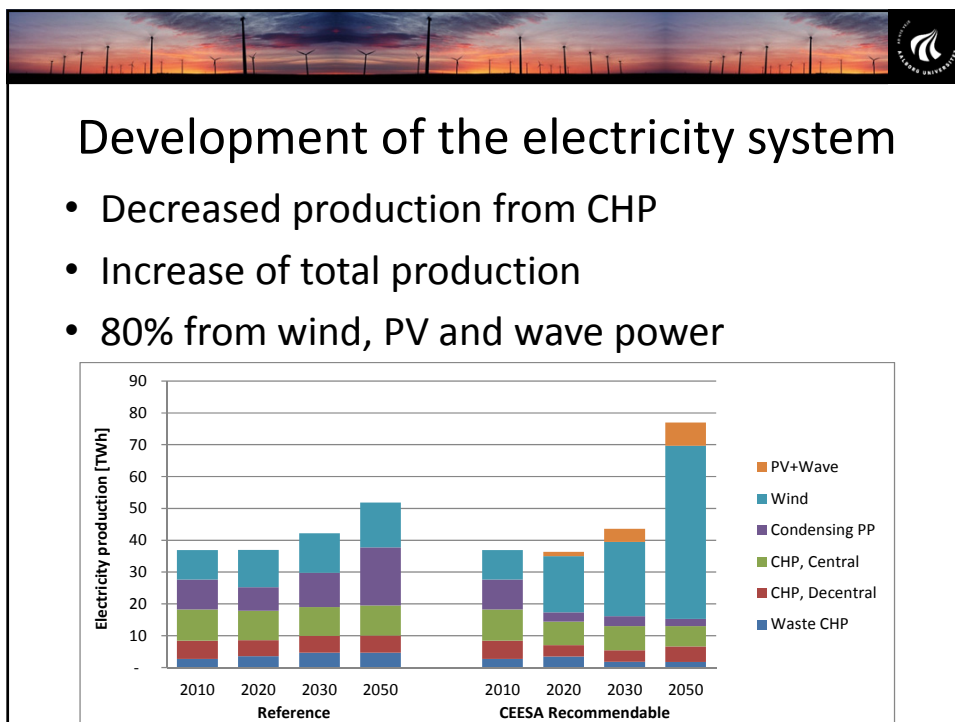
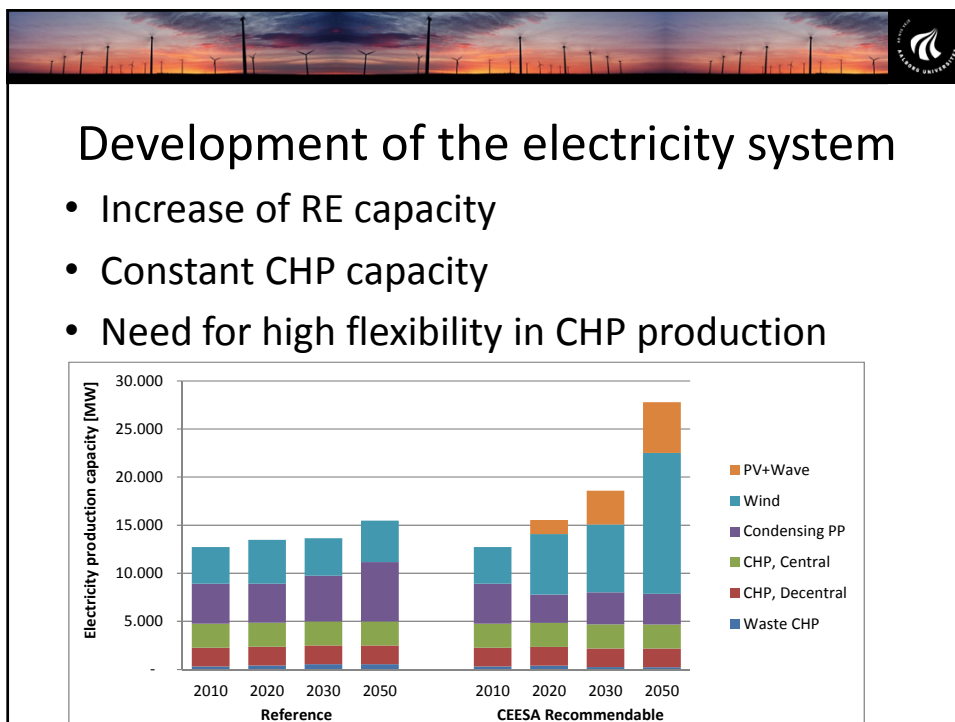


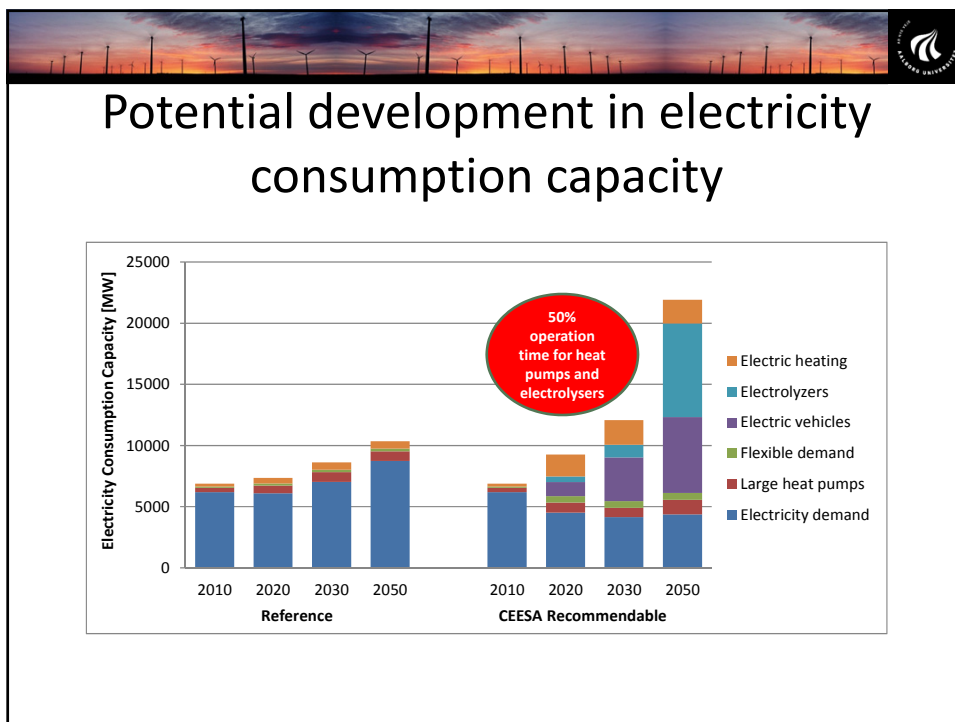
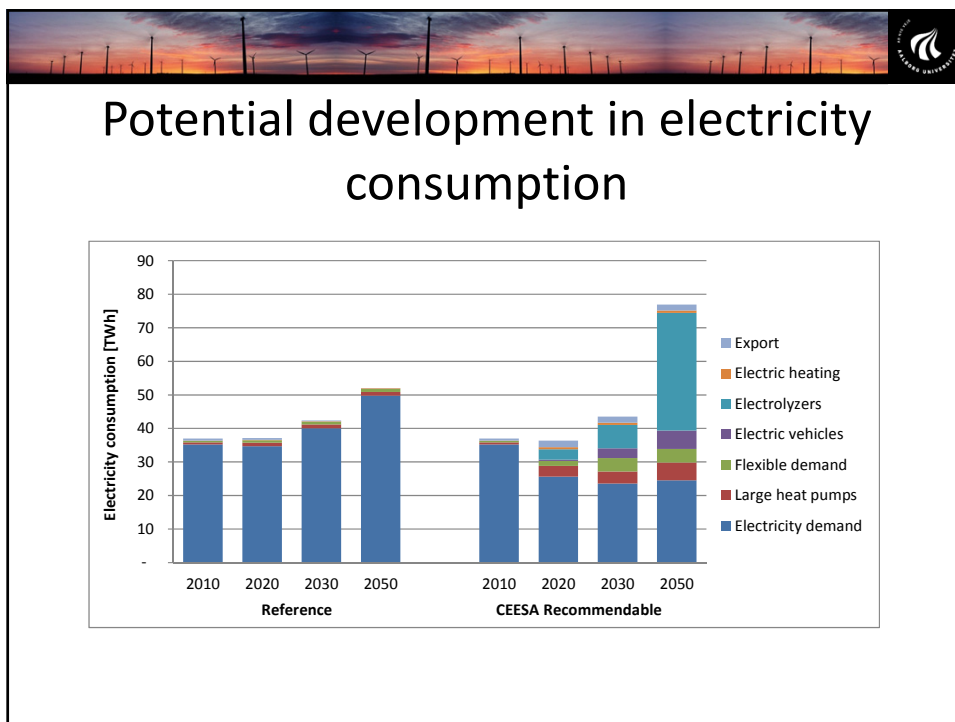

















## The need for flexibility on the production side





- **Larger gas turbines**
  - 10% of full load pr. min
  - Good part-load efficiencies
  - Best efficiencies in base load
  - Quick start-up
  - From Natural gas to biogas and gasified biomass
  - Low investment costs
  - Fuel cells may eventually perform better.
- **New demands for wind turbines**
  - Can be used in the regulation power markets
  - +5MW/min/200MW or 2,5% incr./min of full load



## What can we do on the demand side?

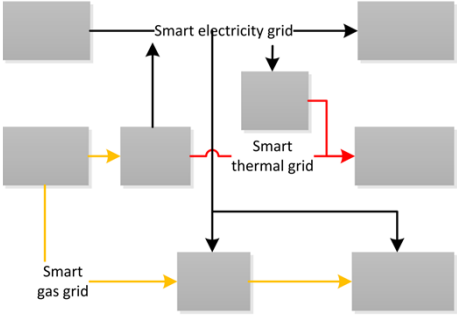
- **Smart Electricity Grids** and infrastructure
  - Connects to storage with flexible electricity demands such as heat pumps and electric vehicles to the intermittent renewable resources such as wind and solar power.
- **Smart Thermal Grids** - District Heating and Cooling infrastructure
  - connects electricity & heating sectors.
  - Enables thermal storage and other heat sources in the energy system to be used.
- **Smart Gas Grids** and infrastructures
  - Connects the electricity, heating, and transport sectors. This enables gas storage to be utilised for creating additional flexibility. (Liquid fuel storages can also be utilised)



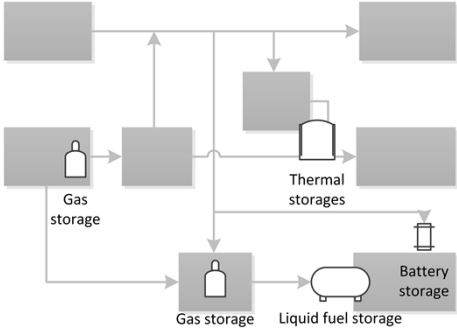



## Grids and storages in Smart Energy Systems



Smart energy system grids



Smart energy system storages



10/9/2013
Copenhagen
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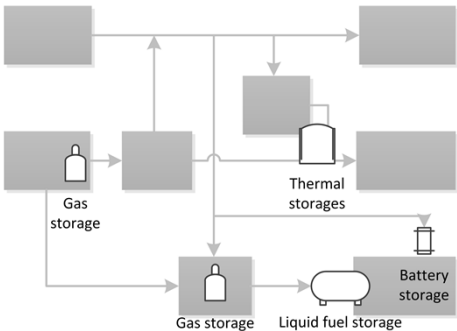



## Grids and storages in Smart Energy Systems

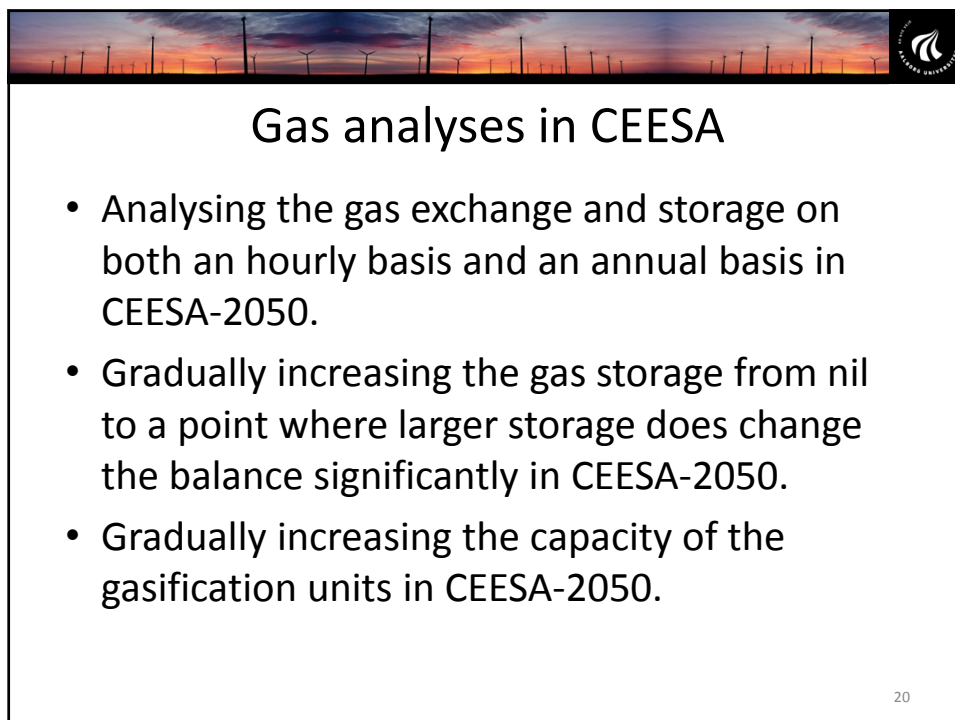
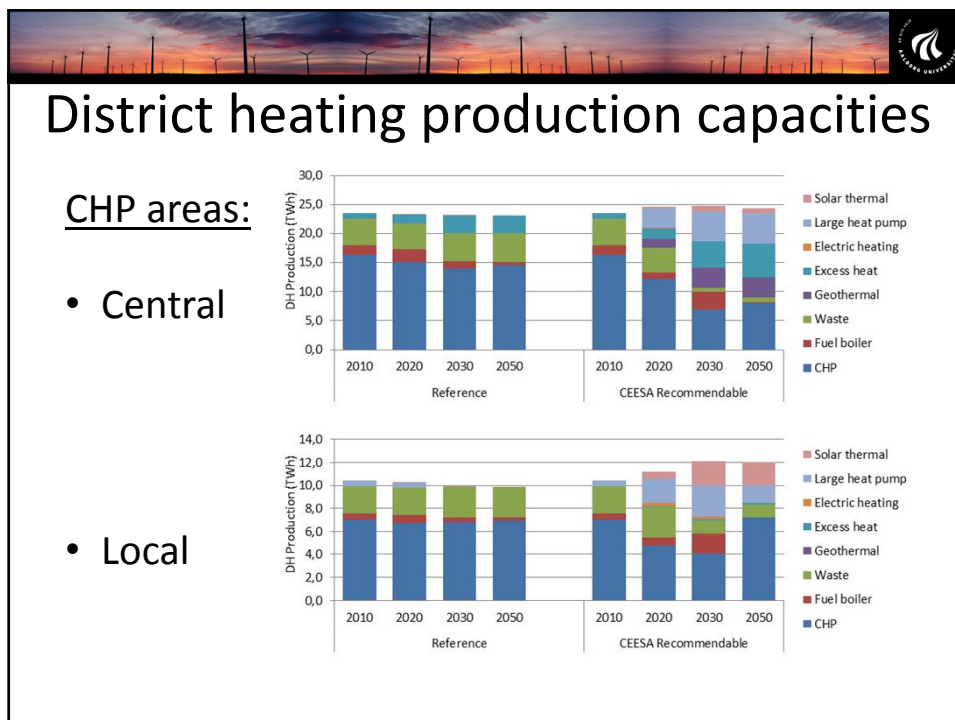
**Selected storages in CEESA**

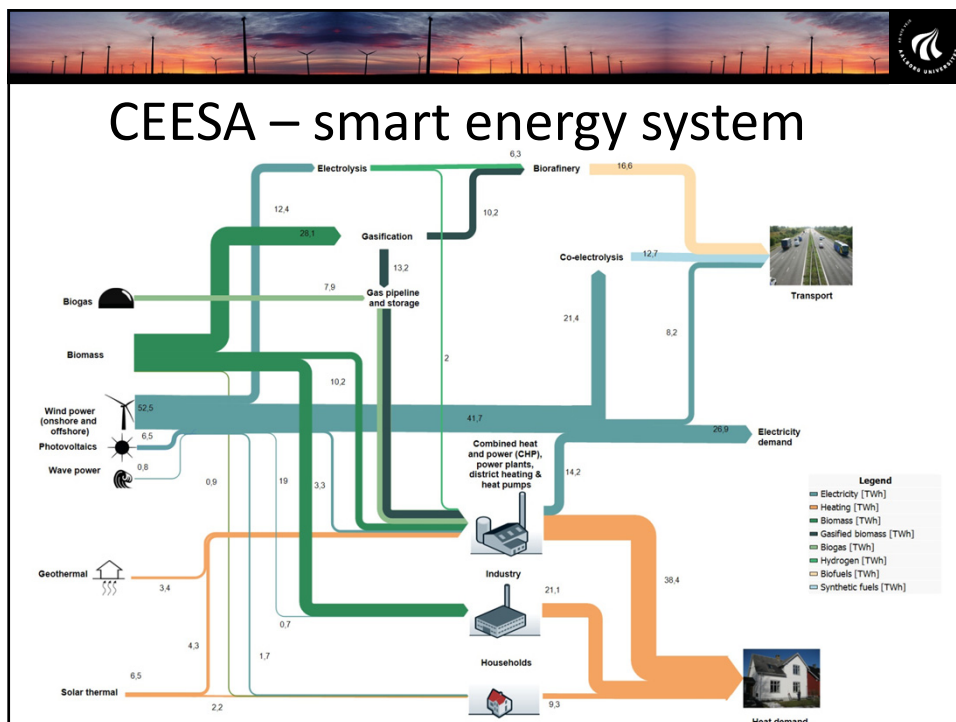
- Battery storages
  - 13,35 GWh (50% of 20 KWh)
  - 0,85 GWh (50% of 8 KWh)
- Thermal storage for CHP plants
  - 40+10 GWh for CHP (10h)
  - 80+10 GWh for solar thermal (long term)
  - 1 GWh (1 day average)
- Gas storages
  - 477 GWh for hydrogen (1 week)
  - 6000 GWh
- Liquefied fuel storage
  - (32,15 TWh)

Smart energy system storages

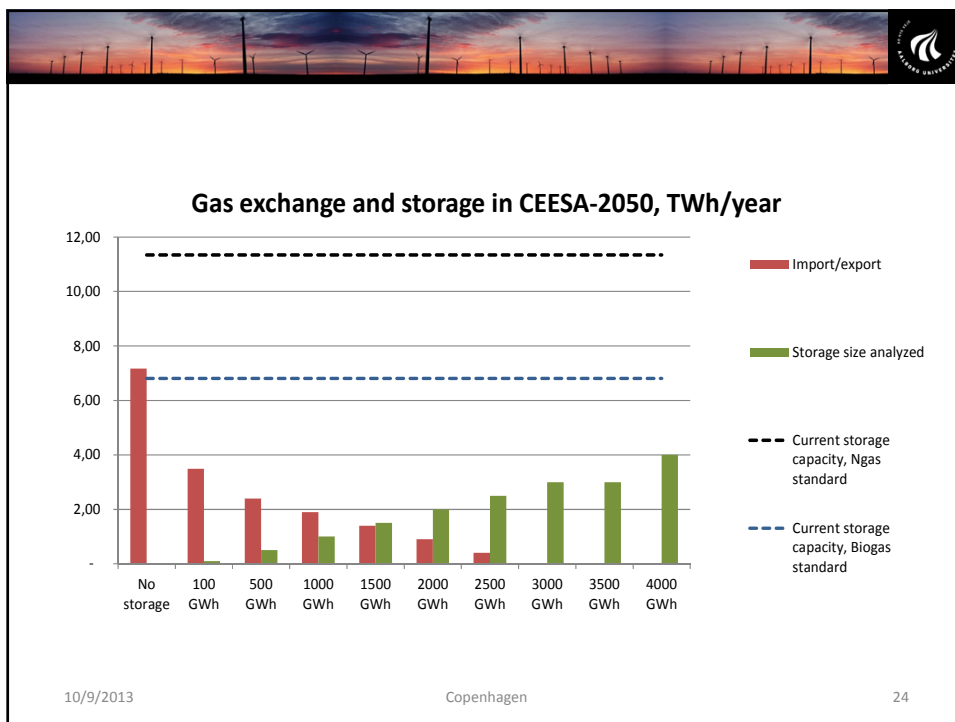
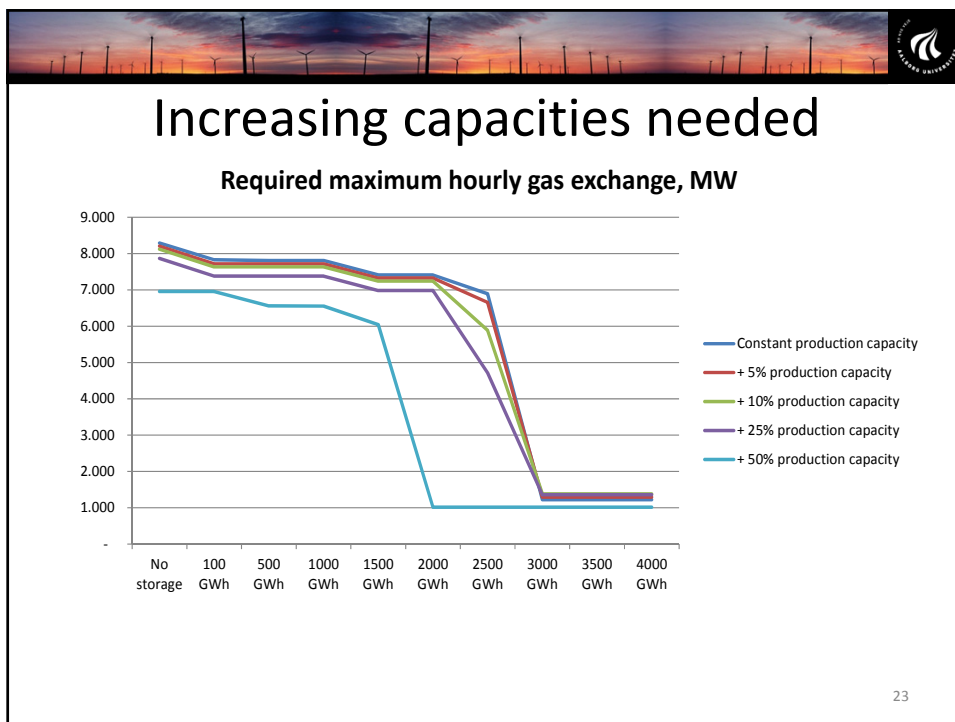


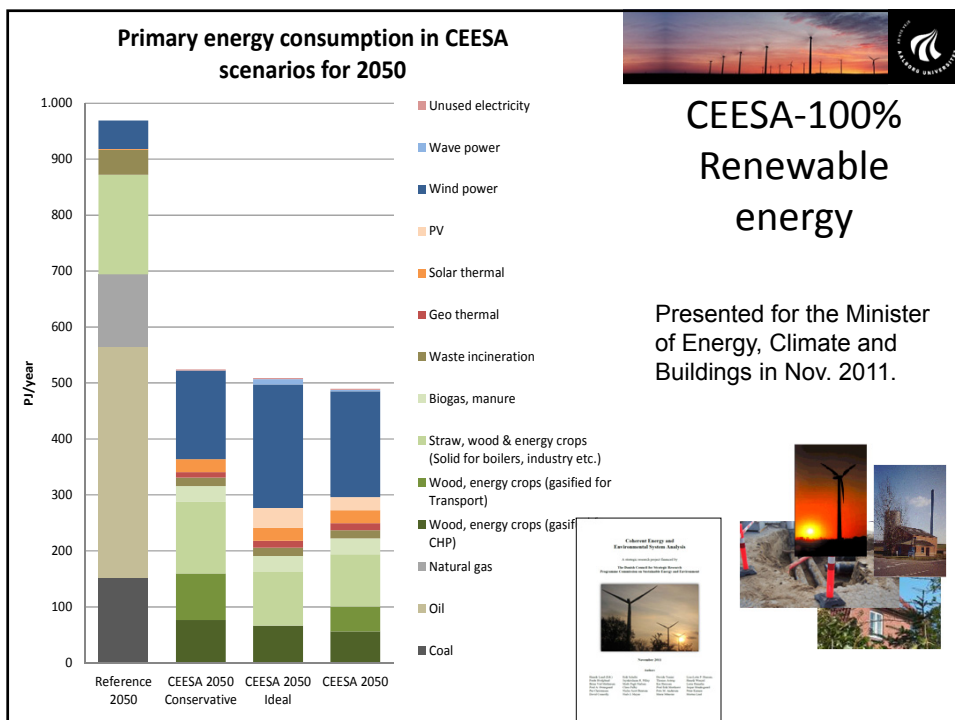
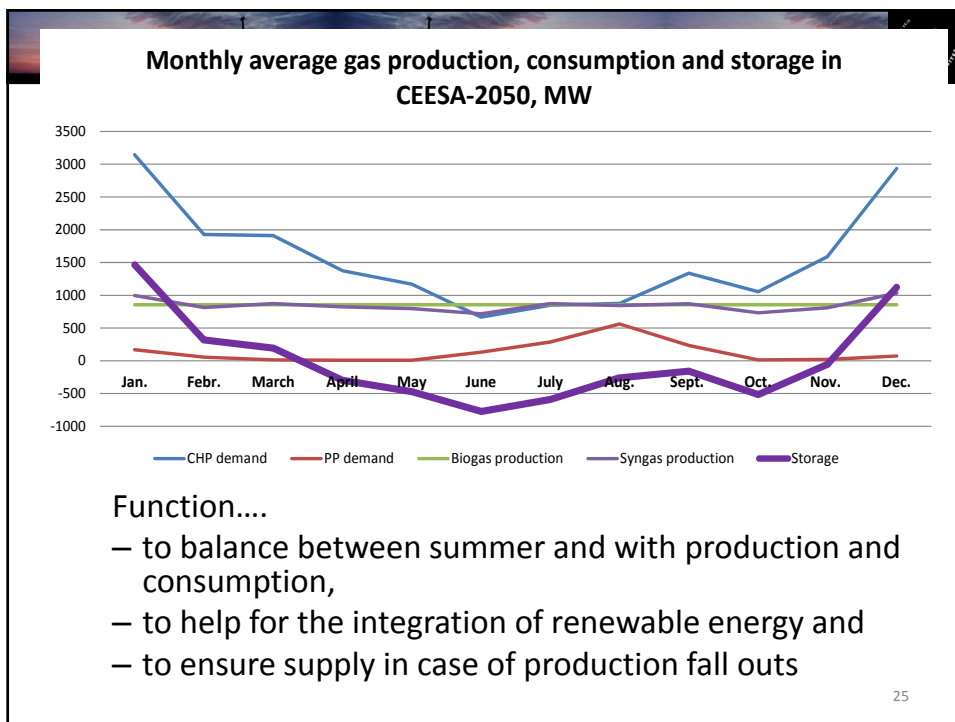
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- Currently
  - 40 GWh natural gas consumption
  - 80 GWh natural gas production
- In CEESA
  - About 8 TWh of biogas used
  - About 20 TWh of gasified biomass for CHP









Large scale integration of intermittent resources require integration:

- Regulation of CHP and heat storage (implemented in DK in 2004): Makes possible to integrate 20-25% Wind Power (and 50% CHP)
- Adding large heat pumps and heat storage capacity to existing CHP plants: Makes possible to integrate 40% Wind Power (and 50% CHP)
- Electricity for transportation (integrate approx. 60% wind power)
- Important to involve the new flexible technologies in the grid stabilisation task

...and also

- ***“...all kinds of electricity storage should be avoided, if the aim is to put electricity back on the grid!”***
- ***“...transport demands should be meet by electricity and where direct electricity cannot be used, synthetic fuels using renewable energy should be used due to the limitations in the biomass resources.”***
- ***“...synthetic fuels based on gasified biomass and electrolysis can pave the way to entirely phasing out biomass if CO<sub>2</sub> sources are available”***



Potential for no biomass!



Thank you for your attention

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