



SMART ENERGY SYSTEMS FOR LARGE-SCALE RENEWABLE ENERGY INTEGRATION -

- HOW CAN ELECTRICITY GRIDS AND DISTRICT HEATING SYSTEMS BE OPTIMISED IN AN INTEGRATED WAY?

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SUSTAINABLE ENERGY PLANNING RESEARCH GROUP, AALBORG UNIVERSITY



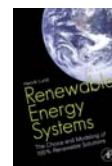
KEY CHALLENGES



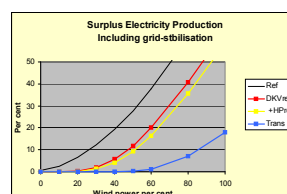
1. Key enabling technologies towards 2030?
2. Potential disruptive technology developments looking towards 2030?
3. Main barriers to further integration of variable renewable electricity in a 2020 and 2030 perspective?



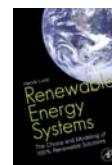
RECOMMENDATIONS I



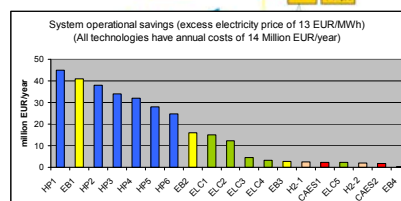
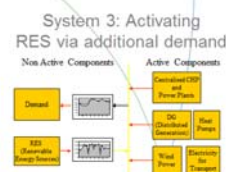
- Make CHP (and PP) unit regulation depend on wind power input (10-20% wind without loss of efficiency)
- Add large scale heat pumps (and heat storage capacity) to the CHP units (approx. 40 per cent Wind Power)
- Use electricity for transport as much as possible
- Other kinds of flexible demands are of less importance



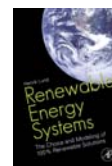
RECOMMENDATIONS II



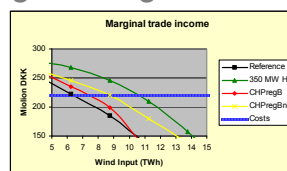
- Not much gained - (integration of wind nor profit) from investing in electricity storage options including batteries
- However the inclusion of CHP, heat pumps and transportation units in securing grid stability is essential.



RECOMMENDATIONS III



- The kind of flexibility one need from a technical point of view (CHP, HP and transport) is the same kind of flexibility which is needed to raise profits of exchange in international electricity or gas markets.
- Interconnections will not help the integration of more wind but rather help share capacity and/or force a market opening through.



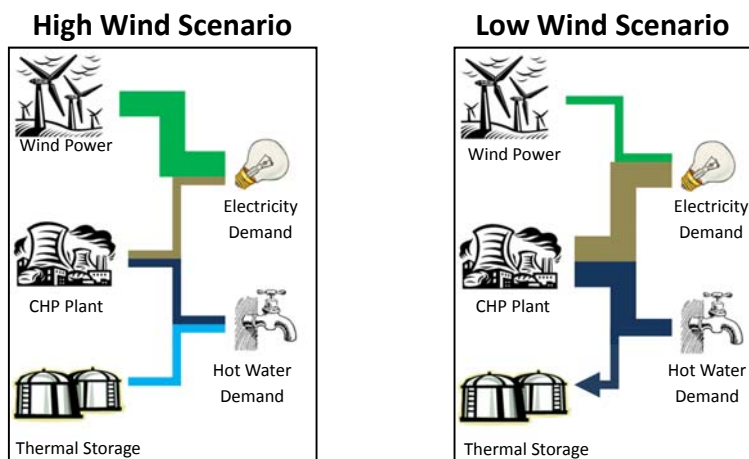
RECOMMENDATIONS IV



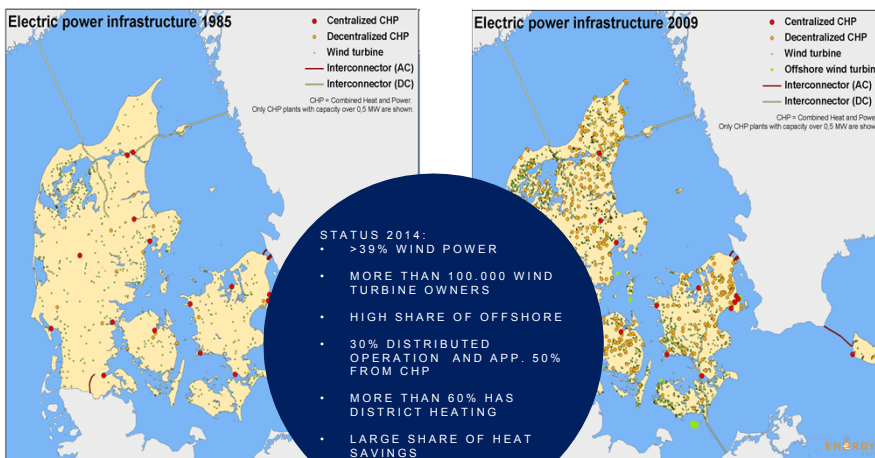
- In the medium long term perspective RES electricity has to be transformed into RES gases and liquid fuels (in combination with biomass) to supplement the limited biomass resource. Such conversion opens for the use of gas storage and liquid fuel storage.
- Hydrogen should not be used directly and not be used in micro-CHP.



COMBINED HEAT & POWER (CHP) - REGULATION



TRANSITION FROM A CENTRALISED ENERGY SYSTEM TO A PARTLY DE-CENTRALISED SYSTEM BASED ON RENEWABLE ENERGY



RENEWABLE ENERGY STRATEGIES FOR SUSTAINABLE DEVELOPMENT IN EUROPE

FLEXIBLE TECHNOLOGIES
INTEGRATED ENERGY SYSTEMS

STUDY FOR THE EU27

by

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HEAT ROADMAP CHINA

- NEW HEAT STRATEGY TO REDUCE ENERGY CONSUMPTION TOWARDS 2030

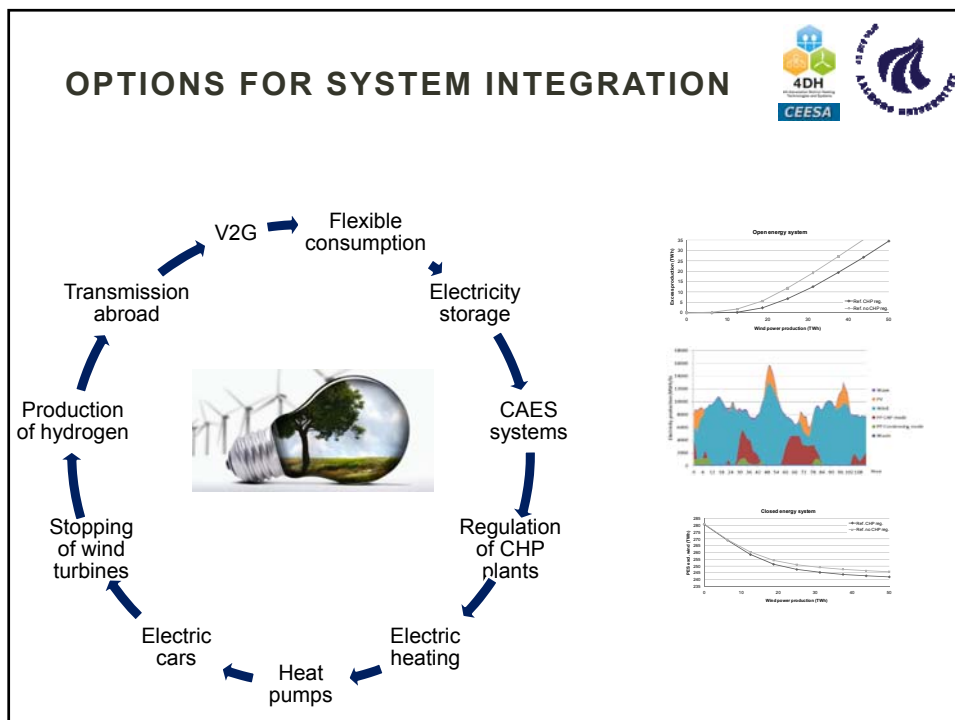
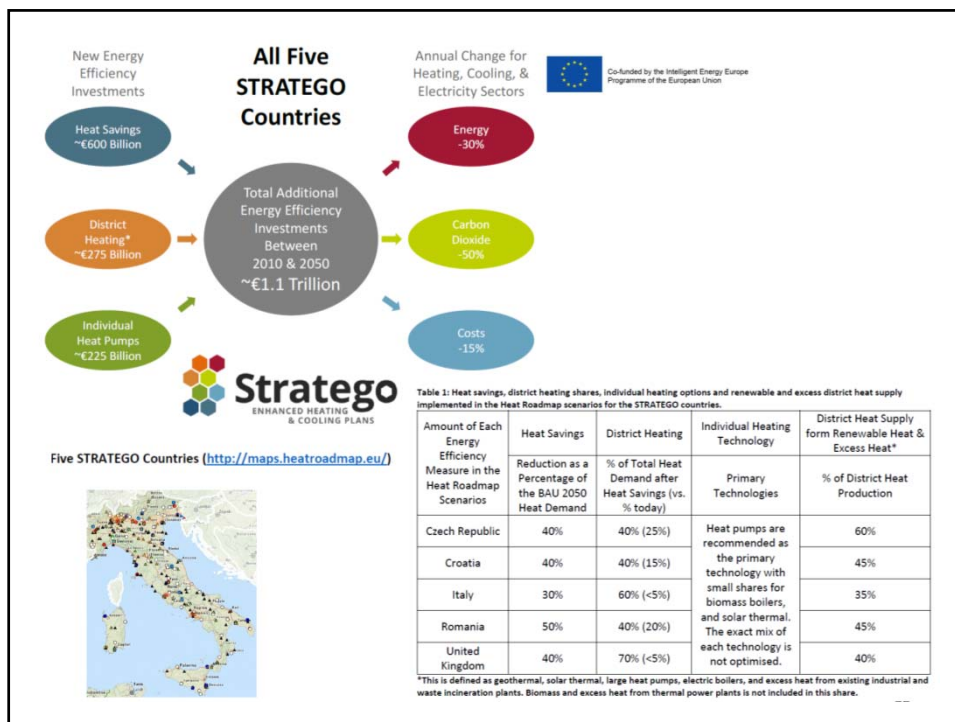
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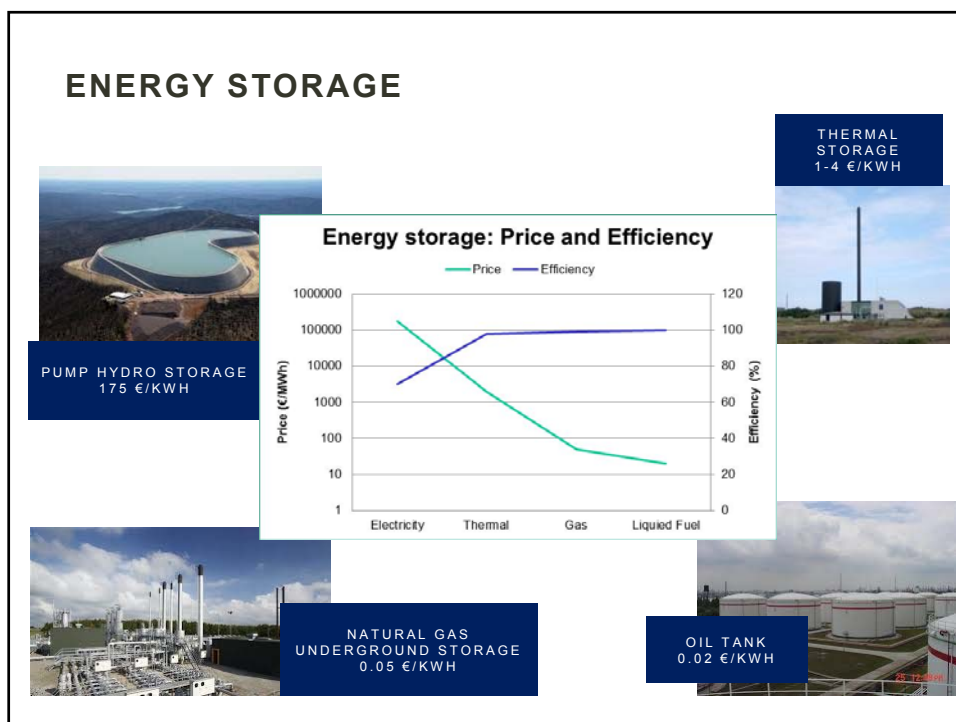
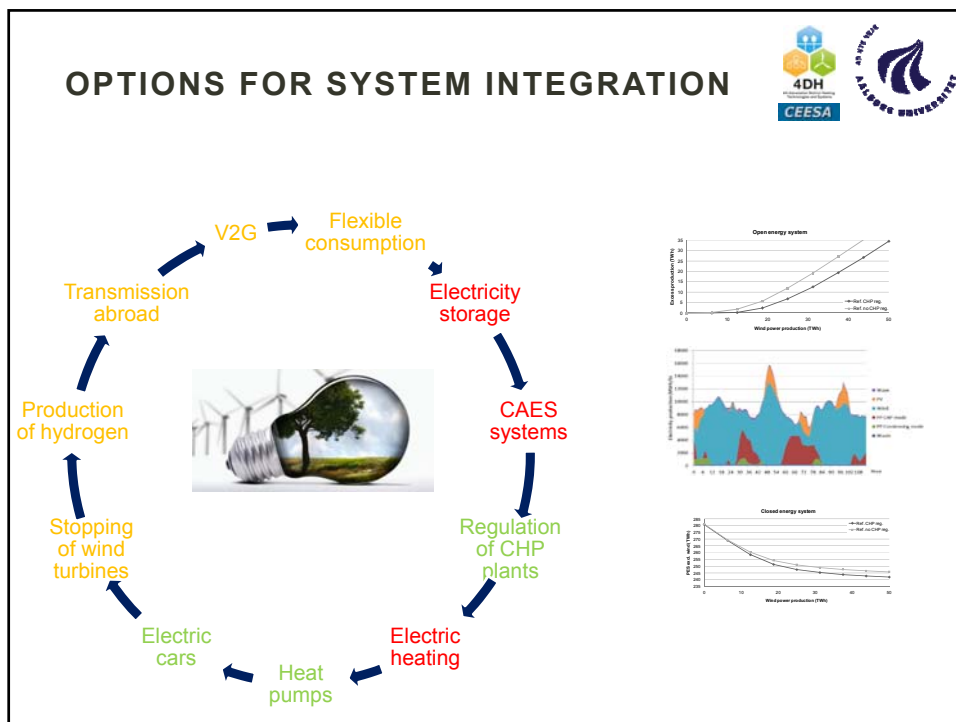
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- DISSEMINATION OF RESEARCH

- EU RESEARCH STRATEGY INFLUENCE AND PROJECTS

- KNOWLEDGE AND TECHNOLOGY TRANSFER








SMART ENERGY SYSTEMS

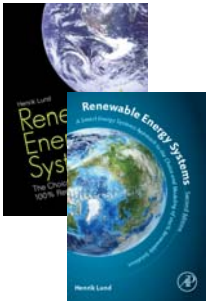
- THE KEY TO COST-EFFICIENT 100% RENEWABLE ENERGY

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



LEADS TO:

- ELECTRICITY STORAGE,
- FLEXIBLE DEMANDS




- 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


SMART ENERGY SYSTEMS


- ARE CRUCIAL IN 100% RENEWABLE ENERGY SYSTEMS




A cross-sectoral and coherent energy system solution

- **Smart Electricity Grids** to connect 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) to connect the electricity and heating sectors. This enables thermal storage to be utilised for creating additional flexibility and heat losses in the energy system to be recycled.
- **Smart Gas Grids** to connect the electricity, heating, and transport sectors. This enables gas storage to be utilised for creating additional flexibility. If the gas is refined to a liquid fuel, then liquid fuel storages can also be utilised.







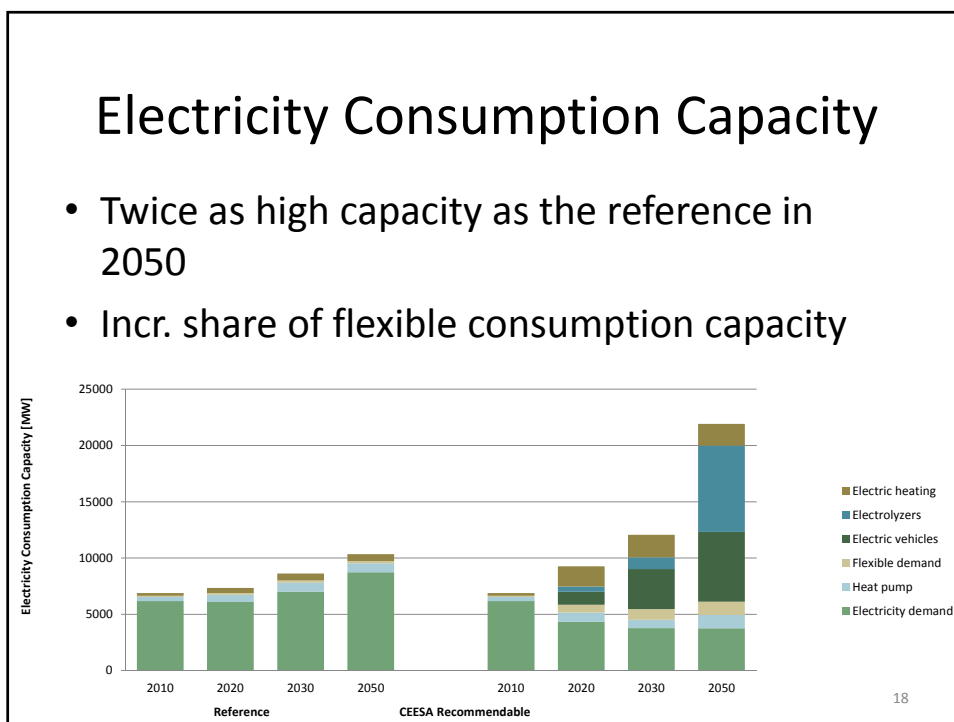
SMART ENERGY SYSTEMS - ARE CRUCIAL IN 100% RENEWABLE ENERGY SYSTEMS

A cross-sectoral and coherent energy system solution

- **Smart Electricity Grids** to connect flexible electricity demands such as heat pumps and electric vehicles to the intermittent renewable resources such as wind and solar

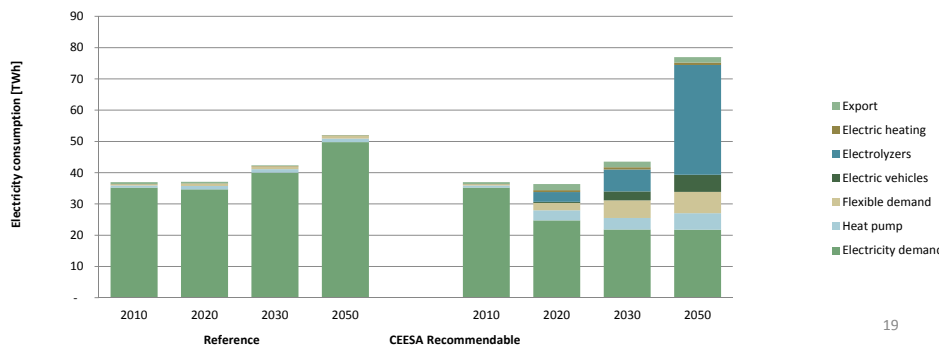
SMART ENERGY SYSTEM IS DEFINED AS AN APPROACH IN WHICH SMART ELECTRICITY, THERMAL AND GAS GRIDS ARE COMBINED AND COORDINATED TO IDENTIFY SYNERGIES BETWEEN THEM IN ORDER TO ACHIEVE AN OPTIMAL SOLUTION FOR EACH INDIVIDUAL SECTOR AS WELL AS FOR THE OVERALL ENERGY SYSTEM.

- **Smart Gas Grids** to connect the electricity, heating, and transport sectors. This enables gas storage to be utilised for creating additional flexibility. If the gas is refined to a liquid fuel, then liquid fuel storages can also be utilised.



Electricity Consumption

- Reduction in traditional electricity demand
- Increase of new flexible demands
- Ensures flexibility for wind integration



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100 % RENEWABLE ENERGY SCENARIOS IN THE CEESA PROJECT 2011

WE CAN REACH 100% RENEWABLE COST AND FUEL EFFICIENTLY IN 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..

Figure 2. Primary Energy Supply in CEESA.

ISSUES TO BE ADDRESSED IN THE ENERGY UNION.....



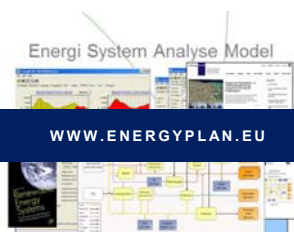
- CO2-kvota markets only solve a very small part of the problem and only addresses certain sectors
- New cables does not provide more renewable energy!
- The existing actors may not be able to lift the task (goes against existing business model)
- Energy savings good for society cost but hard to implement
- Existing marginal electricity price markets cannot survive as they are
- Feed-in-tariff model under pressure from ignorant civil servants and industry
- Public support and ownership needs a big boost



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4DH
4th Generation District Heating
Technologies and Systems

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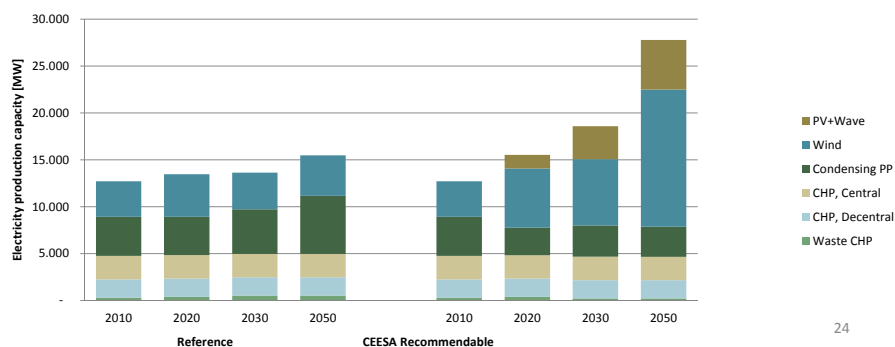
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• SMART ENERGY DENMARK IN 2050?
• SMART ENERGY EUROPE IN 2060?

ekstra

Electricity Production Capacity

- Increase of RE capacity
- Constant PP/CHP capacity
- Need for high flexibility in PP/CHP production



Electricity Production

- Decreased production from PP/CHP
- Increase of total production
- 80% from wind, PV and wave power

