The CEESA Smart Energy Systems Approach for Denmark and Europe
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The purpose and methods

Energy systems are undergoing a transition from fossil fuels to renewable energy. The question is if a transition towards 100% renewable energy is feasible for Denmark in 2050.

The methods involved:
- Further development of several existing tools such as vehicle drive cycle analysis and energy systems analysis tools
- Development of a new CEESA transport scenario tool
- A method for qualitative modelling of electricity system control structures and a tool for evaluating control resource use in scenario studies
- Further development of the methodology for combining energy systems analysis with life cycle assessment (LCA).

The CEESA (Coherent Energy and Environmental System Analysis) project included five universities: Aalborg University, Technical University of Denmark, University of Southern Denmark, University of Copenhagen & Copenhagen Business School. The project was funded by the Danish Council for Strategic Research (Now Innovation Fund Denmark).

CEESA Key Results

The CEESA project presents technical scenarios as well as implementation policies and a road map of Denmark’s transition to a system based on 100% renewable energy with a dominating part of intermittent sources like wind and solar power. Energy conservation and a certain technological development are prerequisites for this transition. The transition can be performed before 2050 mainly through the use of known technologies combined with significant energy conservation.

Modelling and Analysis results:
- Development of biomass resource scenarios and review of potential biomass conversion technologies
- Design and modelling of a transport scenario
- Combined energy system and LCA analyses of a 100% renewable scenario including hour balances of bio(syn)gas production, storage and exchange (additional to balancing and exchange of electricity)
- Evaluation of electricity grid stabilisation with electric vehicles
- Design of a policy and implementation strategy

Smart Energy Systems by AAU

A cross-sectoral and coherent energy system solution

A smart energy system consists of new technologies and infrastructures which create new forms of flexibility, primarily in the ‘conversion’ stage of the energy system in combination with significant energy savings. This is achieved by transforming a simple linear approach in today’s energy systems (i.e. fuel to conversion to end-use) to a more interconnected approach. In simple terms, the electricity, thermal, and transport sectors are merged so that the flexibility across these different areas can compensate for the lack of flexibility from renewable resources such as wind and solar. The smart energy system uses technologies such as:
- 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 the utilisation of thermal storage for creating additional flexibility and recycling of heat otherwise lost in the energy system.
- Smart Gas Grids to connect the electricity, heating, and transport sectors. This enables the utilisation of gas storage for creating additional flexibility. If the gas is refined to a liquid fuel, then liquid fuel storages can also be utilised.

From Smart Energy Denmark to Smart Energy Europe?

Preliminary analyses of a 100% renewable energy system in Europe by the year 2050 using a Smart Energy System approach suggests that such a transition is technically possible and economically feasible. Changes required:
- decommissioning of nuclear power,
- implementing a large amount of heat savings,
- converting the private car fleet to electricity,
- providing heat in rural areas with heat pumps,
- providing heat in urban areas with district heating,
- converting fuel in heavy-duty vehicles to synthetic fuel, and replacing natural gas with synthetic methane.

Hour-by-hour analyses indicate that by using the Smart Energy System approach, a 100% renewable energy system in Europe is possible without consuming bioenergy that exceeds sustainable levels. The additional flexibility that is created by connecting the electricity, heating, cooling, and transport sectors enables more than 80% intermittent renewable penetration in the electricity sector. There are major practical and political barriers to carrying out such a transition, but in doing so, the EU28 balance of payment would improve significantly, while meeting targets of de-carbonisation and creating approximately 10 million more jobs than in a fossil and nuclear power energy system.

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www.ceesa.dk
www.smartenergysystems.eu