# The CEESA Smart Energy Systems Approach for Denmark and Europe

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# 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 basis for **combining energy system analysis with life cycle assessment (LCA)**.

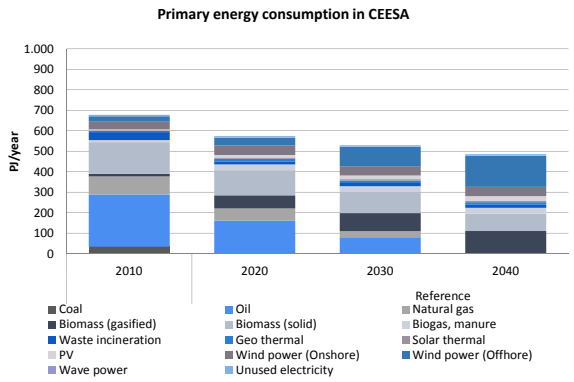
The CEESA (Coherent Energy and Environmental System Analysis) project included five universities: Aalborg University, Technical University of Denmark, University of Southern Denmark, University of Copenhagen & Copenhagen Business School. The project was funded by the Danish Council for Strategic Research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




**The scenario includes:**

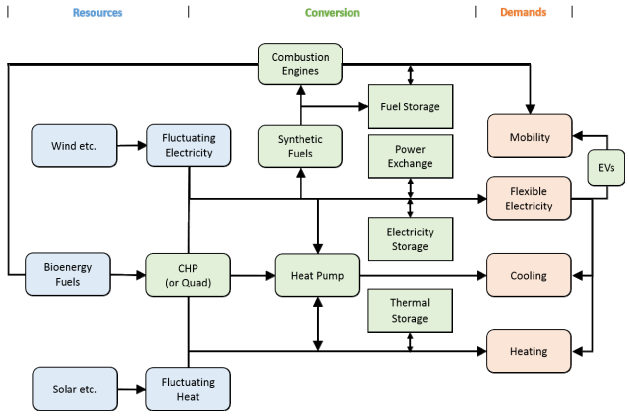
- The Smart Energy Systems approach provides feasible options limiting the use of biomass to a sustainable level (240 PJ)
- CEESA shows how the transport system can be transformed to 100% renewable energy
- Greenhouse gas (GHG) emission reductions by 70% until 2030; in 2050 emissions approach nearly zero
- Creation of 20,000 additional jobs until 2050 in the transition towards 100% renewable energy
- Socio-economic costs compared to reference fossil-based energy system are approximately 20 billion DKK/year lower by 2020 and increasing towards 2050 (excl. job creation and externalities)
- A potential to increase current exports of energy technologies from 50-60 billion DKK/year today towards 200 billion DKK/year in 2030. This can create 8-10 times the jobs connected to the transition.

## 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 the 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.

## Acknowledgement

This poster was created in Oct. 2014 for Innovation Fund Denmark's Conference: ENERGY AND ENVIRONMENT FOR THE FUTURE, Sustainable energy for a fossil free society and environmentally friendly technologies - A conference presenting state of the art research.

A new book release!
**Renewable Energy Systems (2nd Edition)**
**A Smart Energy Systems Approach to the Choice and Modeling of 100% Renewable Solutions, Elsevier Academic Press, 2014**


Smart Energy Systems – the road to a fossil-free Denmark
Find video on: **www.smartenergysystems.eu**

**www.ceesa.dk** **www.smartenergysystems.eu**