OUT-PHASING OF FOSSIL FUELS BEFORE 2050

Danish Case Study:
Coherent Energy and Environmental System Analysis (CEESA)

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INTERNATIONAL BACKGROUND

- Failing international negotiations on mitigation of global warming and climate change (COP15/16).
- Acute need for new and efficient national policies, taking *Peak Oil* and the *Precautionary Principle* seriously.
- Most attention has been given to technological solutions (renewable energy and energy efficiency).
- Less attention to *efficient policy means*, the concept of *limits to growth* and the need for new economic paradigm – including *ecological economics*.
- These points are analysed in the Danish project: ”Coherent Energy and Environmental System Analysis”, (CEESA).

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PROJECT GOALS FOR CEESA

- **Overall goal**: Develop detailed scenarios for outphasing of fossil fuels in the whole Danish energy supply system (including transport) before 2050.
- **Scenario road map***:* years 2015, 2020, 2030 and 2050.
- **Framework:** Goal to be reached, in principle, by national resources, i.e. as little energy import and export as possible.
- **Policy instruments:** Focus on new and efficient policy means, securing desired goal with balanced societal consequences.
- **Secondary criteria:** Low costs, positive employment and export effects. .

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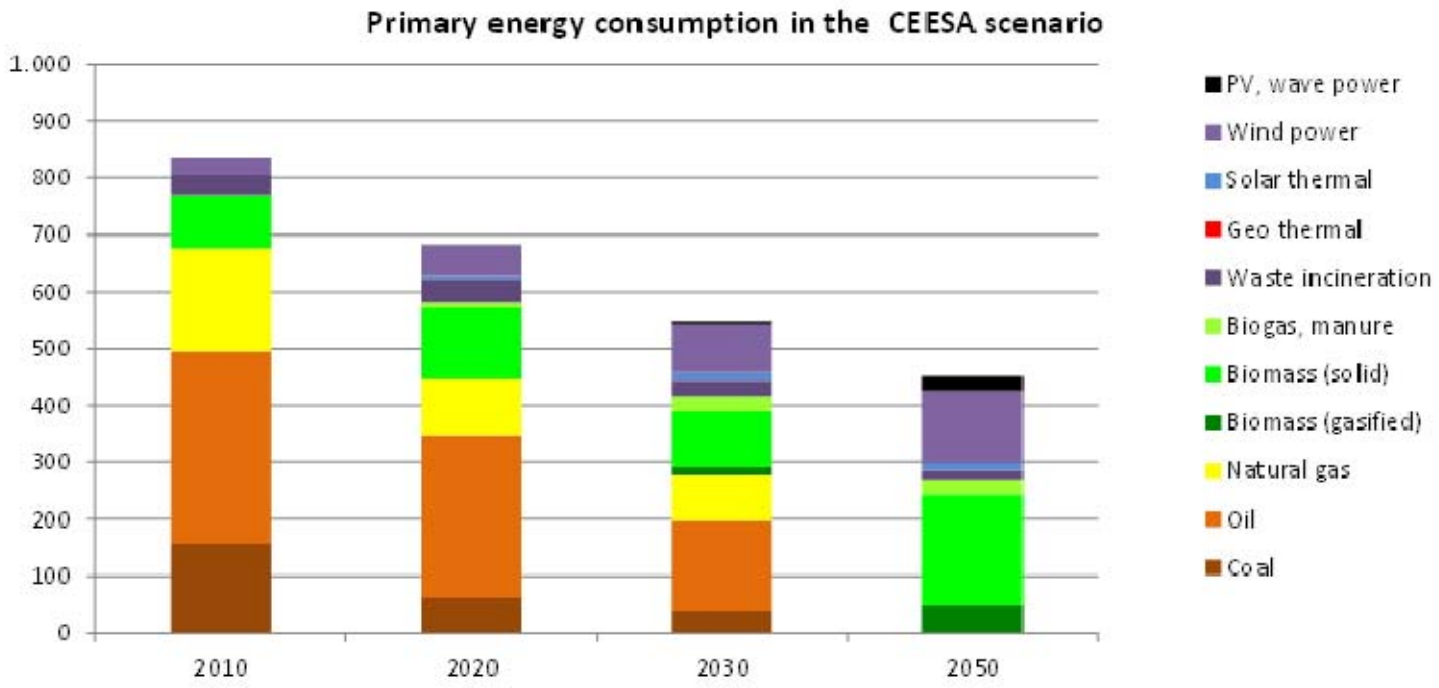
MAIN CHALLENGES

- Dominant intermittent energy supply sources (wind, solar, waves) require new systems thinking on grid balance.
- Large consumer demand for biomass (high temperature processes, biofuels for transport, peak-load plants etc.)
- Limited amount of biomass in Denmark (competition with other forms of land use – including ecological farming).
- Lock-in to fossil fuel technologies, neoclassical economics, short sighted market planning and high discount rates.
- Overcoming these barriers requires radical changes in planning methodologies, institutions and tax and tariff systems.

METHODOLOGY

- Scenarios based on bottom-up, hour-to-hour computer model (”EnergyPLAN”) developed by Henrik Lund (Aalborg Univ.)
- Three main scenarios, with priority to wind, not to biomass:
- *CEESA-Conservative:* Technologies on the market but with certain improvements in efficiences.
- *CEESA-Ideal:* Developing technologies are included.
- *CEESA-2050:* Balanced and realistic assessment of technology improvements and implementations. This is the main scenario.

RESULTS FOR MAIN CEESA SCENARIO (1)



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BIOMASS PROBLEMS

- *Estimated residual biomass resources* is around 240 PJ including wood, straw and biogas, increased to 270 PJ when adding waste from households and industry.
- *CEESA-2050 scenario* requires 285 PJ, which is rather close to 270 PJ, but requires further energy conservation or improvements of technical efficiences, especially in case of higher penetration of ecological farming.

MAIN RESULTS FROM CEESA (1)

RES coverage of Danish **electricity** by 2050

- *Land-based wind power:* 25 %
- *Offshore wind power:* 38 %
- Wind power total *63 %:* land based 4,450 MW (13 TWh/y) and offshore 4,600 MW (19 TWh/y)
- *Solar electricity (PVs):* 10 %
- *Biomass, including waste:* 22 %
- *Wave power:* 5 %

Forecast for total Danish electricity by 2050: **50 TWh** compared to 38 TWh in 2010. Increase due to heat pumps, electricity replacing fossil fuels in industrial production, electric cars, and more electric trains. Partly compensated by reductions from higher efficiency of electric appliances, lightening and it-equipment.

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MAIN RESULTS FROM CEESA (2)

Supply of heat

- Annual heat consumption reduced from 800 to 440 PJ – *strict builing codes* and *general renovation of existing houses*.
- 50 % of heat supply from CHP and district heating. (*20 % of electricity from CHP*).
- 1,200 MW heat-pump capacity in district heating areas – *unit capacities from 1 MW to 5 MW*.
- *Heat storage* in CHP plants corresponding to 8 hours consumption (average).
- Some geothermal heating included – problems with monopoly ownership (DONG).

MAIN RESULTS FROM CEESA (3)

Transport sector by 2050

- 80 % of cars are electric or hybrid coupled to smart grids.
- Economic or direct control systems to avoid charging at the same time. Most charging beteen 11 p.m. and 6. a.m.
- Biomass for energy is reserved for aviation and for gas turbines (gasified biomass) in peak hours.
- Grid stability is based on controlled use of heat-pumps, fuel cells, gas turbines (gasified biomass) and active, local cell structures in the distributed electric system *(refs.)*.

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ECONOMIC RESULTS OF CEESA 2050

- Three average fuel prices per barrel used : $60, $122, $132.
- With $122/barrel the economic *advantage* of CEESA 2050 compared to the reference in 2020 and 2030 is 10 and 20 billion DKK/year respectively (1.33billion €, 2.66 billion €).
- Taking into account international exchange of electricity yields insignificant changes of the benefits of CEESA 2050.
- Increase of transmission capacities to neighbouring countries from 2,500 MW to 5,000 MW yields marginal extra incomes in comparison to the costs of the extra capacity.

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EXMPLES OF PROPOSED POLICY MEANS
Individual means for each sector

- Phase out of fixed charges for district heating tariff systems.
- Immediate change of the annual tax on private cars to depend strongly on kilometers driven.
- Introduction of an advanced road pricing system.
- Reduction of official discount rate to below 3 % p.a.
- Economy of wind and solar based on flexible feed-in tariffs.
- Green taxes on private households based on cap system, eventually changed into ”personal carbon allowances” *(ref)*.
- Promotion of ”smart grids” (two-way communication).

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POLICY EXAMPLES FROM BUILDING SECTOR
CEESA-project

- All new houses of passive house standard.
- *Renovation of existing buildings:*
  a) Energy labelling of all buildings combined with graduated green tax crediting low energy consumption.

  b) Investment subsidy for strong renovation and introduction of RES (solar heat and PVs, heat pumps).

  c) Investment subsidy for replacement of selected old houses by passive houses.

These policies can reduce energy consumption in Danish house sector by more than 40 % compared to the present situation.

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CONCLUSIONS (1)

- Possible to phase out fossil fuels in Denmark before 2050 at no net cost – even with a moderate oil price (122 $/barrel).
- This process will make Denmark independent of insecure suppliers of fossil fuels and an approaching ”peak oil”.
- The process will require changes in present Danish energy planning, tariff and tax systems, and institutional arrangements - with high priority to sustainability.
- The goal may be reached without international exchange of energy - but this may not be the optimal economic solution.

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CONLUSIONS (2)

- Combined planning for heat, el. and transport is needed.
- Intermittent RES based on flexible feed-in tariffs and taking advantage of heat pumps and fuel cells for grid stability.
- Distributed energy systems may contribute to grid stability – *autonomous cell structure in distribution areas.* Present projects at Bornholm (21 million €) and South Jutland *(refs.)*.
- Biomass is a scarce ressource in great demand. Primary energy customers: aviation, and CHP plants (gas turbines).
- Land-based wind turbines should offer local ownership and have a maximum capacity of 1 MW to avoid opposition.

CONCLUSIONS (3)

International proposals

- A new club of international fore-runners should be created.
- New economic paradigm with less attention to GDP and more attention to sustainability, ecological economy - and*"limits to growth"*, *equity* and *global solidarity (ref)*.
- Changes needed in present employment policies including lower working hours, sharing of paid work, more free time.
- New institutional frameworks and taxation systems.
- Precautionary Principle - No new coal plants without CCS.
- 50 % of known coal and oil reserves to remain underground to keep global temperature increase below 2 degrees.

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THANK YOU FOR YOUR ATTENTION

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NEOCLASSICAL VERSUS ECOLOGICAL ECONOMICS

Herman Daly: Ecological (sustainable) economy

- *Neoclassical Economics* (NE): Isolated economic system with circular flow of production and consumption.
- *Ecological Economics* (EE): Economy is an open subsystem of a finite, non-growing biosphere with non-growing input of sun.
- *NE*: focus on efficient allocation with no attention to scale.
- *EE*: focus on sustainability of economic scale and its material throughput. Also attention to a just economic distribution.
- *NE*: focus on narrow GDP, neglecting many externalities, applying a discount rate to balance between generations.
- *EE*: GDP in affluent societies may hide *un-economic* growth. Flexible choices should be kept open for future generations.

LIMITS TO GROWTH

- The report *The Limits to Growth* (LtG, 1972) was ridiculed by most traditional economists –now it has got a renaissance.
- Several LtG scenarios - but public focus on *collapse scenario.*
- Recent analyses have shown that the actual development from 1972 to 2009 has followed the LtG scenario with collapse in the middle of this century.
- LtG should be revisited with attention both to collapse scenario and sustainable LtG scenarios.
- The concept of *limits to growth* must be included in present strategies and policies for mitigation of global warming.
- Wellfare without growth requires new employment concept.

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