

# **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 (COP15/16/17, Rio + 20)).
- 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).

# LIMITS TO GROWTH

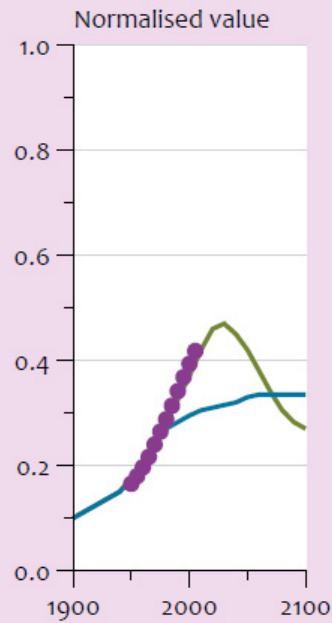
- The report *The Limits to Growth* (LtG, 1972) was ridiculed by neoliberal economists –now it has got a renaissance.
- Several LtG scenarios - but public focus on *collapse scenario*.
- Recent analyses have shown that the actual development from 1972 to 2009 has followed the LtG scenario ending with collapse in the middle of this century (*next slide*).
- 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 economy and strategies for mitigation of global warming.
- Welfare without growth requires new employment concept.

# THE LIMITS TO GROWTH (2)

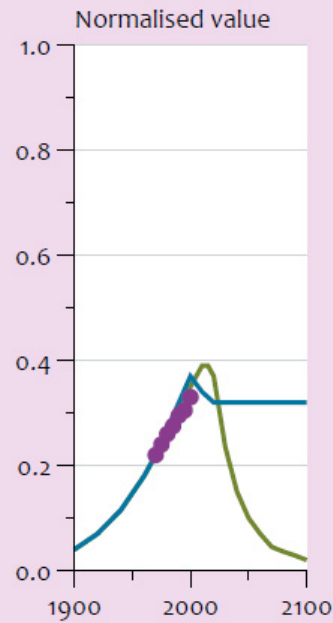
Figure 2.2

Comparing 'Limit to Growth' scenarios to observed global data

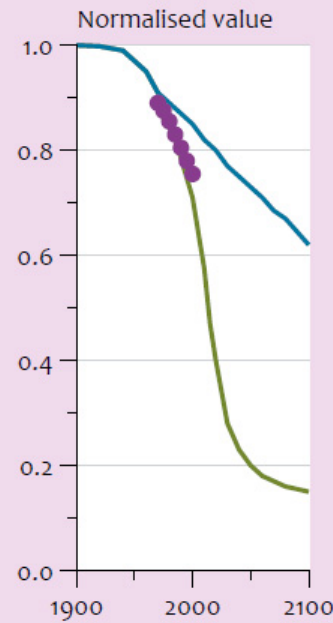
Population



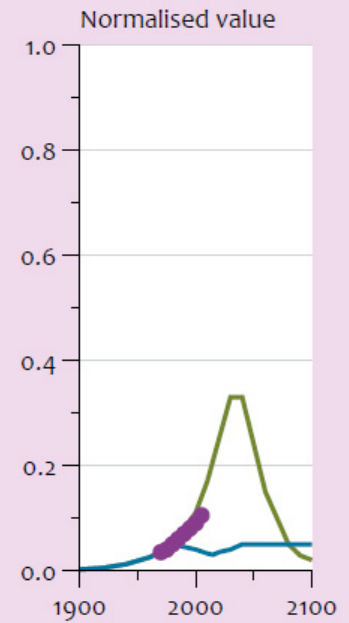
Industrial output



Non-renewable resources



Pollution



'Limit to Growth' scenarios

— Standard run  
— Stabilized world

● Observed data

# NEOLIBERAL VERSUS ECOLOGICAL ECONOMICS

Herman Daly: Ecological (sustainable) economy

- *Neoliberal 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.

# EU DIRECTIVE ON ENERGY CONSERVATION

June 2012

- Energy conservation targets by 2020 confirmed in June 2012.
- Compromise: Original target of 20 % reduction compared to BAU by 2020 reduced to 15-17 % (estimate).
- Reduction compared to 2012: less than 2 % (estimate).
- Utilities are obliged to secure 1.5 % reduction per year of national energy consumption.
- Utilities are obliged to promote district heating and CHP.
- 3 % energy renovation per year of government buildings.
- Energy analysis of all large commercial enterprises.
- Long range national plans for renovation of buildings.

# DANISH BACKGROUND (1)

## Overall framework

- Denmark data: 5,5 million inhabitants; 44,000 km<sup>2</sup> of land, 110 inhabitants per km<sup>2</sup>; 500 islands (rounded numbers).
- No hydro power (no mountains).
- Broad political agreement on new energy programme in March 2012.
- Detailed targets for 2012 to 2020 plus overall targets for 2030 and 2050.
- Energy conservation is promoted by obligations for utilities in co-operation with enterprises and households.
- Detailed policy means for the energy programme supposed to be worked out during 2012 and 2013.

## DANISH BACKGROUND (2)

Examples of targets in national energy agreement

- Wind power to cover 50 % of Danish electricity consumption by 2020 – a doubling compared to 2012 (*ambitious*).
- Renewable energy covering 35 % of total energy by 2020.
- CO2 emission reduced by 34 % by 2020 compared to 1990.
- Coal plants phased out by 2030.
- Oil heaters phased out by 2030.
- Electricity and heat covered completely by RES by 2035.
- Total Danish energy consumption covered by RES by 2050, including transportation.



# WIND POWER IN DANISH ENERGY AGREEMENT

Before 2020

- 1,000 MW new offshore wind at Kriegers Flak (Baltic Sea) and Horns Reef (North Sea).
- 500 MW near-shore wind parks.
- 500 MW new land based wind capacity (total 1.800 MW).
- New land based wind will have reduced environmental premium after January 2014 with total tariff less than 7.7 eurocents per kWh.

# PROJECT GOALS FOR CEESA

Sponsored by Danish Strategic Research Council

- **Overall goal:** Develop detailed scenarios for outphasing of fossil fuels in all sectors of the 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 cost solutions, positive employment and export effects.

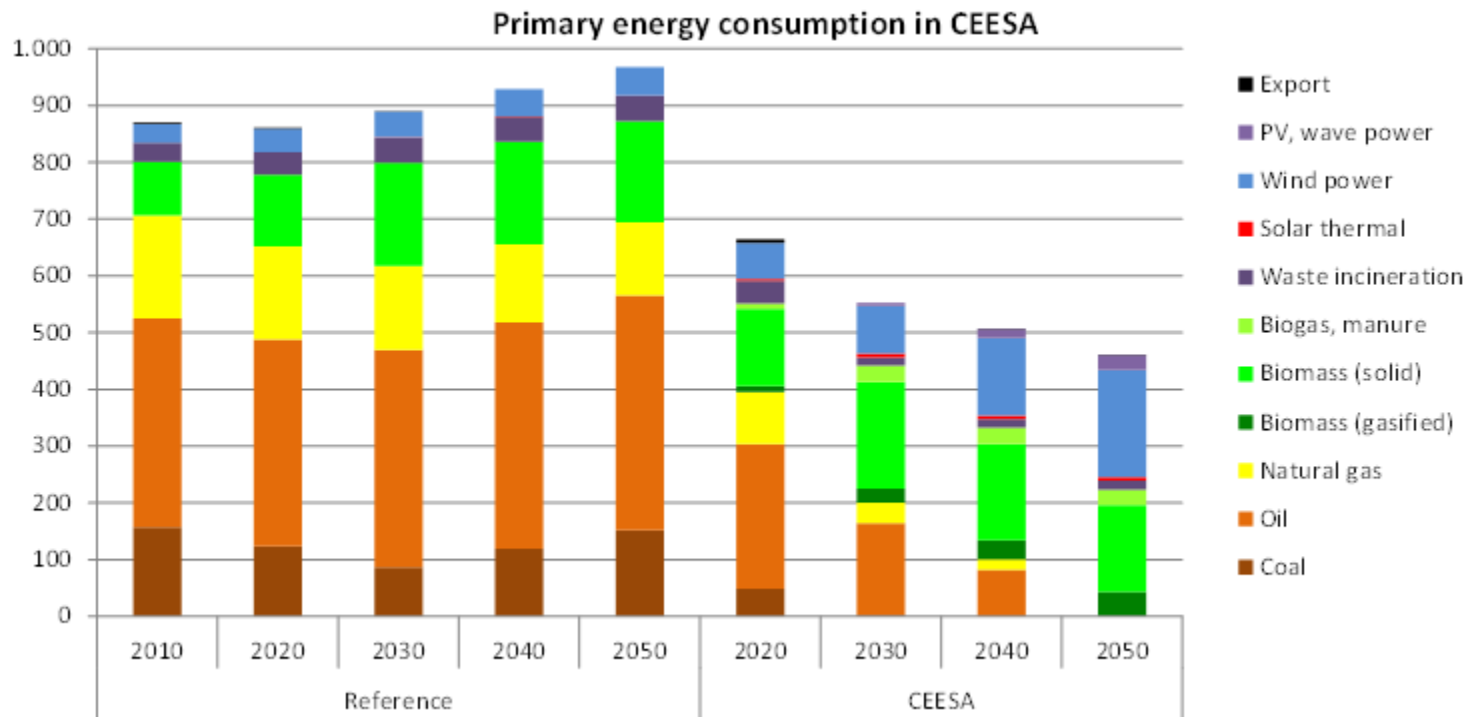
# MAIN CHALLENGES

- Intermittent (fluctuating) 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, neoliberal 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 efficiencies.
- *CEESA-Ideal*: Developing technologies are included.
- *CEESA-2050*: Balanced and realistic assessment of technology improvements and implementations. This is the main scenario.

# RESULTS FOR THE MAIN CEESA SCENARIO



# BIOMASS PROBLEMS

- *Estimated residual Danish 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 efficiencies, 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 2011. 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.*

## MAIN RESULTS FROM CEESA (2)

### Supply of heat

- Annual heat consumption reduced from 800 to 440 PJ – *strict building codes and general renovation of existing houses.*
- 50 % of heat supply from CHP and district heating. (*20 % of electricity from CHP plants*).
- 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 interplay with rest of the energy system (local suboptimisation).



# MAIN RESULTS FROM CEESA (3)

## Transport sector by 2050

- 80 % of cars are electric or hybrid coupled to smart grids.
- Economic incentives or control systems to avoid charging at the same time. Most charging between 11 p.m. and 6. a.m.
- Biomass energy is reserved for aviation, high temperature industrial production 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.*).

## 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 economic 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.

# EXAMPLES 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 energy systems" (including two-way communication).

# POLICY EXAMPLES FROM BUILDING SECTOR

## CEESA-project

- All new houses are 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.*

## 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.

## CONCLUSIONS (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 resource. Primary customers: aviation, high temperature industry and peak CHP plants (gas turbines).
- Land-based wind turbines should offer local ownership and have a maximum capacity of 2 MW to avoid opposition.

# CONCLUSIONS (3)

## Personal reflections on international solutions

- 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.
- Rich countries can afford a general *citizens salary*.
- New institutional frameworks and taxation systems.
- Precautionary Principle - No new coal plants without CCS.
- 50 % of known coal and oil reserves to remain underground in order to keep global temperature increase below 2 degrees.

**THANK YOU FOR YOUR ATTENTION**

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