Benefits of 100% renewable energy systems for Denmark - the IDA Climate Plan 2050

2011 Workshop – The road to 100% Renewable Energy Systems

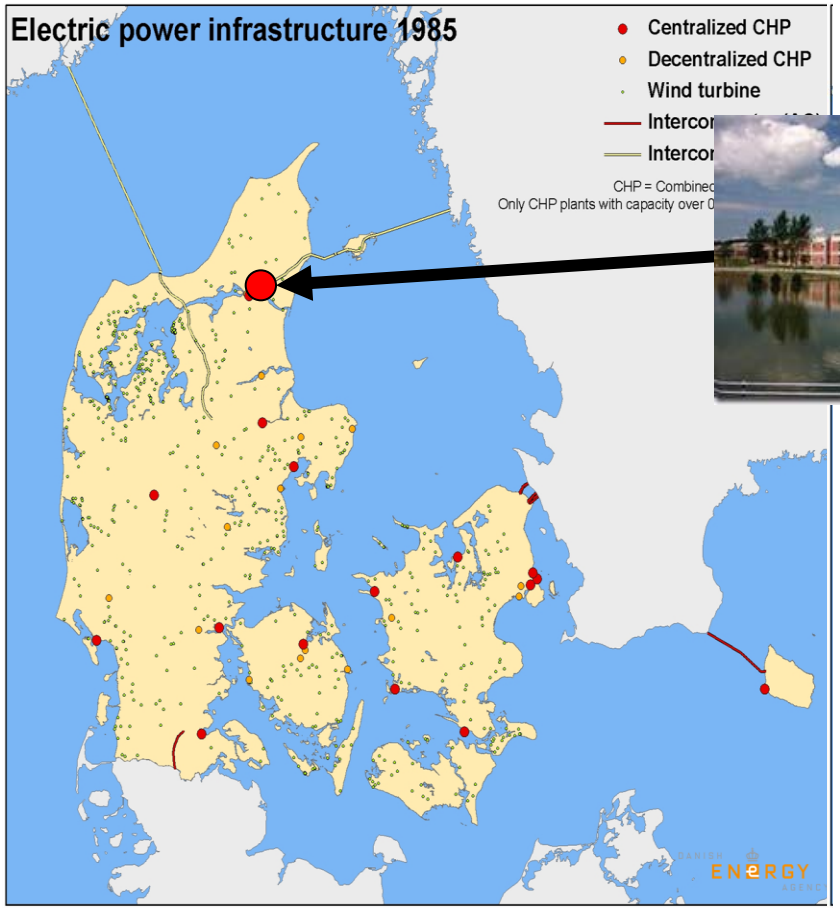
Milpitas – Silicon Valley, California, August 1, 2011

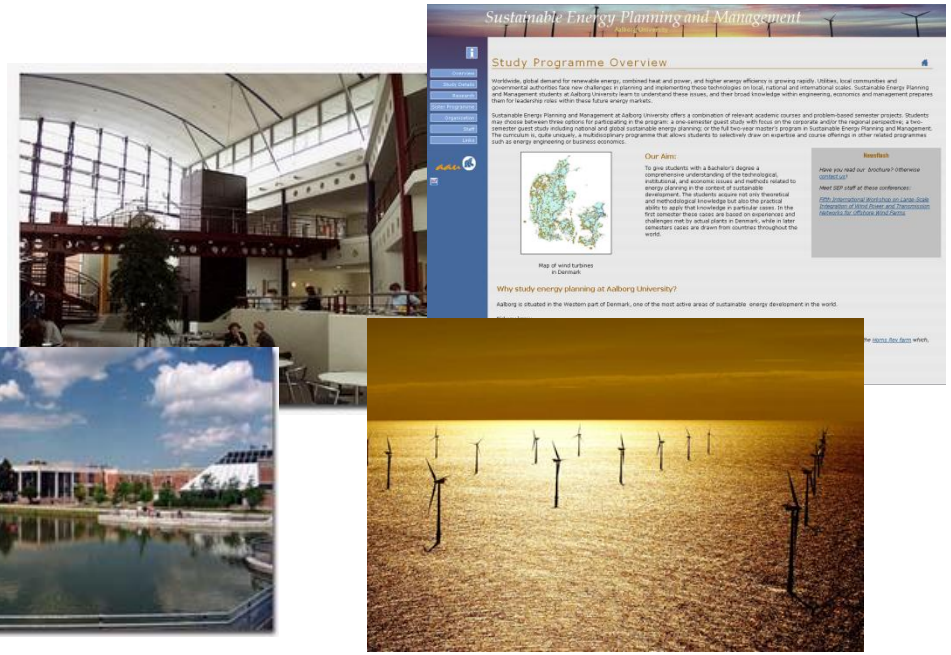
Associate Professor, Dr. Brian Vad Mathiesen

Department of Development and Planning, Aalborg University

people.plan.aau.dk/~bvm/

General introduction

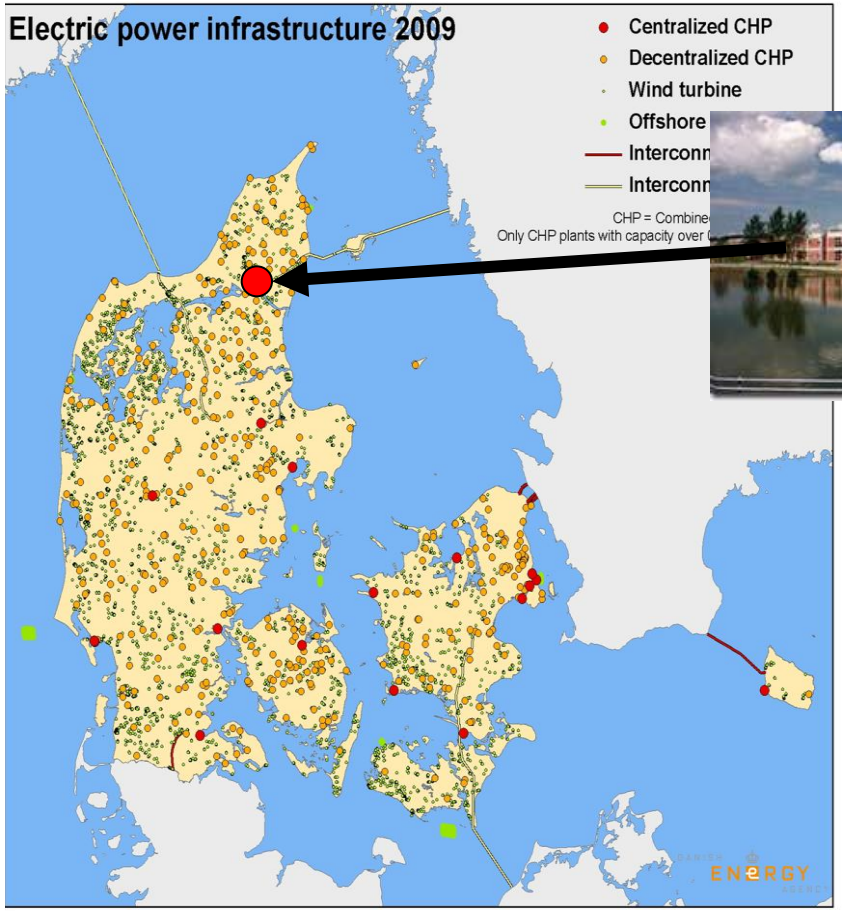


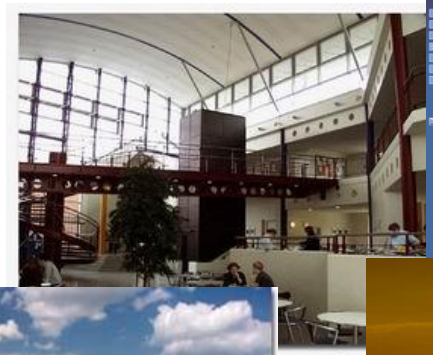


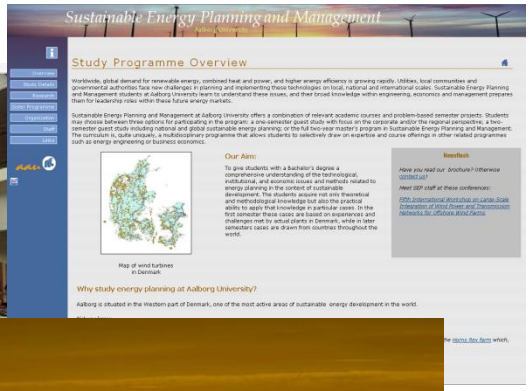
Aalborg University, Denmark

- Master of Sustainable Energy Planning and Management
- PhD courses within the area
- More information at www.energyplanning.aau.dk

General introduction



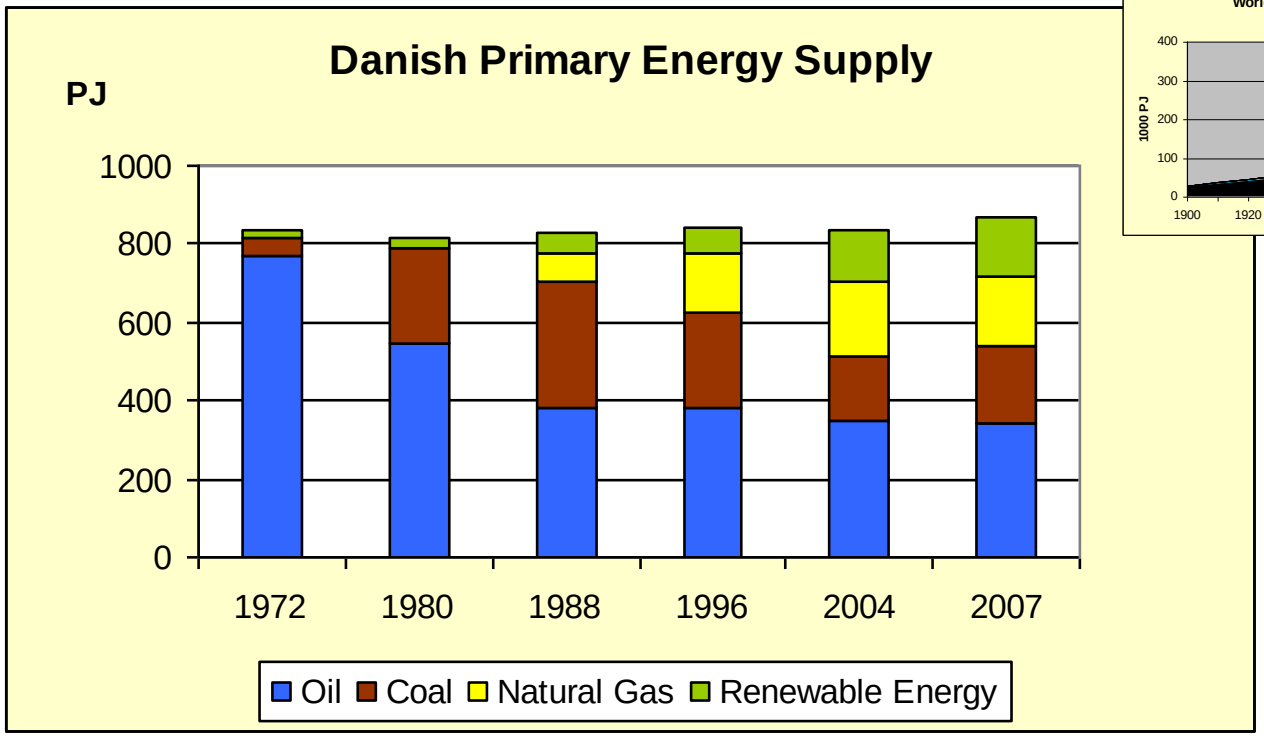


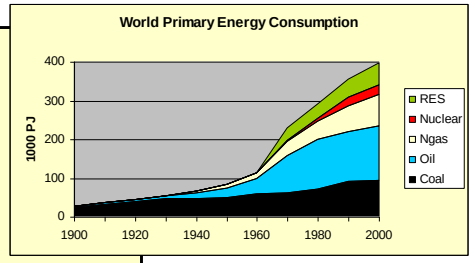


Denmark

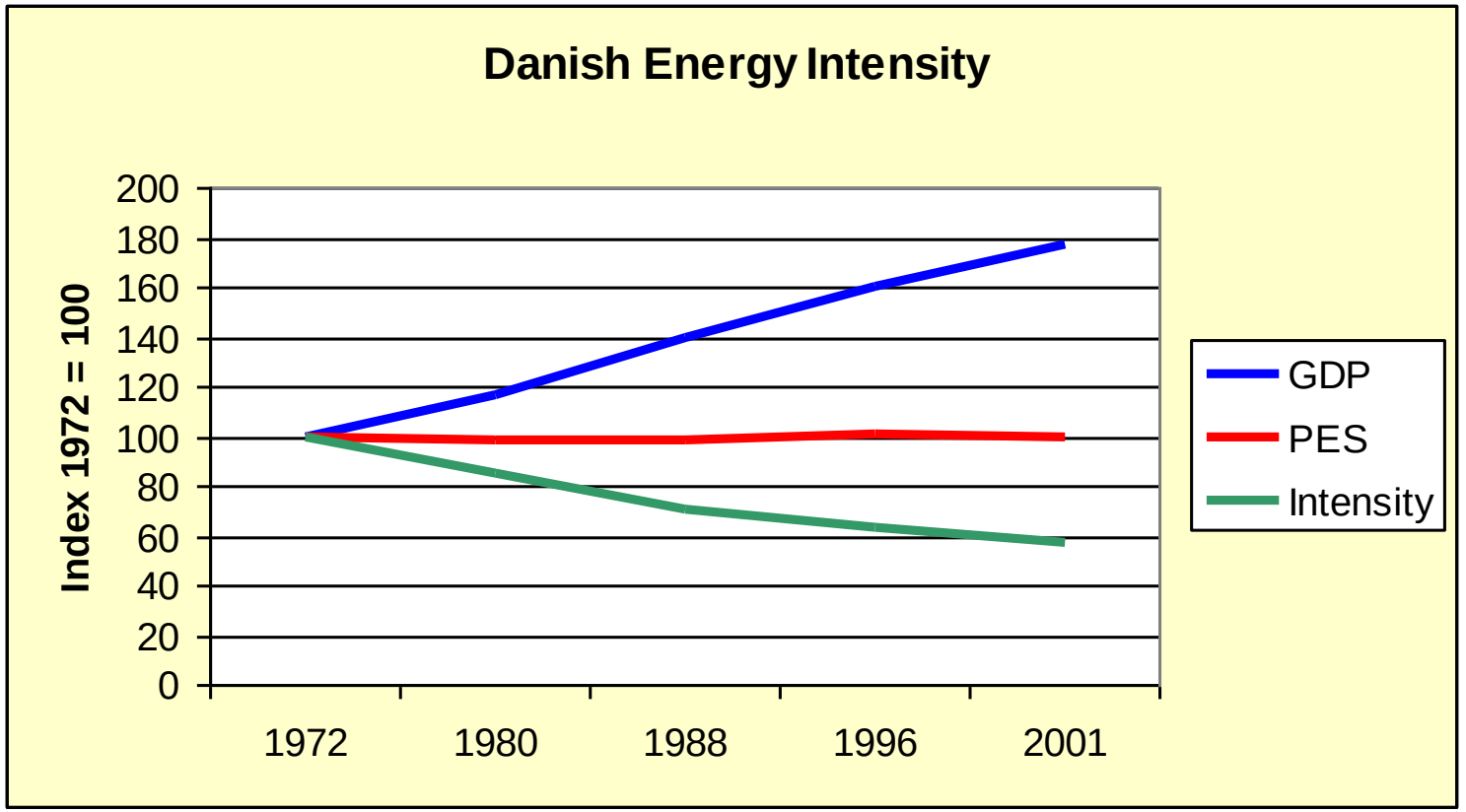
- 22% wind power
- 120,000 owners of wind turbines (of 5. mill.)
- High share of the world's offshore power
- (800 MW going on 1.200 MW)
- More than 30% distributed generation
- 50% of electricity from CHP
- Comprehensive energy conversation policy

Four decades of years of stable energy consumption with an active energy policy





Energy and Economic Growth in Denmark



40 years of active Energy Planning

- 40 years of active Government and Parliament Energy Policies.
- Active Energy Policy put on hold by new government in 2001
- NGO strategies and public debate in more than 40 years

The long-term Objective of Danish Energy Policy

Expressed by former Prime Minister Anders Fogh Rasmussen in his opening speech to the Parliament in 2006 and in several political agreements since then:

To convert to 100% Renewable Energy

Former Prime Minister Rasmussen 16 November 2008:
"We will free Denmark totally from fossil fuels like oil, coal and gas"
"… position Denmark in the heart of green growth"

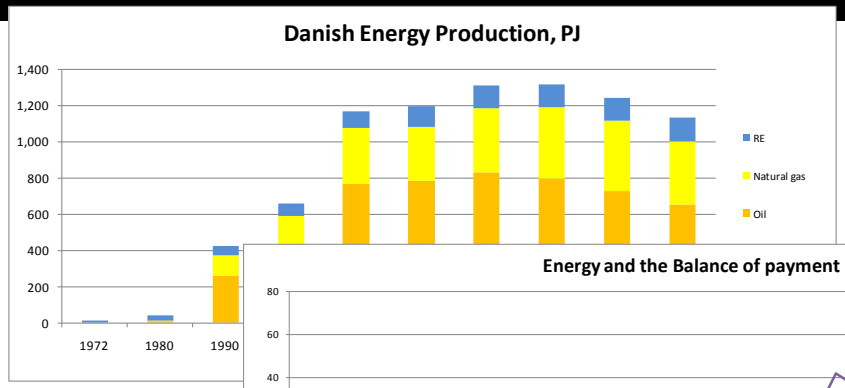
Prime Minister Lars Løkke Rasmussen 6 October 2009:
"… before the next general elections we will present a plan of how and when Denmark will be free of fossil fuels"

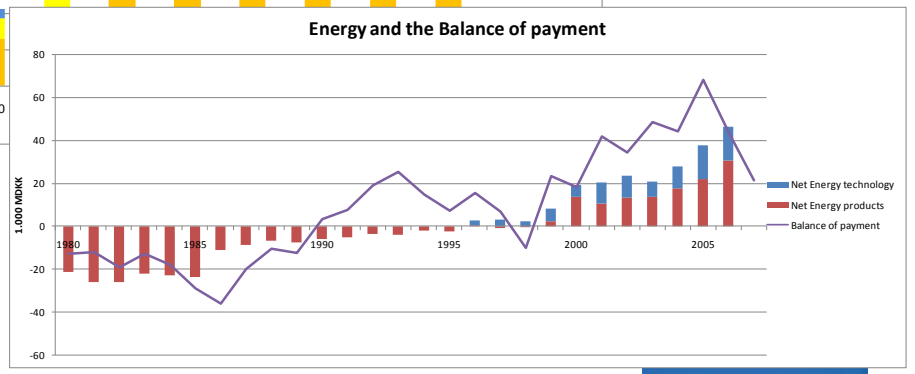
One scenario out of many possible pathways

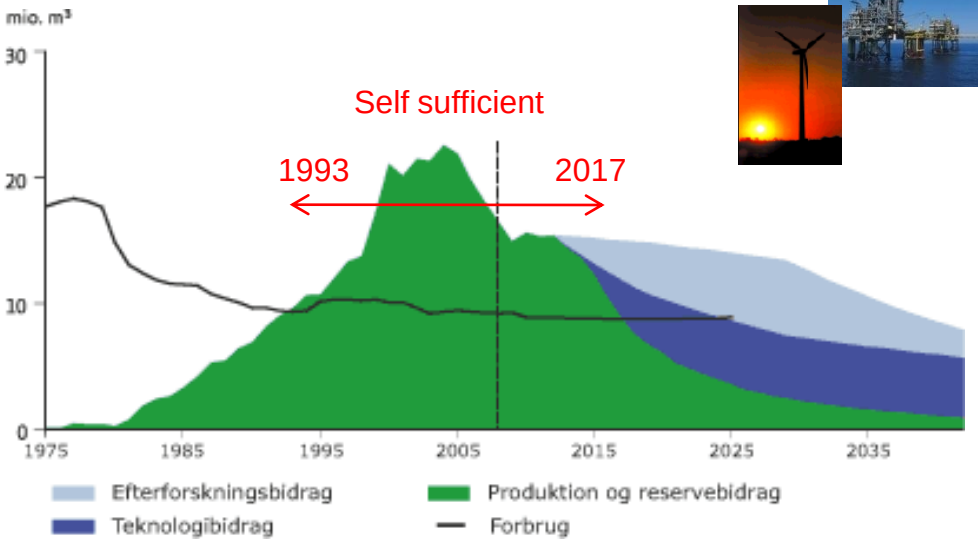
- IDA's Climate Plan 2050
  (IDA: The Danish Society of Engineers)
  - Consists of:
    - Main report
      (also available in English)
    - Technical background report
      (also available in English)
    - 9 other technical reports

The IDA Climate Plan 2050

- 4 targets
  - To reduce the emission of green house gasses by 90% in 2050 (including farming)
  - To maintain security of energy supply
  - To expand Denmark's position within energy and climate technologies
  - To improve the Danish economy and prosperity







Danish Energy Authority, 2008

Future Climate
Engineering Solutions

The IDA Climate Plan 2050

- Builds on two previous plans:
  IDAs Energy Plan 2030 (2006), Green future (2008)
  - Inputs based on 40 meetings and seminars conducted by the IDA groups and societies
  - More than 1600 participants
- More than 15 seminars and workshops following up on with updates of inputs
- Draft report presented on the May 11, 2009
- Subject to a public hearing until May 21, 2009
- Coordination by the IDA Committee for energy and climate and 12 groups of professionals
- Overall technical and socio-economic analyses at Aalborg University

AALBORG UNIVERSITY

The IDA Climate Plan 2050

- Input from 6 themes by IDAs groups
  - Energy systems and energy production
  - Agriculture
  - Industry, process and service
  - Buildings
  - Transportation and mobility
  - Climate adaptation

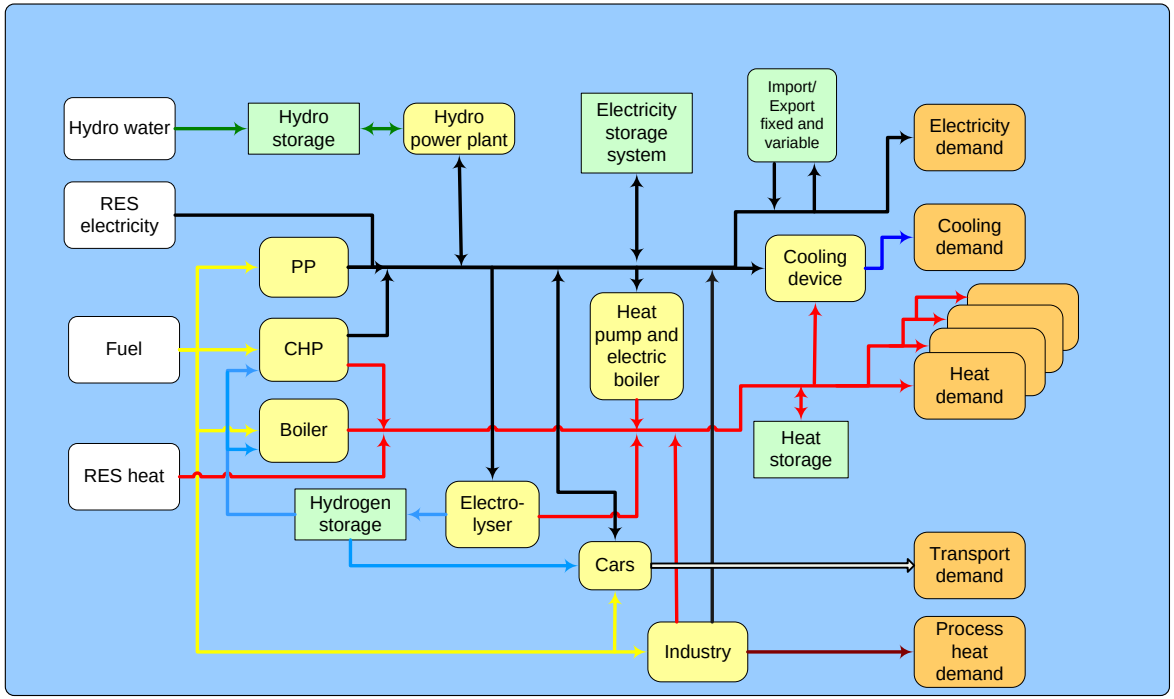
- Type of inputs:
  - Technology characteristics, costs and future potentials

For each theme
- Knowledge-seminar
- Future-seminar
- Roadmap-seminar
- Reality check

Coherent energy systems analyses

- Technical energy system analyses.
  - Potentials and problems?
  - Barriers and synergies?
  - System solutions?

- Socio-economic analyses.
  - Good and bad proposals?
  - What proposals make up a coherent total energy plan?
  - What is the total costs?
  - What are the abilities to profit from international trade?

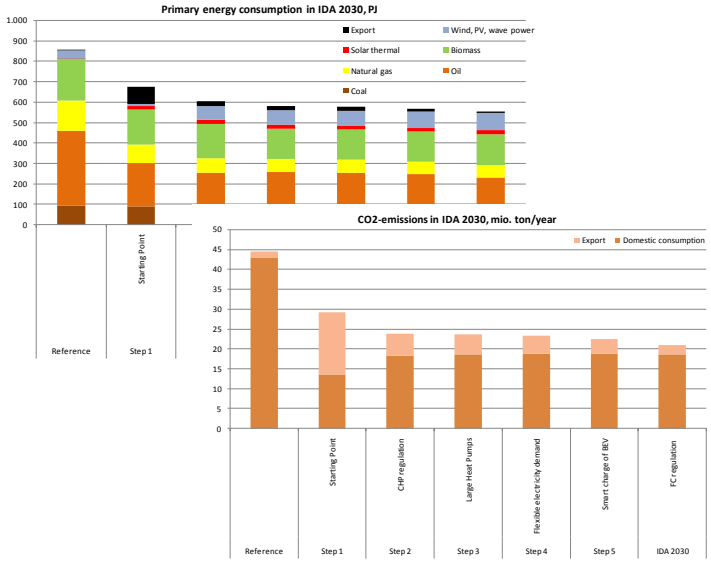


- EnergyPLAN energy system analyses model
  - Planning model
  - Deterministic input/output model
  - Enables modelling of radical changes
  - Integration of electricity, heat and transport sectors
  - Modelling of large-scale integration of renewable energy
  - Separation of technical and economic modelling not bound by current institutional schemes

www.EnergyPLAN.eu

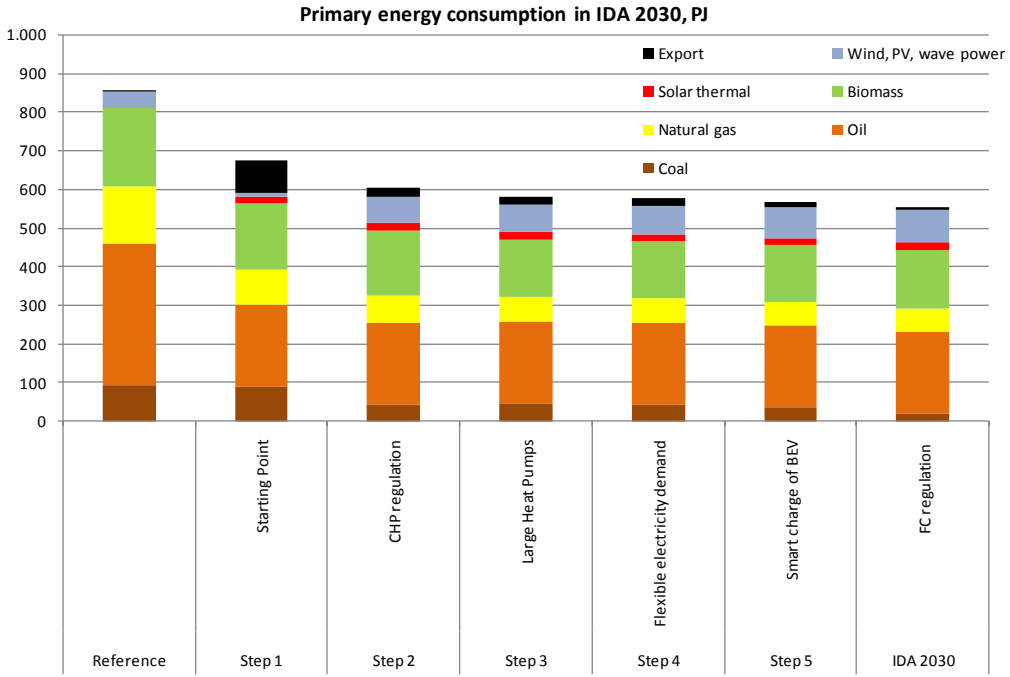
Technical energy system analyses of IDA 2030

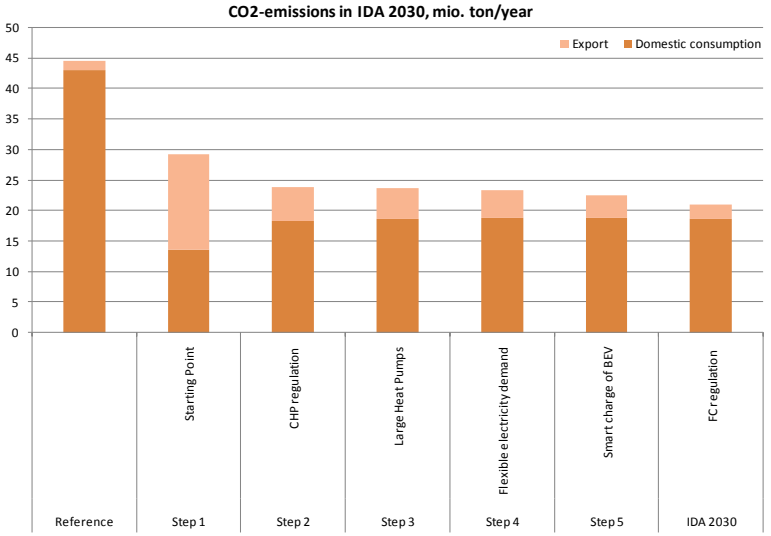
- Objectives:
  - Reduce excess electricity
  - Decrease fuel demand



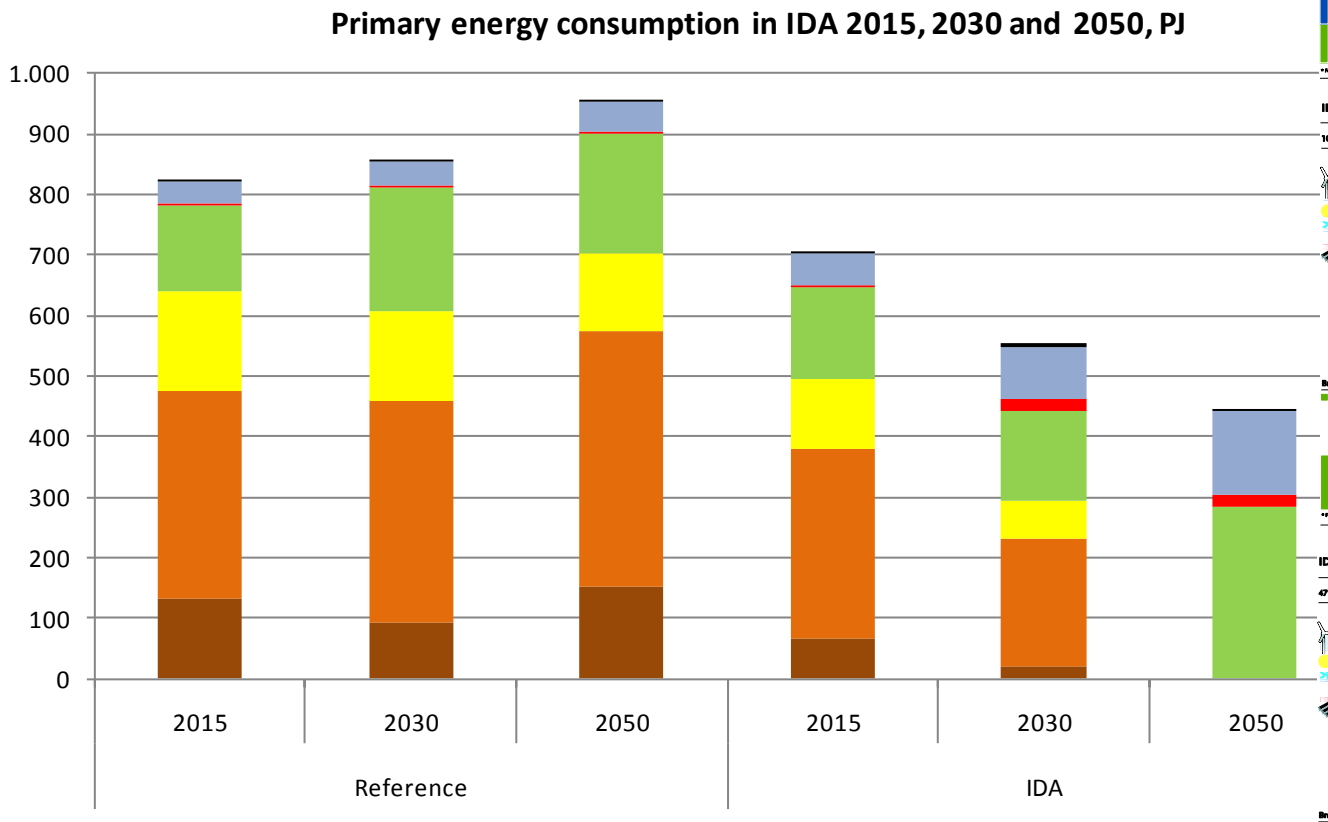
	Excess electricity	Boiler share
Step 1: Starting Point	44%	10%
Step 2: CHP regulation	17%	36%
Step 3: Large Heat Pumps	16%	15%
Step 4: Flexible electricity demand	14%	16%
Step 5: Smart charge of battery electric vehicles	10%	20%
Step 6: FC regulation	5%	23%

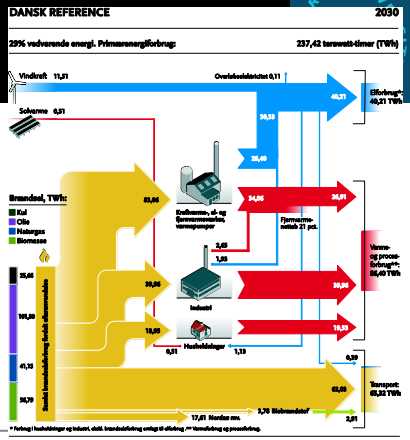
IDA 2030


Primary energy consumption in IDA 2030, PJ
1.000
900
800
700
600
500
400
300
200
100
0
Export
Wind, PV, wave power
Solar thermal
Biomass
Natural gas
Oil
Coal
Reference
Step 1
Starting Point
Step 2
CHP regulation
Step 3
Large Heat Pumps
Step 4
Flexible electricity demand
Step 5
Smart charge of BEV
IDA 2030
FC regulation

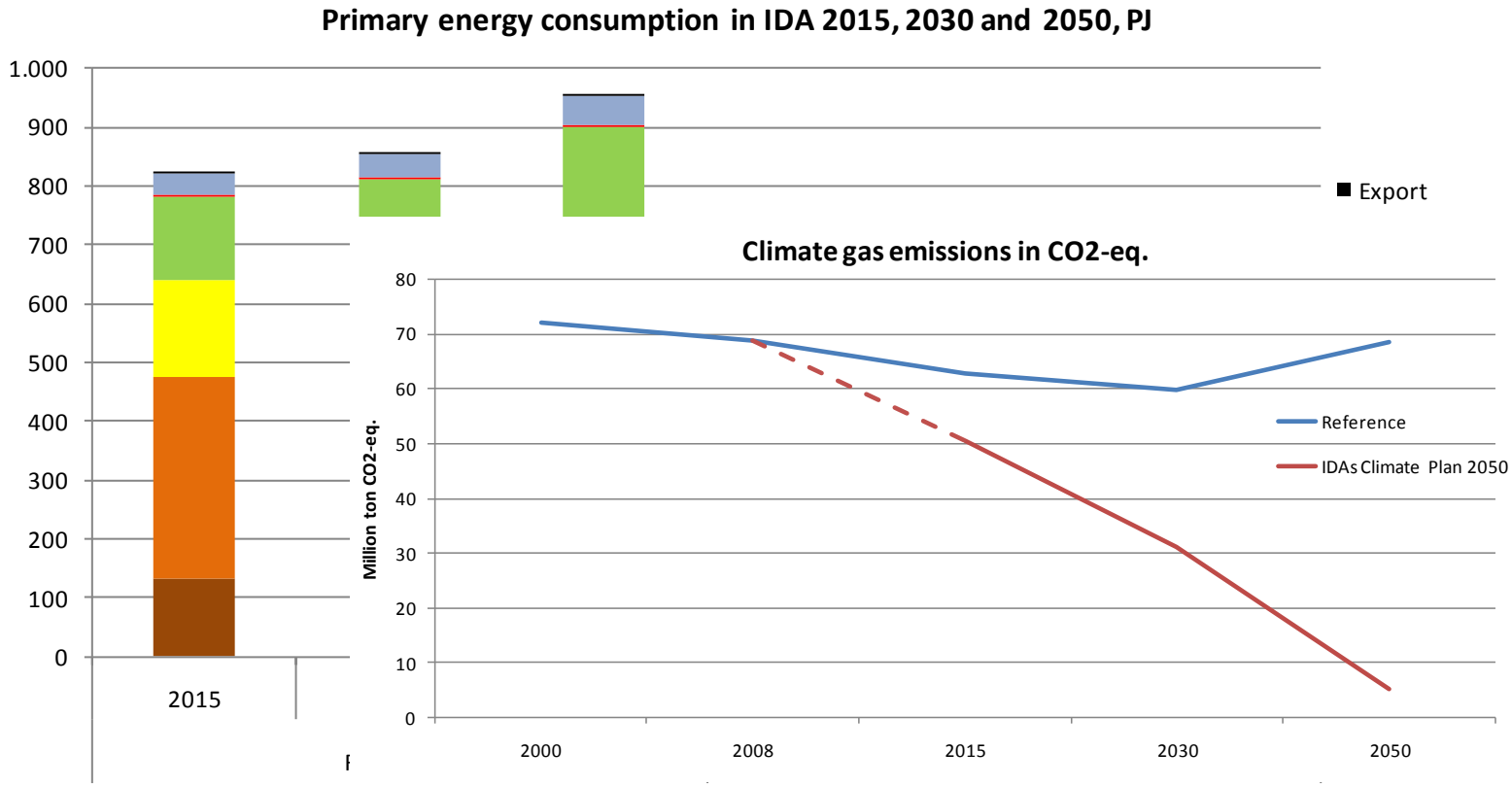

CO2-emissions in IDA 2030, mio. ton/year
50
45
40
35
30
25
20
15
10
5
0
Export
Domestic consumption
Reference
Step 1
Starting Point
Step 2
CHP regulation
Step 3
Large Heat Pumps
Step 4
Flexible electricity demand
Step 5
Smart charge of BEV
IDA 2030
FC regulation

Technical comparison

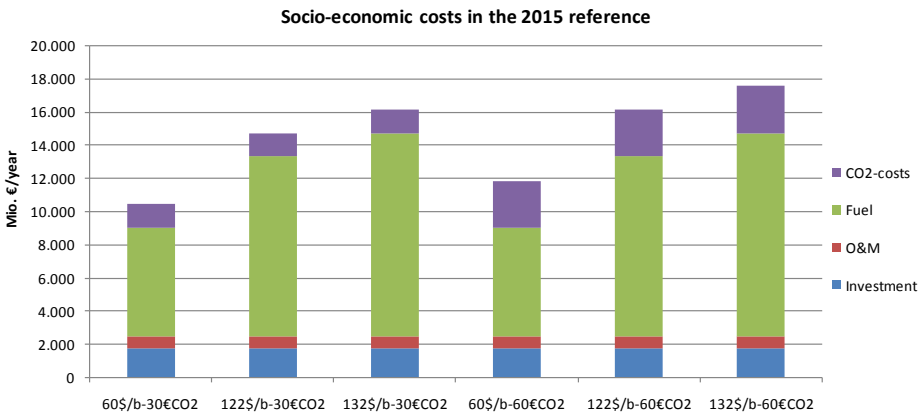


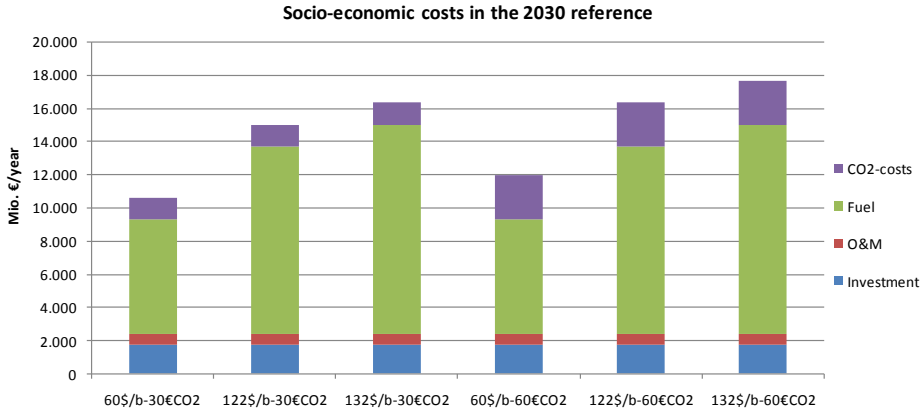


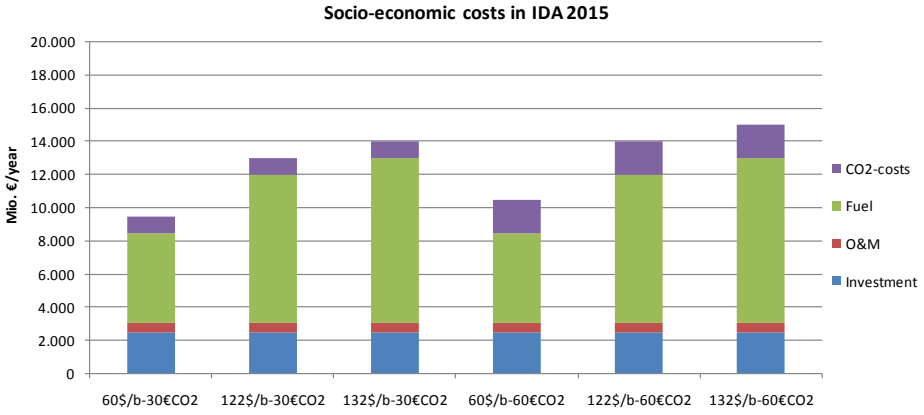
Technical comparison

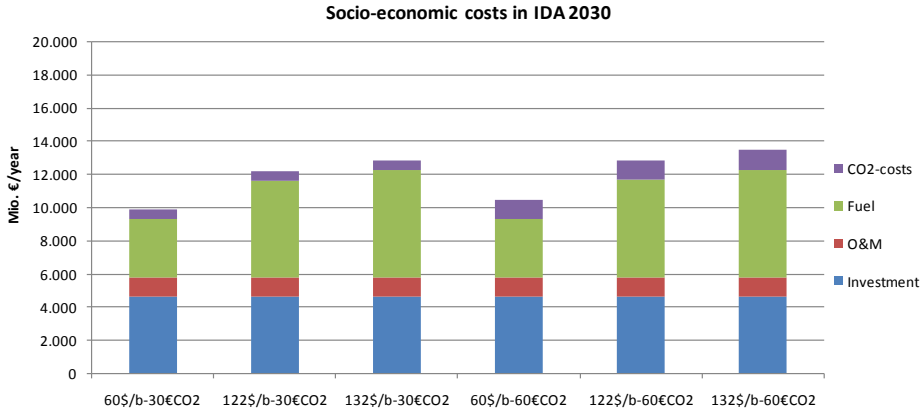


Socio-economic costs

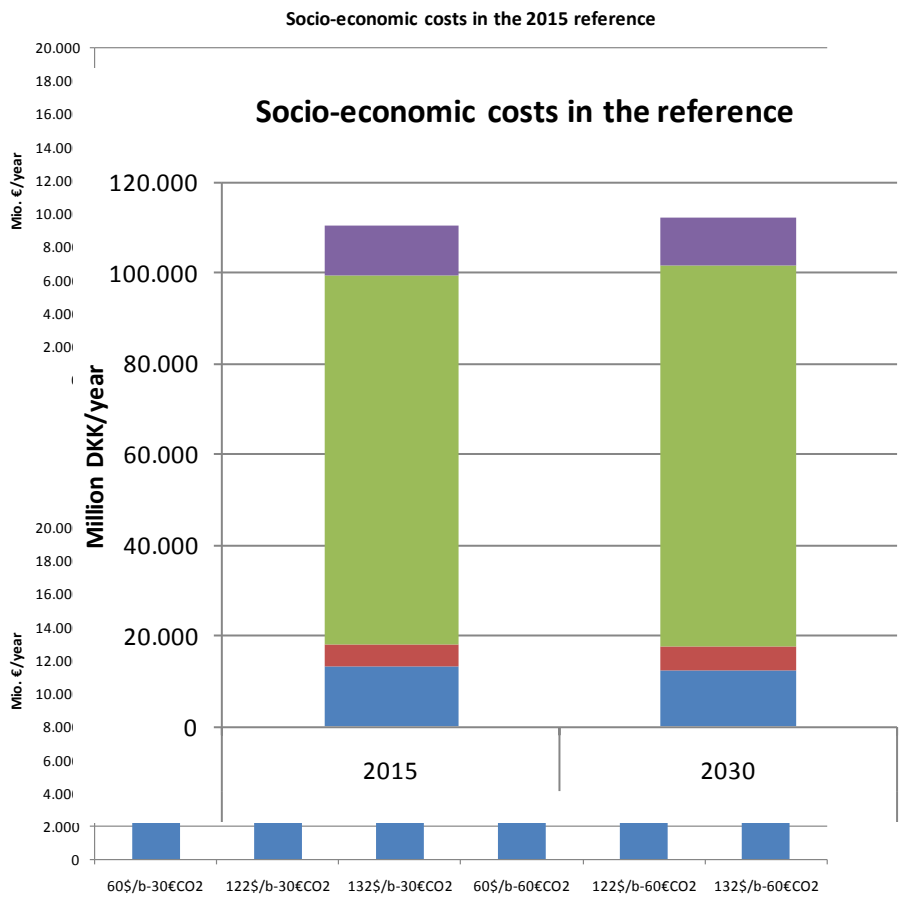


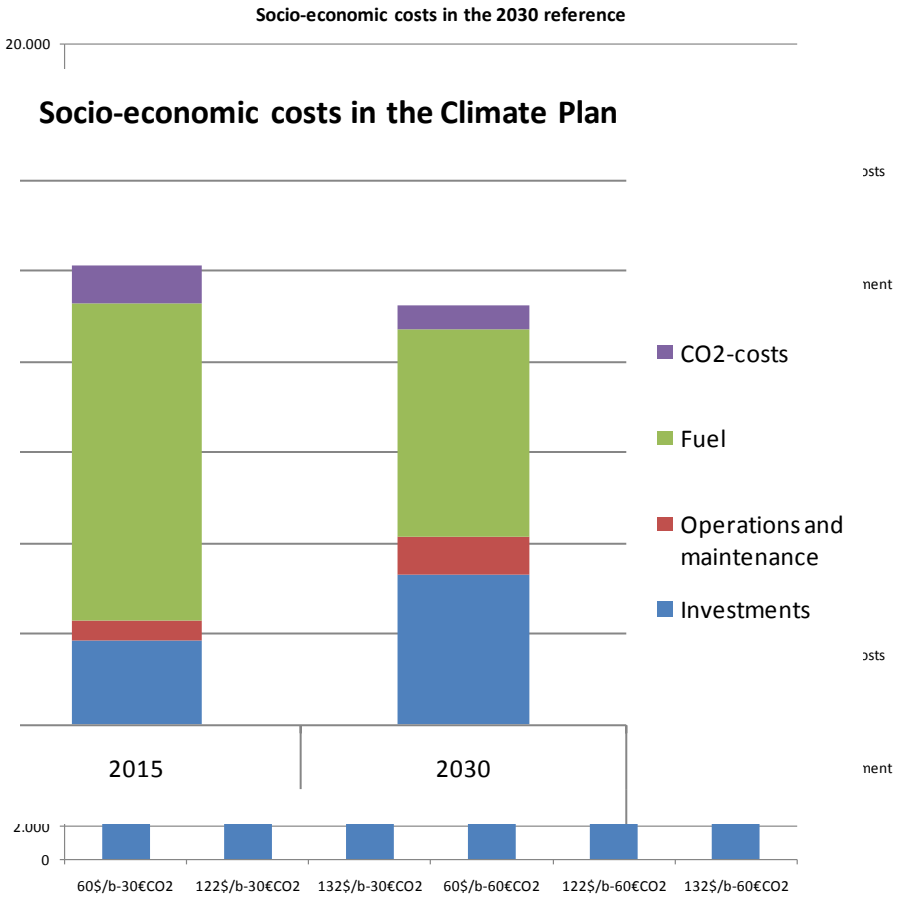


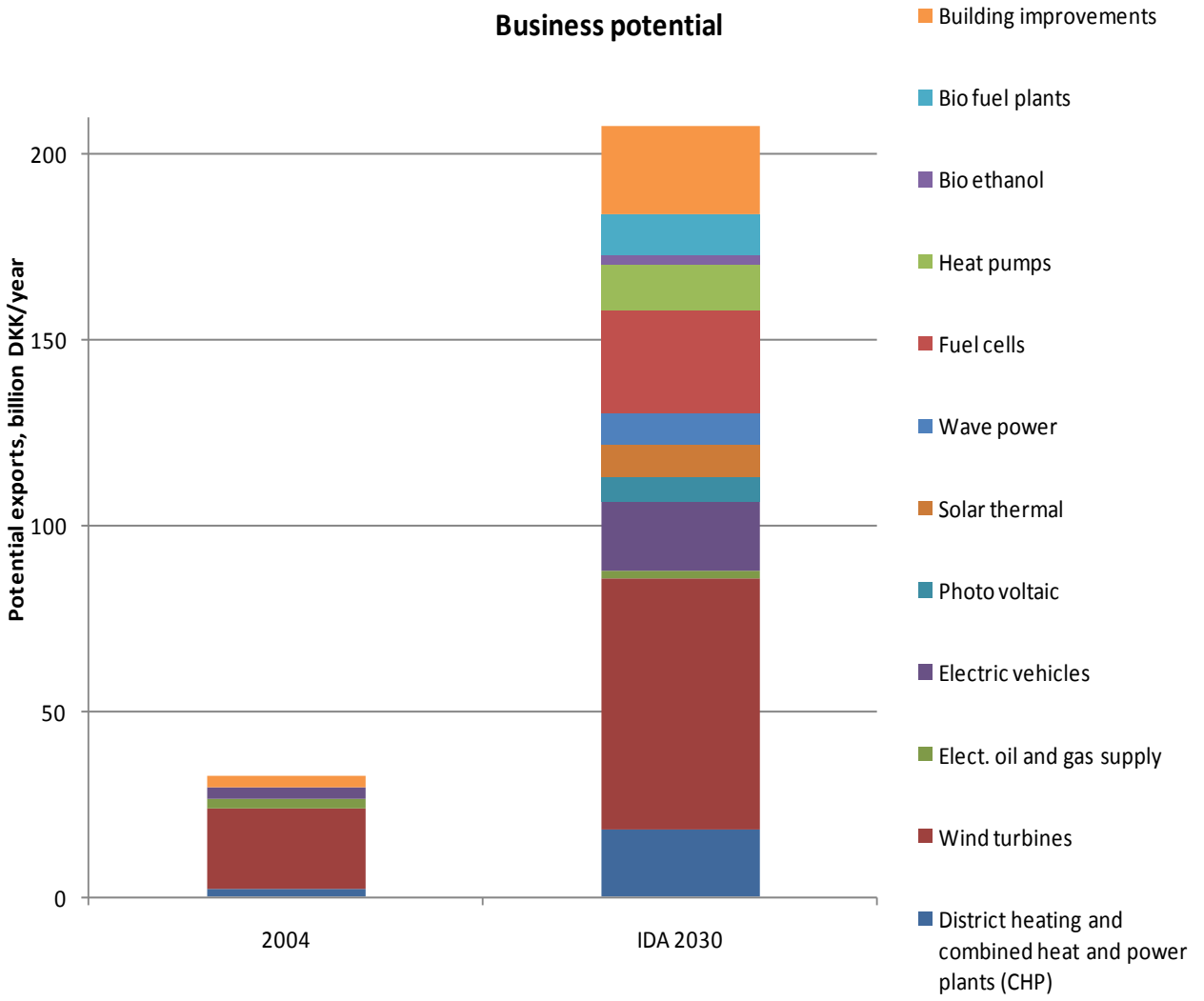




Socio-economic costs







- Status 2008 approx. 64 mia. DKK and approx. 30.000 jobs
- IDAs Energy Plan 2030 from 2006: 160 mia. DKK
- Association of Danish Industry and the energy Industry in: 200 mia. DKK and approx. 60.000 jobs

Please note that such estimates, are associated with significant uncertainties

Job effects

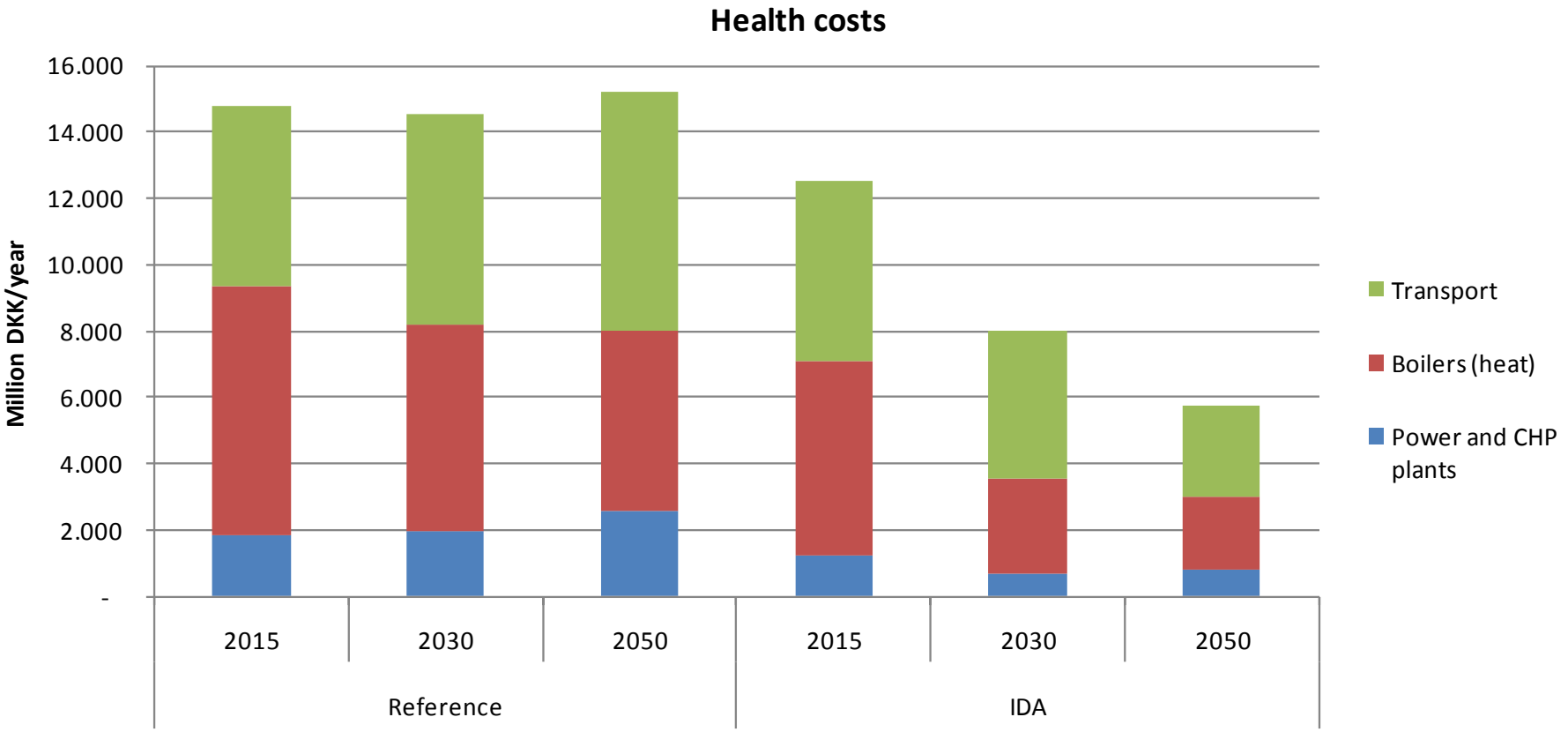
- The extra jobs created in the Climate Plan compared to the reference are in the range of 30.000-40.000 in the period towards 2050
  - Fewer jobs for fossil fuel handling
  - Jobs created from investments in renewable energy technology, in building improvements and in the handling of biomass
  - The amount of jobs in the short term depends on when the initiatives are started
  - In the long term, when the Climate Plan is fully implemented the extra employment will fall to approx. 15.000

	2010	2030	2050
Fuels	-2,929	-16,431	-4,177
Operations and Maintenance	-451	5,838	18,312
Inv. (Civil works)	23,450	22,190	20,930
Inv. (Prod. & Machinery)	9,420	9,300	9,180
Total	29,490	20,898	44,245

Job effects

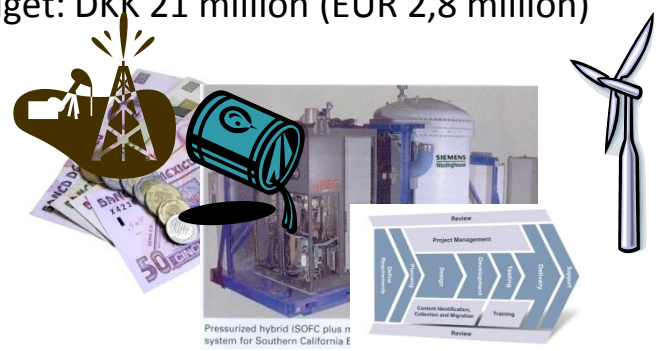
- There are two reasons to start the conversion in the beginning of the period towards 2050:
  - Labour is available in the beginning of the period as the work force of the total population is falling towards 2040
  - More and more labour will be available as fossil fuels in the North See becomes less and less.
- Additional potential job effects as a result of the potential for increased export:
  - Approx. 200.000 jobs (with 50 per cent import share)
- ***Please note that such estimates, are associated with significant uncertainties***

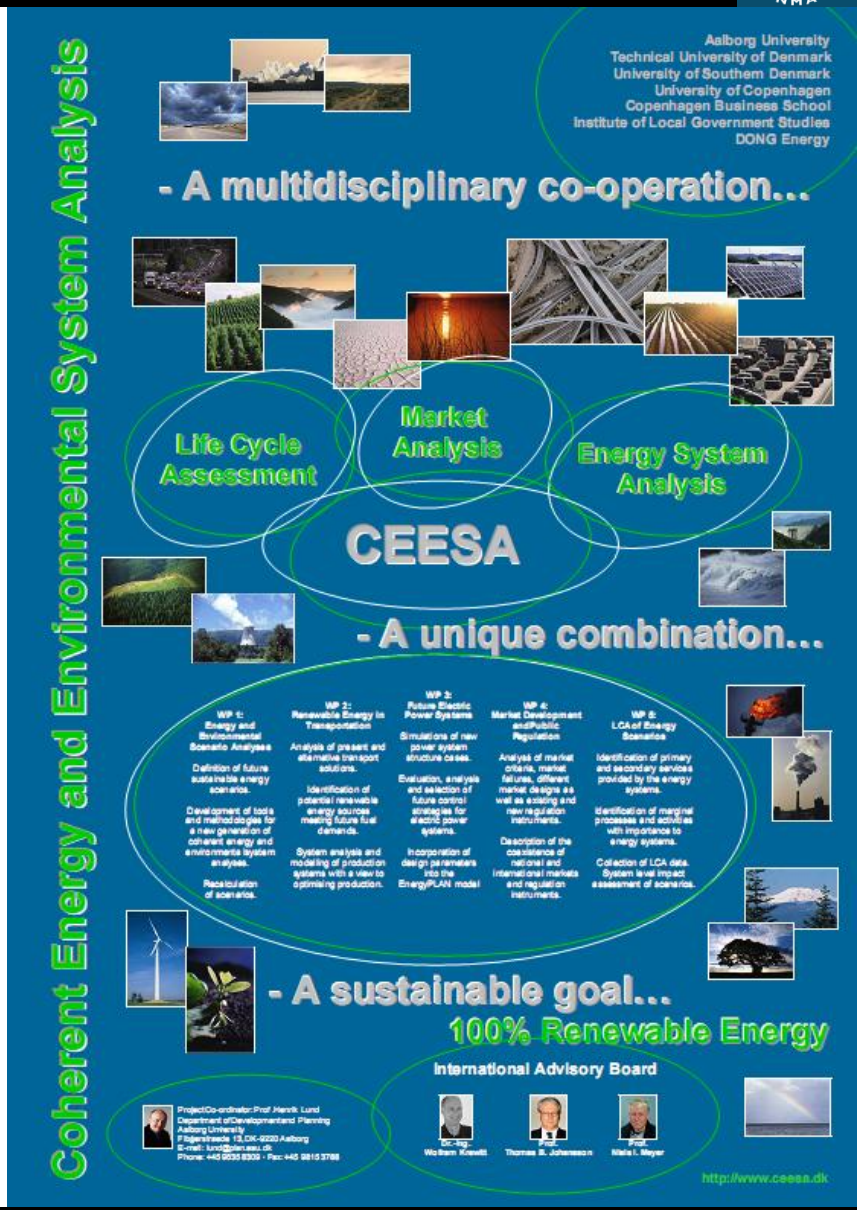
Health costs in the Climate Plan



CEESA Overall Objective

- Coherent Energy and Environmental System Analyses www.ceesa.dk
- A multi-disciplinary co-operation involving:
  - Life cycle assessment
  - Market analyses
  - Energy system analyses
- Goal – pathway to implementing and technically handling 100% renewable energy system and coherent analysis of 100 per cent renewable energy systems
- To integrate existing energy and environmental analysis tools through a combination of life cycle assessment (LCA) and energy system and market analysis methodologies (ESA).
- Budget: DKK 21 million (EUR 2,8 million)





Summary and conclusions

- Showing what may be possible is important to illustrate and document possible changes
- IDA's Climate Plan 2050 has already had that effect in Denmark
- The results in the Climate Plan are:
  - 100% renewable energy systems will be technically possible
  - In the short term the Danish society can benefit from lower costs
  - In the long term the cost of 100% renewable energy systems are potentially lower than traditional systems (the total system)
  - The total emissions of green house gasses incl. Agriculture can be reduced by 90%.
  - There are additional potential benefits for job creation, export and lower health related costs.
  - 80% of technologies invested in are known today

Thank you

- 100% Renewable energy systems, climate mitigation and economic growth. /Mathiesen, Brian Vad ; Lund, Henrik ; Karlsson, Kenneth. In: Applied Energy, Vol. 88, No. 2, 02.2011, p. 488-501.
- IDA´s klimaplan 2050 : Tekniske energisystemanalyser og samfundsøkonomisk konsekvensvurdering - Baggrundsrapport. (IDA's Climate Plan 2050, Background Report) / Mathiesen, Brian Vad ; Lund, Henrik ; Karlsson, Kenneth. København V. : Ingeniørforeningen i Danmark, IDA, 2009. 174 p..

2011 Workshop – The road to 100% Renewable Energy Systems

Milpitas – Silicon Valley, California, August 1, 2011

Associate Professor, Dr. Brian Vad Mathiesen

Department of Development and Planning, Aalborg University

people.plan.aau.dk/~bvm/