

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

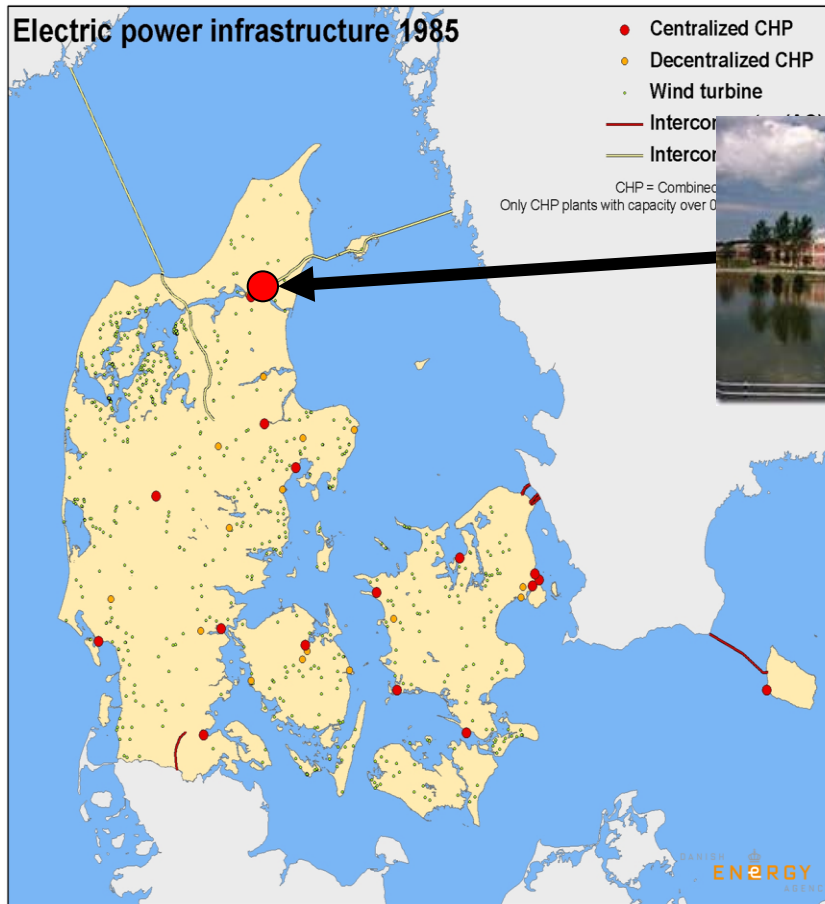
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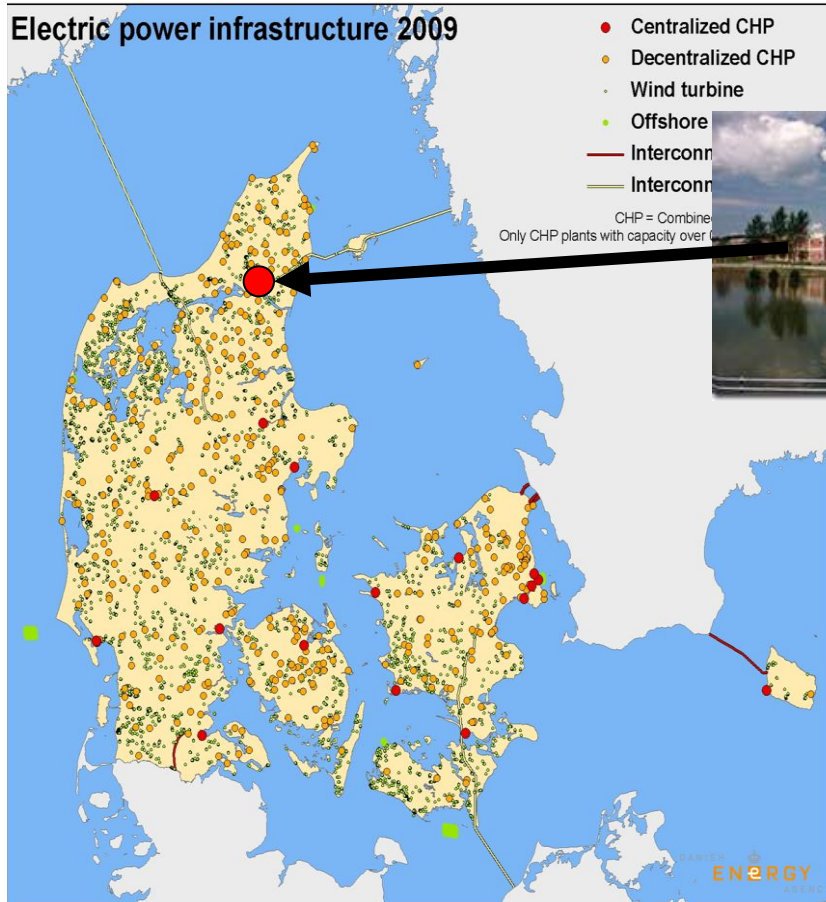
General introduction




Aalborg University, Denmark

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

General introduction



Sustainable Energy Planning and Management

Study Programme Overview

Worldwide, global demand for renewable energy, combined heat and power, and higher energy efficiency is growing rapidly. Leaders, local communities and governmental authorities face new challenges in planning and implementing these technologies on local, national and international scales. Sustainable Energy Planning and Management students at Aalborg University learn to understand these issues, and their broad knowledge within engineering, economics and management prepares them for leadership roles within these future energy markets.

Sustainable Energy Planning and Management at Aalborg University offers a combination of relevant academic courses and problem-based seminar projects. Students can choose between three options for participating in the program: a minor seminar project course with focus on the regional and/or the national perspective, a two-semester part-time evening program and a full-time sustainable energy planning. In the full-time master program in Sustainable Energy Planning and Management, the curriculum is split uniquely, a multidisciplinary programme that allows students to selectively draw on expertise and course offerings in other related programmes such as energy engineering or business economics.

Our Aim:
To give students with a Bachelor's degree a comprehensive understanding of the technological, institutional, and economic issues and methods related to energy planning in the context of sustainable development. The students acquire not only theoretical and methodological knowledge but also the practical skills to solve their own energy planning tasks. In the first semester these topics are based on engineering and challenges met by actual plants in Denmark, while in later semesters cases are drawn from countries throughout the world.

Benefits:
Have you read our brochure? Otherwise contact us!
Meet some staff at these conferences:
[EHP International Conference on Large Scale Integration of Wind Power and Distributed Generation](#)
[Sustainable Energy Planning and Management](#)

Map of wind turbines in Denmark

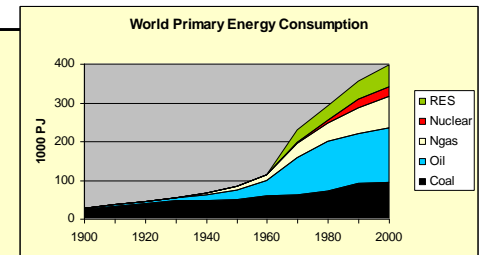
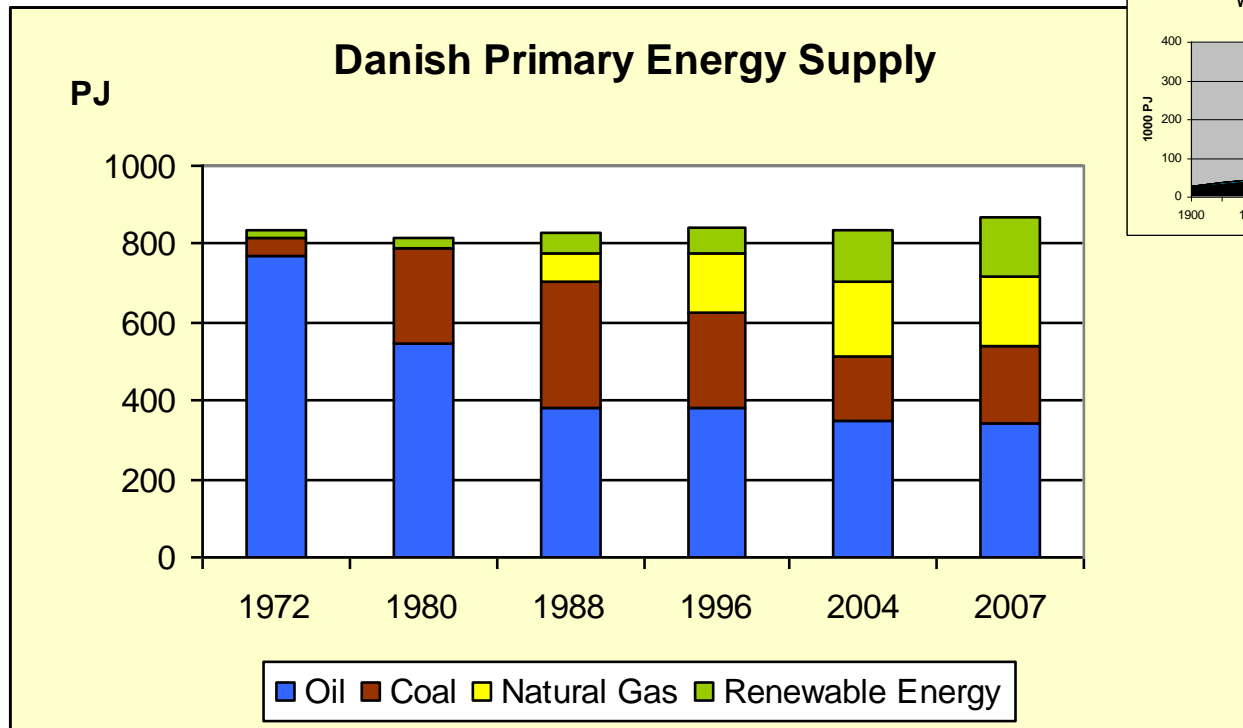
Why study energy planning at Aalborg University?
Aalborg is situated in the western part of Denmark, one of the most active areas of sustainable energy development in the world.



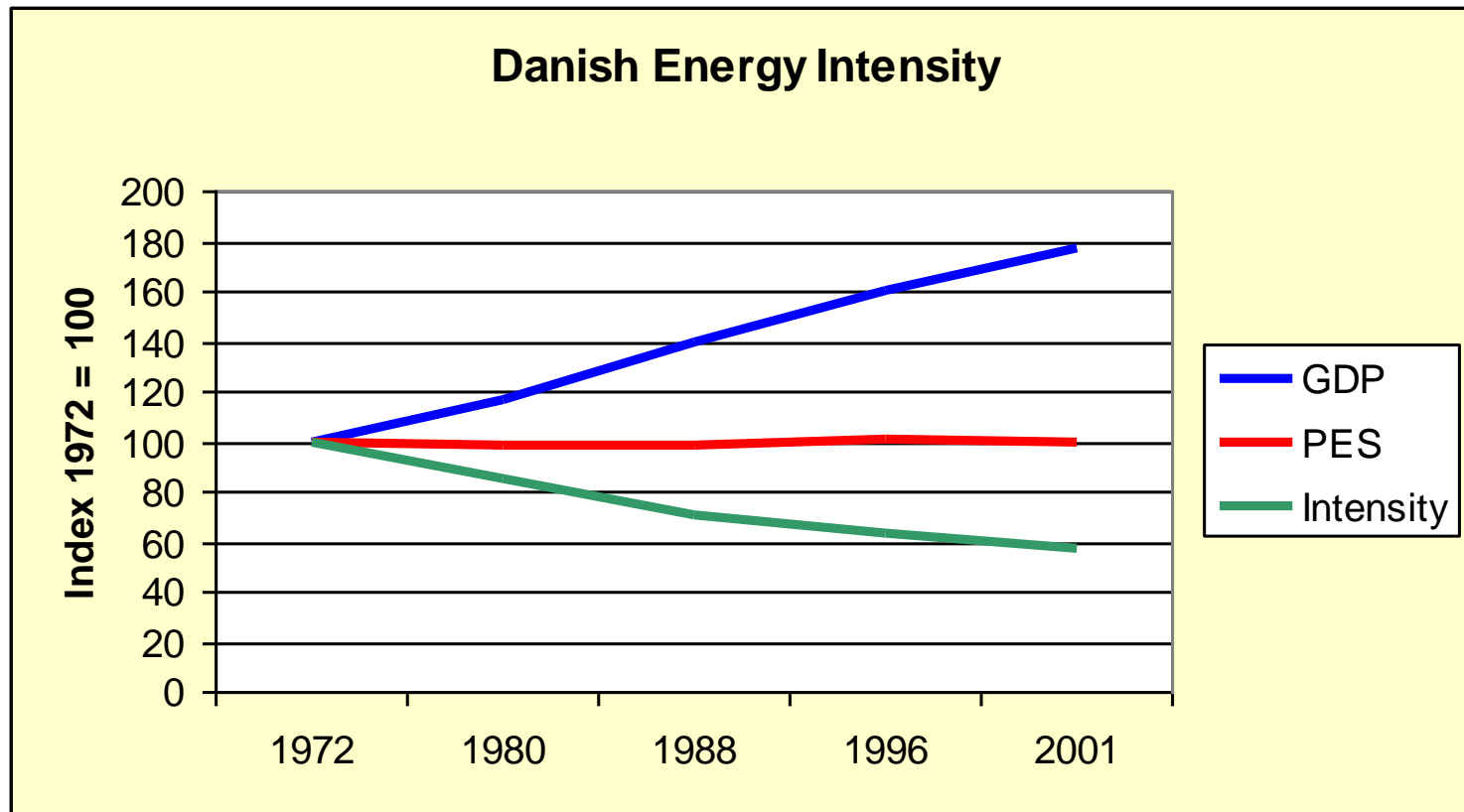
Denmark

- 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)

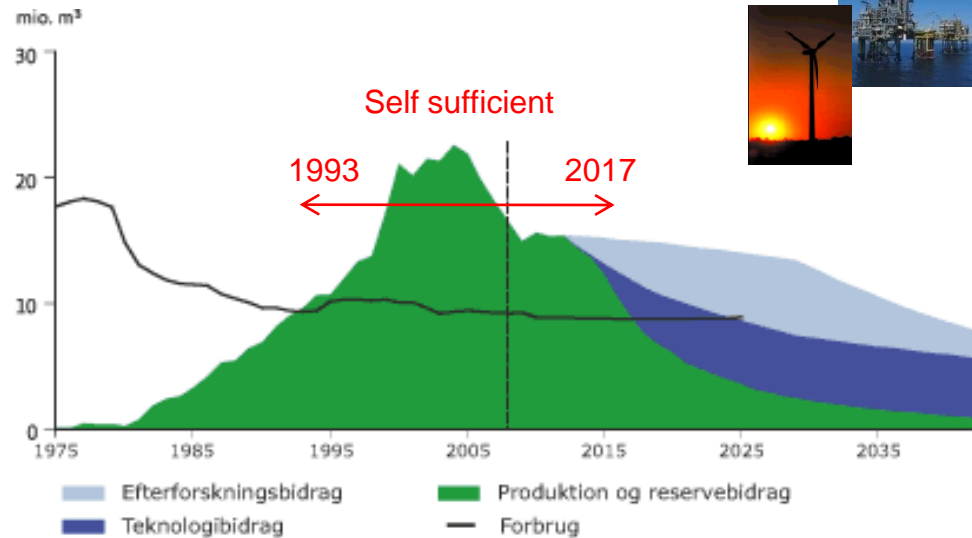
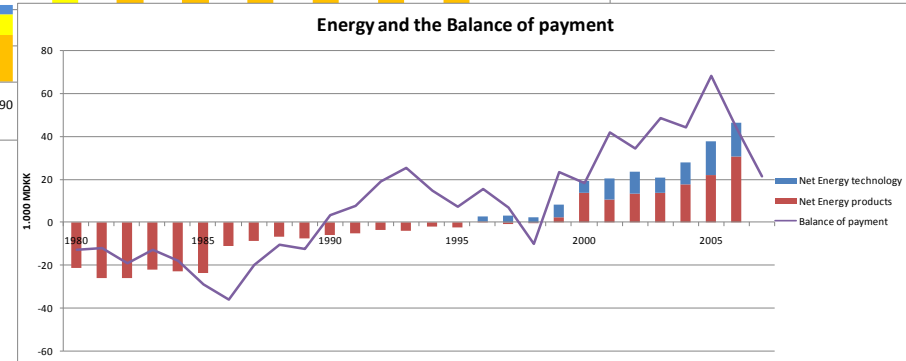
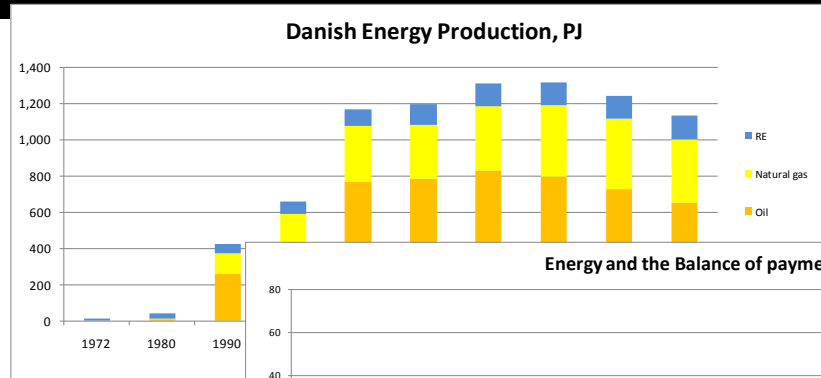
– Consists of:

- 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



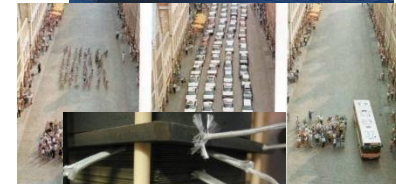
The IDA Climate Plan 2050

- 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



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



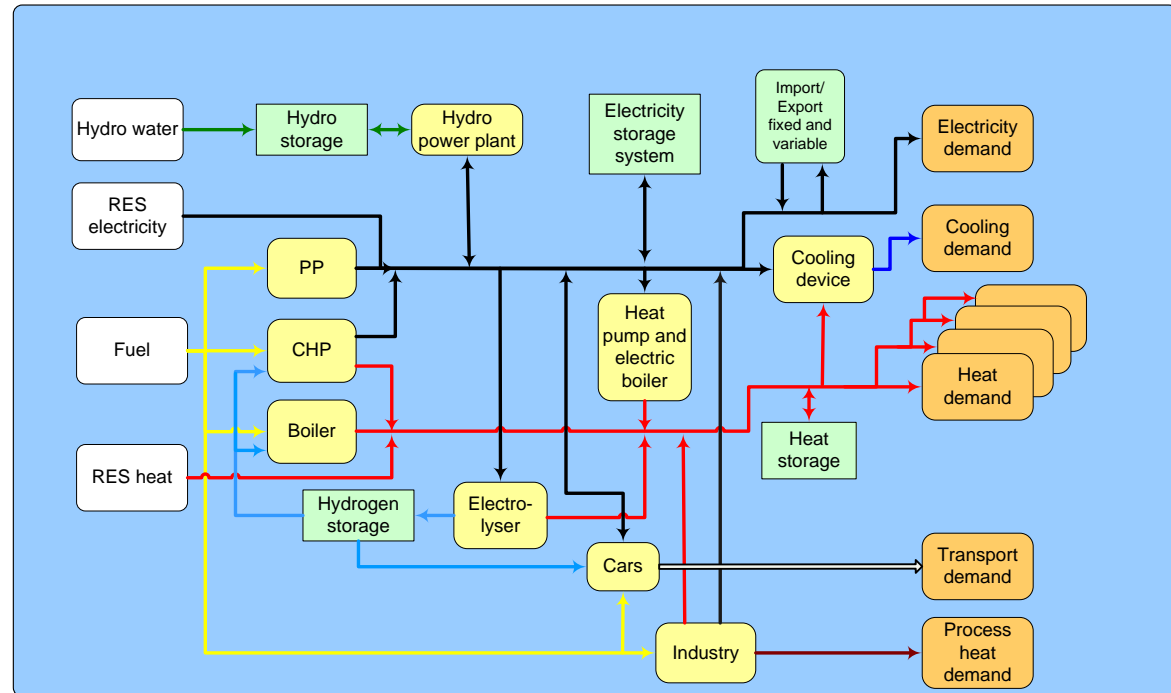
- Type of inputs:
 - Technology characteristics, costs and future potentials

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



Coherent energy systems analyses

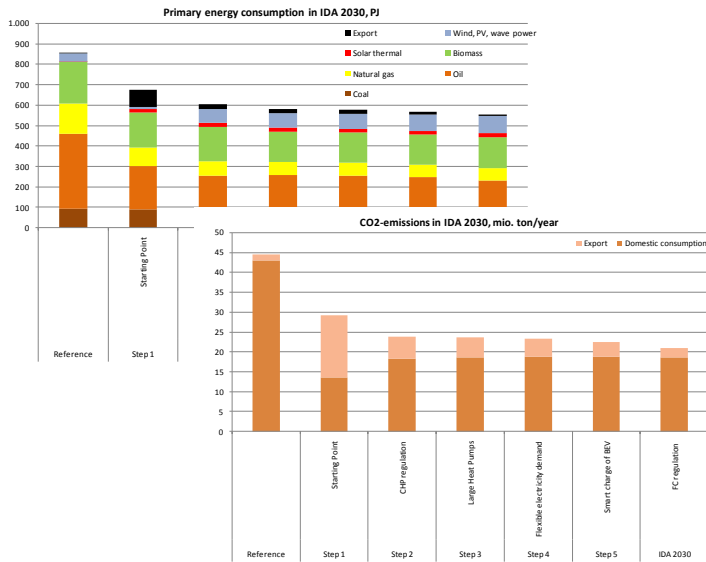
- Technical energy system analyses.
 - Potentials and problems?
 - Barriers and synergies?
 - System solutions?
- Socio-economic analyses.
 - Good and bad proposals?
 - What proposals make up a coherent total energy plan?
 - What is the total costs?
 - What are the abilities to profit from international 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

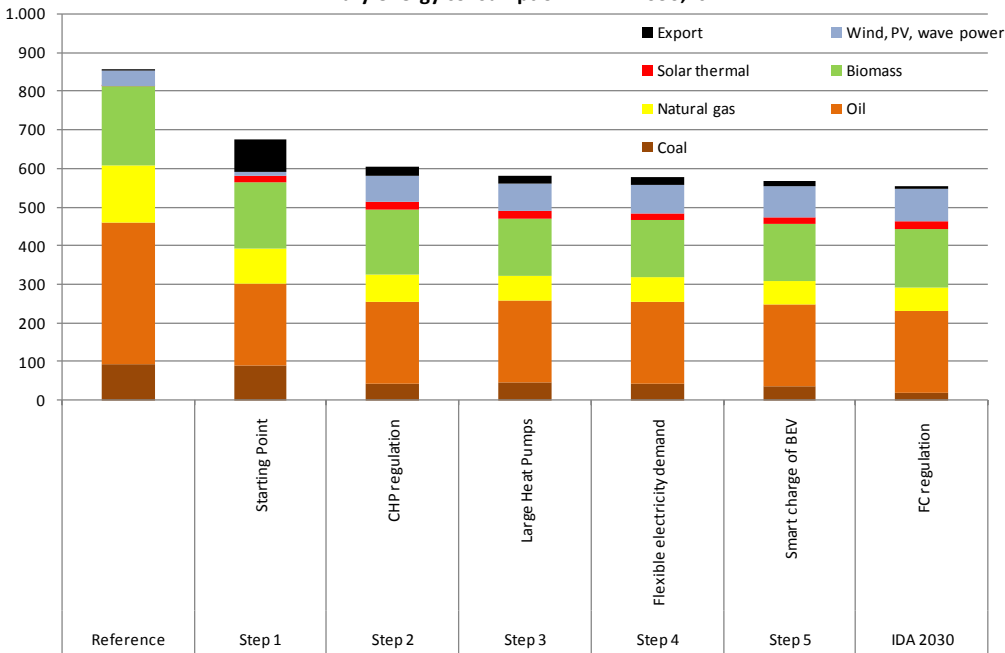
Technical energy system analyses of IDA 2030

- Objectives:
 - Reduce excess electricity
 - Decrease fuel demand



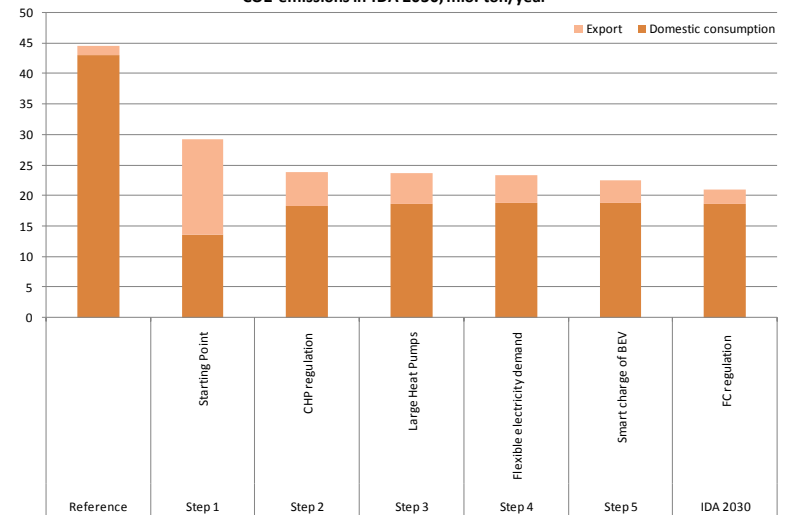
	Excess electricity	Boiler share
Step 1: Starting Point	44%	10%
Step 2: CHP regulation	17%	36%
Step 3: Large Heat Pumps	16%	15%
Step 4: Flexible electricity demand	14%	16%
Step 5: Smart charge of battery electric vehicles	10%	20%
Step 6: FC regulation	5%	23%

Primary energy consumption in IDA 2030, PJ



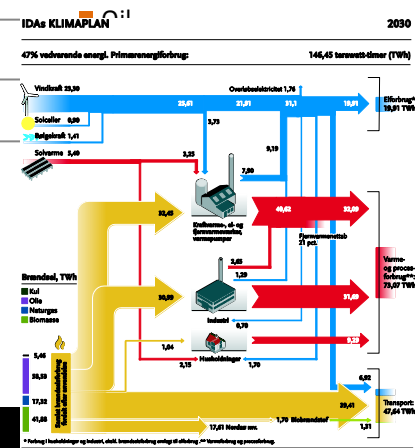
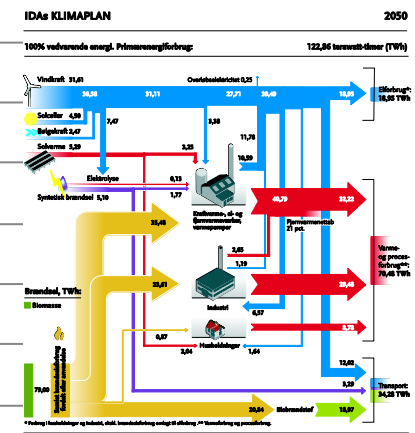
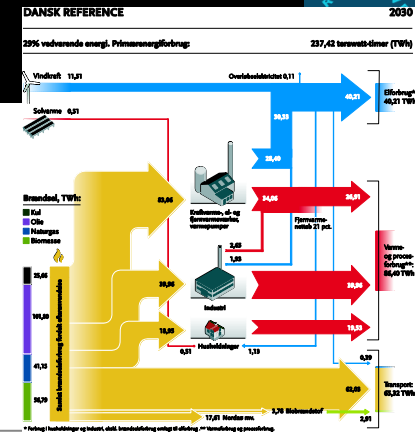
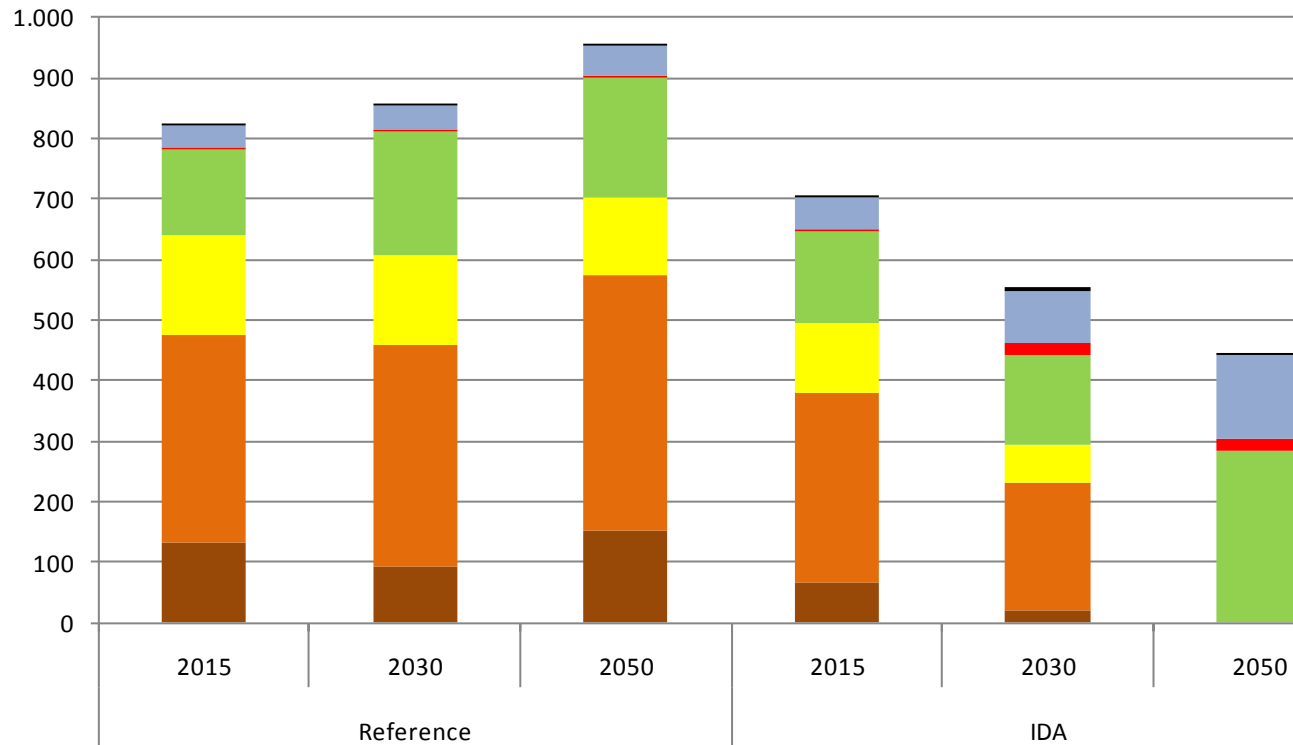
IDA 2030

CO2-emissions in IDA 2030, mio. ton/year



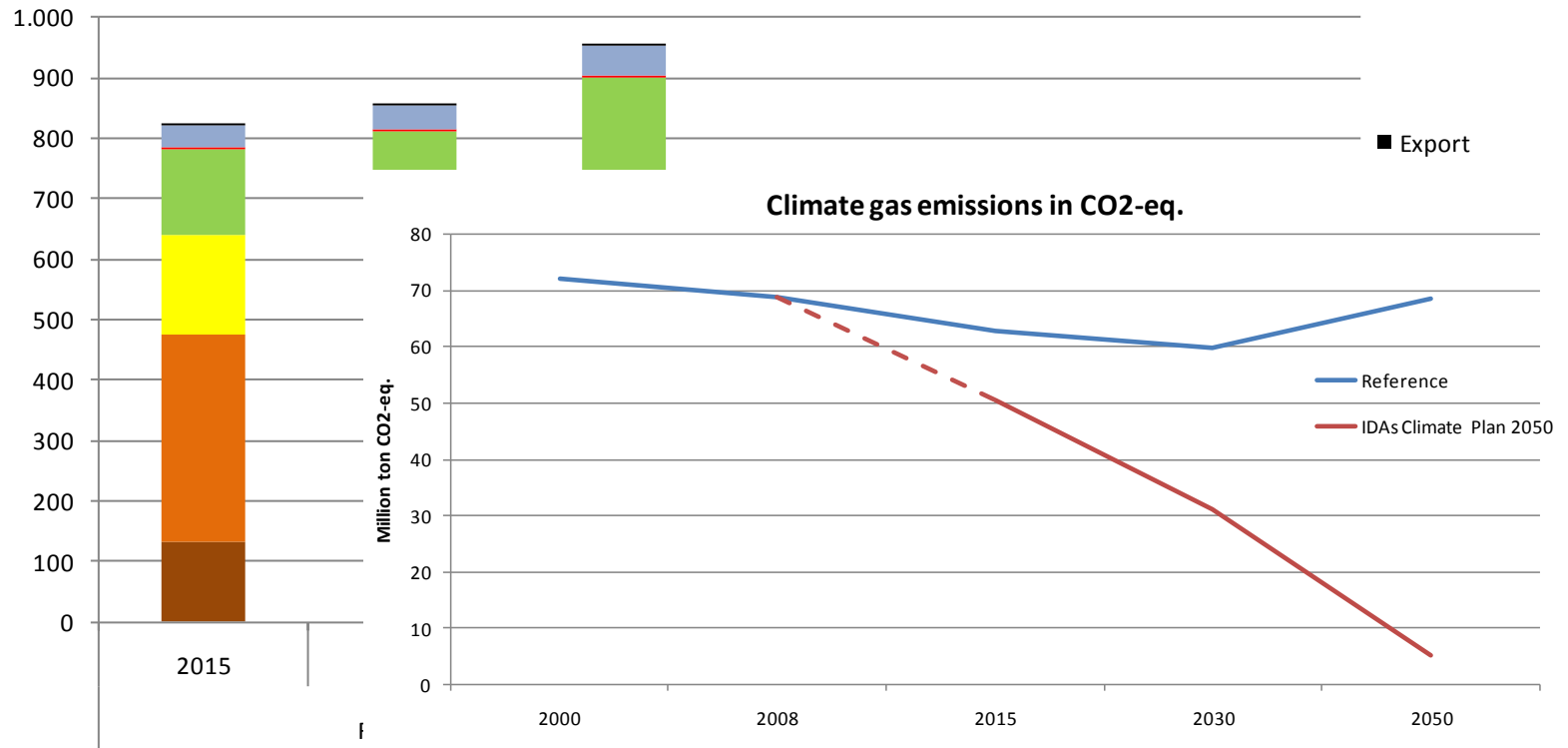
Technical comparison

Primary energy consumption in IDA 2015, 2030 and 2050, PJ



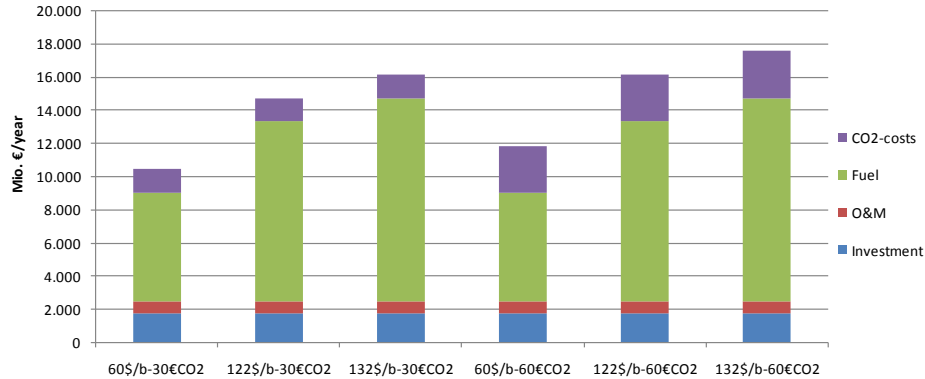
Technical comparison

Primary energy consumption in IDA 2015, 2030 and 2050, PJ

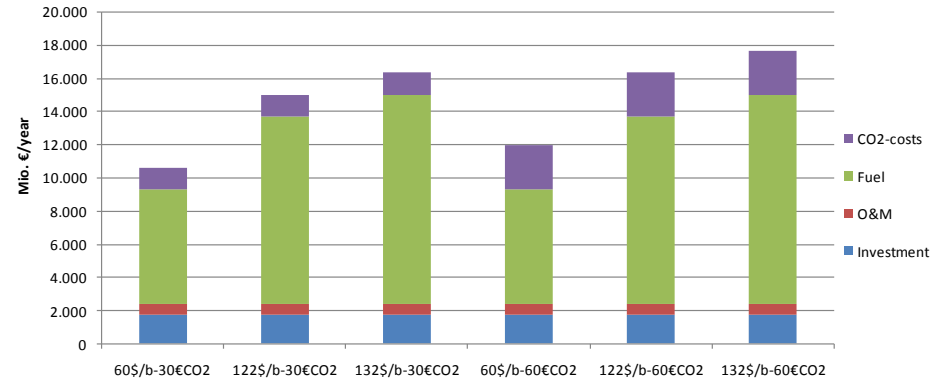


Socio-economic costs

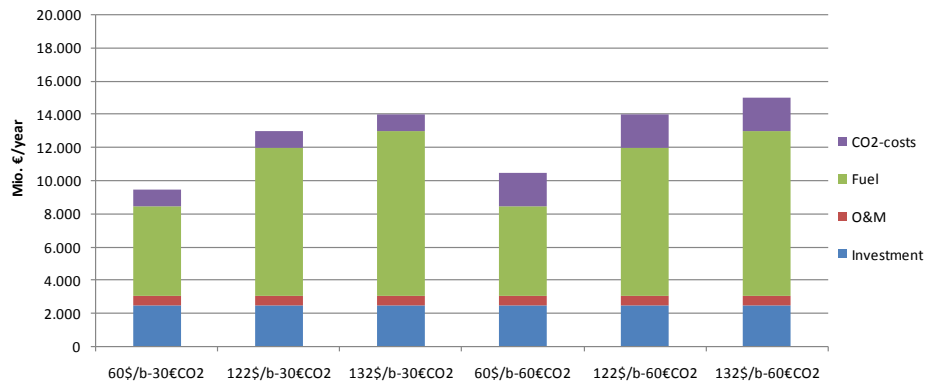
Socio-economic costs in the 2015 reference



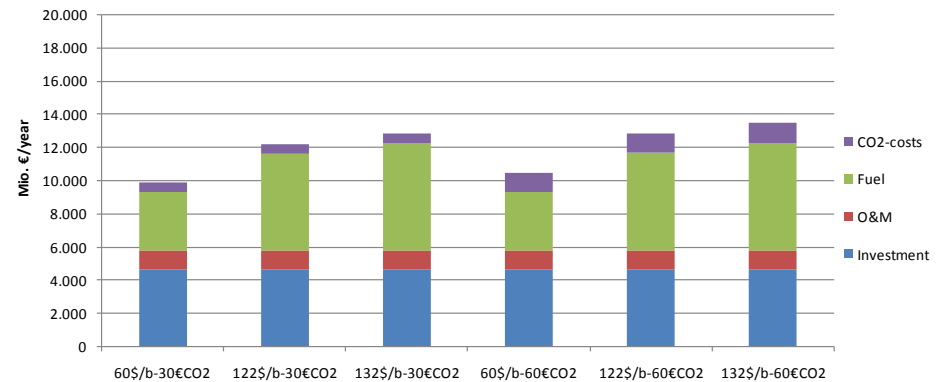
Socio-economic costs in the 2030 reference



Socio-economic costs in IDA 2015



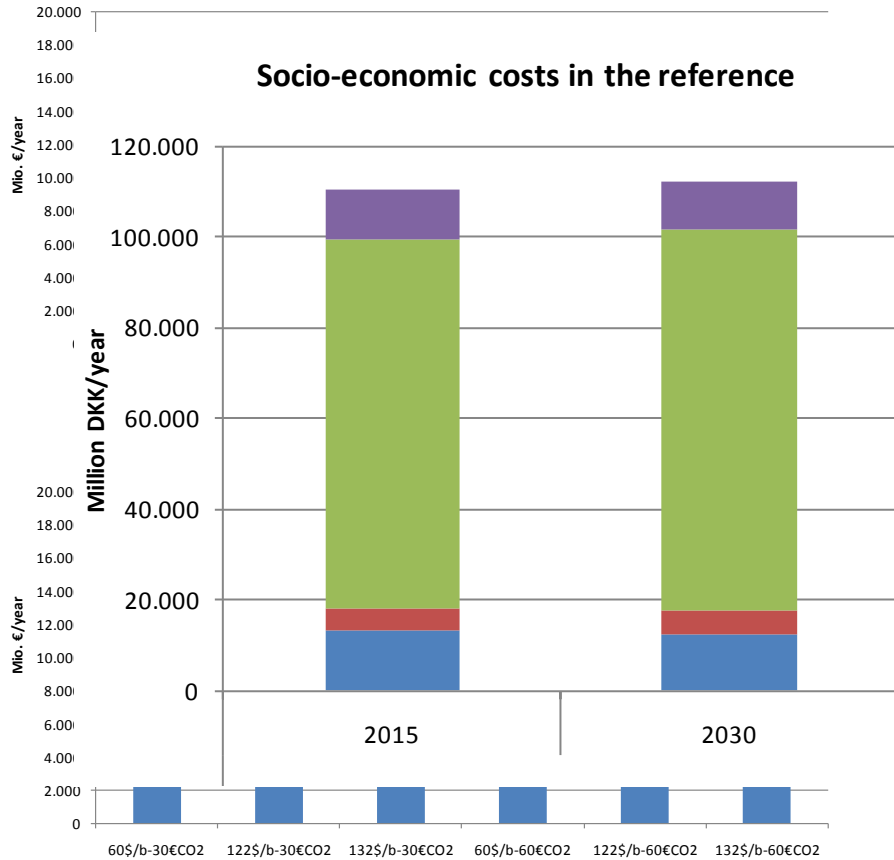
Socio-economic costs in IDA 2030



Socio-economic costs

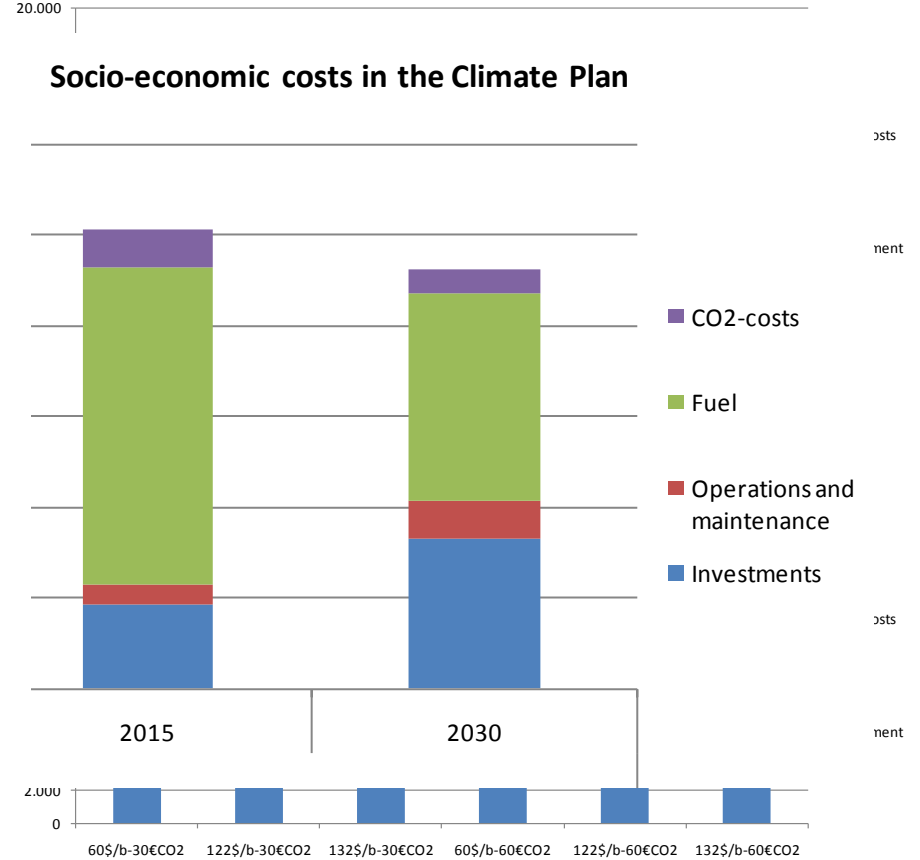
Socio-economic costs in the 2015 reference

Socio-economic costs in the reference

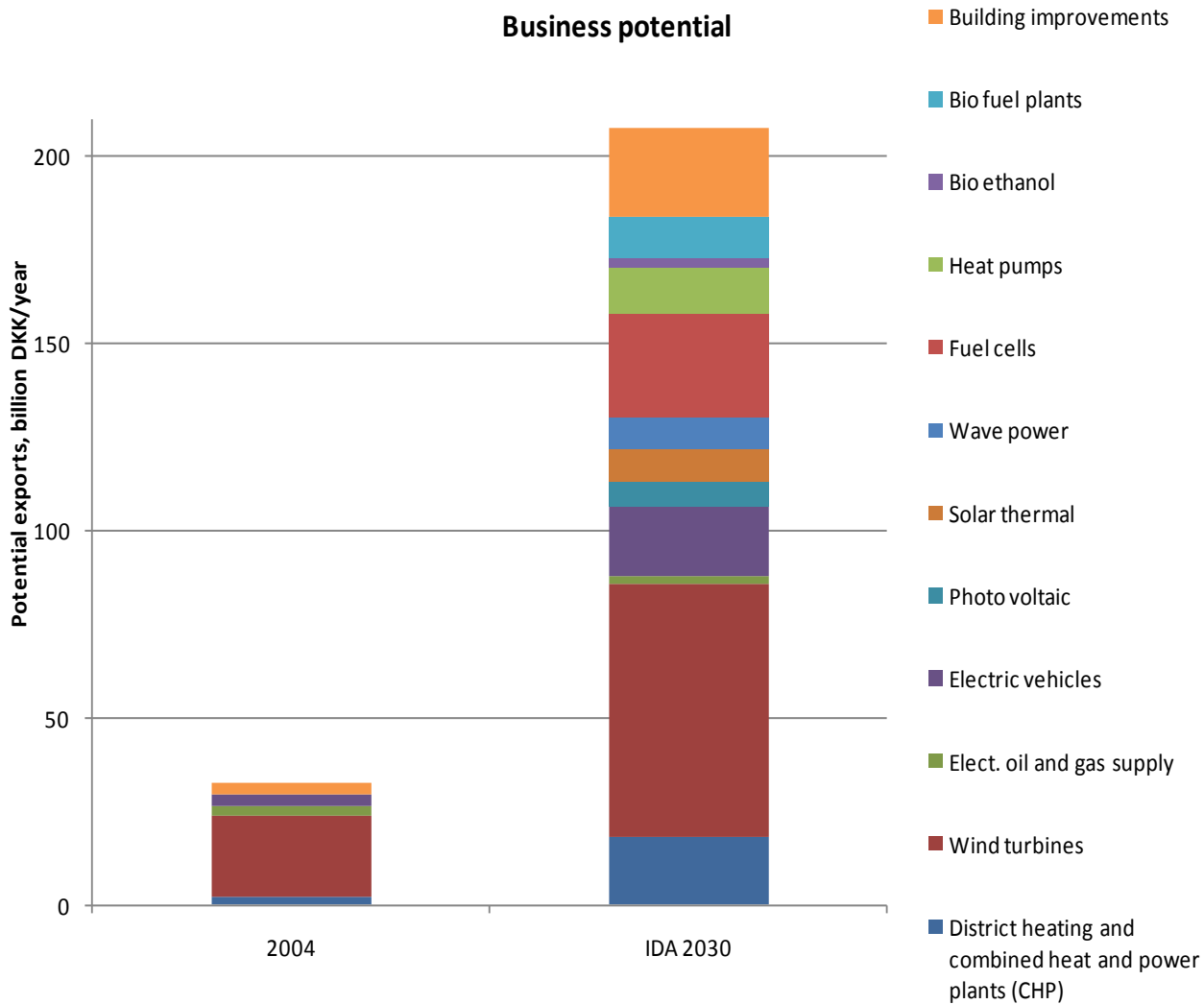


Socio-economic costs in the 2030 reference

Socio-economic costs in the Climate Plan



Business potential



- 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

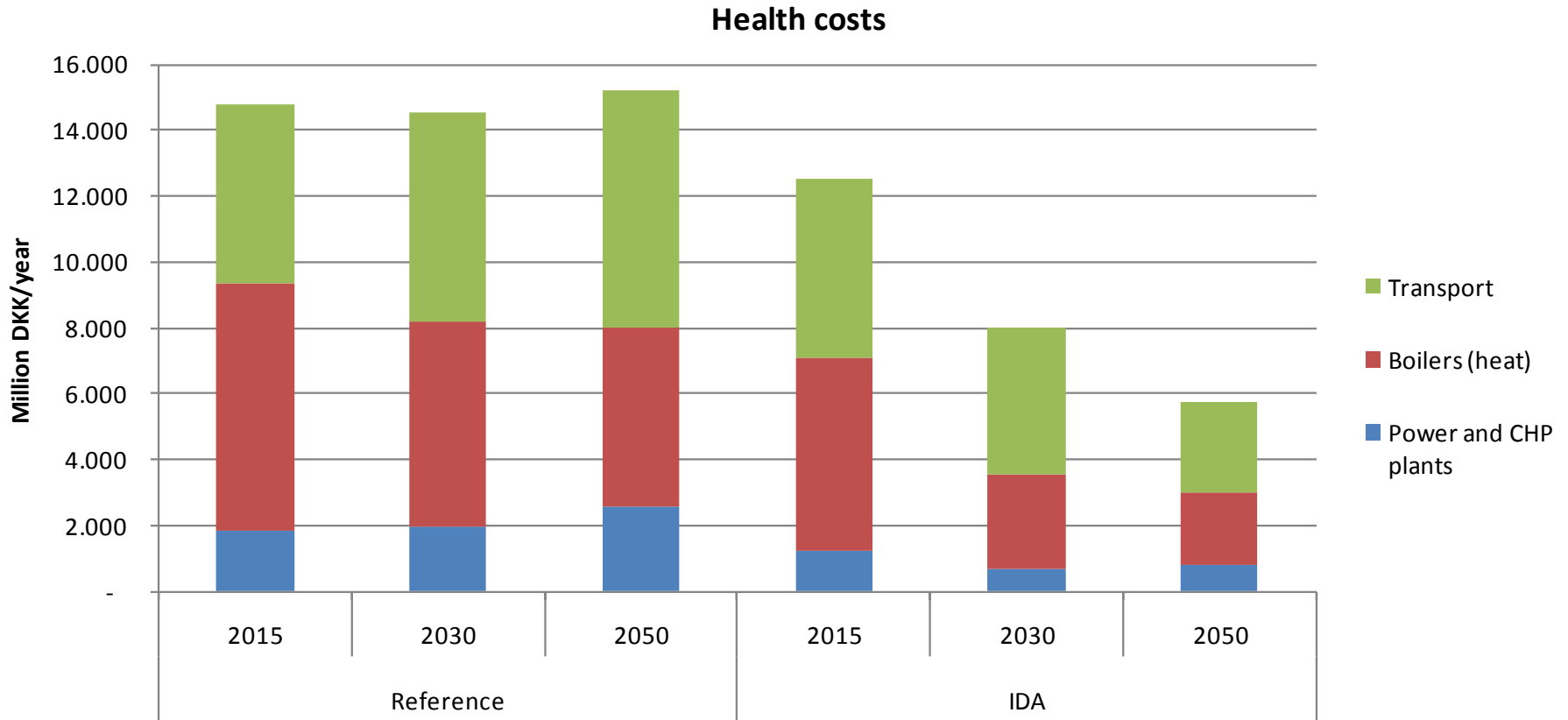
- The extra jobs created in the Climate Plan compared to the reference are in the range of 30.000-40.000 in the period towards 2050
 - Fewer jobs for fossil fuel handling
 - Jobs created from investments in renewable energy technology, in building improvements and in the handling of biomass
 - The amount 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 Sea 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)

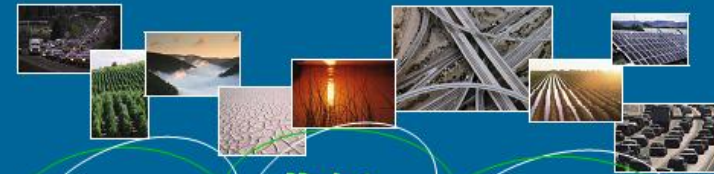


Coherent Energy and Environmental System Analysis



Aalborg University
 Technical University of Southern Denmark
 University of Copenhagen
 Copenhagen Business School
 Institute of Local Government Studies
 DONG Energy

- A multidisciplinary co-operation...



Life Cycle Assessment

Market Analysis

Energy System Analysis

CEESA

- A unique combination...



- A sustainable goal...

100% Renewable Energy

International Advisory Board



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Wolfram Knechtl



Thomas B. Johansson



Heide I. Meyer

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..

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