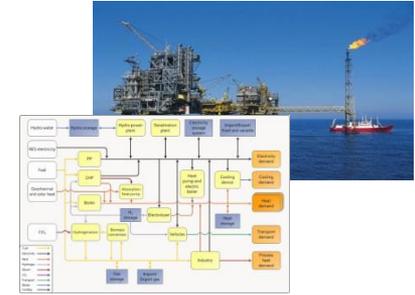


RENEWABLE ENERGY – NOW MORE THAN EVER !

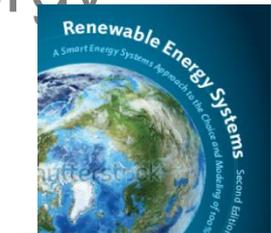
REScoop.eu INTERREGIONAL CONFERENCE, EUPEN (BELGIUM), Tuesday 17
January 2017



Smart Energy Europe Technological & Economic Status: A Scenario of 100% Renewable Energy



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Professor in Energy Planning
Aalborg University



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DENMARK

Smart Energy Europe

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Smart Energy Europe: The technical and economic impact of one potential 100% renewable energy scenario for the European Union



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^a Department of Development and Planning, Aalborg University, A.C. Meyers Vænge 15, 2450 Copenhagen SV, Denmark

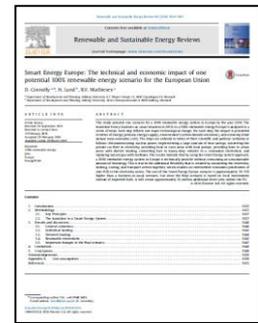
^b Department of Development and Planning, Aalborg University, Vestre Havnepromenade 9, 9000 Aalborg, Denmark

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ABSTRACT

This study p
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www.EnergyPLAN.eu/SmartEnergyEurope

Report Online

Paper Published

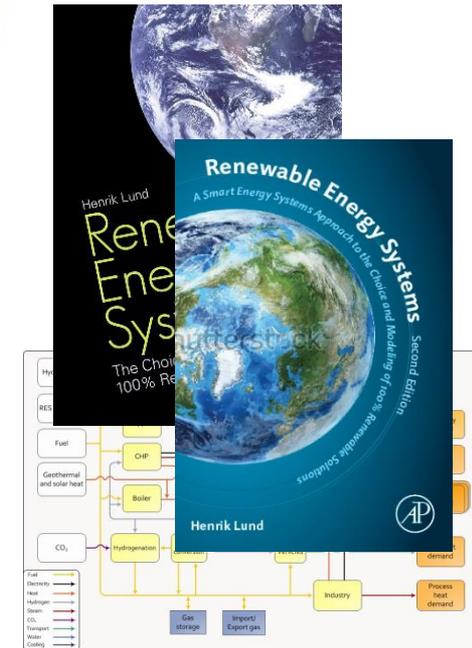


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Smart Energy Systems

The key to cost-efficient 100% Renewable Energy

- A sole focus on renewable **electricity (smart grid)** production leads to electricity storage and flexible demand solutions!
- Looking at renewable electricity as a part **smart energy systems** including heating, industry, gas and transportation opens for cheaper and better solutions...

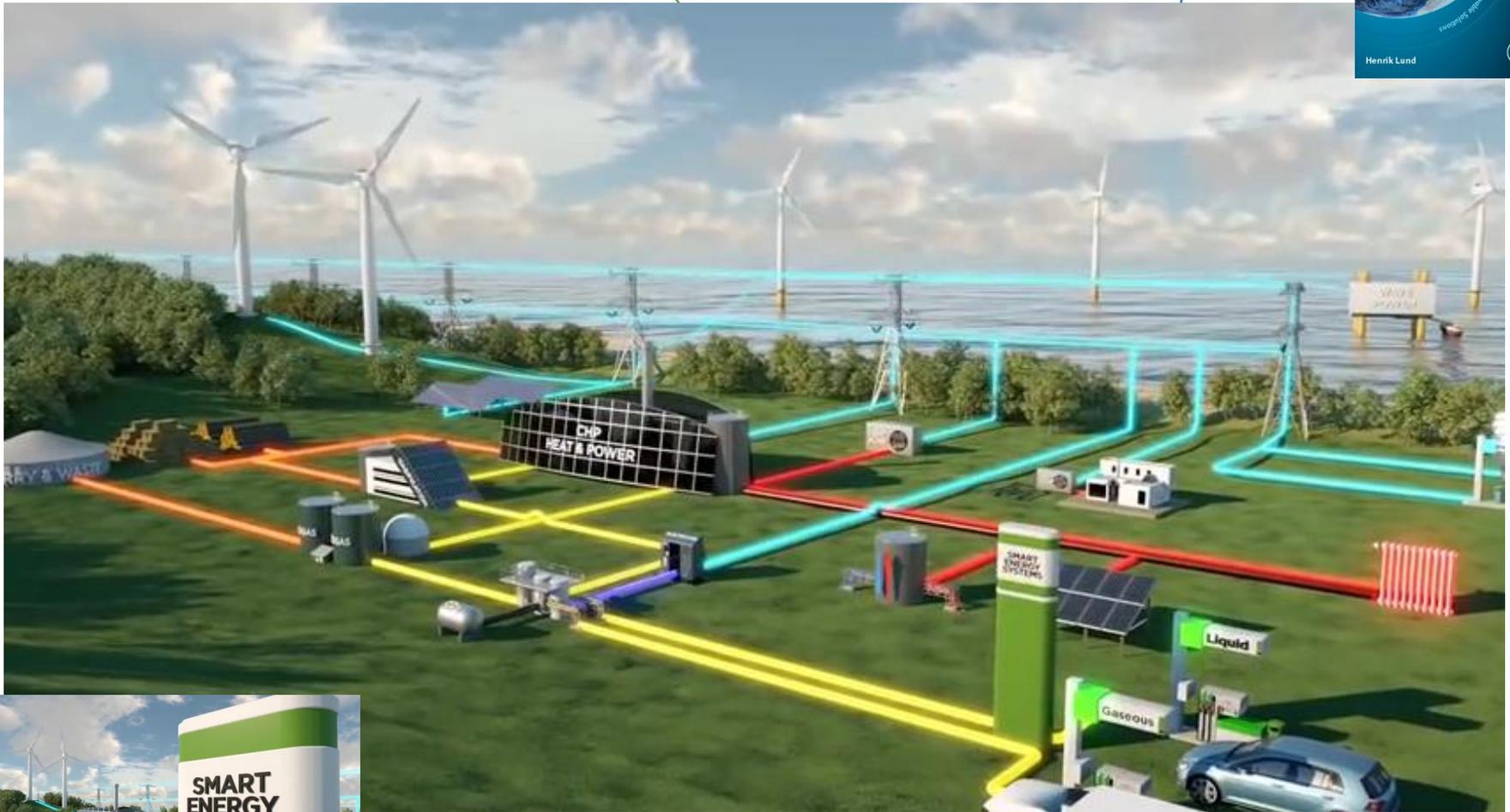
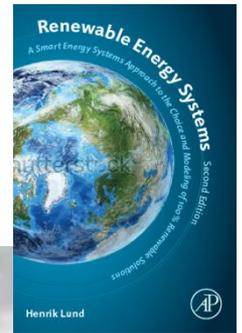


Power-to-Heat

**Power-to-Gas
Power-to-Transport**



Smart Energy Systems



Smart Energy Systems



www.energyplan.eu/smartenergysystems/



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Energy Storage

Pump Hydro Storage
175 €/kWh

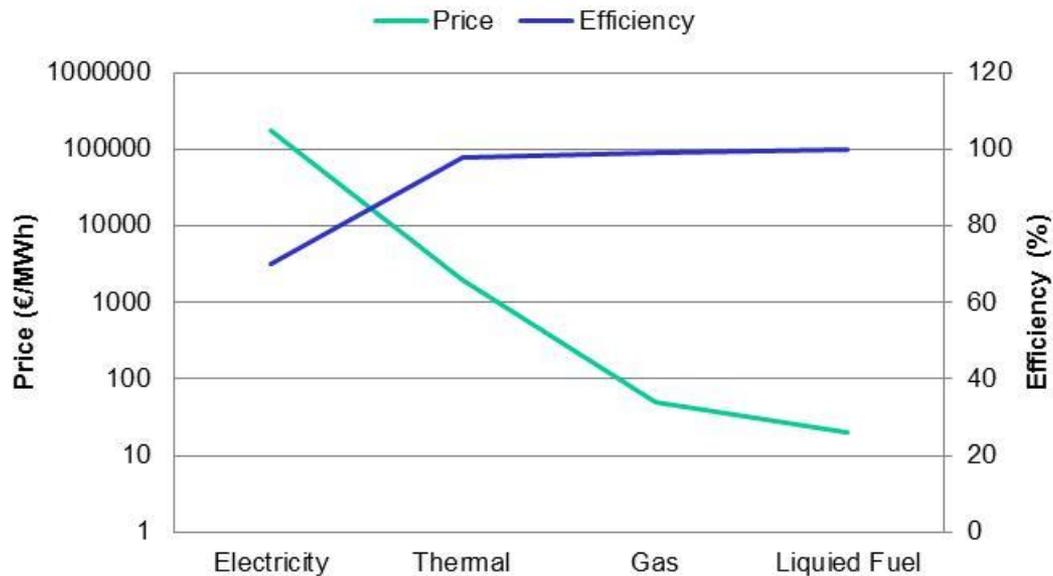
(Source: Electricity Energy Storage Technology Options: A White Paper Primer on Applications, Costs, and Benefits. Electric Power Research Institute, 2010)



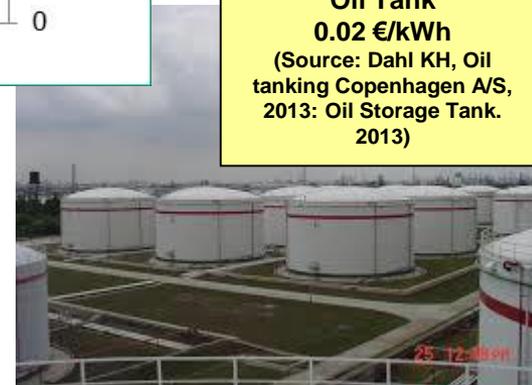
Thermal Storage
1-4 €/kWh
(Source: Danish Technology Catalogue, 2012)



Energy storage: Price and Efficiency



Oil Tank
0.02 €/kWh
(Source: Dahl KH, Oil tanking Copenhagen A/S, 2013: Oil Storage Tank. 2013)



Natural Gas Underground Storage
0.05 €/kWh

(Source: Current State Of and Issues Concerning Underground Natural Gas Storage. Federal Energy Regulatory Commission, 2004)



Thermal Storage

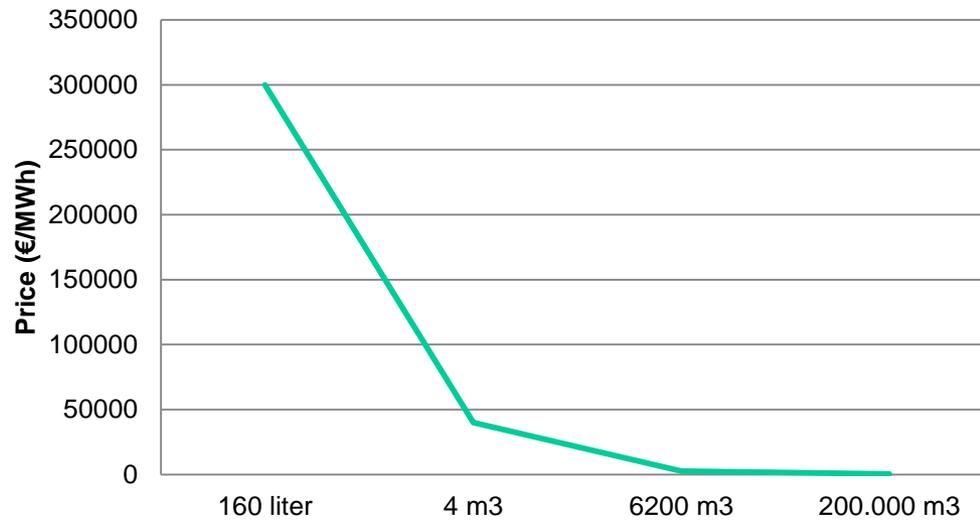
0.16 m3 Thermal Storage
300.000 €/MWh
(Private house: 160 liter
for 15000 DKK)



6200 m3 Thermal Storage
2500 €/MWh
(Skagen: 6200 m3
for 5.4 mio. DKK)



Thermal storage: Price and Size



4 m3 Thermal Storage
40,000 €/MWh
(Private outdoor: 4000 m3
for 50,000 DKK)



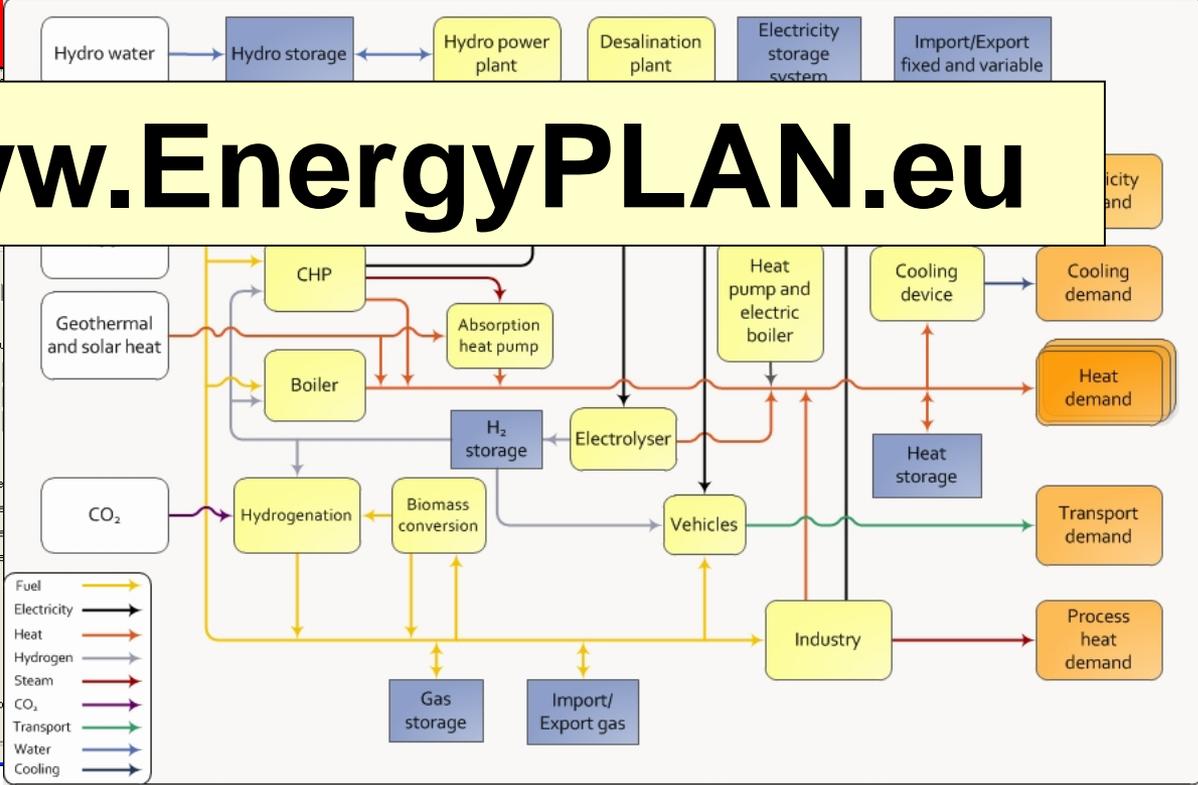
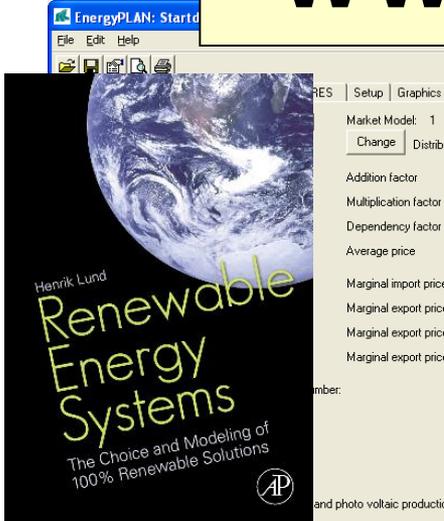
200,000 m3 Thermal Storage
500 €/MWh
(Vojens: 200,000 m3
for 30 mio. DKK)



Energy System Analysis Model

The top section displays the EnergyPLAN software interface. On the left, a window titled 'EnergyPLAN: DK2020Reference' shows two stacked area charts: 'Electricity Demand: 3 Days in January' (yellow and red areas) and 'Electricity Production: 3 Days in January' (red and green areas). The y-axis represents MW, ranging from 0 to 10,000. To the right, a website snippet for 'Energy City Frederikshavn - A 100% Renewable Energy Scenario for the Town of Frederikshavn' is visible, featuring a map and a 'Download Model' button.

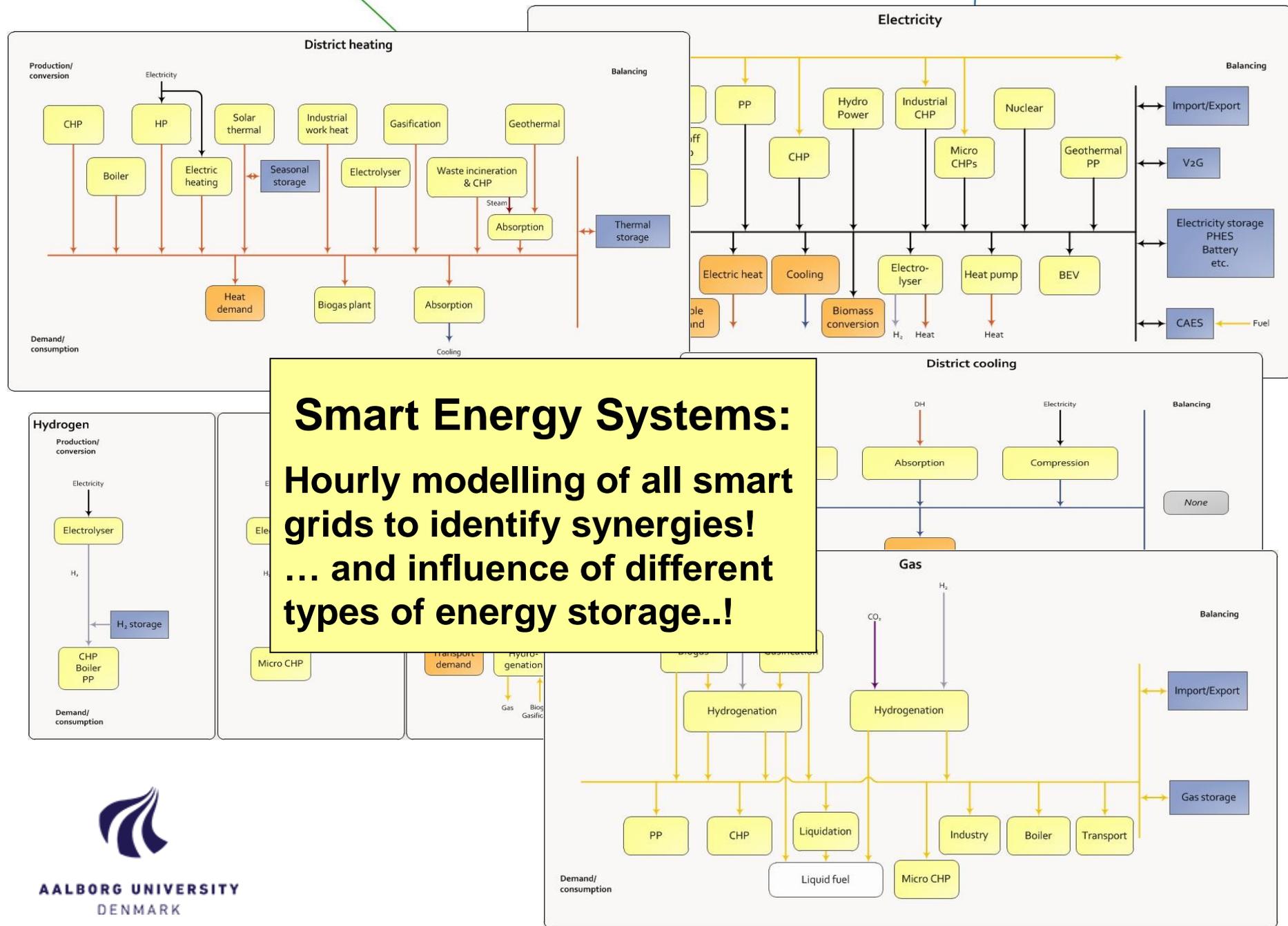
www.EnergyPLAN.eu



The right side of the image shows the EnergyPLAN website sidebar. It includes a navigation menu with links for 'Home', 'Download', 'About', 'Contact', 'Get Started', 'Training', 'FAQs', 'Case Studies', 'Forum', 'Theory', and 'Other Tools'. Below the menu, there is a 'Benefits' section with a list of advantages:

- Free of charge
- Access to a network of global users
- User-friendly and very fast for normal PC
- Detailed hourly analyses of a complete energy system
- Easy access to library of hourly data
- Long list of case studies from various countries
- Free online training, guides, and documentation

 A 'Download Model' button is prominently displayed, with a note: 'Download the latest version now and get started right away!'. At the bottom, there is a small diagram of the EnergyPLAN model structure and the date 'September 2013'.





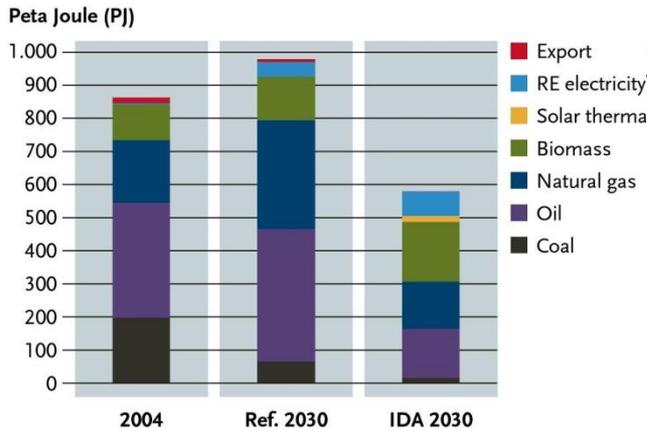
IDA Energiplan 2030

IDA
The Danish Society of Engineers, IDA
a modern professional association for
technical and science professionals

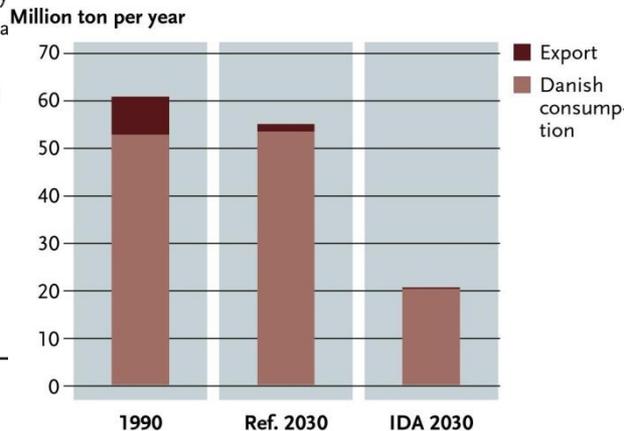
Executive Summary
IDA's Energy Vision 2030
A smart energy system strategy for 100% renewable Denmark

Business

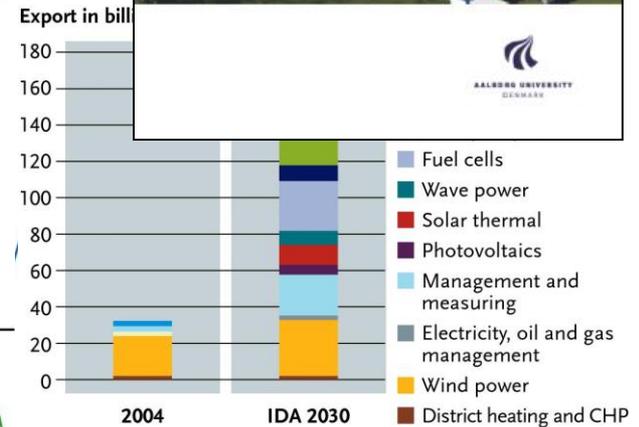
Primary energy supply

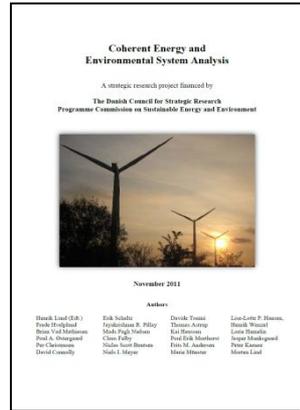


CO₂ emissions



Business





CEESA Project 2011/2012

Transport:

Electric vehicles is best from an energy efficient point of view. But gas and/or liquid fuels is needed to transform to 100%.

Biomass:

.. is a limited resource and can not satisfy all the transportation needs.

Consequence

... Electricity from Wind (and similar resources) needs to be converted to gas and liquied fuels in the long-term perspective...

Primary energy consumption in CEESA

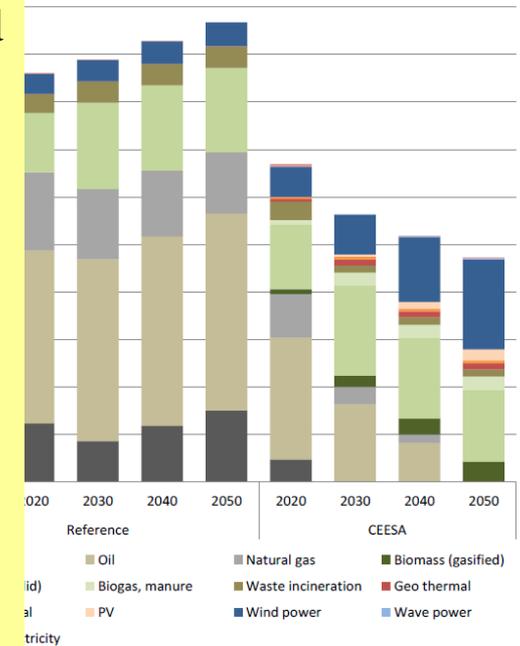
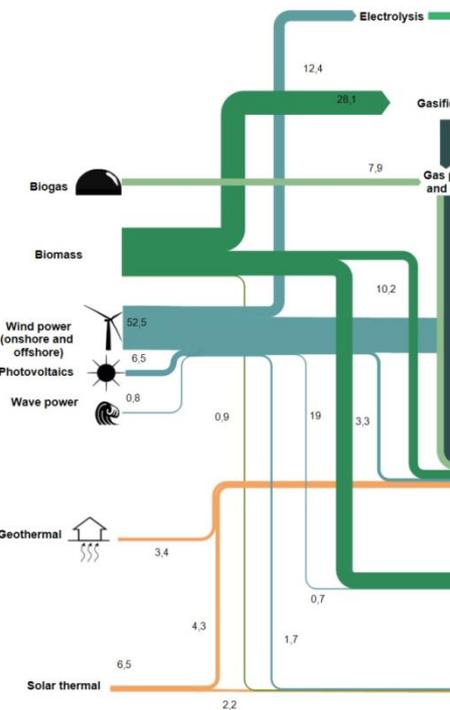


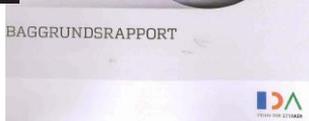
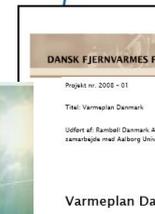
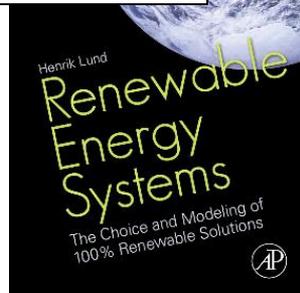
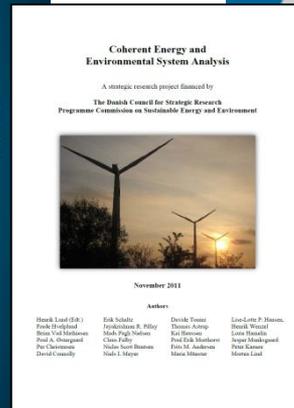
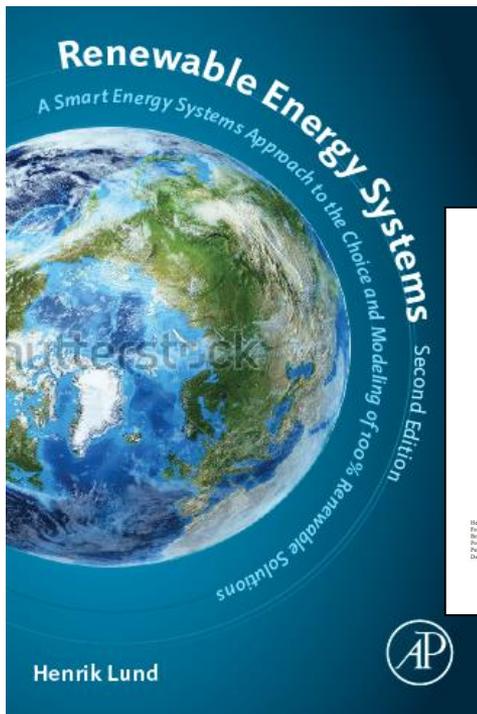
Figure 2: Primary Energy Supply in CEESA.

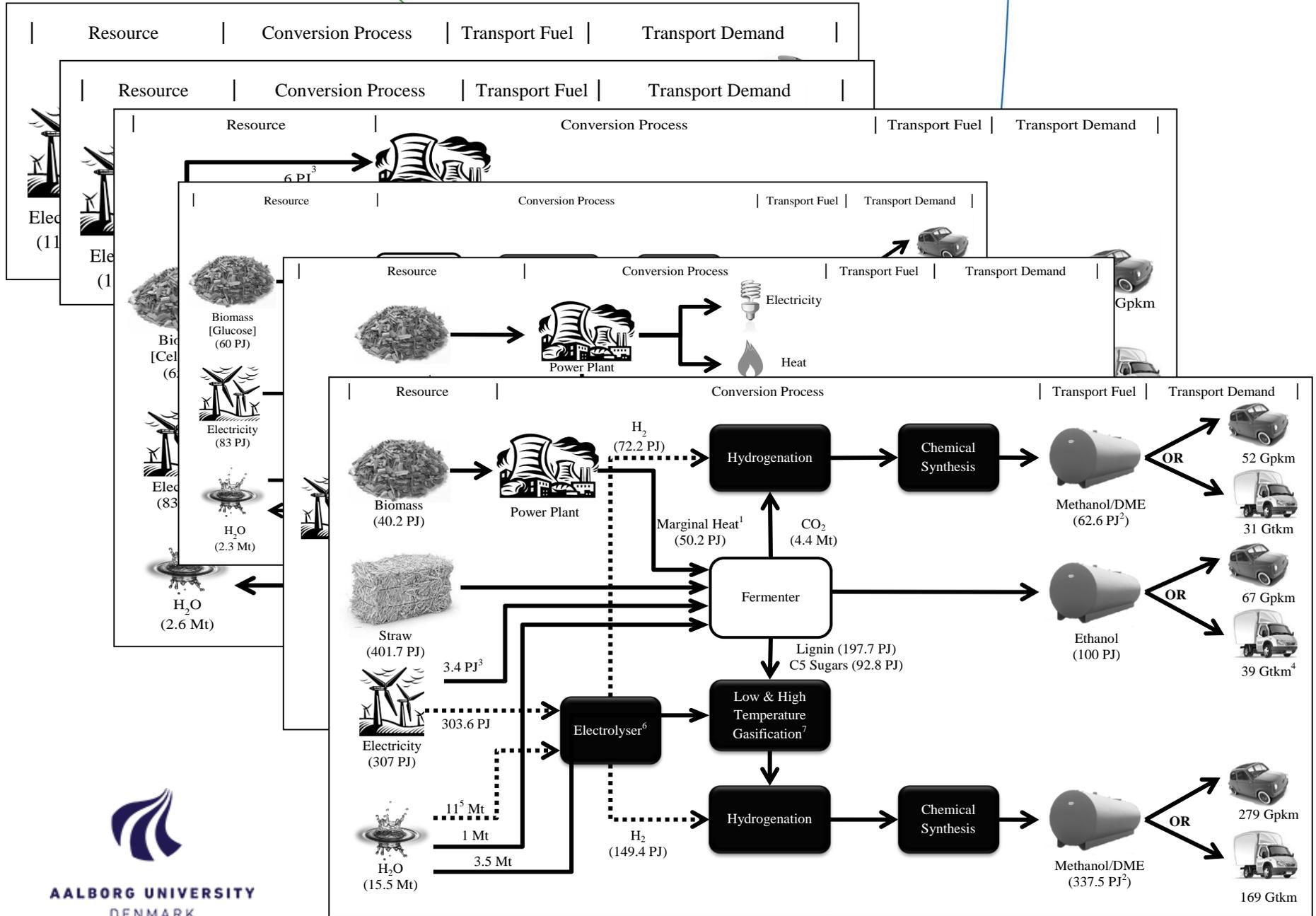


Electro-fuels

100% Renewable Energy 2050

Power-to-Transportation





Smart Energy Europe

Renewable and Sustainable Energy Reviews 60 (2016) 1634–1653



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Smart Energy Europe: The technical and economic impact of one potential 100% renewable energy scenario for the European Union



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ABSTRACT

This study p
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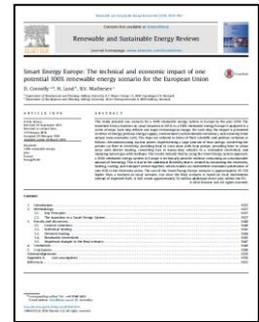
www.EnergyPLAN.eu/SmartEnergyEurope

Report Online

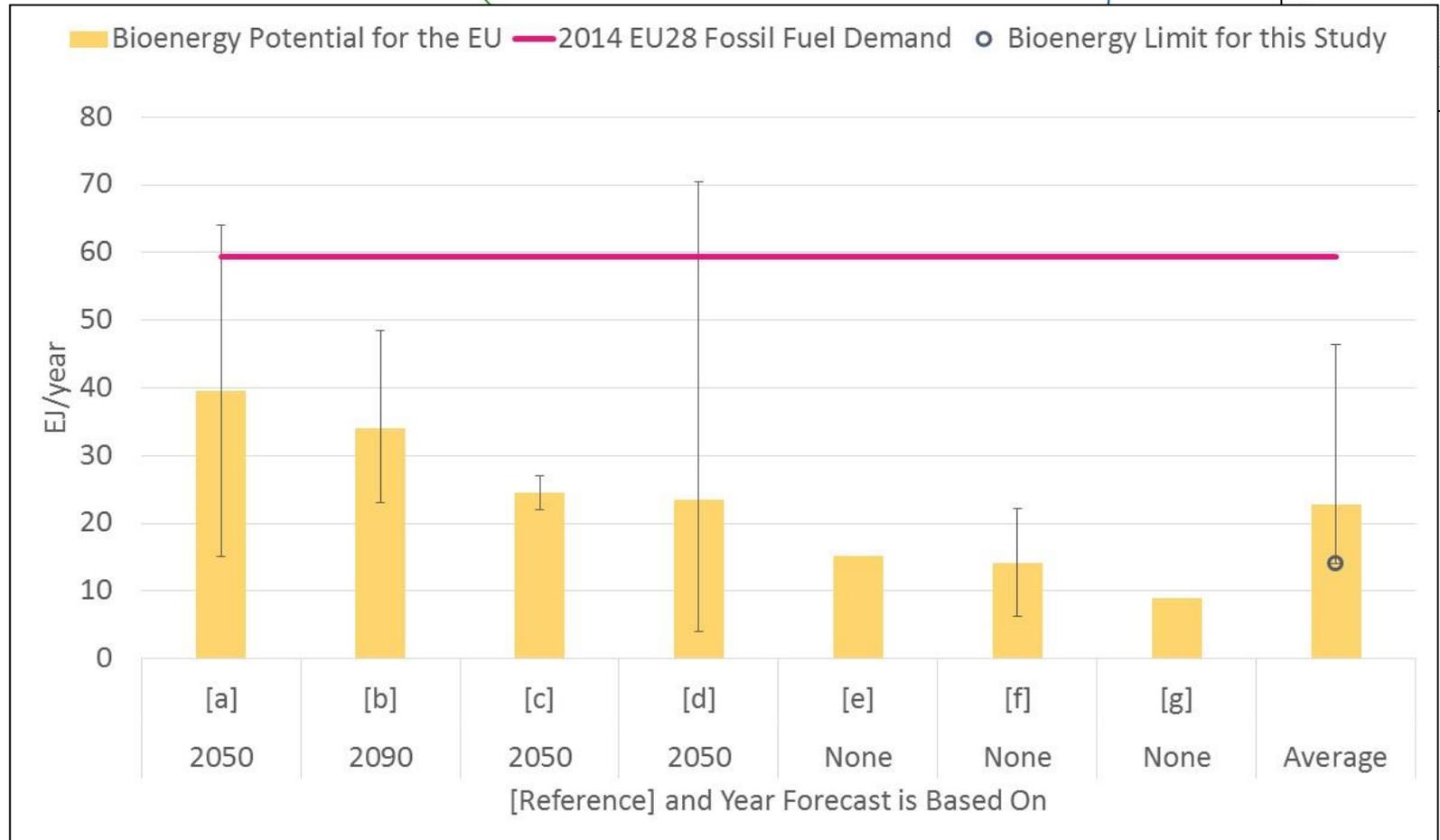
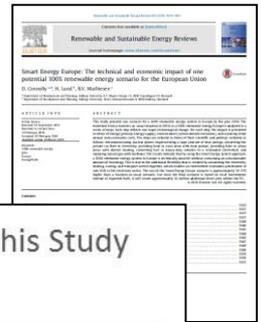
Paper Published



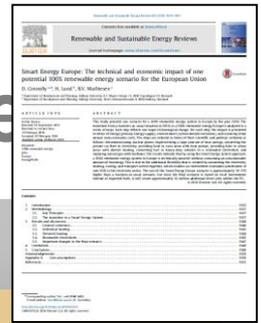
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Bioenergy Is Limited



10 Steps to Smart Energy Europe



Starting Point

1. EU28 CPI 2050

General Consensus

2. No Nuclear

3. Heat Savings

4. Electric Cars

Maximise Wind in All Scenarios

Heating

5. Heat Pumps

6. District Heating



Transport / Fuels

7. Electrofuels

8. Replacing Coal & Oil

9. Replacing Natural Gas

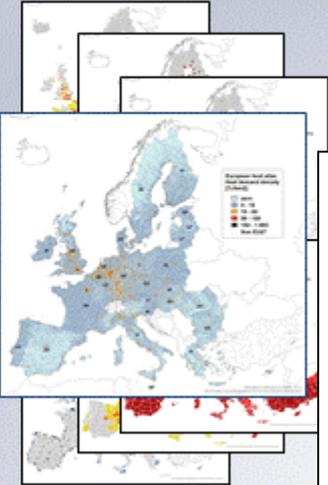


Heat Roadmap Europe

Heat Roadmap Europe 2050

GIS Mapping: Many Heat Sources

- Urban areas (Heating Demands)
- Power and Heat Generation
- Waste Management
- Industrial waste heat potential
- Geothermal heat
- Solar Thermal
- the study indicates that the **market shares for district heating for buildings can be increased to 30% in 2030 and 50% in 2050.**



EUROHEAT & POWER **AALBORG UNIVERSITY DENMARK** **ECOFYS** **PlanEnergi**

HEAT ROADMAP EUROPE 2050

FIRST PRE-STUDY FOR THE EU27



By
Aalborg University
David Connolly

HEAT ROADMAP EUROPE 2050

SECOND PRE-STUDY FOR THE EU27



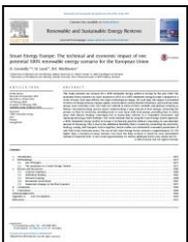
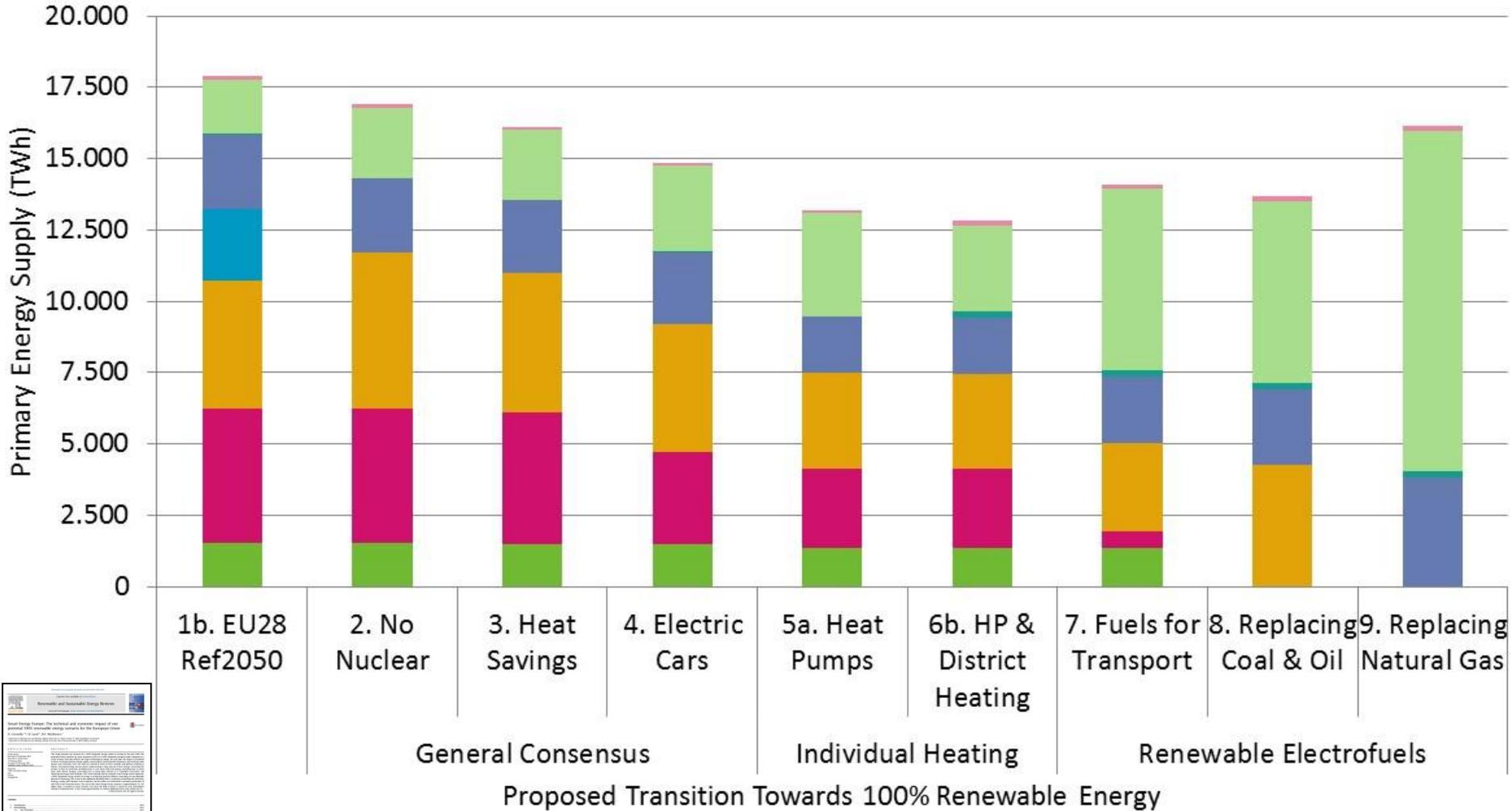
By

- Aalborg University**
David Connolly
Brian Vind Mathiesen
Poul Alberg Østergaard
Søren Møller
Steffen Nielsen
Henrik Lund
- Halmstad University**
Urban Persson
Sven Werner
- Ecofys Germany GmbH**
Jan Gröninger
Thomas Boermans
Michelle Bouquet
- PlanEnergi**
Daniel Trær

For **EUROHEAT & POWER**

Smart Energy Europe: Primary Energy Supply

■ Coal
 ■ Oil
 ■ Natural Gas
 ■ Nuclear
 ■ Biomass
 ■ Waste
 ■ RES
 ■ Solar Thermal



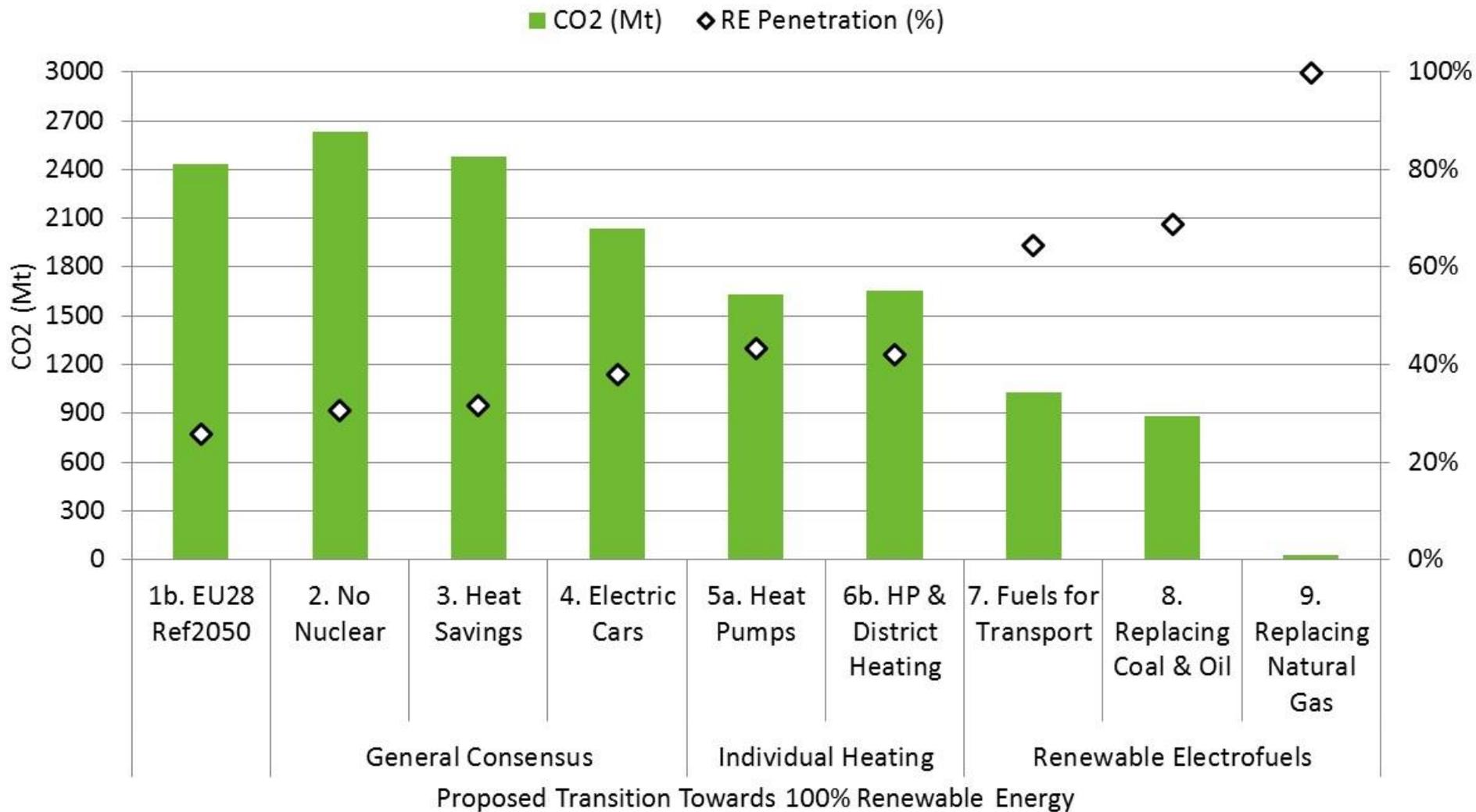
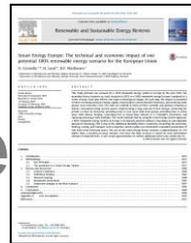
General Consensus

Individual Heating

Renewable Electrofuels

Proposed Transition Towards 100% Renewable Energy

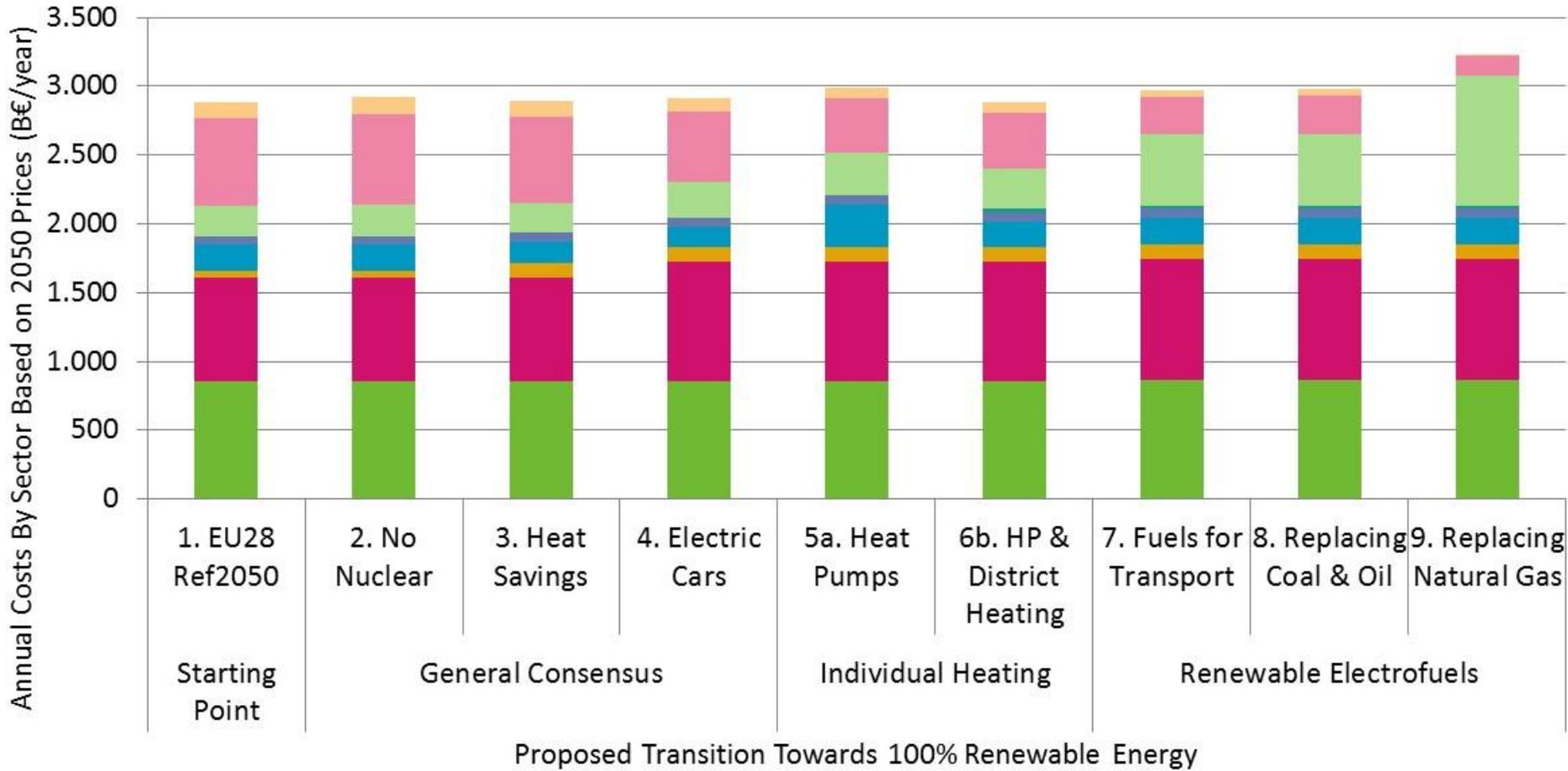
Smart Energy Europe: CO2 emission and Renewable Share



Smart Energy Europe: Annualized Costs



- Trucks/Buses
- Cars
- Heat Savings Costs
- Individual Heating Units
- Central Heating Systems
- District Heating Pipes
- Centralised Electricity & Heat
- Fuel
- CO2



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4th Generation District Heating
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<http://energy.plan.aau.dk/book.php>

Renewable Energy System
A Smart Energy Systems Approach to the Climate and Energy Challenges of the 21st Century

Henrik Lund



www.energyplan.eu/SmartEnergyEurope



Energy System Analyse Model



www.EnergyPLAN.eu

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- 1. Introduction
- 2. Methodology
- 3. The transition to a Smart Energy System
- 4. Energy System Analysis
- 5. Energy System Analysis
- 6. Energy System Analysis
- 7. Energy System Analysis
- 8. Energy System Analysis
- 9. Energy System Analysis
- 10. Energy System Analysis
- 11. Energy System Analysis
- 12. Energy System Analysis
- 13. Energy System Analysis
- 14. Energy System Analysis
- 15. Energy System Analysis
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- 17. Energy System Analysis
- 18. Energy System Analysis
- 19. Energy System Analysis
- 20. Energy System Analysis

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