

# Country Report Denmark

December 2014



DONG Energy cellulose ethanol demonstration plant, Kalundborg, Denmark

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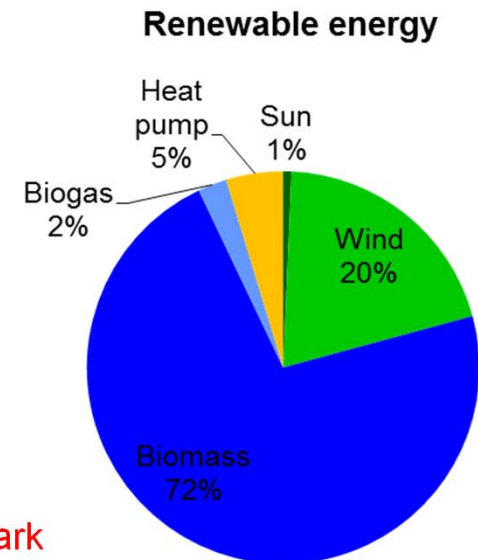
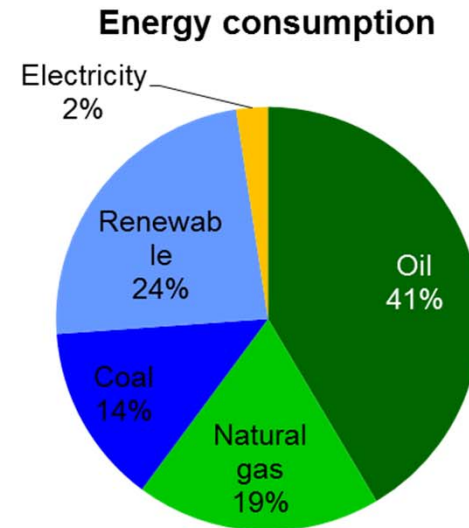
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# Energy consumption 2012

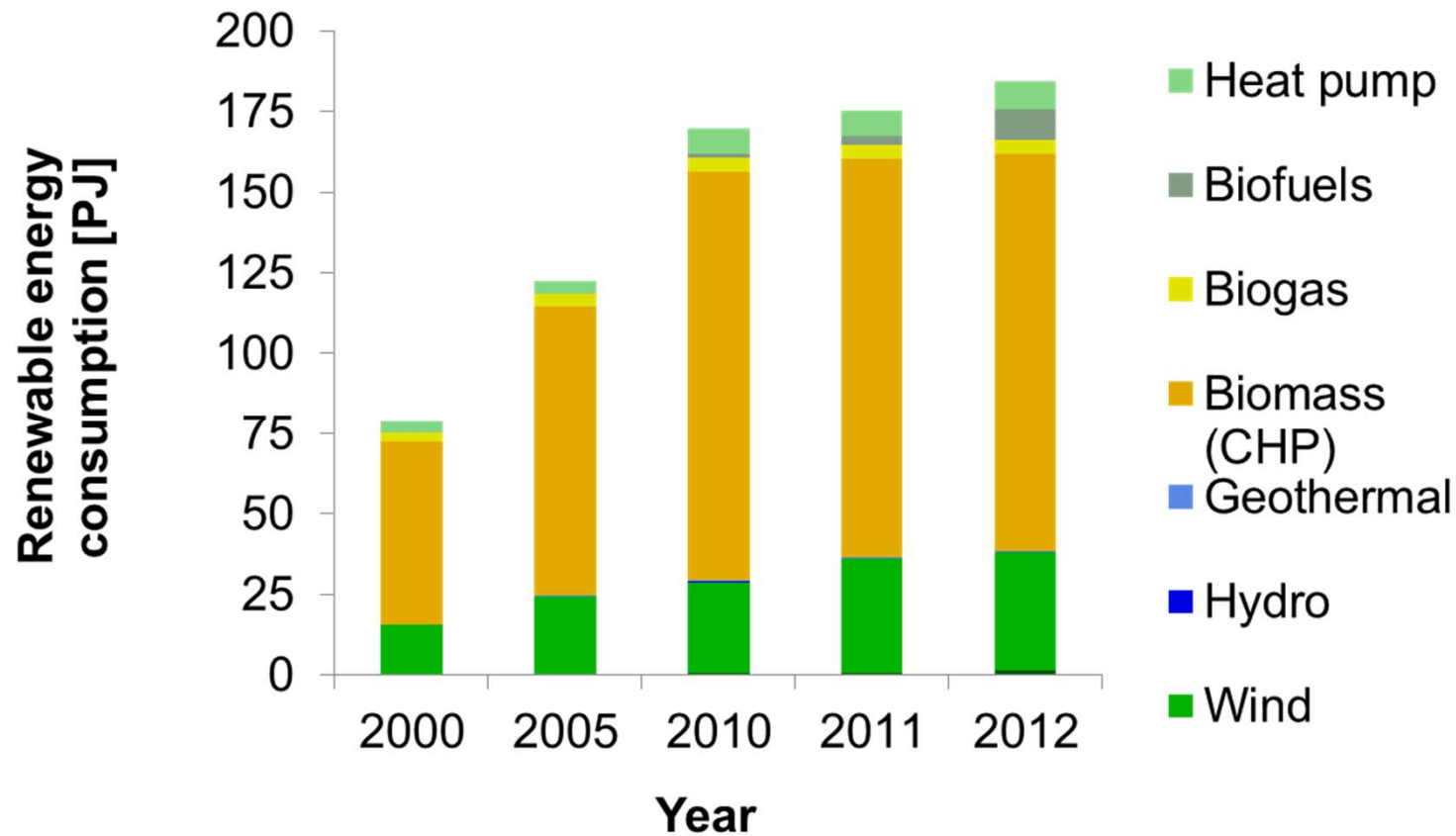
- **Total energy consumption 760 PJ**
- Oil consumption 322 PJ (production 429 PJ)
- Natural gas consumption 145 PJ (production 218 PJ)
- Renewable 184 PJ
  
- Consumption of biofuels for transportation 8.5 PJ or 4.2% transportation fuel
  
- 36% of biomass is imported wood, wood chips and wood pellets

Source: Danish Energy Agency, Energy statistics 2012.



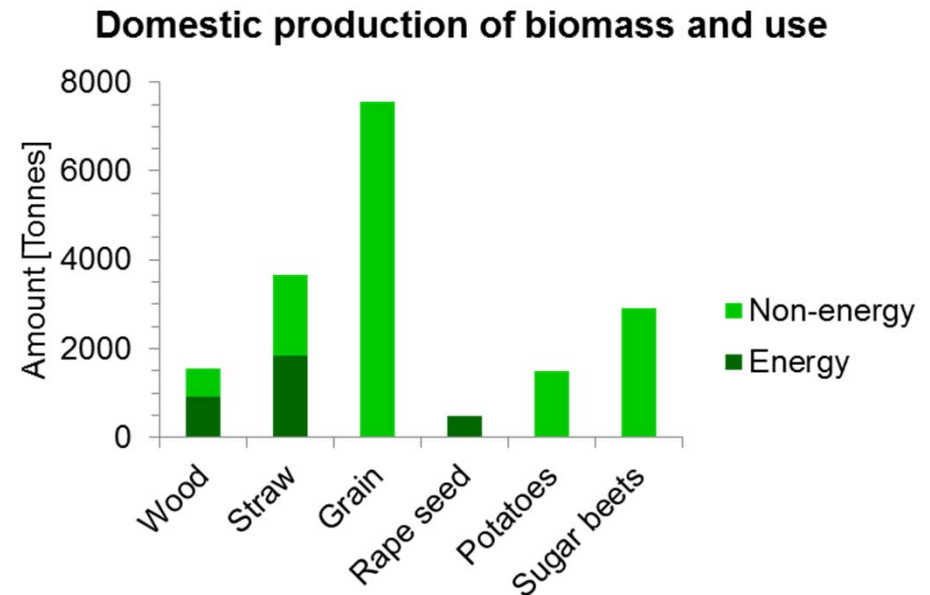
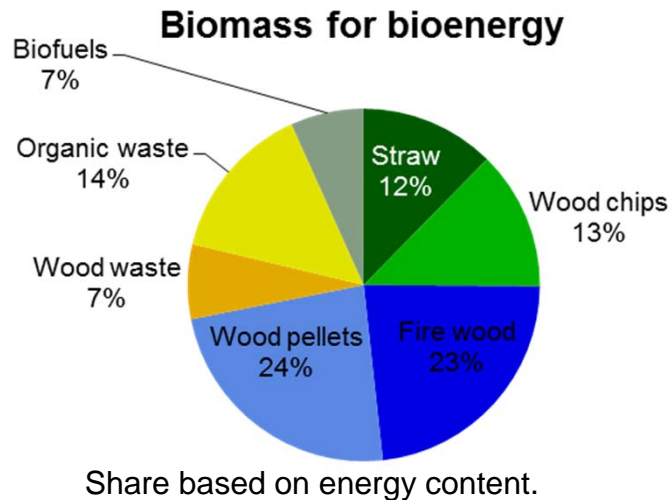
# Renewable energy in the Danish energy system

Renewable energy in the Danish energy system has increased steadily over the past decade



Source: Danish Energy Agency, Energy statistics 2012.

# Biomass use for energy and non-energetic applications



Source: Danish Energy Agency, Energy statistics 2012 and Statistics Denmark.

Wood contribute to 67% of bioenergy – 44% of wood is imported  
 Denmark has no production production of 1st generation bioethanol  
 Biodiesel is produced from tallow and rape seed.

New energy plan passed by the Danish Parliament in 2012 (Accelerating green energy towards 2020):

- The long term target of Denmark is 100% renewable energy in the energy and transport sectors by 2050.
- Renewable energy to cover 35% of total energy consumption by 2020
- Focus on wind and biomass – BUT biomass to replace coal in large scale CHP plants
- Increase utilization of manure for biogas by introducing subsidy for biogas sold to natural gas grid and new subsidy for biogas used for transport.
- No support for traditional biofuels (e.g. 1<sup>st</sup> generation bioethanol) and 2<sup>nd</sup> generation bioethanol is also not mentioned



# Biomass related (national) policy issues

Study on availability and potential for increased production of sustainable biomass published in 2012

- Currently around 4 mio tonnes DM biomass is used for energy
- Three scenarios proposed:
  - Business as usual – 4 mio tonnes extra (mainly from manure and use of straw potential)
  - Biomass – 10 mio tonnes extra (changes in practices agriculture and forestry – new varieties and plantations)
  - Environmental – 8 mio tonnes extra (as biomass but focus on not utilizing sensitive areas/habitats)
- Conclusion of study is that substantial amount of additional biomass is available and can potentially be further increased without compromising sustainability



### THE + 10 MILLION TONNES STUDY

Increasing the sustainable production of biomass for biorefineries



Morten Gylling, Uffe Jørgensen og Niclas Scott Bentsen (2013): The + 10 million tonnes study. Increasing the sustainable production of biomass for biorefineries, Frederiksberg, Denmark 2013.

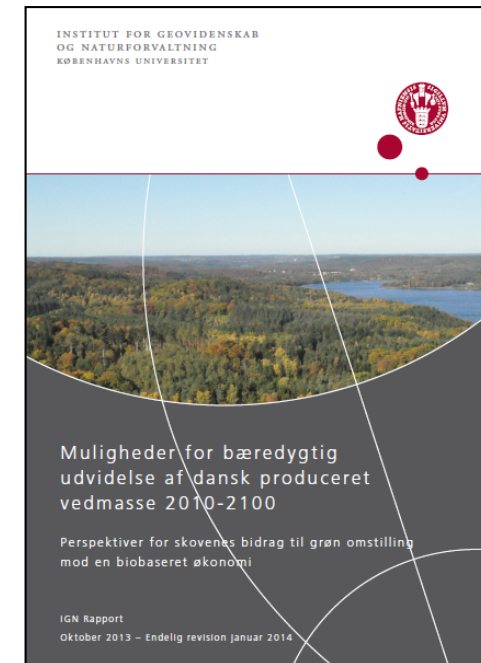
# Biomass related (national) policy issues

Study on potential for increased sustainable production of wood from the Danish forest between 2010 and 2100 published in 2013

Conclusion of study is that on a sustainable basis the annual cut of wood can be increased by 30% towards 2050 concurrent with an equal increase in carbon stock

The share of Danish wood in the energy sector can be increased from current 2% to 5% by 2020, 7% by 2050 and 13% by 2100.

The main tool to reach these targets is an increase in the Danish forest area, which also in accordance with the national forest policy from 1989 to double to forest coverage within one tree generation.



Graudal, L., Nielsen, U.B., Schou, E., Thorsen, B.J., Hansen, J.K., Bentsen, N.S., og Johannsen, V.K. (2013): Muligheder for bæredygtig udvidelse af dansk produceret vedmasse 2010-2100. Perspektiver for skovens bidrag til grøn omstilling mod en biobaseret økonomi, Institut for Geovidenskab og Naturforvaltning

Currently no official national bioeconomy strategy (BE)

In 2014 a bioeconomy panel involving 27 experts from industry, research, NGO and government was appointed to analyse the potential for developing bioeconomy in Denmark and give directions for the government. It analyzed the most potential value-chains for the Danish scenario.

From the report five recommendations were highlighted that could promote the development of bioeconomy in the near to long term perspective:

- An advanced integrated industrial scale biorefinery has to be established. The demand for biobased alternative products has to be stimulated in order to move from demo to commercial scale.
- Need for constant identification and solving of regulatory issues creating barriers for the BE development
- Creation of public-private partnerships to focus on attracting funding (incl. EU funding)
- Relevant ministries should work closely together and coordinate to assist in developing BE
- Criteria has to be developed to support increased public consumption of biobased products



# Bioeconomy strategy

National green growth plan “Water, Bio and Environment” released by the government 2013. In relation to biorefining the government will commit itself to:

- Work on increasing demand for biobased and sustainable products through common sustainability criteria in EU
- Create good environment for research, demonstration and commercialization of new biobased products
- Prepare the supply chains for the marked pull from biobased economy by e.g. increased availability of sustainable biomass



# Bioeconomy strategy

Biorefining Alliance (Alliance founded by DONG Energy, Novozymes, Haldor Topsøe and Landbrug & Fødevarer) launched its strategy in July 2012 "Denmark in a Global Bio-based Society - do we want to be customers or producers?".

The report recommends that bioeconomy becomes a new strategic national focus area and has 19 recommendations for an political action plan covering:

- Development of new markets for biobased products
- Sustainability criteria for biomass
- Facilities for demonstration and commercialisation
- Research and development



Country Report **Denmark**

# Biorefinery demonstration and pilot plants overview



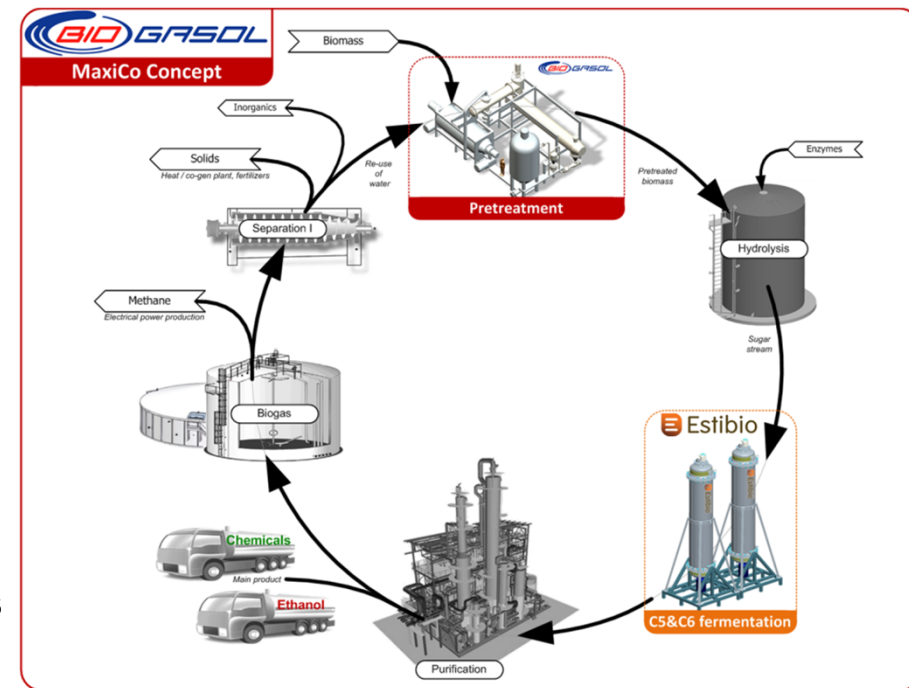
**State-of-the-art:** Pilot Plant; an integrated, continuous pilotplant, based on pre-treatment (BioGasol) and C5 fermentation technology (Estibio). Pre-treatment demonstrated at 1t/h, and commercial deployment of a 4t/h pre-treatment unit.

**Type of biorefinery:** A 3-platform (C5&C6 sugar, lignin and biogas) biorefinery for the production of bio-methane, bioethanol, solid fuel and fertilizer from straw or agricultural residues

**Location:** Ballerup, Denmark

**Owner:** Biogasol ApS (Estibio was founded in 2012 as a spin out of BioGasol ApS)

**Description:** The pilot-plant focusses on the development and demonstration of BioGasol's Carbofrac® pre-treatment and Estibios Pentoferm™ fermentation using Pentocrobe®, an in-house genetically modified microorganism, derived from the thermophilic species *Thermoanaerobacter italicus*.



**State-of-the-art:** Demonstration Plant

**Type of biorefinery:** A 5-platform (C6 sugars, C5 sugars, lignin, electricity and heat) biorefinery producing bioethanol, electricity, heat and feed from straw, corn stover, bagasse and EFB

**Location:** Kalundborg, Denmark

**Owner:** Inbicon A/S (subsidiary of DONG Energy A/S)



**Description:** The Inbicon pretreatment technology is based on a continuously operated one-step hydrothermal pretreatment. Key to the Inbicon technology is the ability to operate at high dry matter concentration (up to 30% DM). The demonstration plant has been in operation since 2009, and the annual production is about 5.4 mio liter of cellulosic ethanol, 11,400 metric tons of lignin pellets, and 13,900 metric tons of C5 molasses.



# IEA Bioenergy

## Task 42 Biorefining

**State-of-the-art:** Pilot Plant

**Type of biorefinery:** A 1-platform (biooil) biorefinery producing biooil, high grade char or coal and CO<sub>2</sub> from wood and wet organic waste

**Location:** Aalborg, Denmark

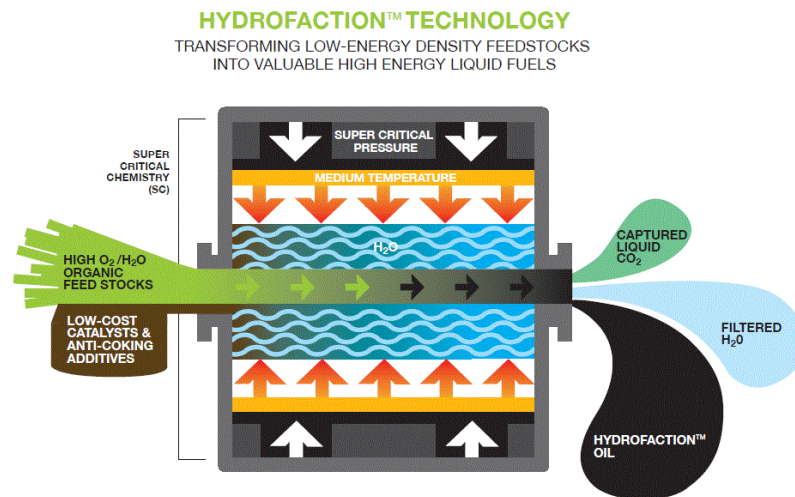
**Owner:** Aalborg University and Steeper Energy

# Steeper Energy



**Description:** The Steeper Energy Hydrofaction™ technology uses super critical conditions (300 bar and 400°C) to transform low-energy density (wet) organic feedstocks into valuable high-energy density products (biooil).

Bench/pilot scale plant operated at Aalborg University since early 2013 – 15-20 kg biomass/h resulting in 3 l/h biooil



# IEA Bioenergy

## Task 42 Biorefining

# REnescience



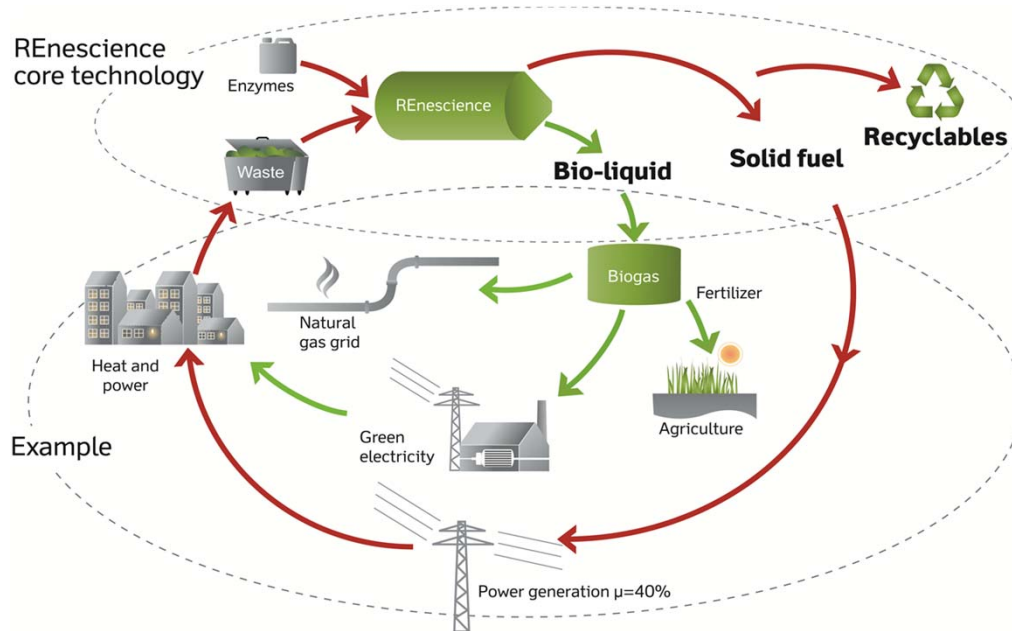
**State-of-the-art:** Pilot Plant

**Type of biorefinery:** A 2-platform (bio-slurry and biogas) biorefinery producing biogas, heat and power and fertilizer from unsorted municipal solid waste

**Location:** Copenhagen, Denmark

**Owner:** DONG Energy

**Description:** Renescience is developing technology, which uses enzymes to separate unsorted municipal solid waste and other waste streams into a bio-liquid containing the organic material from waste, a solid fuel and a recyclable output (glass, metals). A 800 kg/hr pilot plant has since 2009 been in operation in collaboration with the waste-to-energy company Amager Ressource Center in Copenhagen



# Major R&D projects

| Name         | Type     | Description   | National coordinator           | Duration and total budget         |
|--------------|----------|---|--------------------------------|-----------------------------------|
| MycoFuelChem | National | The core of the present project is development of fungal cell factories where biomass is degraded and compounds are produced in the same tank using low cost biomass (primarily garden/park refuse and household waste). The project will work with development of a consolidated fungal cell factory that directly converts biomass into either hydrocarbons or organic acids. | Aalborg University             | 4/2012 - 6/2016<br>30,57 mio. DKK |
| B21st        | National | The vision is to expand our knowledge and development of biomass resources and technologies to go beyond their current use for heat, power and ethanol towards future areas of chemicals and maritime fuels.  | University of Copenhagen       | 2011-2016<br>113,00 mio. DKK      |
| MAB3         | National | The MacroAlgaeBiorefinery – sustainable production of 3G bioenergy carriers and high value aquatic fish feed from macroalgae  | Danish Technological Institute | 3/2012 - 2/2016<br>23,67 mio. DKK |

# Major R&D projects

| Name             | Type     | Description  | National coordinator           | Duration and total budget          |
|------------------|----------|--|--------------------------------|------------------------------------|
| Biowalk4biofuels | EU       | The BioWALK4Biofuels Project aims to develop an alternative and innovative system for the treatment of biowaste and use of GHG emissions to produce biofuels, using macroalgae as a catalyser, in a multidisciplinary approach.  | Danish Technological Institute | 4/2010 – 3/2015<br>EUR 4.1 mio     |
| C3BO             | National | Center for BioOil. The aim is to bring research and development in this field to the very front through setting new standards for hydrothermal liquefaction in the context of continuous processes.  | Aalborg University             | 1/2014 - 12/2017<br>30,09 mio. DKK |
| Kalundborg Next  | National | This project aims at developing a sustainable and competitive lignocellulose based microbial oil technology for production of renewable biofuels. The project will demonstrate the production of microbial oil from lignocellulosic sugars produced from straw and will provide the necessary techno-economic data for scale-up to commercial scale. | DONG Energy                    | 2/2014 - 8/2017<br>124,47 mio. DKK |
| Bio-Value        | National | Bio-Value targets the entire value chain from sustainable biomass production to separation and conversion of all components of biomass into value-added products.  | University of Copenhagen       | 7/2013 – 6/2018<br>160 mio. DKK    |

# Major R&D projects

## B21st – Biomass for the 21<sup>st</sup> century

- Total budget 15 mio €
- Development of feedstocks to supply biomass for future biorefineries and biofuels
- Focus on producing fuel and chemicals from lignin – a residue after ethanol production from biomass
- Target is fuel for shipping industry

### Partners



MAERSK

DONG  
energy

novozymes

Rethink Tomorrow



HALDOR TOPSØE  
CATALYSING YOUR BUSINESS

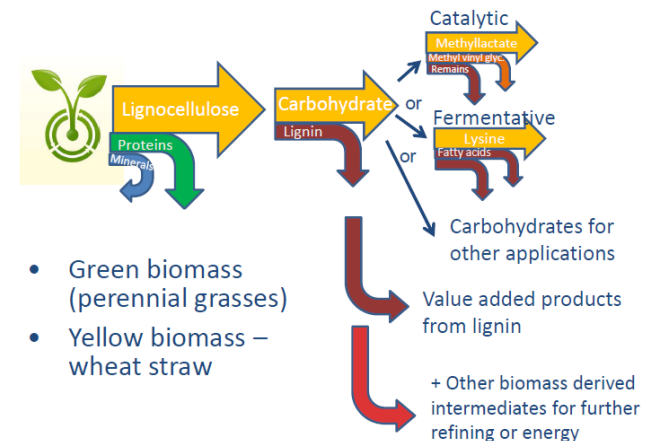


DTU



## Bio-Value - Value-added products from biomass

- Total budget 25 million € funded by Danish Strategic Research Council (25%), the Council for Technology and Innovation (25%), and the Partners (50%)
- Target is the entire value chain from sustainable biomass production to separation and conversion of all components of the biomass into value-added products
- Involves 4 universities, 9 companies and 2 innovation organizations



- Green biomass (perennial grasses)
- Yellow biomass – wheat straw

# Major national stakeholders involved in the field of biorefining

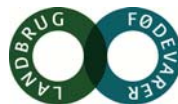
## BIOREFINING ALLIANCE LOCAL SOLUTIONS TO GLOBAL NEEDS

Founded December 2011 by DONG Energy, Novozymes, Haldor Topsøe and Landbrug & Fødevarer.

The aim is to promote the Danish position in the whole value chain from sustainable use of biomass to bio-based products.

Launched its strategy in July 2012 "Denmark in a Global Bio-based Society - do we want to be customers or producers?".

Link: [www.biorefiningalliance.com/english](http://www.biorefiningalliance.com/english)



# Major national stakeholders involved in the field of biorefining (1)

## Administration/Associations

| Name   | Website  |
|--|--|
| Danish Energy Agency                                   | <a href="http://www.ens.dk">www.ens.dk</a>                                   |
| Danish Ministry of Climate and Energy                  | <a href="http://www.kebmin.dk">www.kebmin.dk</a>                             |
| Ministry of Food, Agriculture and Fisheries of Denmark | <a href="http://www.fmv.dk">www.fmv.dk</a>                                   |
| Biorefining Alliance                                   | <a href="http://www.biorefiningalliance.com">www.biorefiningalliance.com</a> |
| Confederation of Danish Industry                       | <a href="http://www.di.dk">www.di.dk</a>                                     |
| Innovation network for biomass (INBIOM)                | <a href="http://www.inbiom.dk">www.inbiom.dk</a>                             |
| AgroTech   | <a href="http://www.agrotech.dk">www.agrotech.dk</a>                         |
| Danish Forest Owners Associations                      | <a href="http://www.skovdyrkerne.dk">www.skovdyrkerne.dk</a>                 |
| Landbrug og Fødevarer                                  | <a href="http://www.lf.dk">www.lf.dk</a>                                     |
| Danish Biogas Association                              | <a href="http://www.biogasbranchen.dk">www.biogasbranchen.dk</a>             |

# Major national stakeholders involved in the field of biorefining (2)

## Research and Development - Universities

| Organisation                    | Website                                    |
|---------------------------------|--|
| Technical University of Denmark | <a href="http://www.dtu.dk">www.dtu.dk</a> |
| University of Copenhagen        | <a href="http://www.ku.dk">www.ku.dk</a>   |
| Aalborg University              | <a href="http://www.aau.dk">www.aau.dk</a> |
| Århus University                | <a href="http://www.au.dk">www.au.dk</a>   |
| Roskilde University             | <a href="http://www.ruc.dk">www.ruc.dk</a> |
| University of Southern Denmark  | <a href="http://www.sdu.dk">www.sdu.dk</a> |
| Danish Technological Institute  | <a href="http://www.dti.dk">www.dti.dk</a> |

# Major national stakeholders involved in the field of biorefining (3)

## Companies

| Company        | Website  | Company                    | Website  |
|----------------|--|----------------------------|--|
| Hamlet Protein | <a href="http://www.hamletprotein.com">www.hamletprotein.com</a> | Biogasol                   | <a href="http://www.Biogasol.com">www.Biogasol.com</a>                           |
| DONG Energy    | <a href="http://www.dongenergy.com">www.dongenergy.com</a>       | Estibio                    | <a href="http://www.estibio.com">www.estibio.com</a>                             |
| Novozymes      | <a href="http://www.novozymes.com">www.novozymes.com</a>         | Terranol                   | <a href="http://www.terranol.dk">www.terranol.dk</a>                             |
| Haldor Topsøe  | <a href="http://www.topsoe.com">www.topsoe.com</a>               | Steeper Energy             | <a href="http://www.steeperenergy.com">www.steeperenergy.com</a>                 |
| Arla           | <a href="http://www.arla.com">www.arla.com</a>                   | Biofuel Technology         | <a href="http://www.biofueltechnology.dk">www.biofueltechnology.dk</a>           |
| KMC            | <a href="http://www.kmc.dk">www.kmc.dk</a>                       | Bigadan                    | <a href="http://www.bigadan.com">www.bigadan.com</a>                             |
| DLG group      | <a href="http://www.dlg.dk">www.dlg.dk</a>                       | Xergi                      | <a href="http://www.exergi.dk">www.exergi.dk</a>                                 |
| Mærsk          | <a href="http://www.maersk.com">www.maersk.com</a>               | Daka Ecomotion             | <a href="http://www.dakaecomotion.dk">www.dakaecomotion.dk</a>                   |
| Emmelev Mølle  | <a href="http://www.emmelev.dk">www.emmelev.dk</a>               | Maabjerg Bioenergy Concept | <a href="http://www.maabjergenergyconcept.eu/">www.maabjergenergyconcept.eu/</a> |

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