IEA Bioenergy

Task42 Biorefining in a Future BioEconomy

Country report Denmark

August 2018

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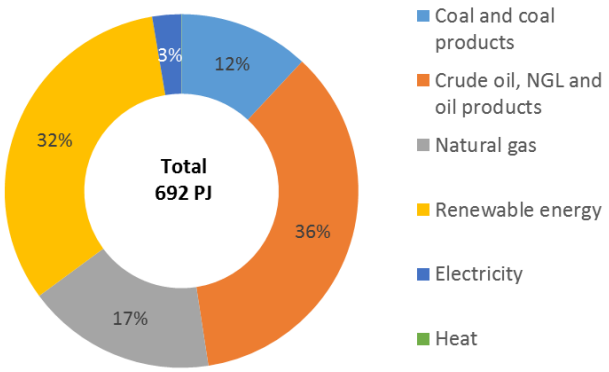
1. Total primary energy supply (TPES)

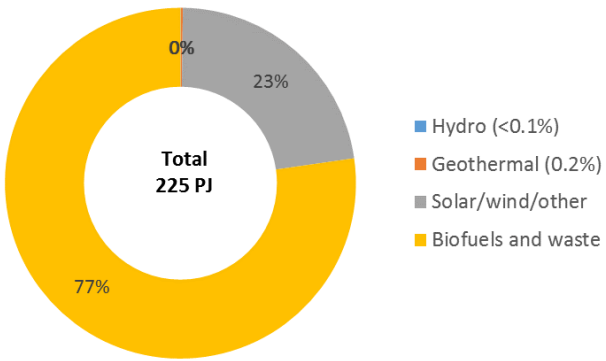
TPES in Denmark was 692 PJ in 2016 of which 32% (225 PJ) was renewable energy. The largest share of renewable energy is from biofuels and waste (bioenergy), accounting for 25% of TPES. Wind power contributes with 7% of TPES, but the share of wind power in the electricity production is 38%

Denmark is a net exporter of oil and natural gas (106% self sufficient), whereas all coal and 29% of bioenergy is imported.

Total primary energy supply in Denmark 2016



Total primary renewable energy supply in Denmark 2016



IEA (2018) "World energy balances", IEA World Energy Statistics and Balances (database), https://doi.org/10.1787/data-00512-en

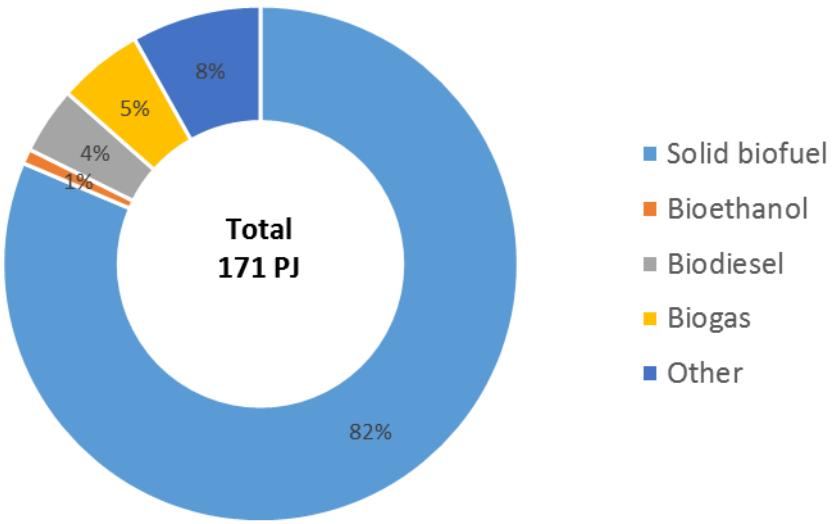
2. TPES from bioenergy and trend in evolution

TPES from bioenergy was in 2016 171 PJ, which was 25% of total TPES.

The share of energy from bioenergy has increased steadily the last many years. The largest amount of bioenergy is in the form of solid fuel, mainly for CHP.

In the 5 years 2011-2016, the largest increase was for biogas (120% up) and biodiesel (65% up). Solid fuel only increased 14% and the use of bioethanol was stable.

With the new National Danish Energy Plan (2020-2024) agreed 2018, (https://efkm.dk/ministeriet/aftaler-og-politiske-udspil/energiaftalen/) solid biomass for CHP has to decrease in the coming years. One reason is to reduce import of biomass (wood chips/pellets).



Bioenergy in the transport sector is currently in the form of biodiesel and bioethanol (5.75%). Biogas is used in a few bus fleet tests. In the new energy plan, expansion of the biogas production is planned and also upgrading and use for transport is expected.

There is no Danish production of bioethanol but two biodiesel plants

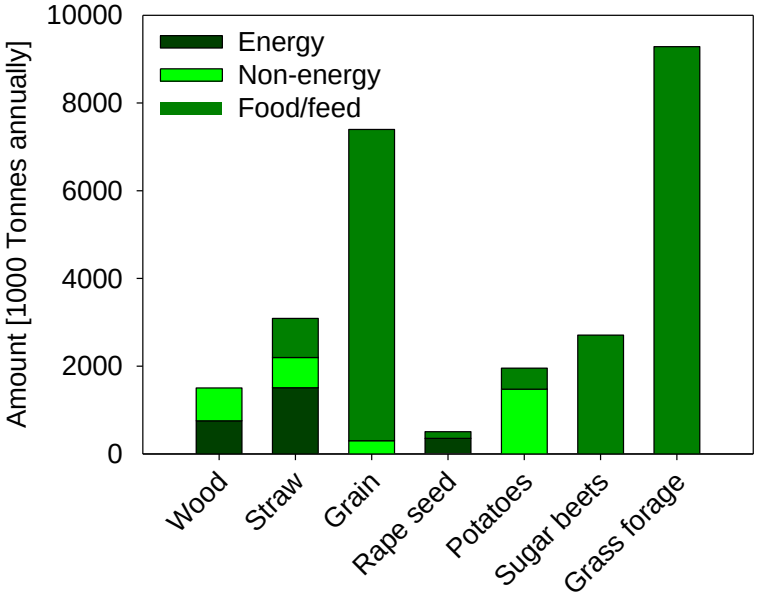
Denmark has agreed on a mandate for 0.9% advanced biofuels by 2020.

3. Biomass use for non-energetic purposes

In Denmark energy production from biomass is in the form of wood and straw for heat and power and rape seed for biodiesel production.

Due to a large animal production a large amount of grain (almost 80% of total harvest) and grass forage is used for feed.

Denmark do not have a pulp and paper production and all non-energy use of wood is for construction, furniture etc.



Source: Statistics Denmark, www.dst.dk

Non-energy use of straw is e.g. for bedding

Non-energy use of grain is for industrial use

Non-energy use of potatoes is for industrial processing for starch and protein (potentially for food/feed)

4. Biorefinery targets, policies and legislation

- Denmark do not have a biorefinery strategy, but the government have twice established a National Bioeconomy Panel.
  - The first National Bioeconomy panel was setup in 2013 and evaluated in 2016. In 2014 the first report with four recommendations for how to promote the development of bioeconomy in the near to long term perspective was published followed by reports focused on 'green', 'yellow' and 'blue' biomass. https://mst.dk/erhverv/groen-virksomhed/biooekonomi/ (Danish)
  - In 2017 the National Bioeconomy Panel was re-launched by the Minister of Environment and Food. The panel consists of 15 members from industry, universities and organizations (e.g. Confederation of Danish Industry).
  - In 2018 the report 'Proteins for the future' was published, focusing on protein from e.g. green biomass. https://mfvm.dk/miljoe/anbefalinger-om-biooekonomi/
- In 2016 the government established an Advisory Board for Circular Economy and in June 2017 the advisory board published their recommendations https://mfvm.dk/miljoe/anbefalinger-om-cirkulaer-oekonomi/ (Danish)
- Based on this the Government has in in June 2018 launched their strategy for circular economy which also contains parts related to biorefining. https://mfvm.dk/miljoe/strategi-for-cirkulaer-oekonomi/ (Danish)

5. Biorefinery related funding programmes

The are in Denmark no funding programs directly targeted biorefining, but there are funding programs funding biorefiniery related research, development and demonstration.

Public funding programs:

- EUDP: Funding of energy development and demonstration projects, including bioenergy.
- GUDP: Funding development and demonstration projects mainly in the area of agriculture and food/feed industry.
- MUDP: Funding of environmental development and demonstration projects, e.g. waste recycling, reduced emissions and circular economy.
- Innovation Fund Denmark: Different funding programs, largest being "Grand Solutions" that have thematic calls, e.g. bioresources and energy.
- Independent Research Fund Denmark: Open calls within the area of basic research within technology and production sciences

Private funds:

- Novo Nordisk Foundation - Biotechnology-based synthesis and production research: Funding biorefinery projects involving biotechnology aspects, e.g. fermentation or enzymes.
- The Velux Foundation – Open calls within technical and natural sciences

6. Commercial biorefinery facilities

Biodiesel production

Emmelev Biodiesel – Annual production around 150,000 tonnes based on rapeseed, www.emmelev.dk

EMMELEV A/S

DAKA Ecomotion– Annual production around 100,000 tonnes based on slaughterhouse waste, http://www.dakaecomotion.dk/en

6. Commercial biorefinery facilities

Biogas production

As of March 2017 a total of 166 biogas plants were in operation in Denmark:

51 Sewage sludge

5 industrial

27 landfill

28 Shared

55 Farm/agriculture

The Danish Biogas production has increased by 40-45 % during 2016-2017, compared to 2015 due to economical favorable conditions.

Gas up-grading is common for the majority of the plants.

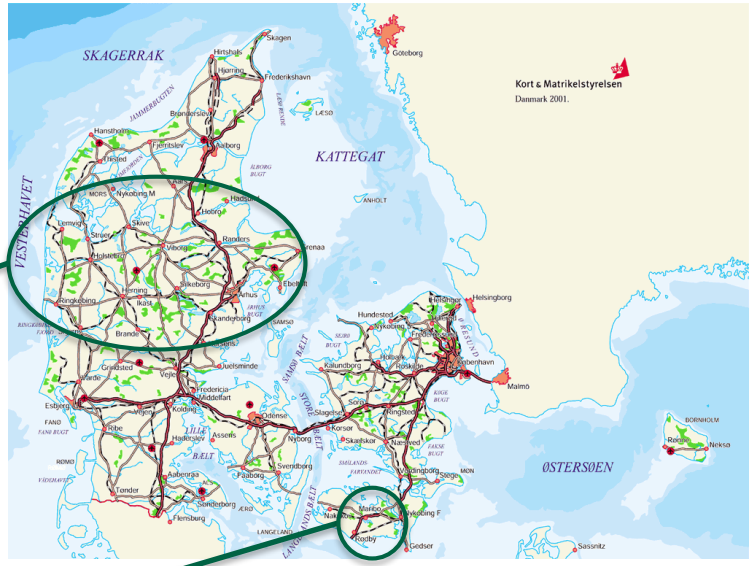
https://ens.dk/sites/ens.dk/files/Statistik/biogas_2018_10.pdf

7. Regional initiatives

There are two regional initiatives with strong focus on biorefining activities:

Green Growth in Central Denmark Region -

https://www.rm.dk/om-os/english/regional-development/energy-hub/bio-economy/



Bioeconomic Growth Center Guldborgsund -

http://www.bioguldborgsund.dk/

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www.task42.ieabioenergy.com

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8. Demo and pilot plants

steeper ENERGY

DANISH TECHNOLOGICAL INSTITUTE

AARHUS UNIVERSITY

Technical University of Denmark DTU

Billund BioRefinery
Resource Recovery for the Future

Renescience by Ørsted

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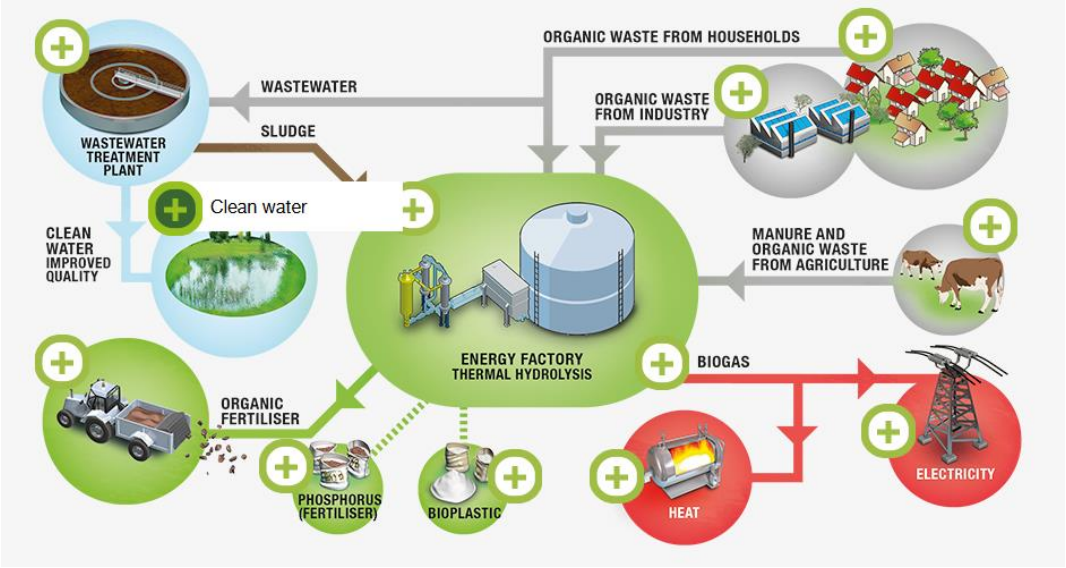
8. Billund Biorefinery

Billund BioRefinery
Resource Recovery for the Future

- Demonstration project run by the utility company Billund Vand A/S and the technology provider Krüger A/S
- Billund BioRefinery combines a wide range of technologies, e.g the Exelys™ thermal hydrolysis, in a unique way lower energy demand for wastewater treatment. At the same time more energy is recovered from the wastewater and waste, and the amount of the sludge is reduced and refined to an odourless, easily manageable and very efficient organic fertiliser for agricultural purposes.
- More information is available at www.billundbiorefinery.dk

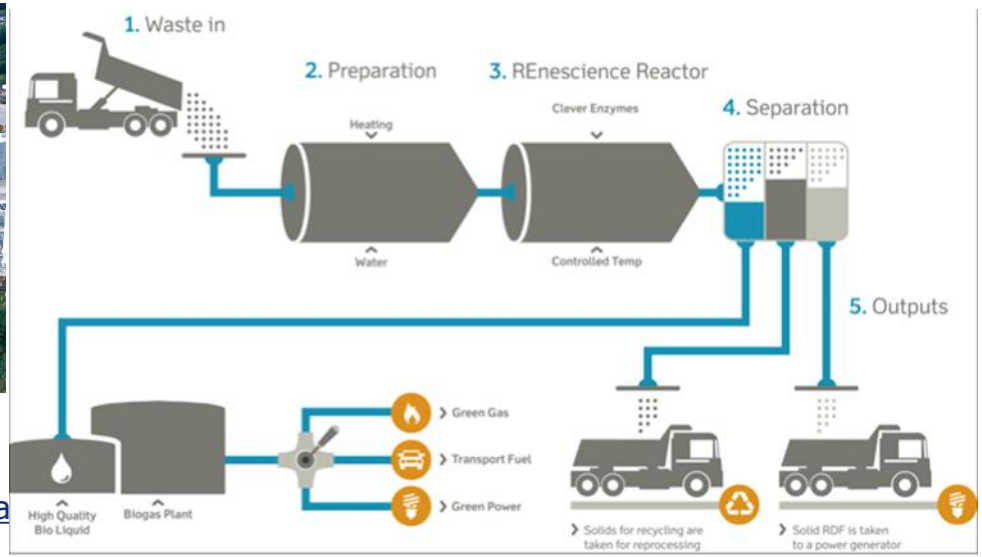


Powered by KRÜGER VEOLIA

Billund Vand

8. Renescience

- Ørsted (Previously DONG Energy) is developing the "Renescience" 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). The organics liquid is easily converted to biogas with high yields.
- 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.
- Ørsted also has pilot scale facilities at their research center in Ballerup, Copenhagen.
- The Renescience technology was brought to full scale in 2017 with the construction of the Northwich plant in the UK. Capacity up to 144,000 tonnes of waste per year, and the biogas produced from the organic fraction will generate 5 MW electricity
- More information is available at https://orsted.com/en/Our-business/Bioenergy/Renescience



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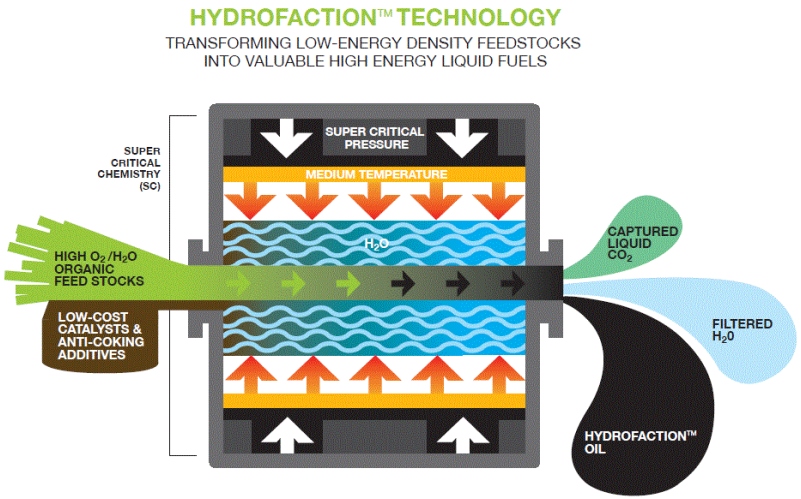
8. Steeper Energy Pilot Plant

State-of-the-art: Pilot Plant
Type of biorefinery: A 1-platform (biooil) biorefinery producing biooil, high grade char or coal and CO_2 from wood and wet organic waste
Location: Aalborg, Denmark
Owner: Aalborg University and 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



8. Pilot Plant Aarhus University

AARHUS UNIVERSITY

- Under the umbrella of Center for Circular Bioeconomy (CBIO), Aarhus University is operating a pilot plant in Foulum.
- Among the facilities are the world largest biogas plant for research purposes, pilot scale facilities for refining of green biomass (protein from grass) and a pilot plant for hydrothermal conversion of biomass to biooil.
- More information is available at www.Cbio.au.dk.

8. Danish Technological Institute pilot plant

DANISH TECHNOLOGICAL INSTITUTE

- DTI operates a pilot plant with the aim to:
  - Serve as a hub for companies and projects to develop and test their ideas for "value-added products"
  - To validate economical viability of the biorefining processes of biomasses
  - To generate sample material for product test, animal feed trials and
- The facilities include: Mills, wet mills, tanks up to 800 l for chemical and enzymatic reactions, pasteurization, decanter centrifuge, ultrafiltration, column chromatography and spray drying
- More information is available at www.dti.dk

8. Technical University of Denmark pilot plants

Technical University of Denmark

- **Department of Chemical and Biochemical Engineering** operates a pilot plant for thermal processes. The facilities include:
  - A 100 kw circulation gasification fluid bed
  - A high temperature (up to 600°C) and high pressure (up to 100 Bar) flow reactor used for studies on catalytic and homogenous processes
  - A high temperature (up to 1500°C) entrained flow reactor used for combustion, gasification and pyrolysis studies
- Pilot scale facilities for most unit operations (fermentation, distillation, filtration, spray drying) are also available
- More information is available at https://www.kt.dtu.dk/English
- **DTU Biosustain** operates a pilot plant for fermentation and downstream processes
- The facilities include:
  - Fermentors up to 150 l
  - Unit oprations for product separation and purification including chromatographic columns, evaporators, etc
- More information is available at http://www.biosustain.dtu.dk/

9. Major innovation activities (International)

Acronym	Project name	Funding source	Coordinator	Duration	Weblink
MacroFuels	Developing the next generation Macro-Algae based biofuels for transportation via advanced bio-refinery processes	H2020	Danish Technological Institute (DTI)	2016-2019	www.macrofuels.eu
EnzOx2	New enzymatic oxidation/oxyfunctionalization technologies for added value bio-based products	H2020	CSIC (Spain), Danish participation	2016-2019	www.enzox2.eu
Macro cascade	Cascading Marine Macroalgal Biorefinery	H2020	DTI	2016-2020	https://www.macrocascade.eu
DAFIA	Biomacromolecules from municipal solid bio-waste fractions and fish waste for high added value applications	H2020	AIMPLAS (Spain), Danish participation	2017-2020	www.dafia-project.eu
Pro-Enrich	Development of novel functional proteins and bioactive ingredients from rapeseed, olive, tomato and citrus fruit side streams for applications in food, cosmetics, pet food and adhesives	H2020	DTI	2018-2021	https://www.bbi-europe.eu/projects/pro-enrich
URBIOFIN	Demonstration of an integrated innovative biorefinery for the transformation of Municipal Solid Waste (MSW) into new BioBased products (URBIOFIN)	H2020	Industrias Mecanicas Alcudia SA (Spain), Danish participation	2017-2021	www.urbiofin.eu

9. Major innovation activities (>10 mio DKK)

Acronym	Project name	Funding source	Coordinator	Duration	Weblink
BioValue	Value-added products from biomass	IFD	University of Copenhagen	2013-2018	www.biovalue.dk
SYMBIO	Integration of biomass and wind power for biogas enhancement and upgrading via hydrogen assisted anaerobic digestion	IFD	Technical University of Denmark	2013-2018	www.biogasupgrade.dk
TEMPEN	Temperature activation of enzymes for degradation of biomass	IFD	Roskilde University	2016-2019	www.energiforskning.dk/node/8593
SYNFUEL	Sustainable synthetic fuels from biomass gasification and electrolysis	IFD	Technical University of Denmark	2016-2019	www.energiforskning.dk/node/8087
	Demonstration of 2G ethanol production at industrial scale, MEC	EUDP	DONG Energy	2016-2019	https://energiforskning.dk/node/8597
MAB4	Microalgae Biorefinery	IFD	Danish Technological Institute	2016-2020	www.mab4.org
GRØN-BIORAF	Danish Demonstration scale technology platform for green biomass research	GUDP	Aarhus University	2018-2021	https://mst.dk/erhverv/groen-virksomhed/groent-udviklings-og-demonstrationsprogram-gudp/gudp-projekter/2017-projekter/dansk-demoskala-teknologiplatform-for-forskning-i-groen-biomasse-groenbioraf/
REMAPP	Resource efficient MicroAlgae Protein Production	IFD	Danish Technological Institute	2018-2022	https://www.teknologisk.dk/ydelser/marker-med-mikroalger-skaber-fremtidens-baeredygtige-protein/39973

IFD – Innovation Fund Denmark

10. Major stakeholders

Governmental organisations

Name	Weblink
The Ministry of Energy, Utilities and Climate	https://en.efkm.dk/
Ministry of Environment and Food of Denmark	https://en.mfvm.dk/
The Danish Energy Agency	https://ens.dk/en
Danish Ministry of Higher Education and Science	https://ufm.dk
Innovation Fund Denmark	https://innovationsfonden.dk/en

NGOs

Name	Weblink
Algecenter Danmark	http://www.algecenterdanmark.dk/
Danish Biogas Association	https://biogasbranchen.dk/
Danish Biotech	https://danskbiotek.dk/
Danish Energy	https://www.danskenergi.dk/
Danish Environment Technology Association	www.danskmiljøteknologi.dk/en
Danish Forest Owners Associations	www.skovdyrkerne.dk
Danish Fuels Industry Association	http://www.drivkraftdanmark.dk/
Innovation network for biomass (INBIOM)	www.inbiom.dk
The Danish Agriculture & Food Council	https://agricultureandfood.dk/

10. Major stakeholders

Universities and Research Institutes

Name	Weblink
Danish Technological Institute	www.dti.dk
Technical University of Denmark	www.dtu.dk
University of Copenhagen	www.ku.dk
University of Southern Denmark	www.sdu.dk
Aarhus University	www.au.dk
Aalborg University	www.aau.dk

Companies/industries

Name	Weblink
Arla	www.arla.com
Bigadan	https://bigadan.dk/
Biogasclean	http://www.biogasclean.com/
Daka Ecomotion	www.dakaecomotion.dk
DLG group	www.dlg.dk
Emmelev Mølle	www.emmelev.dk
Haldor Topsøe	www.topsoe.com
Hamlet Protein	www.hamletprotein.com
KMC	www.kmc.dk
Novozymes	www.novozymes.com
SEGES	https://www.seges.dk/
Steeper Energy	https://steeperenergy.com/
Terranol	www.terranol.dk
Ørsted	https://orsted.com/

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