

Country Report Denmark

IEA Bioenergy Task 42

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Country introduction

Denmark has for many years had focus on the use of renewable energy and energy from biomass. Despite the small size of Denmark, the country has a large and intensive agricultural production that also holds large potential for production of biomass for bioenergy and biorefineries. Already by the “Biomass action plan” from 1993 the Danish government set specific targets for the use of biomass in the production of heat and power. The law forced the power companies to introduce incineration of wood and co-firing of straw. Today roughly one-fifth of the total available amount of straw is used for heat and power generation and Denmark is importing wood pellets to cover the demand. Danish industry is also focused on technologies for renewable energy production. Denmark is well-known for the wind turbine industry but also has several large and internationally known companies involved developing and producing technologies for biorefineries.

Table DK1. Characteristics of Denmark in 2009 (Danish Statistics).

	Total area [10 ³ km ²]	Population [10 ⁶]	Utilized Agricultural area [10 ³ km ²]	Forest land [10 ³ km ²]
Denmark	43.098	5.51	26.24	5.34

Energy production and consumption based on biomass

In 2009 the primary production of energy in Denmark was 1,007 PJ or 24.05 Mtoe and the total energy consumption was 808 PJ, thereby giving a self-sufficiency of 124%. Since 1997 Denmark has been self-sufficient with energy primary due to the oil and natural gas production, which accounts for 86% of the primary energy production. In 2009 Denmark was the only country in Europe with a self-sufficiency above 100%. The total energy consumption has been between 808 and 880 PJ in the years 2005-2009. However, the primary energy production has gradually decreased with 23% since 2005 due to declining production of oil and natural gas. Current estimates predict that the oil and gas reserved corresponds to 13 years of production at 2009 production levels.

Renewable energy accounted for 17.6% of the Danish energy consumption in 2009. Of this 78% of the energy was supplied from biomass. The use of biomass for bioenergy was in 2009 110.3 PJ of which 21% or 23.5.7 PJ was imported biomass, mainly wood pellets chips. Since 2005, the use of bioenergy has increased by 16%. The import of biomass for bioenergy, primarily wood pellets, has increased almost 10-fold since 2000 and by 44% since 2005.

Table DK2: Current bioenergy production in Denmark (Danish Energy Agency):

Use	Year	Unit	Amount	% of total bioenergy	Feedstock(s)	Number of plants
Power ¹	2009	PJ	32.9	29.8	Wood, pellets, straw, MSW	
Heat ¹	2009	PJ	30.9	28.0	Wood, pellets, straw, MSW	132
CHP ¹	2009	PJ	46.9	42.5	Wood, pellets, straw, MSW	64
Bioethanol		PJ	0.20	0.2	No production in Denmark	0
Biodiesel	2009	PJ	0.18	0.2	Rapeseed, animal waste	2
Biogas	2009	PJ	4.17	3.8	Manure, animal waste	76
Other ²	2009	PJ	42.9	38.9	Wood, pellets, straw	

¹ All power and 45% of heat produced from biomass is from CHP, see also text
² Mainly household and industry heating other than district heating

The primary use of biomass is for heating, either as district heating (30.9 PJ) or as private or industrial installations (43.9 PJ). District heating is widely used in Denmark and almost 60% of all house holds are heated this way. Around 45% the heat for the district heating system originating from biomass is produced by co-generation with electricity (Combined Heat and Power - CHP). All the electricity produced from biomass is produced in CHP plants. There are around 64 CHP plants (centralized or decentralized CHP's) using biomass (wood, straw or MSW) or biogas and 132 district heating plants using biomass.

Biogas is produced at 76 farm or centralized plants. Manure combined with organic waste (typically slaughter house waste) is the feedstock. The biogas is used almost exclusively for combined heat and power production.

There is a small production of biodiesel at two facilities in Denmark (3.1 PJ or 100,000 m³ annually). One plant is using rapeseed as feedstock and the other one is using animal fat/tallow from slaughter houses (2nd generation biodiesel). The total production capacity of the two plants is around 150,000 m³. In 2010 there was no mandatory blending of biodiesel into diesel in Denmark

and almost the entire biodiesel production was exported. Only a very small amount was used in a fleet test trail. From 2011 it will be mandatory to blend 7% biodiesel into the diesel.

In 2009 there was no production of bioethanol in Denmark, but one company has since November 2009 been operating a 2nd generation bioethanol demonstration plant with an annual capacity of 5400 m³. Since 2006, one oil company has been selling gasoline with 5% bioethanol. In 2009 this accounted for 0.204 PJ (around 10,000 m³) of bioethanol being imported. From July 2010 it has been mandatory to blend 5% bioethanol into gasoline. Consequently, the consumption of bioethanol is going to increase sharply from 2010. The 2nd generation bioethanol produced at the running demonstration plant is exclusively sold to one oil company, which is distributing it nation wide in a 5% blend marked as 2G 95 octane gasoline with a premium of 0.1 €/l.

Table DK3: Breakdown of Danish biomass energy use on feedstock (calculated from reported energy content, Danish Energy Agency):

Source	Year	Unit (Mm ³ or kton)	Amount	% of biomass energy reported above
Round wood	2009	kton	1,432	23
Forest wood chips	2009	kton	1,350	13
Wood industry residues	2009	kton	384	5
Wood pellets/briquettes	2009	kton	1,107	18
Black liquor and sludge		kton		
Wastes (organic fraction)	2009	kton	2,162	21
Straw/agricultural residues	2009	kton	1,196	16
Sugar beet/sugar cane	2009	kton	0	
Cereals (grain, corn)	2009	kton	0	
Other (rapeseed)	2009	kton	150	3

The majority of the biomass used for energy production in Denmark originates from wood. Wood, chips, pellets and wood residues account for almost 60% of the energy produced from biomass. Interestingly, one third of this wood was in 2009 imported and mainly as wood pellets. Almost 90% of the wood pellets used in Denmark are imported. Incineration of the organic/biodegradable fraction of municipal solid waste contributes with another 21% of the bioenergy.

Agricultural residues in the form of straw has been used for heat and power generation for more than 20 years. Since 2005 the amount used annually have remained fairly stable around 1.100 to 1.300 million tons. However, the share of total bioenergy has decreased slightly from 20 to 16% due to increased production of bioenergy from wood and wood pellets.

The production of biodiesel from rapeseed has remained stable for a number of years and requires the processing of approximately 150,000 tons of rapeseed annually.

Biomass used for non-energy purpose

Danish forests cover only a small part of the country (12.3% or 5,340 km²) since the dominant land use in Denmark is agriculture (61% or 26,240 km²). The last 4 years the annual cutting have remained very stable and was in 2009 2.40 million m³ of which 45% was used for energy purposes.

Consequently, the forest industry is limited in Denmark. There is no pulp and paper production from new fibers, but one factory is recycling around 120,000 tons of paper annually.

The agricultural production contributes significantly to the Danish economy. The production and export of animals was in 2010 519.000 cattle/cows, 28.5 million pigs and 108 million heads of poultry. These number have been stable over the last few years. This large animal production gives large potential for biogas production (potentially 10-fold higher than the current level). However, it also influences the biomass production. The annual production of grain/cereals is between 8 and 9 million tons. In 2010, 8.42 million tons of grain/cereals were harvested and of this 6.72 million tons were used for feed and only 0.32 million tons were used for industrial purpose. The rest was either used for food or exported. There is no statistical information on how the 0.32 million tons were used for industrial purposes.

The starch production was in 2010 215,000 tons (189,000 tons in 2009). The majority of the starch is produced from potatoes. Three factories in Denmark produce annually process around 700,000-900,000 tons of potatoes (691,000 tons in 2010) into 120,000-130,000 tons of starch. The pulp from the production is sold as an animal feed product.

The Danish sugar production is based on sugar beets that are processed at two factories owned by NordicSugar, which in 2009 became member of the Nordzucker group. In 2010 the production of sugar beet was 2.36 million tons (up from 1.90 in 2009) resulting in the production of 262,000 tons of sugar (down from 394.000 tons in 2009) and 78,000 tons of melasse. Besides this, the beet pulp is processed into an animal feed product.

Rapeseed is the main oilseed grown in Denmark. The production increased from 342,000 tons in 2005 to 637,000 tons 2009. In 2010 the 580,000 tons of which roughly one fourth was processed into biodiesel. From the oil production a rapeseed press cake is also produced, which is used as animal feed. In 2010 222,000 tons of press cake was produced.

Currently there is no commercial production of algae, but pilot projects are running with the aim of investigate the production of macro algae (*Ulva lactuca* and *Laminaria saccharina*) for biofuels production.

Table DK4: Use of biomass for non-energy purpose

Use*	Year	Unit	Amount
Wood for particle boards			n.a.
Wood for pulp and paper			n.a.
Wastes from pulp and paper			n.a.
Chemicals from biomass			n.a.
Cereal production	2009	kton	8,420
Sugar production	2009	kton	2,360 ¹
Starch production	2009	kton	215
Oilseed production	2009	kton	580 ²
Algae production			

¹ Reported as production of sugar beets for sugar production
² Reported as production of oilseeds (rapeseed)

Policy issues related to biomass, bioenergy or biorefineries

In February 2008 the Danish Parliament entered an energy agreement on Danish energy policy for 2008-2011. The purpose of the agreement was to reduce the dependence of fossil fuel and reduce the emission of carbon dioxide. The agreement includes measures for the energy consumption and production towards 2025. The target is to reduce the energy consumption by 4% by 2025 compared to 2006 and the share of renewable energy has to increase from 16 to 30%. In 2011, renewable energy has to cover 20% of the energy consumption, which actually achieved already for 2010. These targets has to be meet by increased energy savings, expansion of existing wind energy production and increased use of biomass for heat and power production, including biogas production. In addition, Denmark will implement the European biofuels directive by ensuring 5.75% of biofuels in the transport sector by 2011. In 2020 the target is 10% of the transportation fuel to be covered by biofuels. No direct targets for the future use of biomass for bioenergy is specified other than a three-fold increase in the biogas production.

Until July 2010 there was no mandatory blending of biofuels in the transportation fuels and therefore no policy measures promoting the use of biofuels (bioethanol or biodiesel) in the transport sector. However, a bill on the use of sustainable biofuels from 2009 set targets for future use of liquid biofuels. The act will ensure stepwise introduction of biofuel towards 2012. The target is 0.75% of ethanol (on energy basis) from mid 2009 and 5% in 2011. Biodiesel will be introduced by a target of 3.3% (energy basis) in 2011. From 2012 both biodiesel and bioethanol will be blended to 5.75% (energy basis). The act follows the European Renewable Energy Directive on the definition of sustainability of biofuels. The double-counting of 2nd generation biofuels will be possible and again the definition of 2nd generation biofuels is in accordance with the European directive. According to this definition the biodiesel from Danish biodiesel producer DAKA (feedstock animal waste) is likely to be regarded as 2nd generation biodiesel. Similarly, the ethanol produced by Inbicon in their demonstration plant utilizing wheat straw could benefit from the double-counting.

The Danish policy is that the growth in production of biomass for bioenergy has to be sustainable. As part of an agreement called "Green growth" from 2009 it is now possible for farmers to apply for grants of 430 €/ha for establishing perennial energy crops on farm land. The grand scheme is focused on establishment of short rotation crops such as willow, poplar and hazel. For 2010 there was allocated 4.3 mio € corresponding to 100,000 ha of energy crops. The aim is that this increased production of biomass will contribute with additional 23 PJ of bioenergy annually towards 2020, which would increase the bioenergy production by roughly 20%.

The "Green growth" plan also includes supporting schemes for the biogas production from animal manure. The aim is to increase the utilization of animal manure from the current level of 5% of the manure being utilized to 40% by 2020. This will increase the biogas production by a factor of 3 before 2020. In addition the government is working on changing the legislation to allow biogas being feed into the natural gas grid and to allow incineration of the fiber fraction in manure.

Currently there is no direct policy regarding the use or expanded use of biomass in biorefineries for production of other products than bioenergy. The "Green growth" agreement is mainly focused on increasing the bioenergy production from the agriculture and to advance the food industry and food production.

In 2011 a new energy policy plan has to be negotiated in the parliament, but 2011 is also election year for the parliament. The outcome of the election can have significant impact on the directions for such a new plan. The economical crises that have had impacted investments and funding the last few years is still not over and the ambitions for a new energy plan, funding programs etc. will be influenced by this as well.

Biorefinery related funding programs

Danish funding for research and development within bioenergy and biorefineries is through four major agencies or funding programs of which two are specifically oriented towards energy research. Currently no programs are specifically directed towards biorefineries. In 2009 the funding granted for energy research within biomass and biofuels was 23.5 mio € out of a total budget for energy research of roughly 87 mio €. For 2010 the government has originally allocated 133 mio € for research, development and demonstration of energy technologies. However, in May 2010 a new economical plan to restructure the Danish economy after the economical crisis was passed in the parliament. Part of this plan put a limited on the size of funding going to research and thereby also the funding of energy research.

Danish National Advanced Technology Foundation (Højteknologifonden)

This funding program supports advanced technological research and/or innovation projects with special attention to the areas of nano-, bio-, and/or information and communication technology. The program was established in 2005 and 25% of the money granted (41 mio €) has to be to projects within environment or energy research and development. A number of bioenergy/biofuel projects have been supported. The projects and consortiums that receive support must live up to three criteria: 1) Noticeable commercial potential, 2) Technology transfer, 3) Public-private cooperation and private co-funding must amount to min. 50% of the project costs.

Projects can be funded for up to 5 years and in 2009 the Danish National Advanced Technology Foundation had 37 mio € for distribution. In 2010 the budget is nearly 70 mio €.

The Danish Council for Strategic Research – Program commission on sustainable energy and Environment

Funding program that supports strategic research in sustainable energy and environment. The specific themes are defined in the calls. In 2009 the calls were “Energy Systems of the Future” with a budget of 22 mio € and “Competitive Environmental Technologies” with 17 mio €. The projects are with focus on basic and applied research, often cross-disciplinary. The strategic research programmes are open to all public and private actors and substantial co-financing is expected from public as well as private partners. Projects can be funded for up to 7 years depending on type: Strategic research centres (appr. 0.7 mio € each year for five-seven years), Strategic research alliances (total 1.3 to 2.7 mio € over appr. five years), Strategic research projects (up to a total budget of at least DKK 1.3 mio € million and 3-5 years’ duration). For 2010 the budget is 40 mio €.

The Danish Council for Strategic Research – Program commission on health, food and welfare

Similar to the other Strategic research program. The themes “Foods including biological manufacturing” and “Bioresources, foods and other biological products” could be used to fund biorefinery projects. In 2010, the budget for these two themes is 17 mio €.

Danish Energy Agency - Energy technology Development and Demonstration Program (EUDP)

Funding program established in 2008 that supports research, development and demonstration within new efficient energy technologies, including: Biomass technologies and systems for transport and energy. Several bioenergy and biofuel projects have been supported. In 2009 the program had a

budget of 40 mio € of which 13 mio € was granted to projects related to biofuels. The budget for 2010 was 53 mio € and for 2011 47 mio €.

Danish Energy Agency – Green Labs DK

Funding program established in 2010 that supports the establishment of facilities to develop and test energy technologies in demonstration scale. Only nonprofit organizations, universities or GTS organizations can obtain support. The total budget for 2010 to 2012 is 28 mio €.

Energinet.dk – Program ForskEL

Energinet.dk is the transmission system operator (electricity and natural gas) in Denmark and must by law ensure that research and development (R&D) is conducted for the benefit of Danish society and the electricity sector. Energinet.dk finances its R&D activities on the basis of tariffs charged for the transmission of electricity in the high-voltage grid and natural gas in the natural gas grid. The ForskEL program funds R&D in environmentally-friendly electricity generation technologies, including bioenergy (e.g. CHP from biomass or biogas). The budget is around 17 mio € annually.

Running commercial biorefineries

Table DK5. Examples of the most representative existing biorefineries – preferable not conventional biofuel production facilities or traditional use of biomass (e.g. pulp and paper):

Company	Feedstock	Products	Description	Size
CP Kelco	Citrus peel and algae	Pectin, carageenan	www.cpkelco.com	€ 150 mio
Daka biodiesel	Animal waste	Biodiesel, glycerol	www.dakabiodiesel.com	

Demo and pilot plants

Table DK6. Examples of the most representative demo and pilot plants:

Company	Feedstock	Products	Description	Status (demo/pilot)
Inbicon/DONG Energy	Straw and agricultural residues	Bioethanol, solid biofuel and feed	Pilot plant with capacity of 1000 kg feedstock per hour. www.inbicon.com	Pilot
Inbicon/DONG Energy	Straw	Bioethanol, solid biofuel and feed	Demonstration plant integrated with CHP plant. Production capacity 5,400,000 l bioethanol per year www.inbicon.com	Demo
Biogasol	Agricultural residues	Bioethanol, solid biofuel, biogas, hydrogen and feed	Pilot plant www.biogasol.com	Pilot
Technical University of Denmark	Biomass	Bioethanol, solid biofuel		Pilot
Aarhus University/Xergi	Manure, energy crops	Biogas	Full scale test facility for biogas production	Demo
Organic Fuel Technology	Straw	Biooil	Pilot scale, www.organicfueltechnology.com	Pilot
Pyroneer/DONG Energy	Straw and agricultural residues, MSW	Gas for	Low Temperature Circulating Fluid Bed gasifier producing a combustible synthetic gas (syngas)	Demo
REnescience/Amager-Forbrændingen and DONG Energy	MSW	Biogas, fertilizer, recycling materials	System sorting MSW into a organic liquid fraction suitable for biogas production, a solids fraction for CHP and recyclable materials	Demo

Major RTD activities

Table DK7. Major RTD activities:

Name of project	Type of project	National coordinator	Description	Duration	Size (€s, US\$)
Bio4Bio	Danish Strategic Research Council	KU	The goal and purpose of the Centre is to link and focus Danish research within plant biology, biomass technology, microbiology and processing technology for the advancement of biotechnologies for conversion of non-food plant biomass to sustainable energy carriers.	2009-2014	€ 5 mio
BIOREF	Danish Research Council	AAU	Development of a biorefinery concept for Integrated Production of Biomedicals, Biochemicals, Feed and fuels from selected Plant Materials	2008-2011	€ 2.3 mio
BioWALK4Biofuels	EU FP7	AU/DTI	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.	2010-2014	€ 3.97 mio
Energy production from Marine biomass	PSO	DTI	Utilisation of macro algae (<i>Ulva Lactuca</i>) for production of bioenergy (bioethanol, biogas and CHP)	2008-2011	€ 1.4 mio
Glyfinery	EU FP7	DTU	The GLYFINERY project is targeted to development of a novel technology based on biological conversion of the glycerol by-product into known and new advanced liquid biofuels, bioenergy and valuable biochemicals in an integrated biorefinery concept.	2008-2012	€ 4.47 mio
HYPE	EU FP7	KU	Development of a novel integrated concept for hydrolysis and fermentation of lignocellulosic feedstocks.	2008-2012	€ 5.4 mio
Kacelle	EU FP7	Inbicon	Based on the Inbicon demonstration plant to optimise the plant and lower the production costs for ethanol through: Improving the capacity of the plant, reducing the energy consumption and water balance, adding a fermentation step for C5 sugars and recycle the enzymes in the process.	2009-2013	€ 16.1 mio
Proethanol2G	EU FP7	Inbicon A/S	The project focus on the effective integration and development of advanced technologies through the combined use of Biology and Engineering for the	2010-2013	€ 2.51 mio

			production of second generation (2G) bioethanol, from the most representatives European (wheat straw) and Brazilian (sugarcane bagasse and straw) feedstocks.		
Renescience2	EUDP	DONG Energy A/S	The objective of the REnescience project is to upgrade household waste for optimum utilisation of its content of energy and minerals	2011-2012	€ 5.7 mio
Retrogas	EUDP	Nordic Bioenergy A/S	Demonstration of cost-effective production of biogas from manure only comprising new pre-separation technology and enzyme liquefaction	2009-2012	€ 1.7 mio
Supra-Bio	EU FP7	AAU	Research, development and demonstration of novel intensified unit operations that can be integrated into economic and sustainable biorefinery options for the production of second-generation biofuels, intermediates and high value products,	2010-2014	€ 14.8 mio

AU – Aarhus University

AAU – Aalborg University

DTI- Danish Technological Institute

DTU – Technical University of Denmark

KU – University of Copenhagen

EUDP - Energy development and demonstration funding program

PSO – Public Service Obligation, funding program mainly focused on research and development related to heat and power sector

Stakeholders

Table DK8. Major stakeholders in Denmark:

Name	Short Description
Industry	
Novozymes	Producer of enzymes for biorefineries, www.novozymes.com
Danisco/Genencor	Producer of enzymes for biorefineries, producer of food ingredients, www.danisco.com
Haldor Topsøe	Development of technologies for synfuel production, www.haldortopsoe.com
CP Kelco	Production of food ingredients from biomass, www.cpkelco.com
Organic Fuel Technology	Development of technologies for producing oil from biomass. www.organicfueltechnology.com
DONG Energy	Major power company in Denmark, involved in oil and gas production in Denmark, www.dongenergy.com
Vattenfall	Power company, www.vattenfall.dk
Inbicon	Company developing technologies for 2 nd generation biofuels, www.inbicon.com
Biogasol	Company developing technologies for 2 nd generation biofuels, www.biogasol.dk
DBH Technologies A/S	Company currently constructing plant for producing bioethanol and co-products from grain, www.danishbiofuel.dk
DAKA Biodiesel	Producer of biodiesel from animal waste, www.dakabiodiesel.dk
Emmelev Mølle	Producer of biodiesel from rapeseed, www.emmelev.dk
Bigadan	Producer of technologies for biogas production, www.bigadan.dk
Xergi	Producer of technologies for biogas production, www.xergi.dk
Research Institutes	
Danish Technological Institute	www.teknologis.dk
Innovation Centre for Bioenergy and Environmental Technology	www.cbmi.dk
Universities	
Aalborg University	www.aau.dk
Aarhus University	www.au.dk
Roskilde University	www.ruc.dk
Technical University of Denmark / Risø	www.dtu.dk
University of Copenhagen	www.ku.dk
University of Southern Denmark	www.sdu.dk
Governmental Organisations	
Danish Energy Authority	www.ens.dk
Ministry of Climate and Energy	www.kemin.dk
Ministry of Food, Agriculture and Fisheries	www.fvm.dk
Ministry of Science, Technology and	www.vtu.dk

Innovation	
Energinet.dk	www.energinet.dk
Non-governmental Organisations (NGOs)	
Danish Agriculture and Food Council	www.agricultureandfood.dk
Danish Forest Association	www.skovforeningen.dk
Confederation of Danish Industries	www.di.dk
Danish Biomass Association	www.danbio.info
Danish Biogas Association	www.biogasbranchen.dk
Partnership for Biofuels	www.biobrændstof.com
Others	

