Case study 3

Denmark's Capital Region

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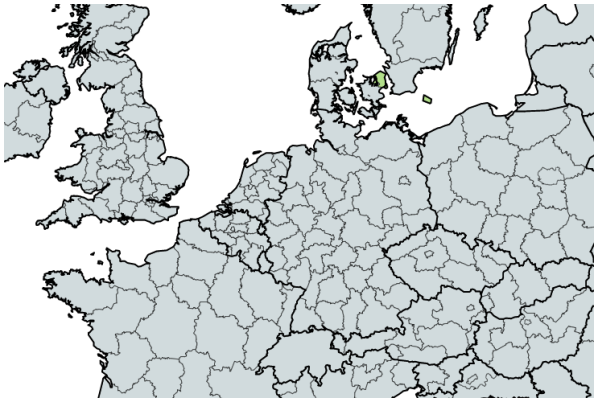
Denmark's Capital Region (Copenhagen), Denmark



GDP per capita	€51,000 (2018)
Population	1,835,562 (2019)
Population density	720/km^2
Unemployment rate	5,1% (2019)
People at risk of poverty or social exclusion	17.5%
Share of renewable energy (% of gross final energy consumption)	17% (2015)
Total installed RES capacity	3,300 MW (2015)
Employment in RES	0.5% direct (2016)

1. A BRIEF OVERVIEW OF THE DANISH CONTEXT

1.1 Denmark's socio-economic conditions

Denmark is a small country with an open, export dependent economy. Its nominal GDP per capita was 53 470 Euros in 2020, the 3rd highest out of all EU Member States, about 20 000 more than the European average.[1] GDP growth has been solid in recent years, averaging 2.5% between 2014 and 2019.[2] 4.9% of the active population were unemployed prior to the COVID-19 pandemic in January 2020, while the rate has risen to 6.1% as of spring 2021.[3] The country has a relatively low unemployment rate and high and rising labour participation rate. The economy features advanced industry with world-leading firms in pharmaceuticals, maritime shipping, and renewable energy, and a high-tech agricultural sector. Denmark is a net exporter of food, oil, and gas and enjoys a comfortable balance

[1] Eurostat (2021). Gross domestic product at market prices. Data code: tec00001. URL: https://ec.europa.eu/eurostat/web/products-datasets/-/tec00001. Accessed on: 04.05.2021.

[2] World Bank. (2021) GDP growth (annual %) – Denmark. https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?end=2019&locations=DK&start=2014 Accessed 29 July 2021

[3] Eurostar. (2021) Unemployment by sex and age – monthly data . https://ec.europa.eu/eurostat/databrowser/view/UNE_RT_M__custom_1018178/default/table?lang=en Accessed 29 July 2021

of payments surplus but depends on imports of raw materials for the manufacturing sector.

Denmark has relatively low-income inequality (ranking 5th in the EU when measured by Gini-Coefficient)[4] and comparatively high social mobility.[5]

The present Social Democratic government was elected in 2019 and is supported by a number of left-of-centre political parties, but not in a formal coalition. One of the main promises of the new government was to increase climate ambition, with a new overall greenhouse gas reduction target for 2030 of -70% compared to 1990.

According to EU Statistics on Income and Living Conditions, an estimated 2.8 per cent of the Danish population were unable to afford to keep the home adequately warm in 2019, [6] while 3.6 per cent of Danish households reported arrears on utility bills in 2012.[7]

1.2 Renewable energy deployment in Denmark

Denmark has a relatively high level of gross final energy consumption from renewable sources at 37.2% in 2019, or 4th highest in the EU.[8] This level has been increasing steadily for many years. The consumption of electricity from renewable sources is high in Denmark at 65% (3rd in the EU). The level for heating and cooling is 48%, or 5th in the EU.

The country has thus significantly outperformed its own renewable energy targets for 2020 set in the 2010 National Renewable Energy Action Plan. (30% overall, 40% heating and cooling, 52% electricity).[9]

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[4] OECD Data. (2021) Income inequality. https://data.oecd.org/inequality/income-inequality.htm Accessed 29 July 2021

[5] OECD. (2018) A Broken Social Elevator? How to Promote Social Mobility. https://www.oecd.org/social/soc/Social-mobility-2018-Overview-MainFindings.pdf

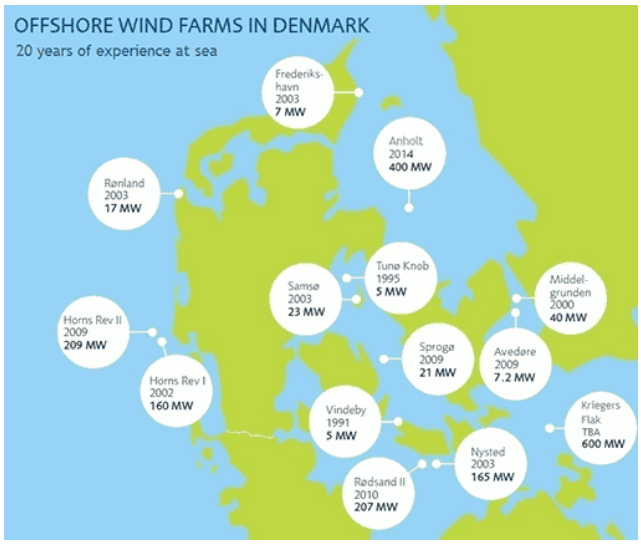
[6] Eurostat. (2021) Can you afford to heat your home? https://ec.europa.eu/eurostat/en/web/products-eurostat-news/-/ddn-20210106-1?redirect=/eurostat/en/news/whats-new Accessed 29 July 2021

[7] Nierop. (2014) Energy poverty in Denmark? https://www.energypoverty.eu/publication/energy-poverty-denmark

[8] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Renewable_energy_statistics

[9] European Commission, National renewable energy action plans 2020, https://ec.europa.eu/energy/topics/renewable-energy/national-renewable-energy-action-plans-2020_en?redir=1

Figure 1: Offshore Wind Farms in Denmark 2017[10]



The largest farms are not located in the Capital Region.

Denmark was a pioneer of renewable energy already in the 1970s following the oil crisis, notably in wind energy. It has the highest share of wind in both total primary energy consumption and electricity of any IEA country.[11] 20% of renewable energy is produced by wind (2018). Supported by a flexible domestic power system and a high level of interconnection, Denmark is now widely recognised as a global leader in integrating variable renewable energy while at the same time maintaining a highly reliable and secure electrical-power grid.

Denmark's large-scale use of combined heat and power plants (CHP) with heat storage capacity, and the increasing deployment of wind power, offer good potential for efficient integration of heat and electricity systems.

The largest source of renewable energy in Denmark is bioenergy (64% in 2018), based significantly (ca. 50%) on imported wood chips and pellets (mainly from the Baltic countries, Russia, and the USA, but also other EU countries).[12] Straw, renewable waste, wood waste, and domestic firewood are also significant sources of bioenergy. Recent years have seen a very significant increase in the use of wood

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[10] Source: http://energylawgroup.eu/itrfile/_1_/a0dea4f646f5449749afa53390f93296/Danish%20Offshore%20Wind%20Tender%20Model.pdf

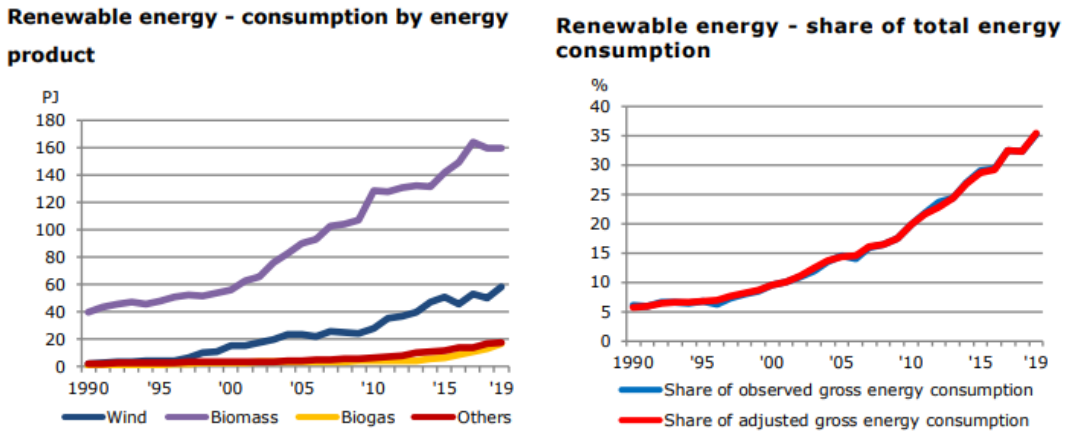
[11] International Energy Agency (2021), Country profile, https://www.iea.org/countries/denmark, Access date: 3 June 2021

[12] Danish Energy Agency, Energistatistik 2019, and accompanying detail tables: https://ens.dk/en/our-services/statistics-data-key-figures-and-energy-maps/annual-and-monthly-statistics; Statistics Denmark Foreign Trade statistics, www.statbank.dk/KN8Y

based bioenergy, partly to replace retired coal capacity. Increasing concerns about the sustainability of large-scale biomass use has led to the introduction of voluntary sustainability criteria at national level in 2014 and binding rules in 2020. The Danish Long Term Strategy (LTS) projects that biomass will continue to play a significant role in the country's energy mix, but that its role will stabilise, while other RES such as offshore wind, heat pumps, and solar PV will increase substantially.[13]

[13] Danish Government. (2019) Denmark's Long-Term Strategy. https://ec.europa.eu/clima/sites/lts/lts_dk_en.pdf

Figure 2: National renewable energy consumption



Source: 2019 Energy Statistics, Danish Energy Agency[14]

1.3 Political governance structures regarding the deployment of renewable energies in Denmark

Denmark has a tradition of cross-party support for renewable energy deployment through broad energy agreements. The IEA praises this tradition for providing "predictability and continuity in energy policy (thus creating a good environment for investors)."[15]

The current energy agreement has the objective of 100% of electricity and 55% of overall energy consumption to be covered by renewable energy by 2030. In addition, 90% of district heating is to come from non-fossil sources by 2030. This agreement was agreed by most parties in parliament in 2018 under the previous liberal (*Venstre*) led government. These targets are presented in the National Energy and Climate Plan (NECP) of 2019, but it further outlines that climate plans will be adapted in line with the new -70% overall GHG target for 2030.[16]

The previous energy agreement dating from 2012 targeted 35% renewable energy in gross energy consumption in 2020 and 50% wind power in electricity

[14] https://ens.dk/sites/ens.dk/files/Statistik/energystatistics2019_webtilg.pdf
[15] IEA. (2017) Energy Policies of IEA Countries: Denmark, https://www.connaissancedesenergies.org/sites/default/files/pdf-actualites/energypoliciesofieacountriesdenmark2017review.pdf
[16] Danish Ministry of Climate, Energy, and Utilities (2019) Denmark's Integrated National Energy and Climate Plan under the REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the Governance of the Energy Union and Climate Action. https://ec.europa.eu/energy/sites/ener/files/documents/dk_final_necp_main_en.pdf

consumption by 2020. The first target has certainly been achieved, and the second is close to being achieved.

The Danish Ministry of Energy, Utilities and Climate is responsible for national and international policies to mitigate climate change, as well as for energy, national geological surveys, and for meteorology.[17] The ministry consists of the Department itself, the Geological Survey of Denmark and Greenland, the Agency for Data Supply and Efficiency, the Danish Meteorological Institute, the Danish Geodata Agency, the Danish Energy Agency and the associated independent bodies: the Danish Energy Regulatory Authority, Energinet.dk, and the Danish Council on Climate Change.

Wind, solar, biomass, biogas and hydro energy are subsidized. RES used as a fuel is exempted from taxation, while energy taxes are levied on all fossil fuels, that is, oil, natural gas and coal with the exemption of fossil fuels for power production; instead electricity consumed is taxed in order to avoid influencing the costs of exported electricity. [18]

Denmark has had a tradition of community involvement and ownership in renewable energy projects, primarily wind. From 1970s to the mid-1990s, wind turbines were predominantly owned by grassroots actors – individuals and communities in cooperative structures. This feature has become less marked since the year 2000 as projects have increased in size and various other political and institutional pressures have changed. After 2009 the government has tried again to engage communities in ownership of RES projects, partially to improve acceptance of wind projects. The renewable energy law provides an option-to-purchase scheme that gives the local population the right to purchase at least 20% of a new wind energy project, with residents within 4.5 km having a priority purchase right. However, the provision has been criticised as not providing sufficient possibilities for community ownership.[19]

Most large-scale power plants are owned by Ørsted A/S, formerly DONG Energy A/S. The Danish state holds 50.1%of the shares in Ørsted A/S. Copenhagen and two large municipalities have recently bought large-scale power plants in their cities from the former owner of the Swedish company Vattenfall. In the district

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[17] IEA. (2017)

[18] Rønne, A., & Gerhardt Nielsen, F. (2019). Consumer (Co-)Ownership in Renewables in Denmark. In Energy Transition (pp. 223–244). Springer International Publishing. https://doi.org/10.1007/978-3-319-93518-8_11

[19] Mey, F., & Diesendorf, M. (2018). Who owns an energy transition? Strategic action fields and community wind energy in Denmark. Energy Research & Social Science, 35, 108–117. https://doi.org/10.1016/j.erss.2017.10.044

heating sector, cooperative and municipal ownership is common. Of the suppliers, 83 per cent are cooperatives with 34 per cent of the total heat supply. Municipalities account for 12 per cent of the suppliers and 58 per cent of the supply. Among the municipalities are the four largest cities in Denmark. Only two per cent of the suppliers are commercially owned with a total supply of 5 per cent.[20]

The Danish Energy Agency (DEA) is responsible for the implementation of policies and measures related to the production, transmission and utilisation of energy, and their impact on climate change. It acts as a one-stop shop regarding offshore energy projects, allocates the necessary permits and co-ordinates consultation processes with other authorities.

Regional and municipal authorities have an important role in the implementation of national energy and climate change policies through regional and municipal plans for urban and industrial development. Municipalities are responsible for planning onshore energy projects (wind power, biomass, biogas and solar PV) and district heating. Many municipalities also own local district heating companies.

[20] Rønne, A., & Gerhardt Nielsen, F. (2019). Consumer (Co-)Ownership in Renewables in Denmark. In Energy Transition (pp. 223–244). Springer International Publishing. https://doi.org/10.1007/978-3-319-93518-8_11

2. RENEWABLE ENERGY DEPLOYMENT AND DENMARK'S CAPITAL REGION'S SOCIO-ECONOMIC DEVELOPMENT

2.1 Denmark's Capital Region's socio-economic conditions

Information drawn from European Commission economic profile of the region unless otherwise stated.

The Capital Region of Denmark (*Region Hovedstaden* in Danish) is one of five administrative regions in Denmark. It is comprised of 29 municipalities, including most of the Copenhagen area and the remote island of Bornholm. However, it does not include all of the functional area of the Greater Copenhagen Metropolitan Area, as some of the southern suburbs are part of the neighbouring region. The island of Bornholm has a significantly different geographical, economic, and social profile than the rest of the region, but is included in the region for administrative reasons. The region was created in 2007 as part of the Danish municipal reform.

It had a population of 1,835,562 people in 2019, corresponding to around 31.61% of the Danish population, and is the most highly educated, innovative and cosmopolitan region in Denmark. The region is geographically the smallest in Denmark, with only 2,560 km^2, or 6% of the Danish area. Population density is 720/km^2. The population has grown significantly over recent decades, and population growth is expected to be strong for the foreseeable future. The region is by far the most urbanised in Denmark, with relatively little agricultural area compared to the Danish average.[21]

In 2018, the region had a gross domestic product (GDP) of €122.2bn (2020). The region therefore generates about 40.6% of the Danish GDP. The strong economic performance in Copenhagen is shown in the high growth in the GDP compared to the rest of the Danish regions. In the period from 2010 to 2018, the GDP increased by 30.9% in the region, compared to a national increase of 23.9% and the increase for EU average being 23.9% (2020). The regional GDP can also be expressed as GDP per capita in purchasing power standards (PPS), 51,000 in 2018, a figure above the national average (39,700) and the EU average (31,000) (2020).

[21] Denmark's Capital Region. (2018) FÆLLES STRATEGISK ENERGIPLAN FOR HOVEDSTADSOMRÅDET. https://www.regionh.dk/til-fagfolk/miljoe/en-groennere-region/Energiomstilling/Documents/EPT_F%c3%a6lles-Strategisk-Energiplan_WEB.pdf

The region has been increasing in terms of GDP since 2011, with a value of €93.3bn.

In 2019, 33.3% of the employed people in Denmark were in the Capital region. Here they are distributed mainly in tertiary sector activities (such as in wholesale and retail trade, transport, accommodation and food service activities; and public administration, defence, education, human health and social work activities) with 86.5% of the working population. This number is considerably high, having in mind that the average of people working in tertiary activities in all Denmark is of 79.1%. Therefore, in the secondary sector, the Capital region of Denmark has 12.4% of the population and 0.1% in the primary sector (2020).

With more than 1% decrease in unemployment rate in the period 2009-2019, it is the region that has been the least affected since the onset of the global financial crisis in 2007. In 2019, the Capital Region had an unemployment rate of 5.1%, the lowest in recent years, below the EU average (6.3%) and slightly above the national average (5%) (2020). According to Eurostat, the region has a 17,5% rate of people at risk of poverty or social exclusion (2019).[22]

The innovation performance is strong in the Capital region. The region is home to a number of large and top-performing universities including the University of Copenhagen (the largest university in Northern Europe), the Technical University of Denmark and the Copenhagen Business School. Roughly 60% of all Danes with higher education live in the region.

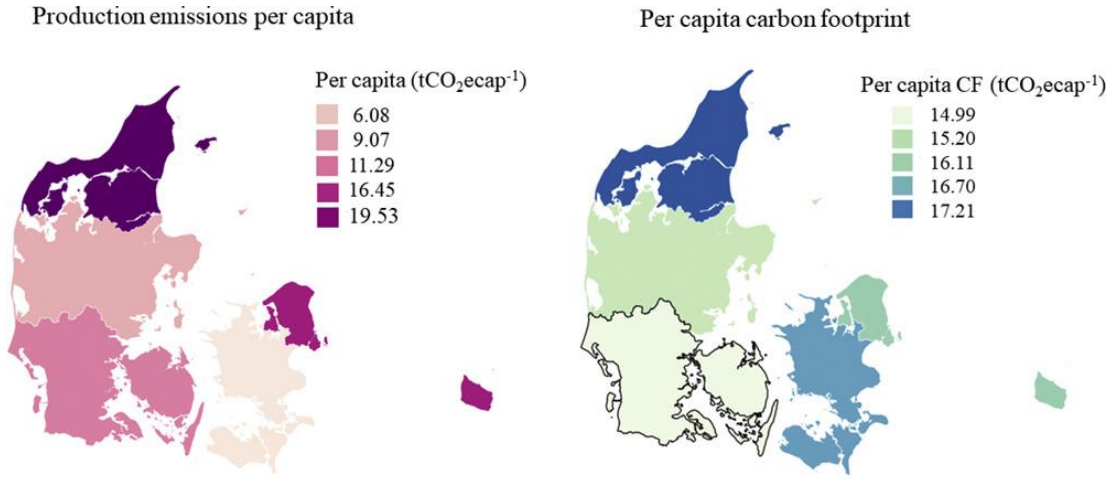
The region contains municipalities with among the largest intra-municipal household income inequality in the Nordic region as measured by disposable income Gini index, and the level of inequality has been growing over the last decade.[23] The considerable intra-municipality inequality is explained by the very large amount of disposable income (excluding capital) of the highest-earning households (both the top 10% and the top 1%).

[22] https://ec.europa.eu/eurostat/databrowser/view/ilc_peps11/default/table?lang=en
[23] State of the Nordic Region 2020. (2020). Nordic Council of Ministers. https://doi.org/10.6027/no2020-001

2.2 Denmark's Capital Region: Context for renewable energy

2.2.1 Greenhouse gas emissions and renewable energy deployment in Denmark's Capital Region

Figure 4: Regional per capita GHG emissions in Denmark



The per capita GHG emissions (t CO_2e) of Denmark's five regions from a production and consumption perspective in 2011. Darker shades represent relatively high per capita emissions regions while lighter shades represent relatively low per capita emissions regions.

Source: Osei Owusu et al, 2020

Denmark does not track GHG emissions by region. However, there has been some academic work to produce estimates, notably the 2020 article by Osei-Owusu et al.[24] The article produced estimates for both consumption and production-based emissions for Denmark's five regions based on municipal data from 2011.

Based on this research, Denmark's Capital Region accounts for 41% (28 MtCO2e) and 31% (27 MtCO2e) of Denmark's production and consumption-based emissions respectively. In terms of emissions per capita, this equals just over 16 tCO2e per capita for both measures, significantly higher than the national average of 12.48 tCO2e for production emissions, and slightly above average (15.71 tCO2e) for consumption emissions.

The study highlights that mobility and buildings are the most important sectors for emissions from a production point of view nationally (accounting for more than 60% of emissions), and that the Capital Region accounted for the highest

[24] Osei-Owusu, A. K., Thomsen, M., Lindahl, J., Javakhishvili, L. N., & Caro, D. (2020). Tracking the carbon emissions of Denmark's five regions from a producer and consumer perspective. Ecological Economics, 177, 106778. https://doi.org/10.1016/j.ecolecon.2020.106778

regional shares of these sectors (83% and 25% respectively). Deploying renewable forms of energy for heating/cooling and electrification of buildings and transport is thus a very important part of reducing emissions in the Capital Region (and the country as a whole).

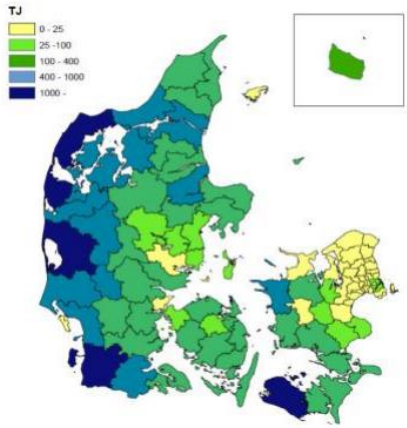
The Capital Region has put together a strategic plan for energy development in the region, in cooperation with all 29 regional municipalities, 10 utilities, and with four additional municipalities in suburban Copenhagen which are functionally a part of the Copenhagen urban area (Greve, Solrød, Køge and Roskilde), but a part of the neighbouring region.[25] The area covered in this plan is referred to as EPT33, and the best figures for energy usage are available for this functional area. The aim of the strategic plan is to move to a fossil-free electricity and heating sector for the area by 2035, as well as fossil-free transport by 2050.

In terms of gross energy consumption (2015), including transport, oil is the largest source of energy at 37%, followed by natural gas (20%), imported electricity (17%), and biomass (16%). Wind and solar made up only a small portion (1%). 17% can thus be considered renewable, of which the vast majority is from biomass. (See below for details on the imported electricity).

During the period 2012-2017, energy consumption for heating seems to be decreasing slightly while electricity consumption and energy consumption for transport has increased. Oil consumption is increasing, natural gas consumption and coal consumption is decreasing, biomass consumption is decreasing slightly and there has been a significant increase in electricity imports to EPT33. The increasing import of electricity is linked to a decrease in local electricity production. However, there has also been an increase in electricity production from both offshore and onshore wind and solar.

[25] Denmark's Capital Region. (2018)

Figure 5: Energy production from land-based wind turbines (2014)[26]



Since 2015 there has been a significant conversion to biomass in district heating and cogeneration, as well as an incipient phasing in of biogas into the natural gas network. This means that large parts of the coal consumption and parts of gas and oil consumption has already been converted to biomass. This conversion is nearing completion for district heating production. During the same period, heat production from waste has increased, probably due to optimization, biomass waste and imports of residual waste. At the same time, the application of gas boilers in the district heating supply increased significantly, particularly at the expense of gas cogeneration.

The net import of electricity is a notable feature of the region. The electricity consumption in EPT33 was almost 9,000 GWh in 2015, while electricity production was around 2,700 GWh, meaning that 70% of electricity was imported. According to the accepted accounting principles, the majority of imported electricity can be considered to be generated from coal. There was an increase in production from wind and sun in the period 2012-2015, and an increase in production from biomass in the period 2015-2017. However, wind energy production capacity in the region continues to represent a marginal amount compared to the national installations, with only 1% of total installations between 2012-16.[27] Electricity production from solar has increased by 471%, but also represents a small fraction of production.

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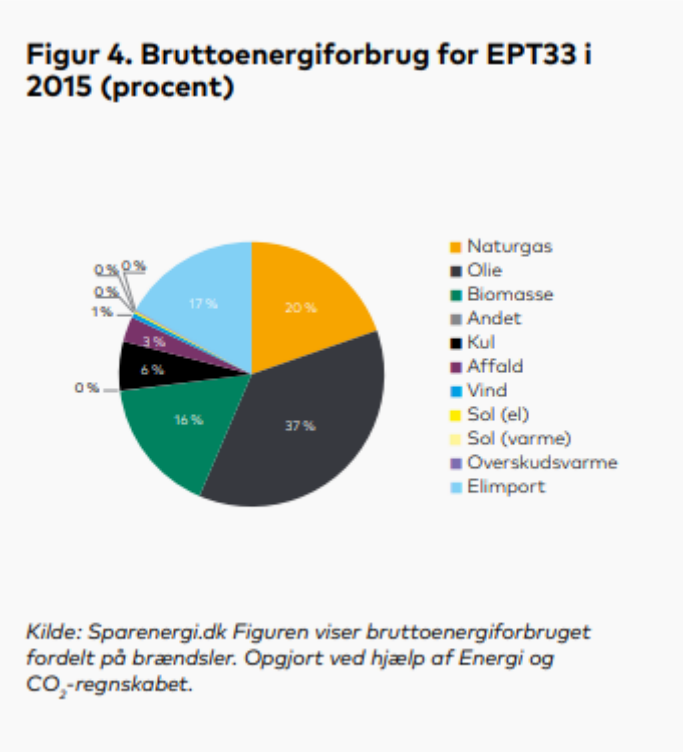
[26] Source: https://www.ea-energianalyse.dk/wp-content/uploads/2021/04/1525_potentialenotat_lokale_vedvarende_energiressourcer.pdf

[27] CONCITO. (2018) Lokal accept og udvikling af vindmølleprojekter: Opsamling på Wind2050-projektet. https://concito.dk/files/dokumenter/artikler/lokal_accept_og_udvikling_af_vindmoelleprojekter_maj2018.pdf

Over half of the heat consumption comes from district heating and about 45% from natural gas. District heating production takes place almost exclusively as cogeneration (80%) and in boiler plants (19%), with a small contribution from surplus heat, solar heat and heat pumps (1%). Looking at the fuels, the largest contribution comes from biomass, followed of coal, natural gas and waste.

Figure 6: Gross energy consumption in EPT33 (Copenhagen region) (2015)



Orange=natural gas; black=oil; green=biomass; grey=other; black=coal; purple=waste; dark blue=wind; dark yellow=solar(electricity); light yellow=solar (heat); violet=excess heat; light blue=imported

In terms of capacity, the region has a total production capacity of 2,569 MW of electricity and 6,402 MW for heating.[28] Using a very rough calculation, about 3300 MW of combined capacity is renewable.[29] Of this, only 295 MW is not biomass.

A 2015 study for the Capital Region found relatively limited potential for renewable energy generation within the region, due primarily to its urban, densely

[28] Denmark's Capital Region. (2018)

[29] based on 37% renewable out of heating and electricity, assuming oil is used in transport, and imported electricity is discounted. Oil is also used in heating, and a small percentage of renewable (roughly 6.4% is used in transport, but this is only intended as a rough calclulation.

populated character.[30] According to the study the RES potential of the region could cover about 37% of total 2012 energy consumption (including transport). Heating could be 89% covered by RES. The potential of land-based wind and solar is to cover 23% of the region's 2012 electricity needs. The region could thus cover far more of its energy use by renewables, but imports will continue to be a big part of the future energy mix. Nonetheless, the remaining uninstalled potential capacity represents a potentially significant source of jobs in coming years and decades.

2.2.2 Governance structures concerning renewable energy deployment in the Danish Capital Region

Danish regions have limited direct powers in the area of energy policy. However, municipalities have important powers around spatial planning, and the regions can coordinate the plans of municipalities, as is the case in the Capital Region with its regional strategic plan for energy: *Energi på Tværs*, or the broader regional development strategy.[31] As mentioned above, this plan brings together all of the region's municipalities, as well as 4 from suburban Copenhagen outside of the region, and 10 utilities to make a unified energy development plan. The decision was made by the Regional Council and the 29 mayors to set up the strategic energy plan in June 2015, with the goal of fossil-free energy for heating and electricity by 2035, and transport by 2050. The strategic plan allows the individual municipalities to make a coordinated and strategic input to these plans. There is a broader strategic plan, as well as a "Roadmap 2025" with 34 concrete measures to implement the plan toward 2025.[32] The project is managed by an independent organisation, Gate 21. The project's steering group has been composed of seven municipal representatives, seven representatives from utilities, one from Gate 21 and one from the Capital Region.

Municipalities may have their own Strategic Energy Plans, and they have been encouraged and supported to develop them by the Danish Energy Agency since 2012. However, not all have done so. A first generation of municipal heating strategies was established in the 1980s, followed by a second generation of municipal heating strategies in the 1990s to initiate the transition to more eco-

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[30] Ea Energianalyse. (2015). Lokale vedvarende energiressourcer: Potentialevurdering til "Energi på tværs". https://www.ea-energianalyse.dk/wp-content/uploads/2021/04/1525_potentialenotat_lokale_vedvarende_energiressourcer.pdf

[31] Denmark's Capital Region. (2020) En region for den næste generation: Regional Udviklingsstrategi 2020-2023. https://www.regionh.dk/til-fagfolk/miljoe/en-groennere-region/Energiomstilling/Documents/RUS_RT_opslag.pdf

[32] Gate 21. (2018) Roadmap 2025. https://www.regionh.dk/til-fagfolk/miljoe/en-groennere-region/Energiomstilling/Documents/EPT_Roadmap-2025_WEB.pdf

friendly energy sources. However, heating planning stagnated after that. Electric energy – except for siting of wind power facilities and general project approvals – has until now not been a planning issue for municipalities. Most energy related planning was done by utilities at the local level, but approved by the municipalities. However, due to lack of coordination and passive planning, the national government wanted to move to a more strategic approach in 2012.[33]

The general political consensus around climate action across the mainstream political parties, and the national energy plans setting a direction of travel, means that political leadership has been relatively stable at regional and local level.

[33] Petersen, J.-P. (2018). The application of municipal renewable energy policies at community level in Denmark: A taxonomy of implementation challenges. Sustainable Cities and Society, 38, 205–218. https://doi.org/10.1016/j.scs.2017.12.029

3. ANALYSIS AND CONCLUSIONS

3.1 The socio-economic impacts of renewable energy deployment in Denmark's Capital Region

Overall, Denmark is a strong player in the renewable energy industry, and the green economy more broadly. Early investment into renewable energy technologies, continued R&D in the sector, and ambitious domestic climate goals have played a role in the development of this industry. From 2014 to 2016, the number of "green energy" jobs grew by 6% annually on average nationally. That is six times more than the growth of business in general.[34]

Nationally, 42.6% of all energy sector jobs are in "green energy".[34] This amounted to 31,221 jobs in 2016 when the last national survey was taken, or about 1.4% of all jobs. (3.3% for all energy sector jobs)

Green energy technologies make up an important part of total export value for the country: about 5% of total exports in 2015.[36]

The largest centres of employment are in Jutland where green energy, particularly wind, is a very important employer. According to research by Damvad Analytics, green energy employed 4310 people in the Capital Region in 2016. This constitutes about 14% of the national total, so it is relatively much less important than for the rest of the country, given the area's population makes up about 32% of the national population, 37% of employment, and 41% of GDP.[35] Green energy employment made up less than 1% of regional jobs. However, it is growing more quickly in Greater Copenhagen than nationally,[36] and is only a small part of a regional "green economy" industry in the region.[34]

The wind industry employed 4431 people in the Capital Region in 2016 (note: not all of these are officially counted as being in "green energy"). With a turnover of approximately EUR 1.75 billion in the region, this represents about 40% of "green" turnover in the region.[36] Although the industry is primarily based in Jutland, the Greater Copenhagen Region is particularly important for research and

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[34] DAMVAD Analytics. (2018) Energibeskæftigelsen. https://kefm.dk/media/6885/efkm-energibeskaeftigelse-2016.pdf

[35] Erhvervsstyrelsen. (2021) Statistik om regional udvikling. https://regionalt.statistikbank.dk/statbank5a/default.asp?w=1920 (Accessed 21/07/2021)

[36] Damvad Analytics. (2017) Analyse for Gate 21: GRØN VÆKST I DANMARK OG GREATER COPENHAGEN. https://www.gate21.dk/wp-content/uploads/2018/05/Gr%C3%B8n-v%C3%A6kst-i-DK-og-Greater-CPH_DamvadAnalytics.pdf

development in the industry, with some of the most important research centres located there. Estimates by Damvad Analytics foresee between 4700-8300 new jobs in the region in the wind industry by 2035.

A number of companies active in the field of bioenergy are headquartered in Greater Copenhagen, and looking at the regional distribution of the manufacture of chemical products, which accounts for the vast majority of green revenue in this area, we see that itis located in Greater Copenhagen.[36] However, it is an industry segment that is harder to measure due to its heterogenous nature. 2357 are employed in waste management and recycling, a portion of which is in bioenergy (biomass). 1887 are employed in the manufacture of chemical products, which is likely mostly biofuels related production. It is in Greater Copenhagen that revenue growth for this industry has been strongest in recent years. This is an area of international strength for the country, as R&D is advanced and impactful compared to the OECD average. Estimates by Damvad Analytics foresee between 2100-3300 new jobs in the region in the bioenergy industry by 2035 and between 1500 and 5700 in biofuels.

Full estimates are not available for employment in district heating, but there are at least 617 jobs in this field.[36] Important plants and companies include Avedøre power plant and Burmeister & Wain Scandinavian. Key players within district heating-related consulting such as Cowi and Rambøll are also located in Greater Copenhagen. It is possible that the figures somewhat under-represent total RES employment, as this is a relatively important part of the RES picture in an urban context and in the Copenhagen area.

A number of wind turbine developments are partially community owned, in accordance with the relevant national laws and traditions. For example, the 40MW Middelgrunden cooperative offshore wind farm in Copenhagen harbour is 50% community owned, and 50% owned by HOFOR, the Copenhagen Utility company.[37] There are 8650 members of the cooperative. It was built in 2000 and was the largest offshore wind farm in the world at that time.[38]

Estimates by the City of Copenhagen (the municipality, not the region) showed that although the high cost of bioenergy compared to coal could increase energy costs for the municipality, but these would be offset in the long-run by energy

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[37] Middelgrunden Windmill Cooperative, https://www.middelgrunden.dk/middelgrunden-windmill-cooperative/

[38] Hans Christian Sørensen; Lars Kjeld Hansen; Jens H. Mølgaard Larsen. (2002). "Middelgrunden 40 MW offshore wind farm Denmark: Lessons Learned". https://web.archive.org/web/20060820062226/http://www.emu-consult.dk/includes/middelgrunden_munich.pdf Accessed 31 July 2021.

efficiency improvements and by income from wind turbines.[39] The city asserts that initially, district heating customers will not notice the added costs since biomass enjoys the benefit of an indirect tax exemption compensating heat producers for rising fuel costs.

3.2 Key factors that determine renewable energy deployment and the accompanying socio-economic development in Denmark's Capital Region

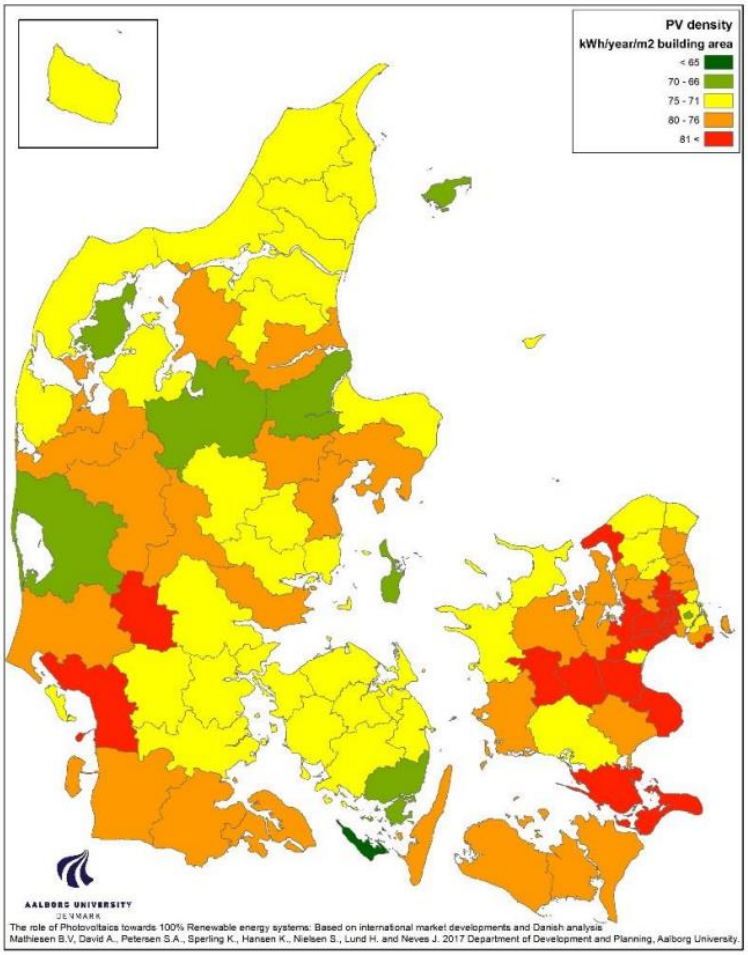
Although Denmark as a whole is world leader in the renewable energy industry, and has been a pioneer in this area, Denmark's Capital Region has less renewable capacity, and employs fewer people in this area than the other areas of the country. The vast majority of Danish employment and value added and employment from renewable energy are found in Jutland, particularly the Central-Jutland Region. This is due to the concentration of large wind power firms and their suppliers located there, including large firms such as Vestas and Ørsted.

As a relatively densely populated region, it is not as well suited as more rural areas for large scale wind power deployment, and will remain dependent on net imports of renewable energy in the future. However, municipalities in the region do have significant plans to expand wind power in coming years, partially within the region, but also offshore, and in other regions.[40] As a result, the economic effects of this construction will be partially dispersed to other regions.

[39] City of Copenhagen. (2012) CPH2025 Climate Plan. pp. 59. https://kk.sites.itera.dk/apps/kk_pub2/index.asp?mode=detalje&id=983

[40] KBH 2025 klimplan.

Figure 7: Potential PV production calculated per km2



Source: Mathiesen et al, 2017

Denmark as a whole has been making significant progress in terms of renewable energy deployment, and has plans to phase out all coal by 2028, and the Capital Region cannot be viewed in complete isolation from these developments. There are spill-over effects from the large industries in Jutland, mainly in R&D jobs. Projections show significant improvements in local GDP and jobs by 2030 if the national targets are met. Nonetheless, from a purely regional socio-economic development perspective it is not benefitting from RES transition as much as other parts of the country, either in terms of use of RES or in terms of jobs and value added.

However, the urbanized region is better suited to rooftop solar deployment and district heating than the rest of the country. Rooftop solar deployment remains low, but has been increasing recently, as costs have decreased and the technology has improved. Solar is expected to play a significant role in national electricity supply by 2050 (10-15% of fluctuating RES) according to a study by Aalborg

University,[41] indicating the level could be higher in the Capital Region due to population and rooftop density (see map of potential PV production).

District heating is the focus of most renewable energy production and consumption today, but the jobs in this area may be under-counted by the sources available, so it is likely that there is more direct employment than indicated in this report.

The municipality of Copenhagen also has initiatives to ensure that local citizens are able to buy shares in the local windmills, also as stipulated in national legislation. Denmark as a whole has a good history of providing ownership opportunities to citizens through cooperatives and other measures. However, given the relatively small number of windmills in the area this is not likely a major economic factor. In addition, the ownership provisions of the current renewable energy law have been criticized for still being inaccessible to many citizens due to expense, insufficient discount for the closest residents, barriers from the companies implementing the projects, and barriers resulting from attitudes toward the projects (see CONCITO 2018).[42]

It is worth noting that the region does have a concentration of other "green" industries, including in the area of energy and heat efficiency, which employs more people than renewable energy itself, as well as "reducing resource use", and "research into resource and fossil fuel efficiency". In 2019, "green industries" employed over 36,000 people in the region, just under 4% of total regional employment.[43] The region also has a higher level of income from green and renewable industries than it does in terms of direct employment (as a percentage of the national totals). Over 60% of Danish research related jobs in green industries are located in the region.[44] In terms of the Danish green industry as a whole it is still relatively under-represented compared to other regions, in large

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[41] Mathiesen, B. V., David, A., Petersen, S., Sperling, K., Hansen, K., Nielsen, S., Lund, H., & Neves, J. B. D. (2017). The role of Photovoltaics towards 100% Renewable energy systems: Based on international market developments and Danish analysis. Department of Development and Planning, Aalborg University. https://vbn.aau.dk/ws/portalfiles/portal/266332758/Main_Report_The_role_of_Photovoltaics_towards_100_percent_Renewable_Energy_Systems.pdf

[42] Leer Jørgensen, M., Anker, H. T., & Lassen, J. (2020). Distributive fairness and local acceptance of wind turbines: The role of compensation schemes. Energy Policy, 138, 111294. https://doi.org/10.1016/j.enpol.2020.111294

[43] Based on employment of 926,000 in 2019. Eurostat: https://ec.europa.eu/eurostat/databrowser/view/lfst_r_lfe2emp/default/table?lang=en

[44] Erhvervsstyrelsen, Regional udvikling, https://regionalt.statistikbank.dk/statbank5a/default.asp?w=1920 Accessed 29 July 2021.

part because of the major concentration of employment in Central Jutland. However, this is a reflection of the strength of the Danish green sector as a whole rather than a weakness of the region. In absolute terms, the Danish sector is larger than in neighbouring Sweden which has a significantly larger population. It is worth highlighting the very significant employment, particularly in the Central Denmark Region, centred around Aarhus, where direct employment in renewable energy accounts for 13.5% of all jobs. This highlights the potential for very significant employment in regions that are able to form an industrial hub centred around renewable energy.

Interviews conducted

The research in this case study was supplemented by an interview with Damvad Analytics on 23 June 2021.

3.3 Conclusions

- Employment in the renewable energy industry is relatively low compared to other Danish regions, probably because of the relatively low level of RES deployment, itself a result of the urban, densely populated nature of the region. However, the employment figures available likely undercount the number of jobs due to some jobs in district heating not being fully counted. Rooftop solar is also potentially a good source of jobs in the region in coming years that is so far only in its initial phase of development.

- The region has a relatively high proportion of research related jobs in renewable energy, and many more jobs in other "green industries" (such as related to energy efficiency) possibly as a result of urban agglomeration effects. These are high quality jobs and areas of significant potential employment growth in coming years and are not directly linked to local RES deployment. "Green business" is a particular strength in Denmark as a whole, and the national strength in this area does translate into jobs in in the capital region despite the relatively low level of RES deployment there.

- The regional distribution of jobs and economic activity in Denmark, with a very high concentration of jobs and economic benefits in Jutland, shows the importance of building up RES manufacturing and supply chain capacity for broader employment and economic benefits as well as the first mover advantage in combination with a supportive national policy environment.

- The ownership of renewables in the capital region is mostly in the hands of utility companies and larger corporations, but some large community owned projects have also been present for many years. This partly reflects the reliance

on larger biomass facilities in the region, but also the orientation toward larger institutional owners and imperfect system to incentivise local ownership in recent years, despite the strong Danish tradition of community RES ownership.