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D2.3

District Heating and Cooling Stock at EU level

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[1] PU = Public
PP = Restricted to other programme participants (including the Commission Services)
RE = Restricted to a group specified by the consortium (including the Commission Services)
CO = Confidential, only for members of the consortium (including the Commission Services)

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Executive Summary

Summary of Deliverable
The deliverable 2.3 *"District Heating and Cooling Stock at EU level"* is a result of task 2.1 in work package 2 of the WEDISTRICT project. The objective of this report is to establish an overview of the current stock of DHC and the future development trends for the district energy markets in Europe. The report finds the most reasonable RES technologies to further develop the district energy market and identifies inefficiencies and suggestions for improvements of both technical and organisational level.

Part of the report is an annex with data collected over the past year for each country evaluated. These can be found in annex 1 and 2 at the end of the report.

Disclaimer

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Nomenclature

ATES	Aquifer thermal energy storage
CBA	Cost-benefit analysis
CHP	Combined heat and power
DC	District cooling
DH	District heating
DHC	District heating and cooling
DHW	Domestic hot water
ECS	Energy Concept of Slovenia
ESCO	Energy service company
EH&P	Euroheat & Power
EED	Energy Efficiency Directive
EEA	European Environment Agency
GHG	Greenhouse gas emissions
HP	Heat pump
PV	Photovoltaic
RES	Renewable energy sources
HRE	Heat Roadmap Europe

Countries	
AT	Austria
BE	Belgium
BG	Bulgaria
HR	Croatia
CY	Cyprus
CZ	Czech Republic
DK	Denmark
EE	Estonia
FI	Finland
FR	France
DE	Germany
EL	Greece
HU	Hungary
IE	Ireland
IT	Italy
LV	Latvia
LT	Lithuania
LU	Luxembourg
MT	Malta
NL	Netherlands
NO	Norway
PO	Poland
PT	Portugal
RO	Romania
SK	Slovakia
SI	Slovenia
ES	Spain
SE	Sweden
UK	United Kingdom

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1 Introduction

1.1 Background

The overall energy policies of the EU are based on several objectives, among them the aim of security of supply by developing energy systems that are resilient and not dependent on politically unstable sources. The supply of energy should also be cost effective to increase the overall welfare and competitiveness. The quality of supply of electricity and the thermal comfort of residents must be sufficient to maintain acceptable living standards. Environmental objectives are to reduce the carbon emissions from the energy sector as well as secure low local environmental impact from the production of energy.

District heating (DH) and district cooling (DC) has a positive impact on all these objectives, given that the expensive infrastructure is planned carefully, and the local opportunities and competitive alternatives are taken into account.

DH has many beneficial qualities and is a critical component for achieving a sustainable energy sector. The DH network is indifferent to the origin of the heat source, meaning that the infrastructure allows the water to work as an energy carrier, which can absorb heat from all available sources. Hot-water DH can utilize the surplus heat from many sources, thereby using heat that otherwise is lost to the surroundings to deliver heating to the consumers. These surplus heat sources include heat from waste incineration, which would otherwise be dumped in landfills, industrial waste heat and surplus heat from combined heat and power (CHP). In the case of the CHP, the surplus heat would otherwise be emitted in cooling towers and seawater cooling and thereby the utilization of the DH network reduces the fuel consumption for heating by around 60% compared to of fuel consumption from boilers, which is equivalent to around 30% of the total fuel consumption for heat and the associated electricity production.

The DH network also enables fluctuating renewable energy sources (RES) such as wind and solar PV to produce heating whenever the supply exceeds demand using large-scale heat pumps (HPs) or electric boilers. This option is essential, as it can help with the regulation of the power system during periods with excess electricity. The large-scale HPs are more cost effective than small individual HPs with significantly lower investment cost due to more efficient use of capacity and economies of scale.

Using the large-scale HPs enables efficient production of heating by the utilization of ambient heat sources, such as the thermal energy of wastewater from water treatment facilities, thereby increasing the overall energy efficiency of the system. The possibility of using heat from ambient sources also allows for combined heating and cooling plants with high efficiencies.

Another benefit of using DH is that the heat supply to the individual apartments can be measured by energy meters at the end user, leading to a horizontal distribution of heating.

The environmental benefits of using the DH networks for heating are evident. The local pollution can be reduced by converting low-level polluting sources to large centralized sources with efficient combustion and flue gas cleaning. This also eliminates the visual disturbance and noise pollution stemming from individual heating solutions on buildings and apartments.

A significant disadvantage is the high capital investments of DH infrastructure which also creates a natural monopoly network. Therefore, it is important to plan the development of the network along with the planning of other urban infrastructure to avoid unprofitable investments and to facilitate a large connection rate.

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The concept of DC is under development and has several beneficial qualities. As with DH, DC can offer reliable, cost-effective and low-carbon cooling to buildings, due to economy of scale and the benefits of interconnecting many end users. It is also possible to utilize free cooling from ambient sources as well as the surplus heat from high-temperature heating for cooling purposes. Furthermore, the uncontrolled cooling with chilled water storage and a combination of sources can reduce the power peak. By using DC, the overall efficiency of the DHC can also be improved.

Like for DH, the disadvantage of DC is large investments in networks. Therefore, it is important that the network is carefully planned, and that a maximal number of end users connects to the grid.

DH based on superheated water or steam may have certain qualities for delivering process energy but can be combined with low-temperature DH for thermal comfort. Likewise, DC at very low temperature may have certain qualities for delivering process cooling but can be combined with cooling for thermal comfort.

To summarize, one may argue that DH and DC is a natural part of the urban low-carbon modern cities, taking into account natural optimal zoning against districts with individual building level solutions that only optimizes on behalf of heat users' own economic gain.

Several studies, e.g. Heat Roadmap Europe (HRE), prove that there is a huge opportunity for harvesting the potential of DHC, contributing to the overall objectives of the EU.

1.2 Aim and Scope

The aim of WP2 of WEDISTRICT is to define the framework for the development of the projects' integrated concepts.

The market penetration of DHC systems varies strongly amongst the member states of the European Union. In Denmark and Estonia, more than 60% of citizens were supplied with DH in 2015, while it was less than 5% in Switzerland and the Netherlands. Similar variations are found with the capacities for DC. The sources for the generation of DH are also very different and impact the GHG emissions of DHC systems. While Denmark generated 73% of the DH through CHP, this share was only 37% in Estonia. Also, 46% of the DH in Denmark was generated directly from renewable energy, while it was less than 15% in Estonia.

These differences in the DHC stock, the market situation and barriers of DHC in the individual countries have a great impact on the future requirements of DHC systems and technologies. It is therefore important to consider the current and expected situation when developing new concepts and technologies.

In this report the overall aim is to:

- Establish the current situation for DHC in Europe;
- Identify and evaluate trends and reasonable evolution of DHCs in Europe with an important focus on those countries with less contribution to network developments, and those countries with less RES integrated with DHC;
- Identify inefficiencies, barriers, and improvement potentials 'lessons learned' to be taken into account in the WEDISTRICT designs for both new districts and retrofitting of existing DHC.

The aims of this task will be achieved by performing an analysis of the DHC systems in Europe, which will include:

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- Overview of the current European DHC stock divided into small, medium, and large DHC sizes:
  - Analysis of the energy use and energy sources for heating and cooling;
  - Analysis of DHC (energy sources, energy use, number of systems, capacity, emissions, thermal efficiency of network/ plants);
  - Establishing typical country-specific DHC projects.

- A market analysis of DHC in Europe divided into small, medium, and large DHC sizes:
  - Identifying key actors in the DHC market, such as stakeholders, investors, and users;
  - Developments (historically) in DHC concerning energy sources and market volume;
  - Identifying country-specific support schemes;
  - Analyse targets for DHC and heating and cooling (e.g. 2050).

- Inefficiencies and 'lessons learned':
  - Evaluation of trends and most reasonable regarding:
    - Network developments in those countries with less contribution to network developments;
    - RES integrated with DHC in those countries with less RES integrated in DHC.
  - Identifying inefficiencies and improvement actions to be taken into account in the WEDISTRICT designs for both new districts and retrofitting of exiting DHC.

The aim is to perform this analysis for each country in the EU28, Norway, the United Kingdom and Switzerland. Due to the expected variations in available data and information amongst the different countries, the level of detail of the analysis will vary amongst countries. Some countries will have a higher level of detail than other countries.

1.3 Approach

The report is divided into two parts. The first part gives an overview of the European DHC stock. First, the information and data which is collected for each country will be defined and its relevance discussed, which will result in a template. Examples of data are energy use for heating and cooling (TJ/year), energy sources for heating and cooling (Distribution in % amongst coal, gas, biomass, solar, etc.) and the capacity of DH and DC (MW_{th}). The required information will be put into the templates. To fill out the templates for each country, the data will be retrieved first from publicly available statistics and academic literature, e.g. Eurostat and Euroheat & Power (EH&P), to make the data comparable and consistent. Missing data in the templates for each nation was obtained through interviews with project partners, local contacts and national DH associations. Furthermore, DHC systems for each country are categorized and described by e.g. size (TJ/year; MW_{th}), resources, temperatures and costs (€/MWh). The establishment of the typical DHC systems will be based on available best practice examples[1] and experience.

The second part of the report is a market analysis, based on an analysis of available information from literature, WEDISTRICT partners, local contacts and national DH associations. Information about the DHC systems and country-specific objectives is identified in the EH&P's country-by-country report for 2019 and will be used to establish future market trends and potentials. Country-specific market information, such as support schemes and market structure, will also be described. The information will be collected via questionaries, where WEDISTRICT partners and local contacts will contribute with missing information.

[1] Galindo Fernández, M., Roger-Lacan, C., Gährs, U., Aumaitre, V. , Efficient district heating and cooling systems in the EU - Case studies analysis, replicable key success factors and potential policy implications, EUR 28418 EN , doi: 10.2760/371045

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With the same approach, risks and barriers for DHC will also be described to collectively pinpoint inefficiencies and summaries the results as 'lessons learnt'.

The collection of information on the two parts will be performed in parallel and a focus will be placed on the status and opportunities of network developments and renewable energy in DHC.

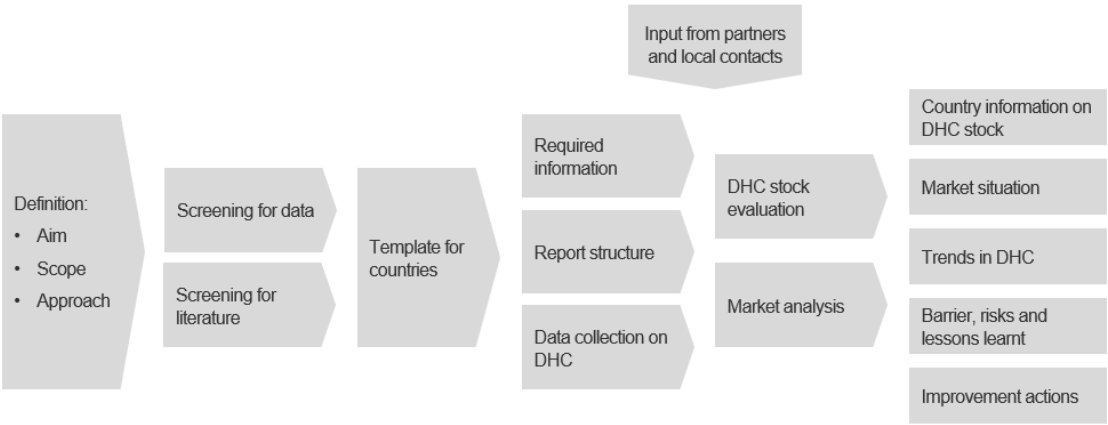

Figure 1-1: Approach and main parts of Task 2.1

1.4 Structure

This deliverable is organized into a report with several Annexes for each country. The report describes the analysis and evaluations divided into countries with a small, medium, and large share of DH to supply the heat demand. The detailed information gathered for each country regarding the DHC stock and market analysis is found in the Annexes. The content of this deliverable is structured in the following way:

- Chapter 2 introduces the methodology and approach for the deliverable. This includes methods for data collection and market analysis;
- In chapter 3, the main outcome of the stock evaluation and market analysis is presented and divided into small, medium and large DHC systems;
- Chapter 4 evaluates the trends and most reasonable developments for networks and RES in DHC systems;
- In chapter 5**,** inefficiencies and improvements are identified with the focus on designs for both new and retrofitting of existing DHC systems.

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2 Methodology

2.1 Introduction

The main elements of the analysis are illustrated in Figure 2-1. The collection of information for the DHC stock and the DHC markets takes place in parallel. In step 3, 'Assessment', countries' DHC stock and market are divided into groups, based on the evaluation criteria. There is no inherently clear method of grouping the countries by the state of DHC, even though some general themes persist throughout the examined countries. Therefore, the countries have been divided into three groups based on their share of DH compared to the total heat demand in the residential sector covered. The evaluation leads to suggestions for actions improving DHC systems and retrofitting of existing DHC systems. A detailed description of the method is presented in the proceeding sections.

Templates	Information compilation	Assessment	Evaluation	Improvement actions
Define necessary data Create templates for data	Data collection Data analysis	Criteria to determine division of small, medium and large DHC networks	Risks Barriers Trends Inefficiencies Developments	New DHC Retrofitting of existing DHC

Figure 2-1: Main elements for the evaluation of DHC stock at EU level

To fulfill the aim of the WEDISTRICT project, the evaluation will take place for all countries, but with a special focus on those countries with less contribution to DHC networks developments and those countries with less RES integrated into DHC systems.

In general, the work will be based on the following five pillars:

1. The necessary data are determined, and a template for stock analysis and a template for market analysis are developed;
2. The DHC stocks and markets are described with the available data. Missing information is identified and collected in collaboration with WEDISTRICT partners and local contacts;
3. An assessment of the data is performed in order to establish criteria to determine small, medium and large DHC;
4. Evaluation of data is done to investigate barriers, risks, inefficiencies and development opportunities;
5. Improvement actions, based on the main findings and conclusions, are identified and formulated.

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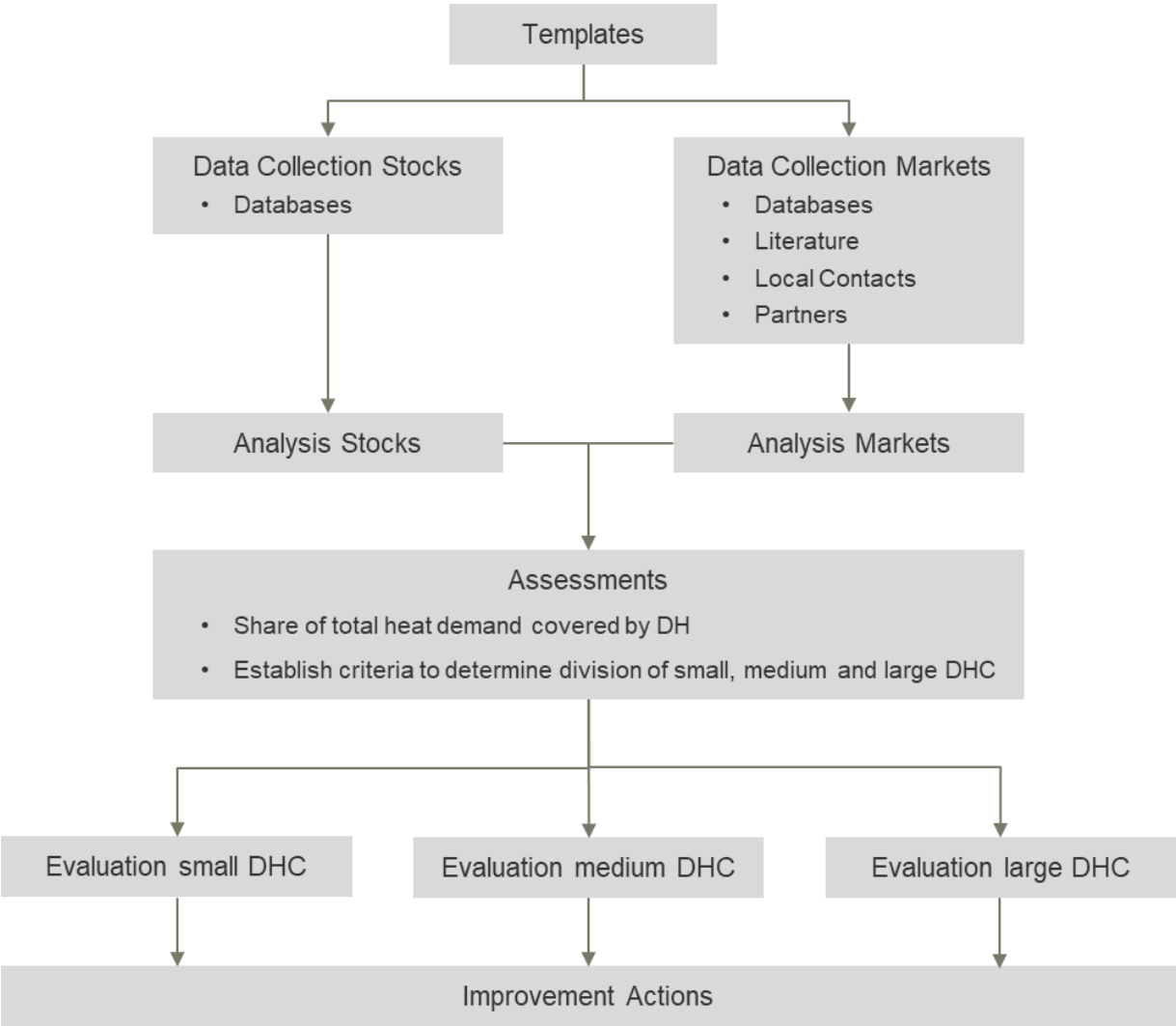

Figur 2-1: Flowchart of the method

2.2 Templates

A template was made to collect the same type of comparable data for each country's DHC stocks and their DHC markets. To decide what data should be collected, a screening was conducted to find sources of data where most of the European countries were included and which were reliable and objective. Data sources as Eurostat[2], EH&P[3], Heat Roadmap Europe[4], and the European Environment Agency (EEA)[5] were used to see what data is available and how much is available for each country.

After getting an overview of the available and relevant data for this task, a template could be created for the DHC stock and market analysis. This template includes both figures of the current status and the development of heat production, DHC, CO_2 emissions, etc, but also questions about barriers, further development and plans for DH, as well as market structures, support schemes and objectives.

[2] https://ec.europa.eu/eurostat/web/energy
[3] https://www.euroheat.org/
[4] https://heatroadmap.eu/
[5] https://www.eea.europa.eu/

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2.3 Data sources

The analysis of the DHC stock and markets in Europe is based on various data sources. Since it is a combination of several sources, the age of available data also varies from source to source and from country to country. The data presented is considered the best available, however numbers can be different in reality than presented in this report.

The following sub-chapters will present some of the key data sources applied in this analysis.

2.3.1 Euroheat & Power

EH&P is an international network for district energy primarily in Europe. Members come from over thirty countries around the globe and include national DHC associations, utilities, manufacturers, universities, research institutes and consultancies.

Every two years, EH&P publishes the Country by Country report, a detailed and comprehensive statistical overview of the DHC sector in Europe. This publication has become a key source of industry data widely used by national and European policymakers, regulators, energy consultants, engineering companies, utilities and other players in the district energy market[6]. In this work, the data of the following surveys where analysed:

- EH&P – Country by Country report: 2015 survey;
- EH&P – Country by Country report: 2019 survey.

The extracted data were split into DHC indicators and DHC supply. The DHC indicators describe the scale of DHC in each country, such as DHC sales, capacity and trench length. Average prices for DH, CO_2-emissions and investments were further included. This data was summarized in a DHC indicator section. The composition of DH generated by energy source and mode (CHP or heat only) was further extracted and is presented as the DHC supply.

For some countries the indicators also include DC, but most data revolve around DH. There are further differences amongst countries, concerning the data quality and quantity. Table 2-1 shows the European countries included in the report, stating when the data was updated, and if both DC and DH are included for countries. It is further shown if the DHC indicator and DHC supply are included in this work.

Comparing the EH&P 2015 and 2019 surveys, some differences in data for overlapping years (2011 and 2013) were identified. Some of the differences can be presumably explained with updated data and differences in the method by the national institutions. However, some data appears to be wrong. The reported DH prices for Norway in 2019 appear to be too low compared to previous years. The DH supply to the industrial and service sectors seems to inverse in the 2019 report compared to the 2015 one for Latvia.

[6] https://www.euroheat.org/cbc_publications/cbc2019/intro/

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EH&P Country	Update	DH Data	DC Data	DHC Supply	DHC Indicator
Austria	2019	Available	Available	Included	Included
Bulgaria	2015	Available	Partly	Included	Included
Croatia	2019	Available	Limited	Included	Included
Czech Republic	2019	Available	Partly	Included	Included
Denmark	2019	Available	Available	Included	Included
Estonia	2015	Available	Limited	Included	Included
Finland	2019	Available	Available	Included	Included
France	2019	Available	Available	Included	Included
Germany	2019	Available	Available	Included	Included
Hungary	2019	Available	Partly	Included	Included
Ireland	2019	Partly	Limited	Excluded	Excluded
Italy	2019	Available	Available	Included	Included
Latvia	2019	Available	Limited	Included	Included
Lithuania	2019	Available	Limited	Included	Included
Netherlands	2015	Available	Limited	Included	Included
Norway	2019	Available	Available	Included	Included
Poland	2019	Available	Available	Included	Included
Portugal	2019	Available	Available	Excluded	Included
Romania	2017	Available	Limited	Included	Included
Slovakia	2017	Available	Limited	Included	Included
Slovenia	2019	Available	Available	Included	Included
Spain	2019	Available	Limited	Excluded	Included
Sweden	2019	Available	Available	Included	Included
Switzerland	2017	Available	Limited	Included	Included
United Kingdom	2019	Partly	Limited	Excluded	Included

Table 2-1: Overview of countries included in this report based on the EH&P Country by Country study and their available data

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2.3.2 Eurostat

From Eurostat[7], several data sets were extracted to be used in this analysis and to find relevant indicators:

- GDP and main components (output, expenditure and income);
- The population on 1 January by age and sex;
- Energy balances for each EU country[8]:
    - Final national energy use by sector and energy carrier;
    - Heat and electricity production by type and fuel.

2.3.3 Heat Roadmap Europe

The EU-funded project HRE developed low-carbon heating and cooling strategies called Heat Roadmaps, by quantifying and implementing changes at the national level for 14 EU Member States, which together account for approximately 85-90% of the total heating and cooling in Europe[9].

In this work, the data "Profile of heating and cooling demand in 2015" was used[10]. This data set distributes the final energy demand for heating and cooling by sector (industry, residential and tertiary), by energy carrier (e.g. solar thermal, oil, gas), by use (e.g. process heating, space heating) and by country. This data is available for the year 2015 for all EU28 countries.

For the 14 EU Member States who participated in the project, HRE created roadmaps for cooling and heating. For each of the countries, a baseline for the year 2015 was created, which includes the installed capacity for heating and cooling, divided by DH technologies and for individual heating.

2.3.4 Others

EEA:

- CO_2 emission intensity of electricity production in the EU[11].

[7] https://ec.europa.eu/eurostat/data/database
[8] http://ec.europa.eu/eurostat/web/energy/data
[9] https://heatroadmap.eu/project/
[10] https://heatroadmap.eu/wp-content/uploads/2018/11/HRE4_D3.1.pdf
[11] https://www.eea.europa.eu/data-and-maps/daviz/co2-emission-intensity-5#tab-googlechartid_chart_11

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3 DHC Stock evaluation and Market Analysis

3.1 Introduction

The following section will provide an overview of the DHC stock and market structure of the countries examined in this report. The state of the DHC varies significantly country by country, both in terms of the capacity to satisfy the thermal demand, but also with the perspective of efficiency and sustainability of the overall networks. Furthermore, the policies and market structures governing the planning, heat sales and operation of these systems are executed in a wide variety of manners. There is no inherently clear method of grouping the countries by the state of the DHC, even though some general themes persist throughout the examined countries. Therefore, the countries have been divided into three groups based on the share of total heat demand in the residential sector covered by DH. The share of DC is not included, since too small an amount of data is available for each country. The groupings are as follows:

1. Small share of DH: Less than 10% of residential heating;
2. Medium share of DH: Greater than 10% but less than 50% of residential heating;
3. Large share of DH: Greater than 50% of residential heating.

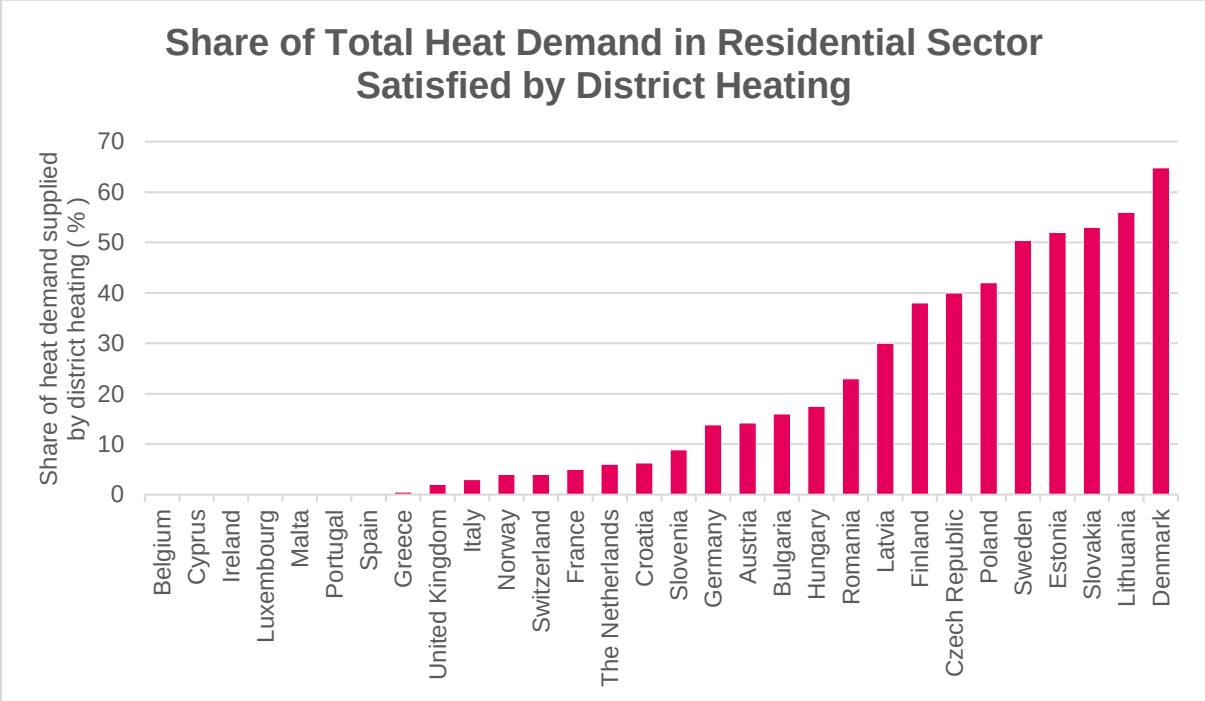

Figure 3-1: Share of total heat demand in the residential sector satisfied by DH

The reason for this division is that the countries with a significant share of DH are generally at the forefront of innovation within the field, with political backing and established market structures to facilitate further improvement. The mid-level group is a mix of countries that have old systems that still provide heating, but require investments for refurbishments of the existing system, and countries which traditionally have relied on other sources for heating but have invested in the development of DHC in recent years. The majority of the countries are represented in the group with a small share of DH and expectedly also show the most diverse range of the state of the DHC. Due to the differences within each grouping, general themes that apply within that grouping will be discussed under the subcategories.

Each of the groups will be discussed based on an evaluation of the current DH stock of the respective countries. The stock evaluation contains an analysis of energy use and sources

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for heating and cooling, the capacity, thermal efficiency and amount of current systems, as well as an estimation of the carbon emission intensity of the DHC system. Once the current stock of DHC is elaborated, a market analysis of the group is presented. The market analysis aims to provide an understanding of the current state of the DHC market as well as present the targets for further development and identify the most common barriers standing in the way of this development. Finally, a summary of the main lessons learned in the examination of this group is given.

3.2 Countries with small share of DH

The countries analyzed in this section are Slovenia, Croatia, the Netherlands, France, Switzerland, Norway, Italy, the United Kingdom, Greece, Spain, Portugal, Ireland and Belgium. Luxembourg, Malta and Cyprus are not included although they are represented in the graph, since no data on DH is found.

3.2.1 Stock Evaluation

3.2.1.1 Heat production

For the countries with a share of DH below 10%, a trend is showing that in Southern European countries as Spain, Greece, Italy, Portugal, France and Slovenia, the gross heat production has increased slightly from the previous years. This is the opposite of the Netherlands, Belgium and Norway, as their heat production has decreased. The United Kingdom is the only Northern European country in this category where heat production has increased. Fuels used in the overall heat production are typical fossil fuels like natural gas, oil and other petroleum products. [12]

[12] Eurostat

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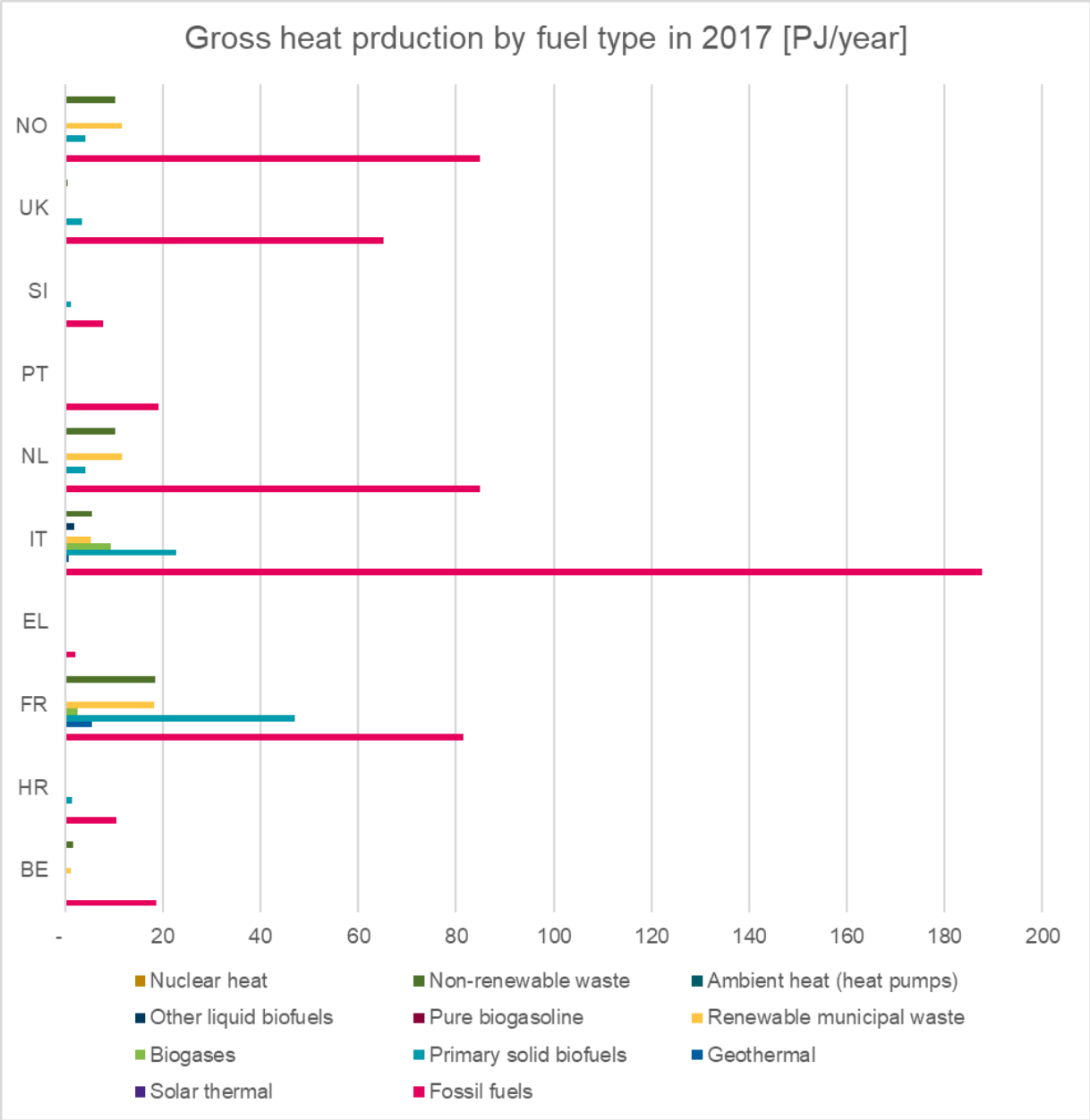

Figure 3-2: Gross heat production in 2017 for countries with a low level of DH and sufficient data[13]

For France, Italy, and Spain, the numbers of DH systems, total trench length and capacity are increasing, while for Croatia and Slovenia they are decreasing[14].

The common trend for all countries shows how installed heat capacity in all of this group's countries is very similarly. Data shows how approximately 75-80% of installed heating capacity comes from individual boilers, mainly on natural gas. 10-15% of the installed healing capacity comes from DH boilers while the rest from CHP. The share of individual HPs in the total installed heating capacity is so low, that they do not have any significant impact[15].

[13] Eurostat, 2017
[14] Euroheat & Power
[15] Heat Roadmap Europe

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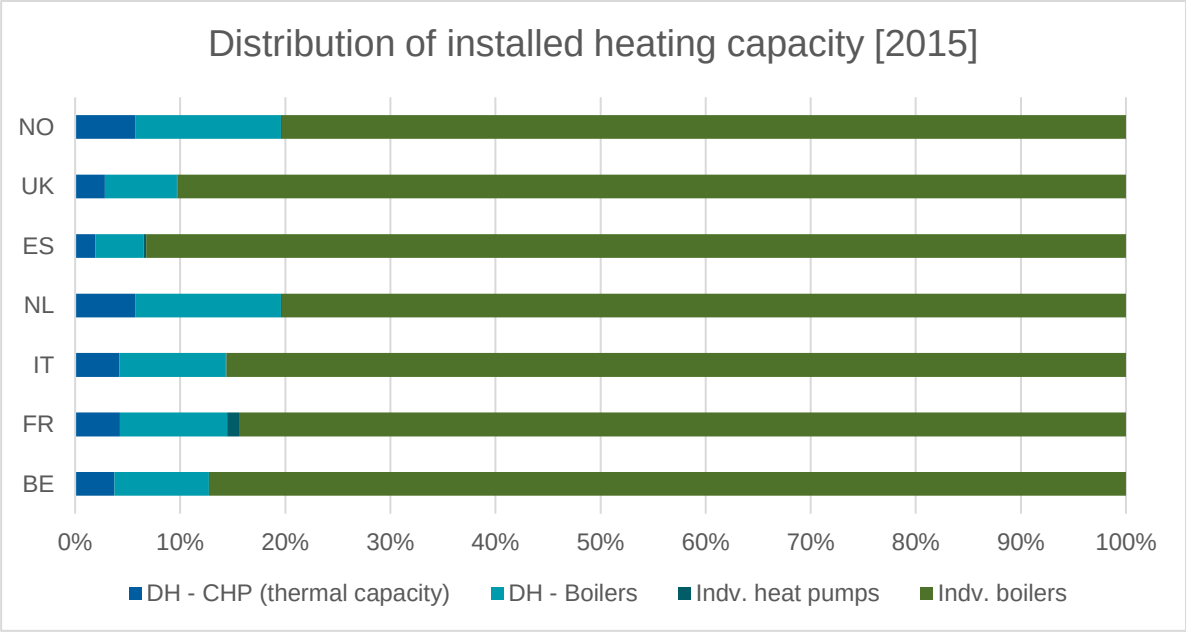

Figure 3-3: Distribution of installed heating capacity for countries with a low level of DH and sufficient data[16]

3.2.1.2 District cooling

In all of the countries with a DH share below 10%, individual cooling is used. However, data from Italy and France indicates that they have DC and the market is expanding when it comes to the number of sales, installed capacity and trench length. Portugal's DC market has remained stable from 2009 to 2017. See Figure 3-1.

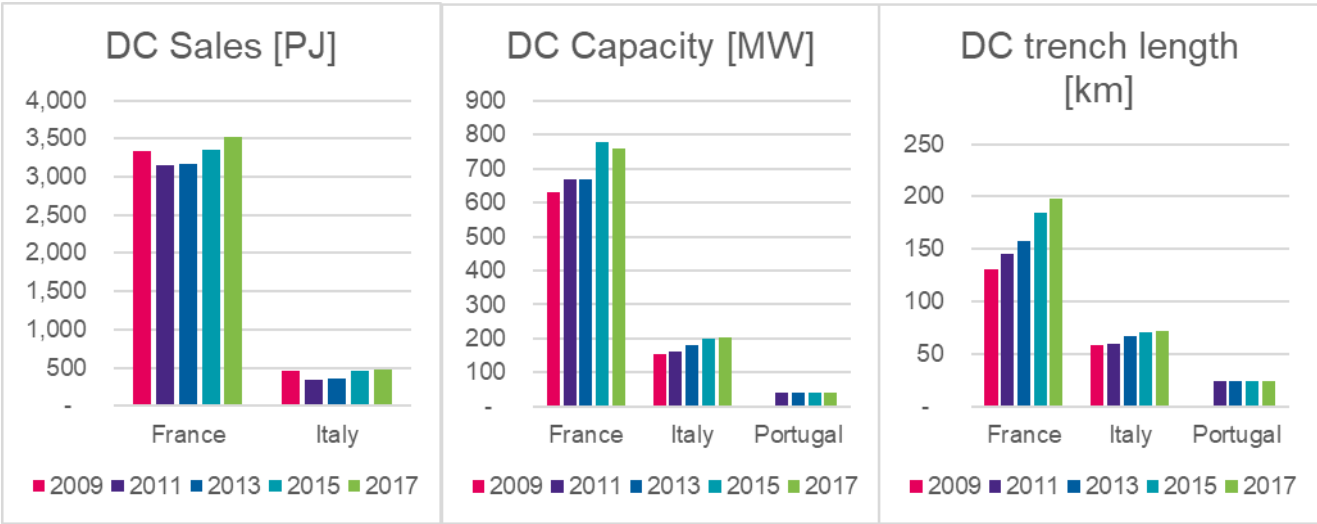

Figure 3-4: District heat indicators for countries with a low share of DH. Based on data from EH&P

3.2.1.3 Typical DHC projects

A typical DHC project for countries with a low share of DHC is the project in Barcelona, Spain. The project is located in the districts of Forum and 22@, where construction started in 2003. This DHC network consists of two independent networks, where heat and cooling are provided from two incineration plants – one located in each district. The capacities and demands have continued increasing from 2003 to 2017, where the capacity for heating was 72 MW and 104 MW for cooling, and the yearly heat demand was 29 GWh/year, and for cooling 48.4 GWh/year. They are providing DHC to hotels, offices and other tertiary buildings in general. From 369,000 tons of urban waste per year, heat is generated as steam from combustions. The steam is mainly used for electricity generation but is also sold to the DHC

[16] Heat Roadmap Europe

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networks. Additionally, the plants have gas boilers used for back-up and peak demand, and the Forum plant is equipped with a 5,000 m^3 water tank for the cooling supply. For heating, the supply temperature is 90°C and the return temperature is 60°C. For cooling, the supply temperature is 5.5°C, and the return temperature is 14°C.[17]

3.2.2 Market analysis

3.2.2.1 Culture of DHC

The most common theme for this grouping is the general low awareness of DHC and the lack of practical know-how for the development of DHC. This creates a dependency on the expertise of international companies to provide solutions for every aspect of developing an efficient DHC market.

3.2.2.2 DHC market structure

The DHC systems are primarily owned by state or municipalities, with private ownership also occurring in certain countries. In Croatia, the entire DH value chain is owned and regulated by the federal government or municipalities, meaning that the DH companies are responsible for production, transmission and distribution to the customer, whereas a regulatory agency is responsible for regulating the heat prices in order to protect the customer. However, in some of the bigger cities, the price regulation is so strict that the DH companies are not able to cover the cost of heat production.

The Netherlands have traditionally been heated by natural gas due to its large gas reserves, and although known to have gas-fired CHP schemes, wider city-spread DHC is a rather new technology in the country. The government is currently in the process of revising the Heating Act that was established to transform the heating sector, which is expected to be finalized in 2022. The first edition of the Heating Act has been scrutinized by politicians, stating that the regulatory framework grants monopoly to private companies under the current format. The proposed plan was to let the municipalities take the lead in forming catchment areas for DH, and then assigning the planning and operation of the network to companies chosen by the municipalities. The companies are given exclusive rights to the area. The companies will be obligated to provide an offer for every household in the catchment area to connect to the network. A pre-condition will be used to reduce the investment risk by implementing tariff regulation, which secures that the companies retain their investment cost.

The most common subsidy found for the DH customers in this group is the reduction of VAT by using a heating solution, which has a high share of the heat deriving from RES. In France, the customers can receive a 5.5% VAT rate reduction if the network has more than 50% heat produced by RES. Italy follows a similar structure, with an additional tax deduction over a ten-year period to cover a part of the cost of connection to the DH network.

3.2.2.3 Development targets for DHC

The development targets of these countries are primarily related to the energy sector as a whole, with limited focus on DHC. France and Slovenia aim to increase their CHP production, whereas Spain and Italy aim to increase the share of RES of the final energy consumption. The Netherlands aim to reduce the carbon emission from buildings by 49% by 2030, mainly done through refurbishment of old buildings and increased energy efficiency demands for newly developed buildings.

[17] https://www.chester-project.eu/wp-content/uploads/2018/11/CHESTER_D2.1_Case-Studies_v5.0.pdf

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The United Kingdom is one of the only countries with a measurable target for DHC, aiming to increase the share of the total heat demand in the residential sector satisfied by DH to 17% by 2050. The Netherlands project that the amount of buildings connected to the DHC system will increase from 420,000 to 750,000 by 2030 and by 2050 DH is projected to provide 15-45% of the total heat supply in the Netherlands.

The EU's Energy Performance for Buildings Directive from 2010, which states that new buildings must have a near-zero energy standard based on local RES, has inspired Belgium to take steps in this direction, by committing to reduce the net energy demand for space heating through efficiency measures, while also demanding that energy consumption for new buildings should derive from RES. The Belgian regions offer subsidies to individuals and businesses for implementing heating based on local RES. The region of Flanders has made an amendment to the Flemish Regional Energy Act, introducing a legal framework for DHC. The bill is intended to clearly define the market roles and obligations of the market contributors. The framework is similar to the rules applicable to the electricity and natural gas network in Belgium.

Slovenia has developed a long-term energy strategy, referred to as Energy Concept of Slovenia (ECS) with the intention of securing a reliable, sustainable and competitive energy sector. A strategy for DHC has been developed, resulting in a guideline for developing efficient DHC networks and CHP usage. This has been performed on the basis of comprehensive spatial analysis and cost-benefit analysis (CBA). To assist national and local project developers, the 'Heat Map of Slovenia' is being developed, contaning relevant information on buildings, energy infrastructure, energy systems, demand, etc.

Programmes for co-financing the construction and expansion of DH systems are made available if the DH companies plan to have the heat generation plants operating on RES.

3.2.2.4 Barriers for further development of DH

In general, there is a lack of legislative and regulatory framework to facilitate the development of the state of DHC in the countries represented in this group. This is mainly due to the unfamiliarity and lack of practical know-how of DHC systems, as well as historical reliance on other heating solutions such as natural gas.

The extensive natural gas networks that are already established makes the case for switching to DH for heat supply difficult, since natural gas prices are relatively low under current market conditions, and the switching cost related to connecting to new DH networks are high.

The warmer climate in the Southern European countries makes the incentive of investing in new DH systems less economically attractive, as the utilization rate of the installed capacity is lower than the Nordic or Eastern European countries. With high capital investment cost, the feasibility of the project relies heavily on the revenues from heat sales, and since the region does not have a long heating season, the resulting long payback time can be a barrier for further development. Especially considering that many of the countries already have a high connection to natural gas networks and, in some cases, also offer incentives for individual renewable heating sources.

In the Netherlands, the monopoly structure suggested by the government creates significant political resistance, which might prove to be a barrier for the sustainable development in the short term. In Belgium, the development is hindered by the general structure of the roles of the regions and the federal government concerning energy policy. The regions are responsible for implementing energy policies, while the energy supply is governed on the federal level. Therefore, disagreements of how the regions intend to implement their energy policies do not necessarily comply with the country's energy strategy. This highlights the fact

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that introducing legislative and regulatory frameworks for the integration of DHC is not a simple task and might be a barrier for many of the nations that do not have any tradition with DH networks.

3.2.3 Conclusions small DHC

The current state of DHC in countries with a DH share of below 10 % shows how buildings are most commonly heated by individual boilers, and that fossil fuels like natural gas and oil are the most used. Furthermore, cooling is primarily supplied by individual chillers, with limited or no DC available.

DHC projects in this category are typical heat recovery from incineration, which provides heat and cooling in smaller networks to public and private buildings like hospitals, schools, offices, hotels, apartment houses, etc.

One general observation is that the majority of these countries do not have any culture of utilizing DH, and therefore do not have well established regulatory frameworks put in place to ensure efficient operation and regulation of the DHC networks. The lack of regulatory frameworks increases the risk of the investors and, with high uncertainty, the significant capital investment cost becomes a barrier for further development or refurbishment of existing systems.

Main conclusions:

High use of fossil fuels

Low awareness and lack of practical knowledge, who have to rely on external expertise to plan and build DHC systems

Lack of masterplan

Lack of legislative and regulatory frameworks. Competing individual renewable solutions have better economic benefits

High investment cost

Warmer climate – lower utilization – higher risk - less attractive to investors

High use of fossil fuels

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3.3 Countries with medium share of DH

The countries analyzed in this section are Poland, Czech Republic, Finland, Latvia, Romania, Hungary, Bulgaria, Austria and Germany.

3.3.1 Stock Evaluation

3.3.1.1 Heat production

Of the countries with a DH share between 10% and 50%, it is most common that the countries' overall heat production is increasing. This is the case for Austria, Germany, Hungary, Latvia and Poland. For Finland and the Czech Republic, the overall heat production is stable, while it is decreasing for Bulgaria and Romania. Furthermore, there are three ways to divide the countries when it comes to fuel use in the overall heat production. For Austria, Finland, and Latvia, there is a 50/50 distribution of solid biofuels and fossil fuels. In Germany and Hungary, it is most common that fossil fuels are used for heat production, but there is also a small share of biofuels and municipal waste used. For Poland, Romania, the Czech Republic and Bulgaria, fossil fuels are the common type of fuel in heat production.[18] See Figure 3-5.

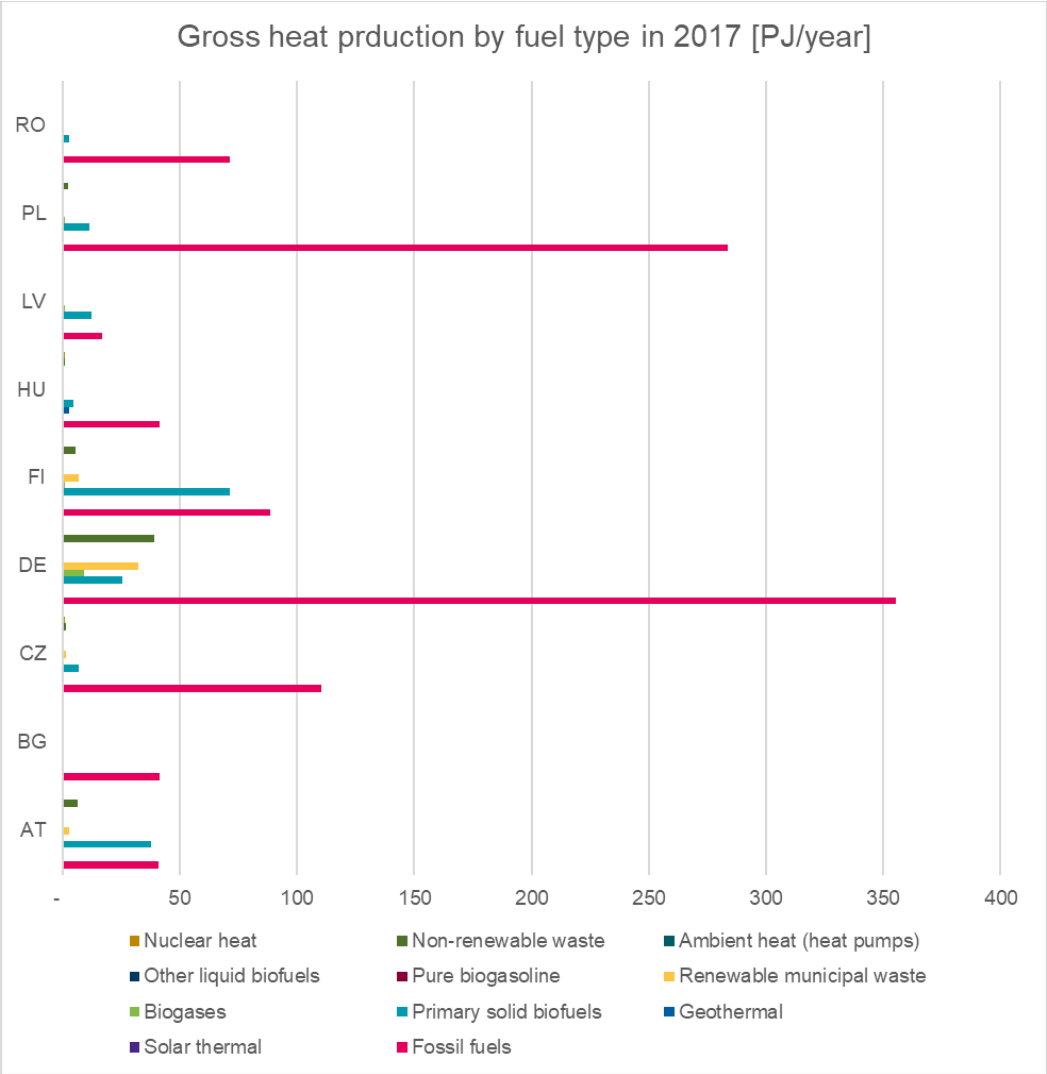

Figure 3-5: Gross heat production in 2017 for countries with a medium level of DH and sufficient data[19]

[18] Eurostat
[19] Eurostat

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Austria and Finland are the only two countries in this category where the DH capacity is increasing, as well as the total trench length and number of DH systems. For the other countries, the total DH capacity is decreasing, however, the trench length and numbers of DH systems vary for all these countries too.[20]

For European countries classified as having a medium share of DHC, a similar trend is showing for all countries when it comes to total installed heating capacity – except for Finland. On a whole, 60-70% of the installed heating capacity is in the form of individual boilers. 20-30% is heat-only boilers for DH, and the remaining 10% is in form of CHP to DH. Finland separates themselves from the other countries by only having 30% of the installed heating capacity as individual boilers, 48% as heat-only boilers in DH, and 20% as CHP in DH. However, only 40% is supplied by DH in Finald. The reasoning of this is that the data only includes residential buildings. Offices and industries are not included when dividing countries into the three groups. This is the case for all countries represented in the graph, as to why their share of DH is not equal to the share of installed DH capacity. Individual HPs represent below 1% for all other countries' total installed heating capacity, expect Finland which has 2% installed.[21] See Figure 3-6.

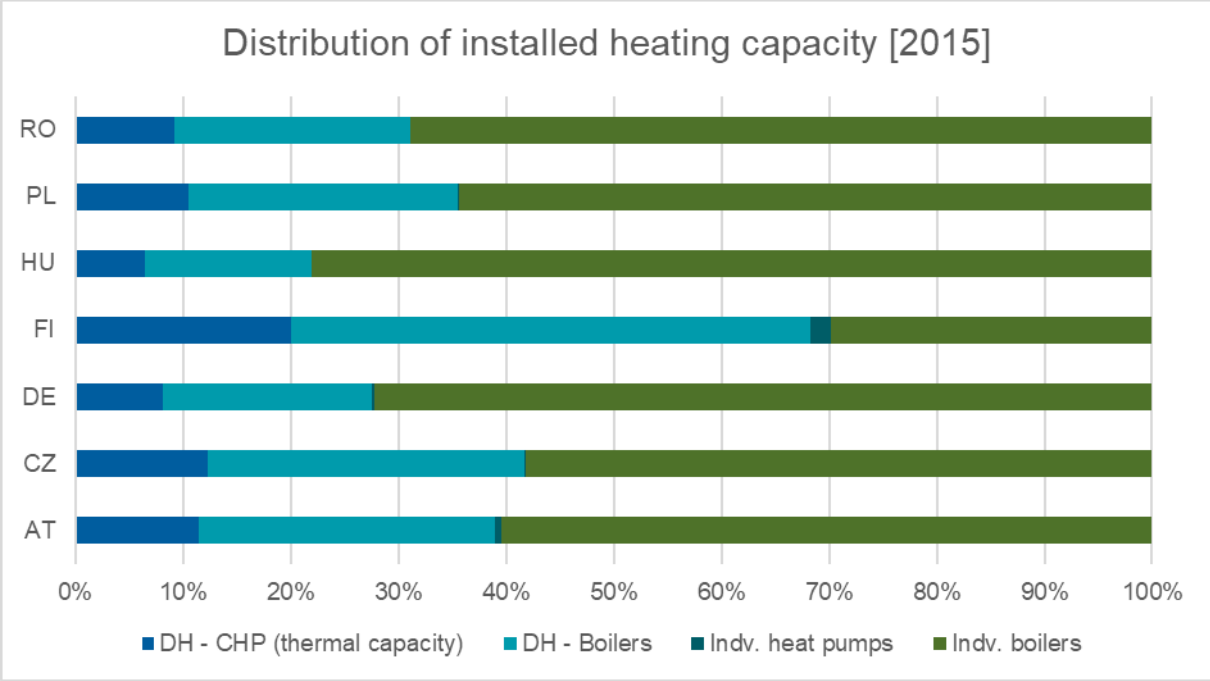

Figure 3-6: Distribution of installed heating capacity for countries with a medium level of DH and sufficient data[22]

In the countries' DH production, the amount of heat is most often produced from CHP plants more than heat-only boilers. In most countries with sufficient data, fossil fuels like coal and natural gas are still commonly used for DH with CHP, but in countries like Austria, Finland, and Latvia, biomass is also used to a greater extent. In heat generated from heat-only boilers, the same three countries that use biofuels are still mainly using biofuels as fuel in heat-only boilers for DH. The remaining countries are still using fossil fuels.[23]

[20] Euroheat & Power
[21] Heat Roadmap Europe
[22] Heat Roadmap Europe
[23] Euroheat & Power

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3.3.1.2 District cooling

Austria, Germany, and Finland have data that shows how their DC market is expanding for sales, capacity and trench length. For the remaining countries, it is not known if they do not have data on DC or do not have any DC[24].

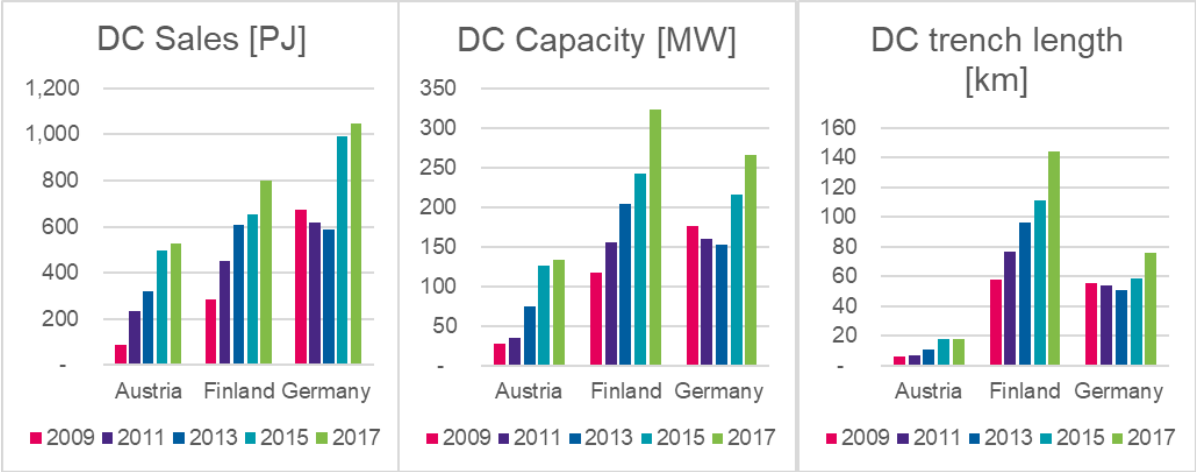

Figure 3-7: District cooling indicators for countries with a Medium share of DH[25]

3.3.1.3 Typical DHC projects

An example of a typical DH project is one of the 1,400 local public utilities in Germany. The HafenCity's DH system in Hamburg is heated by a CHP in which construction has been structured into three phases. In 2014, the first facility opened with a CHP unit running on biomethane with a capacity of 1.6 MW_{th} and 1.5 MW_e. An 8 MW_{th} heat-boiler was installed as well, running on oil and natural gas. It was planned to provide 70,000 MWh_{th}/year and to increase the CHP capacity to 46 MW in 2028. In the second phase, a second heating station was built in 2018 with three biomass heat-only-boilers with a collective capacity of 12 MW_{th}. One of the three boilers is operating today, while the two others will start operating in 2022 and 2024. In the third phase, a HP will start operating with a capacity of 3 MW_{th}. Once finalized, there will be a flexible production with a CHP running on biogas, biomass boilers, a HP, and gas and oil boilers for the peak demand.

In 2015, 6 GWh heat was produced per year while the future target is 70 GWh/year. Just as well is there a 1.5 km trench network and 75 kg CO_2 /MWh are emitted. The customers are paying approximately 90 €/MWh incl. taxes.[26]

Another example of a typical DHC project is the Finnish CHP in Helsinki, Salmisaari power plant. This CHP uses wood pellets together with coal as fuel and has a capacity of 300 MW_{th} and 160 MW_e. However, DC is produced in the same process and, whenever it is possible, cold seawater is used too for DC.[27]

3.3.2 Market analysis

3.3.2.1 Culture of DHC

Many of the countries represented in this group are Eastern European nations and have an established history of using DH networks for satisfying the heating demand of buildings and industry. Most of the networks were constructed during the Soviet era and are generally in poor condition with subsequent high thermal losses, making investments in refurbishment of

[24] Euroheat & Power
[25] Euroheat & Power
[26] https://www.euroheat.org/wp-content/uploads/2017/01/study-on-efficient-dhc-systems-in-the-eu-dec2016_final-public-report6.pdf
[27] https://www.helen.fi/en/company/energy/energy-production/energy-production2

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the existing infrastructure a requirement, in order to improve the energy efficiency of the overall system.

Finland has a significant share (38%) of the total heating demand being supplied from DH systems, although the country is sparsely populated. The market share in some cities is as high as 90%, indicating that the awareness of DHC technology is high. Due to the sparsely placed population, there is a significant difference between market shares and possibility of further development in certain regions.

In general, most of the countries in this group have a high degree of knowledge regarding DHC technology, but other external forces such as the economic affluence, competing individual heating solutions, population density and even population decrease hinder the improvement and development of the DHC systems.

3.3.2.2 Market structure

The stakeholders of the DH network in this group consists mainly of federal government and municipalities as well as private utility companies. The DH companies in Austria, Hungary, Romania, Finland, the Czech Republic and Latvia are either strictly or nearly entirely owned by the public sector. The vast majority of the Polish and Bulgarian DH companies are private companies. In Germany, most of the DH networks are owned by large private utility companies, but ownership is increasingly shifting towards municipalities, as the number of cities that are embracing DH networks for the heating needs grows.

In Austria, subsidies of up to 30% of the capital investment cost of installing efficient CHP plants are given to provide incentive for implementing more sustainable solutions for heating purposes. A similar approach is taken in Poland, where subsidies of up to 50% of the capital investment cost are given for development of CHP plants operating on a high share of RES. In this case, it is a requirement that the local municipality is the majority stakeholder with at least 70% ownership of the company. Additionally, government subsidies are provided if the CHP plant has a certain amount of electrical power capacity.

In recent years, support programs have been used in Romania to promote the implementation of highly efficient cogeneration plants. However, this support program will end in 2023, creating uncertainty and deterring new investment in cogeneration plants.

Subsidy schemes are used in Finland to incentivize renewable energy production but has mainly been used for wind energy and wood chips.

In Germany, support programs mainly exist for the integration of renewable energy technologies and low-temperature heat sources (<95 °C). For the DH distributer to receive the subsidies, the DH network must meet the requirements established. Moreover, programs exist to support the customer with the cost of connection to the DH network. These programs vary from state to state, with the funding programs also supporting other renewable and efficient heating solutions.

No subsidies exist for development of DHC in Bulgaria.

The Czech Republic have subsidy schemes for retrofitting or development of new DHC systems, but the application requirements are very complex.

Latvia is the only country utilizing a feed-in tariff for CHP plants, which was established with the intent of increasing the number CHP plants being developed.

Most of the countries in this group do not use any subsidy schemes for customers of the DH companies. However, similarly to the former group, the strategy of reducing the VAT rate

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compared to other heating solutions is also seen. Hungary uses a 5% VAT rate for heating from DH, compared to a 27% VAT rate when natural gas is used for heating.

The Polish population can apply for subsidies if they install technology for heat usage, that increases the energy efficiency and reduces pollution.

In contrast to most countries, the Finnish DH system is not regulated, meaning that Finland does not have specific legislation concerning the selection or pricing of heating, cooling or heating and cooling methods. Competition between various solutions and service operators in the heating market is meant to ensure efficient operations, reasonable pricing and a high quality of services for customers. However, some regulations are put in place to protect the customer from unreasonable pricing and to secure the supply of heat.

3.3.2.3 Development targets for DHC

The aim of achieving a more sustainable energy sector is a general trend and can also be seen in the national targets of the considered countries. Increasing the share of RES of the final energy consumption is shared by many countries and is the most overarching target. Austria aims for 45-50% by 2050, Poland has a target of 21% by 2030 and Romania had a target of 24% by 2020.

Regarding the targets related to the heat sector, Austria seeks to have the heat supply solely produced by RES by 2050. Germany aims to increase the share of heat production from waste incineration to cover 30% of the total heat production by 2030. The Czech Republic has a target of having 60% of the heat demand covered by CHP by 2040. Furthermore, with respect to DH in particular, many distinct targets are established. Finland target near zero carbon emissions from the DH systems by 2030. In Poland, 70% of all households are to be connected to the DH network by 2030 and the Czech Republic aims to have 20% of DH deriving from RES by 2040. Romania aims to expand the current system and improve the energy efficiency of the DH network, while Latvia aims to reduce the overall energy consumption with 20,500 GWh from 2021 to 2030. No specific targets were found for Bulgaria.

In Poland the focus is on changing the heat market policy by modification of heat price regulation mechanisms, introducing reference price and stimulus for reducing the heat distribution costs. The Energy law will also be revised to clearly define the responsibilities of local governments in terms of heat, energy and gas distribution planning. Furthermore, spatial analysis is used to develop a national heat map for planning purposes.

DH in Austria is not a foreign concept, and although network extension and grid densification is ongoing, a lot of potential for further development still remains.

3.3.2.4 Barriers for further development of DHC

Several of the countries report a decreasing heat demand as one of the main barriers for the development of the DHC networks. One factor is the energy efficiency measures put in place to improve the building envelopes, leading to lower heating demand in the residential sector. In addition, Latvia reports that a decreasing population further reduces the heat demand, resulting in the existing networks becoming over dimensioned. Therefore, in order to reduce the high heat losses caused by this issue, investments are required to refurbish the existing networks, as well as connecting more buildings to further extend the network and ultimately increase the overall heating demand.

In Hungary and Poland, the regulation of heat prices makes it difficult for DH companies to invest in refurbishment of existing networks and development of new project. The DH companies are obligated to have their annual profit not exceed a certain limit, thereby restricting the possibility of securing financing for the needed refurbishments of the infrastructure.

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In Bulgaria, Germany, Hungary, Latvia and Romania there are no requirements for newly constructed building to connect to the DH network.

In Finland, the challenges for further development of DH is the sparse population distribution and the relatively saturated market in the larger cities, as evident with the high connection rate in the large cities. Therefore, the objective for further development of DH should be to secure a higher share of renewables in the heat production, which is also in line with the current energy policy targets.

One general theme for DH is the competition from individual heating solutions available to the customer. In the Czech Republic and Germany, the DH companies are obligated to pay carbon emission taxes, while the individual heating solutions do not, increasing the difficulty of remaining competitive. In Hungary, the price level of natural gas is more attractive than DH heat prices, creating a better financial incentive for the individual heating solution.

3.3.3 Conclusions medium DHC

The countries' DHC stock can in this category be split into two groups: Those who have established DH networks and use a great share of biofuels, and those who are seeing a decrease of DH, and where fossil fuels are more commonly used. For all countries, individual boilers are the most common type of heat production, except for Finland, whose installed heat capacity is mainly installed as DH boilers and CHP. Typical new DH projects are mostly focusing on producing heat with heat-only boilers, but also has a focus on having a flexible production based on biofuels. In countries with DHC projects, cooling is produced from RES like water.

Main conclusions:
Individual boilers are the most typical for heat production.

Either countries are mainly using fossil fuels or using a greater share of biofuels as fuel for heat production.

Refurbishment of existing infrastructure is very important, considering the declining heat demand and current state of the network.

The carbon emission taxes on CHP makes the DH less competitive with individual solutions. Legislative framework favour individual solutions.

Heat price regulation must be thoughtfully constructed in order to increase the competitiveness of DH systems.

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3.4 Countries with a large share of DH

The countries analyzed in this section are Denmark, Lithuania, Slovakia, Estonia and Sweden. The countries represented in this grouping correspond to the nations with the highest share of the residential heat demand being supplied by DH, namely more than 50%.

3.4.1 Stock Evaluation

3.4.1.1 Heat production

For every country with a DH share above 50%, their gross heat production is increasing. Every country, except for Slovakia, uses primarily biofuels as well but is still using some amount of fossil fuels too. In Slovakia, they are mainly using fossil fuels and only a smaller share of biofuels.[28]

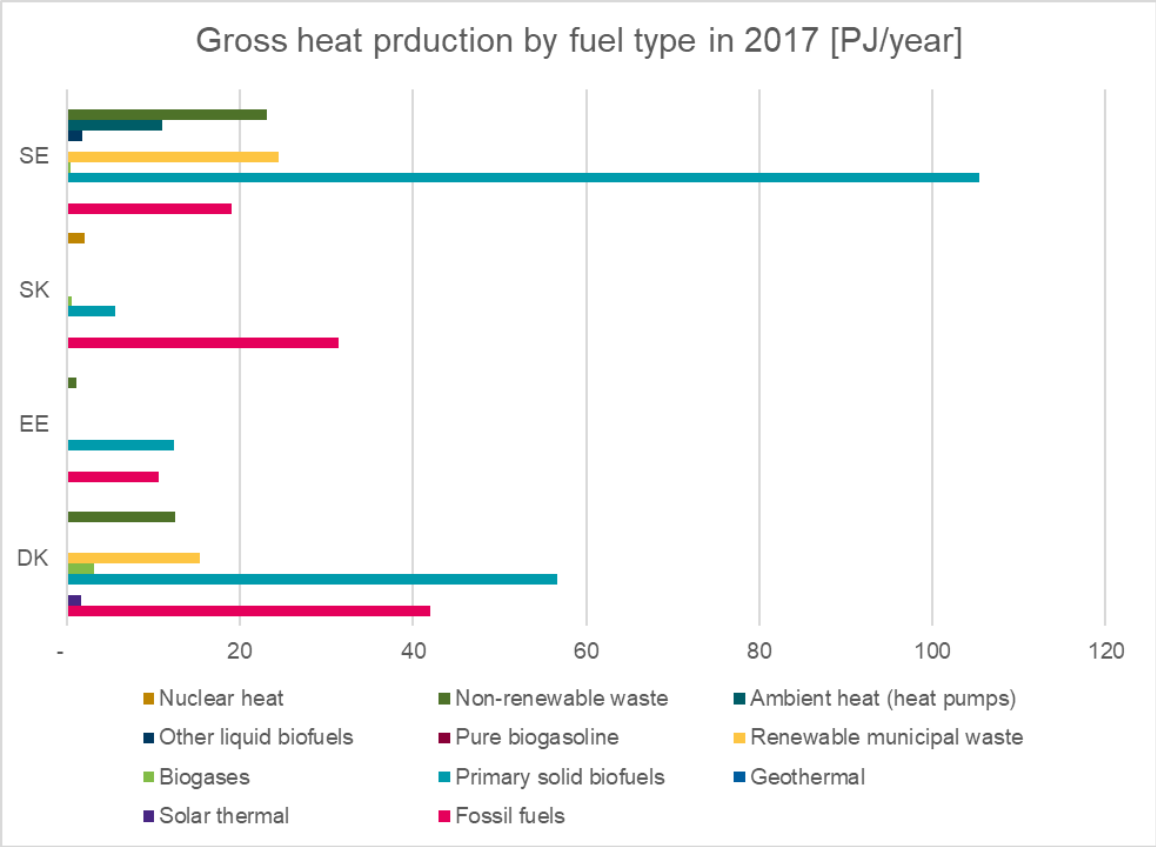

Figure 3-8: Gross heat production in 2017 for countries with a high level of DH and sufficient data[29]

The number of DH systems and trench length for all the countries in this category that have this data are all mostly constant.[30] However, this category is the smallest group of countries, and the level of data is not very sufficient. The same is the case for heat generation, as Sweden is the only country having data on this matter. For Sweden, over half of the heating capacity is installed as boilers for DH, and a fourth is CHP for DH. The percentage of individual boilers and HPs is almost identical.[31]

[28] Eurostat
[29] Eurostat
[30] Euroheat & Power
[31] Heat Roadmap Europe

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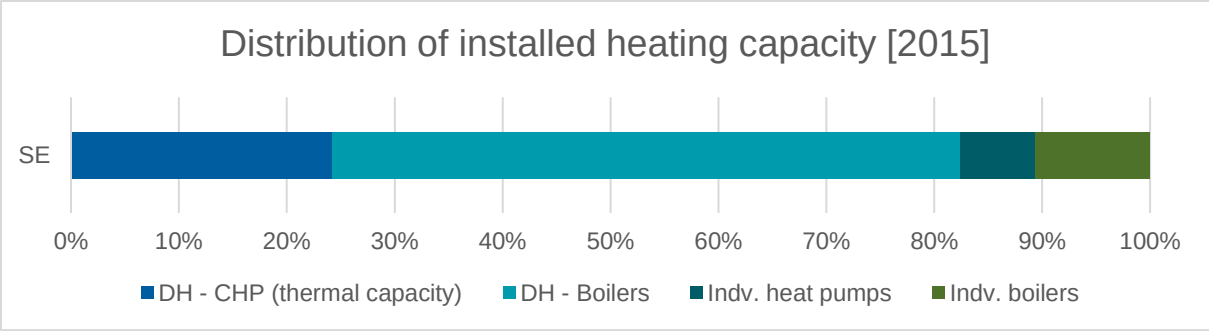

Figure 3-9: Distribution of installed heating capacity for countries with a high level of DH and sufficient data[32]

Of the countries in this category, the Baltic countries produce most of their DH from heat only boilers, while for the other countries, CHP is primarily used. In this group, Scandinavian country's DH production is mostly based on solid biofuels, but waste, excess heat, and fossil fuels are still used too. In Lithuania, they use mostly biofuels but also natural gas. There are no data for Slovakia or Estonia.[33]

For Sweden and Denmark, there is data for the average CO_2 emissions (ton CO_2/TJ) from DH, and for both countries the level of CO_2 emissions is decreasing.[34]

3.4.1.2 District Cooling

As mentioned previously, data for the five countries is very limited. For Sweden and Denmark who are the only countries in this group with data on DC, the amount of DC sales in Denmark is increasing while for Sweden the length of DC-trench has increased as well. The registered number of DC sales in Denmark is so small compared to Sweden that, it seems like there is none. However, the DC market is growing in Denmark in the recent years. The data for Sweden indicate a major spike in DC sales in 2009, and then a steady level of around 1,000 PJ from 2011-2017. The reason for this is unknown, but it could indicate an error in the reported data.[35]

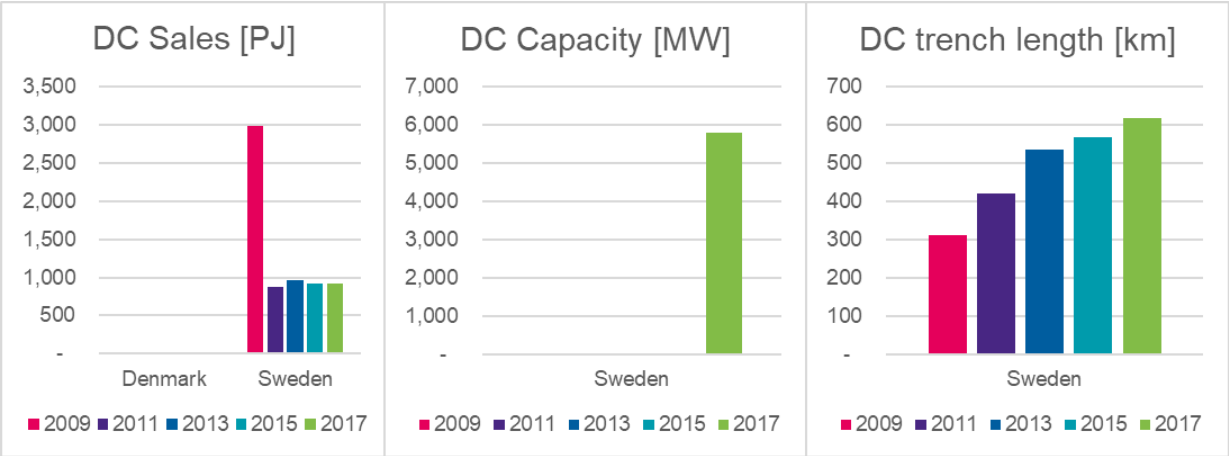

Figure 3-10: District heat indicators for countries with a high share of DH[36]

3.4.1.3 Typical DHC projects

A typical DHC project for the group of countries with a large share of DHC is the one in Tartu, Estonia. With a great tradition for DH in Estonia, this is the first project with DC as well.

[32] Heat Roadmap Europe
[33] Euroheat & Power
[34] Heat Roadmap Europe
[35] Euroheat & Power
[36] Euroheat & Power

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The Tartu DHC system has approximately 80,000 final users, which are supplied by a biomass CHP plant with a capacity of 50 MW_{th} and 25 MW_e, as well as a 15 MW flue gas condenser. Excess heat is also supplied from a local paper industry and for peak capacity, gas boilers are installed. In total, there is a 163 km trench network and 500 GWh heat is produced per year. Tartu's DH price was, in 2016, 51 €/MWh excluding taxes, which is lower than the average national price for DH in Estonia. This is among others due to high-density housing. For the DC network, energy is extracted from the river, and peak chillers are installed for a total of 13 MW. 1.3 GW DC is produced per year. It is mainly a new shopping center and a hotel located in the city center as well as other tertiary buildings that are supplied by DC today.[37]

Another example of a DHC project is the one in Taarnby, Denmark. This project is very innovative as it co-produces heating and cooling on the same HP by utilizing 20-25°C treated wastewater. This allows more full-load hours and increases the economy for both the heating and cooling operation of the energy central. In the colder months, heat is extracted from the wastewater by cooling it down to around 5°C with a HP connected to the local DH-network. The cooled treated wastewater is then let out to the sea. The HP only operates at times when it is economically beneficial in regards to fluctuating electricity prices and other heat-producing units in the network.

In the warmer months, the process is reversed: Instead of cooling down the wastewater, the HP cooles down water and supply it to the nearby commercial buildings with DC. For short periods, the HP produce more heat during summer than needed in the network, in this case, the excess heat is let into the wastewater. If conditions are favorable, the HP produces more cooling than needed, as it can be stored in a 2,000 m^3 accumulation tank. This creates a symbiosis between the wastewater treatment plant, DH, DC and the electricity supply, and saves both resources and CO_2 emissions. In this first phase, there is a capacity of 6.2 MW_{heat} and 6.2 MW_{cold}, and in a second phase when more customers are connected, groundwater will be utilized in an aquifer thermal energy storage (ATES) as well.[38]

3.4.2 Market analysis

3.4.2.1 Culture of DHC

General high awareness of DHC technology is one of the commonalities of this grouping, mainly due to the historical utilization of DH dating many years back and a sustained effort for continuous development of the networks. The main distinction between the countries lies in the general state of the networks and the political framework related to investments and operation of the system.

In Denmark, the DH networks were established as a response to the oil crisis in the 1970s, when it became evident how dependant Denmark was on foreign energy sources, leading to extensive investment in the development of the DH network as a measure to mitigate this dependency, with the utilization of heat derived from the thermal power plants and waste incineration processes being the driving alternative source of heating.

3.4.2.2 Market structure

The market structure of the DH systems in these countries has some common themes. The DH value chain consists of the heat producing units, the heat transmission system operators and the heat distributors. In some countries, the companies are responsible for the entire supply chain from production to distribution, whereas other countries segregate the production, transmission and distribution into separate entities.

[37] https://www.euroheat.org/wp-content/uploads/2017/01/study-on-efficient-dhc-systems-in-the-eu-dec2016_final-public-report6.pdf

[38] https://stateofgreen.com/en/partners/ramboll/solutions/smart-combination-of-district-cooling-district-heating-and-waste-water-in-taarnby/

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The DH companies in Denmark, Estonia and Slovakia are owned by both public bodies, such as state or municipalities, and private companies. The Danish DH companies are mainly owned by the municipalities, however, in some cases, consumers can also own the distribution companies. In Lithuania, 90% of the DH companies are public, with the remaining 10% being leased to foreign and domestic companies. The Swedish DH companies are mainly owned by the municipalities, with a few cases of private investors owning half of the companies.

The support schemes available for DH companies do not follow a similar structure. No support schemes are available for DH companies or customers in Sweden, forcing the DH to compete on the same terms with other heat sources.

In Lithuania, the customers that are supplied by the DH network receive a VAT reduction of 9% compared to natural gas.

The Danish DH companies are non-profit organizations and are therefore able to apply for loans with very low interest rates through government schemes. This reduces the risk from long-term investments of the DH companies and also helps drive down the overall cost of heating. Thus, the DH heat price is reflected in the production cost of each unit.

Estonia utilizes a feed-in tariff for DH production companies operating RES. The Estonian DH market is strictly regulated, and DH companies do not have a free market structure to compete in. This is mainly a factor of the low purchasing power of the Estonian population compared to world market prices. The heavy regulation is a result of historically high DH prices compared to household income, which has drawn a high level of political interest into the matter. The strict regulation of the heating prices also deters industrial entities to deliver the surplus heat from industrial processes to the DH network, since the approval process demands too many resources compared to the value added from heat sales[39].

One general issue in Sweden and Denmark is that the electricity prices are low enough for individual HPs to be competitive with the heat supplied by DH networks. In Estonia, the large CHP plants are obligated to pay emission taxes, where individual heating solutions do not, thereby negatively impacting the DH heat price.

3.4.2.3 Development targets for DHC

The Nordic countries have the most modernized networks, due to continuous investments in improvement and expansion of the network over a long time period. Most of the major cities in Denmark and Sweden have a very high share of the heating being supplied by DH, and with the tendencies of the population moving towards the larger cities, further expansion of the network is expected. However, the market will become saturated, and thus the further development in DHC in Denmark and Sweden will most likely be seen in the energy sources used and the overall energy efficiency. The coupling of the electrical grid and large thermal energy storages enable seasonal storage through the utilization of the fluctuating RES such as wind and photovoltaic (PV), increasing the share of renewable heating supplied by the DH network. This is much in line with the Danish target of having 55% of the energy production deriving from RES by 2050, and the Swedish target of 100% by 2045 and becoming CO_2-negative hereafter[40].

Of the countries examined in the group, Slovakia is the country with the least favourable outlook for further development of the DH network. The network is old and requires significant investment for refurbishment and modernization. The heat demand has decreased steadily in recent years due to warmer climate and implemented energy efficiency measures of buildings. Additionally, customers are switching from DH to individual natural gas

[39] Euroheat

[40] http://www.swedishepa.se/Environmental-objectives-and-cooperation/Swedish-environmental-work/Work-areas/Climate/Climate-Act-and-Climate-policy-framework-/

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solutions, leading to a DH system, which is running on over-capacity and significant heat losses. In order to successfully adapt to the changing conditions, capital investments are required. The DH companies are challenged by strict regulation of the heat sales and the high requirements for return on investments of financers inhibits the refurbishment of the existing network and the development of new networks. According to the 2014 Energy Plan, the Ministry of Economy intends to create support schemes for investment in systems operating on RES, regulations so that electrical utilities move towards co-generation plants operating on biomass, and to refurbish the existing distribution network.

3.4.2.4 Barriers for further development

Unlike the two previous categories, the countries in this group will experience less growth in the share of DH, as the market is saturated. There is a natural limit for when DHC is feasible and when individual solutions are more feasible, this meanly corresponds with the density of the population.

This also means that most DH systems in these countries are facing challenges in competing with new individual solutions, such as high-effecient HPs. If zones with a high heat density currently heated by fossil fuels shall convert to DHC networks, business cases need to be competitive with individual solutions. However, if the DH suppliers do not reach these zones before many individual solutions have been changed to e.g. HPs, the costumer base will not be significant enough to secure a feasible DH project. A barrier here can be unequal regulation, making it more difficult to plan for a collective system of DHC.

Another barrier can be found in the incentives for using excess heat from industries. In some countries there are tax regulation on utilization of excess heat from industrial processes, that means heat that could have been used for DH now simply is cooled away outside.

In general it should be easier to utilize all the various heat sources available for DH, thus making sure the collective system stays competitive and effective in the transition away from fossil fules.

A third barrier is the alternative to fossil fuels. Today, coal still represents a great proportion of the heat production. Often solid biomass is seen as the easiest substitute for coal, however, biomass will become a scare resource in future, if every country simply convert to biomass, therefore other energy sources need to be chosen and sector coupling needs to be promoted to utilise the various correlations among them.

3.4.3 Conclusions large DHC

For the group of countries with a DHC share above 50%, their overall heat production is increasing. Besides, biomass is the most typical use of fuel, but still with a share of fossil fuels. In DH production of the Baltic countries', boilers are mostly used, while for the Nordic countries, CHP is most frequently practiced. This is part of the reason why the level of CO_2 emissions in Nordic countries' DH production is decreasing. Typical DHC projects in this category are often big networks where production has a high capacity. There is a focus on using RES, biofuels and excess heat in the DHC production, while smart solutions as using wastewater as an energy source for both productions of heat and cooling are implemented.

Main conclusions:
Increasing heat production with a focus on using biofuels.

Heat-only boilers are mainly used in Baltic countries, while Nordic countries use CHP.

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Saturated markets shift the development from extension of networks towards increasing the overall efficiency of the networks by use of RES and new technologies.

Support schemes that make individual heating solutions attractive for private households can undermine the potentiale for DHC.

Loans with very low interest rates available for non-profit companies through government schemes decrease the risk of the DH companies, and the non-profit structure drives down the cost of heating.

Private investors have much higher interest rates on loans, meaning they ultimately have to increase heat prices to make the projects feasible.

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4 Evaluation of trends and most reasonable developments

4.1 Technological development of DHC stock

In this section, a brief description of the historical context of the development of DHC is explained, as well as an estimation of the projected development of future DHC systems. The European countries examined have very different trajectories in terms of the political ambitions for securing a sustainable DHC market, but the technological development concerning district energy can be assumed to follow the same principles regardless of country-specific ambitions, as it would be counterproductive to not utilize the most optimal technical solutions independent of the state of the DHC system in each respective country.

4.1.1 Historical background of district heating and future trends

The first DH systems that were established more than 100 years ago were steam-based systems that were implemented in order to meet the heat demand of hospitals and various industries and to use the steam directly from the steam turbines. The steam-based systems are still present in some areas, mainly for industrial process heating purposes or due to lack of innovation. The general development has been to replace the steam-based systems with hot water systems, thereby reducing the supply temperature of the network from approximately 160°C to lower than 100°C. The main advantages of reducing the supply temperature are lower heat losses in the network, optionality of thermal storages, lower risks of accidents, and the ability to utilize low-temperature heat sources to increase the overall energy efficiency of the system.

The development of DH from steam towards superheated water to hot water and low-temperature hot water has been illustrated as a journey through 4 generations (See figure 4-1, or see. E.g. papers in EH&P describing the four generations in detail in the paper Distribution of District Heating 4th generation, by Lund et al.). Even though it is not showed in the figure, a 5th generation DH is being tested. Instead of using hot water, water will be distributed with a temperature near ambient ground temperature. Each building will need a HP to increase the temperature in the colder months, but it can also be benefitted to produce cooling in the warmer months[41]. This method has a high investment cost, as all buildings must install a HP and, at the same time, implement DH pipes. The 5th generation DH will most likely be relevant in warmer climatezones, where cooling is the primary objective. In colder climatezones, this solution might not be the most feasible one, in opposition to 4th generation DH.

[41] (Bünning et al., 2018) (Felix Bunning, 2019)

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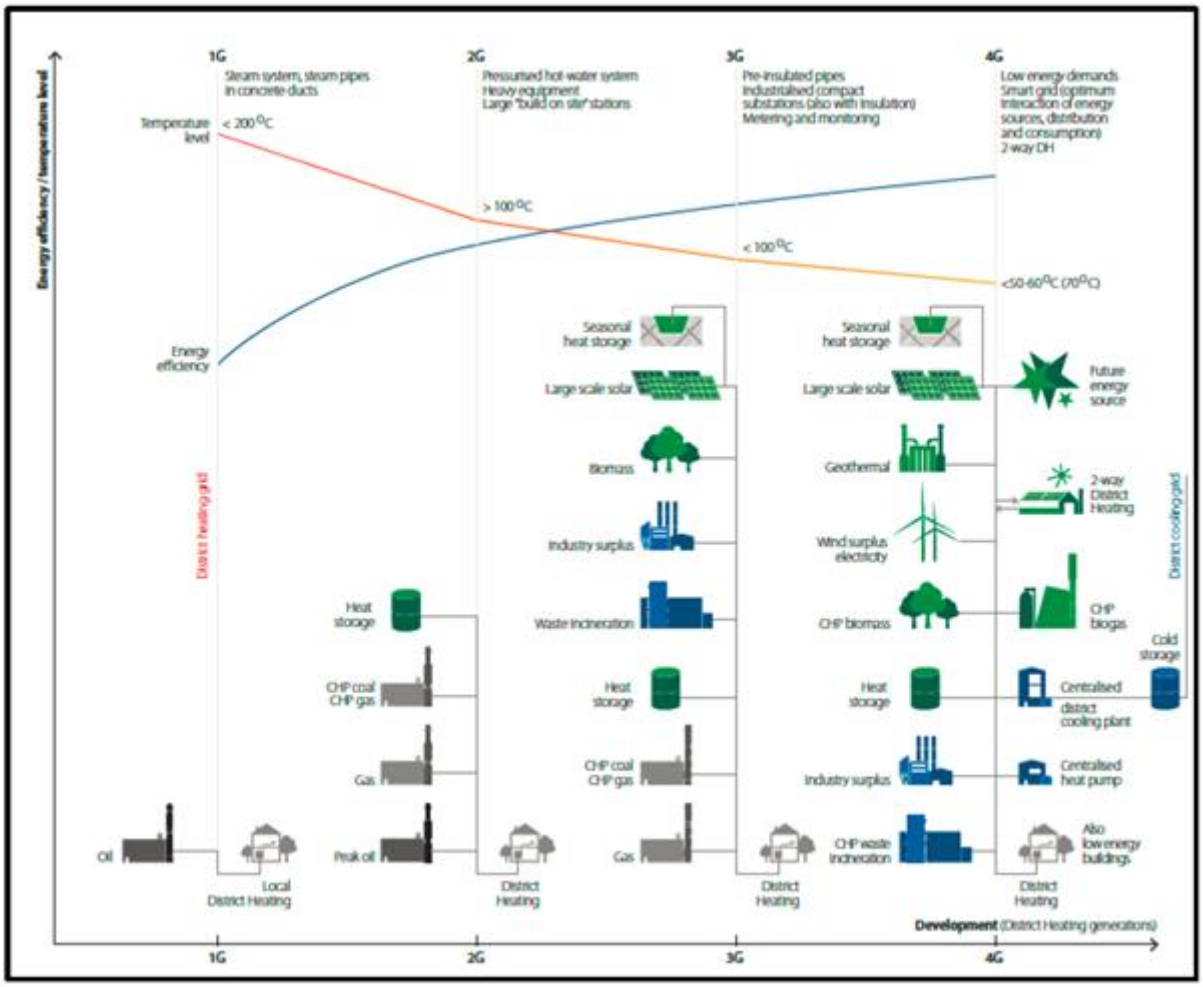

Figure 4-1: *Generations of DH (Lund et al., 2014)*[42]

For the examined countries, the current state of their DH networks spans from the 2nd to the 4th generation of DH. For instance, many of the old Eastern European networks produce heat from fossil fuels and operate with high temperatures and significant heat losses, as being the case for 2nd generation DH. Meanwhile, 4th generation DH is found in most of the Scandinavian countries, as they use pre-insulated piping and have a high variety of RES and storages integrated with the DH system, allowing for lower supply temperatures, just as well as DC is starting to be integrated. In some of the Central European countries, the 3rd generation DH network is practiced as fossil fuels remain the majority, however with biomass starting to become more common.

The network infrastructure is the most critical component of the DHC system due to the high capital investment cost and the long technical lifetime. The network has a technical lifetime of up to 60 years, and therefore necessary to implement infrastructure with the future of the energy sector in mind when refurbishing old existing networks or developing entirely new networks. The use of pre-insulated steel pipes allow for lower heat loss to the surroundings, as well as satisfying the heat demand with lower operating temperatures. The operating temperatures of the system are highly dependent on the energy performance of the buildings. It is therefore crucial that the building is as energy efficient as possible, and policies such as the EU's Energy Performance Directive for Buildings contribute to the overall reduction of the specific heat demand of buildings. However, it is important that the EU's

[42] Lund et al., 2014. Henrik Lund, Sven Werner, Robin Wiltshire, Svend Svendsen, Jan Eric Thorsen, Fred Hvelplund and Brian Vad Mathiesen. 4th Generation District Heating (4GDH) Integrating smart thermal grids into future sustainable energy systems, 2014.

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energy directives are implemented correctly in the national legislation to avoid barriers for connecting to DH.

4.1.2 State of district cooling and expected development

DC has a very little market share in the EU but does present a significant potential, which can be explored taking into account the requirements in the EU directives for buildings' use of renewable energy and energy efficiency.

DC networks have several similarities with DH and there are several synergies between DC and DH:

- The cooling network is an expensive infrastructure and has to be planned carefully, taking into account the economy of scale of the production and storage facilities and the cooling density;
- The cooling pipes can be the same preinsulated pipes, which are used for, however with leak detection and only minimum insulation;
- The economy of scale by establishing a centralized chiller compared to several chillers is similar to the economy of scale by establishing a centralized HP compared to several individual HPs;
- The network integration of the cooling load increases the overall efficiency of production and opens for thermal storages;
- By delivering both DHC to the buildings, the building owner can save internal installations, which are relatively expensive;
- DC are in line with the DH networks, as described in the EU directives a technology, which can transfer efficient and renewable energy to the buildings.

In line with the development from 1st to 4th generation of DH, it is possible to set up a similar development of DC:

- In 1st generation DC, the cooling demand is connected to a cooling grid and the chillers deliver the cooling;
- In 2nd generation DC, a chilled water tank can induce optimal operation and inclusion of more fluctuating energy sources;
- In 3rd generation DC, more efficient cooling sources are included, e.g. cooling sources which are delivered to the energy plant via an ambient cooling pipe, e.g. seawater or river cooling;
- In 4th generation DC, individual chillers and free cooling are replaced step by step by HPs for combined heating and cooling. The operation of heating and cooling will depend on the climate conditions, as in colder months the HP will produce heat and warmer months it will produce cooling.

The balance between DHC depends on climate conditions. In Northern Europe, DC is only of interest in business districts and campuses, e.g. hospital campuses and university campuses. In Southern Europe, DC is of interest for all buildings in order to meet the demand for indoor climate. In very warm climate, DC is more important than DH, which is only of interest in clusters of buildings with large heat density of hot tap water demand.

The stage of the DH system also has an influence on the development of DC. An example is Sweden in 1990, who had no more CHP potential due to low electricity prices from hydro power and nuclear power, and therefore the DH companies found a potential for large HPs. It was natural for the utilities to develop a market for a sale of the cold side of the large HPs. The Swedish business case for DC demonstrates that centralized DC is more efficient and

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cost effective than individual cooling, and the market for DC has grown significantly since 1990, resulting in Sweden being the leading EU member country in DC.

Having in mind the main drivers for DH, the low electricity prices have not been the only reason. The fact that public utilities have taken care of the urban energy infrastructure on behalf of the energy consumers has been a main driver as well.

Another example is Denmark who from 1990 to 2010 had a potential for surplus heat from power generation, while coal-fueled power condensing was still on the margin. Therefore, there was no idea in HPs and combined heating and cooling. Since 2010 the potential for CHP has been fully utilized and the policy is now to integrate wind energy to be the main source of power. Therefore, DH and large scale HPs will play an important role in integrating the fluctuating RES like wind and solar energy, and an outcome of this has provided the possibility to develop combined heating and cooling.

4.2 DHC market development

This section discusses the main results related to the market analysis of the examined countries, with emphasis on the current state of the DHC systems and expected future trends. Special focus is on the need to implement national energy policies and regulatory frameworks that promote optimal implementation of DHC systems.

4.2.1 Current market structures

DH is only fully developed in EU countries, which have considered energy planning as a natural part of the urban planning of infrastructure based on one or more of the following four drivers:

- In communities in which the local governments have established public utilities with the aim of supplying services to the buildings, e.g. electricity, gas, water and wastewater. These utilities have been able to harvest the synergies of CHP as well as waste heat (e.g. all public utilities in Finland, Sweden, Denmark, Austria and Germany);
- In communities in which there has been a tradition for consumer engagement, e.g. in Denmark. These energy communities or co-operatives have played an important role in the development of DH as well as other services, like water supply, to the benefit of consumers;
- In countries which have formed a national energy policy with objectives of energy efficiency and low carbon emissions, DH has been one of the important instruments;
- In the former centrally planned economies, in which the central government has enforced urban planning in all communities in order to minimize total costs, DH has been developed.

In Denmark, the first three drivers for DH has been very strong, as both local governments and consumers have been active, and the government has enforced a national energy planning already in 1979 in order to reduce the dependency on oil in the most cost-effective way, combining an extension of DH from CHP and waste and new natural gas infrastructure.

In Sweden and Finland, the public utilities have been responsible for developing DH without competition from natural gas, and therefore, with no attention to the same planning process as in Denmark.

In the Netherlands (and UK), DH has not been developed due to strong competition from own natural gas sources with low prices, but this policy has now changed due to various

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reasons: Climate change, political resilience and problems with earthquakes in Groningen (the Netherlands).

In Southern Europe, DH has little market share due to low heat demand, but there is an increasing interest for environmental reasons to eliminate pollution from heating, e.g. in Milan, and new urban developments, e.g. in 22@barcelona.

In former centrally planned economies, rehabilitation of the institutional set-up, e.g. homeowners associations, and technical renovation like temperature regulation and network rehabilitation to avoid water losses have been an important element of the transition towards a market economy. In most countries, mainly in Northern and Central Europe, this has been successful, whereas there are problems in some of the Southern Member States, in which imported cheap natural gas has replaced efficient heat from large CHP plants.

The following bullets summaries the current market structures identified:

- Small and medium DHC countries either develop towards more DH or do not have any plans for development;
- Larger DHC countries have a stable number of DH supply, they are not expanding much, as more than 50% is covered by DH but look more into RES for DH;
- Eastern European countries have older pipes/systems, which need to be renovated and optimized to reduce heat loses and losing customers;
- DC is not very developed in any European country, however great potential for coproducing heating and cooling exists. Examples from Denmark showcase this concept. Eventually WEDISTICT can do it as well;
- Most reasonable development depends on several national conditions:
    - Regulation of market;
    - Political belief;
    - Climate (in regard of technologies).

4.2.2 Future scenario for DHC

The most reasonable development of DHC depends heavily on the national energy planning and implementation of regulatory frameworks for each respective country.

The EU energy directives form a legal framework for promoting the development of DHC in EU countries.

The directive for strategic environmental assessment requires that all policies, plans and programs are coordinated across sectors to ensure that actions in one sector take into account other sectors, at least via hearings. Accordingly, the planning of the sectors of power, waste and the DH should be co-ordinated to ensure that power plants and waste incinerators only are established at cities that can use the heat via DH.

The Energy Efficiency Directive (EED) requires that local communities shall plan for DHC and that new power capacity, if cost effective, shall be established near heat markets. This is logic as DH is a precondition for efficient use of energy, which else would be wasted, e.g. in the power sector.

The Renewable Energy Directive requires also that local communities shall plan for DHC in order to use RES. This is also logical, as DHC also is a precondition for efficient use of almost all renewable sources for heating and cooling.

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The Building Directive promotes cost-effective low-carbon buildings and requires that it shall be taken into account that renewable energy and heat from CHP can be transferred to the buildings via DHC.

The ongoing urbanization and the European ambitions for the energy sector place district energy (DHC) in a pivotal role in the future society. Here, cooperation between public and private sectors is vital for a successful implementation

The heat market differs remarkably from the electricity and gas markets. DH is a natural monopoly with its heat production for supply of a network also being monopoly-like in nature.

A DH grid is quite local, even a city-wide scheme, as it does not supply a whole country or region. Although this may vary depending on the size and configuration of a scheme, the establishment and operation of a network and the sale of heat is usually organized in a single company. Therefore, the market principles, including third party access, which is present in the electricity and gas sectors, should not be applied to DH. Having said that, some form of regulation is necessary, if nothing else then, for the protection of the consumer against overcharging. But if the development of DH is left to market forces, as it is suggested in many European countries, it will be important to indicate the boundaries within which it can progress and the future perspective. As DH infrastructure is for the long term, investors need to have a relatively clear view of what they are engaging in.

Similar assumptions can be placed on DC, although here the customer base is generally different and market drivers more acceptable.

In the EU, the objective is to achieve an energy supply that is secure, competitive and sustainable, as this is a prerequisite for a modern way of life, as well as for business. The overall goals of the EU policy highlight three important facts about how energy affects our society:

- **Security of energy supply:** The reliance on oil and gas is regarded as a liability, and an aging and a overloaded transmission system requires action;
- **Affordable energy**: Energy costs make up a significant part of everyday life expenses for many European citizens as well as businesses and are often pointed out to be harming European competitiveness and causing relocations of industries;
- **Sustainable energy:** Energy consumption and use is the primary reason for the current climate changes and increasing global warming, and actions are required to turn the downward spiral.

Local, regional and national authorities must take these overall ambitions and policies into consideration when developing strategies and plans for their geographical area. More than that, they must be aware of the local conditions. For energy, this primarily means access to local energy resources, characteristics of energy demand and interfaces with neighboring areas.

Attaining reliable and long-term energy solutions call for the right structural balance between private sector knowledge and public sector framework. The highly specialized services provided by private sector companies enable the public sector to provide high-quality and cost-effective solutions. Public-private-corporation is vital on several levels (national, regional and local) to ensure the best possible outcome. This applies to the forming of policy, strategic planning, execution of infrastructure projects and subsequent operation and maintenance of networks and supply units.

Historically there has been a number of models that have been used for public–private energy partnerships (Energy service company, ESCO). Each of these models has been driven by local authority leadership, influenced by specific local priorities, and constrained by

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policies governing the apportionment of risk and public sector borrowing. The models can be broadly characterised into five models:

- Private enterprise driven by public sector framework agreement;
- Private enterprise driven by public sector stakeholding;
- Social enterprise driven by public sector stakeholding;
- Social enterprise driven by consumer and public sector stakeholding;
- Public enterprise driven by social and environmental goals.

The variations between these models are largely the result of the following factors:

- *Public sector borrowing:* The need to minimize borrowing that would appear on a local authority's balance sheet, as required by central government. This requirement has been relaxed to some extent, although local authorities are still required to demonstrate prudential borrowing within overall constraints;
- *Exposure to risk:* The need to minimise the potential exposure of a local authority to financial risk if an ESCO was to default on finance repayments. The covenant strength of public and/or private sector partners is an important factor in securing finance, particularly where a new ESCO with no track record is seeking to raise finance. Additionally, public sector customers may require physical assets to revert to them in the case of commercial failure in order to secure continuity of supply;
- *Expansion and replication:* The ability of the ESCO and its partners to expand and replicate energy networks across towns and cities, either by extending networks or developing new decentralized energy 'islands' which in turn will depend on their ability to manage the risks and secure new finance and revenue streams. Local authorities have a significant role to play in supporting the expansion of networks, and they can give confidence by providing 'anchor' loads, the granting of wayleaves to lay DH pipe lines and the enactment of planning requirements and obligations (for example through Section 106 agreements[43]) for the connection of new development;
- *Social and environmental goals:* The ability of an ESCO to strategically deliver on social and environmental goals in the short, medium and long term. The public sector 'anchor' heat loads can play an important role in providing security for projects and opportunities to deliver on social and environmental goals. Larger and more complex projects may require significant capital outlay, and these may not generate sufficient short-term returns to make them attractive to investors.

Central authorities have a large task in providing the right regulatory framework to allow for collective heat supply to develop. A proper framework includes:

- A stable methodology and guides for carrying out CBA of heat supply options in line with the provisions in the EED;
- Access to laying pipes on public and if necessary private land;
- Regulations with the purpose of protecting the consumer are vital and could cover price and/or profit structures, consumer influence, and transparency for utilities.

These obviously have to be independent of ownership and management structures for utilities. All these provisions should be put together in close collaboration with the industry and civil society.

Energy supply is in many cases in a situation that resembles the natural monopoly. One company or utility can carry out the task more efficiently, supplying the good at long-run

[43] https://www.legislation.gov.uk/ukpga/1990/8/section/106

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lowest average cost, compared to a market situation with several companies involved. This can also be seen in other areas e.g. waste treatment, wastewater treatment and water supply. Competing companies servicing the same area would lead to inefficiencies in terms of parallel systems, such as two water pipes and twice the garbage trucks to carry out the tasks. The same can be said regarding heating, and not only with more than one DH company, but also in terms of DH companies competing with gas distributors that essentially deliver substitutable services.

The issue of parallel systems can be avoided with local planning, ensuring that the appropriate zoning is put into place. Based on CBA for society, utilities and customers, local and central authorities should divide cities and regions into zones best suited for gas, DH, or individual heat supply. Zoning ensures that gas and DH networks do not compete within areas with parallel infrastructures as a result. The zoning does not mean that heat consumers are forced to connect to the collective supply, but following the CBA there should be a compelling business case for almost every consumer in the long run ensuring high connection rates.

In the aim of providing good solutions responding to the increasing urbanization, it is vital that public authorities, industries and civil society join forces. The strain is within many areas of infrastructure and calls for strategic planning with a holistic overview, and the public sector plays a key role in providing cities worth living in.

Several studies, including the HRE from 2012-2013, underlines the enormous potential of DHC. Not only will the implementation of more district energy decrease the primary energy supply, allow more RES in the energy mix and cut emissions, it will also be a cost-effective alternative that can sustainably boost job creation.

Denmark, Sweden and Finland are all countries where city-wide DHC concepts have proven both private and socio-economically viable on widely different backgrounds. Developing suitable business models is the key challenge, taking into account national legislation, local resources as well as the existing infrastructure.

Heat supply cannot be left entirely to the market, due to the resemblance of a natural monopoly. Therefore, local and central authorities have a crucial role in providing the right framework for good heat supply, including regulation, planning and a proper incentive structure. When the framework is right, the execution phase is a matter for local authorities in cooperation with the industry. Here a strong buy in from the local authorities is paramount to ensure a successful implementation of district energy.

Only through a tight cooperation between industry and authorities will Europe will be able to fulfill its overall goals, stay competitive and provide livable cities in the future.

4.3 Renewable sources integrated in DHC

This section provides an insight to RES that are possible to integrate in the DHC systems.

4.3.1 District Heating

4.3.1.1 CHP

Surplus heat from power generation, which else would be waste in cooling towers or in seawater cooling, is a renewable source of heat for DH. By extracting heat from an extraction plant, the loss of electricity will be limited equivalent to a COP of 5 to 10. As long as power condensing plants are on the margin, there is a potential, and the additional fuel consumption for generating heat is typically 0,4 MWh fuel per MWh heat, as 0,6 MWh cooling losses are harvested. This use of heat which else would be wasted is not included in the statistics for RES, but it is in fact more valuable.

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In case a CHP fueled by renewable energy replaces heat from a fossil fuel condensing plant, there will be both a fuel saving and a transformation to renewable energy.

There is an economy of scale factor, as large CHP plants are more efficient and cost effective than building level CHP plants.

4.3.1.2 Waste

Municipal and industrial waste can be used for energy, e.g. in incinerators generating heat and power and harvesting waste heat in the flue gas. This saves emissions from landfills, which is the alternative to incineration. Due to economy of scale, waste incinerators need large heat markets and should be located close to high heat density areas in order to utilize the heat.

4.3.1.3 Biomass

Solid biomass such as straw and wood can be utilized efficiently with flue gas condensation and with almost no harmful emissions, whereas they cannot be used at the building level without considerable environmental problems in cities, e.g. from wood stoves or individual biomass boilers.

4.3.1.4 Solar Heating

Solar heating is a common heat source which can be used in single family houses, at large buildings and in large scale for DH. The heat production per m^2 of panel, and thereby the cost of heat from the panels, depends on climate conditions:

- The production per m^2 in Southern Europe is almost 2 times the production in Northern Europe;
- The investment per m^2 in large buildings is 3 times the investment in large-scale panels for DH;
- The investment per m^2 in small buildings is 6 times the investment in large-scale panels for DH.

4.3.1.5 Geothermal

Geothermal DH is the general term used when heat from underground naturally occurring water reservoirs is extracted. The heat can be from deep reservoirs or more shallow reservoirs. The extraction of geothermal energy from reservoirs is done through wells and installations on the surface, where hot groundwater is pumped from the reservoirs. Often, the groundwater has a temperature below 100°C and the heat is extracted using a heat exchanger and possibly an electric HP, in case the the temperature of the groundwater is below the temperature needed in the DH network. After the heat is extracted from the water, the water is returned to a suited reservoir, which is often underground, but at another location to prevent short circuiting of the extraction and the reinjection water.

An important factor regarding the operation phase is the pumping costs. The use of deeper reservoirs with higher temperatures will generally also increase pumping costs, due to lower permeability generally expected for deeper reservoirs.[44]

A benefit of geothermal DH with electric HPs is that they supply heating with high efficiency, thus providing a considerable saving over the use of individual gas-fired boilers.

[44] https://ens.dk/sites/ens.dk/files/Statistik/technology_data_catalogue_for_el_and_dh_-_0009.pdf

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4.3.1.6 Hydro Power

Hydro power from rivers can be an important source for DH in case there are certain seasons of the year with a surplus of hydro power which exceed the power transmission capacity. In that case, DH can use the hydro power in electric boilers or HPs, depending on the duration of the surplus power.

Hydro power from dams and pumped storage can have both a positive and a negative impact on DH. On one hand, this hydro power is compatible with efficient CHP plants in the DH systems, as the power from the combined production can be stored for later use. On the other hand, this hydro power is an alternative to DH in relation to the integration of the fluctuating energy sources, as dams and pumped storages can recharge with cheap surplus renewable electricity.

4.3.1.7 Wind Energy

Wind energy is the natural renewable resource of several northern coastal countries. The challenge of the fluctuating wind is that it is in contradiction with the fluctuations of the demand, and that the power system has to be in balance every second. Moreover, as the marginal production cost of wind energy is zero, the electricity prices will be very low in case wind energy is on the margin, and the prices may be large in case there is no back-up for the wind.

Whereas ordinary electricity consumption and electric energy for heating of individual buildings directly or via HPs have little flexibility, DH is able to use the surplus electricity and even help to stabilize the frequency:

- Large electric boilers can use surplus electricity from wind as an alternative to the curtailment of wind in case of low prices, capacity constrains or as an alternative to investment in power transmission cables for transfer of peak capacity;
- Large HPs in DH can operate as baseload in the DH system, e.g. with 5,000 hours of maximum load and still be able to disrupt with short notice in case of large prices or in case of capacity constraints in production, transmission or distribution of electricity;
- Large electric boiler can be a very competitive way to offer regulation services to the grid and compensate for a deviation in the production plan;
- CHP plants can generate electricity in case of large prices and shortage of wind.

Thus, the DH system with thermal storages and back-up from other heat sources can react on electricity prices and thereby integrate the fluctuating wind even without investments in new capacity in the power grid.

4.3.1.8 Solar PV

Solar PV is, like wind energy, a fluctuating electricity source created by RES and has many of the same benefits. Like it is the case with wind energy, electricity from solar PV can be utilized in DH thugh large electric boilers and HPs. DH can also utilize surplus solar PV and in particular unload the grid in case of large capacities from solar PV and thereby reduce investments in new grid capacity.

4.3.1.9 Ambient Heat Sources via Heat Pumps

The city-wide DH grid opens for access to many ambient heat sources, which can be upgraded with large flexible HPs, which furthermore integrates the wind and PV energy. Although the ambient heat at low temperature does not have the same quality as surplus heat from industrial processes or from power generation, as it has to be upgraded by an electric HP, it is classified as renewable energy. These sources are for example:

- Ground water or drain water;
- Geothermal source (not deep);

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- Seawater;
- Treated wastewater;
- Ambient air.

The COP factors for use of these sources range typically from 3 to 4.

4.3.1.10 Industrial Surplus Heat

Industrial surplus heat is similar to the excess heat from power generation, which is emitted and wasted unless it is utilized.

The COP factors for using these heat sources are typically in the range from 4 to 100 or more, as some sources can be used without HPs. These sources, which are more valuable than the ambient sources, are listed below:

- Surplus heat from process industries, which can be used without HPs;
- Heat from combined heating and cooling;
- Heat from a datacenter.

4.3.2 District Cooling

4.3.2.1 Free Cooling

Unlike heating, there are many ambient sources for cooling, which can meet the cooling demand without any use of fuels or electricity. It depends on the weather conditions or season of the year and not least the temperature requirements for the cooling process.

Many industrial cooling processes operate at temperatures above 10°C or even above 20°C and have access to several ambient sources, whereas comfort cooling normally need temperatures below 10°C.

Some of the free cooling sources which play an important role are:

- For comfort cooling and process cooling:
  - Deep lake water cooling, all year;
  - Ground source cooling, all year, but with environmental restrictions;
  - Treated wastewater, all year, but with environmental restrictions;
  - Seawater cooling, only winter;
  - Ambient air, only winter.
- For process cooling, at larger temperatures, in addition:
  - Seawater cooling, all year;
  - Ambient air, all year.

4.3.2.2 Cooling from Combined Heating and Cooling Processes

HPs that generate heat are an obvious source for highly efficient cooling, as the cooling is ejected to the ambient heat sources unless it is utilized.

In DH systems based on electric HPs, free cooling is therefore a waste product, which is ejected into the air or any ambient heat sources.

Combined heating and cooling is therefore a highly efficient generation, in line with combined heat and power.

This integration is very cost effective, as a HP generates useful capacity and energy for both heating and cooling, in particular in cases where the HP is combined with chilled and hot water storage tanks for short-term storage and ground source cooling or storage pits for seasonal variations.

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4.3.2.3 Absorption Chillers

In case there is a surplus of cheap high temperature heat sources in a city, e.g. from geothermal heat, or in case power capacity is overloaded in the cooling peak, it is beneficial to generate cooling with absorption chillers.

In case there is no need for low-temperature heat, these plants are not efficient as all the thermal energy has to be ejected. However, in case there is a need for low-temperature heat, e.g. at 60°C, all waste heat from the process can be utilized.

Such cooling sources are e.g. installed at several waste incinerators and biomass boilers in which high-temperature heat is available and all the waste heat can be utilized. Using an absorption chiller, it will shortcut the process and save power generators and electrical compressors.

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5 Inefficiencies and Improvements

There is a huge variety of DHC systems in the EU, ranging from 1st to 5th generation DHC in a variety of climate zones and local conditions and subject to a variety of institutional and legal frameworks and traditions.

The EU directives for buildings, renewable energy, and energy efficiency form a logic overall legal framework in which DHC can be planned and implemented and thereby contribute to a resilient cost-effective green transition in the EU. However, we find that there are many inefficiencies and room for improvements.

In the following, we focus on new and existing systems and we give some recommendations based on our findings in the project.

5.1 New DHC

In new cities and large new city districts there is an opportunity to plan a perfect interaction between buildings, DHC, and thermal generation. Buildings should be designed with the following conditions:

- Low temperatures for heating (e.g. supply 60°C / return 30°C), including a booster for domestic hot water (DHW) supply;
- High temperatures for comfort cooling (e.g. supply 10°C / return 15°C);
- Distributed end users in which each apartment or section of a multi-user building is supplied by internal heating and cooling networks, eventually DHC directly to each unit.

This opens for metering at the very end use and good thermal comfort, including hot tap water heating, cooling and dehumidification.

It also opens for efficient DHC, in case this infrastructure is found to be the most cost effective in the urban energy planning, mainly depending on the building and energy density and the local conditions.

These parameters are realistic in case the heating/cooling installations is a combination of under-floor heating/cooling tubes and heating/cooling coils in the ventilation systems.

In case a new efficient district can be supplied from the main grid for DH, it can be connected in such a way (with 3-pipes) that it reduces the return temperature from old inefficient buildings.

One advantage of this is that the building owner in multi-user buildings do not need to establish own distribution of heat and cold.

In order to promote these solutions, it will be beneficial if the EU directives are implemented with regards to the building code for improving the performance of buildings and taking into account use of DHC, as well as the RES and EED with regards to urban energy planning and national strategies for promoting cost-effective solutions.

A few countries have implemented a legal framework for energy planning of DHC, e.g. Denmark, which have had obligatory heat supply planning since 1979. However, there is an increasing interest in energy planning of DHC and many cities' public utilities, who have taken care of the planning and development of DHC to the benefit of the consumers, or a combination of the consumers and the municipal budget.

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The building directive has been interpreted very differently in the EU Member States, often the national building codes primarily focus on a narrow aspect of the building performance and therefore comply with the directives, trying to promote district energy solutions. The national building codes can set up a barrier against fair competition between DHC and building level solutions, as it can give preference to building level solutions although DHC often is the most cost-effective way to integrate renewable energy in accordance with planning.

5.2 Retrofitting and existing DHC

All existing DHC can be retrofitted to better technical and institutional performance, although having very different starting points.

Some DHC systems suffer from a lack of regulation and institutional framework, whereas others play an important role in national and city energy strategies.

Some DHC systems suffer from poor maintenance and regulation, whereas others are very efficient.

5.2.1 Technical solutions

The following measures are important for improving the technical performance of DHC:

- Conversion from steam to hot water DH;
- Lowering the maximal design temperature from super-heated to hot water below 110°C and even lower temperature;
- Leak detection to eliminate uncontrolled water losses;
- Draining of underground constructions to prevent penetration of water and outside corrosion;
- Replacement of old pipe systems with pre-insulated pipes with leak detection;
- Improved water quality to prevent internal corrosion;
- Variable speed drive pumps;
- Pressure and temperature control of all end-user substations;
- Heat meters with remote registration;
- Integration of networks;
- Closing 4-pipe systems for centralized domestic hot water preparation and preparing hot water at building level;
- Closing unnecessary heat exchangers and installing pressure sectioning and temperature shunt if necessary;
- Establishing centralized thermal storages;
- Establishing new cost-effective baseload generation based on efficient sources;
- Establishing combined heating and cooling.

5.2.2 Institutional Solutions

The following institutional and regulatory solutions are important for improving the performance of DHC:

- Formation of homeowners' associations to be responsible for the building infrastructure in case of privatized apartments in multi-apartment buildings with vertical integrated heating systems and centralized generation of DHW;
- Legal framework for energy planning of DHC in local communities with the aim to develop cost effective DHC;

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- Building code, which sets standards for new buildings and considers DHC;
- Monthly billing, seasonal tariff and incentives to improve the return temperature;
- Legal instruments and social security scheme to ensure 100% payment of the bills;
- Opportunity for the state of municipal to guarantee loans to ensure long-term financing of the infrastructure for DHC;
- Long-term financing schemes in line with financing schemes for other infrastructure projects and buildings at low competitive interest rate, e.g. 20 year loans and 1% interest;
- Transparent market for electricity related services taking into account time dependent energy prices, capacity and regulation (an electric boiler can e.g. prevent power curtailment form PV and wind, it can disrupt in order not to load the network with capacity and it can regulate frequency);
- Regulatory framework to balance the enforcement of energy solutions for building infrastructure and DHC infrastructure. It would be more in line with the EU directives if the building code gives credit for connection to the planned DHC than to less cost-effective building level installations.

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6 Conclusion & Lessons learned

DHC in European countries are at very different development stages. This report have categorized the European countries based on their share of DH of their total heat demand. Three categories were developed with respectively a small, medium and large share of DH. The small category has less than a 10% share of DH, the medium category has more than a 10% but less than a 50% share of DH, and the large category has more than a 50% share of DH.

Countries with a small share of DH are Slovenia, Croatia, the Netherlands, France, Switzerland, Norway, Italy, the United Kingdom, Greece, Spain, Portugal, Ireland and Belgium. Luxembourg, Malta and Cyprus were not included, as no data on DHC was found.

In general, countries in this category have a high share of individual heating with high shares of fossil fuels, mainly natural gas. There is a lack of awareness and practical knowledge on how to implement DHC systems. This is reflected in the lack of legislative and regulatory frameworks and masterplans, that currently benefit individual solutions. The high investment cost calls for a stable framework that gives security for investors and allows for long-term investments. In countries with warmer climates, DH might not be the primary focus area, instead, DC can represent the primary district energy to develop.

Countries with a medium share of DH are Poland, Czech Republic, Finland, Latvia, Romania, Hungary, Bulgaria, Austria and Germany.

For these countries, the share of DH differs greatly as the span is from 10-50%. In general individual boilers are still the most common solution. Depending on the country, fossil fuels or bio fuels are the primary fuel for heat production. The condition of the existing networks varies in this category, as some networks have not been maintained properly over the years. Some systems experience great heat losses and declining heat demand, as consumers shift to individual solutions. Therefore, the refurbishment of existing networks is key to maintaining the market share DH currently has in these countries. In order to increase the competitiveness of DH, heat price regulations need to be carefully established, as individual solutions currently are favored in some of the countries in this category.

Countries with a large share of DH are Denmark, Lithuania, Slovakia, Estonia and Sweden.

For the countries with a DH share of more than 50%, the expansion of DH is not the primary focus area. Saturated markets shift the development from extensions of networks towards increasing the overall efficiency of the networks by the use of RES and new technologies. Several of the countries have initiated a transition away from fossil fuels, and often solid biomass is the easiest solution in this transition, as it can serve as a direct substitute for coal in power plants or CHP plants.

The evaluation of trends and reasonable developments for DHC show that DHC can develop in so called generations. European countries are at different stages of the district energy generation development. In general, DH is more developed than DC. The closer DH or DC gets to the 4th generation, the more integrated and flexible it becomes. 5th generation is still new and untested in greater schemes and can have an even greater investment cost compared to 4th generation. However, getting closer to 4th generation DHC allows for the opportunity to co-produce heating and cooling in collective systems and across sectors.

Some of the most apparent trends found for countries with developed DHC systems are:

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- DH is only fully developed in European countries, which have considered energy planning as a natural part of the urban planning of infrastructure based on one or more of the following four drivers:
  - In communities in which the local governments have established public utilities with the aim of supplying services to buildings, e.g. electricity, gas, water and wastewater. These utilities have been able to harvest the synergies of CHP as well as waste heat (e.g. all public utilities in Finland, Sweden, Denmark, Austria and Germany);
  - In communities in which there has been a tradition for consumer engagement, e.g. in Denmark, these energy communities or co-operatives have played an important role in the development of DH as well as other services, like water supply, to the benefit of consumers;
  - In countries that have formed a national energy policy with objectives of energy efficiency and low carbon emissions, DH has been one of the most important instruments;
  - In the former centrally planned economies in which the central government has enforced urban planning in all communities in order to minimize total costs, DH has been developed.

In the centrally planned economies, DH based on surplus heat from power plants was developed as a least-cost solution, which could be implemented due to strong regulation. DH in these countries was developed as a top-down planning, whereas in Scandinavia and in many European cities it was developed as a local driven planning.

An exception to this was Denmark. DH started to develop a market share of around 30% by local driven planning in towns and small communities followed by an enforced planning combining a new natural gas infrastructure with an extension of DH up to 60%. This combination of two natural monopoly grids was coordinated at national, regional and municipal level.

Inefficiencies and improvements were found, mainly related to the implementation of regulatory frameworks. In countries with limited or no DH or DC, there is no culture or historical background for district energy. This makes it difficult for investors to have stable conditions for long-term investments. The EDDs are not implemented to the same degree in every European country and it is interpreted differently. Often national building codes favor individual solutions over district energy solutions. This can lead to sub-optimizations and not necessarily the most cost-effective solutions for communities.

Some of the lessons learned and necessary improvements found in this study are:

Cities take responsibility
The overall observation is that district energy has a significant market share in countries in which the cities have established a public utility being responsible for heating, electricity, waste and gas. These utilities can optimize the zoning of the networks and the integration of these sectors, e.g. take into account that fuel consumption for the heating is only around 15% of the fuel consumption for electric heating from the same power sector.

Many cities operate these systems on behalf of the consumers, whereas other cities are allowed to cross subsidize and use revenues from heat to pay for traffic, etc.

The consumers take responsibility
Some countries have a tradition for local energy communities in which the consumers form cooperatives to establish and operate assets of common interest, e.g. power distribution

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systems and DHC distribution systems. This kind of ownership is in particular important in Denmark. It is a long tradition that is embedded in the Heat Supply Act, which e.g. requires that all profit of DH shall be to the benefit of the consumers. Municipal-owned companies are e.g. managed as if it was a consumer-owned company, as the profit criteria for the management is to maximize profit for the consumers via lowering the heating price.

Commercial interests only

Comparing member states, it is also remarkable that DH only plays an important role in countries in which the state, the municipalities or the consumers have taken the responsibility for developing the urban heating infrastructure and thereby enforced competition between all supply companies and financial institutions to the benefit of the consumers.

Thereby, it has been possible to finance the infrastructure and even at a low interest rate, similar to the financing of traffic infrastructure or building infrastructure.

In countries in which this has been left to private companies that aim for a short payback time, there is little development of DH.

In a few countries, DH has been developed by cities and some of these cities have sold or leased the assets of production or both production and distribution to private companies. This privatization has to some extent reduced the market share of DH compared to the optimal potential in consumer or municipal owned companies.

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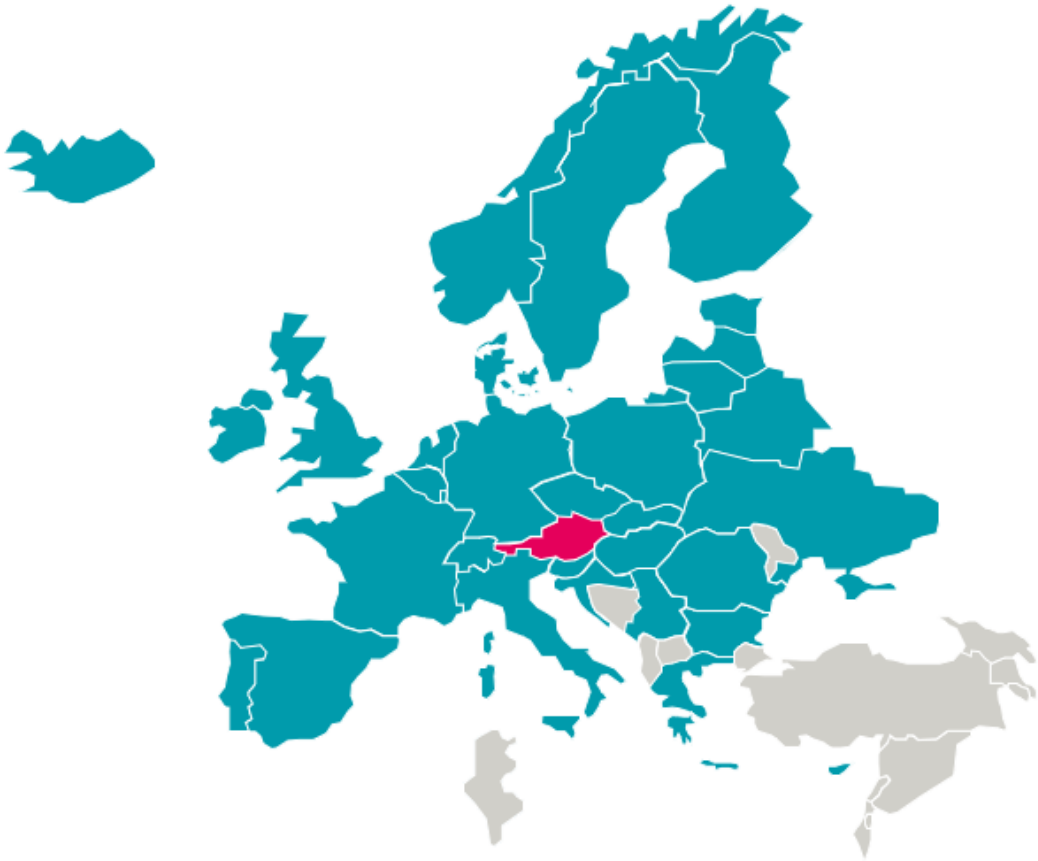
7 Annex

Annex 1. DHC Stock country by country

Data sources:
[1] Eurostat
[2] Euroheat & Power
[3] Heat Roadmap Europe
[4] EEA

7.1 Austria

7.1.1 Country profile



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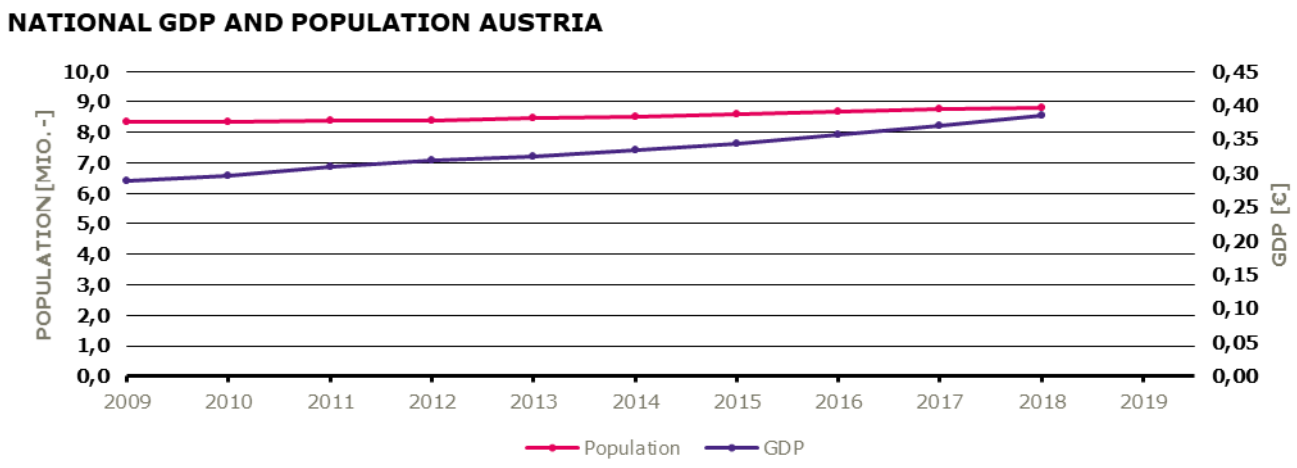

Figure 7-1: GDP and population development in Austria. Based on data from [1]

7.1.2 Energy use

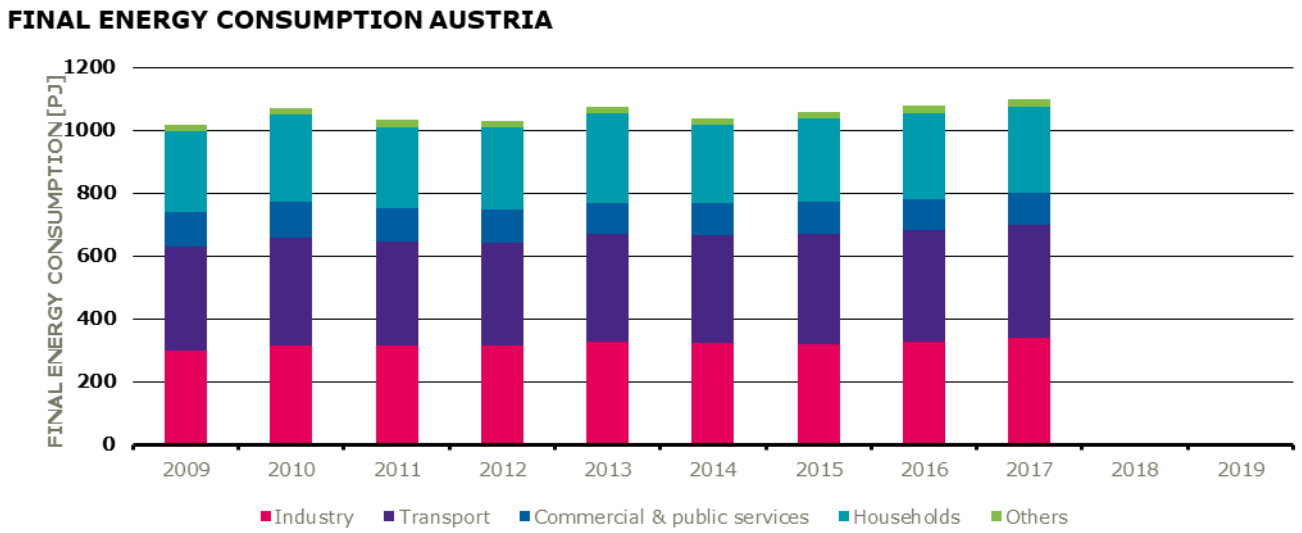

Figure 7-2: Final energy consumption by economic sector and year in Austria. Based on data from [2]

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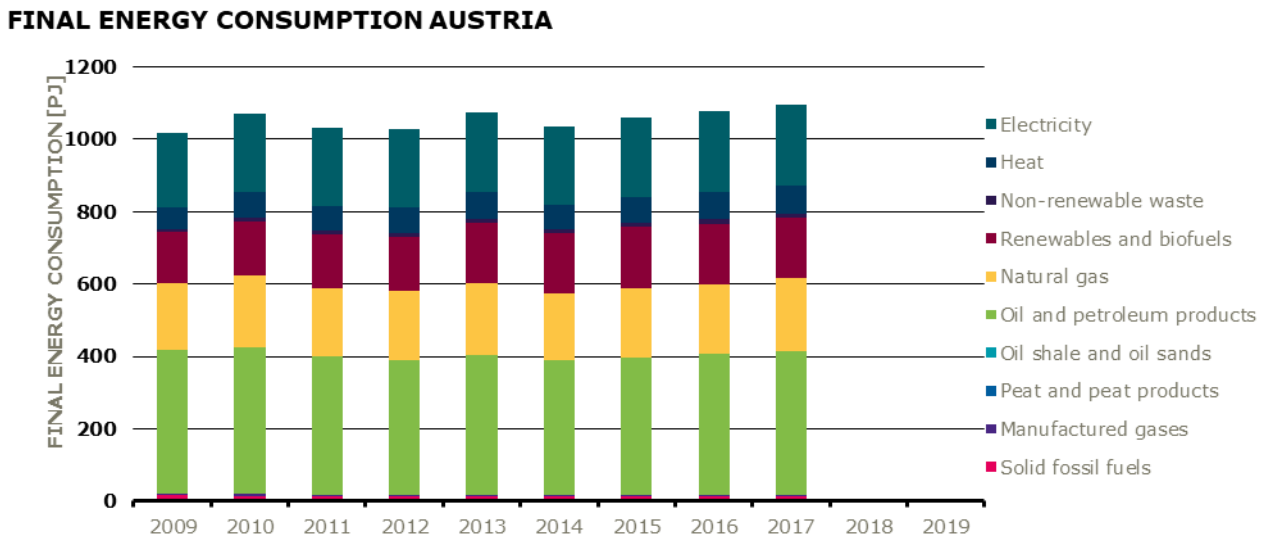

Figure 7-3: Final energy consumption by fuel and year in Austria. Based on data from [2]

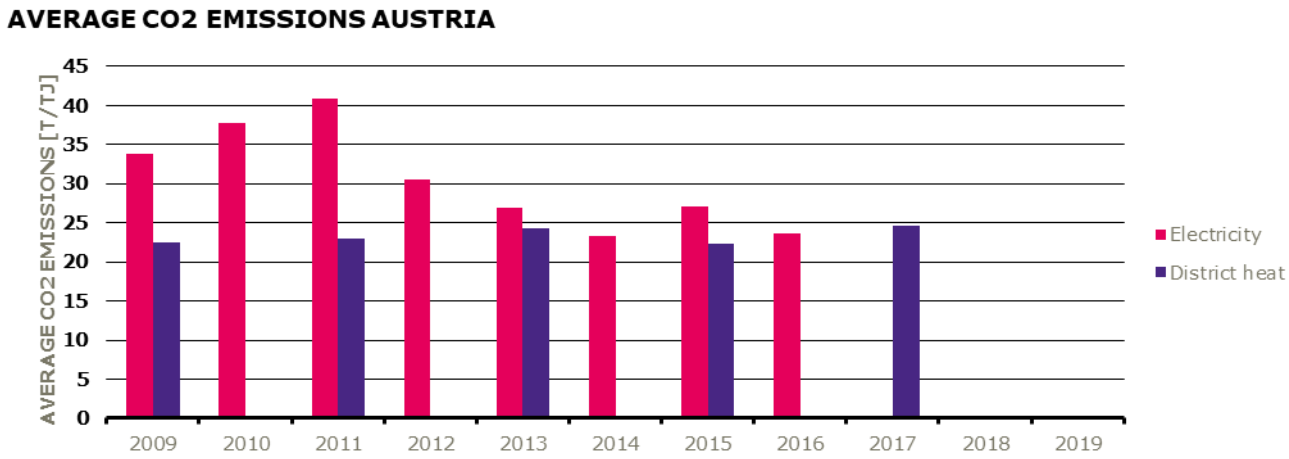

Figure 7-4: Average CO2 emissions in Austria. Based on data from [3] & [4]

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7.1.3 Heat Production

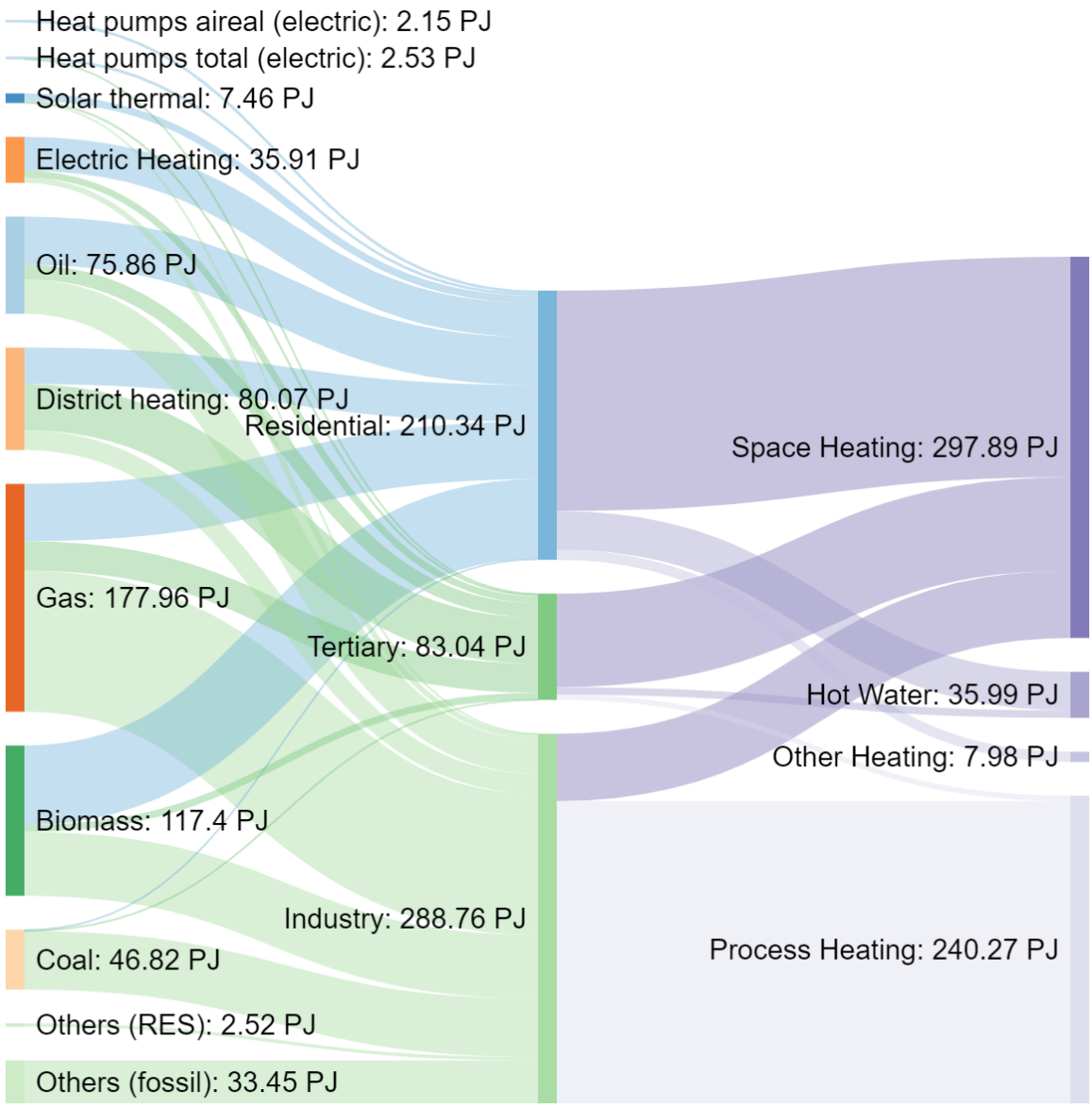

Figure 7-5: Sankey diagram of energy flows for heating purposes in Austria in 2015. Based on data from [3]

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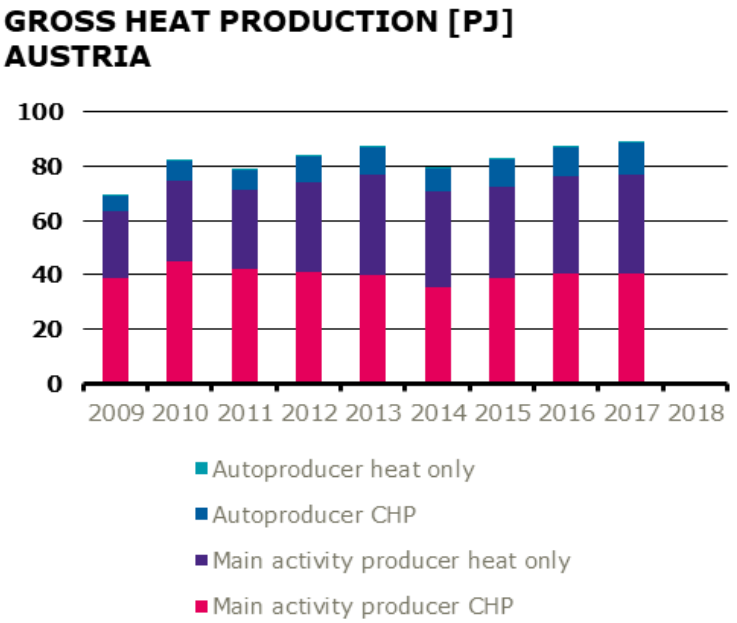

Figure 7-6: Gross heat production by producer type and year in Austria. Based on data from [2]

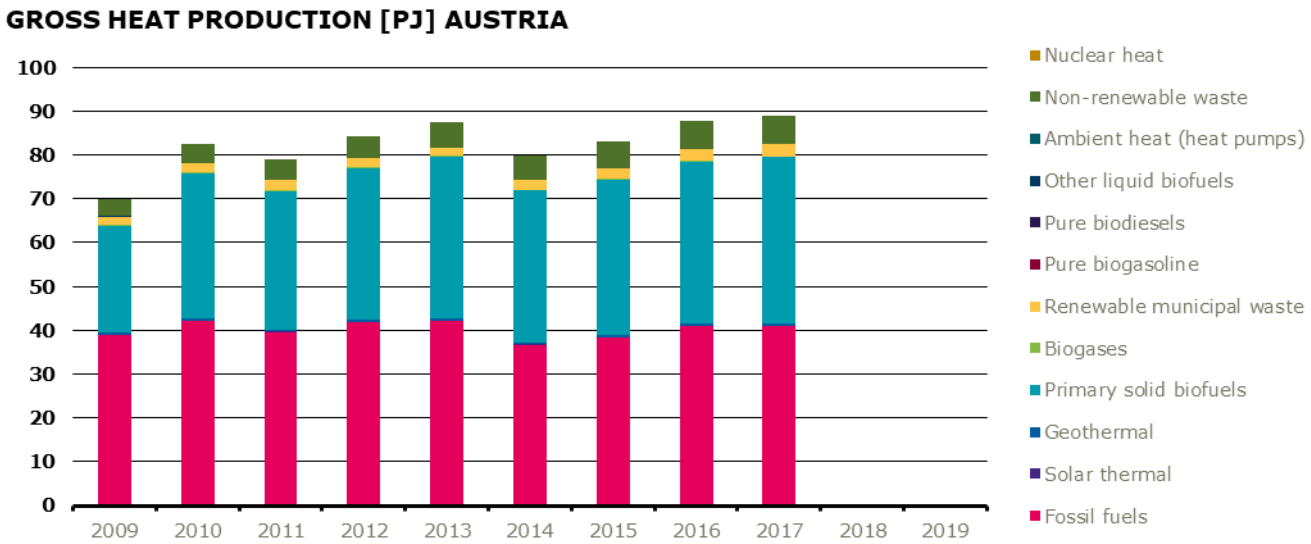

Figure 7-7: Gross heat production by fuel and year in Austria. Based on data from [2]

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7.1.4 Electricity Production

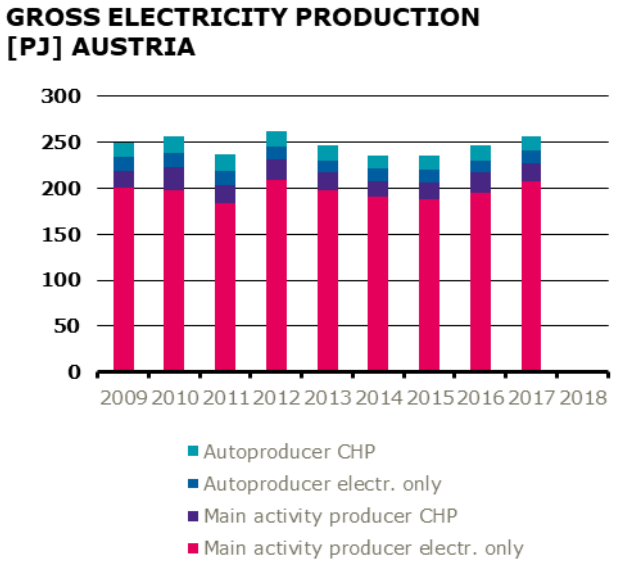

Figure 7-8: Gross electricity production by producer type and year in Austria. Based on data from [2]

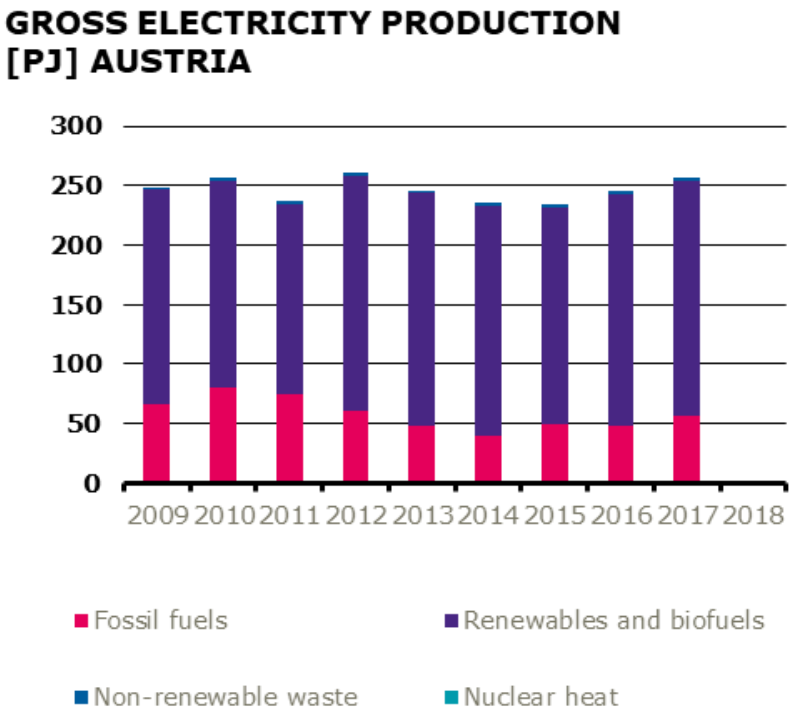

Figure 7-9: Gross electricity production by fuel type and year in Austria. Based on data from [2]

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7.1.5 District Heat

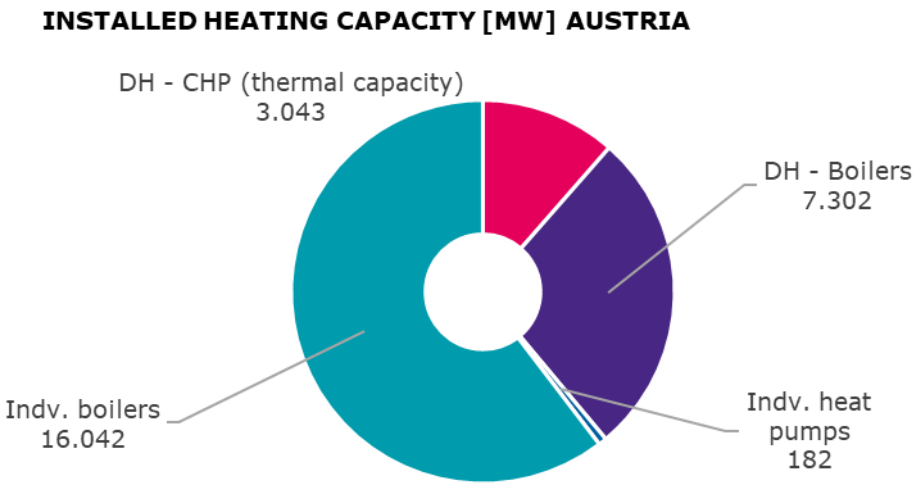

Figure 7-10: Installed heating capacity installed in Austria in 2015. Based on data from [2]

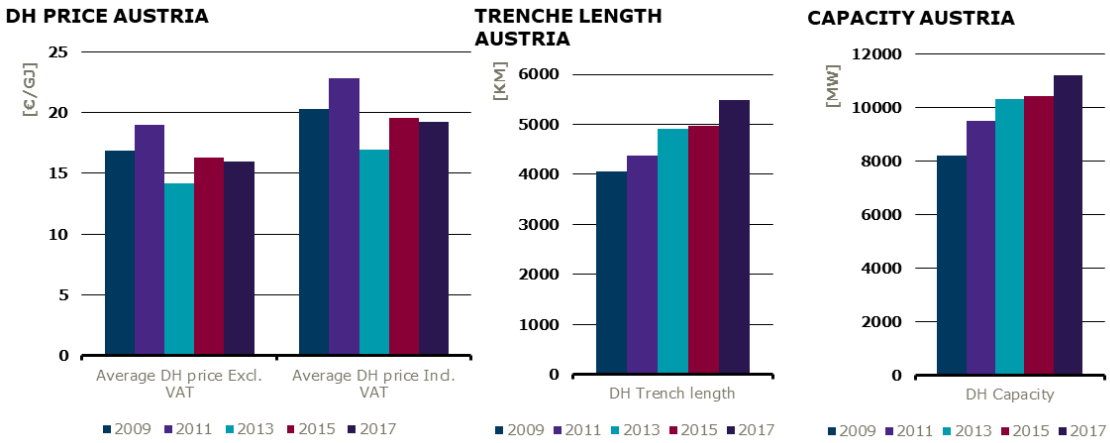

Figure 7-11: District heat indicators for Austria. Based on data from [2]

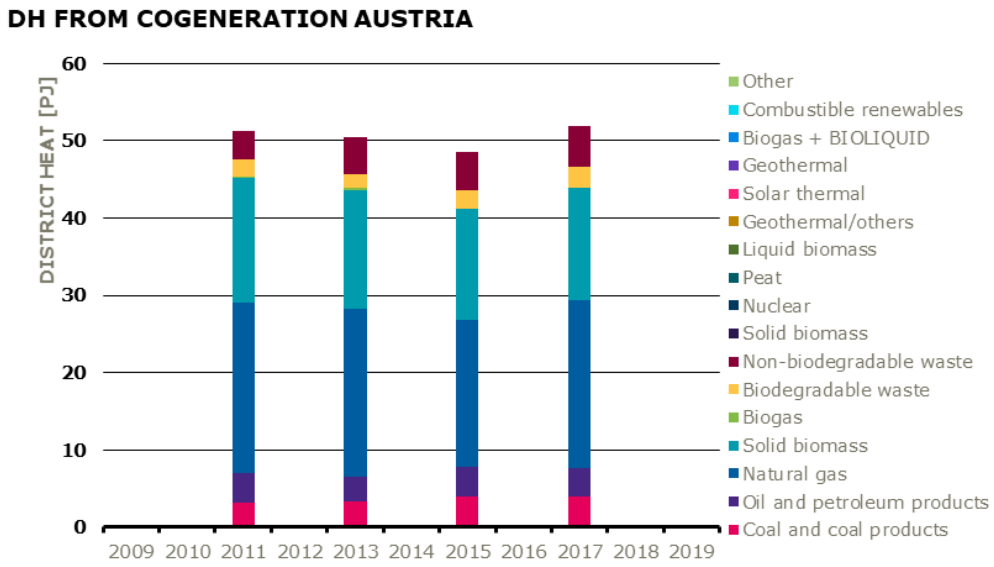

Figure 7-12: District heat generated in CHP plants by year and fuel in Austria. Based on data from [2], [3]

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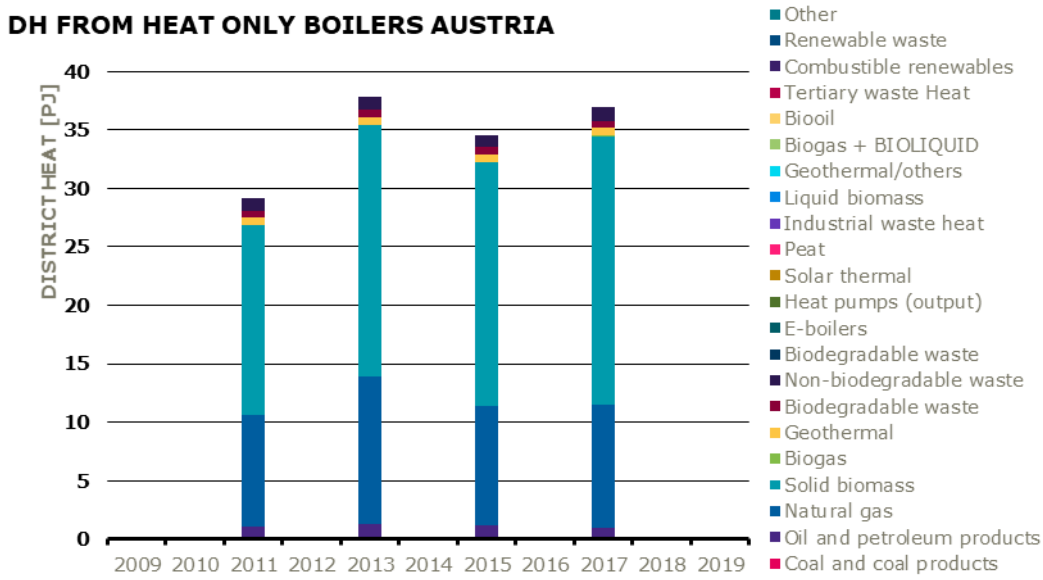

Figure 7-13: District heat generated in heat only boilers by year and fuel in Austria. Based on data from [2], [3]

7.1.6 Energy storage

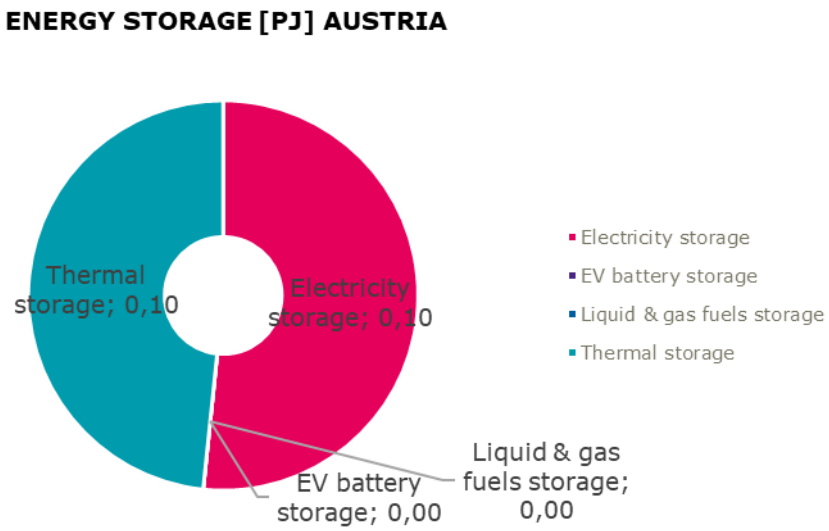

Figure 7-14: Stoage capacity in Austria in 2015. Based on data from [2]

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7.2 Belgium

7.2.1 Country profile

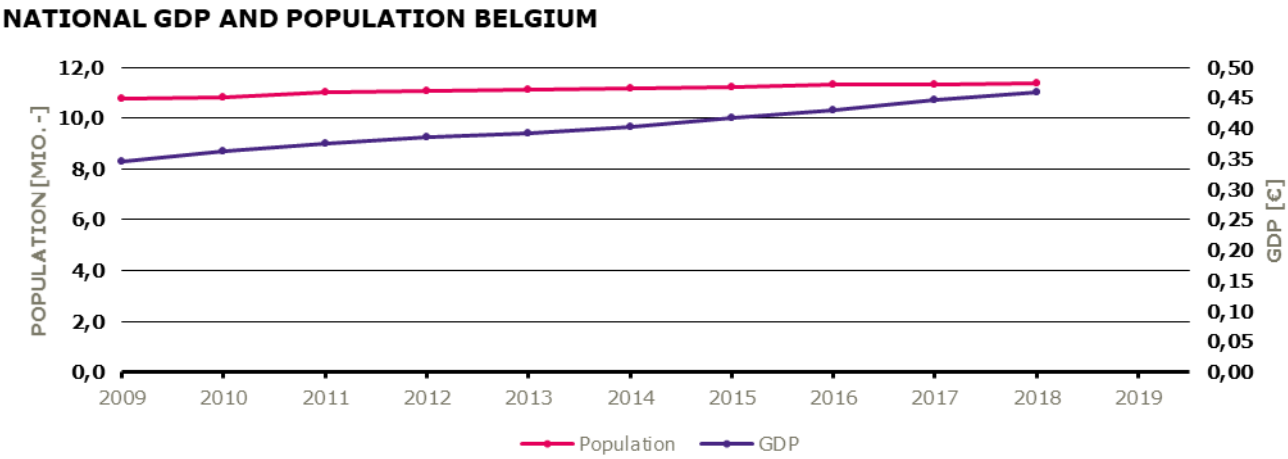

Figure 7-15: GDP and population development in Belgium. Based on data from [1]

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7.2.2 Energy use

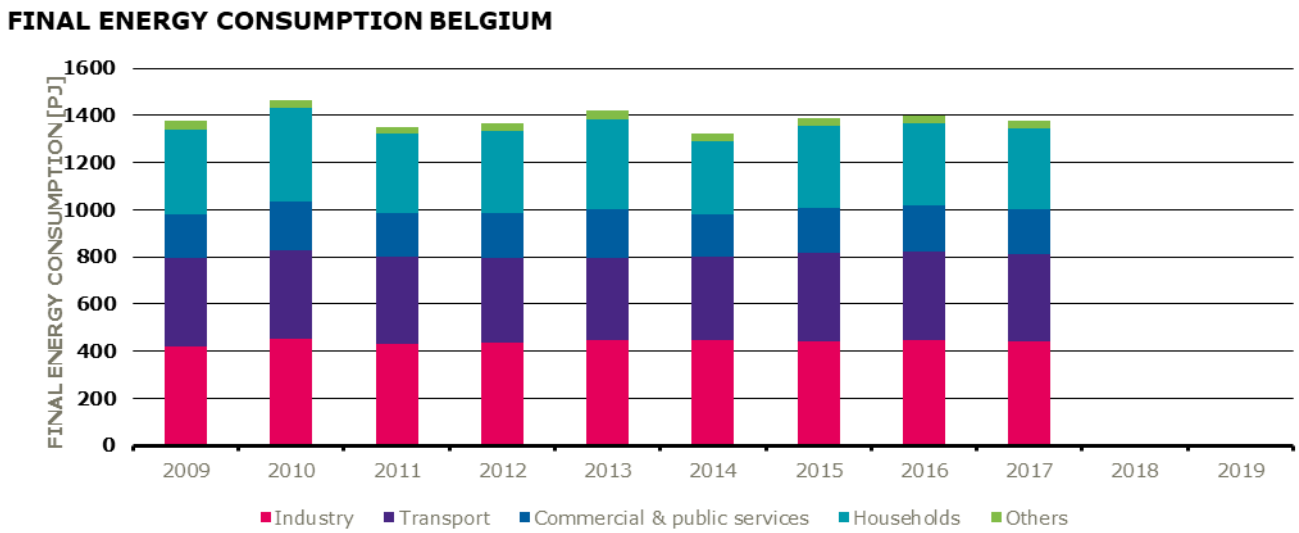

Figure 7-16: Final energy consumption by economic sector and year in Belgium. Based on data from [2]

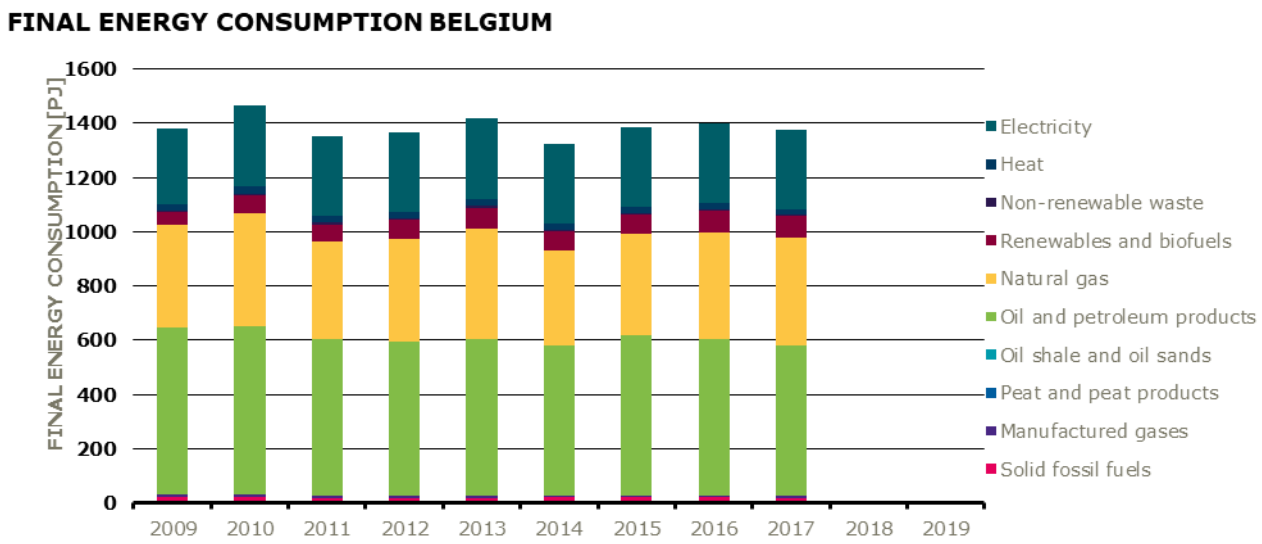

Figure 7-17: Final energy consumption by fuel and year in Belgium. Based on data from [2]

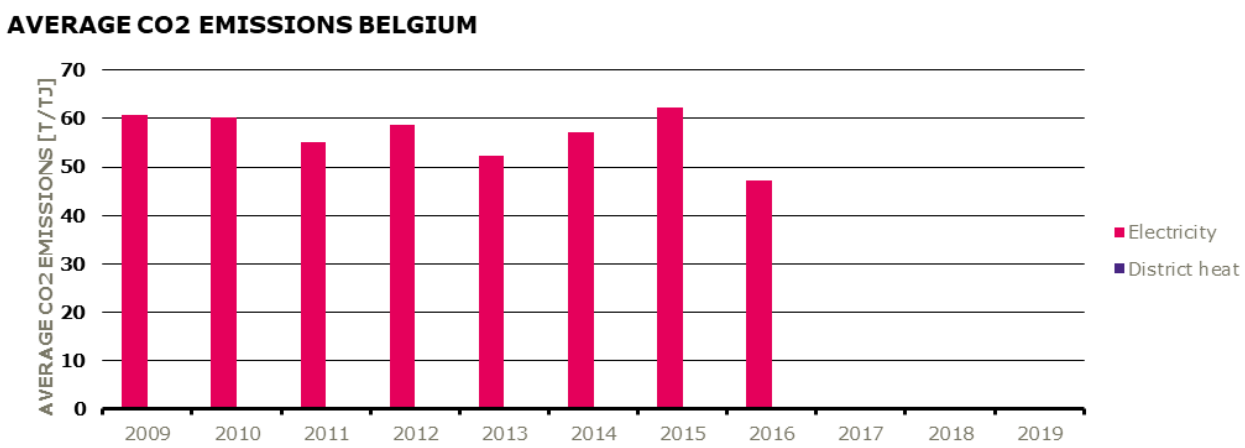

Figure 7-18: Average CO2 emissions in Belgium. Based on data from [3] & [4]

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7.2.3 Heat Production

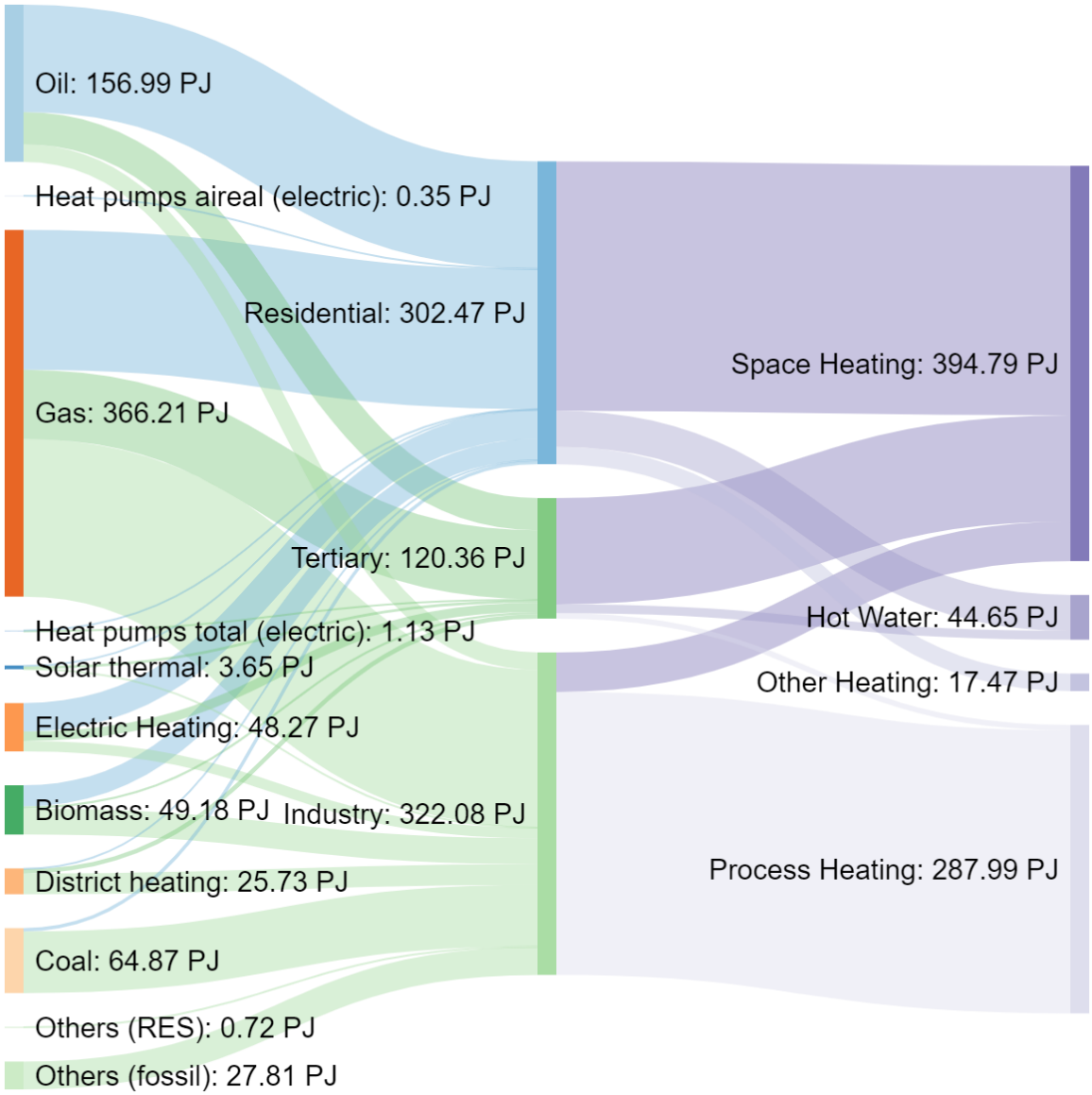

Figure 7-19: Sankey diagram of energy flows for heating purposes in Belgium in 2015. Based on data from [3]

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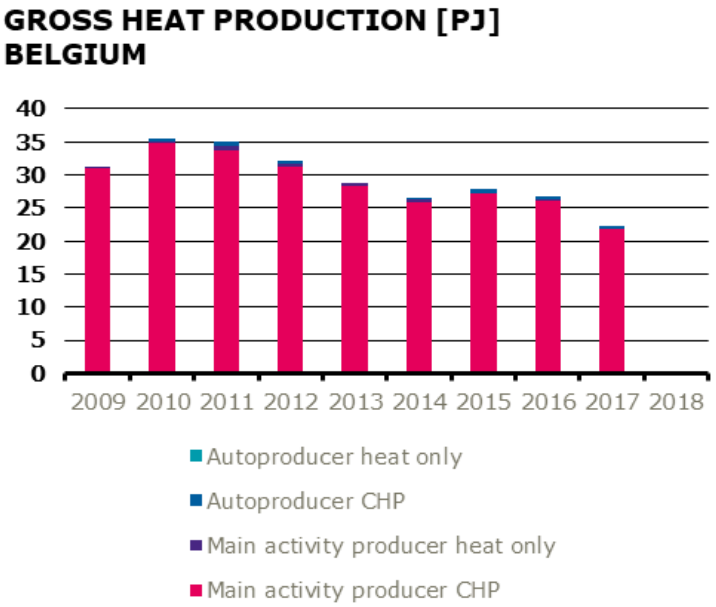

Figure 7-20: Gross heat production by producer type and year in Belgium. Based on data from [2]

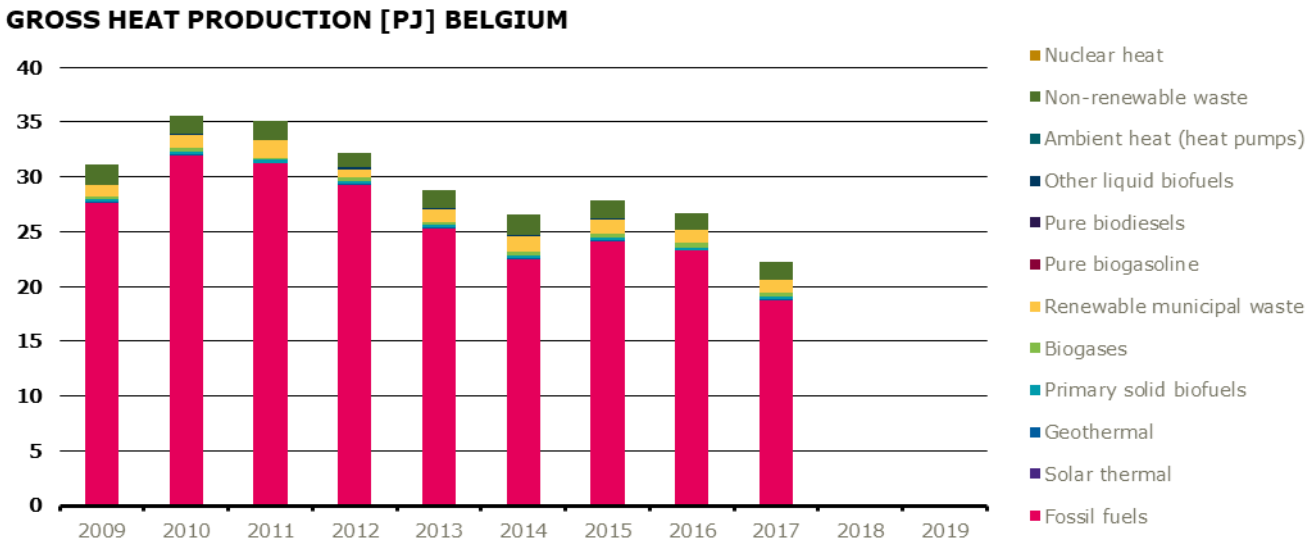

Figure 7-21: Gross heat production by fuel and year in Belgium. Based on data from [2]

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7.2.4 Electricity Production

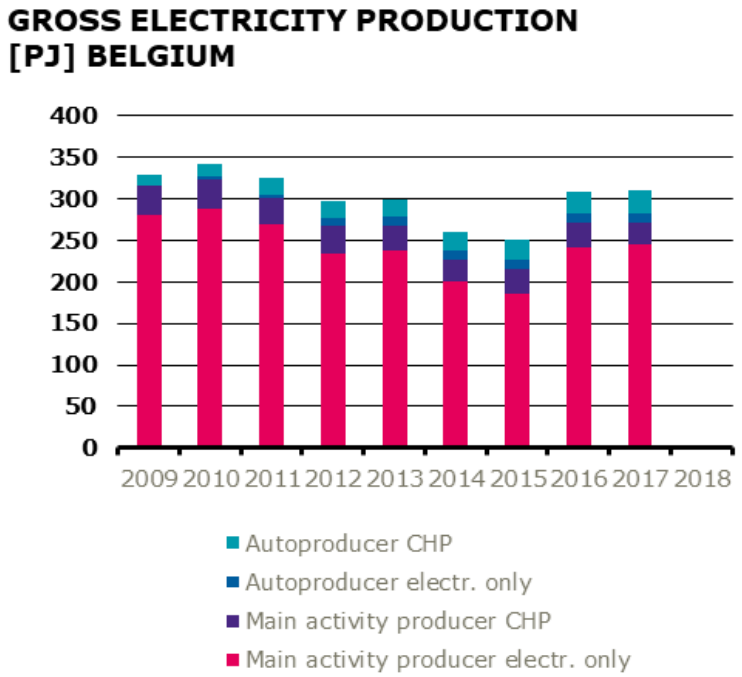

Figure 7-22: Gross electricity production by producer type and year in Belgium. Based on data from [2]

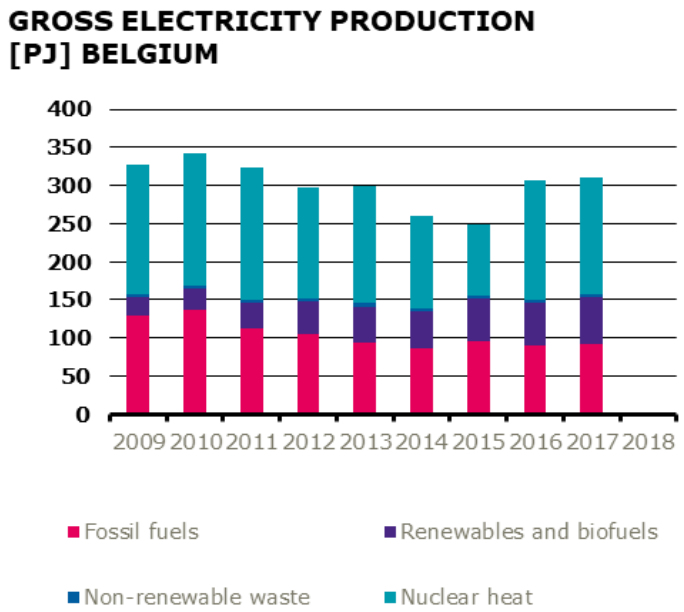

Figure 7-23: Gross electricity production by fuel type and year in Belgium. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.2.5 District Heat

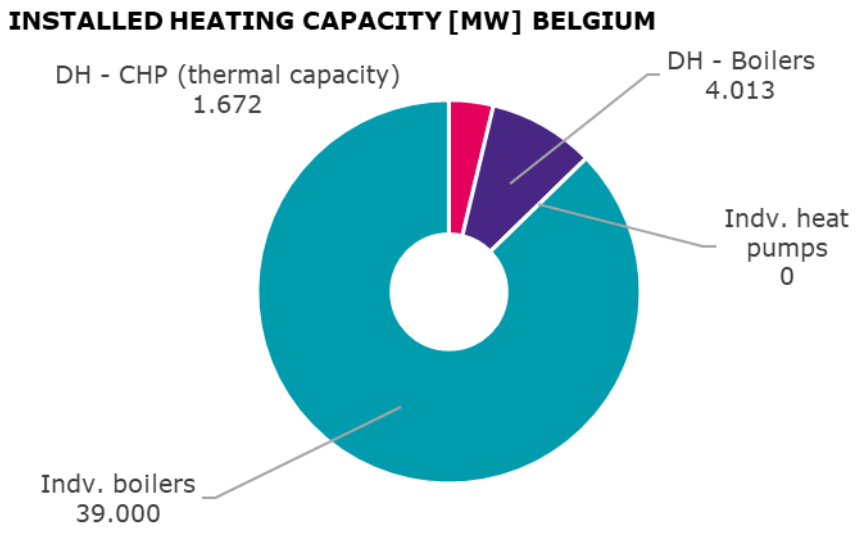

Figure 7-24: Installed heating capacity installed in Belgium in 2015. Based on data from [2]

7.2.6 Energy storage

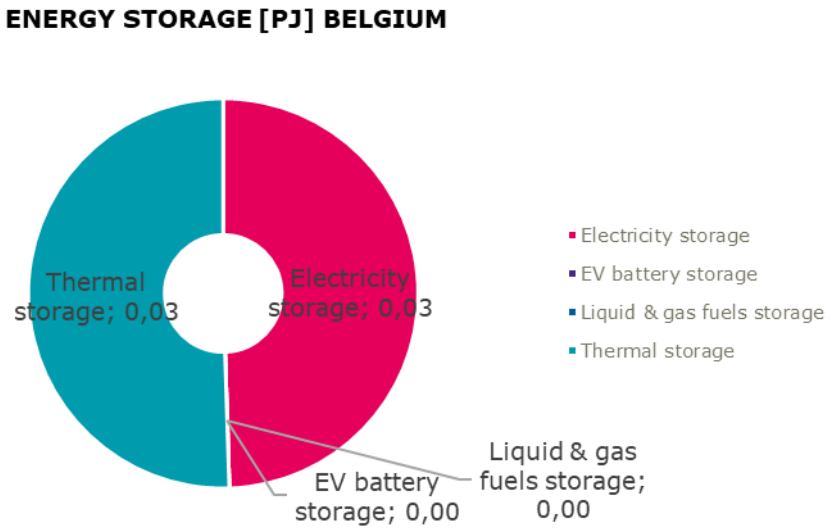

Figure 7-25: Stoage capacity in Belgium in 2015. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.3 Bulgaria

7.3.1 Country profile

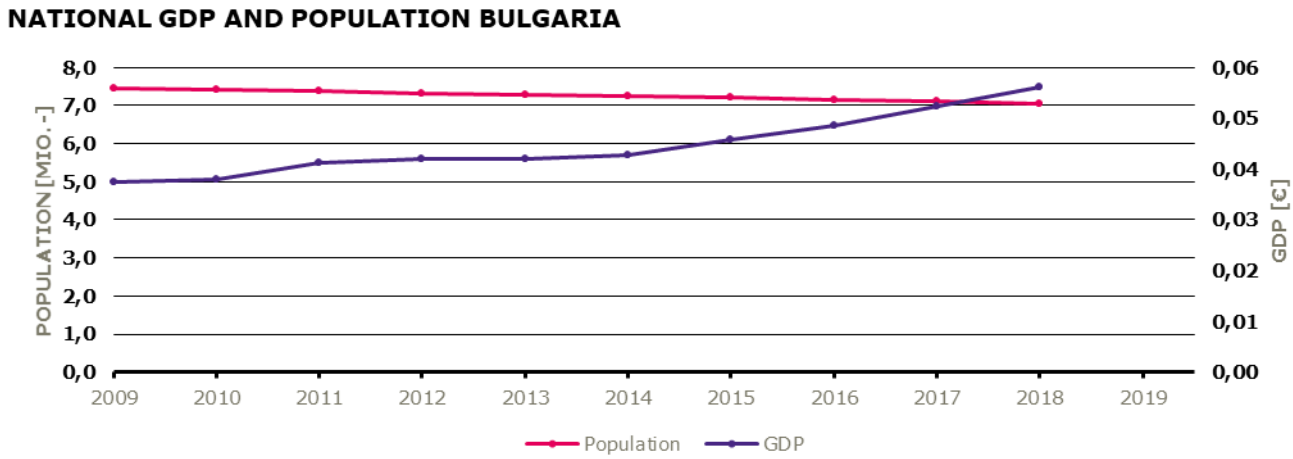

Figure 7-26: GDP and population development in Bulgaria. Based on data from [1]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.3.2 Energy use

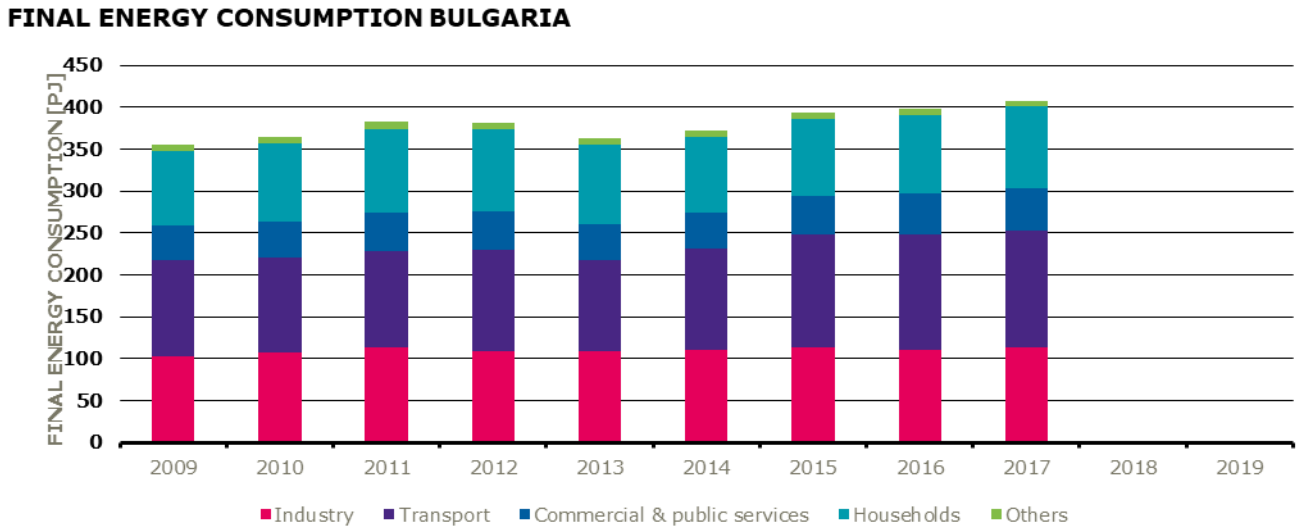

Figure 7-27: Final energy consumption by economic sector and year in Bulgaria. Based on data from [2]

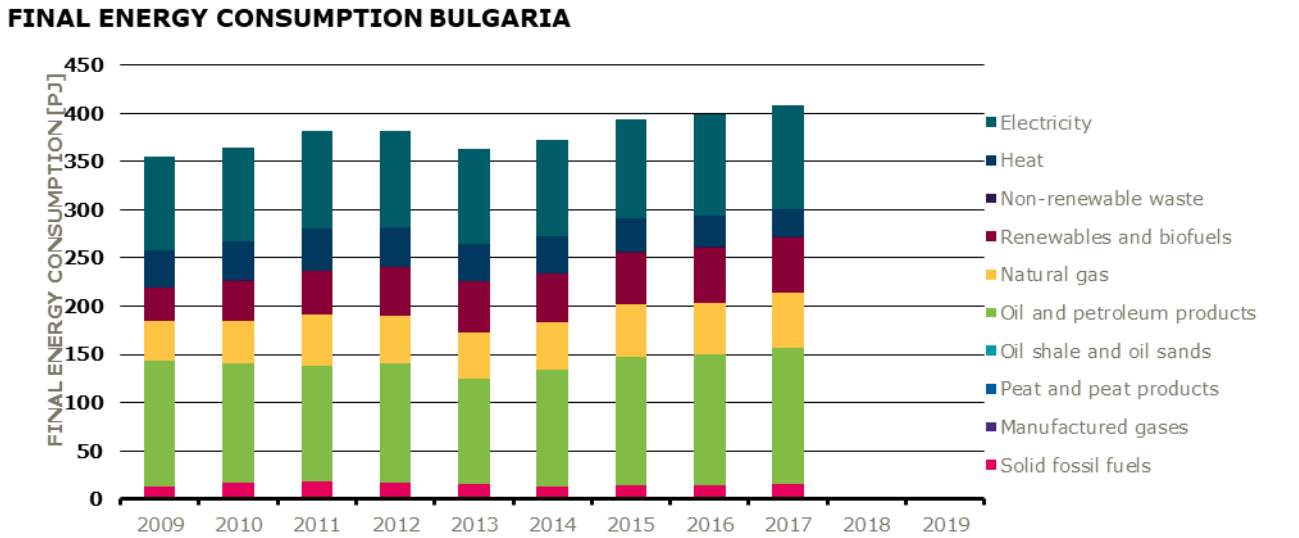

Figure 7-28: Final energy consumption by fuel and year in Bulgaria. Based on data from [2]

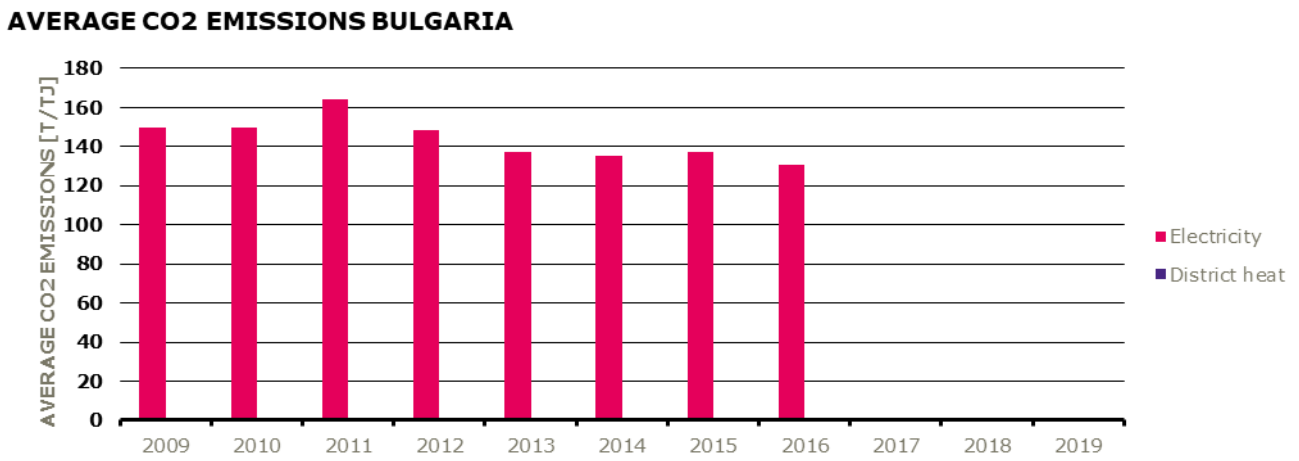

Figure 7-29: Average CO2 emissions in Bulgaria. Based on data from [3] & [4]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.3.3 Heat Production

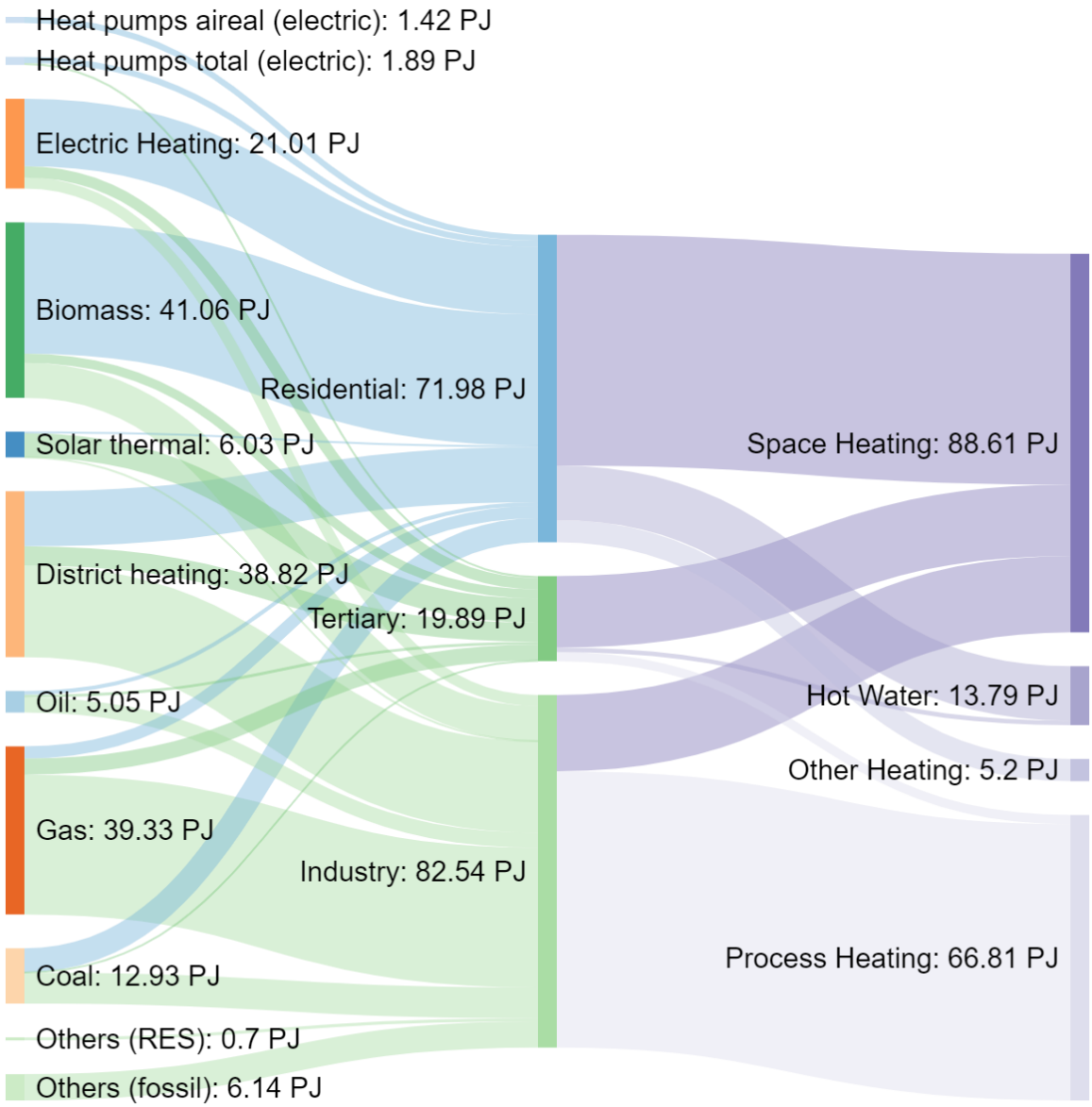

Figure 7-30: Sankey diagram of energy flows for heating purposes in Bulgaria in 2015. Based on data from [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

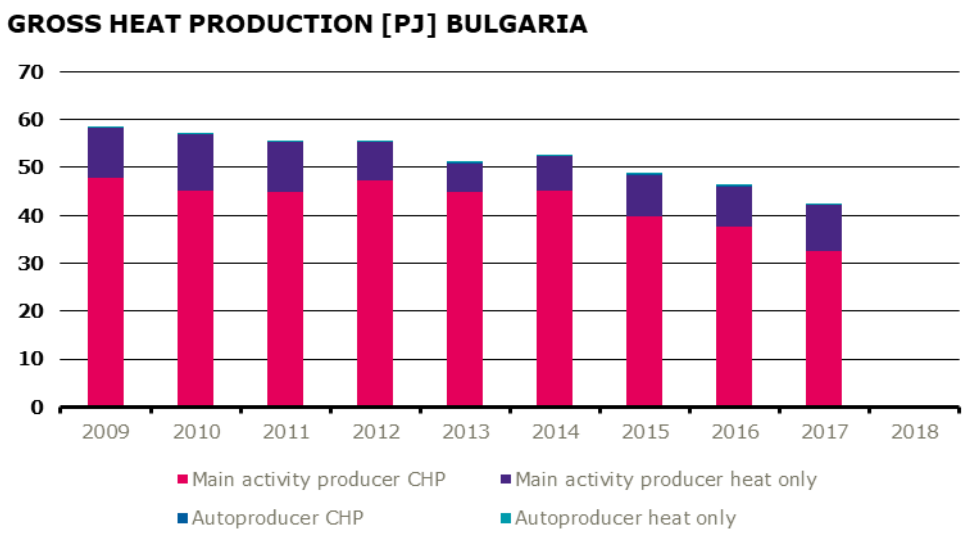

Figure 7-31: Gross heat production by producer type and year in Bulgaria. Based on data from [2]

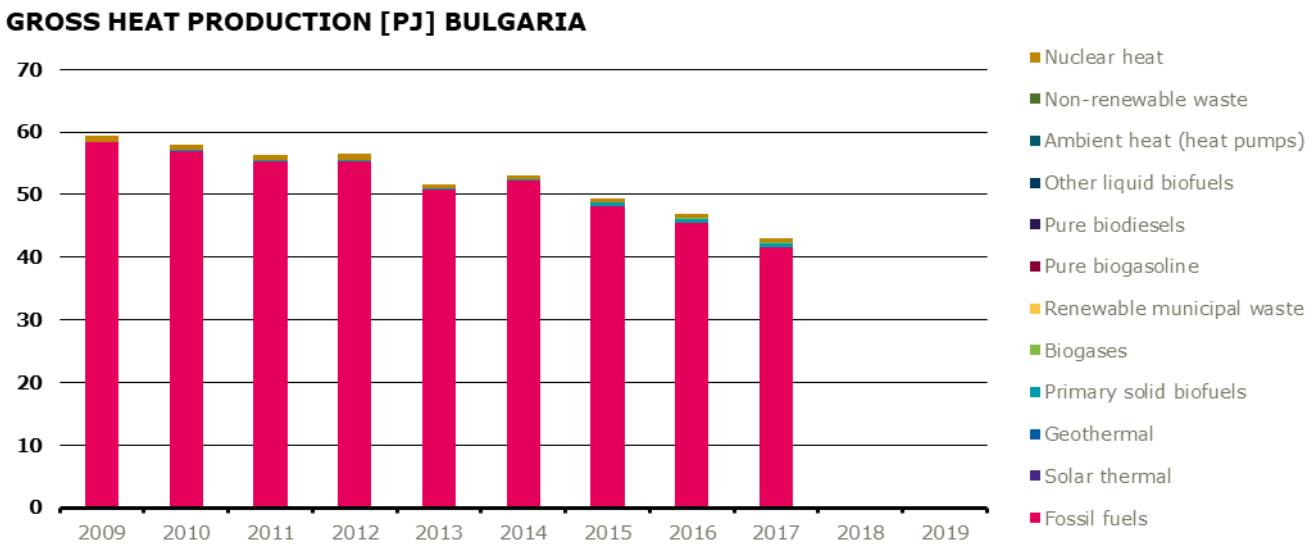

Figure 7-32: Gross heat production by fuel and year in Bulgaria. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.3.4 Electricity Production

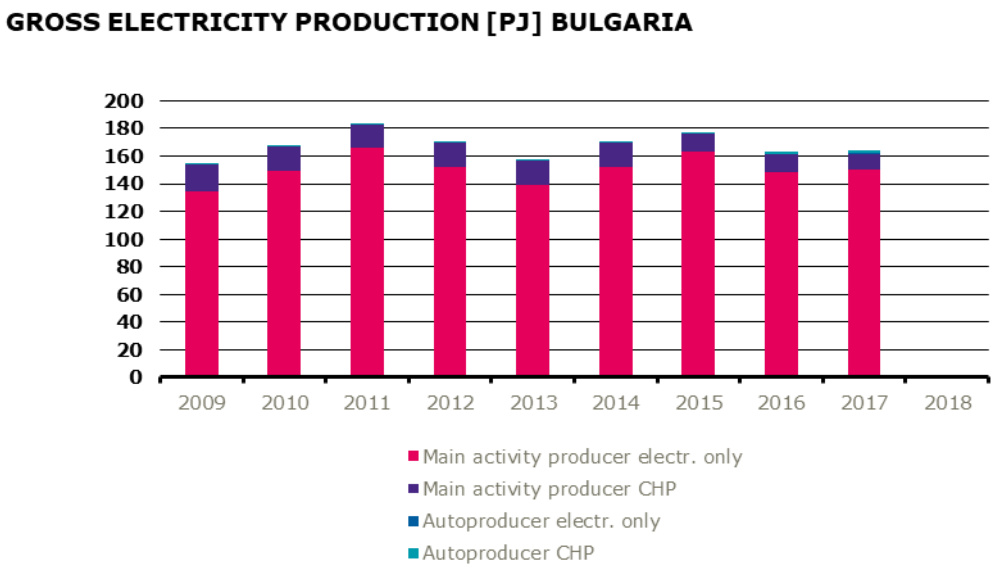

Figure 7-33: Gross electricity production by producer type and year in Bulgaria. Based on data from [2]

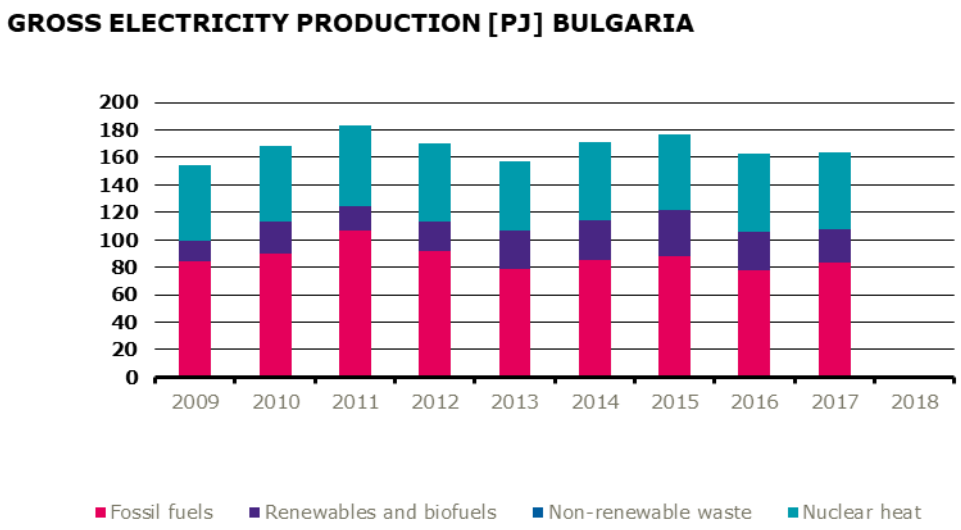

Figure 7-34: Gross electricity production by fuel type and year in Bulgaria. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.3.5 District Heat

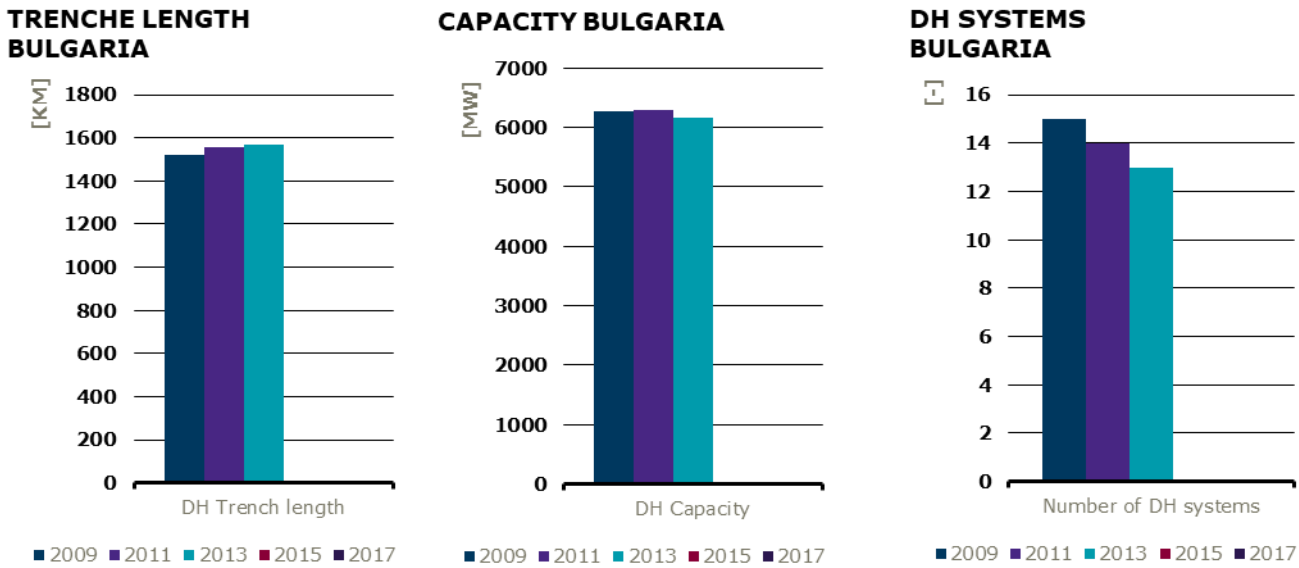

Figure 7-35: District heat indicators for Bulgaria. Based on data from [2]

7.3.6 Energy storage

[*No data available*]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.4 Croatia

7.4.1 Country profile

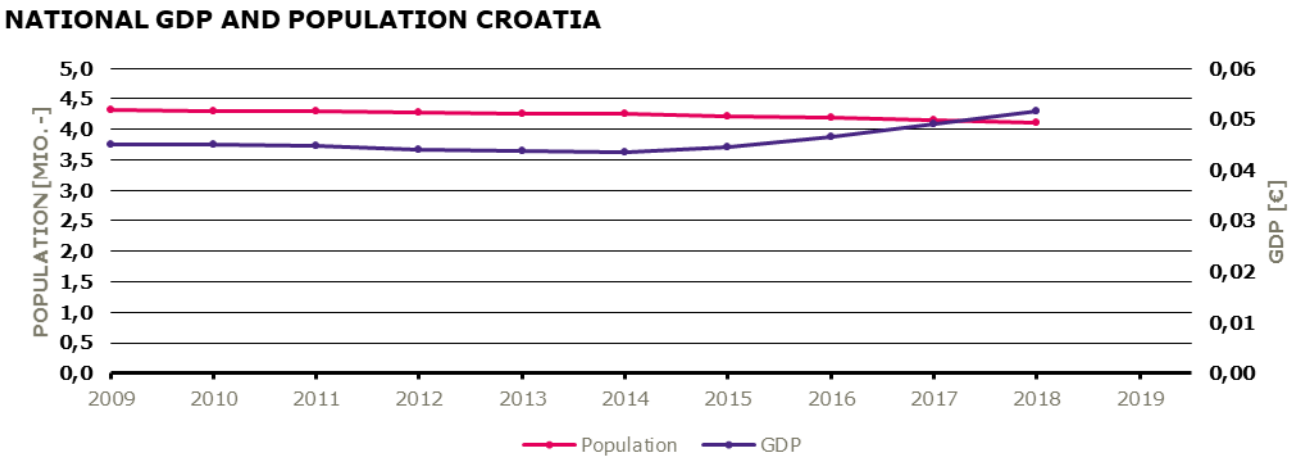

Figure 7-36: GDP and population development in Croatia. Based on data from [1]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.4.2 Energy use

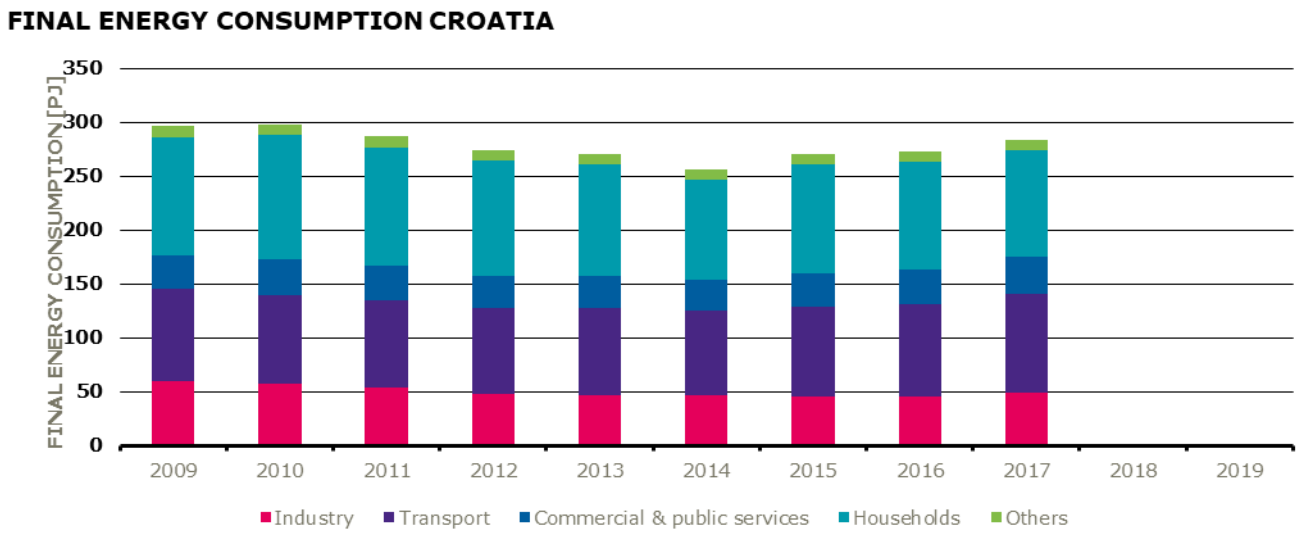

Figure 7-37: Final energy consumption by economic sector and year in Croatia. Based on data from [2]

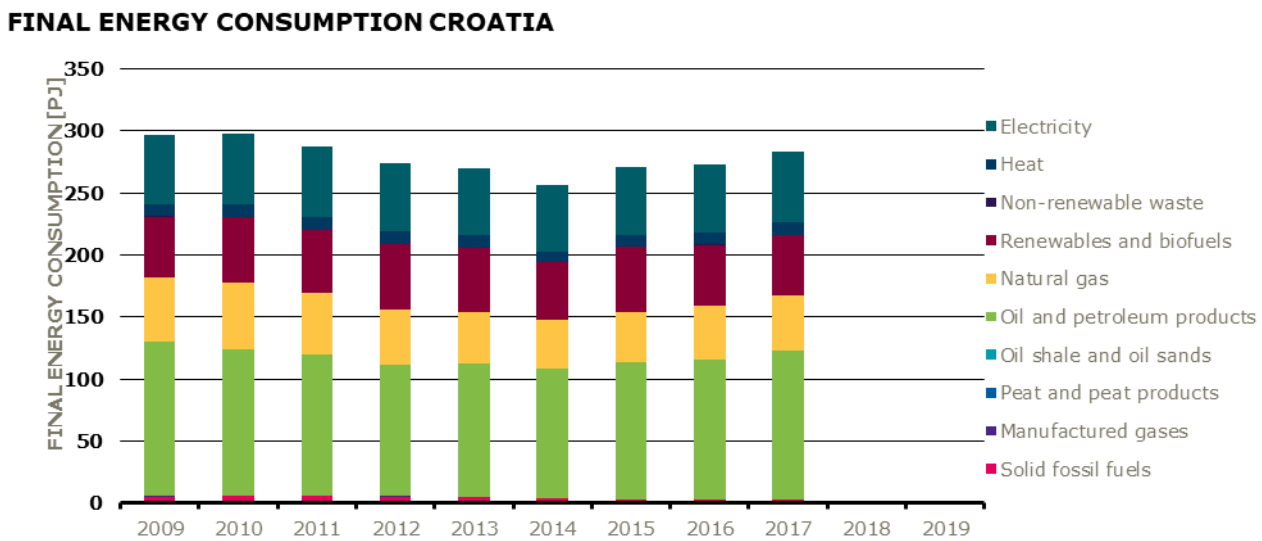

Figure 7-38: Final energy consumption by fuel and year in Croatia. Based on data from [2]

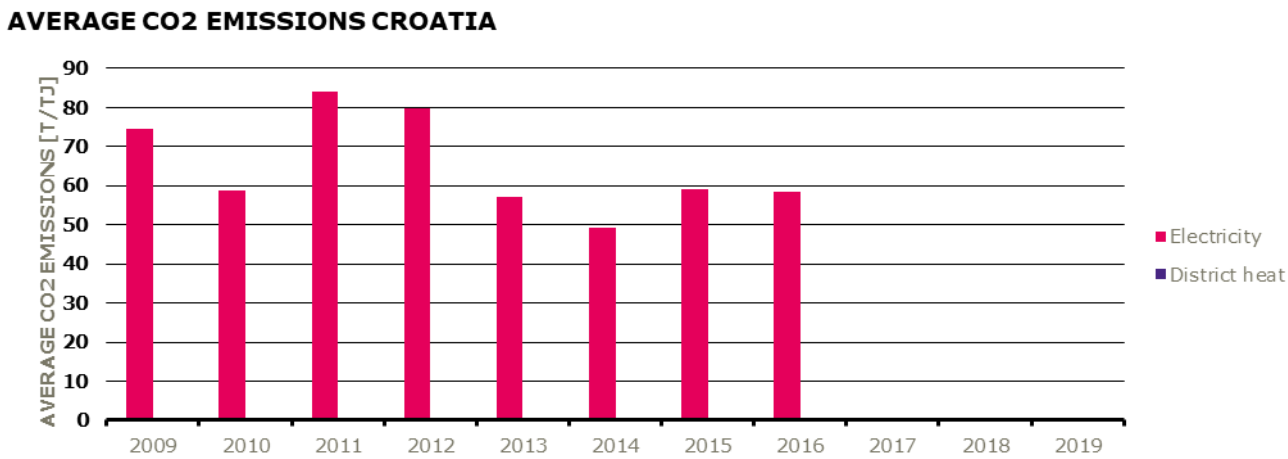

Figure 7-39: Average CO2 emissions in Croatia. Based on data from [3] & [4]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.4.3 Heat Production

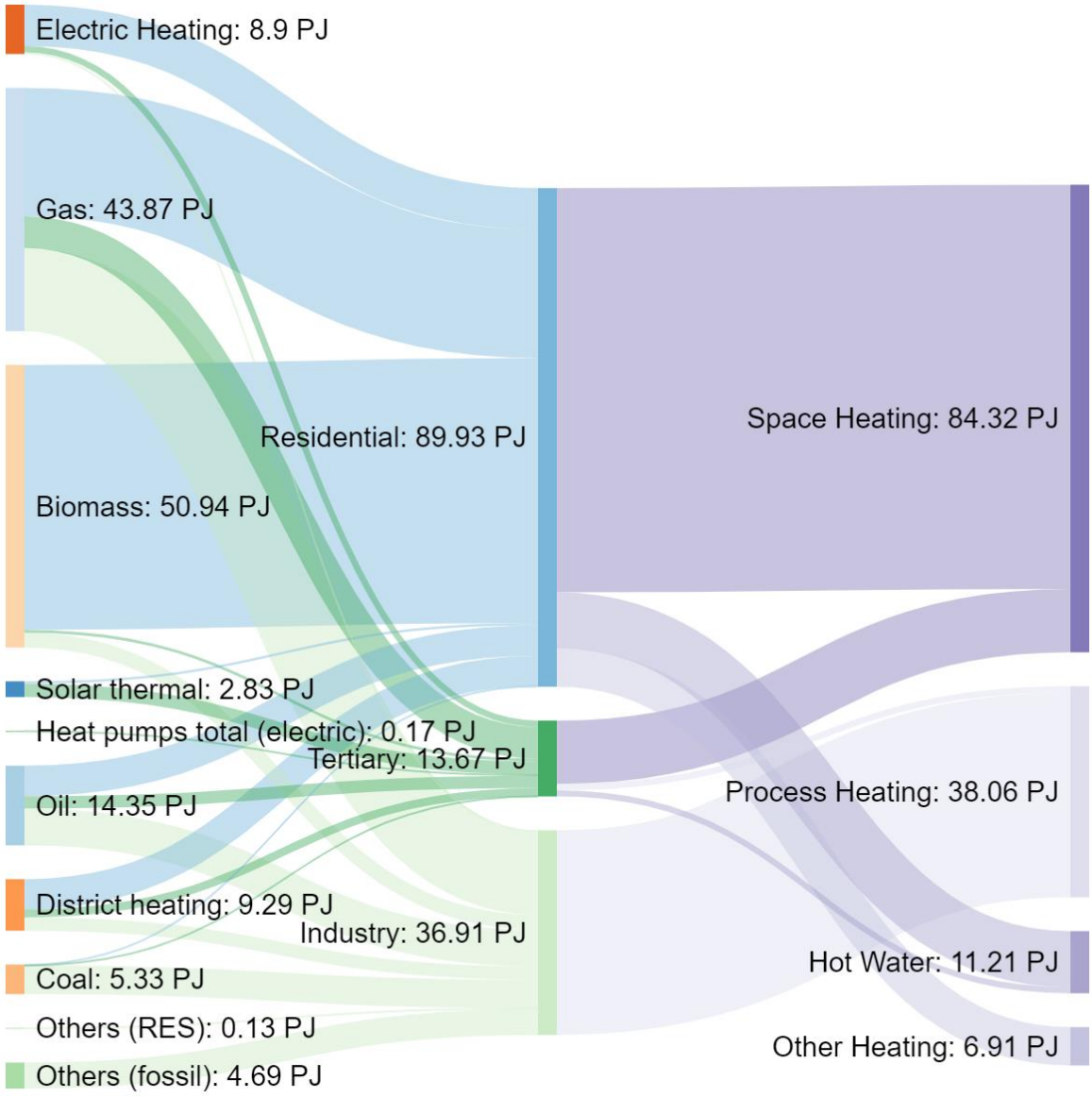

Figure 7-40: Sankey diagram of energy flows for heating purposes in Croatia in 2015. Based on data from [3]

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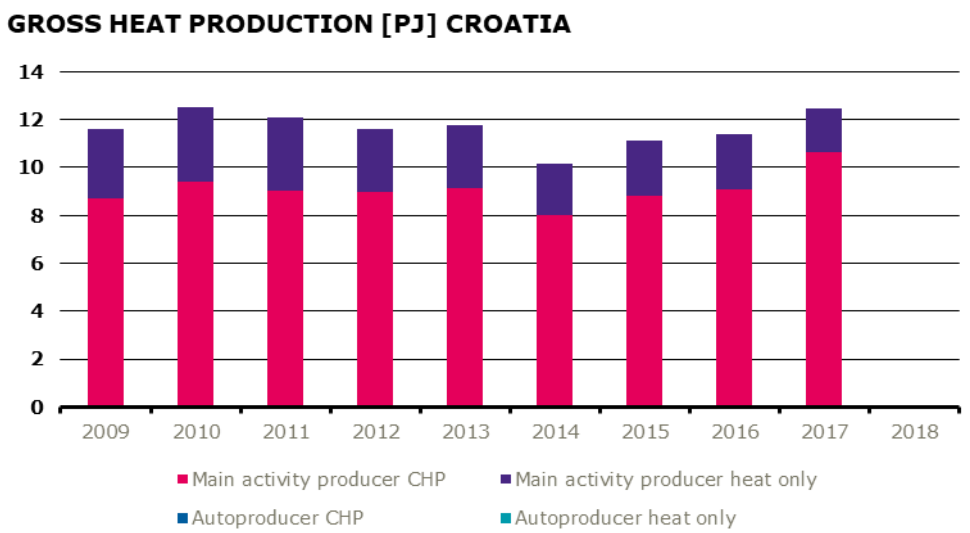

Figure 7-41: Gross heat production by producer type and year in Croatia. Based on data from [2]

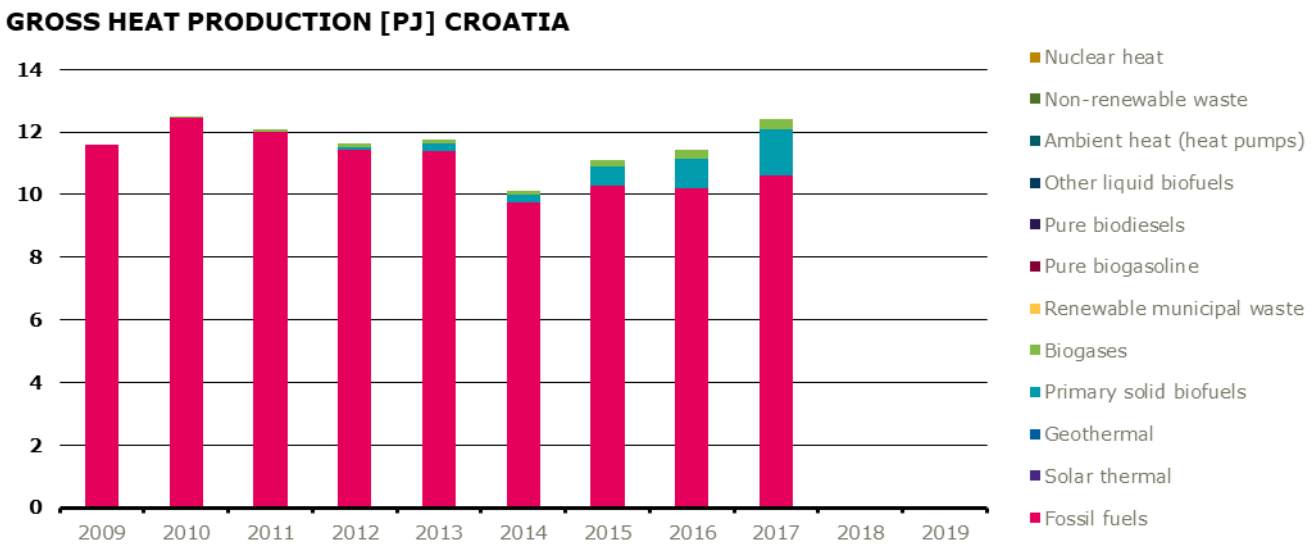

Figure 7-42: Gross heat production by fuel and year in Croatia. Based on data from [2]

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7.4.4 Electricity Production

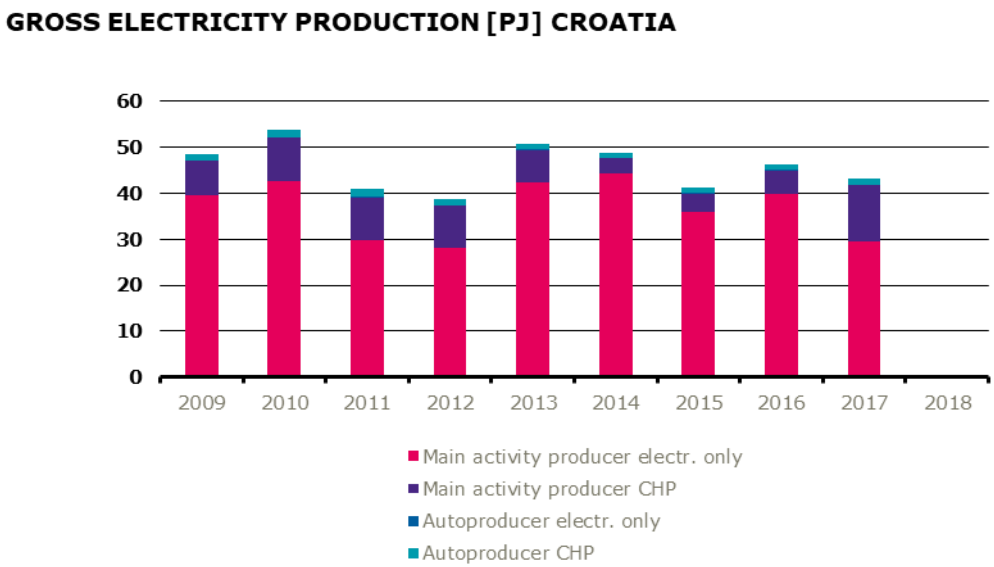

Figure 7-43: Gross electricity production by producer type and year in Croatia. Based on data from [2]

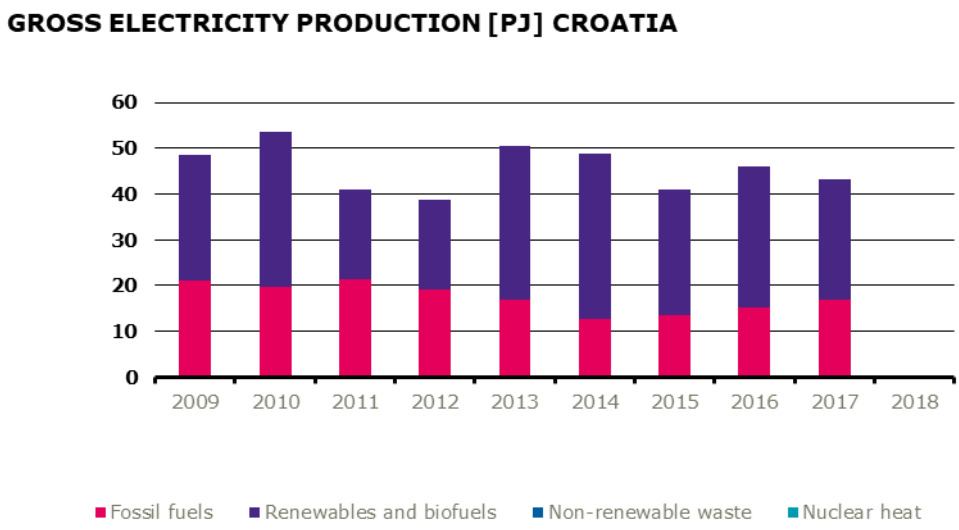

Figure 7-44: Gross electricity production by fuel type and year in Croatia. Based on data from [2]

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7.4.5 District Heat

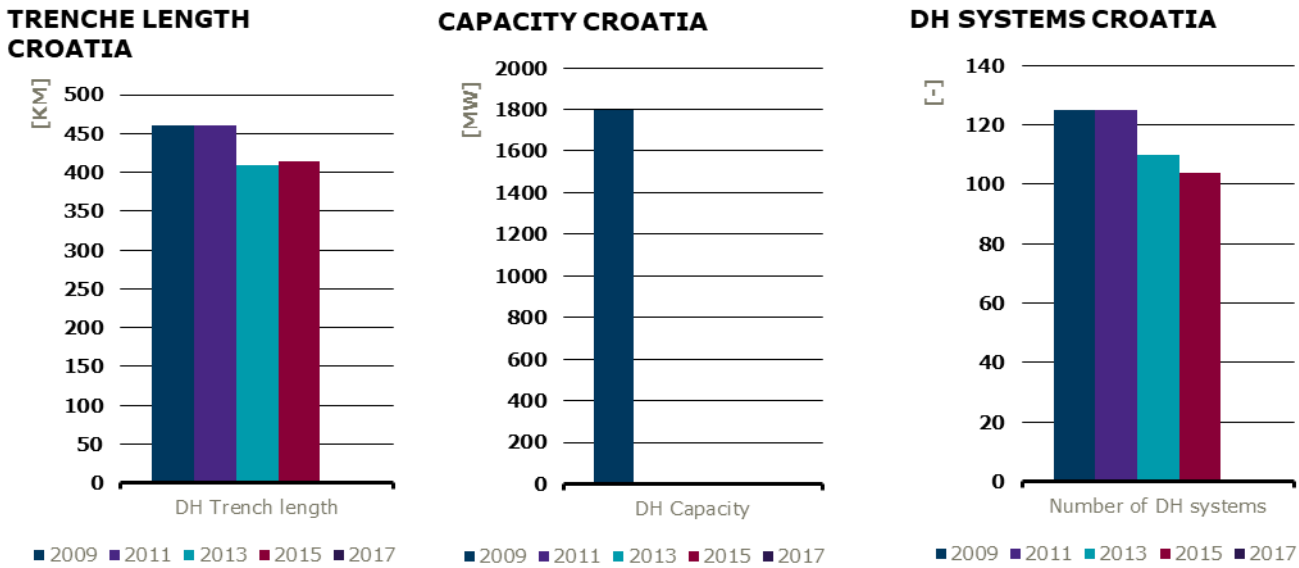

Figure 7-45: District heat indicators for Croatia. Based on data from [2]

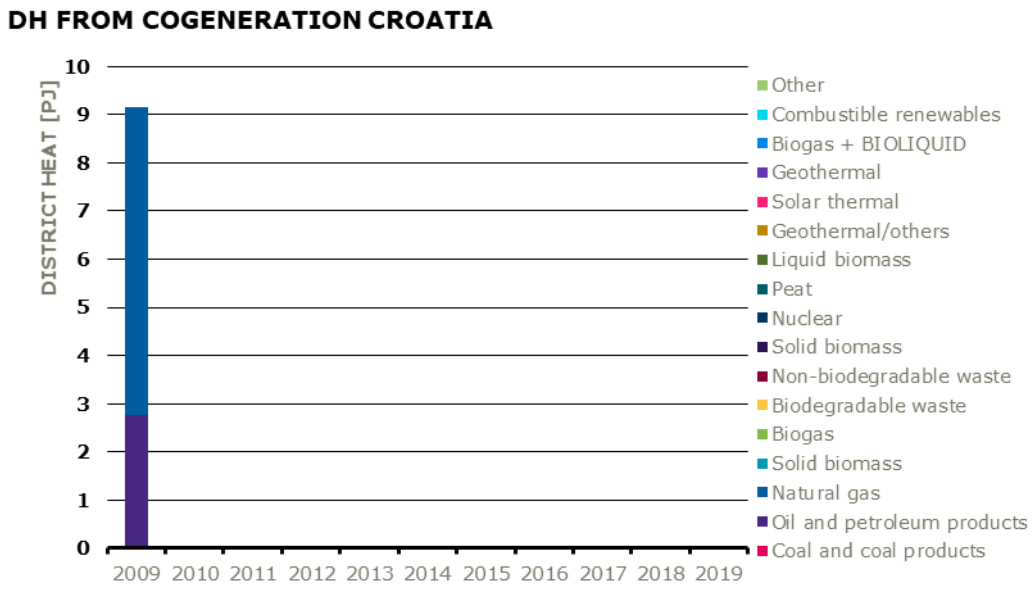

Figure 7-46: District heat generated in CHP plants by year and fuel in Croatia. Based on data from [2], [3]

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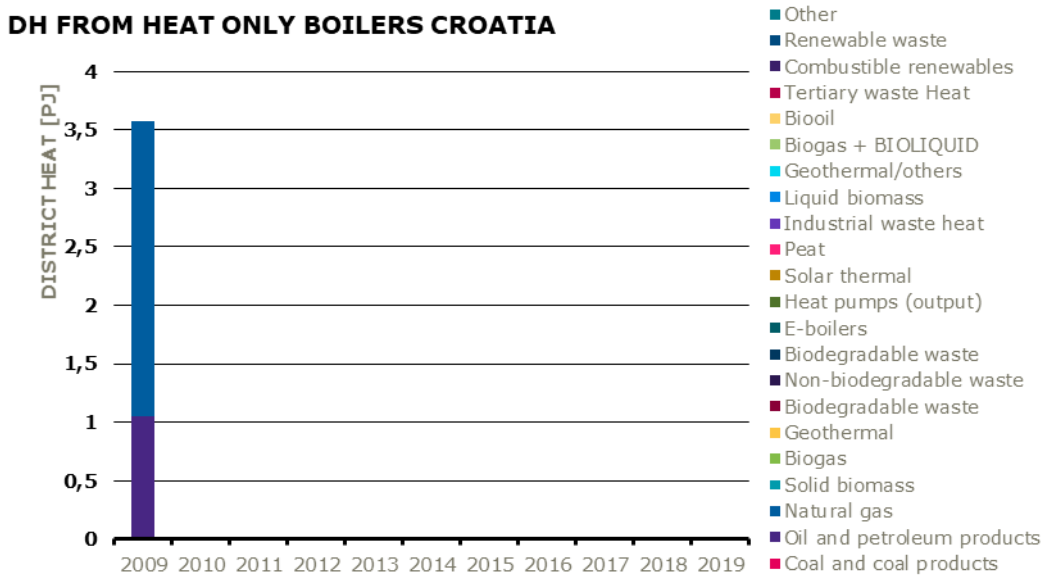


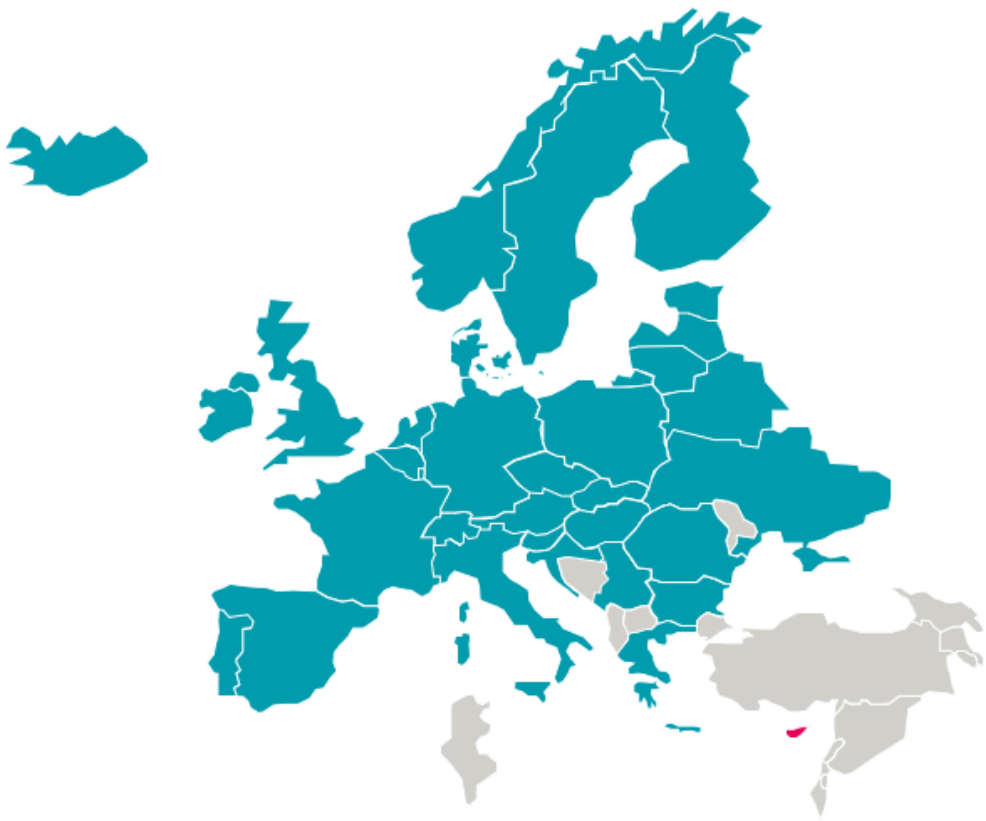
Figure 7-47: District heat generated in heat only boilers by year and fuel in Croatia. Based on data from [2], [3]

7.4.6 Energy storage

[*No data available*]

7.5 Cyprus

7.5.1 Country profile



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

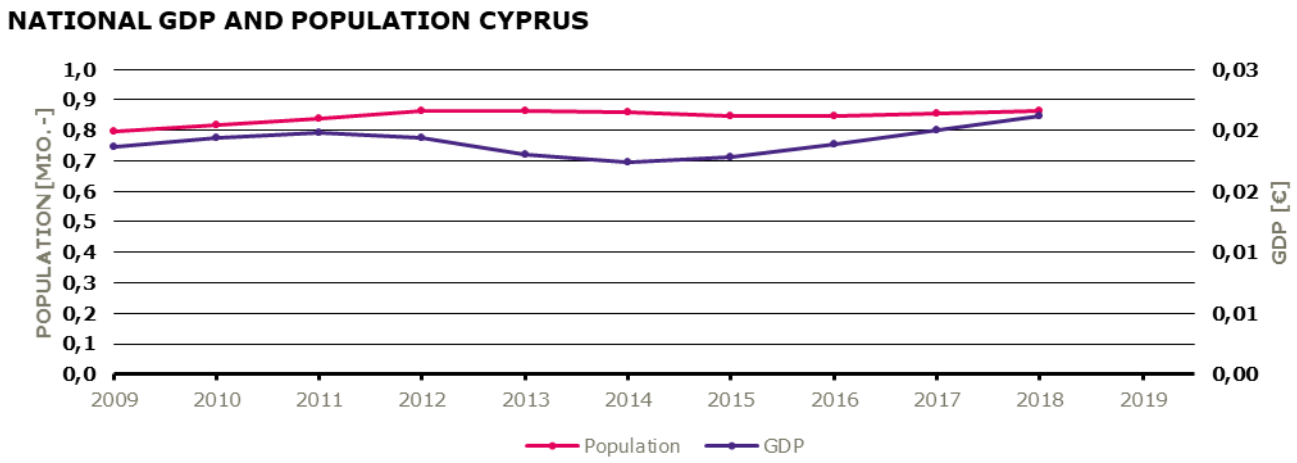


Figure 7-48: GDP and population development in Cyprus. Based on data from [1]

7.5.2 Energy use

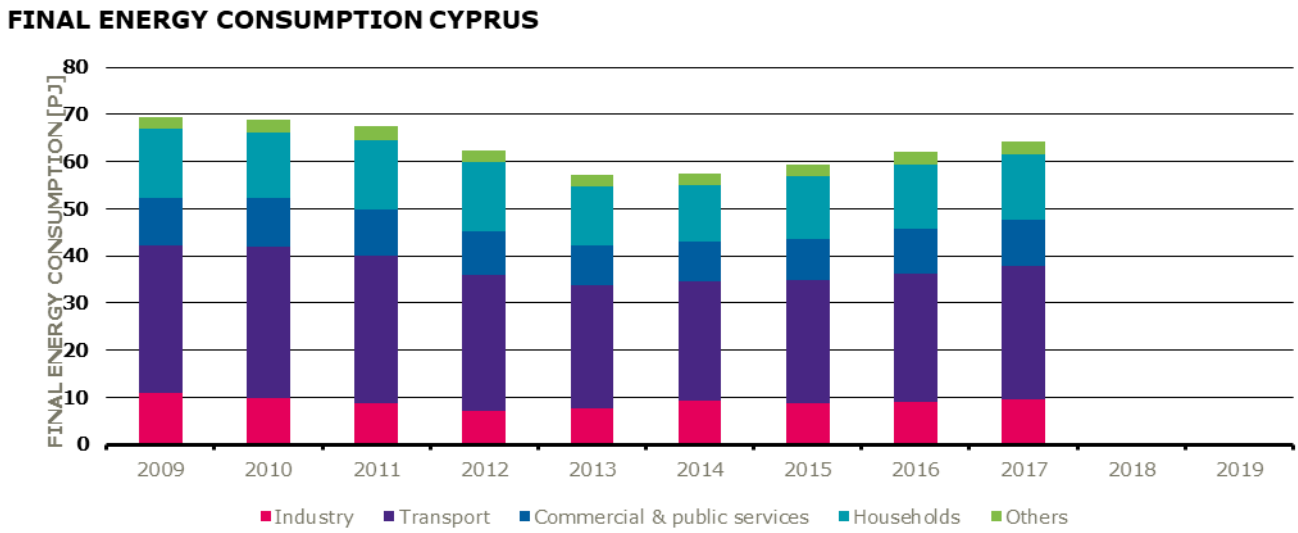


Figure 7-49: Final energy consumption by economic sector and year in Cyprus. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

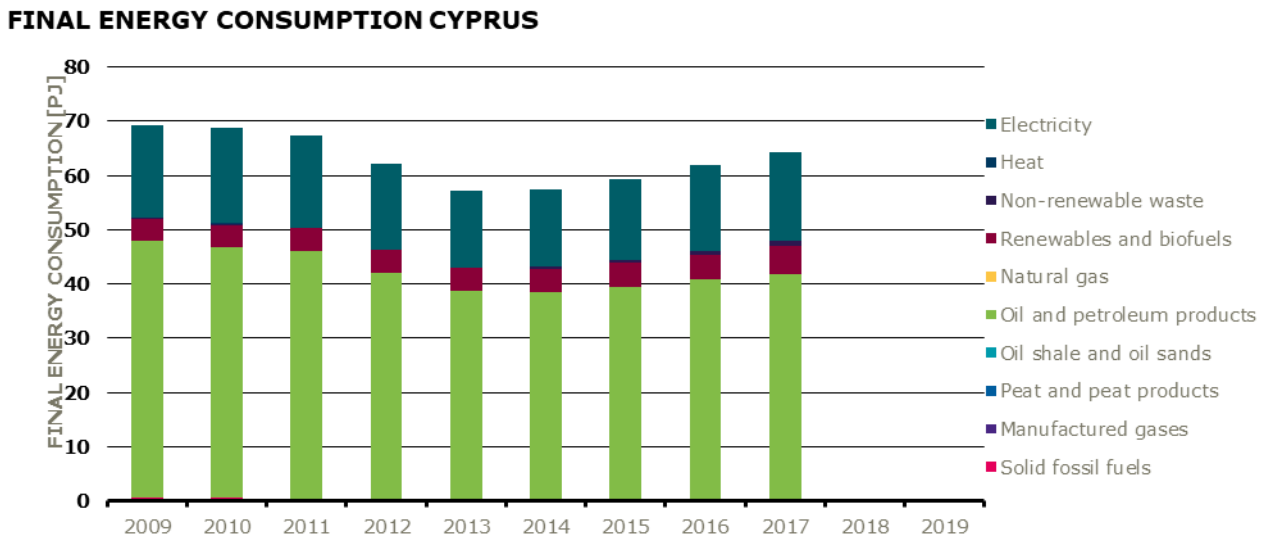


Figure 7-50: Final energy consumption by fuel and year in Cyprus. Based on data from [2]

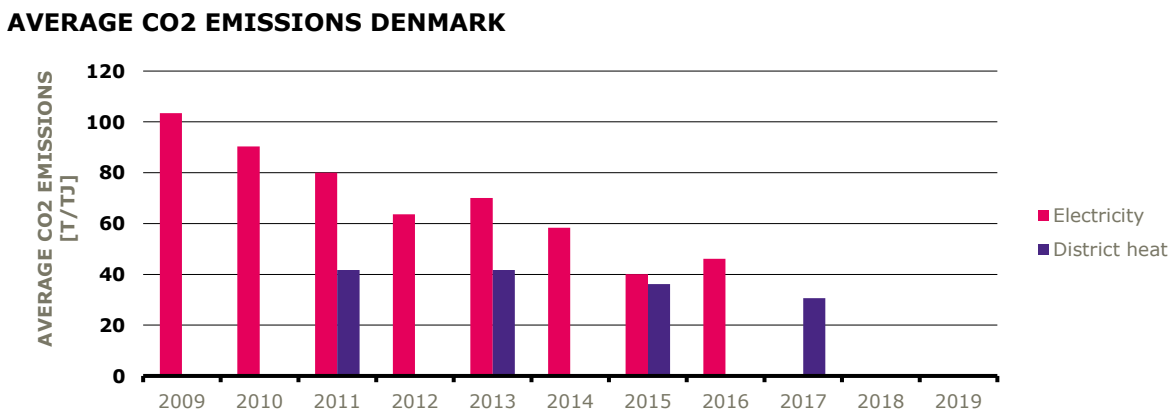


Figure 7-51: Average CO2 emissions in Cyprus. Based on data from [3] & [4]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.5.3 Heat Production

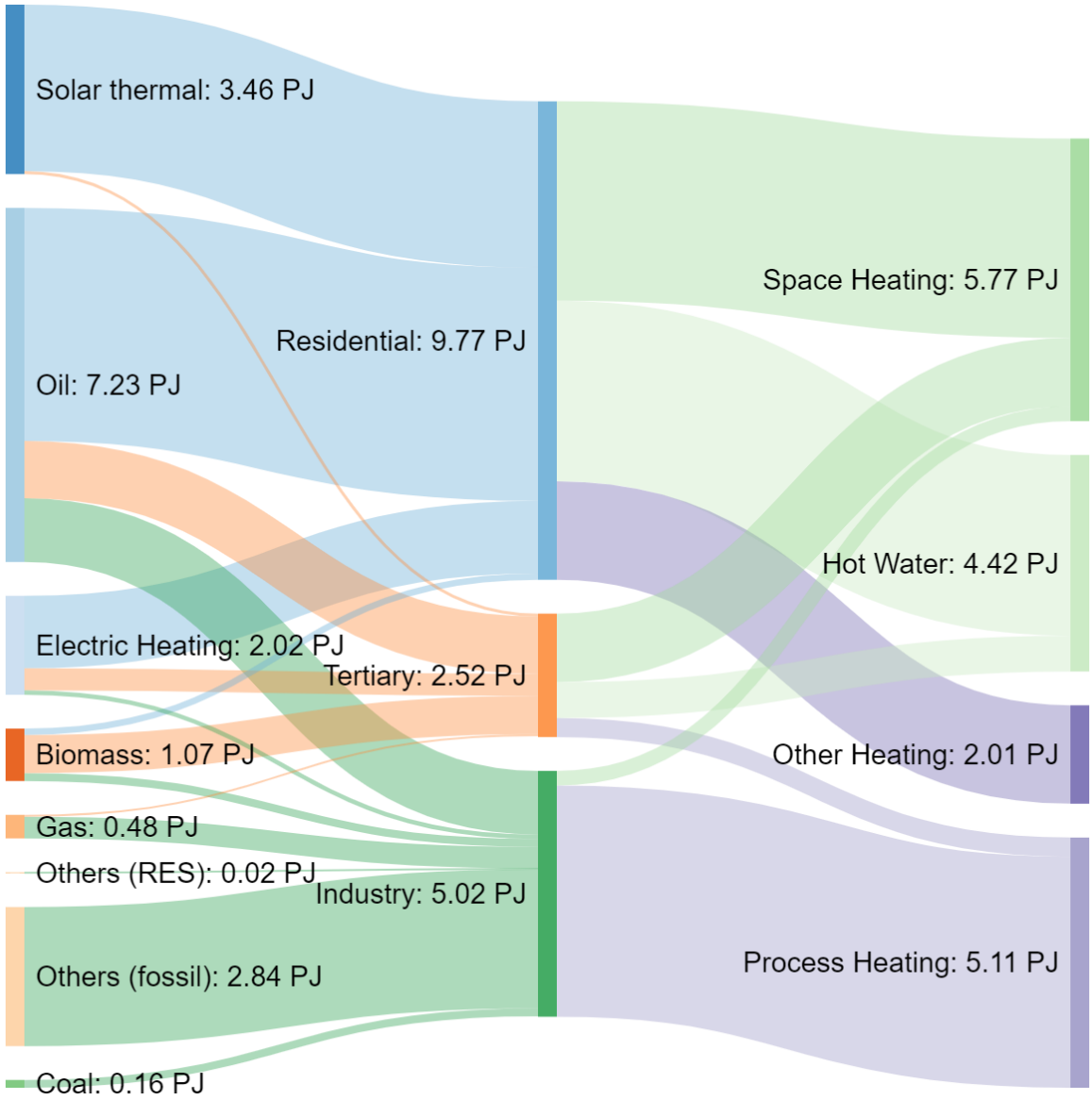


Figure 7-52: Sankey diagram of energy flows for heating purposes in Cyprus in 2015. Based on data from [3]

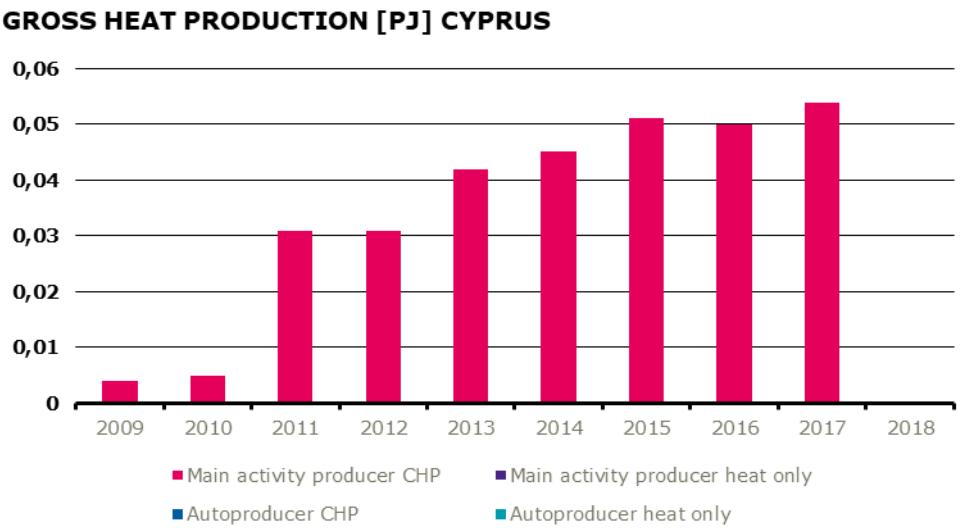


Figure 7-53: Gross heat production by producer type and year in Cyprus. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

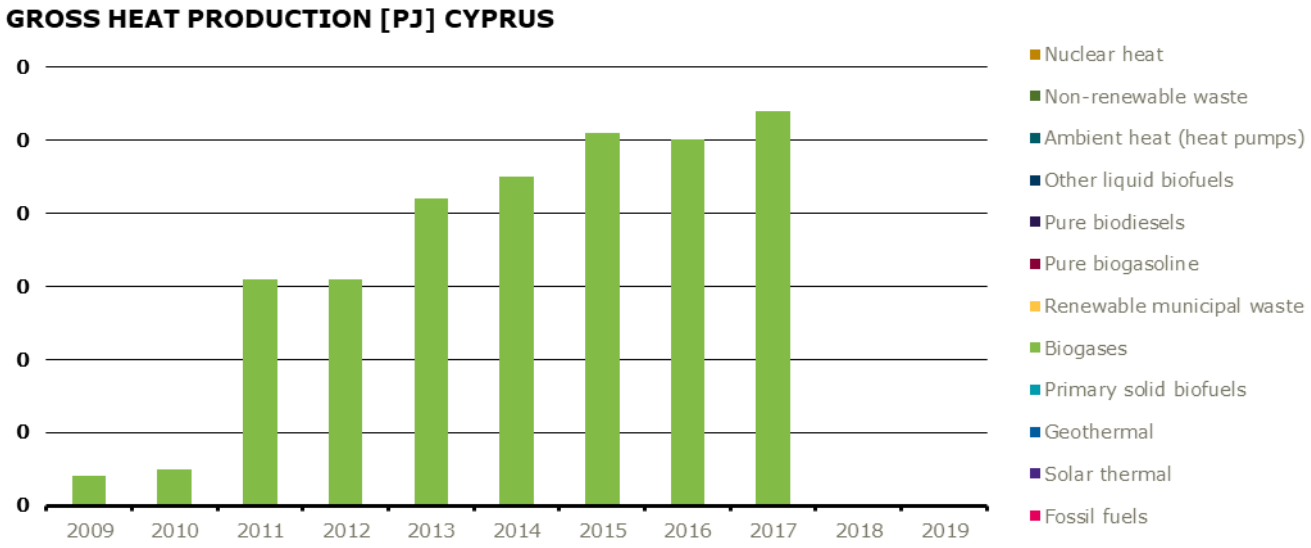


Figure 7-54: Gross heat production by fuel and year in Cyprus. Based on data from [2]

7.5.4 Electricity Production

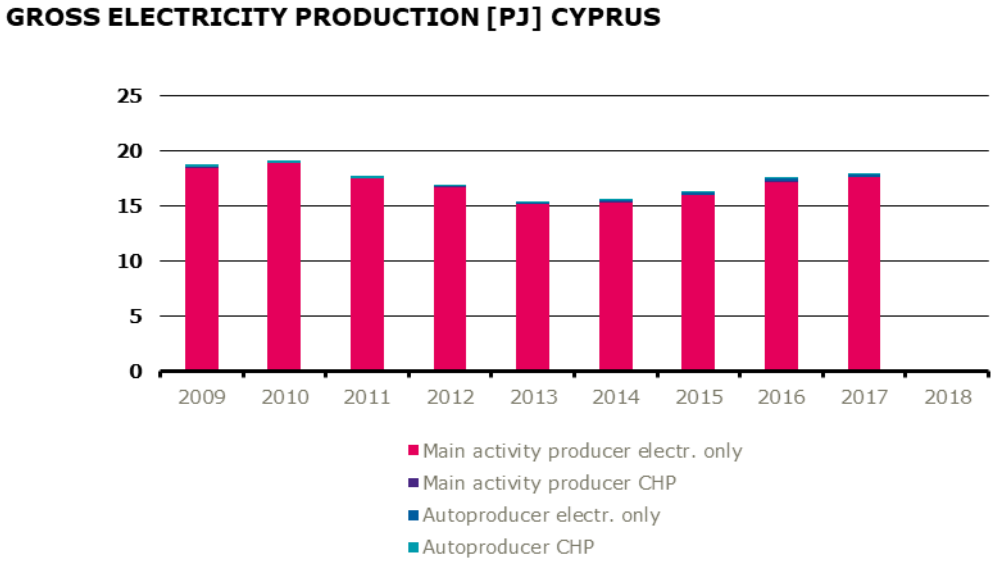


Figure 7-55: Gross electricity production by producer type and year in Cyprus. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

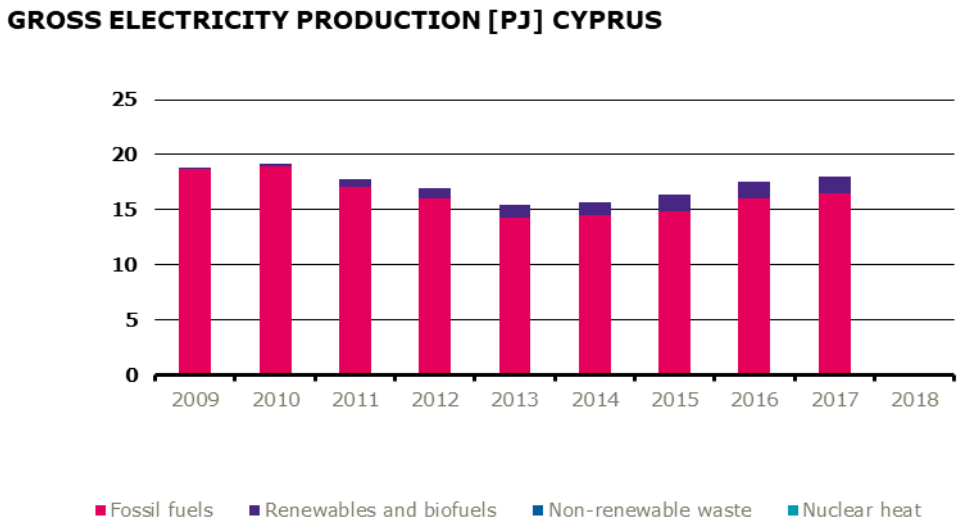


Figure 7-56: Gross electricity production by fuel type and year in Cyprus. Based on data from [2]

7.5.5 District Heat

[*No data available*]

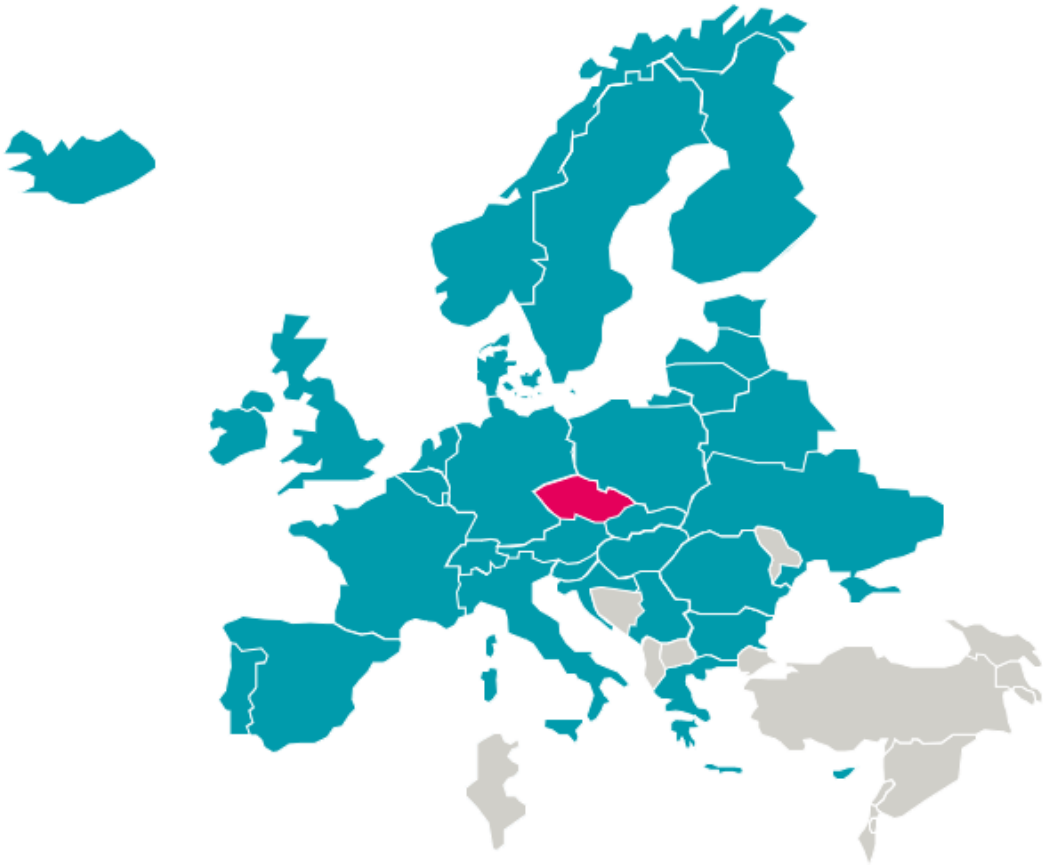
7.5.6 Energy storage

[*No data available*]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.6 Czechia

7.6.1 Country profile



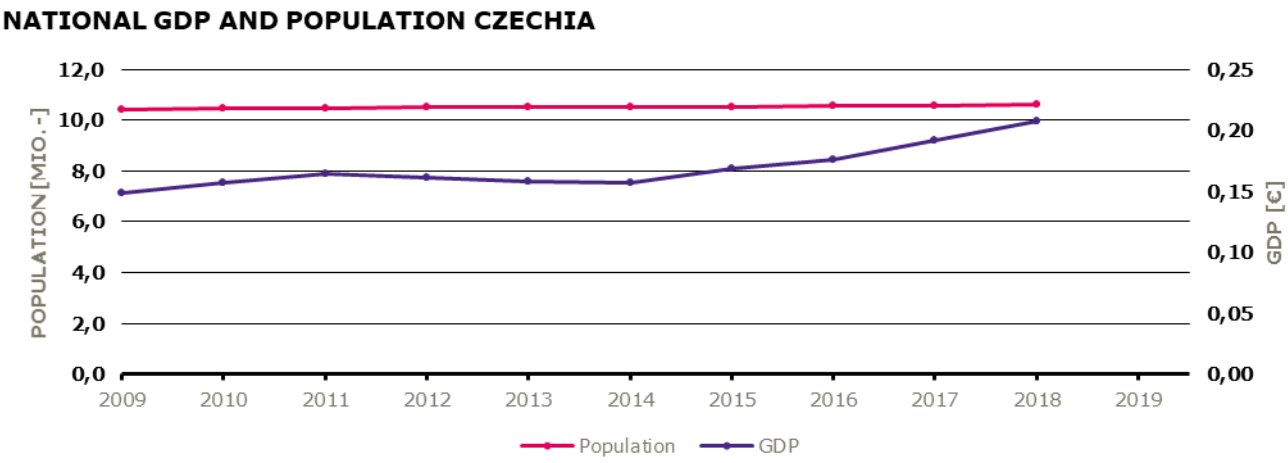


Figure 7-57: GDP and population development in Czechia. Based on data from [1]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.6.2 Energy use

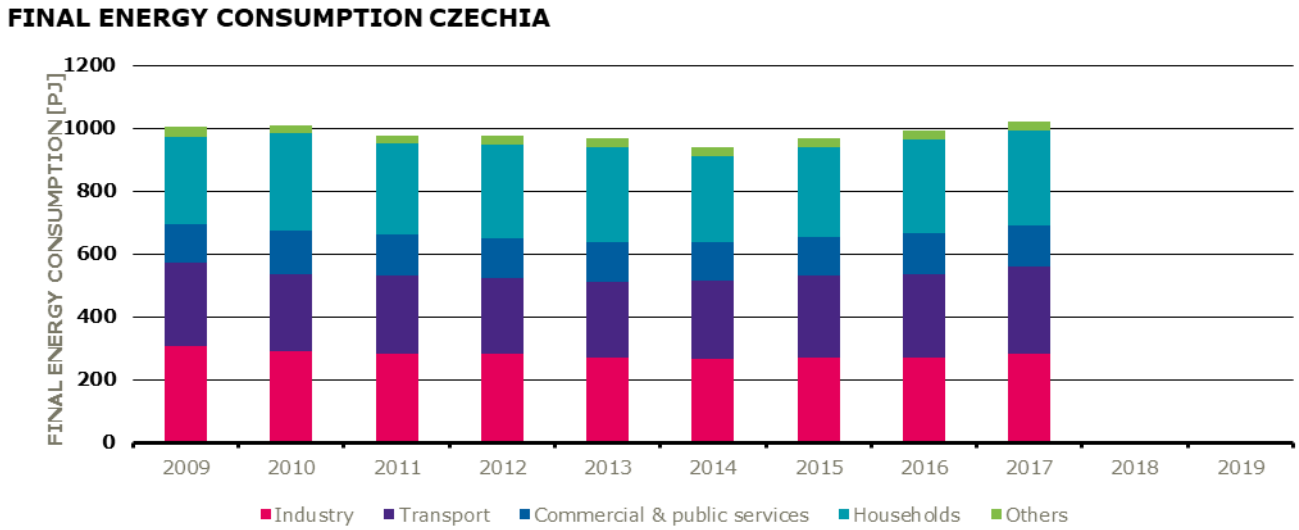


Figure 7-58: Final energy consumption by economic sector and year in Czechia. Based on data from [2]

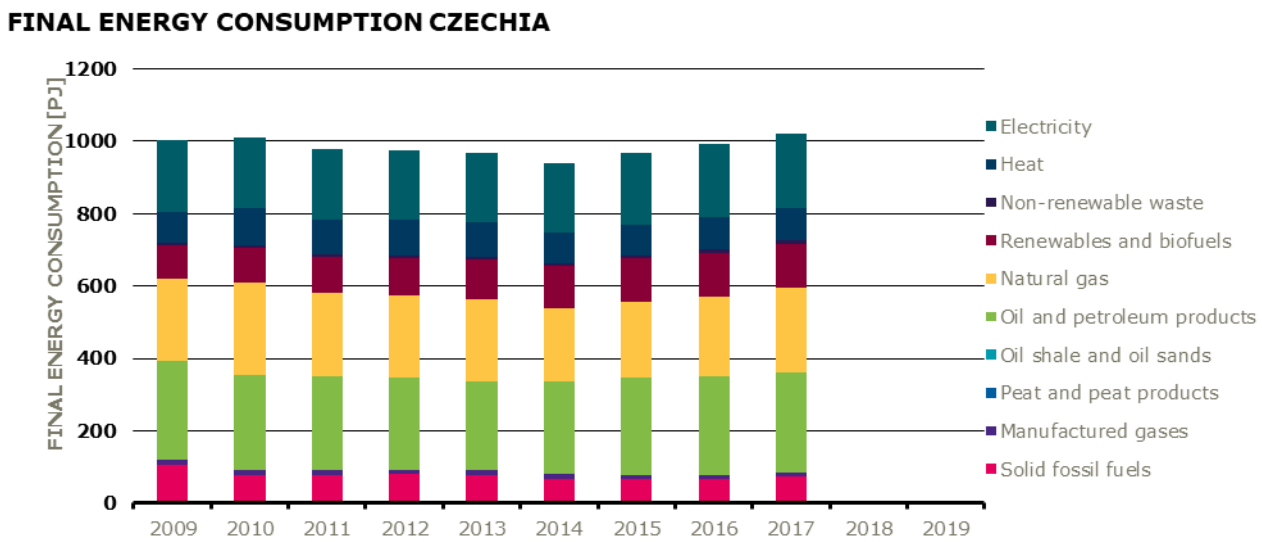


Figure 7-59: Final energy consumption by fuel and year in Czechia. Based on data from [2]

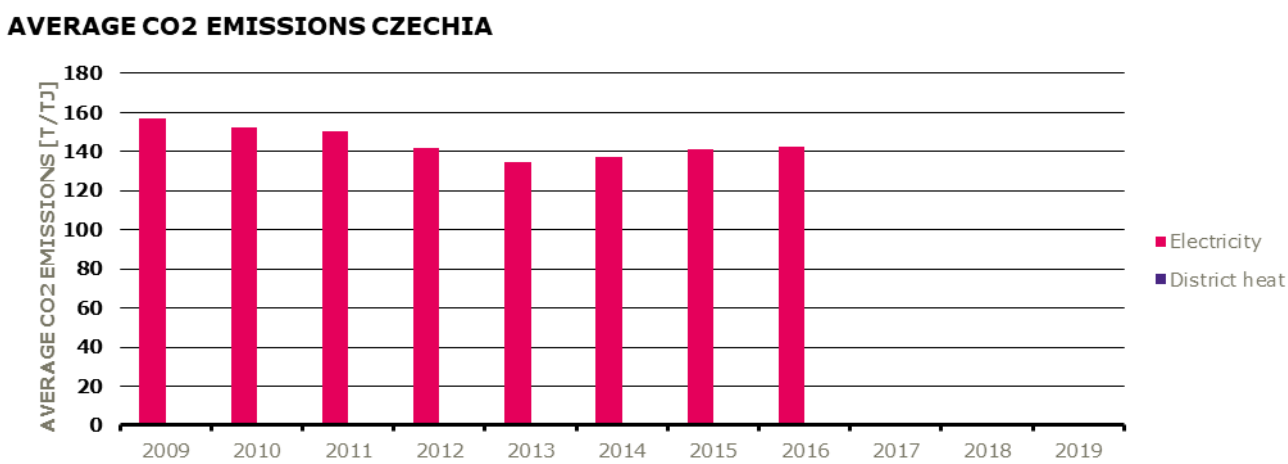


Figure 7-60: Average CO2 emissions in Czechia. Based on data from [3] & [4]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.6.3 Heat Production

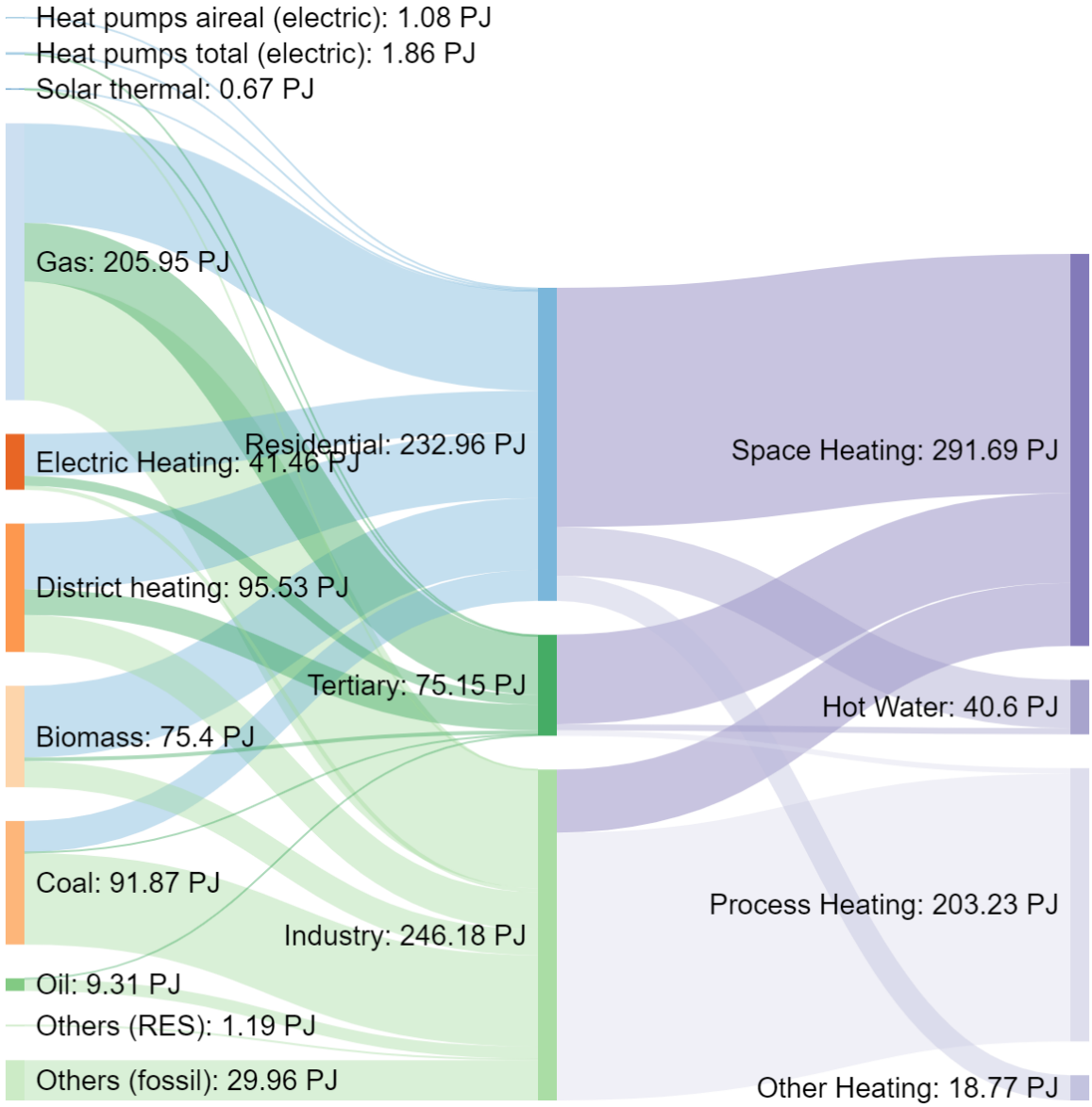


Figure 7-61: Sankey diagram of energy flows for heating purposes in Czechia in 2015. Based on data from [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

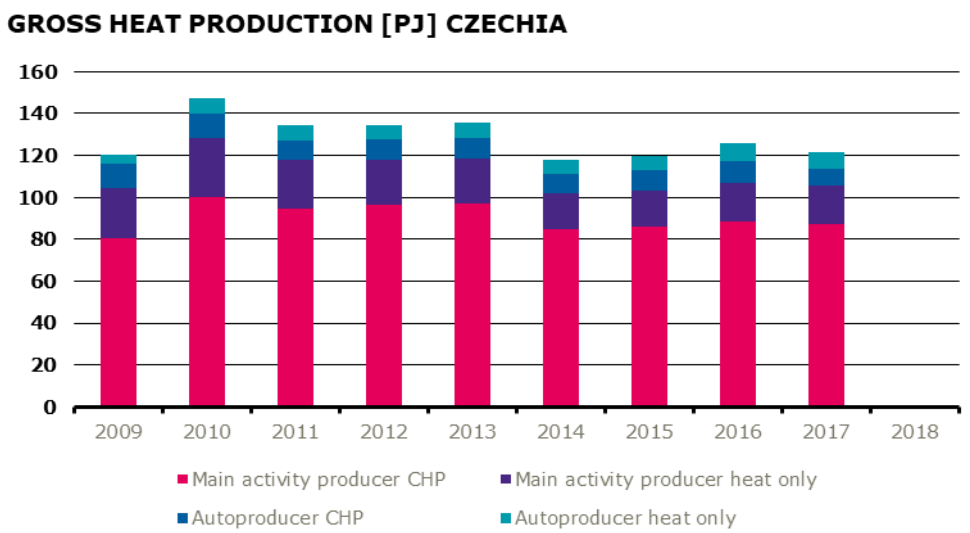


Figure 7-62: Gross heat production by producer type and year in Czechia. Based on data from [2]

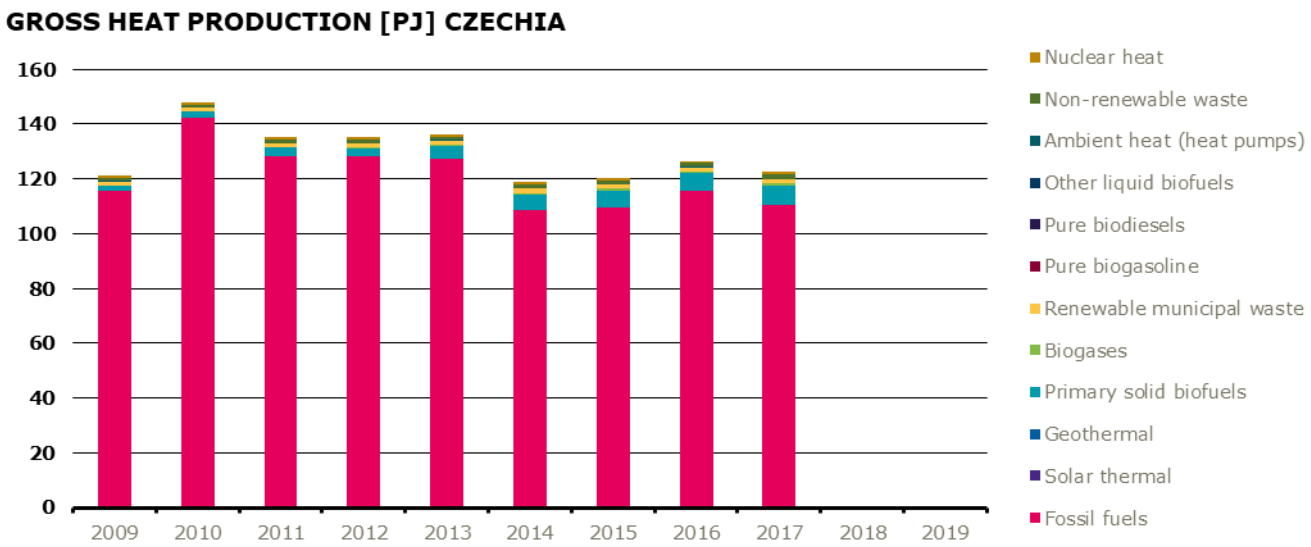


Figure 7-63: Gross heat production by fuel and year in Czechia. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.6.4 Electricity Production

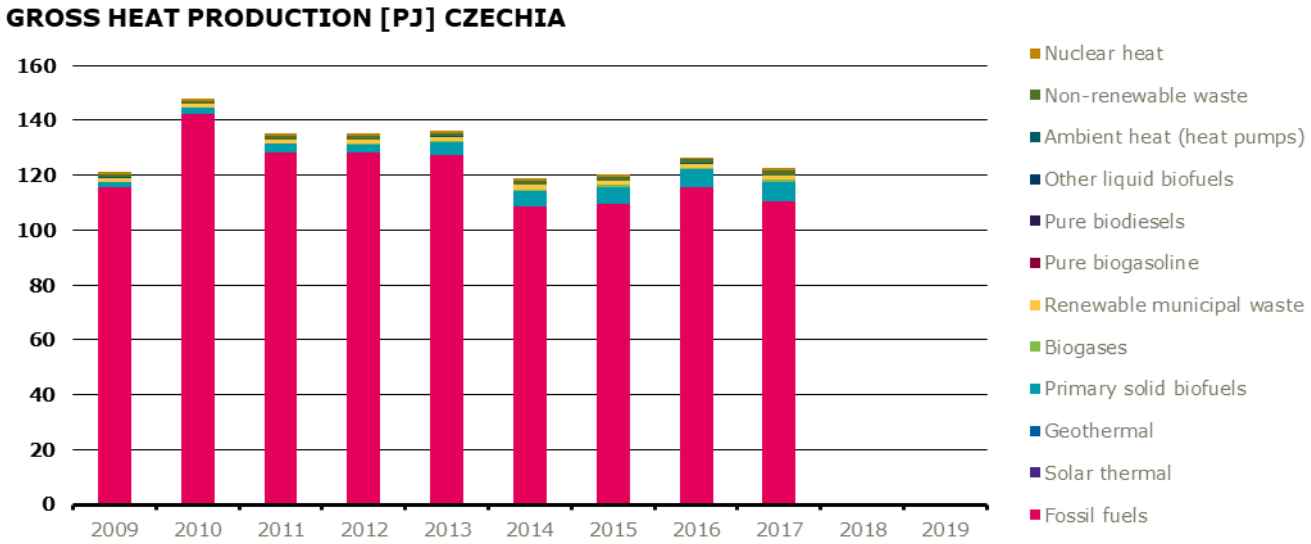


Figure 7-64: Gross electricity production by producer type and year in Czechia. Based on data from [2]

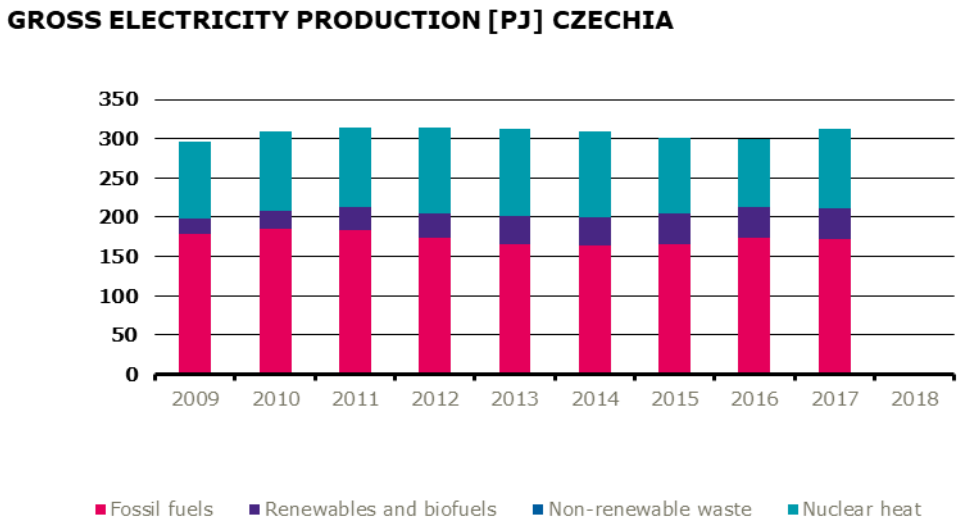


Figure 7-65: Gross electricity production by fuel type and year in Czechia. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.6.5 District Heat

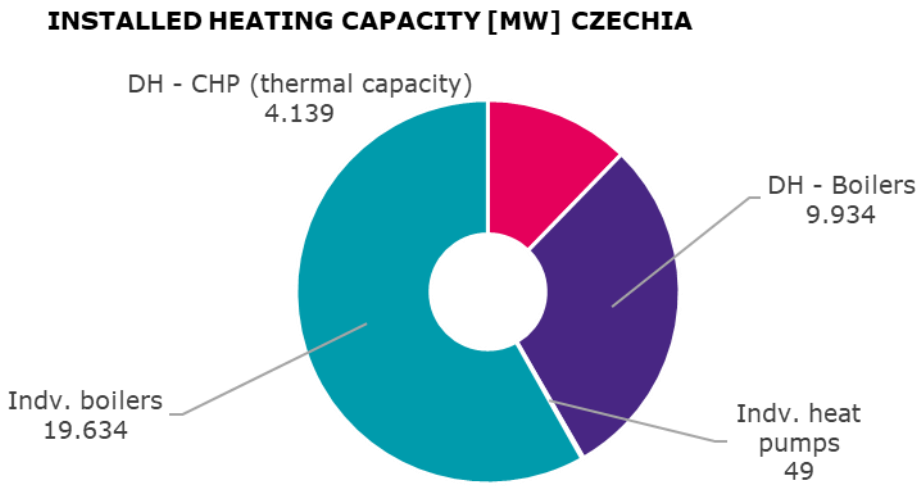


Figure 7-66: Installed heating capacity installed in Czechia in 2015. Based on data from [2]

7.6.6 Energy storage

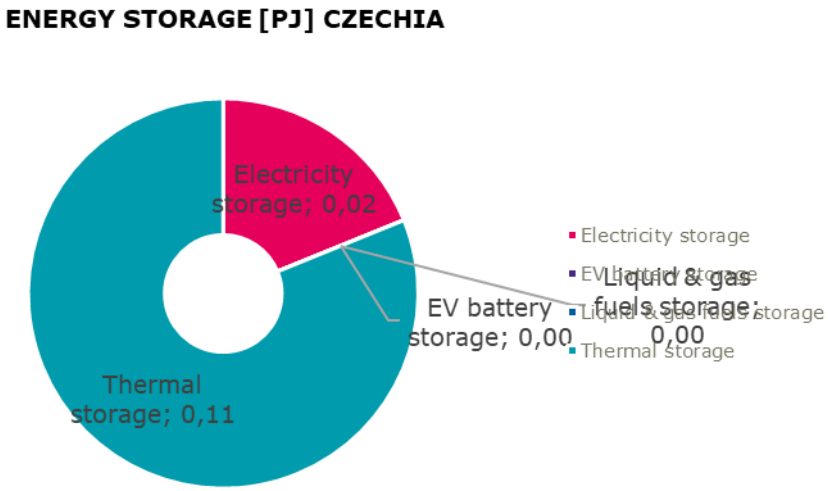


Figure 7-67: Stoage capacity in Czechia in 2015. Based on data from [2]

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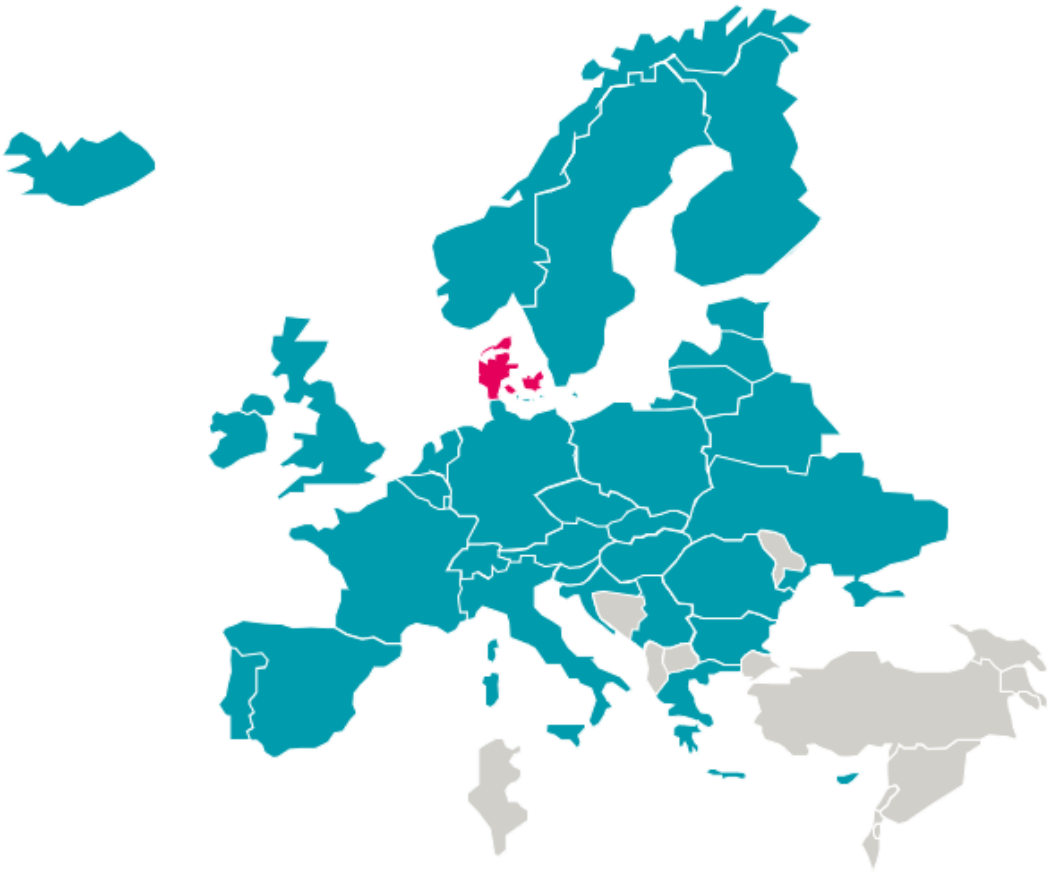
7.7 Denmark

7.7.1 Country profile



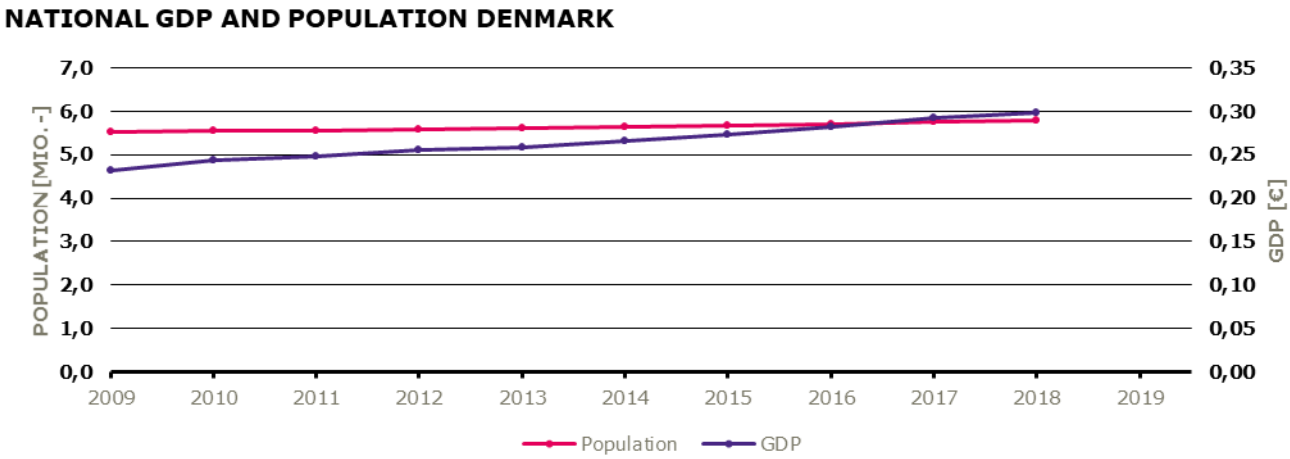


Figure 7-68: GDP and population development in Denmark. Based on data from [1]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.7.2 Energy use

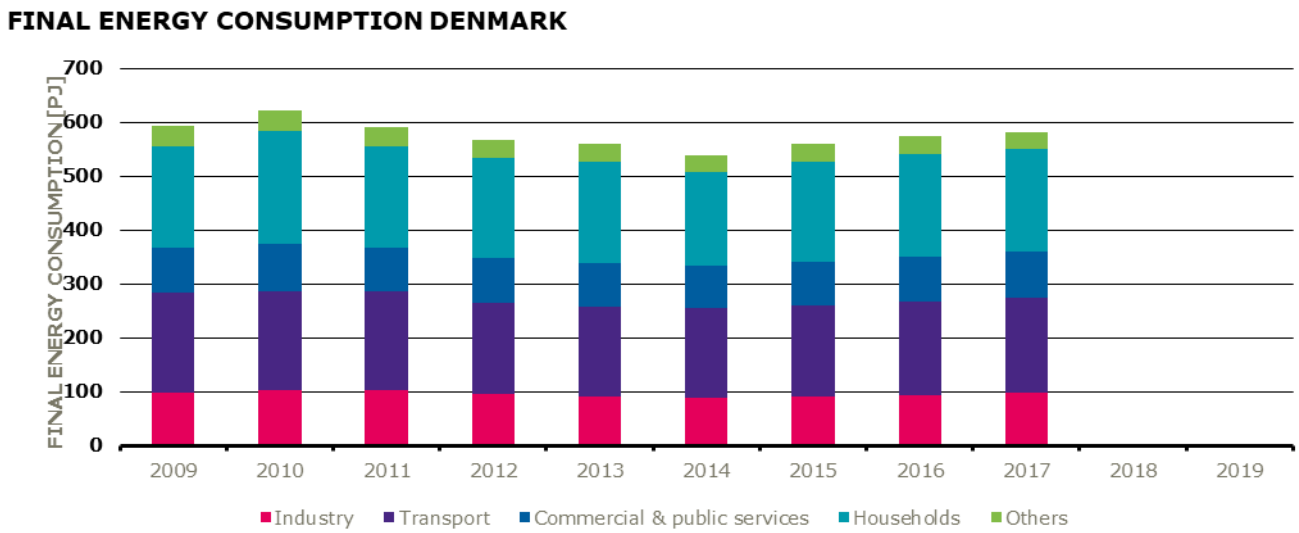


Figure 7-69: Final energy consumption by economic sector and year in Denmark. Based on data from [2]

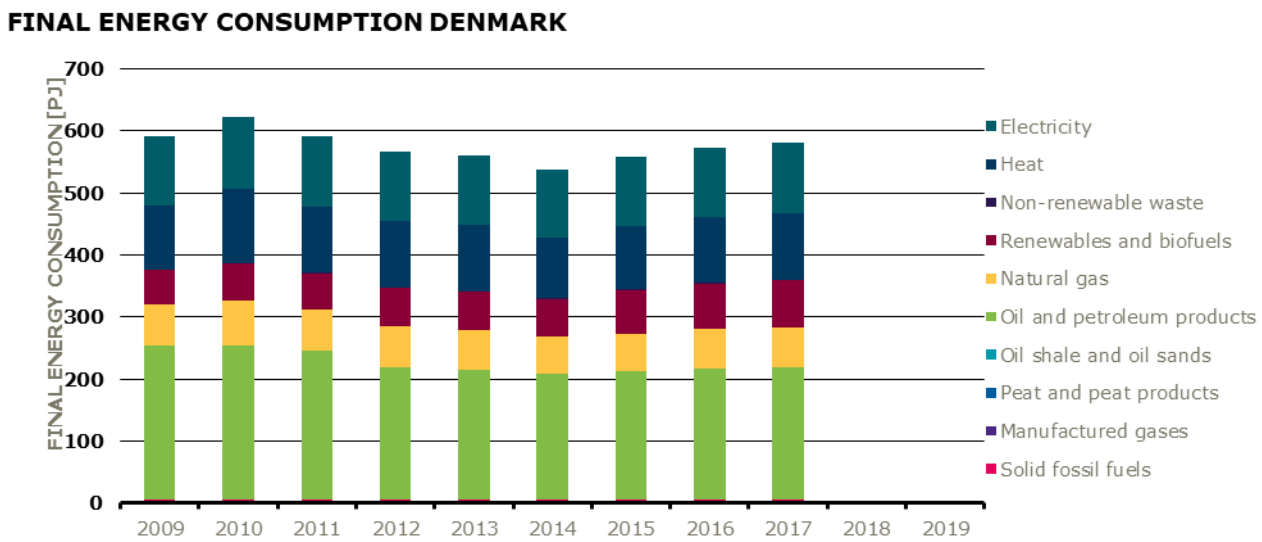


Figure 7-70: Final energy consumption by fuel and year in Denmark. Based on data from [2]

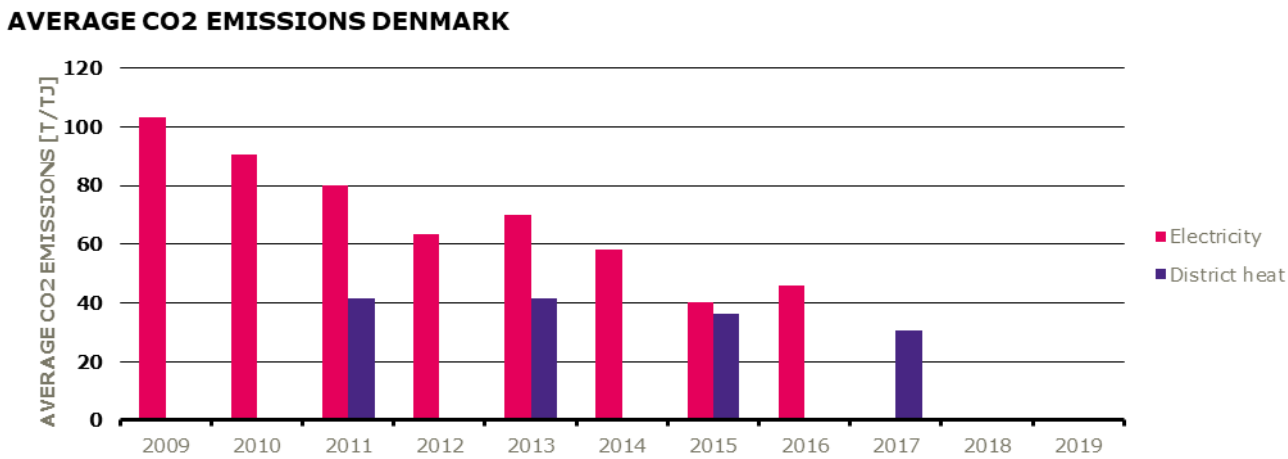


Figure 7-71: Average CO2 emissions in Denmark. Based on data from [3] & [4]

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7.7.3 Heat Production

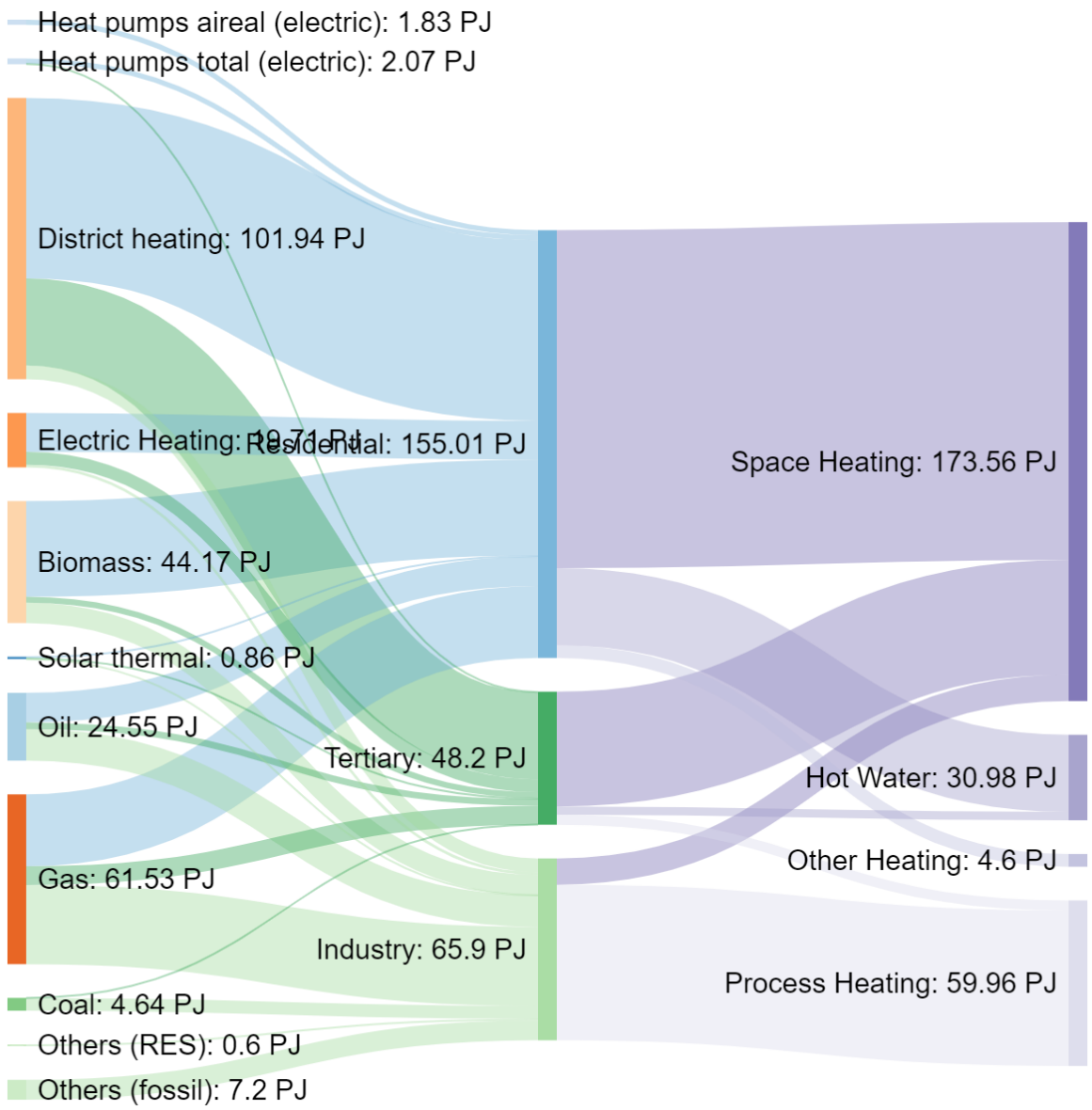


Figure 7-72: Sankey diagram of energy flows for heating purposes in Denmark in 2015. Based on data from [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

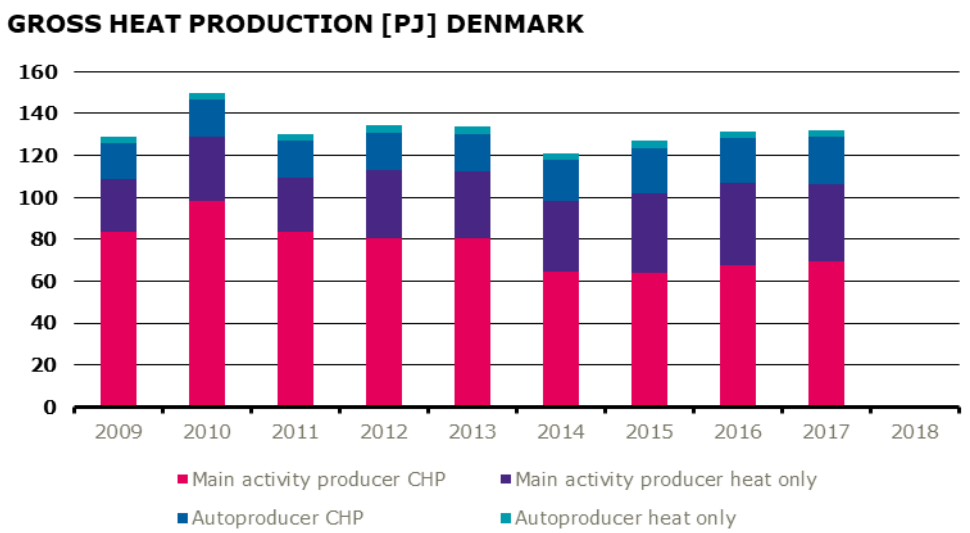


Figure 7-73: Gross heat production by producer type and year in Denmark. Based on data from [2]

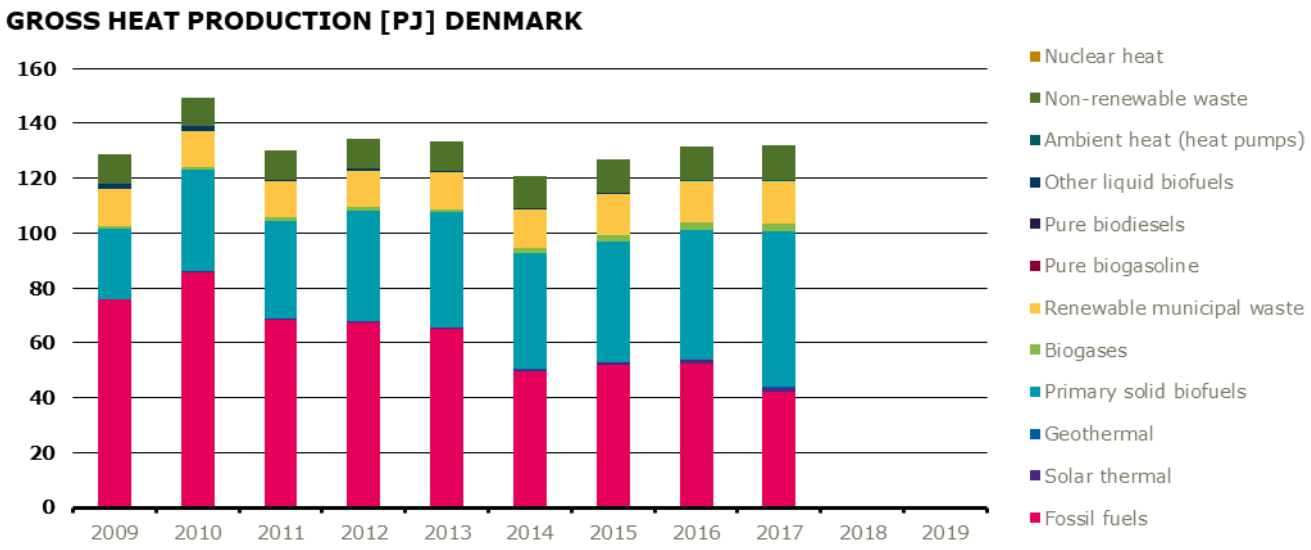


Figure 7-74: Gross heat production by fuel and year in Denmark. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

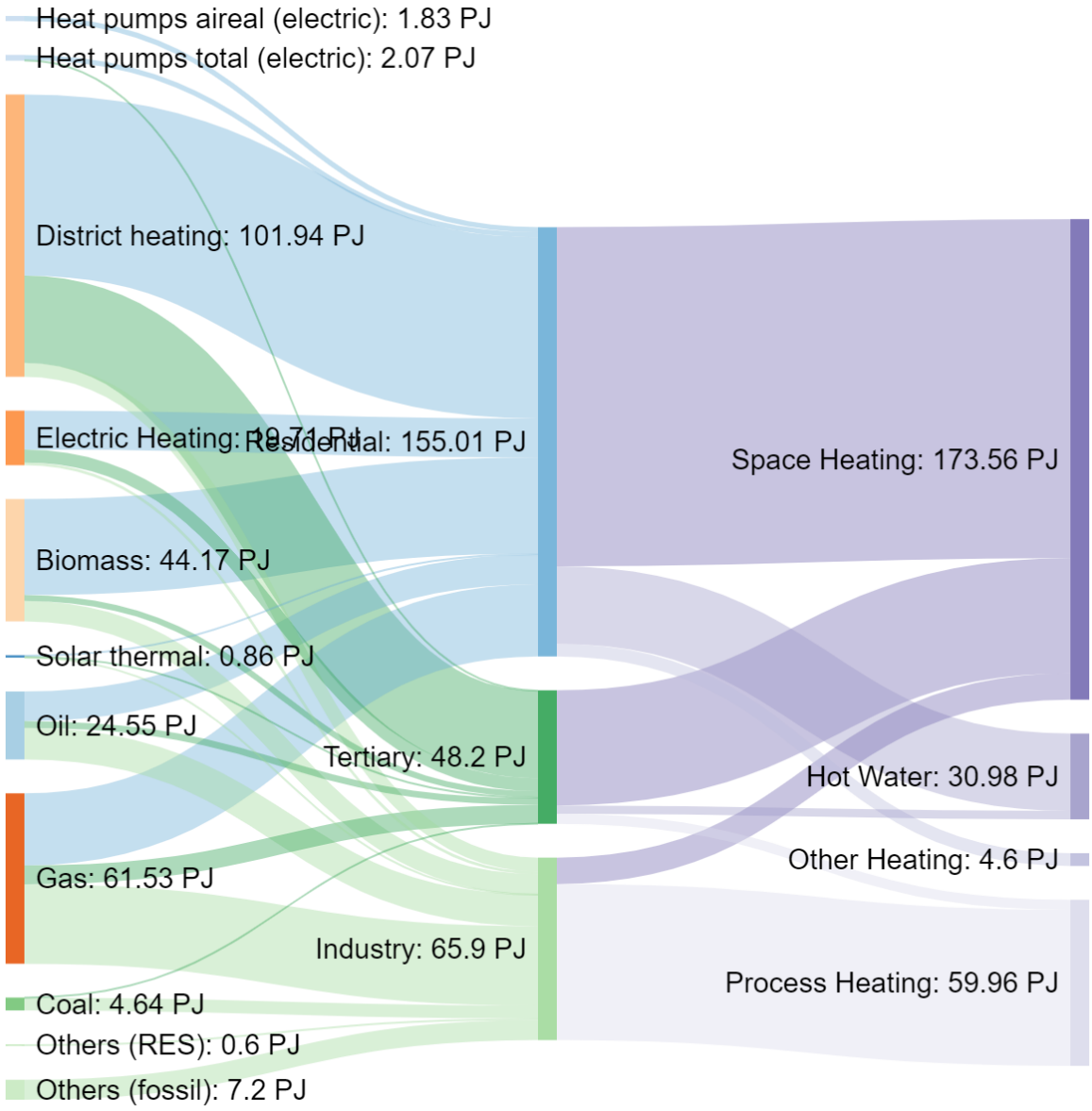


Figure 7-75: Sankey diagram of energy flows for heating purposes in Denmark in 2015. Based on data from [3]

7.7.4 Electricity Production

[*No data available*]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

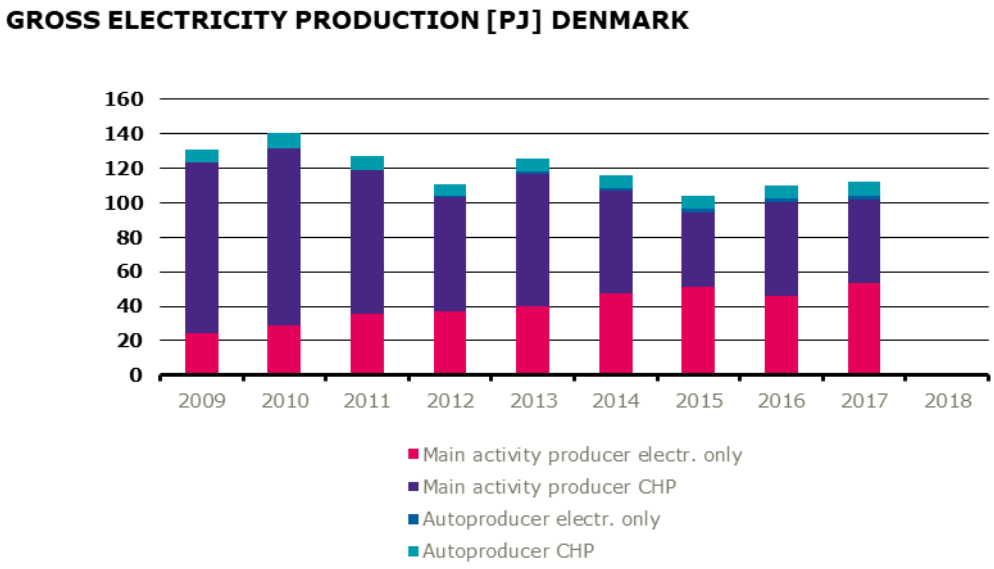


Figure 7-76: Gross electricity production by producer type and year in Denmark. Based on data from [2]

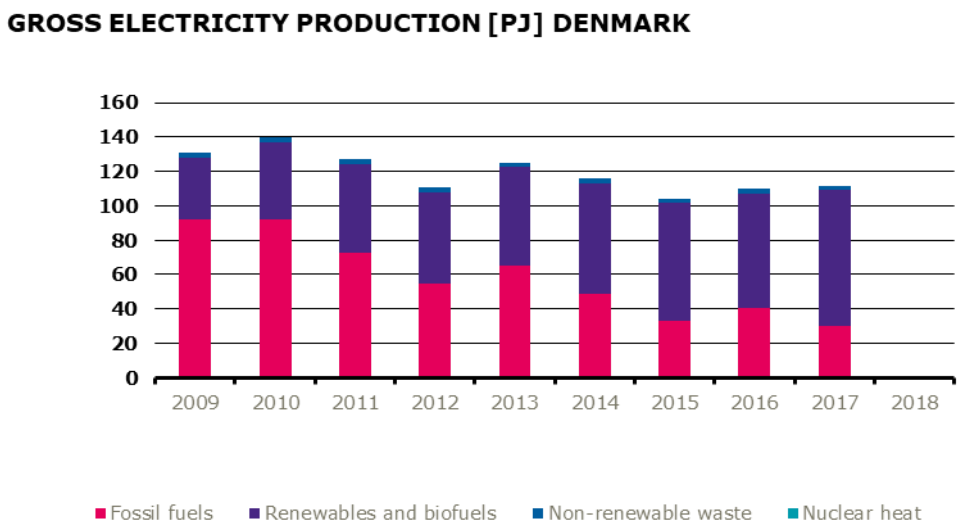


Figure 7-77: Gross electricity production by fuel type and year in Denmark. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.7.5 District Heat

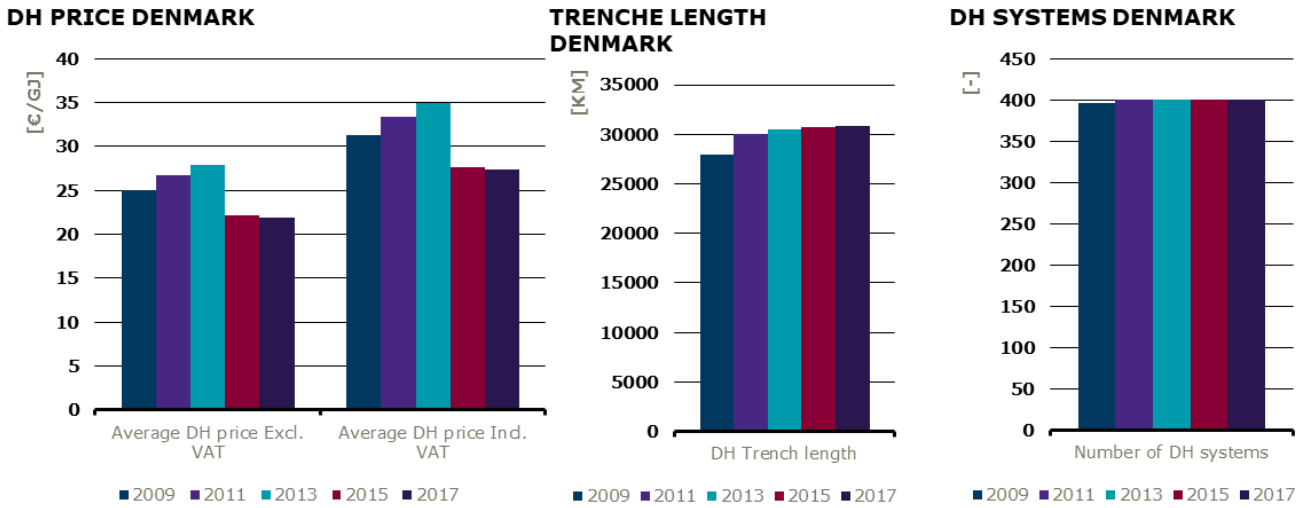


Figure 7-78: District heat indicators for Denmark. Based on data from [2]

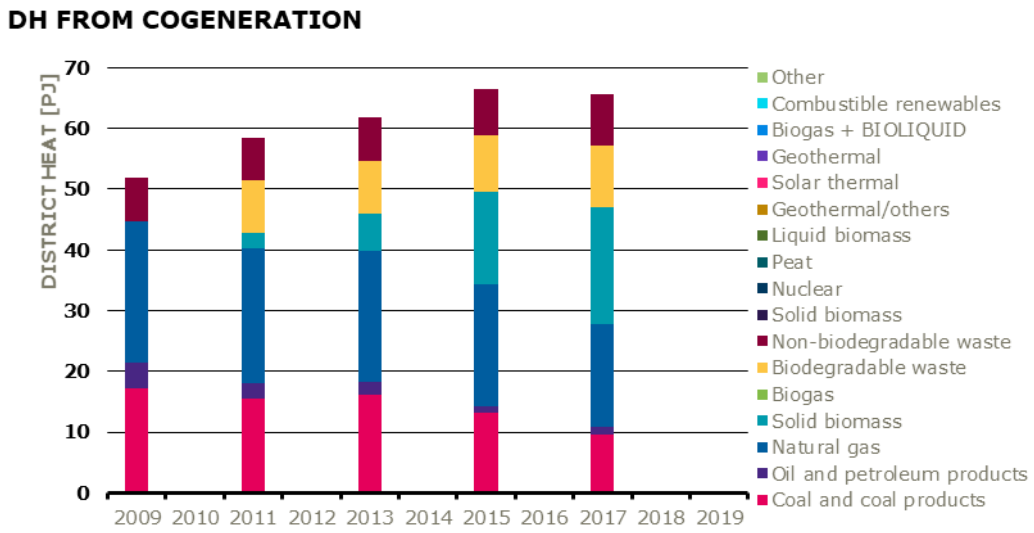


Figure 7-79: District heat generated in CHP plants by year and fuel in Denmark. Based on data from [2], [3]

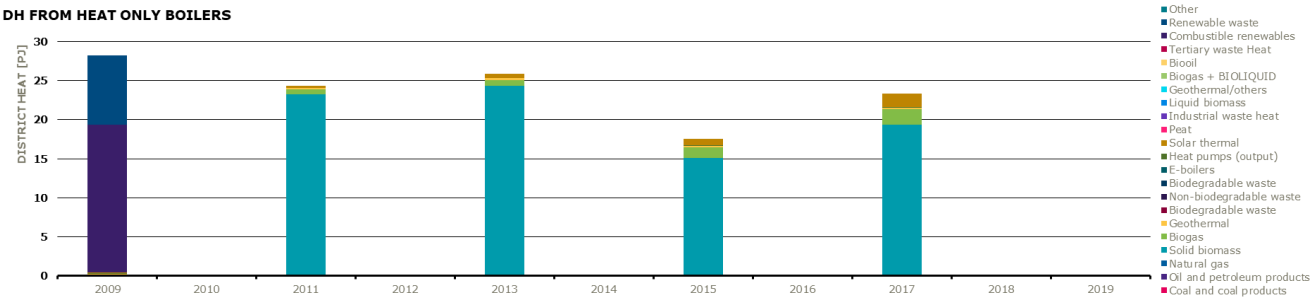


Figure 7-80: District heat generated in heat only boilers by year and fuel in Denmark. Based on data from [2], [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

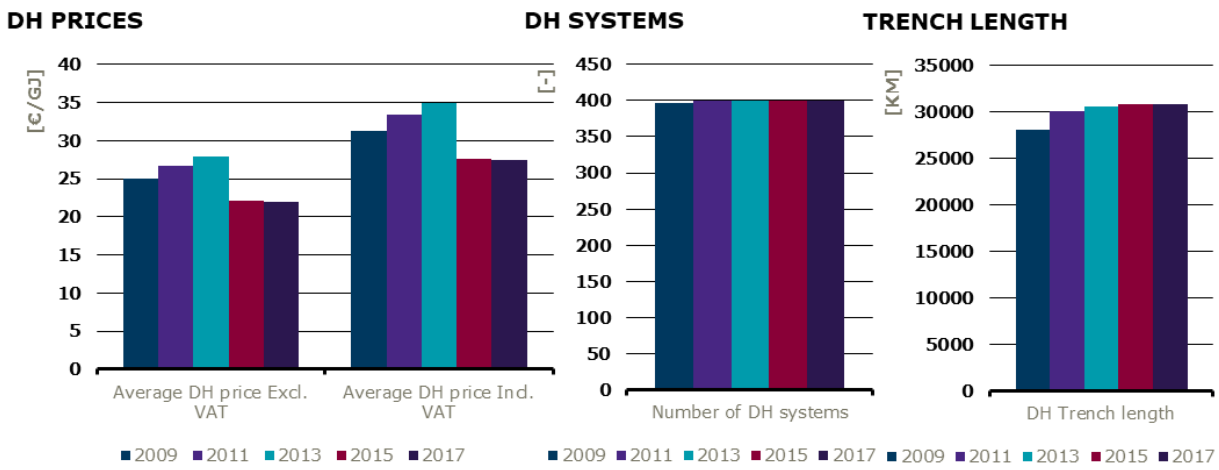


Figure 7-81: District heating indicators for Denmark. Based on data from [4], [5]

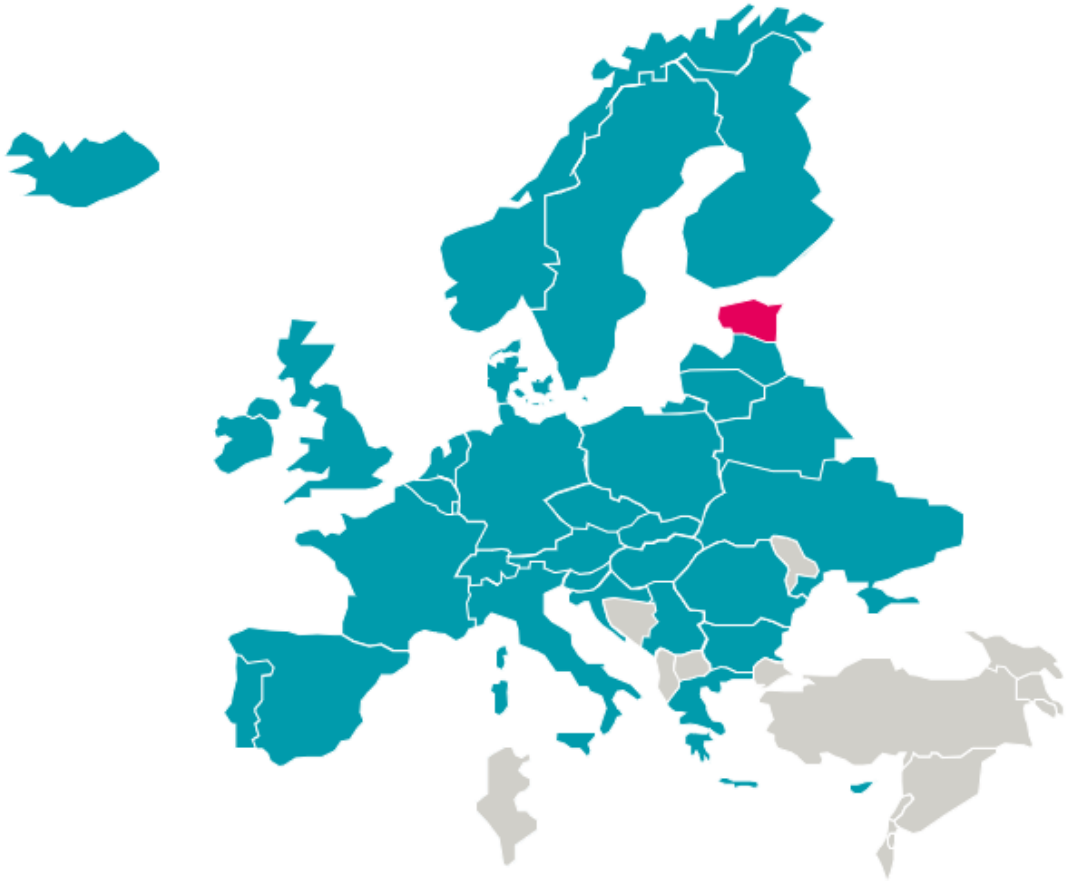
7.7.6 Energy storage

[*No data available*]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.8 Estonia

7.8.1 Country profile



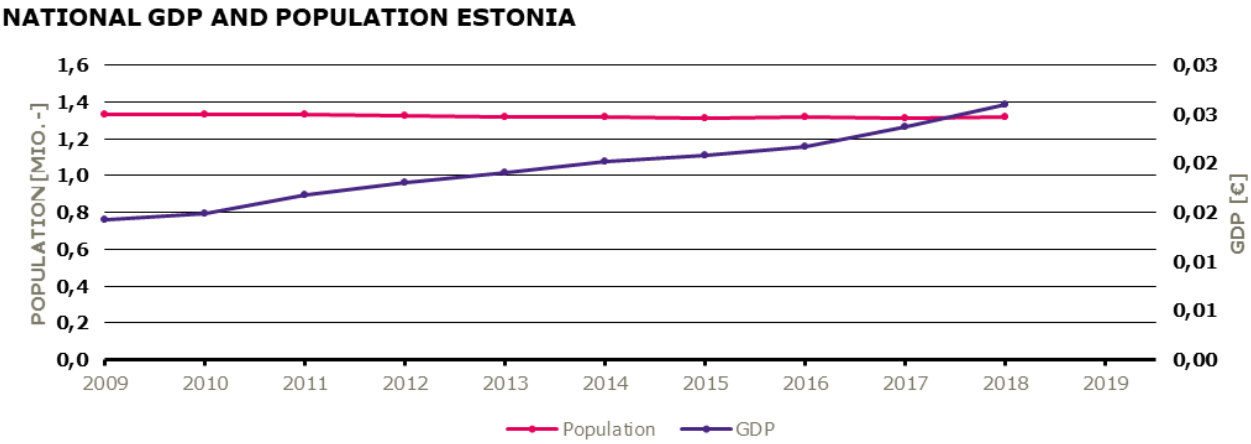


Figure 7-82: GDP and population development in Estonia. Based on data from [1]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.8.2 Energy use

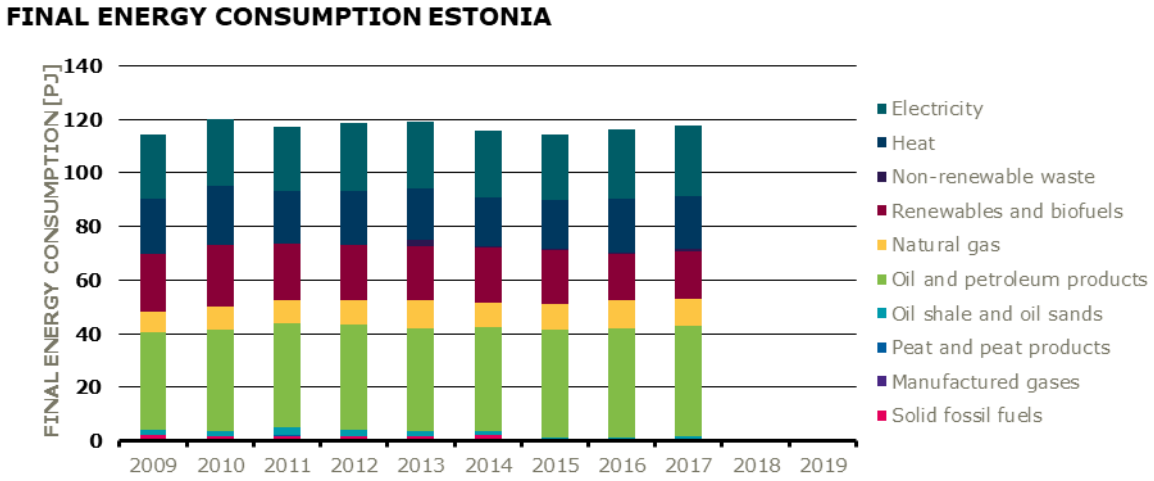


Figure 7-83: Final energy consumption by economic sector and year in Estonia. Based on data from [2]

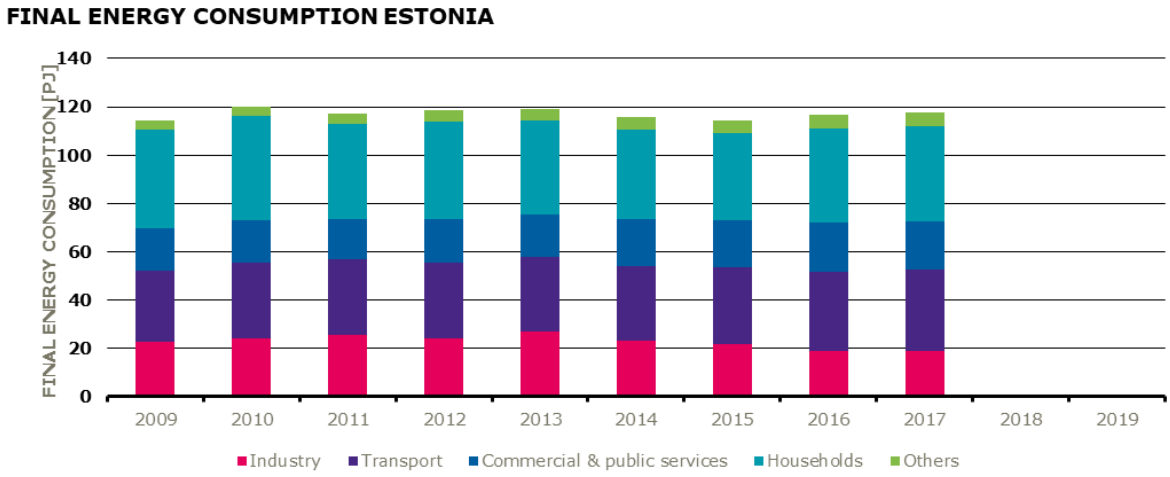


Figure 7-84: Final energy consumption by fuel and year in Estonia. Based on data from [2]

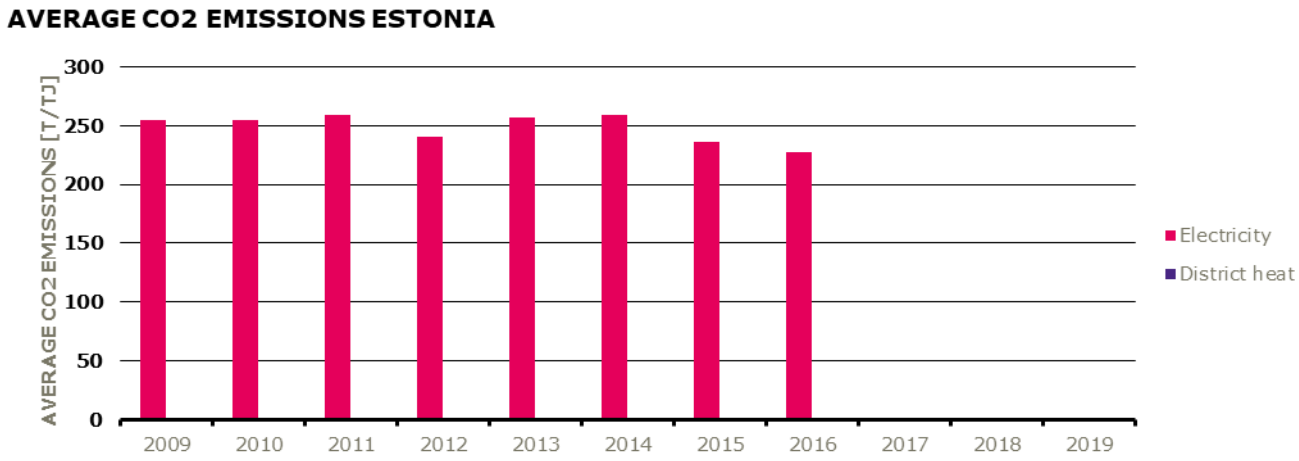


Figure 7-85: Average CO2 emissions in Estonia. Based on data from [3] & [4]

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7.8.3 Heat Production

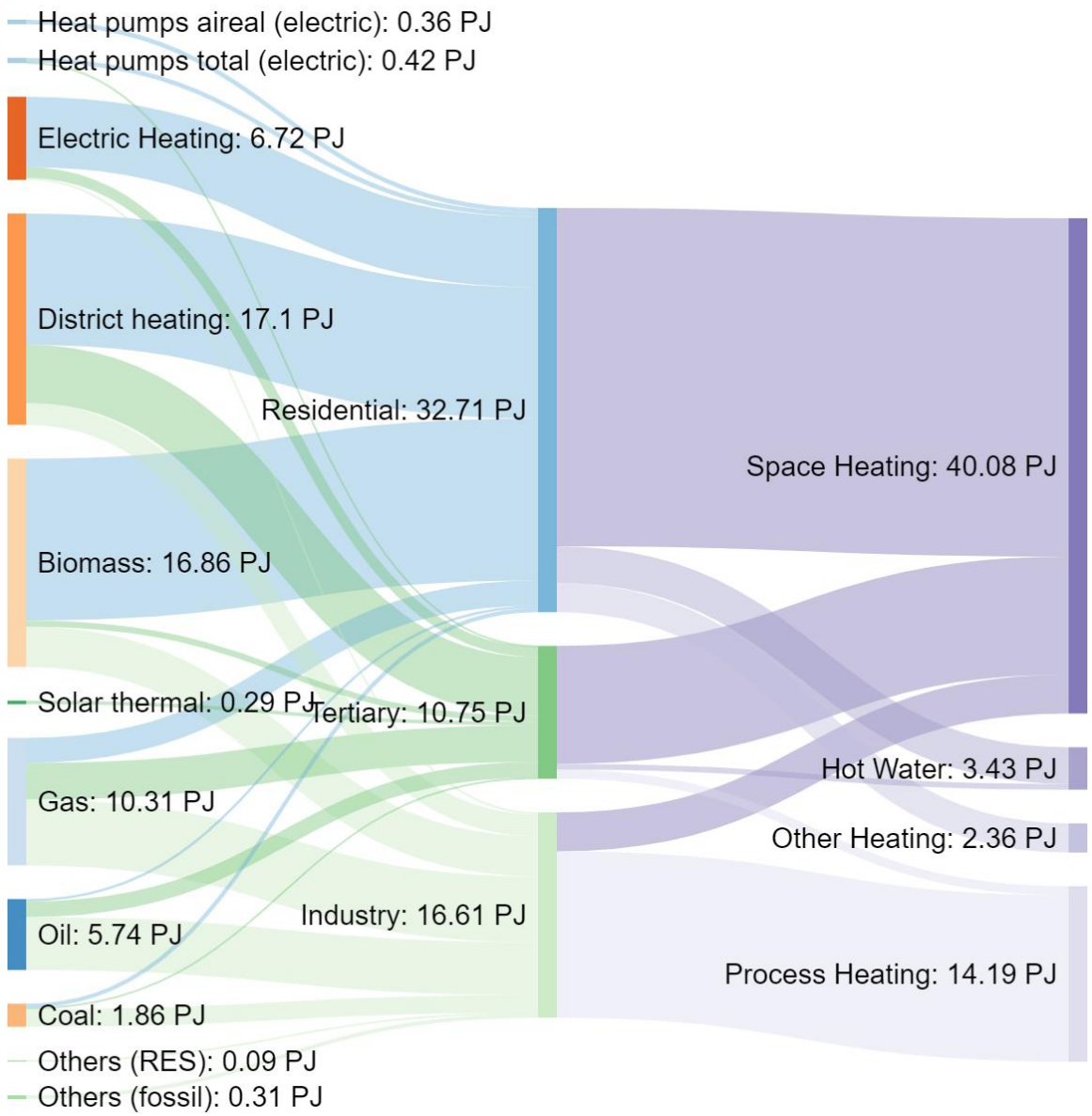

Figure 7-86: Sankey diagram of energy flows for heating purposes in Estonia in 2015. Based on data from [3]

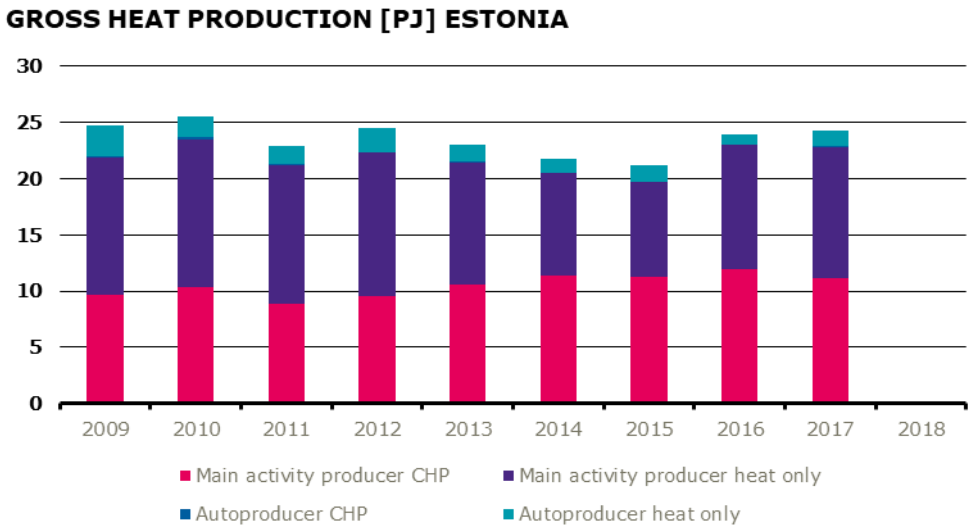

Figure 7-87: Gross heat production by producer type and year in Estonia. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

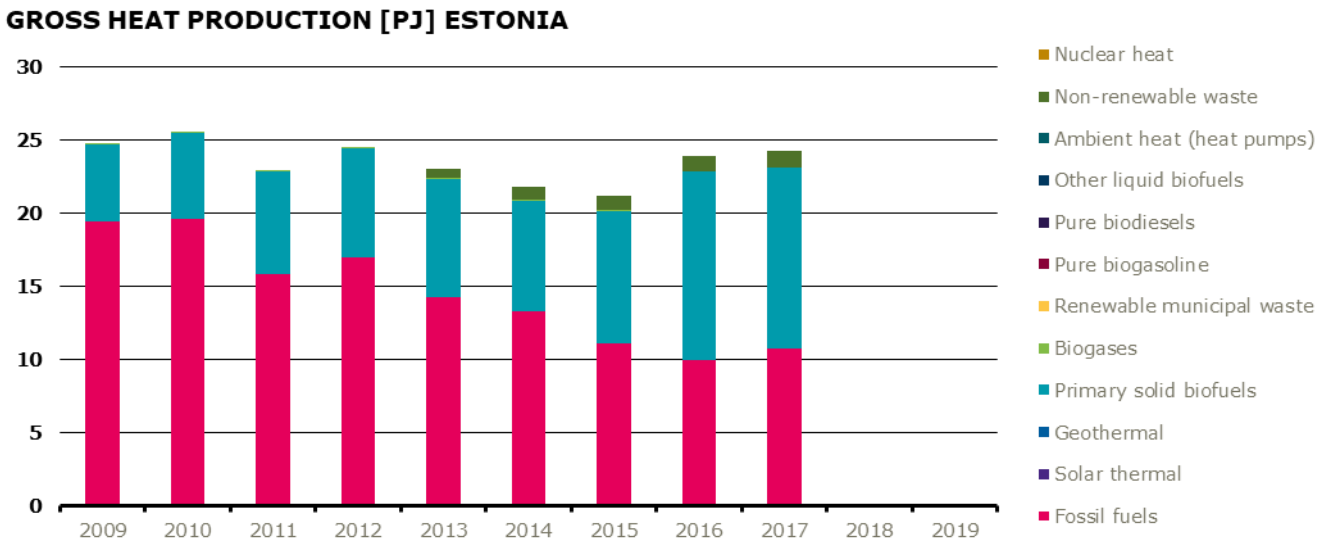

Figure 7-88: Gross heat production by fuel and year in Estonia. Based on data from [2]

7.8.4 Electricity Production

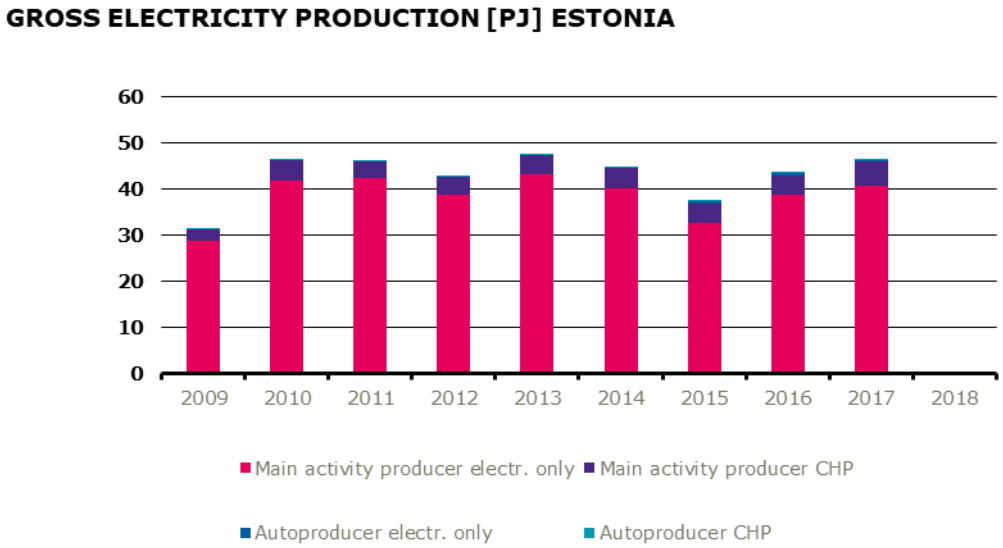

Figure 7-89: Gross electricity production by producer type and year in Estonia. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

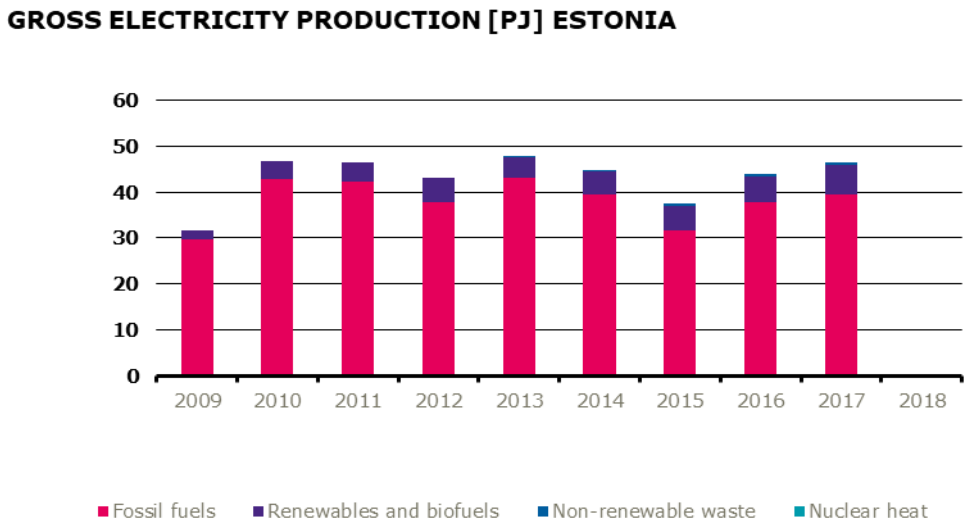

Figure 7-90: Gross electricity production by fuel type and year in Estonia. Based on data from [2]

7.8.5 District Heat

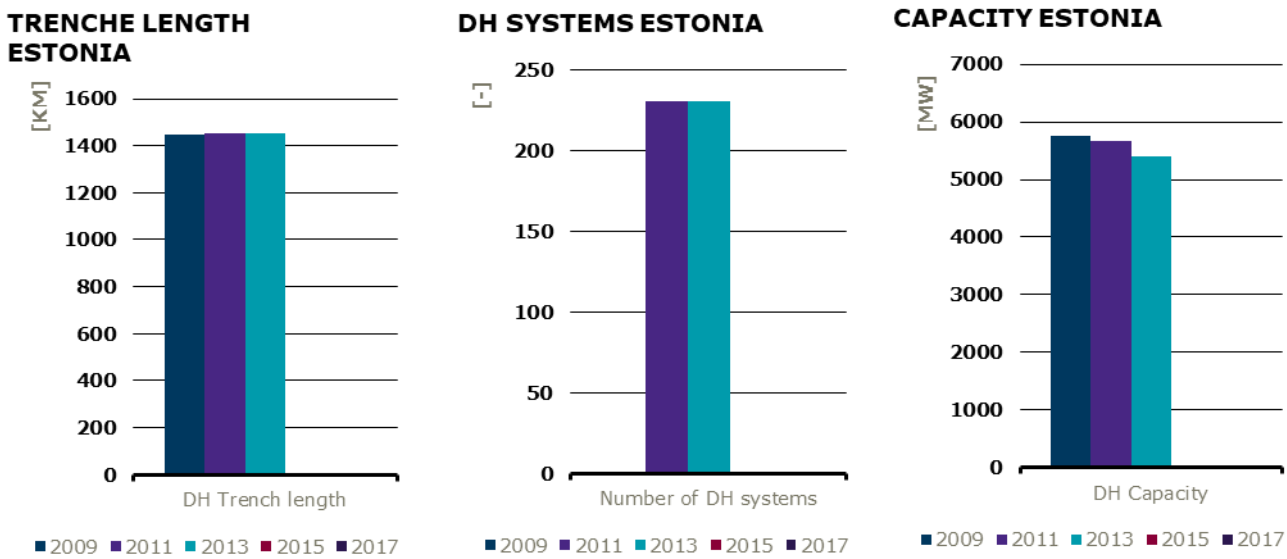

Figure 7-91: District heat indicators for Estonia. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

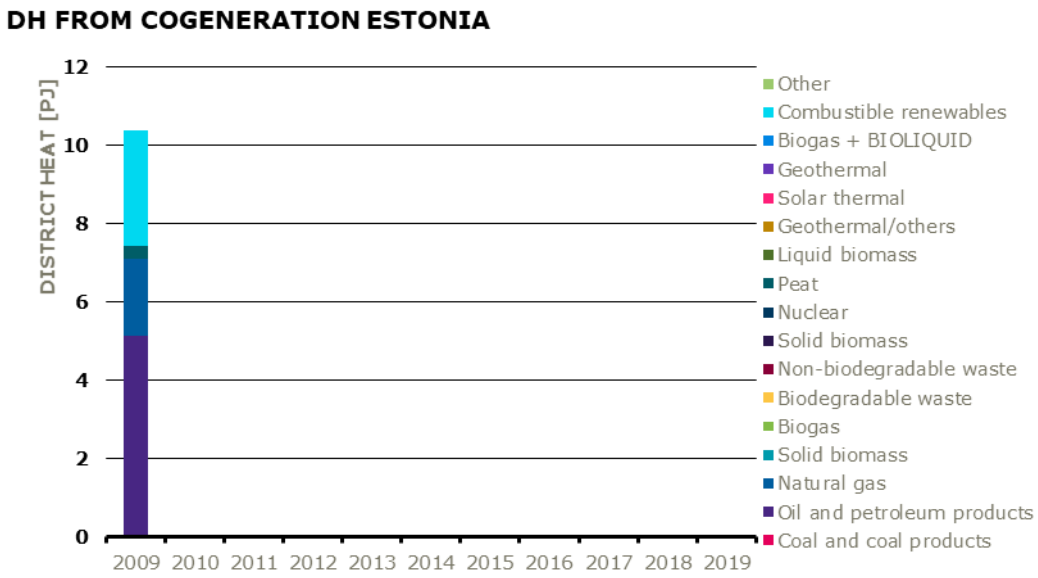

Figure 7-92: District heat generated in CHP plants by year and fuel in Estonia. Based on data from [2], [3]

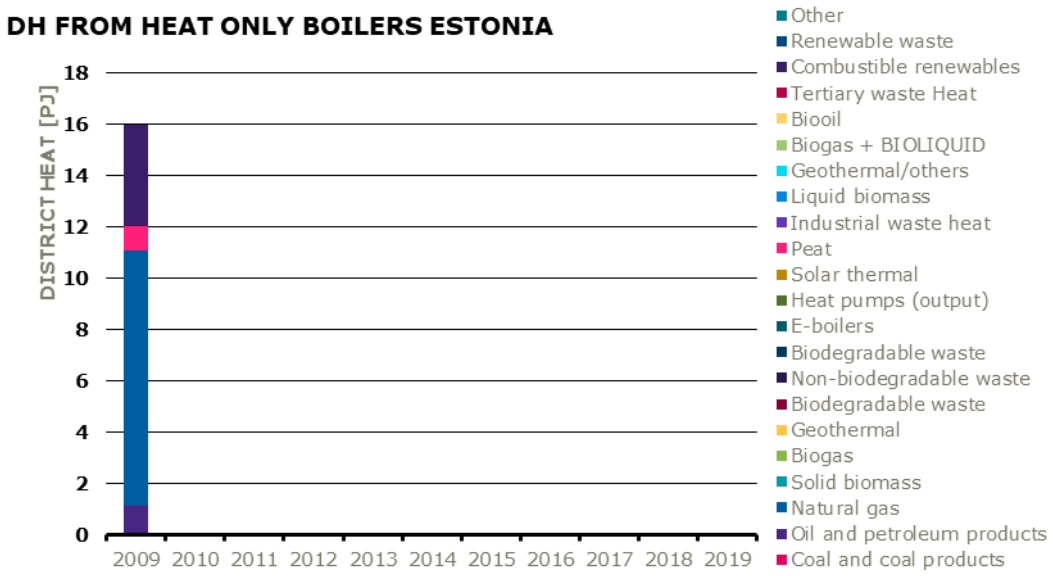

Figure 7-93: District heat generated in heat only boilers by year and fuel in Estonia. Based on data from [2], [3]

7.8.6 Energy storage

[*No data available*]

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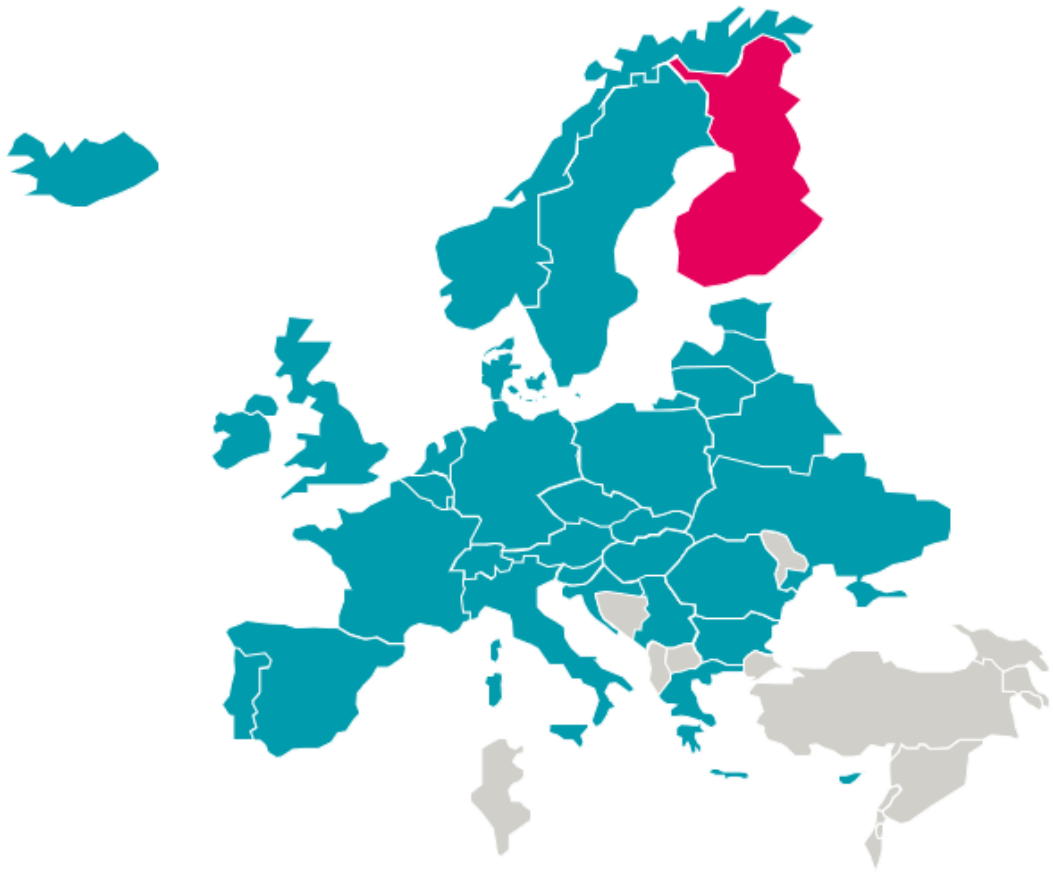
7.9 Finland

7.9.1 Country profile



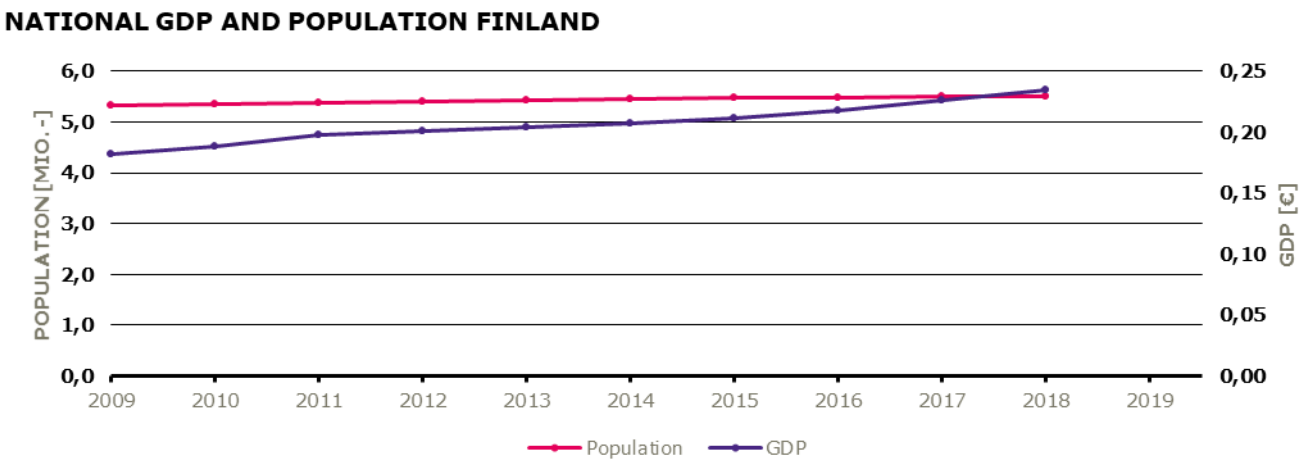


Figure 7-94: GDP and population development in Finland. Based on data from [1]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.9.2 Energy use

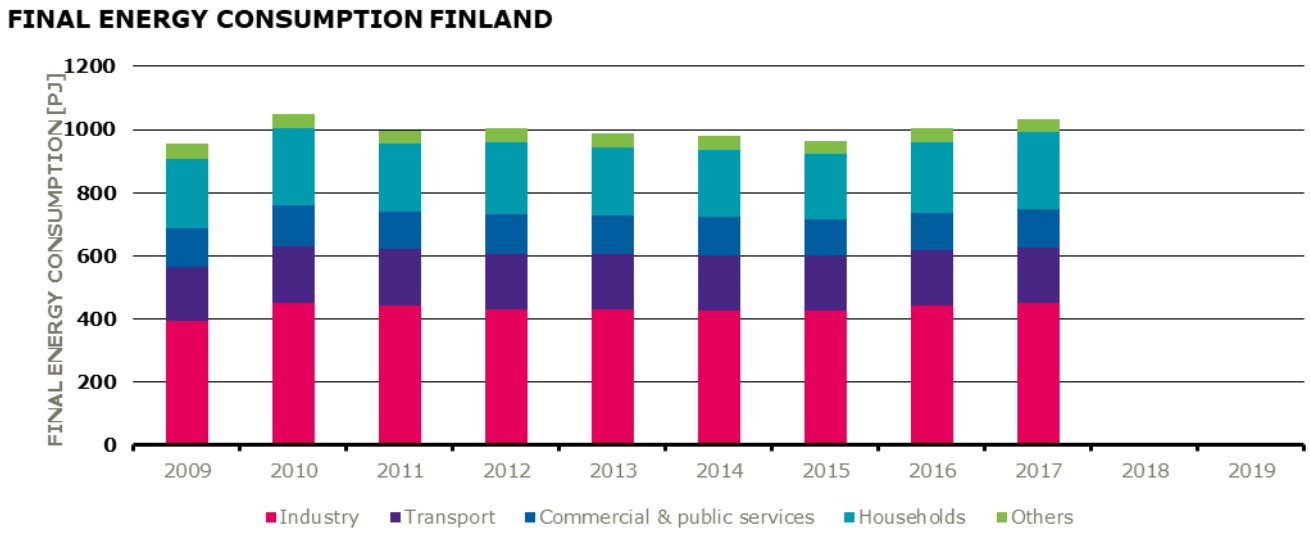


Figure 7-95: Final energy consumption by economic sector and year in Finland. Based on data from [2]

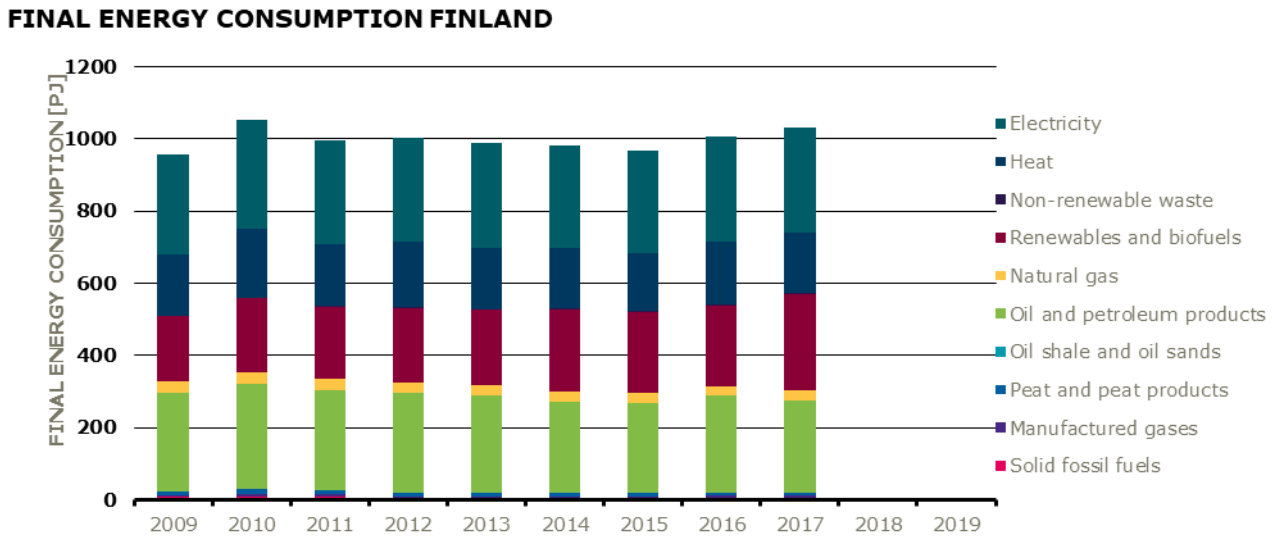


Figure 7-96: Final energy consumption by fuel and year in Finland. Based on data from [2]

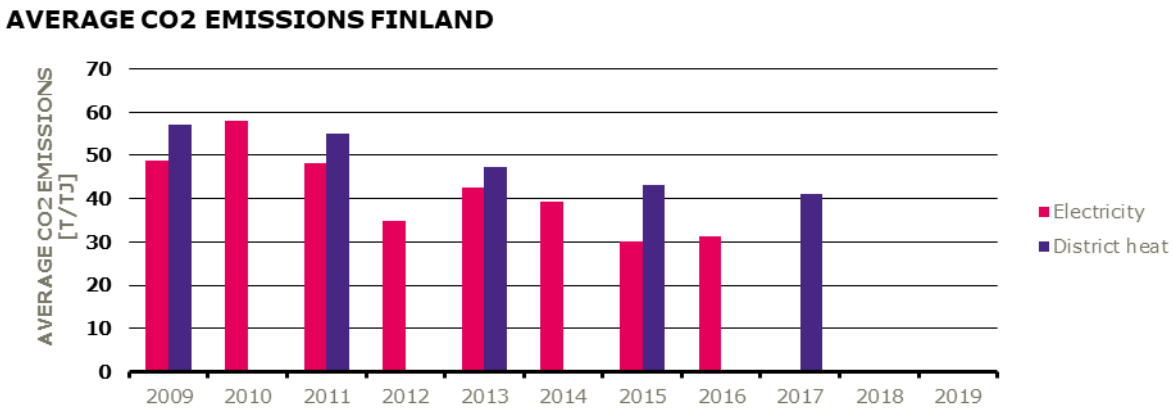


Figure 7-97: Average CO2 emissions in Finland. Based on data from [3] & [4]

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7.9.3 Heat Production

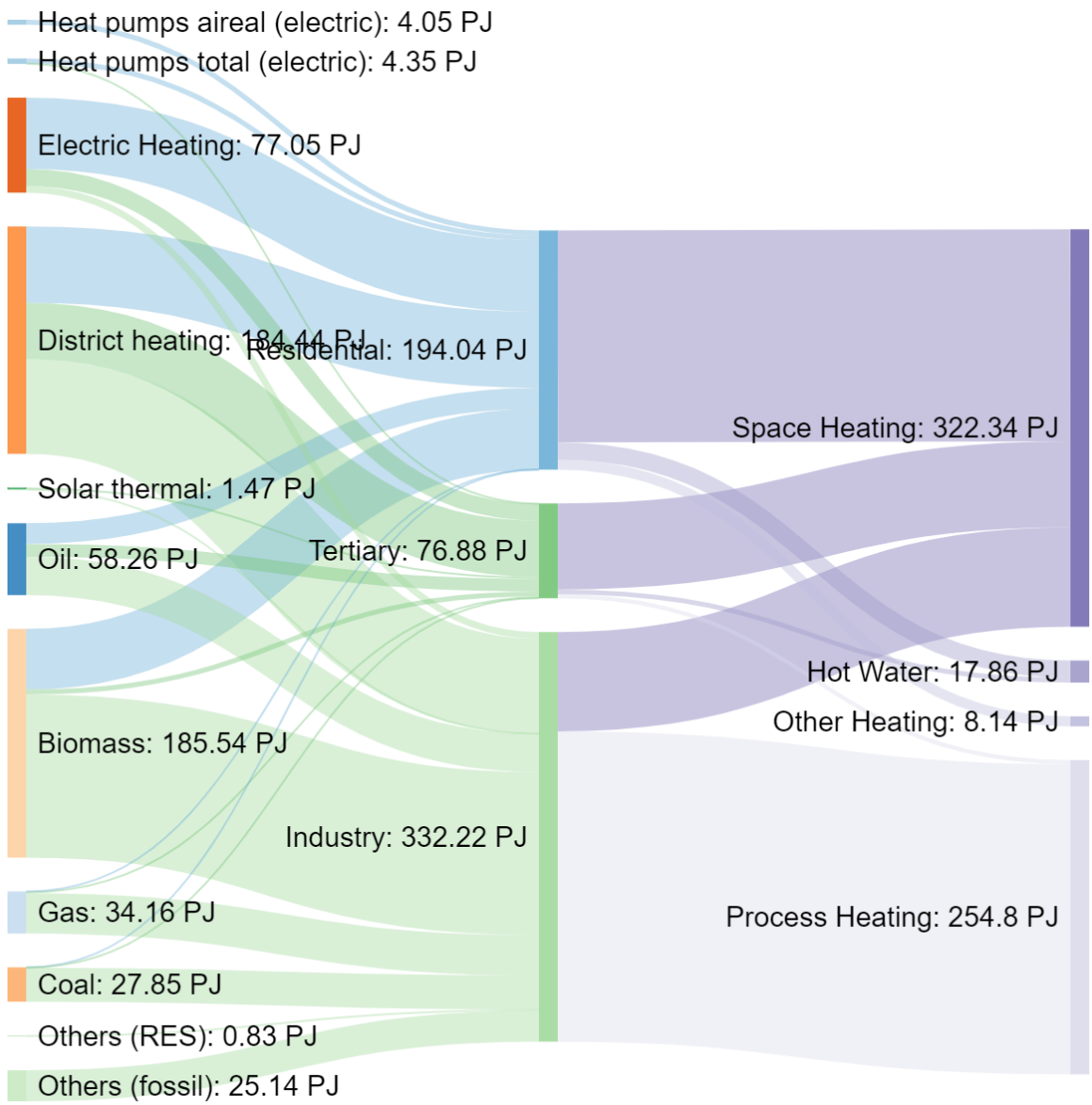

Figure 7-98: Sankey diagram of energy flows for heating purposes in Finland in 2015. Based on data from [3]

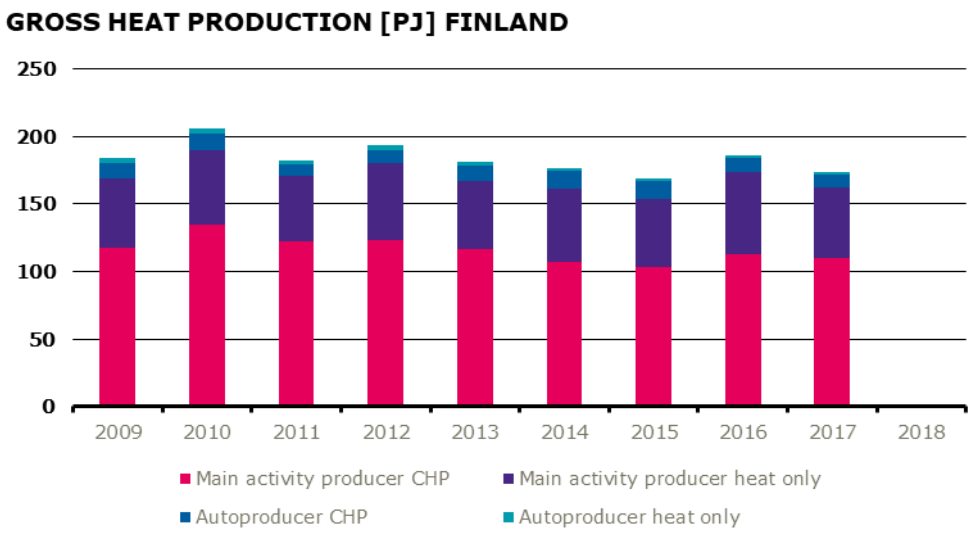

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Figure 7-99: Final energy consumption by economic sector and year in Finland. Based on data from [2]

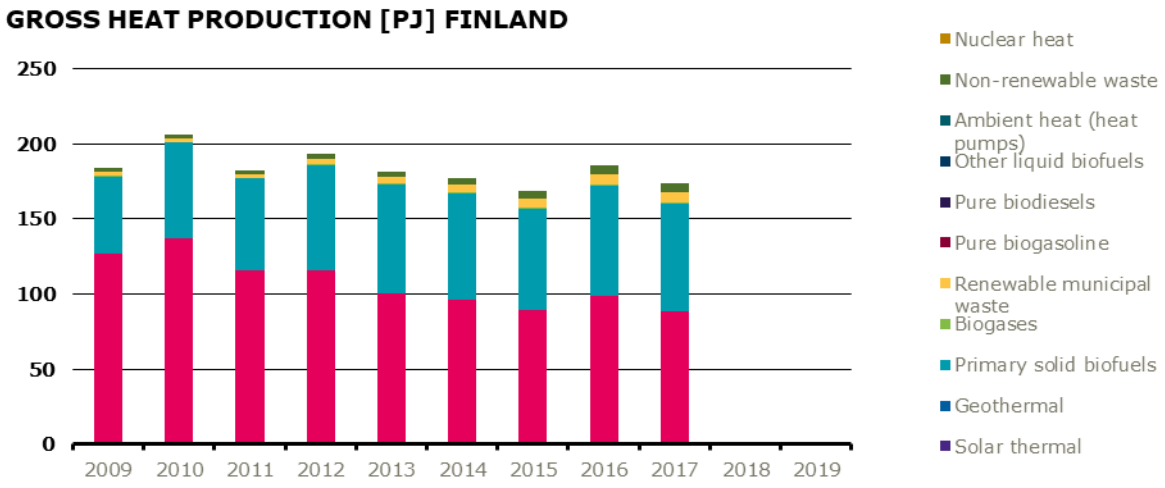

Figure 7-100: Gross heat production by fuel and year in Finland. Based on data from [2]

7.9.4 Electricity Production

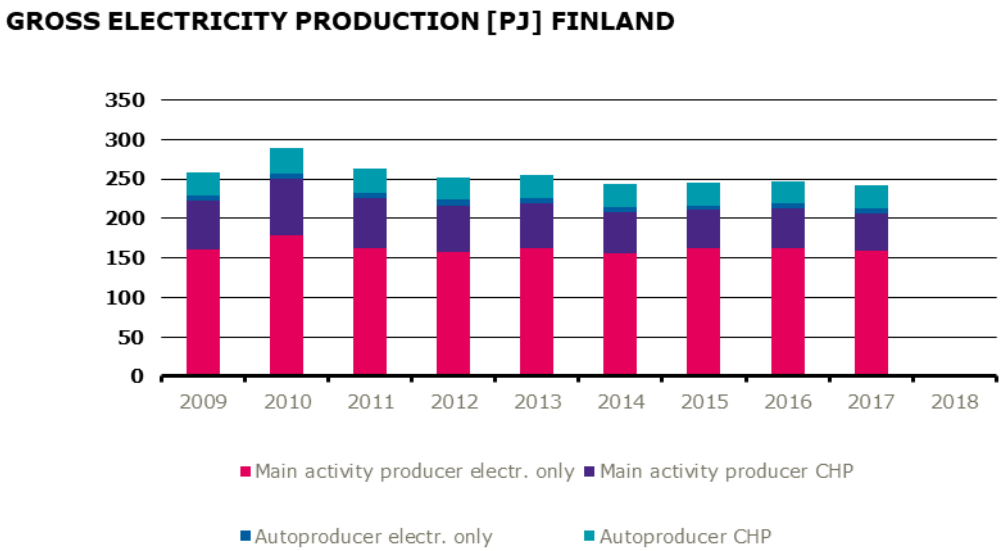

Figure 7-101: Gross electricity production by producer type and year in Finland. Based on data from [2]

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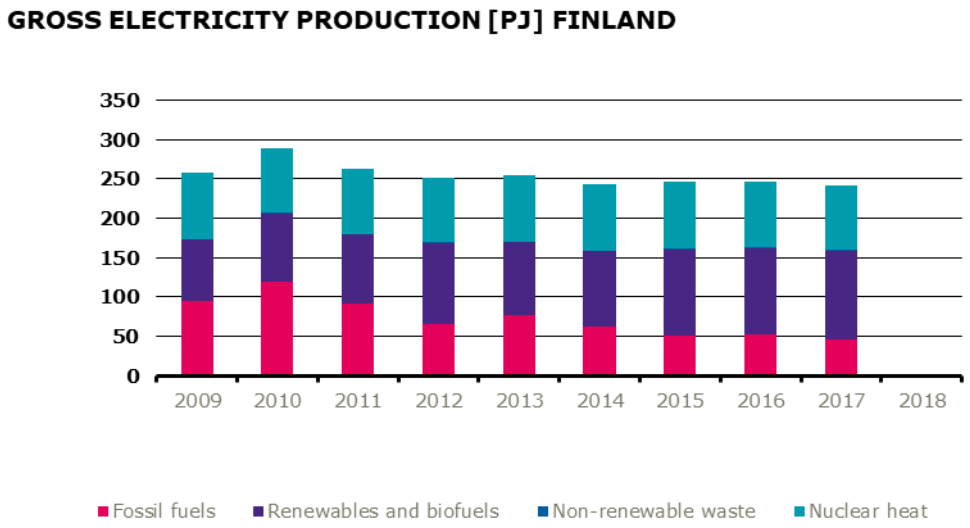


Figure 7-102: Gross electricity production by fuel type and year in Finland. Based on data from [2]

7.9.5 District Heat

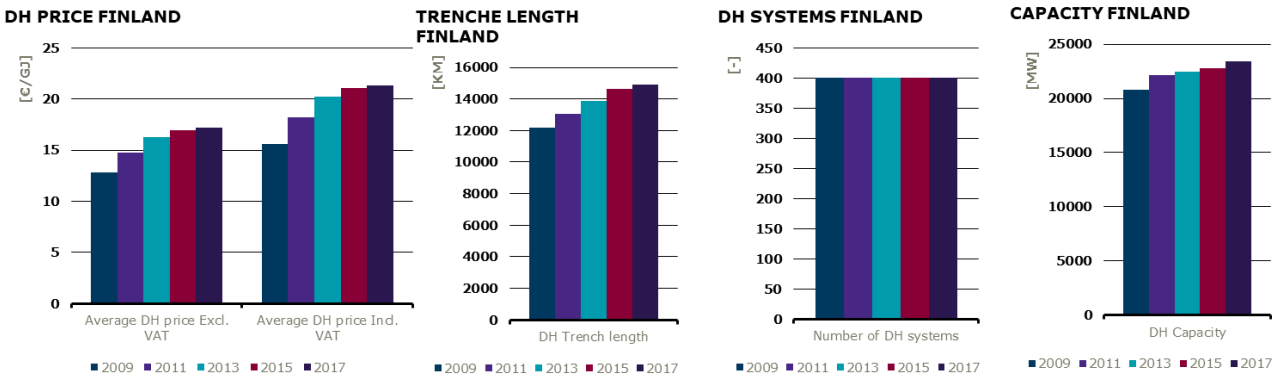


Figure 7-103: District heat indicators for Finland. Based on data from [2]

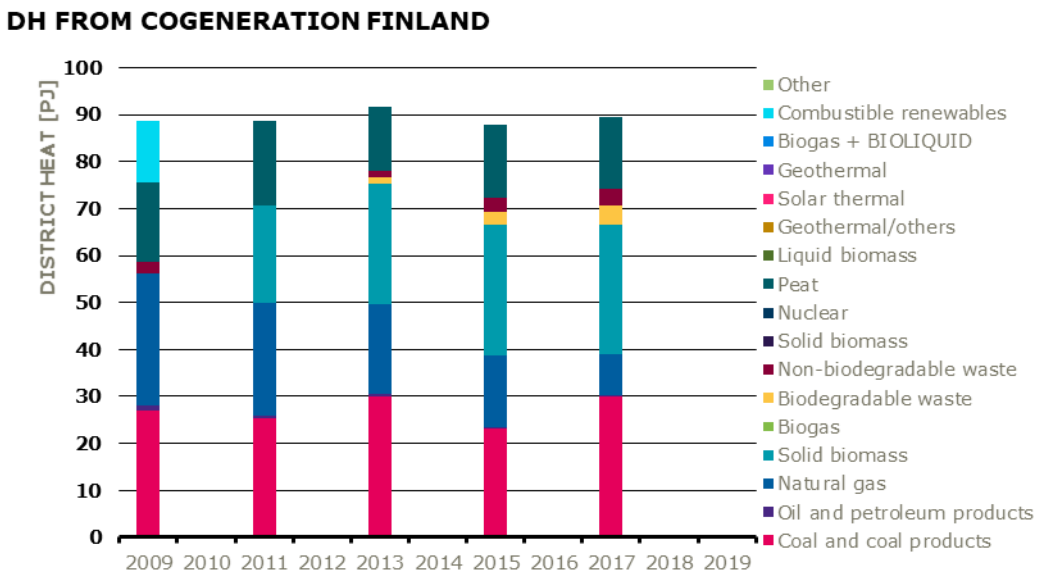


Figure 7-104: District heat generated in CHP plants by year and fuel in Finland. Based on data from [2], [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

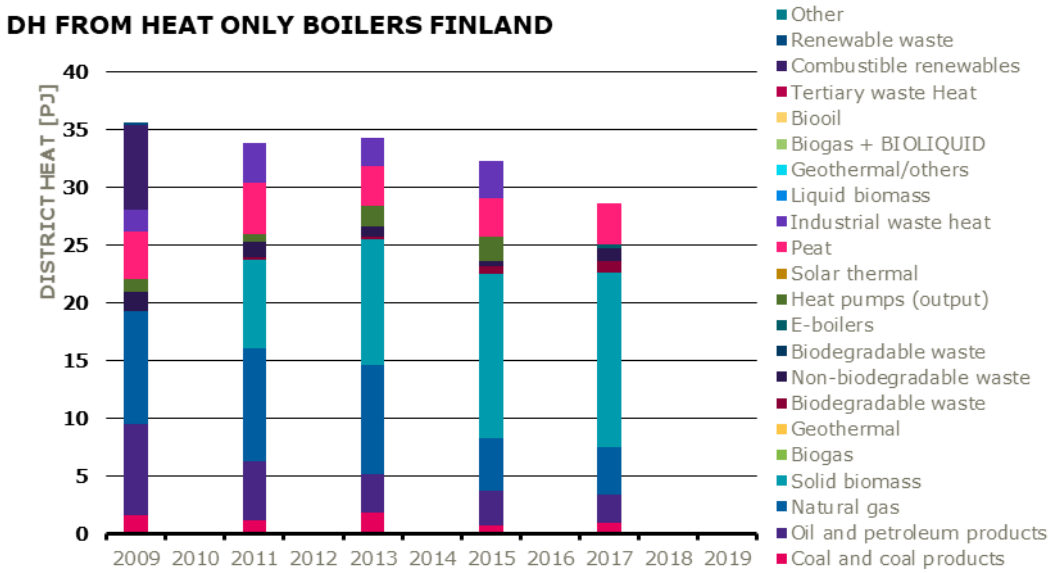


Figure 7-105: District heat generated in heat only boilers by year and fuel in Finland. Based on data from [2], [3]

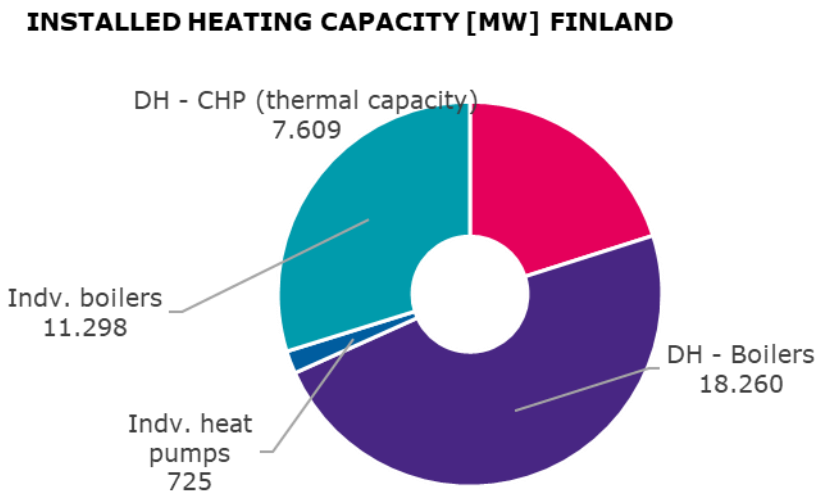


Figure 7-106: Installed heating capacity installed in Finland in 2015. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.9.6 Energy storage

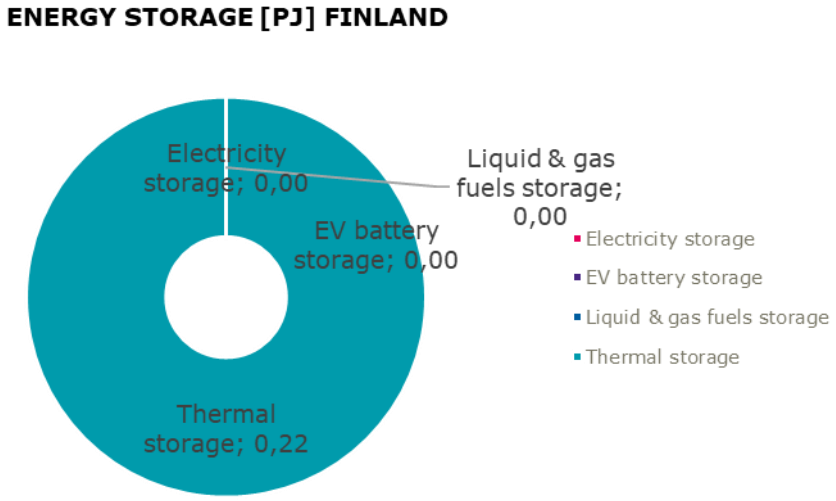
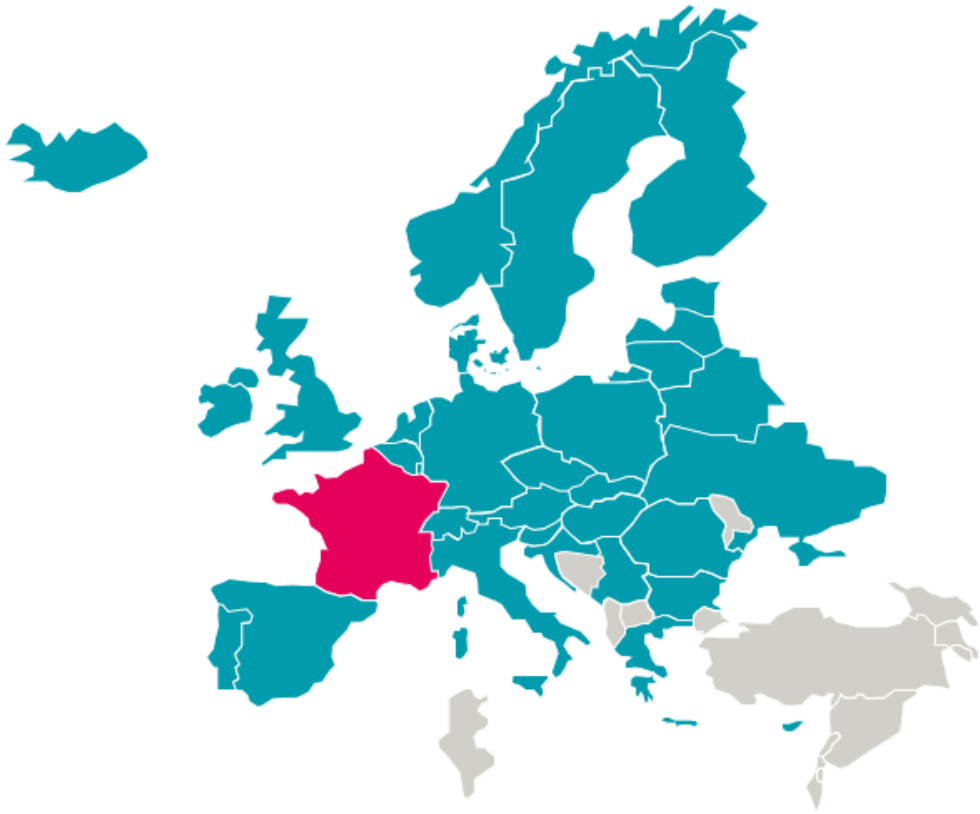


Figure 7-107: Stoage capacity in Finland in 2015. Based on data from [2]

7.10 France

7.10.1 Country profile



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

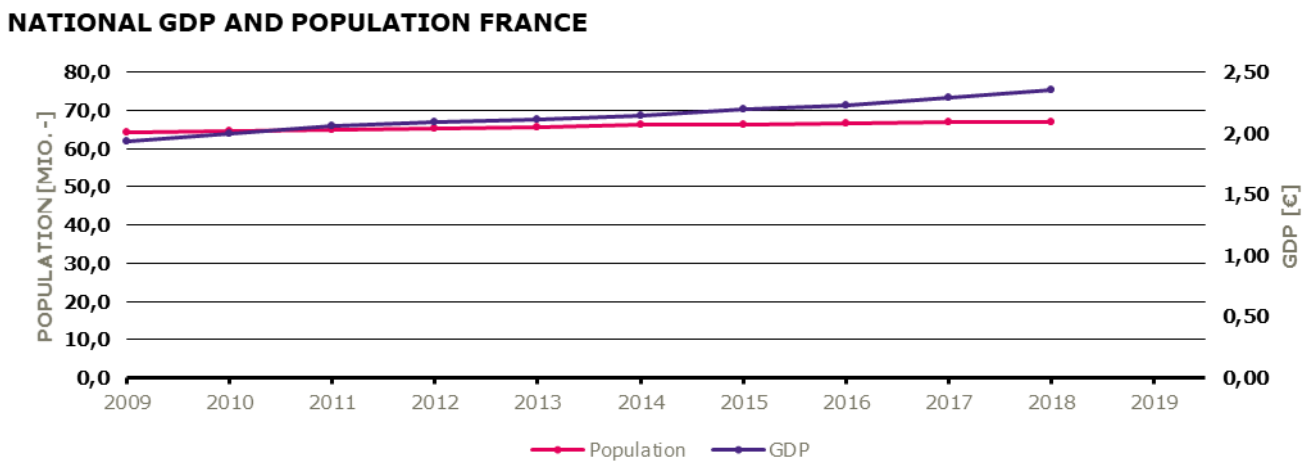


Figure 7-108: GDP and population development in France. Based on data from [1].

7.10.2 Energy use

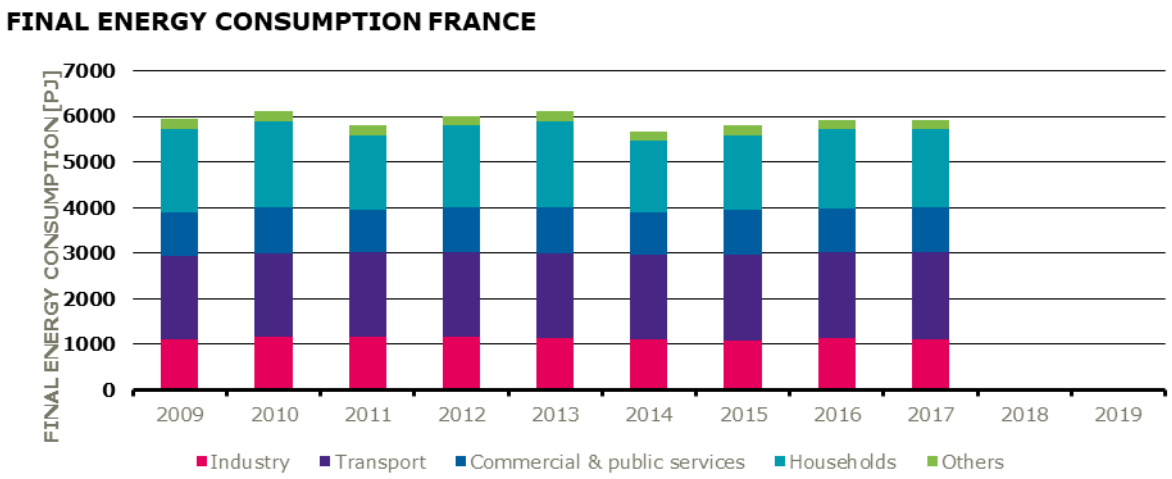


Figure 7-109: Final energy consumption by economic sector and year in France. Based on data from [2]

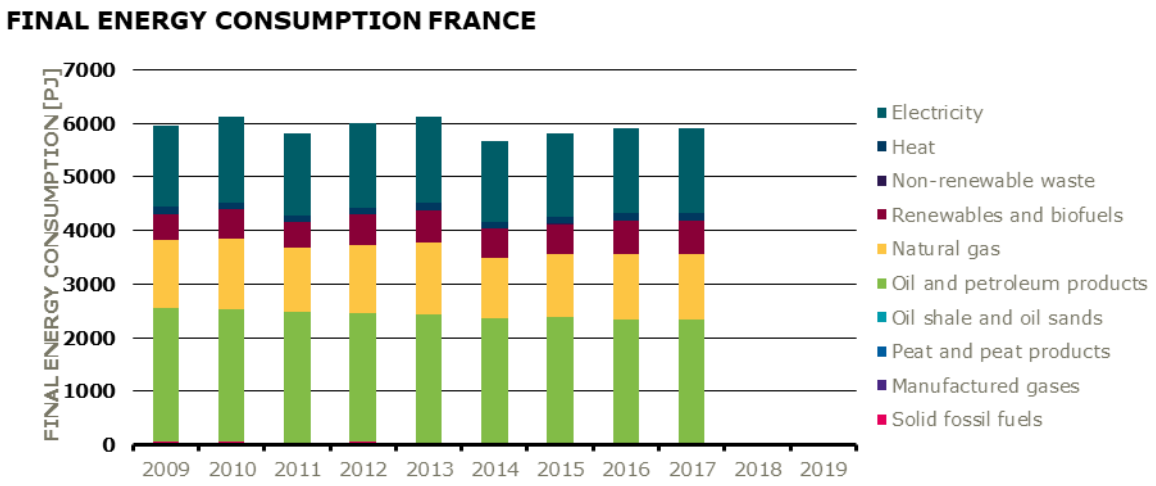


Figure 7-110: Final energy consumption by fuel and year in France. Based on data from [2]

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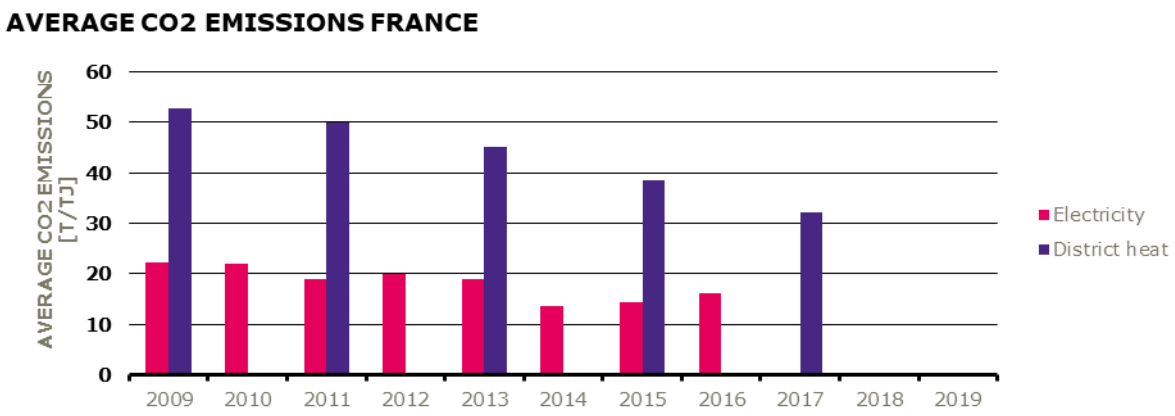


Figure 7-111: Average CO2 emissions in France. Based on data from [3] & [4]

7.10.3 Heat Production

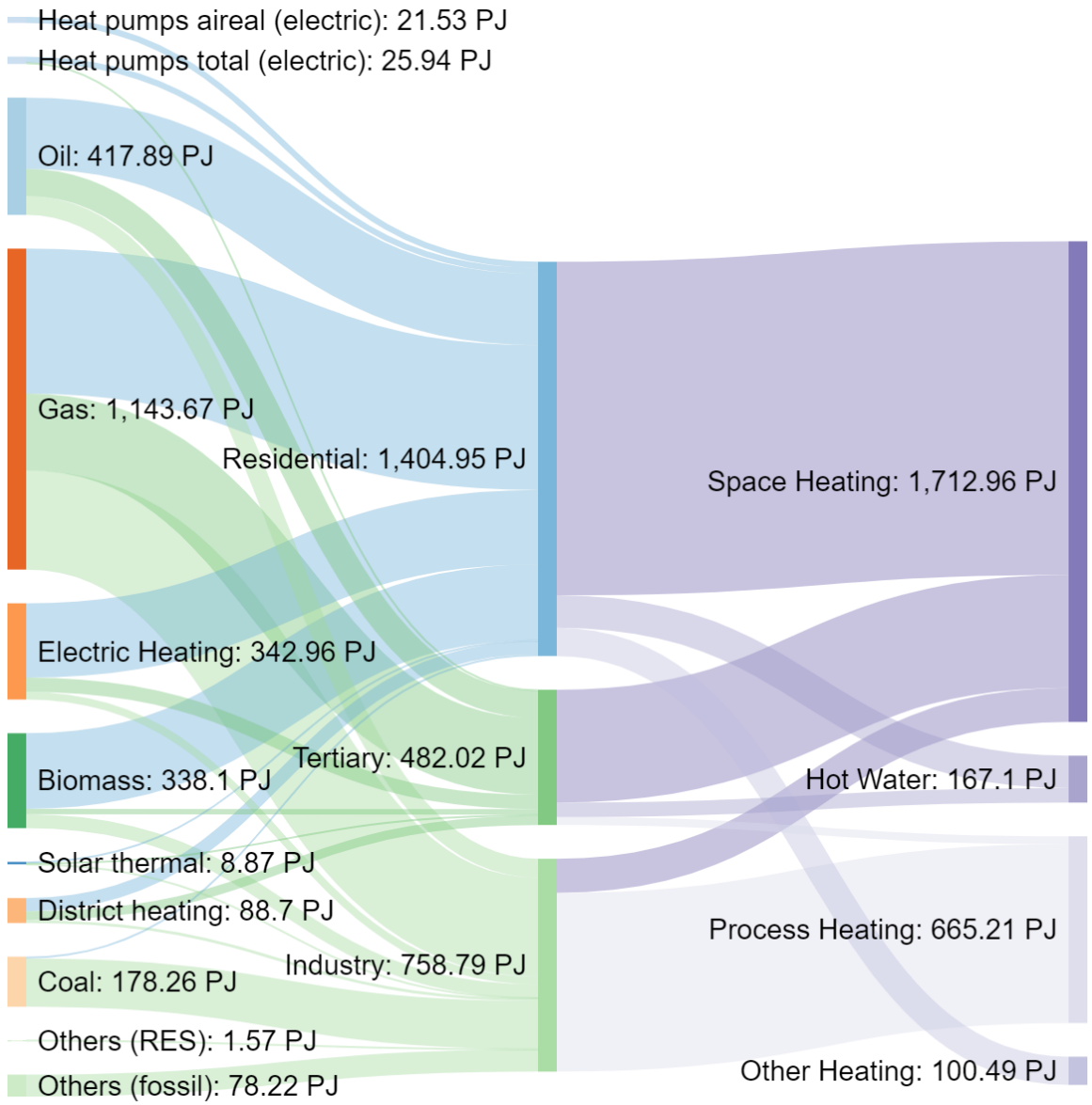


Figure 7-112: Sankey diagram of energy flows for heating purposes in France in 2015. Based on data from [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

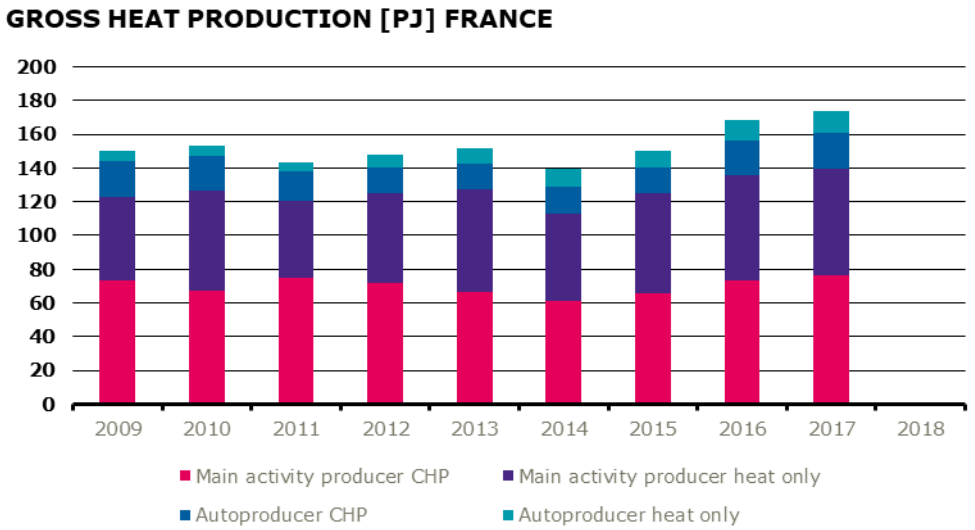


Figure 7-113: Gross heat production by producer type and year in France. Based on data from [2]

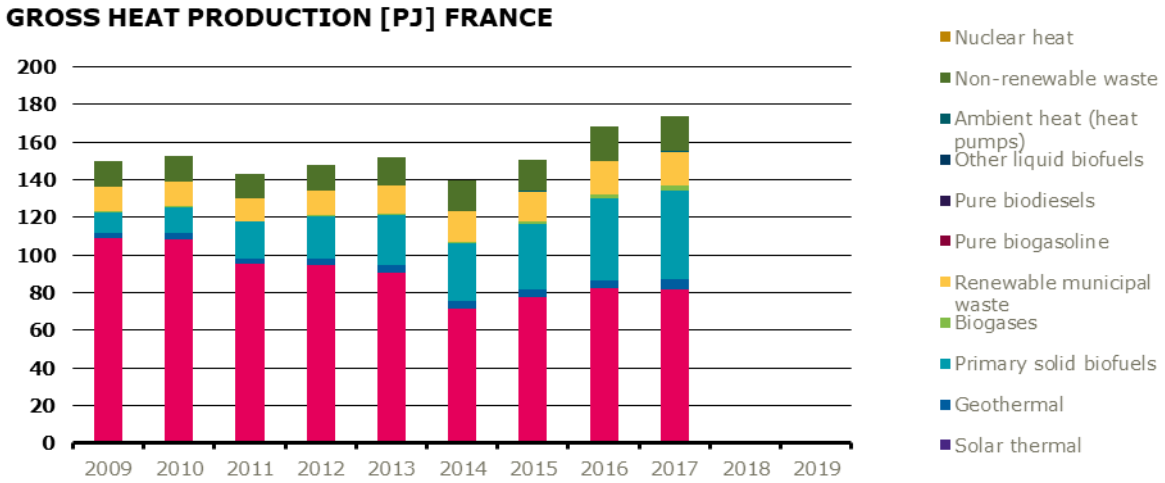


Figure 7-114: Gross heat production by fuel and year in France. Based on data from [2]

7.10.4 Electricity Production

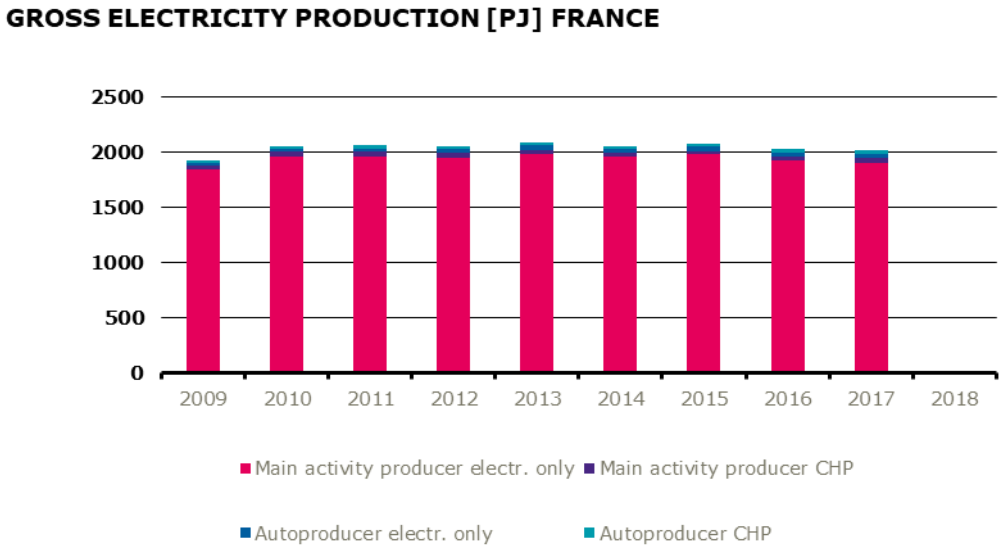


Figure 7-115: Gross electricity production by producer type and year in France. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

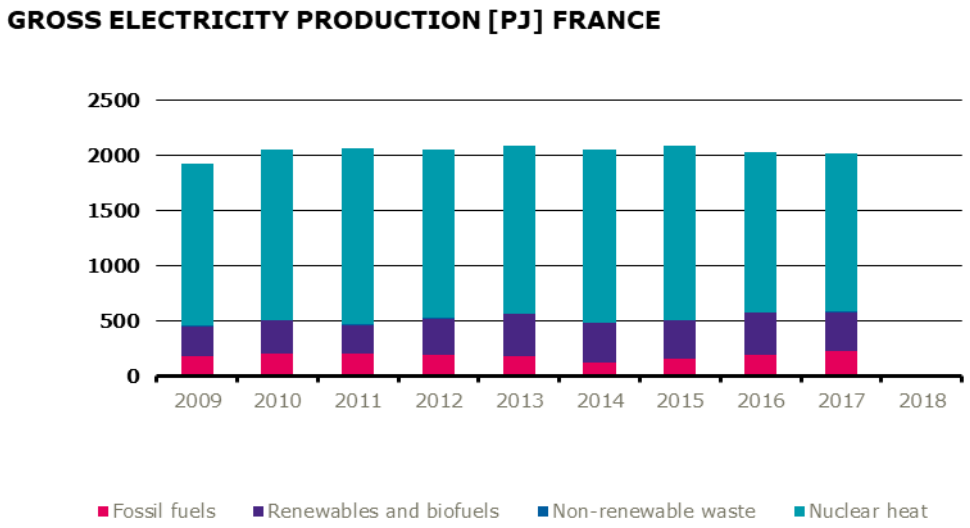


Figure 7-116: Gross electricity production by fuel type and year in France. Based on data from [2]

7.10.5 District Heat

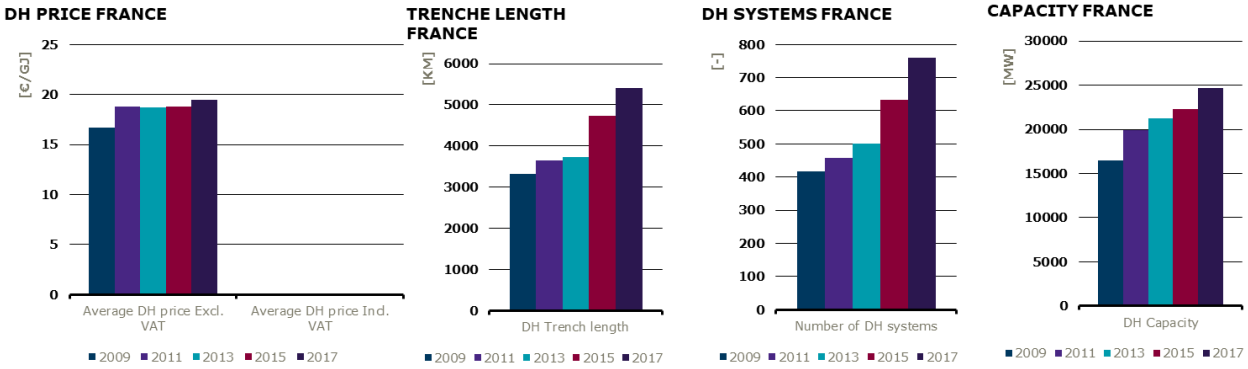


Figure 7-117: District heat indicators for France. Based on data from [2]

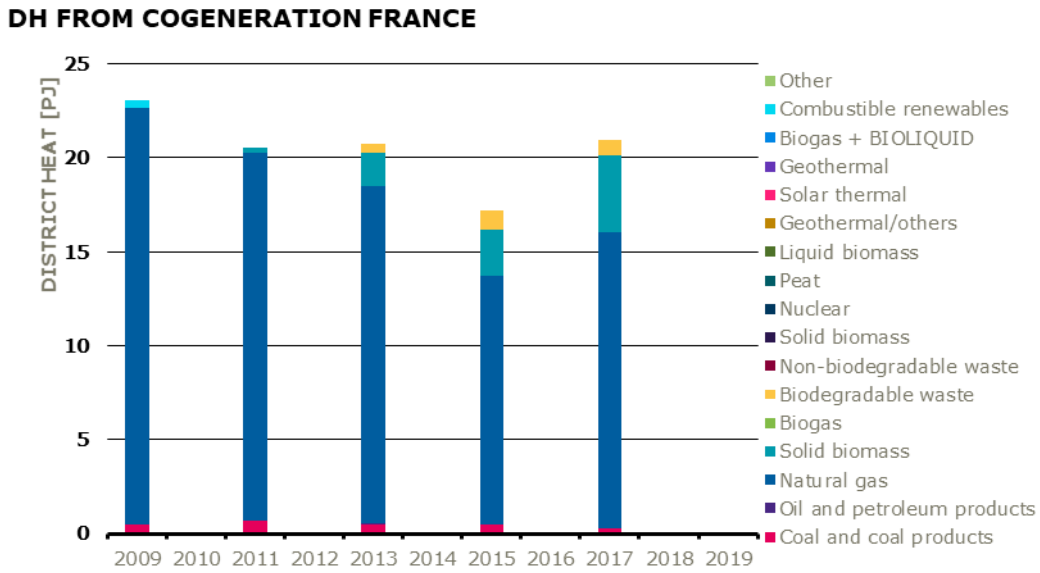


Figure 7-118: District heat generated in CHP plants by year and fuel in France. Based on data from [2], [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

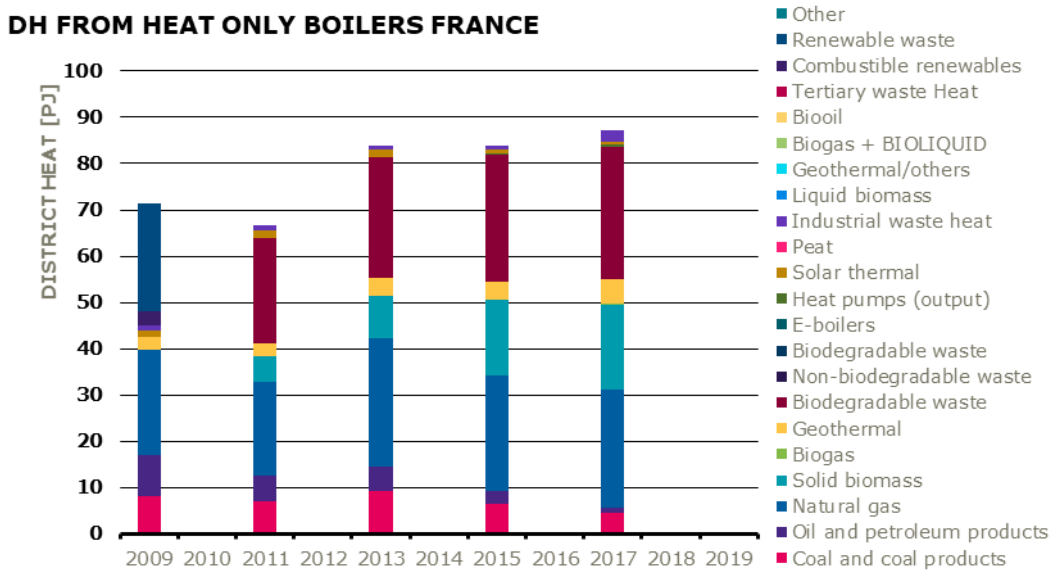


Figure 7-119: District heat generated in heat only boilers by year and fuel in France. Based on data from [2], [3]

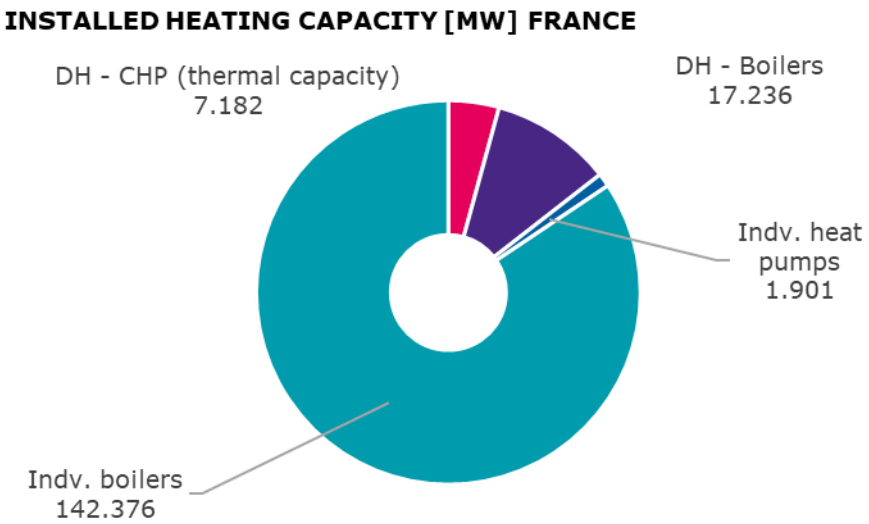


Figure 7-120: Installed heating capacity installed in France in 2015. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.10.6 Energy storage

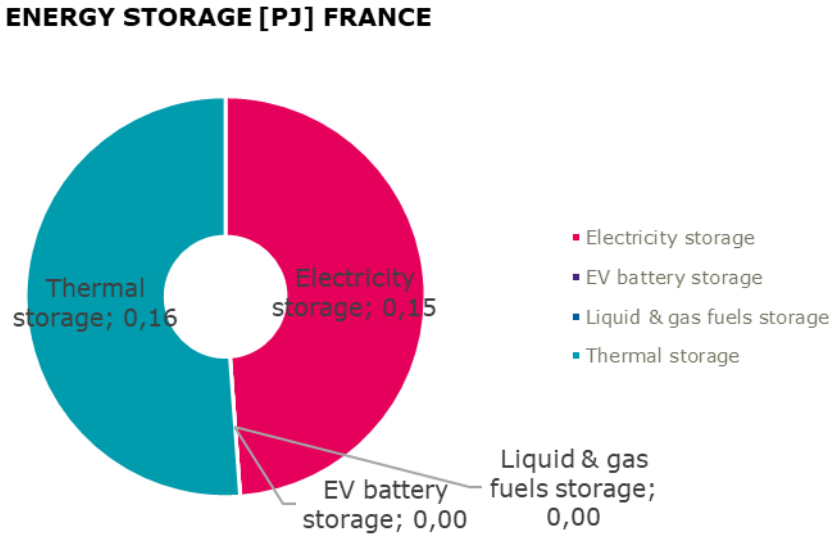
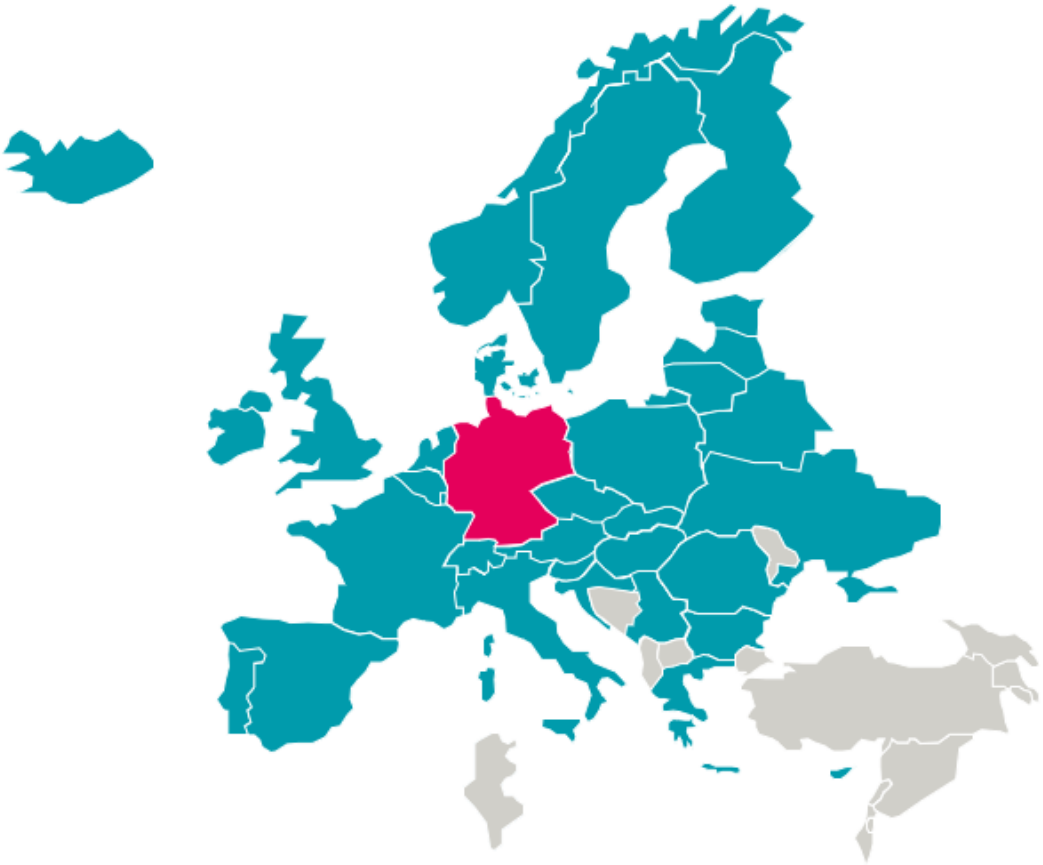


Figure 7-121: Stoage capacity in France in 2015. Based on data from [2]

7.11 Germany

7.11.1 Country profile



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

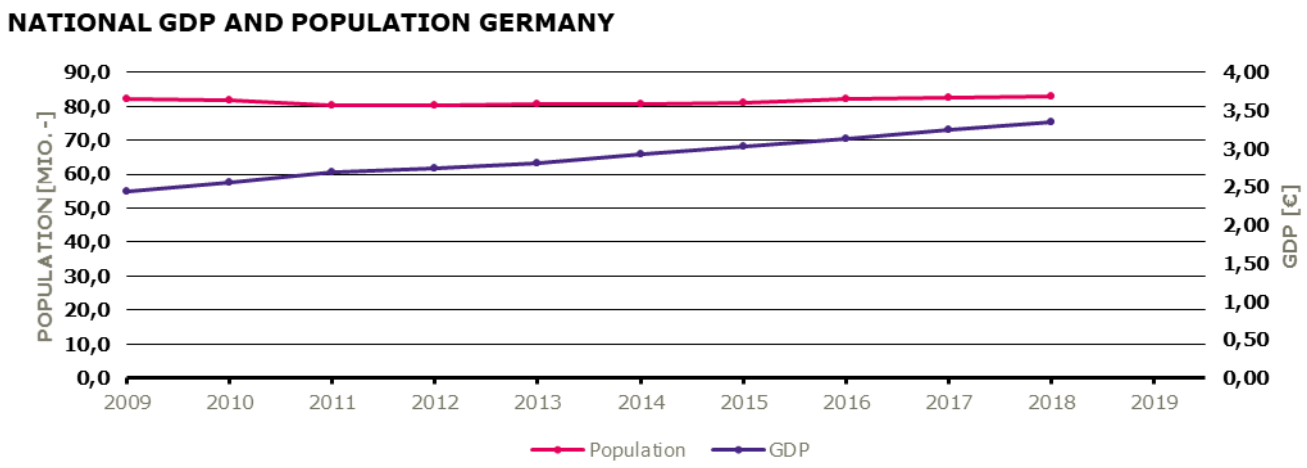


Figure 7-122: GDP and population development in Germany. Based on data from [1]

7.11.2 Energy use

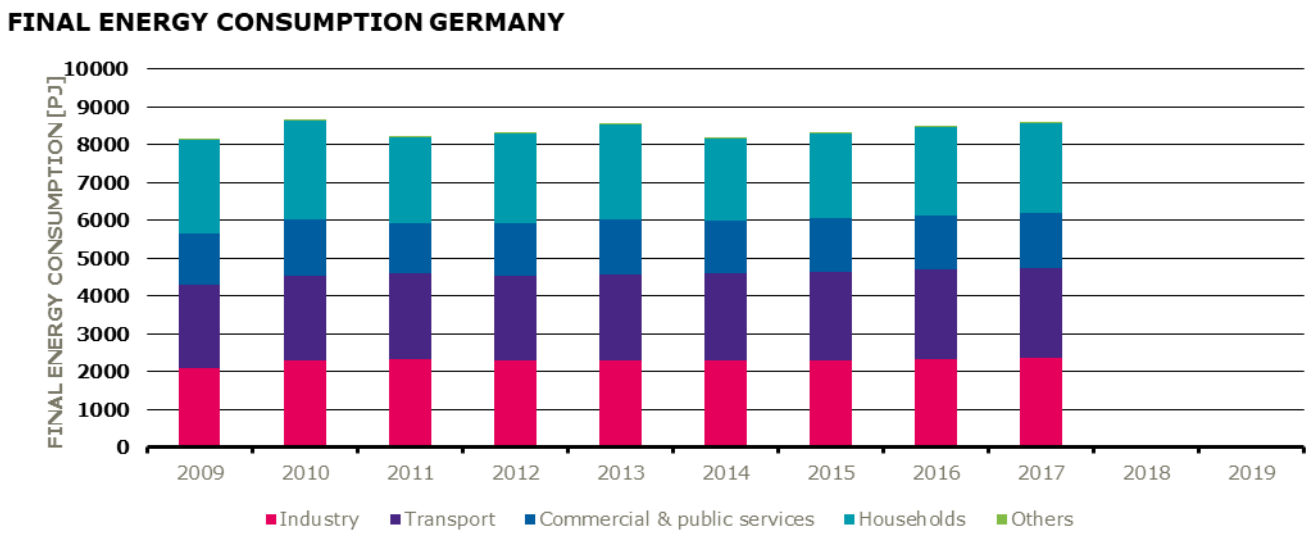


Figure 7-123: Final energy consumption by economic sector and year in Germany. Based on data from [2]

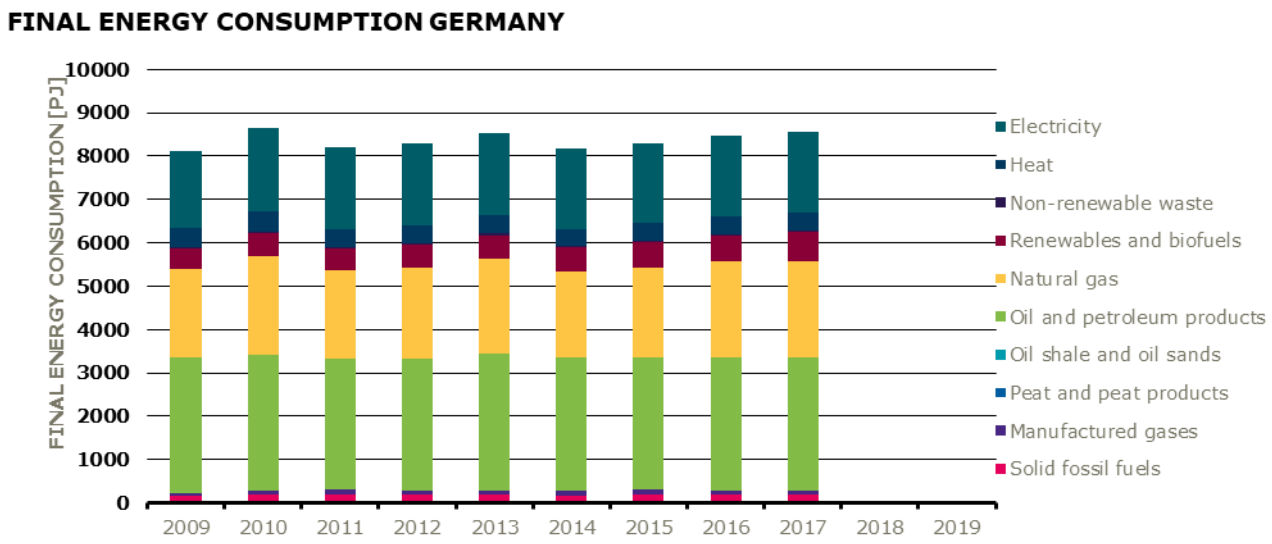


Figure 7-124: Final energy consumption by fuel and year in Germany. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

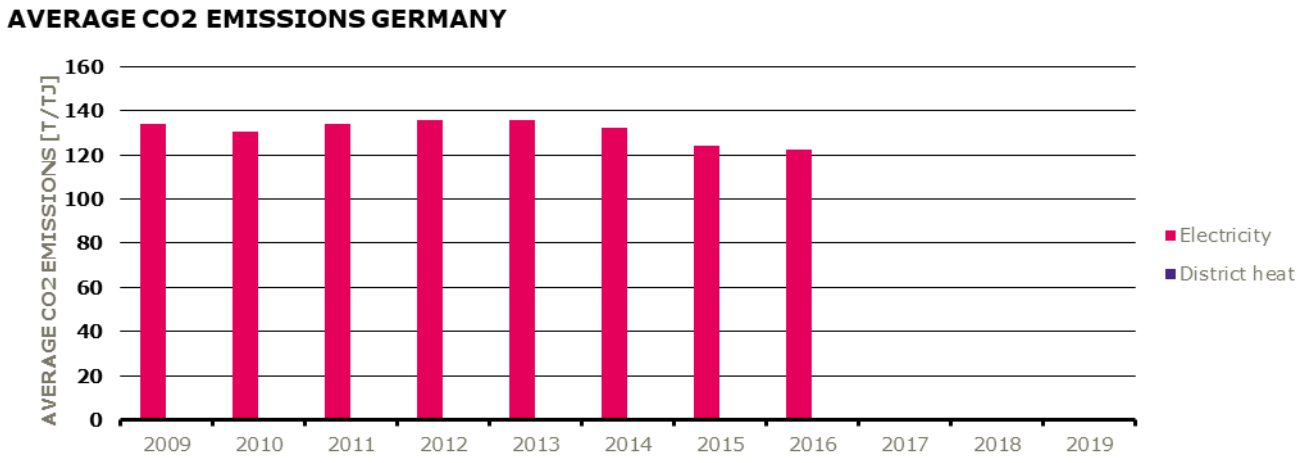


Figure 7-125: Average CO2 emissions in Germany. Based on data from [3] & [4]

7.11.3 Heat Production

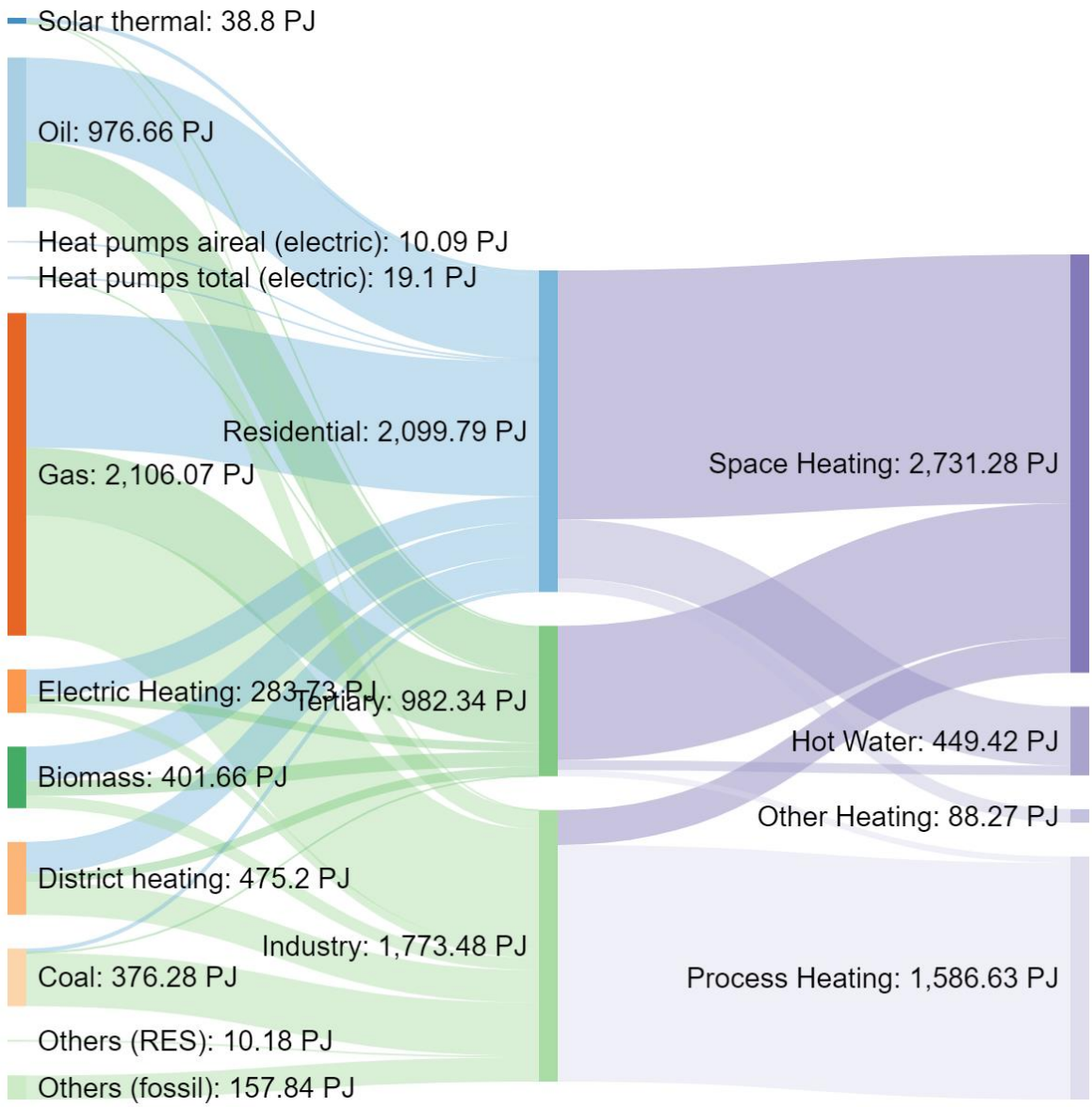


Figure 7-126: Sankey diagram of energy flows for heating purposes in Germany in 2015. Based on data from [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

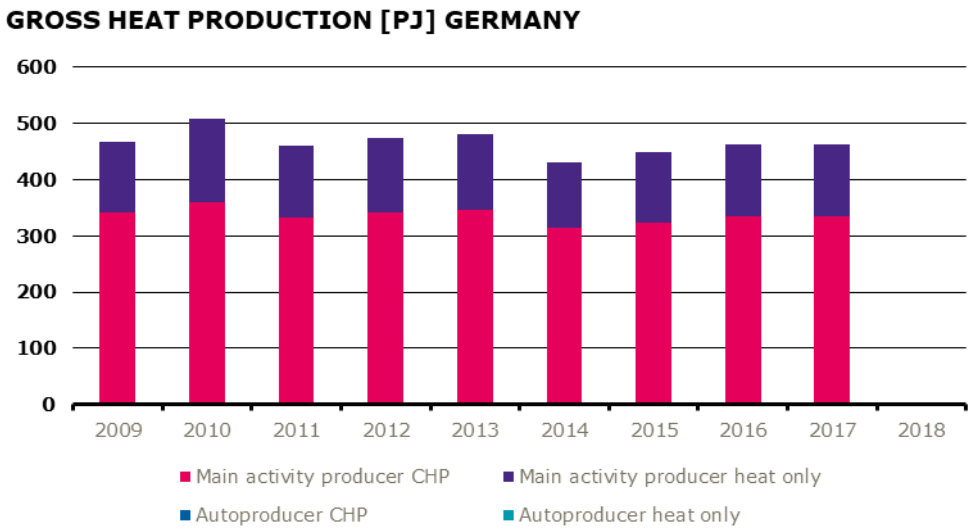


Figure 7-127: Gross heat production by producer type and year in Germany. Based on data from [2]

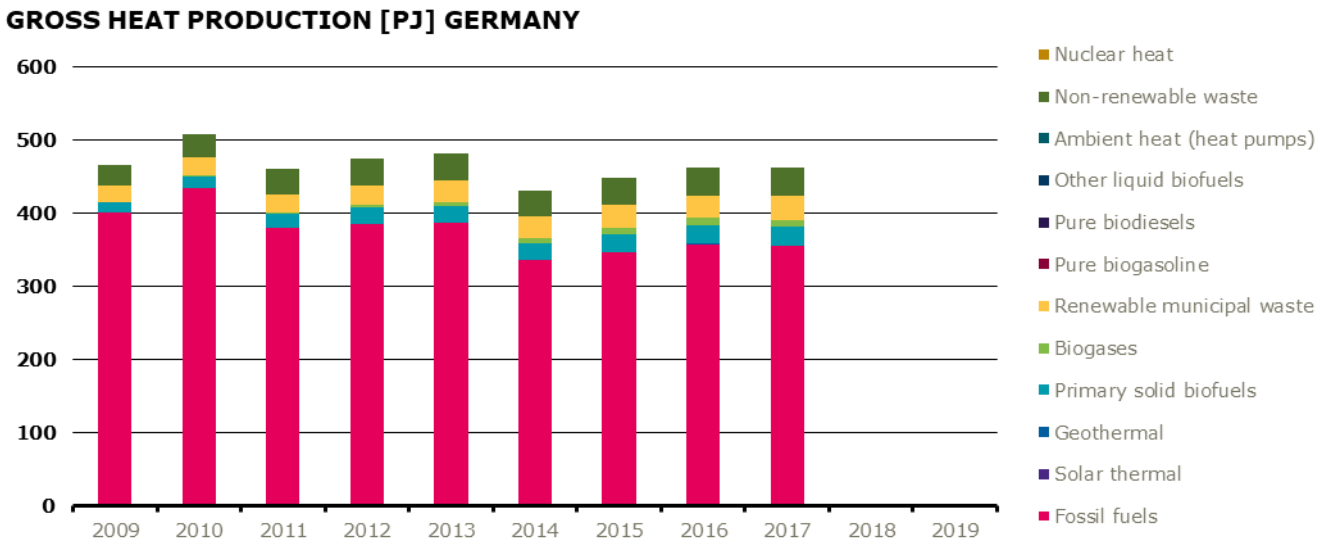


Figure 7-128: Gross heat production by fuel and year in Germany. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.11.4 Electricity Production

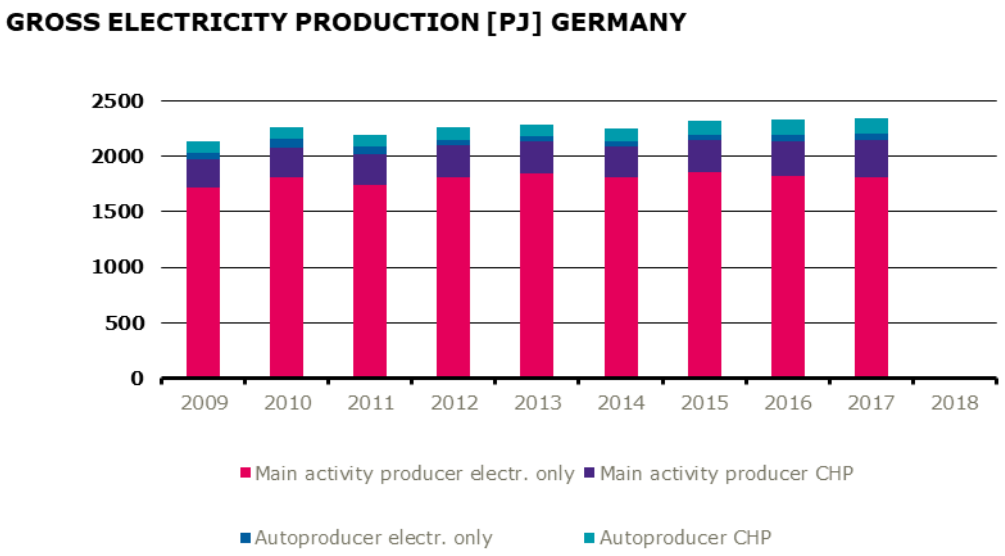


Figure 7-129: Gross electricity production by producer type and year in Germany. Based on data from [2]

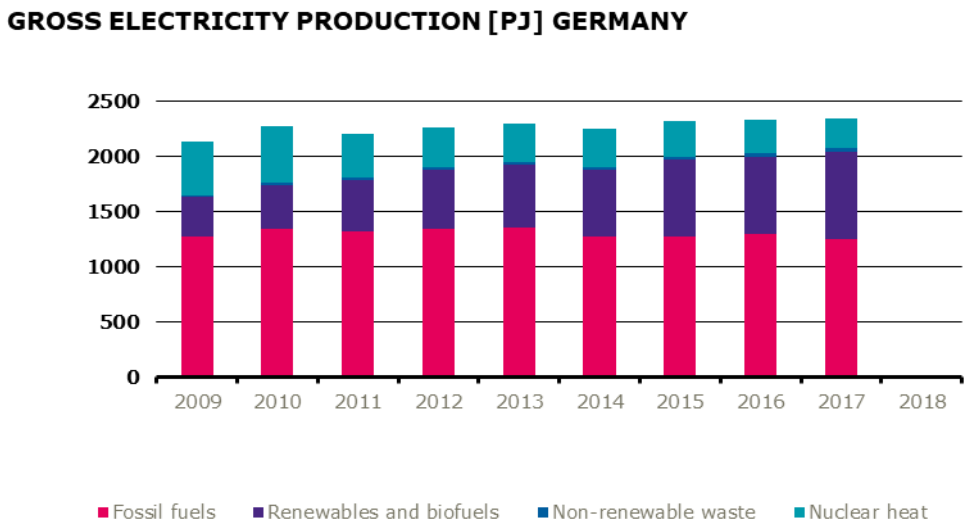


Figure 7-130: Gross electricity production by fuel type and year in Germany. Based on data from [2]

7.11.5 District Heat

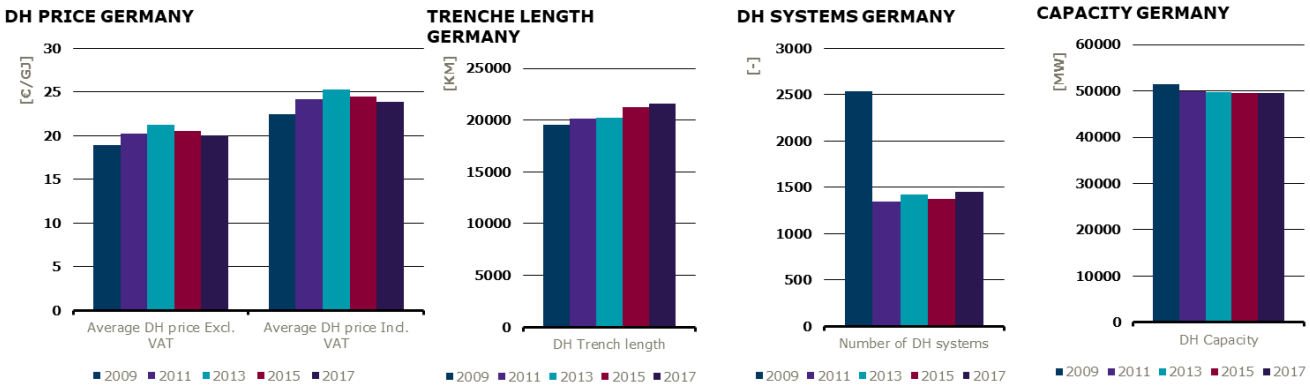


Figure 7-131: District heat indicators for Germany. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

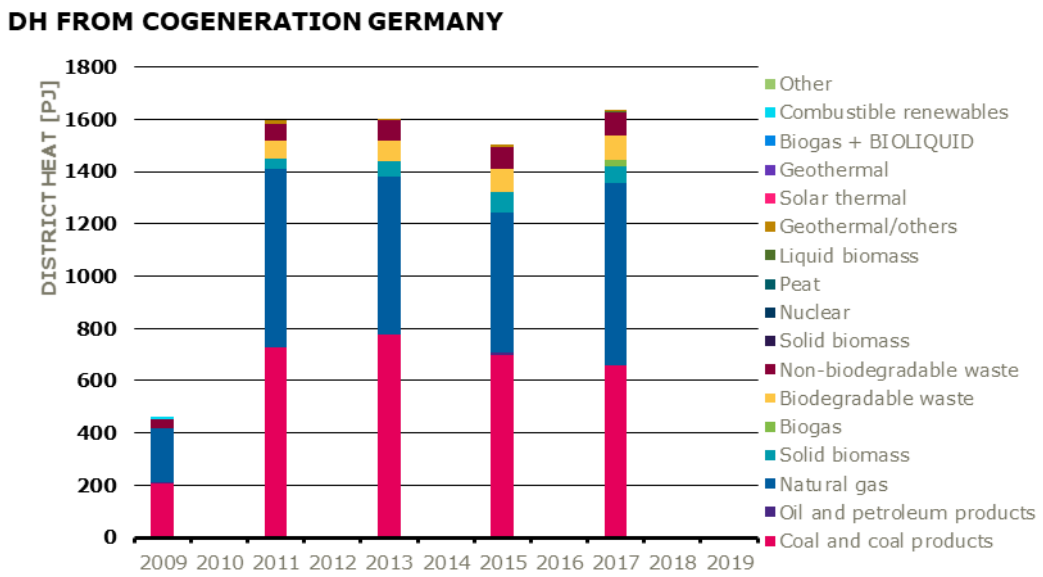


Figure 7-132: District heat generated in CHP plants by year and fuel in Germany. Based on data from [2], [3]

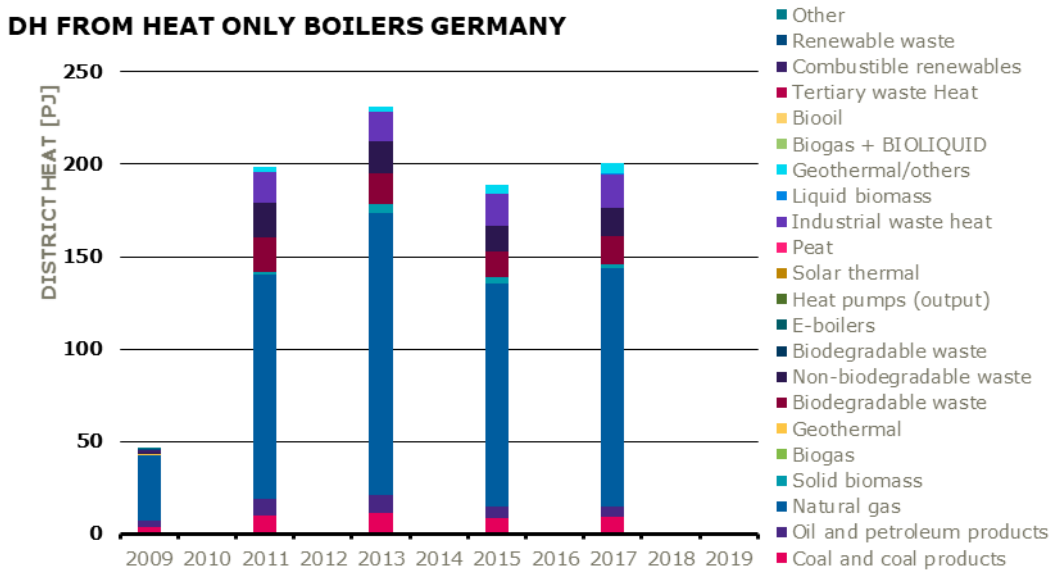


Figure 7-133: District heat generated in heat only boilers by year and fuel in Germany. Based on data from [2], [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

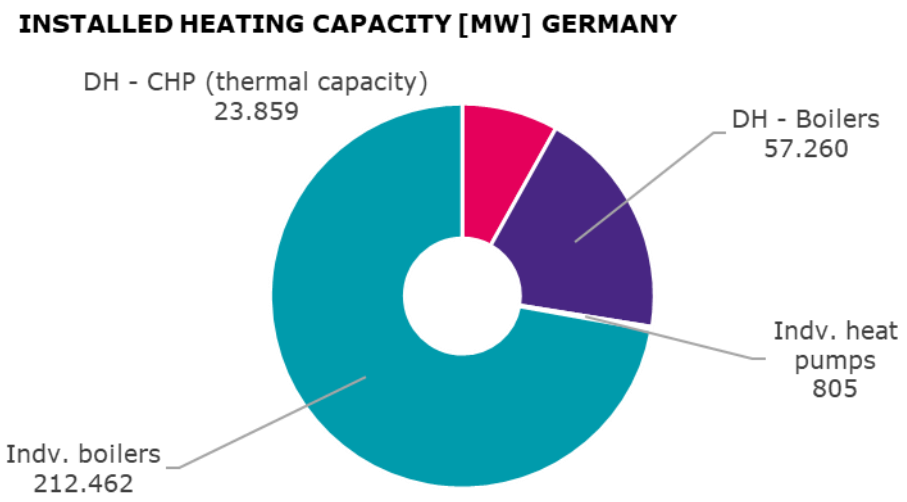


Figure 7-134: Installed heating capacity installed in Germany in 2015. Based on data from [2]

7.11.6 Energy storage

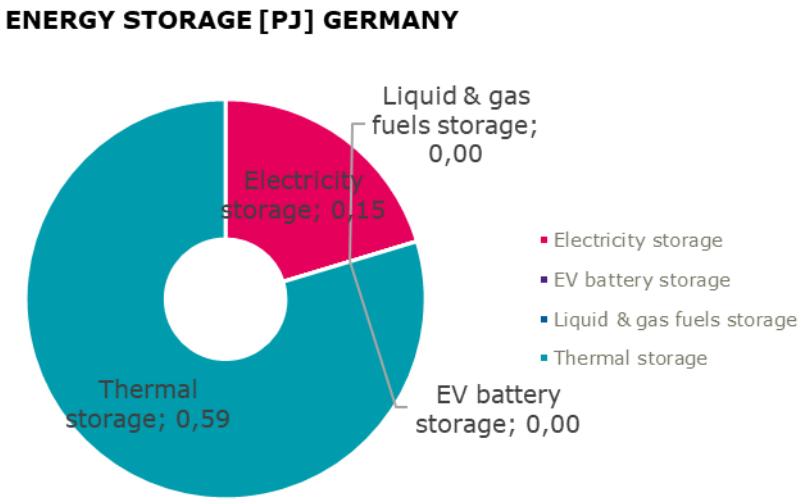


Figure 7-135: Stoage capacity in Germany in 2015. Based on data from [2]

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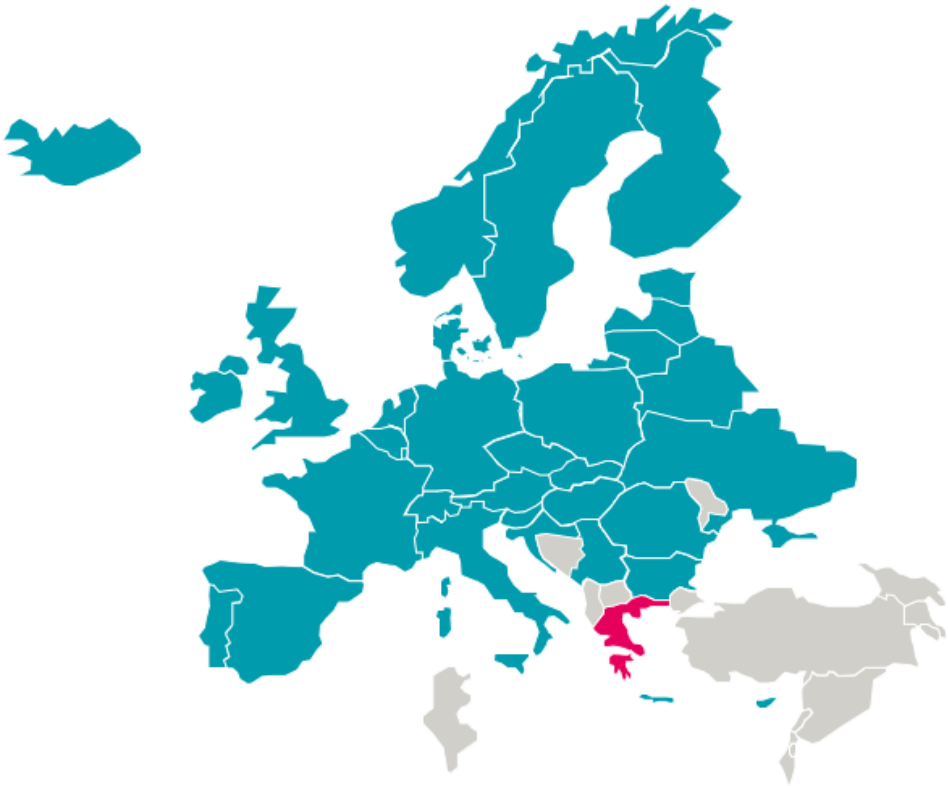
7.12 Greece

7.12.1 Country profile



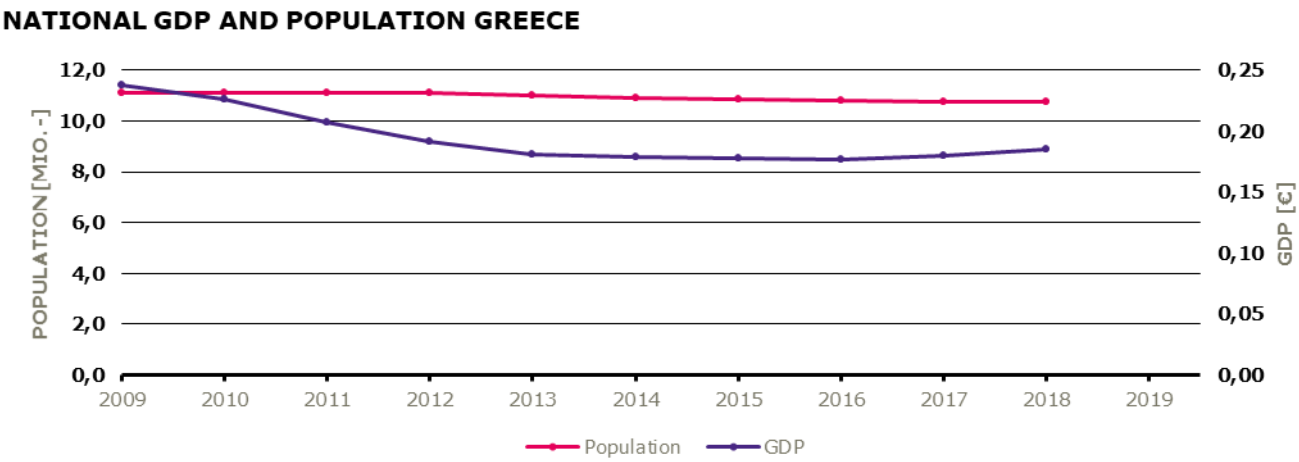


Figure 7-136: GDP and population development in Greece. Based on data from [1]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.12.2 Energy use

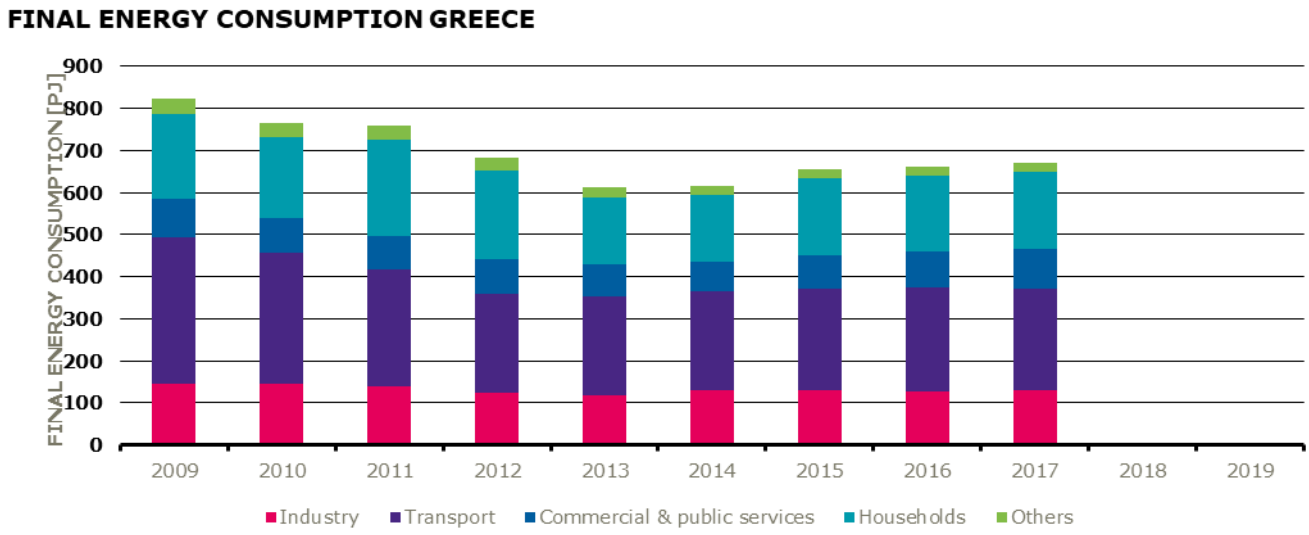


Figure 7-137: Final energy consumption by economic sector and year in Greece. Based on data from [2]

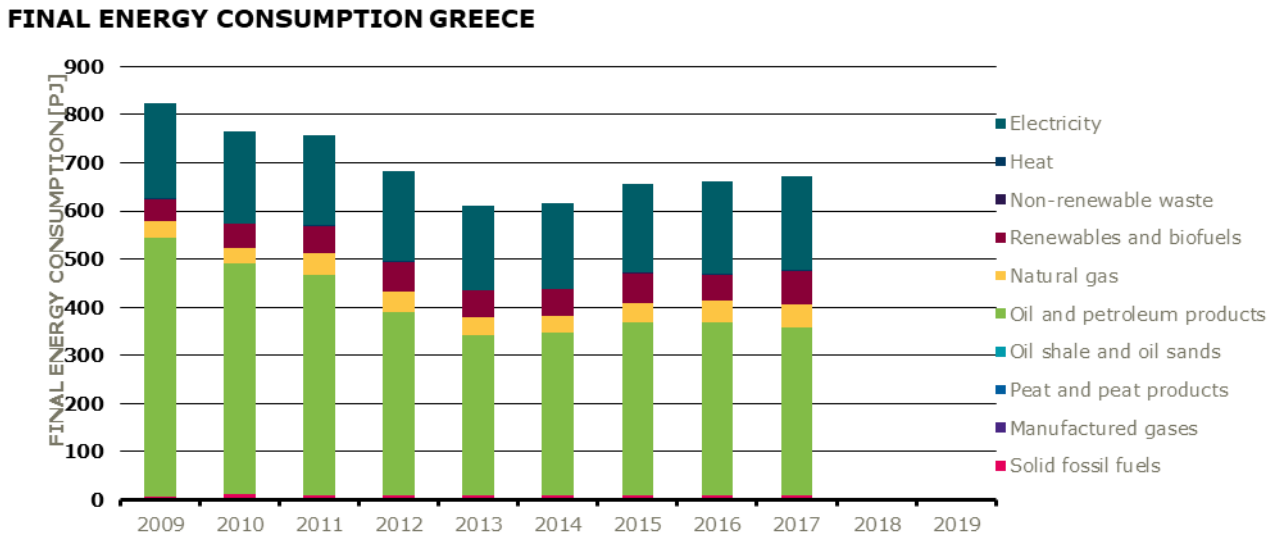


Figure 7-138: Final energy consumption by fuel and year in Greece. Based on data from [2]

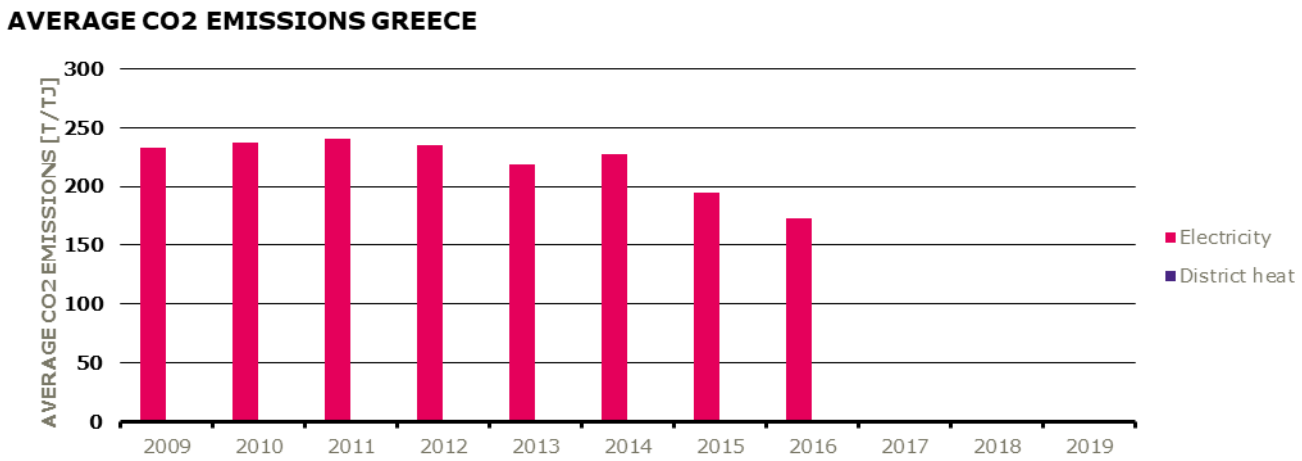


Figure 7-139: Average CO2 emissions in Greece. Based on data from [3] & [4]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.12.3 Heat Production

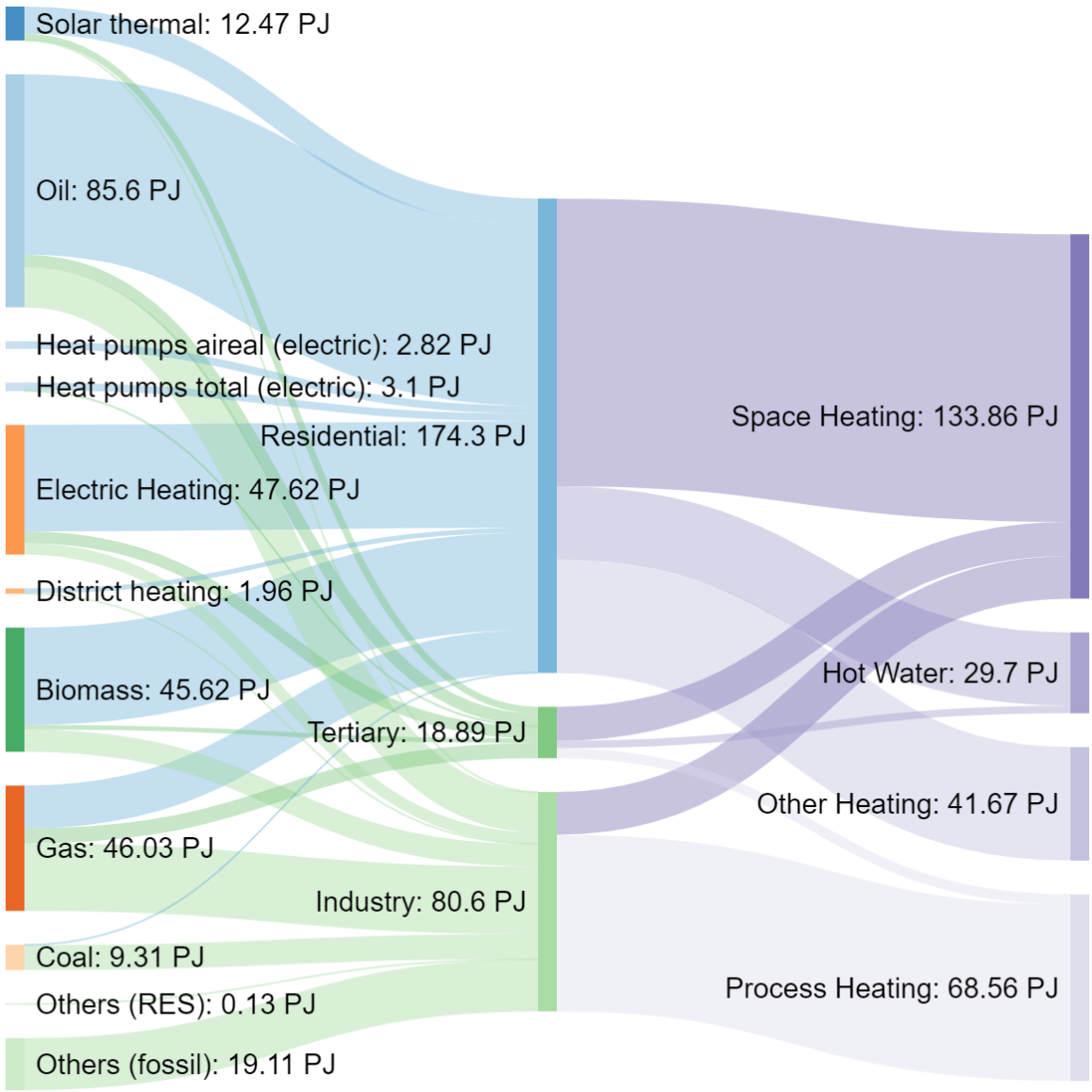


Figure 7-140: Sankey diagram of energy flows for heating purposes in Greece in 2015. Based on data from [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

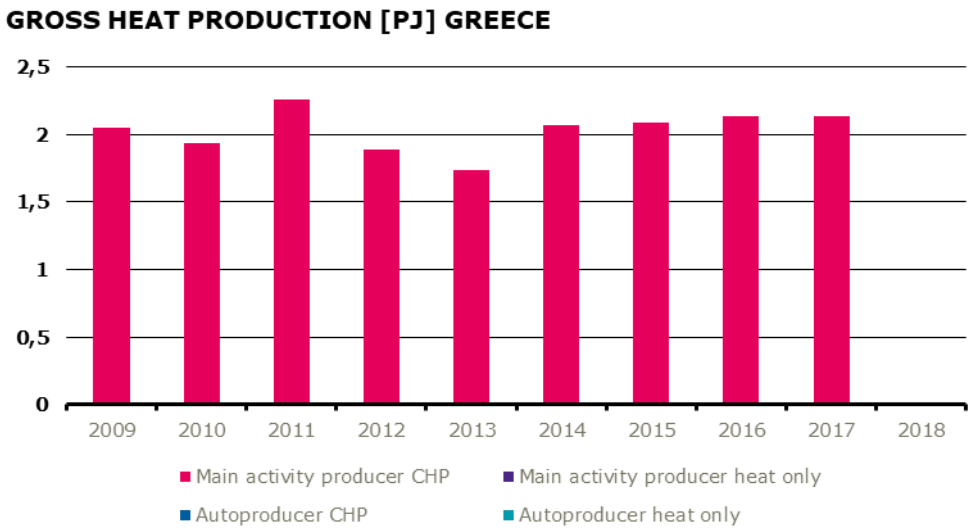


Figure 7-141: Gross heat production by producer type and year in Greece. Based on data from [2]

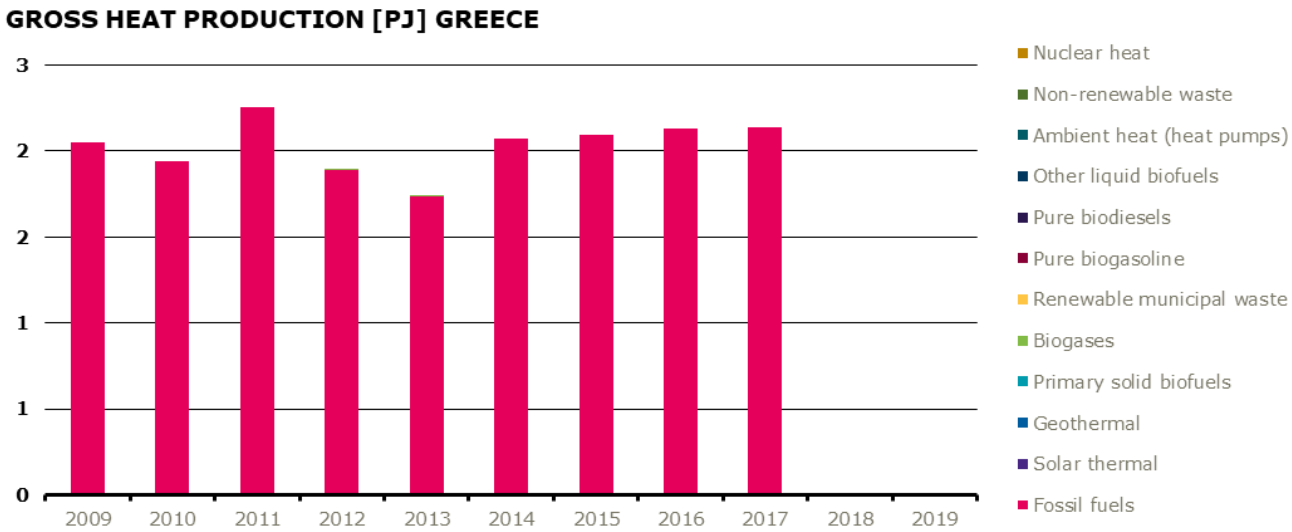


Figure 7-142: Gross heat production by fuel and year in Greece. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.12.4 Electricity Production

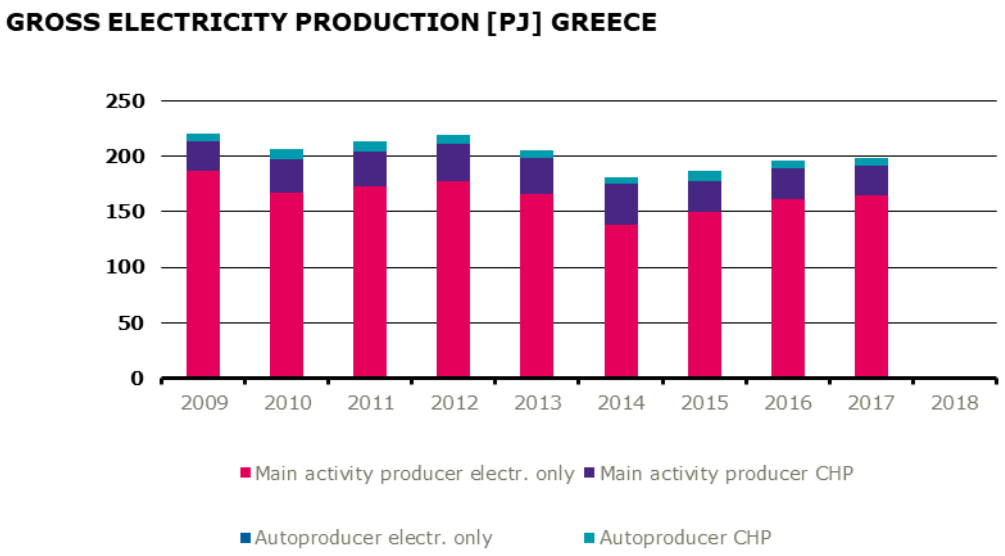


Figure 7-143: Gross electricity production by producer type and year in Greece. Based on data from [2]

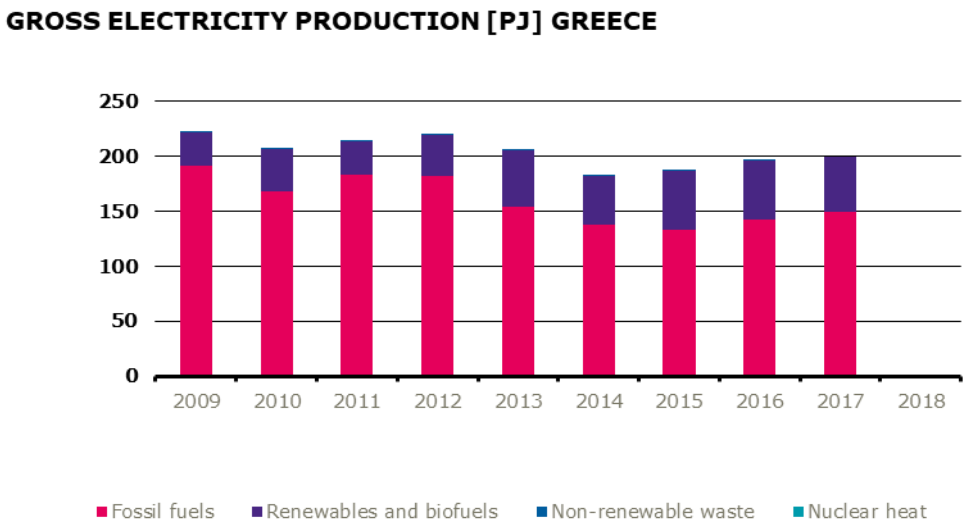


Figure 7-144: Gross electricity production by fuel type and year in Greece. Based on data from [2]

7.12.5 District Heat

[*No data available*]

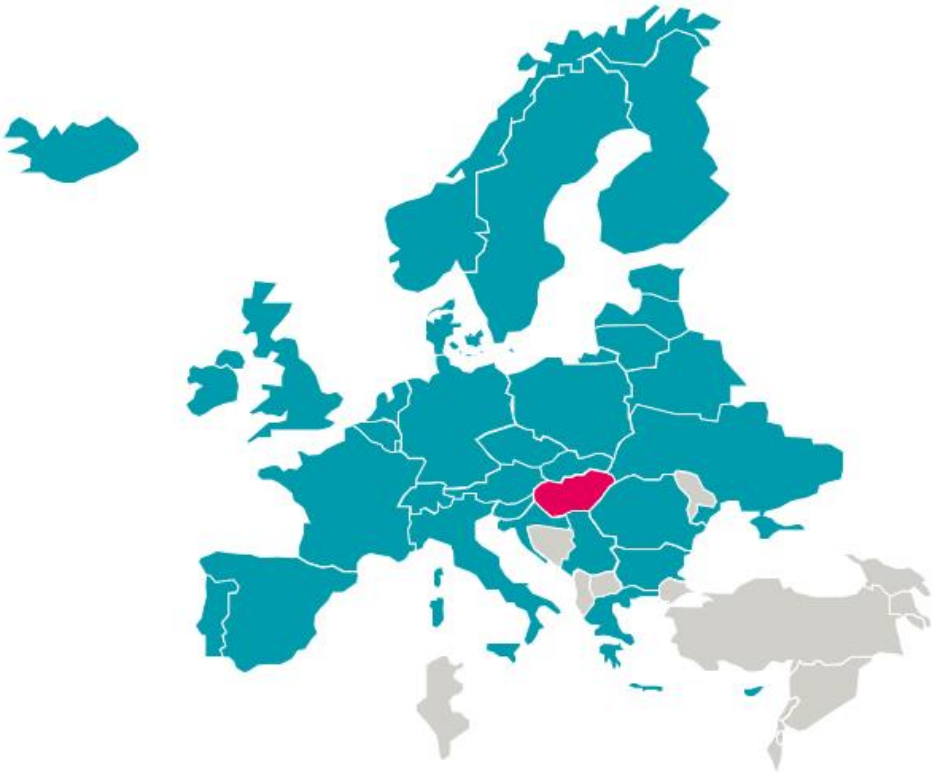
7.12.6 Energy storage

[*No data available*]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.13 Hungary

7.13.1 Country profile



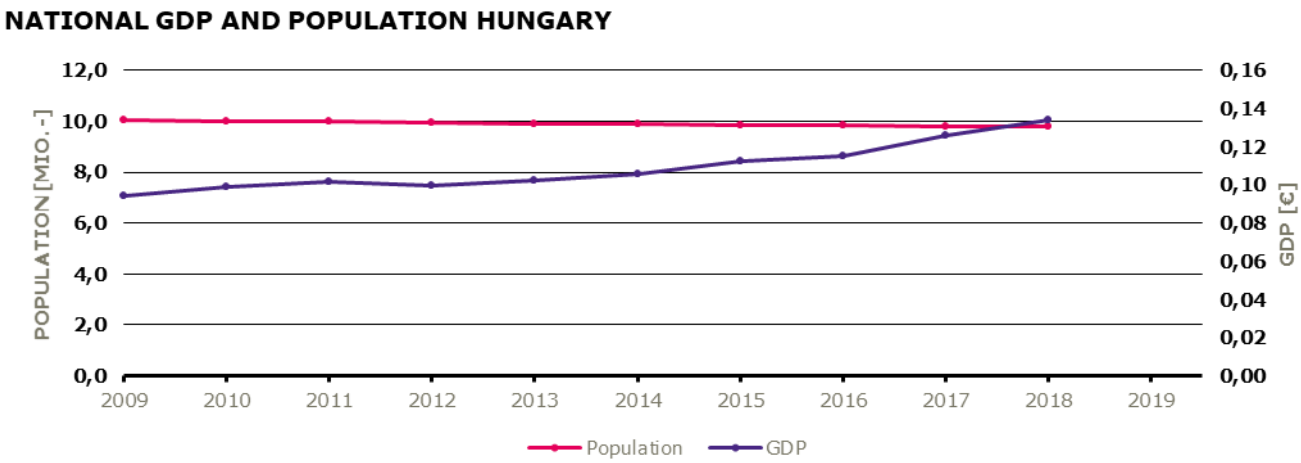


Figure 7-145: GDP and population development in Hungary. Based on data from [1]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.13.2 Energy use

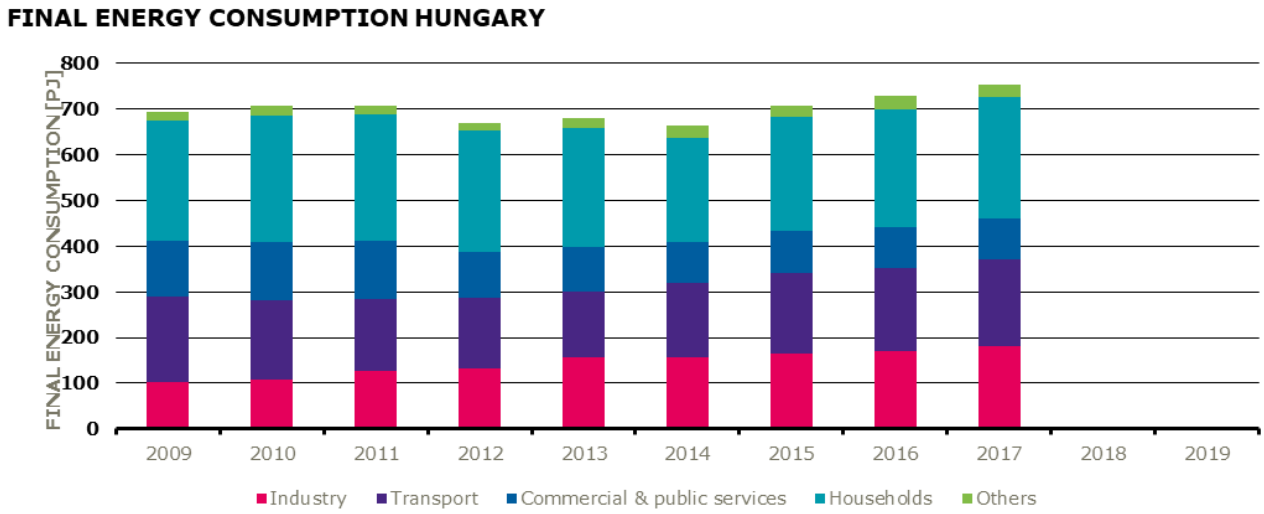


Figure 7-146: Final energy consumption by economic sector and year in Hungary. Based on data from [2]

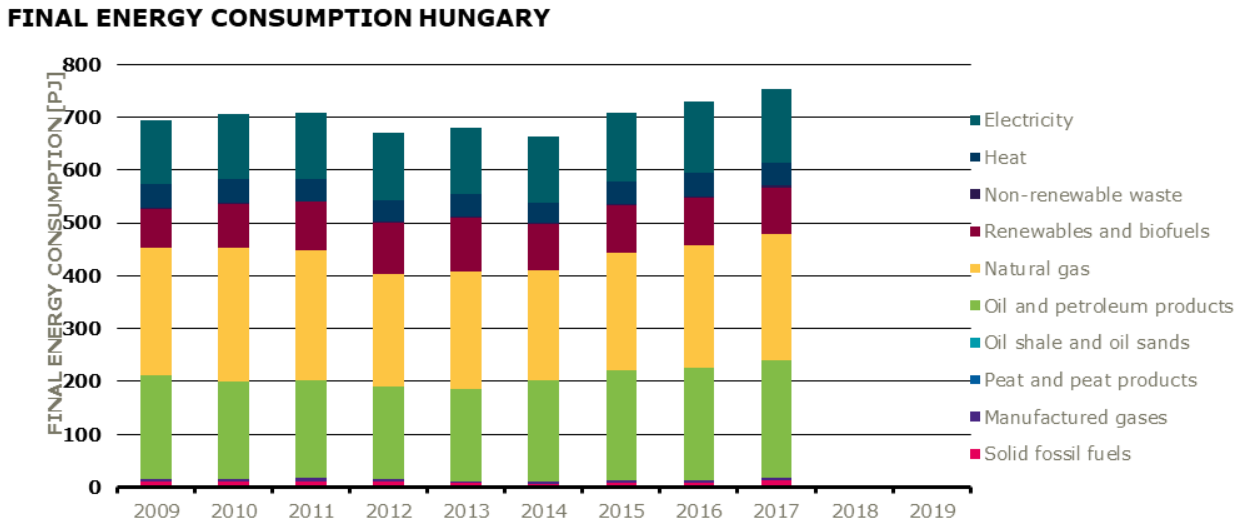


Figure 7-147: Final energy consumption by fuel and year in Hungary. Based on data from [2]

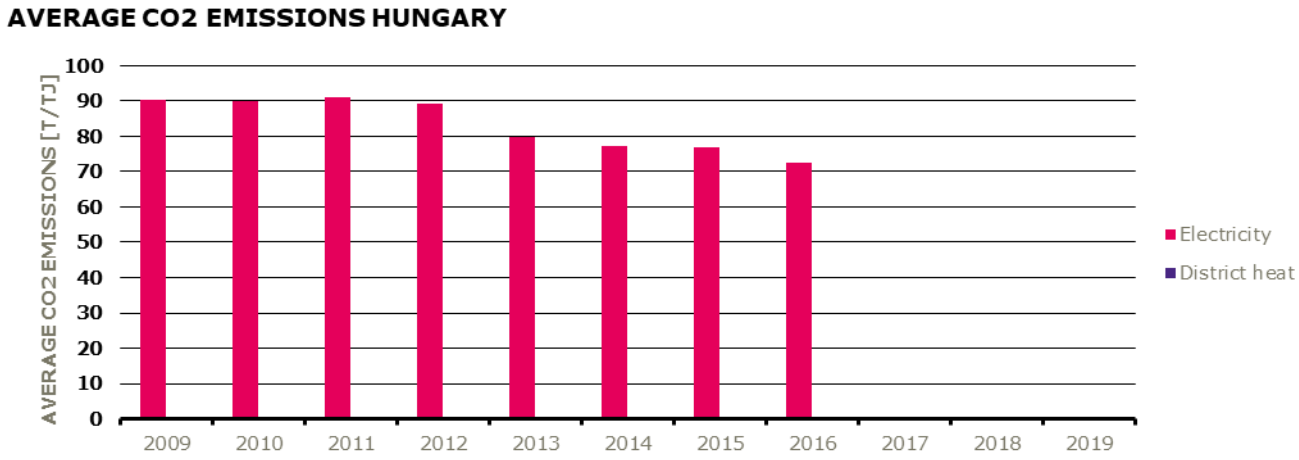


Figure 7-148: Average CO2 emissions in Hungary. Based on data from [3] & [4]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.13.3 Heat Production

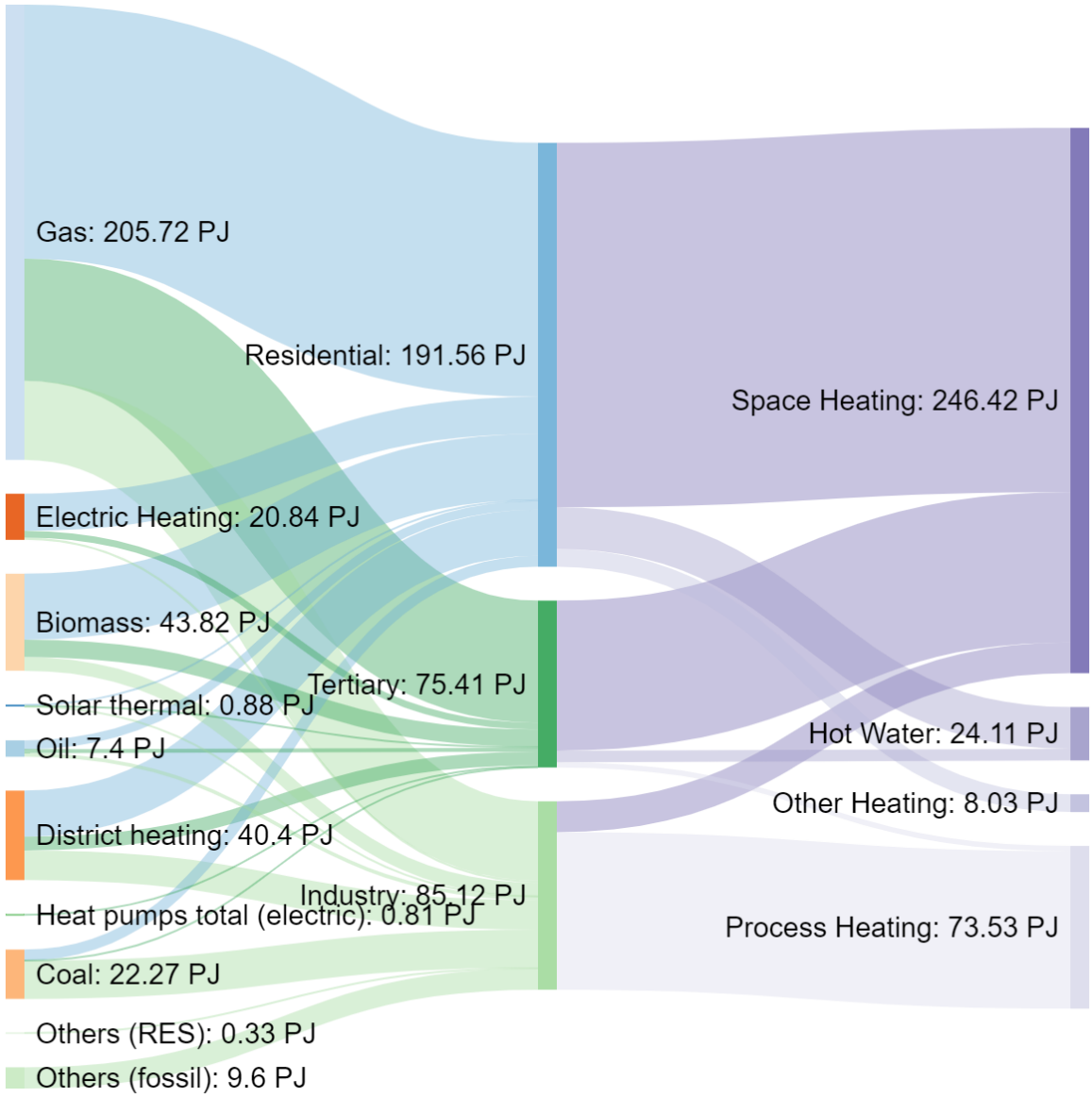


Figure 7-149: Sankey diagram of energy flows for heating purposes in Hungary in 2015. Based on data from [3]

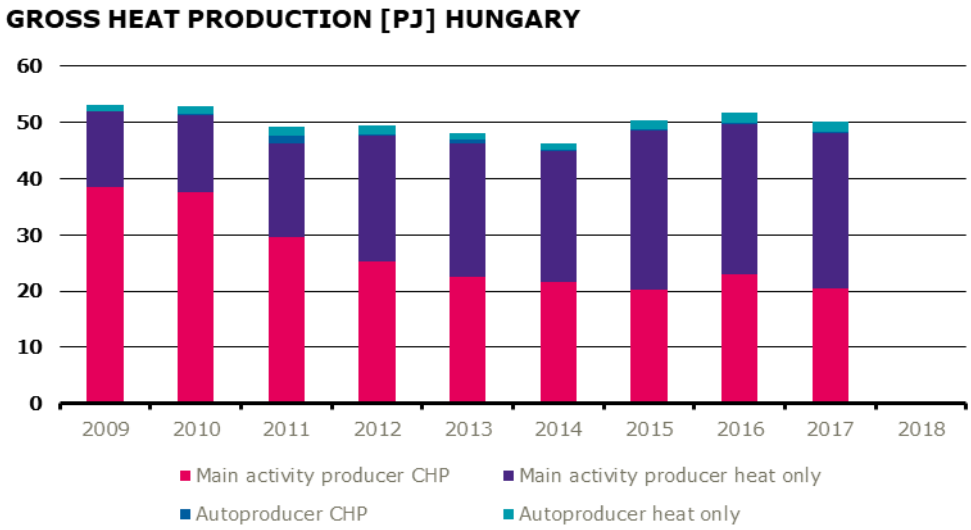


Figure 7-150: Gross heat production by producer type and year in Hungary. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

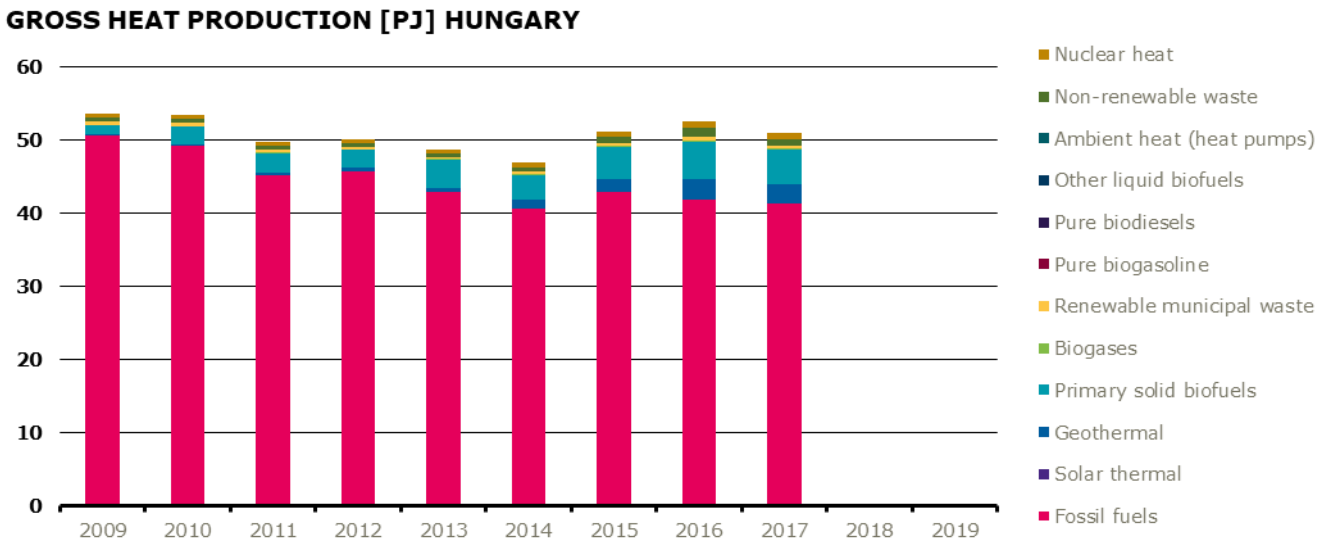


Figure 7-151: Gross heat production by fuel and year in Hungary. Based on data from [2]

7.13.4 Electricity Production

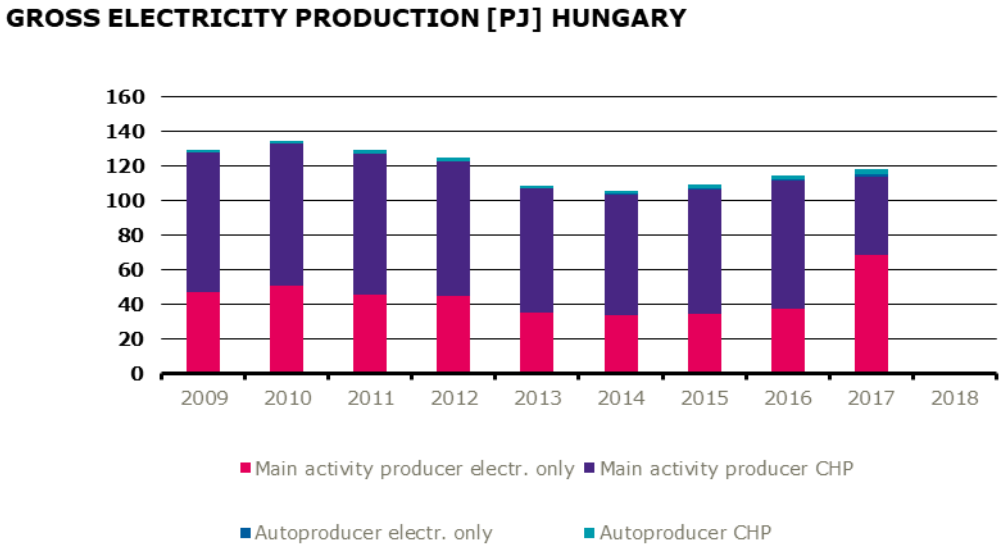


Figure 7-152: Gross electricity production by producer type and year in Hungary. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

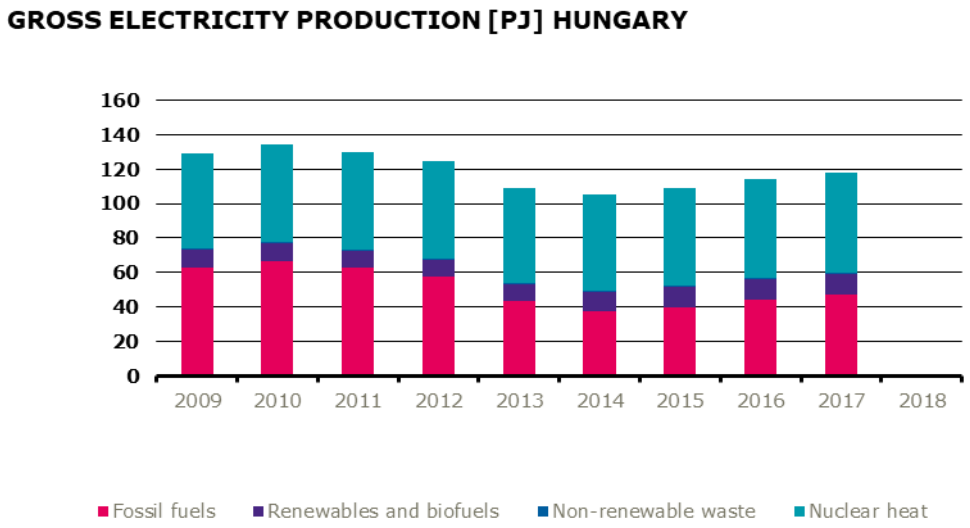


Figure 7-153: Gross electricity production by fuel type and year in Hungary. Based on data from [2]

7.13.5 District Heat

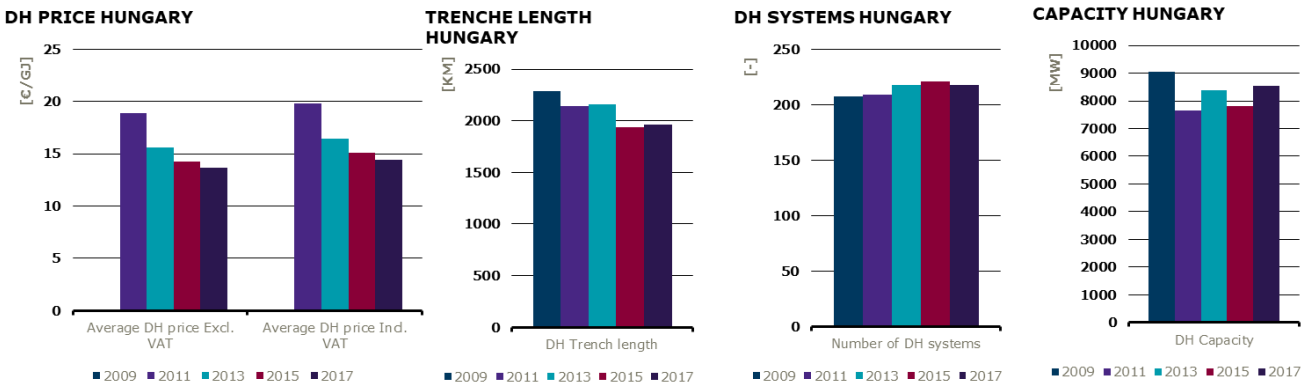


Figure 7-154: District heat indicators for Hungary. Based on data from [2]

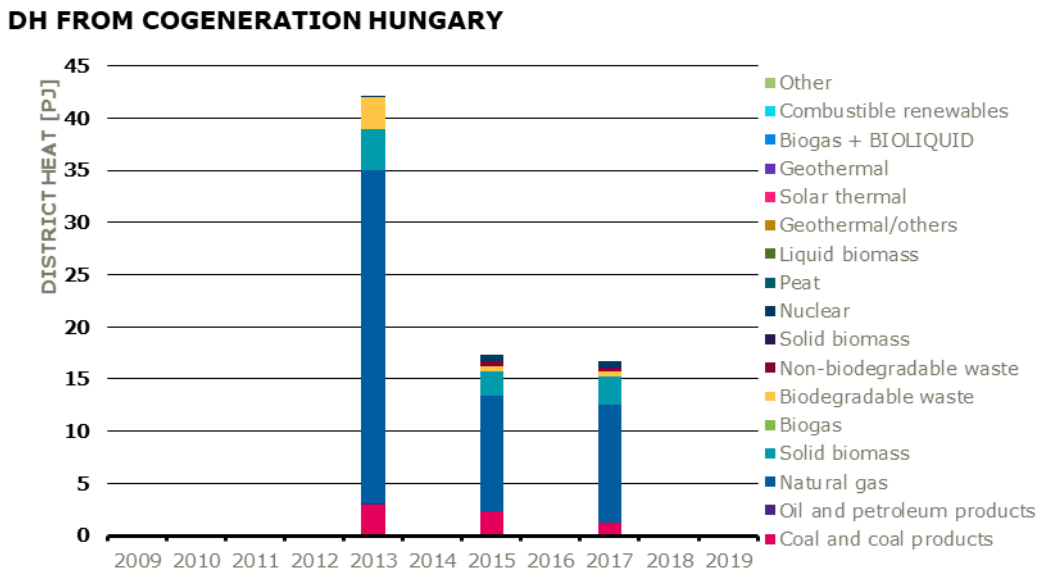


Figure 7-155: District heat generated in CHP plants by year and fuel in Hungary. Based on data from [2], [3]

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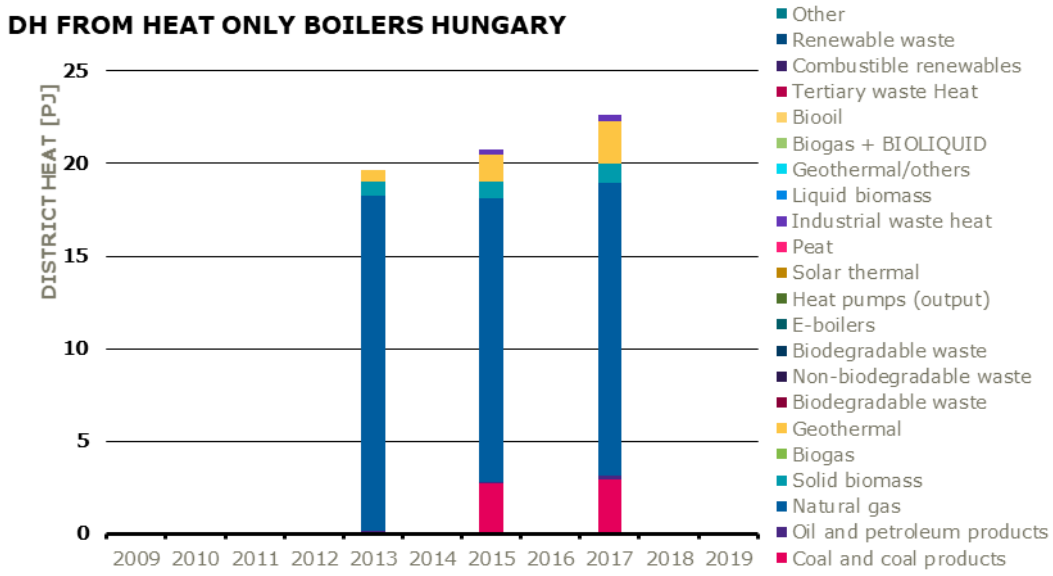


Figure 7-156: District heat generated in heat only boilers by year and fuel in Hungary. Based on data from [2], [3]

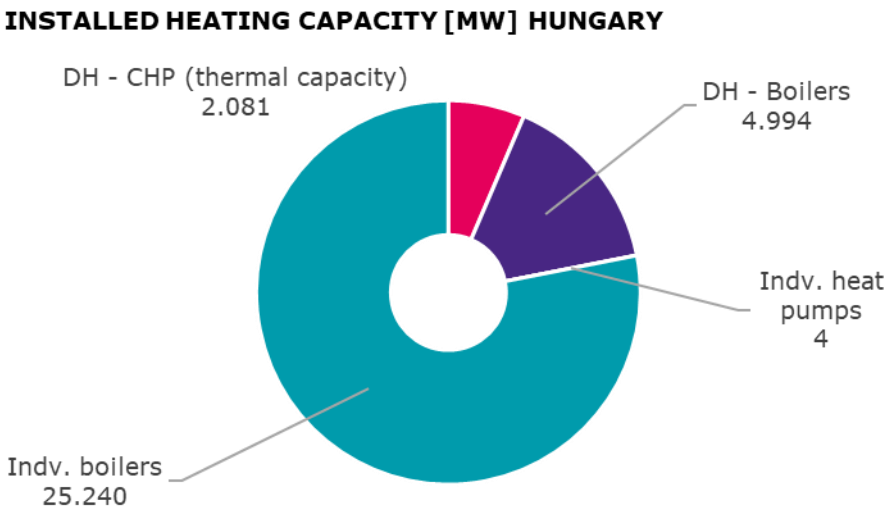


Figure 7-157: Installed heating capacity installed in Hungary in 2015. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.13.6 Energy storage

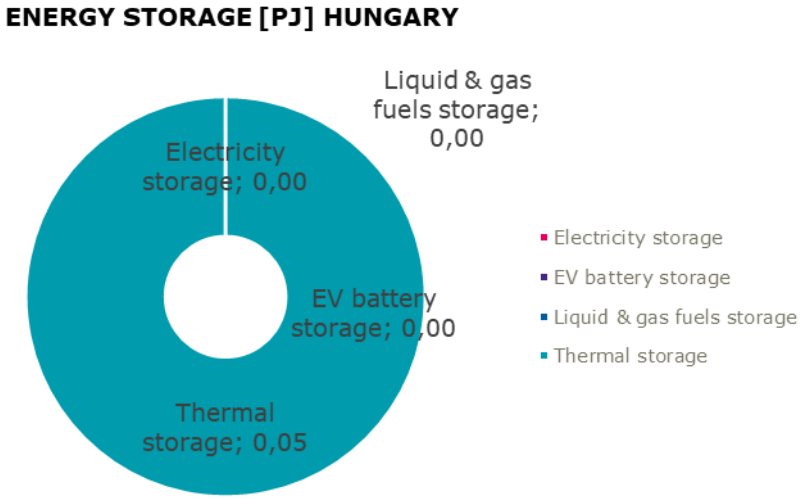
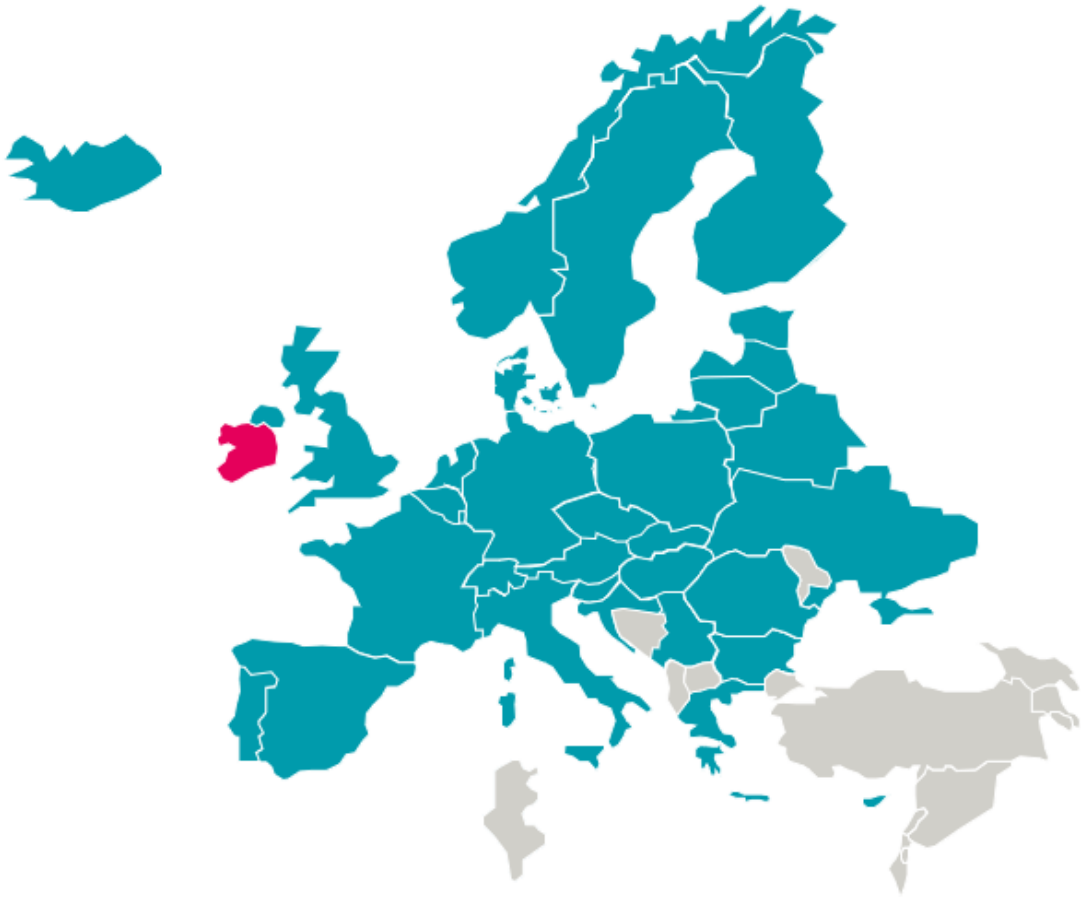


Figure 7-158: Stoage capacity in Hungary in 2015. Based on data from [2]

7.14 Ireland

7.14.1 Country profile



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

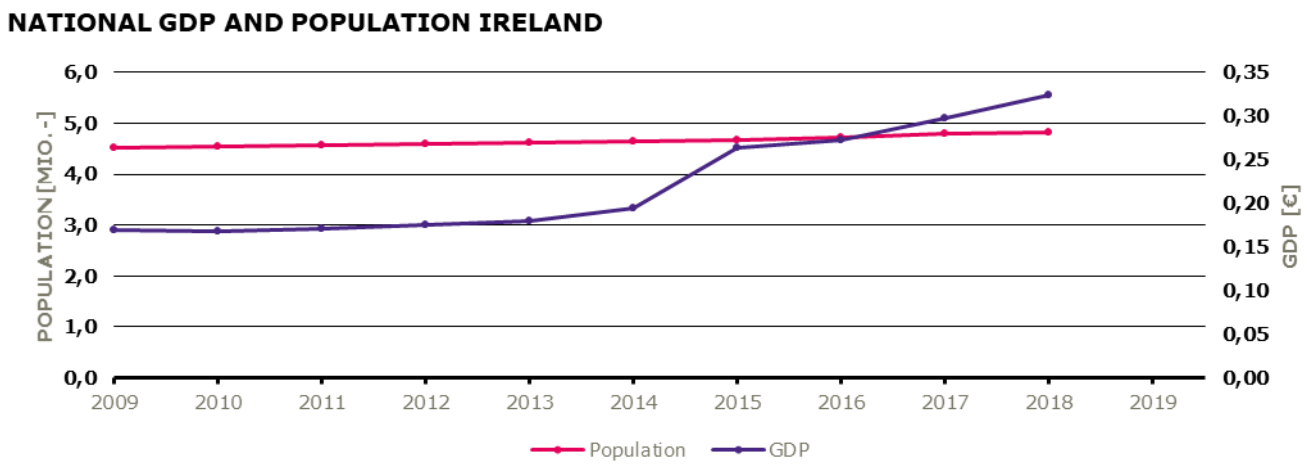


Figure 7-159: GDP and population development in Ireland. Based on data from [1]

7.14.2 Energy use

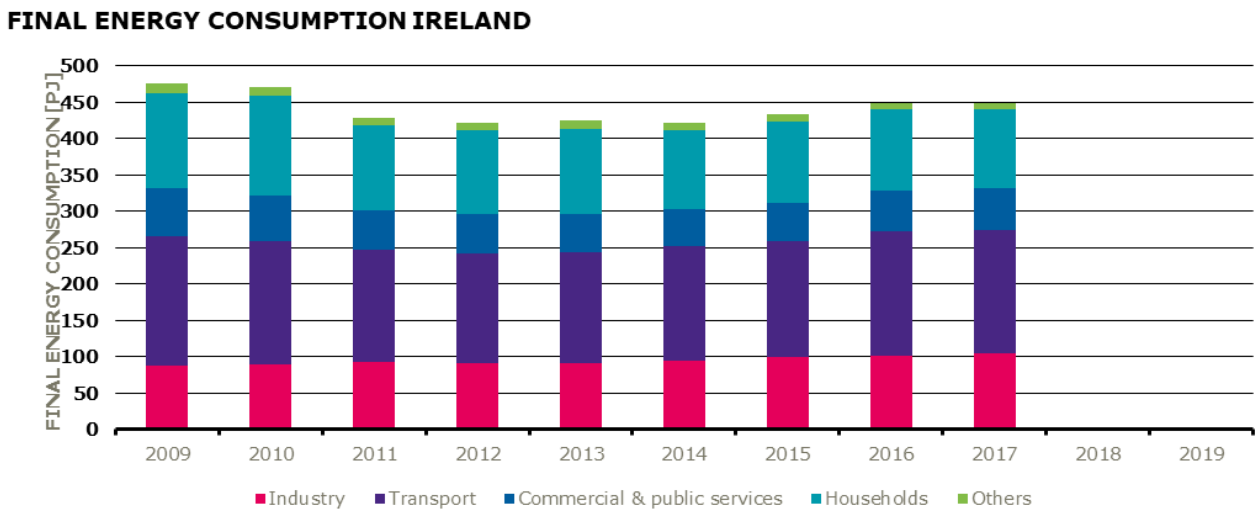


Figure 7-160: Final energy consumption by economic sector and year in Ireland. Based on data from [2]

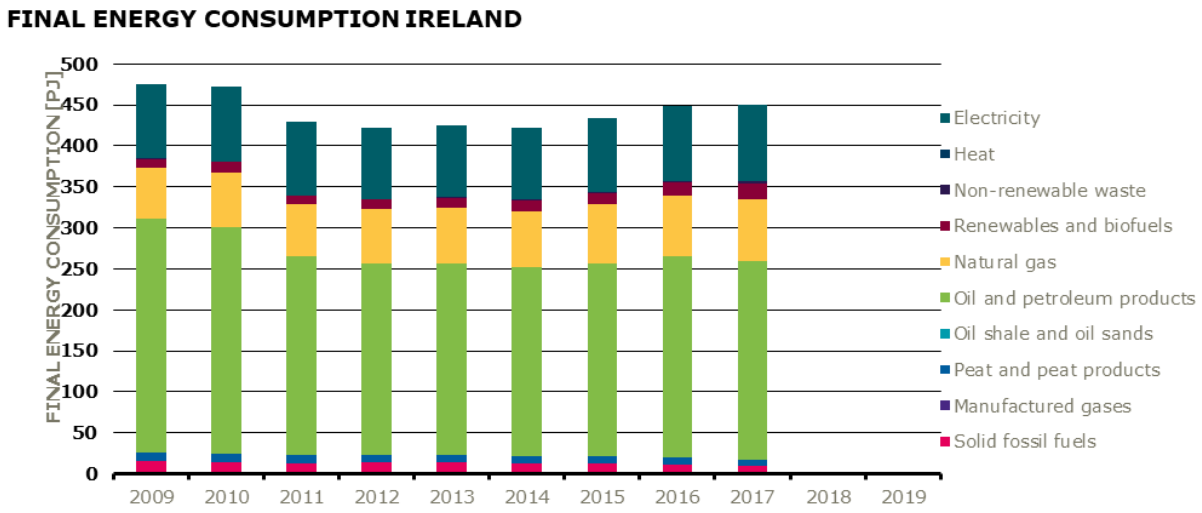


Figure 7-161: Final energy consumption by fuel and year in Ireland. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

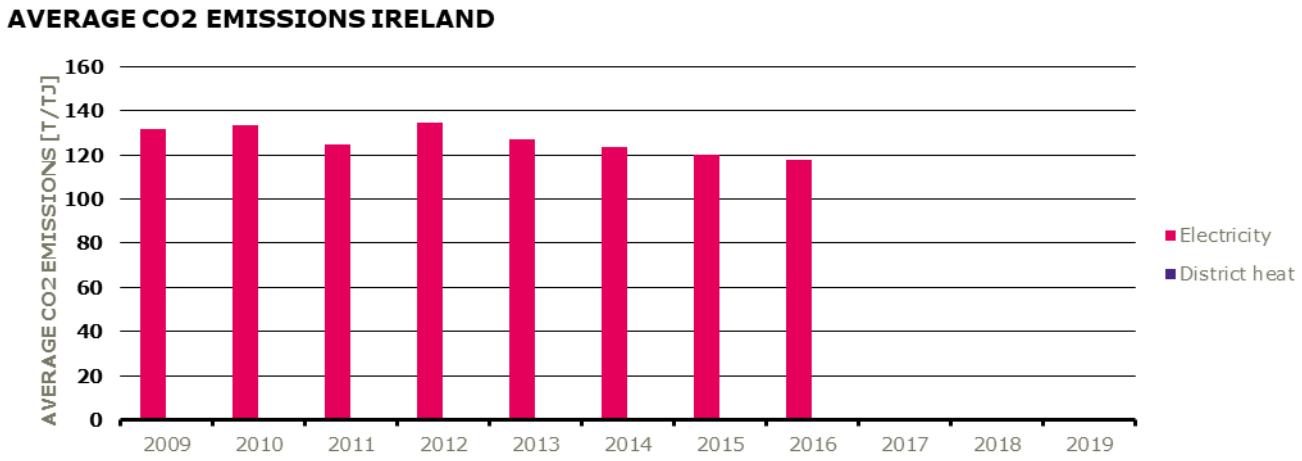


Figure 7-162: Average CO2 emissions in Ireland. Based on data from [3] & [4]

7.14.3 Heat Production

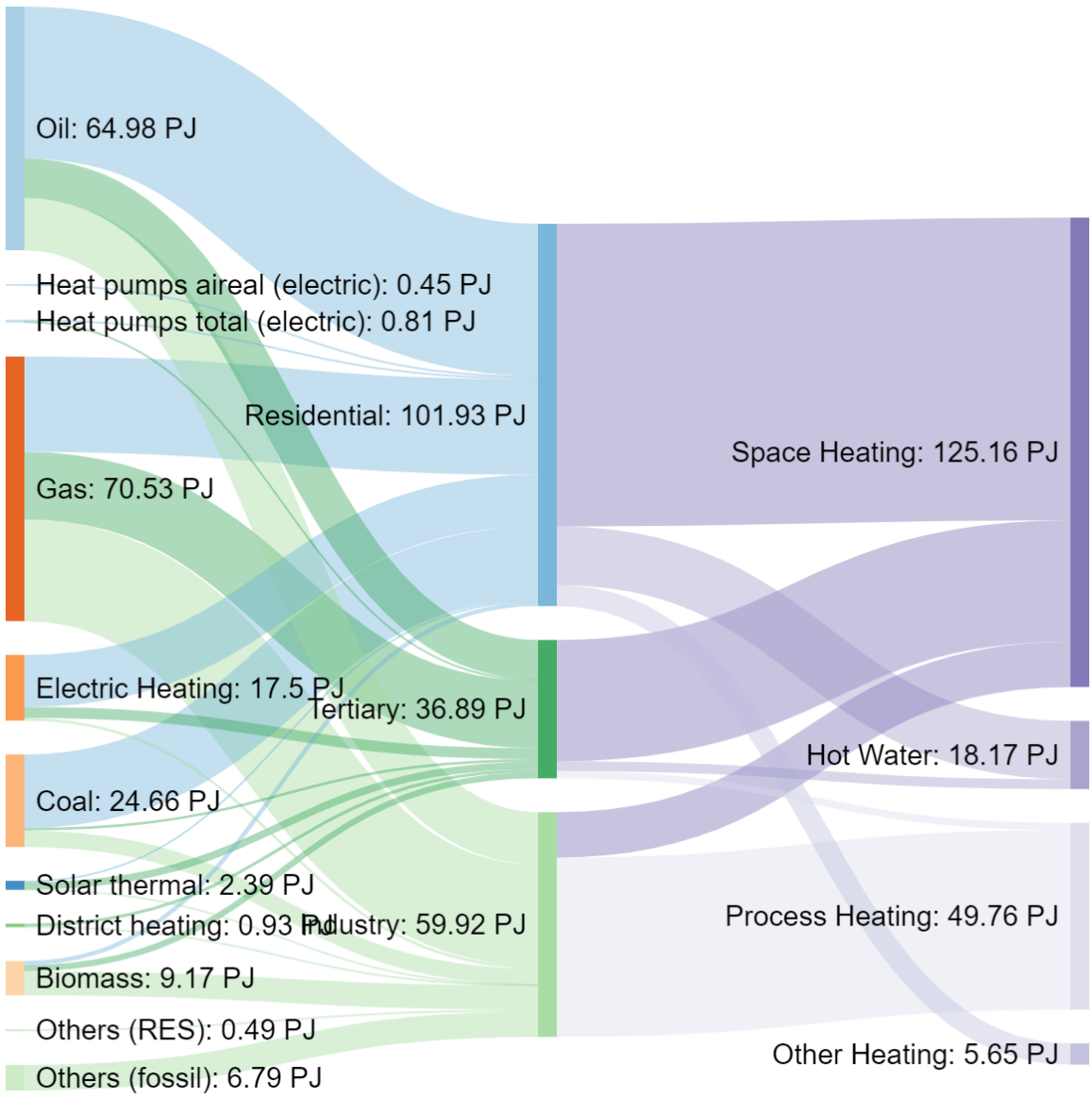


Figure 7-163: Sankey diagram of energy flows for heating purposes in Ireland in 2015. Based on data from [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.14.4 Electricity Production

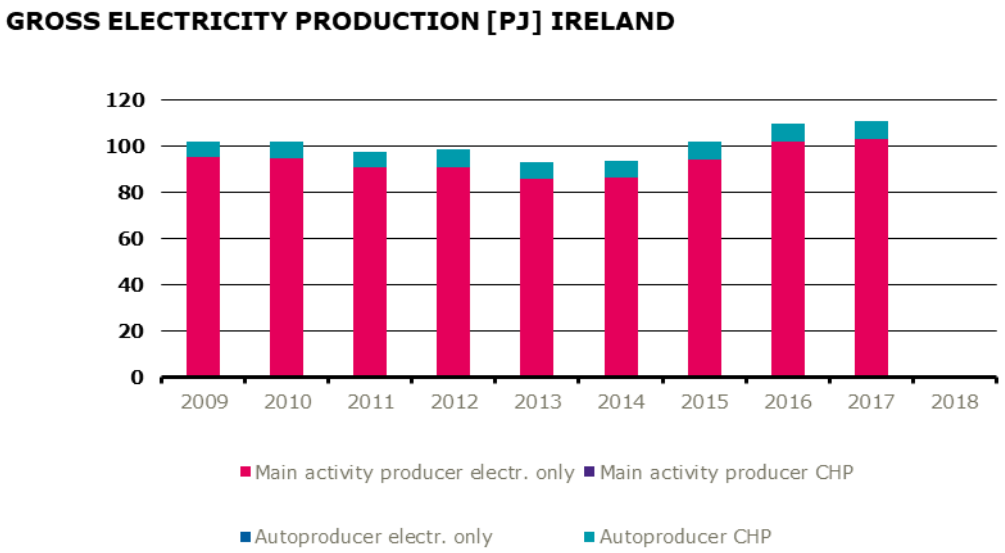


Figure 7-164: Gross electricity production by producer type and year in Ireland. Based on data from [2].

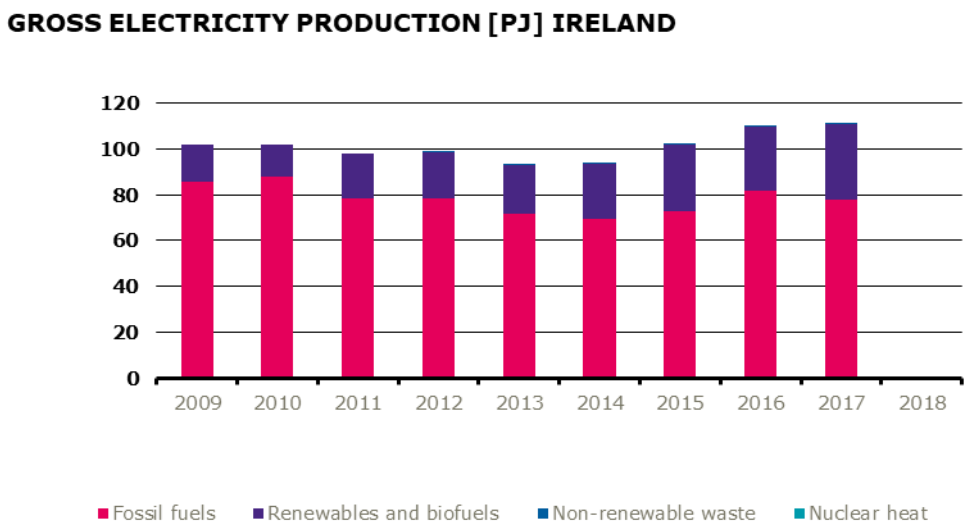


Figure 7-165: Gross electricity production by fuel type and year in Ireland. Based on data from [2]

7.14.5 District Heat

[*No data available*]

7.14.6 Energy storage

[*No data available*]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.15 Italy

7.15.1 Country profile

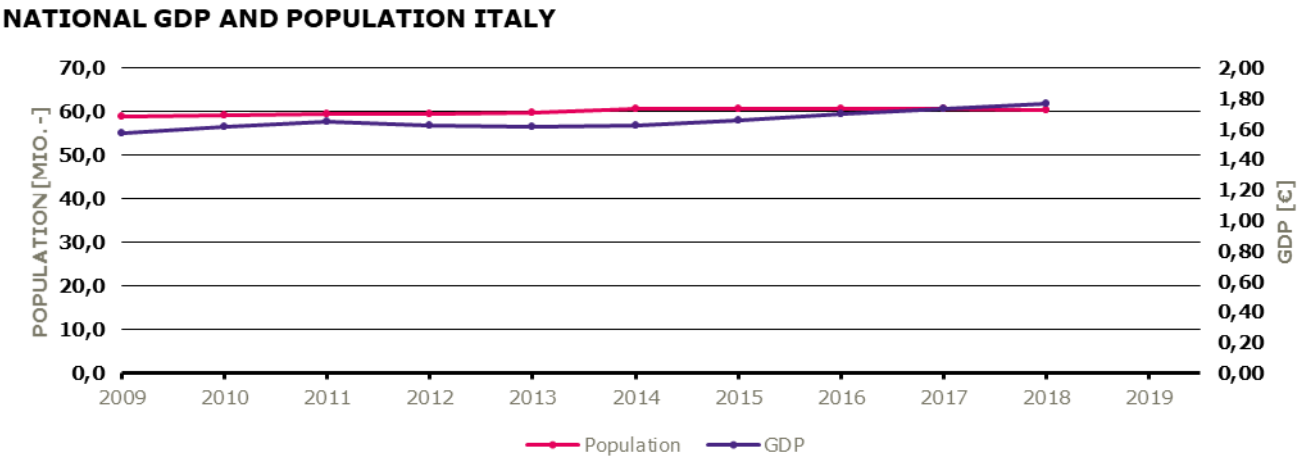


Figure 7-166: GDP and population development in Italy. Based on data from [1]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.15.2 Energy use

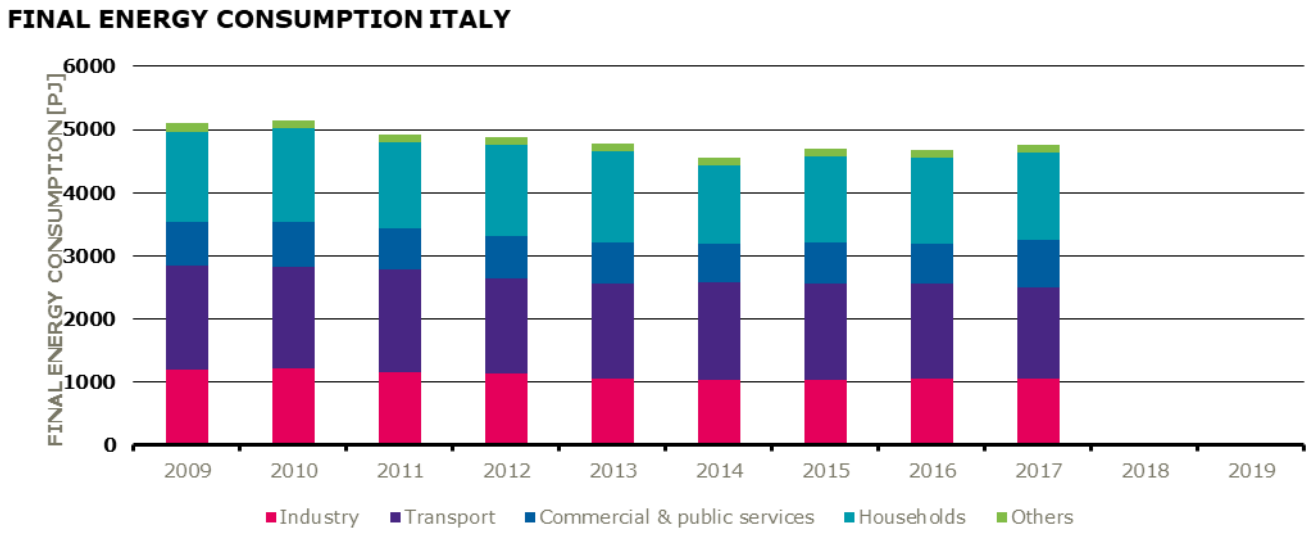


Figure 7-167: Final energy consumption by economic sector and year in Italy 7.15.2. Based on data from [2]

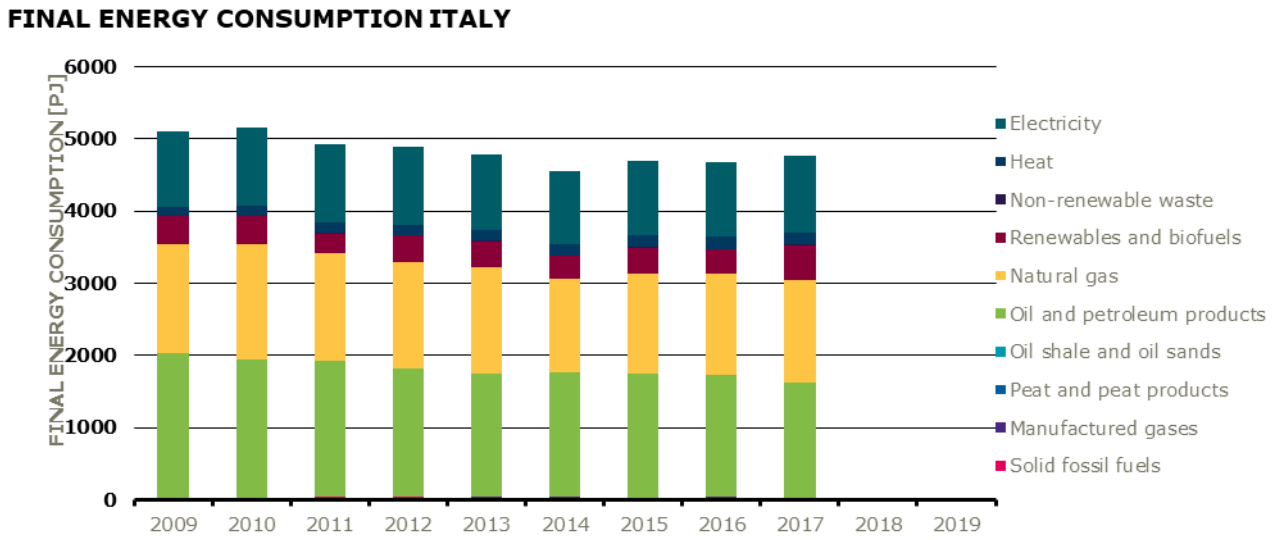


Figure 7-168: Final energy consumption by fuel and year in Italy. Based on data from [2]

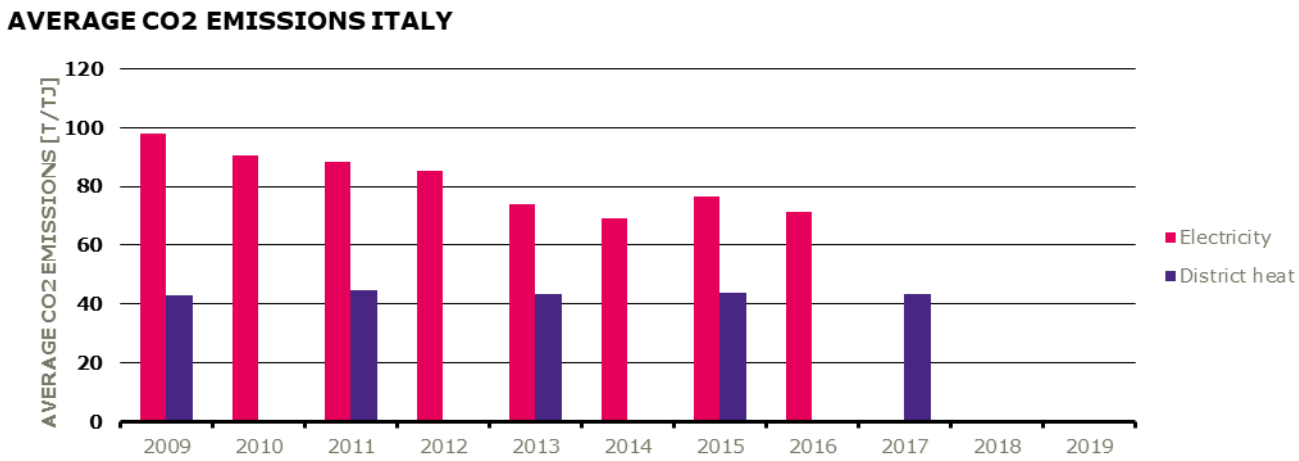


Figure 7-169: Average CO2 emissions in Italy. Based on data from [3] & [4]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.15.3 Heat Production

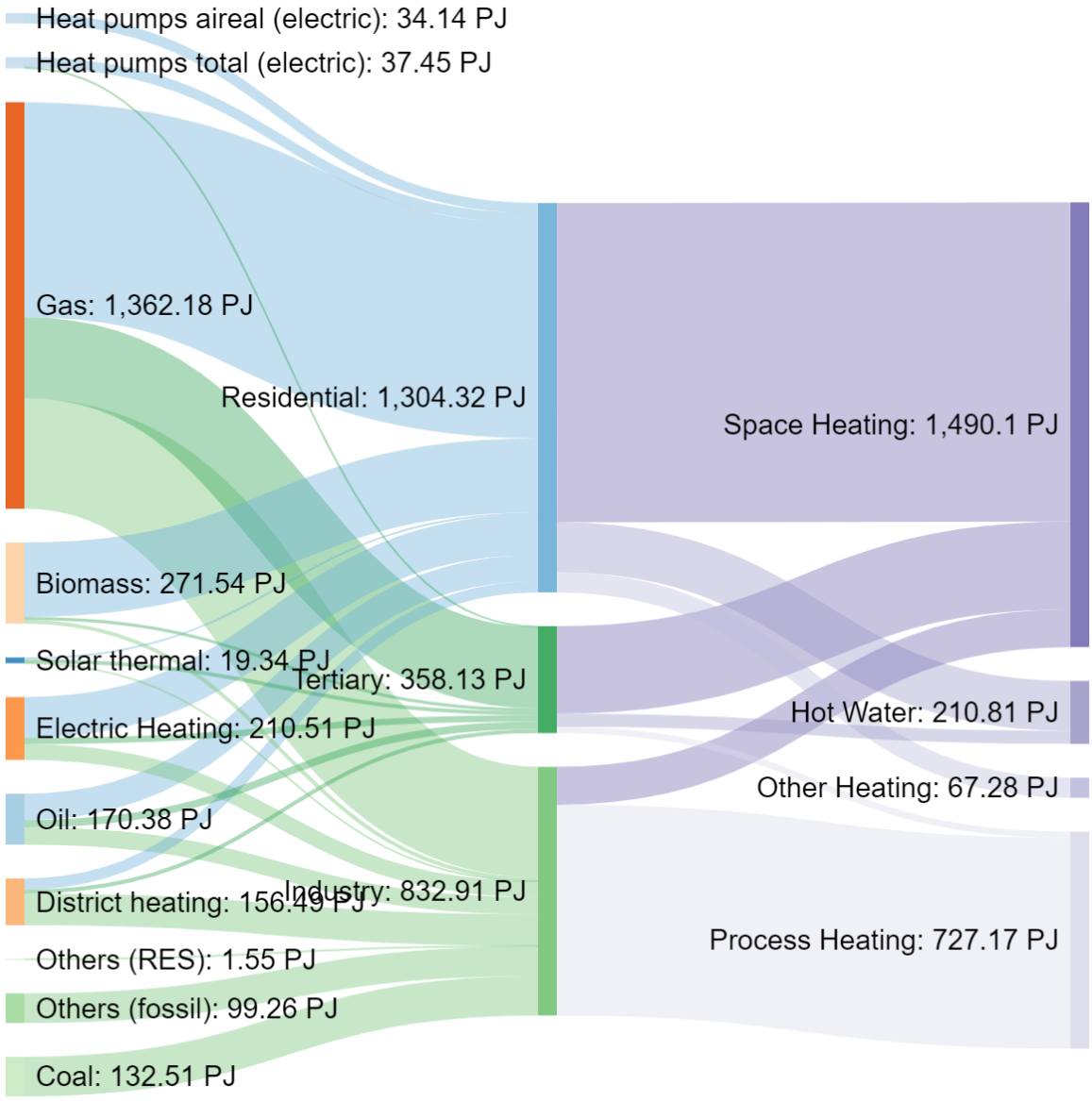


Figure 7-170: Sankey diagram of energy flows for heating purposes in Italy in 2015. Based on data from [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

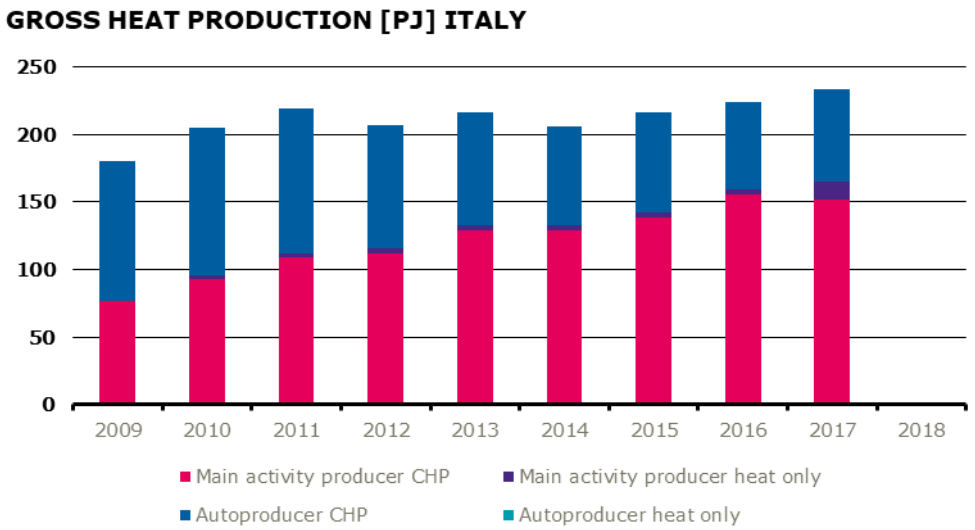


Figure 7-171: Gross heat production by producer type and year in Italy. Based on data from [2]

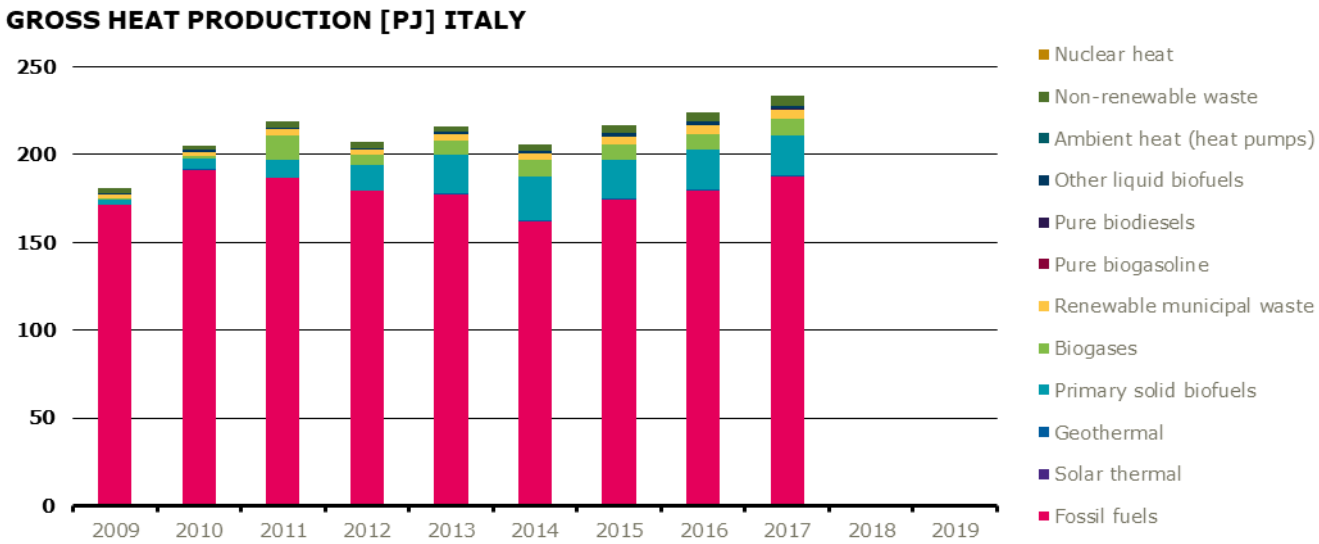


Figure 7-172: Gross heat production by fuel and year in Italy. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.15.4 Electricity Production

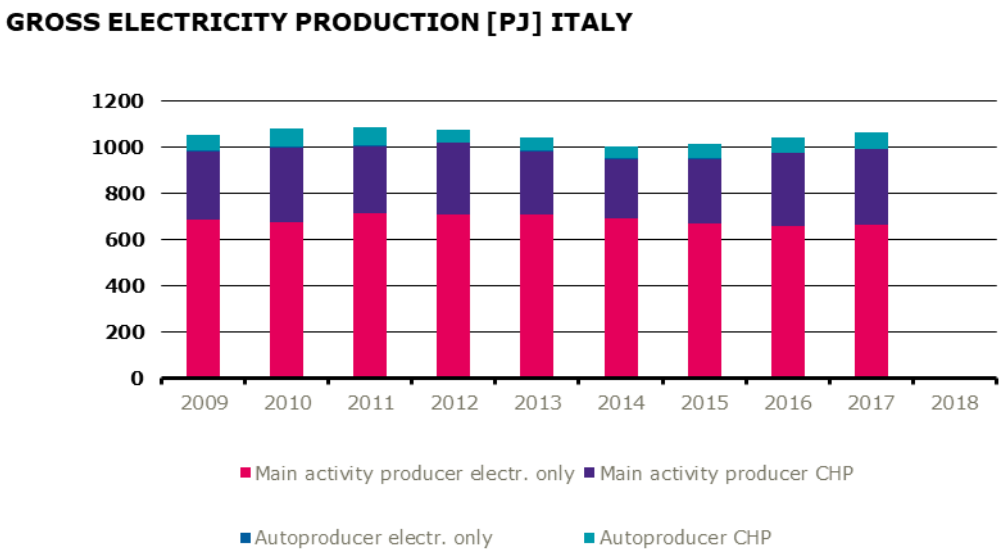


Figure 7-173: Gross electricity production by producer type and year in Italy. Based on data from [2]

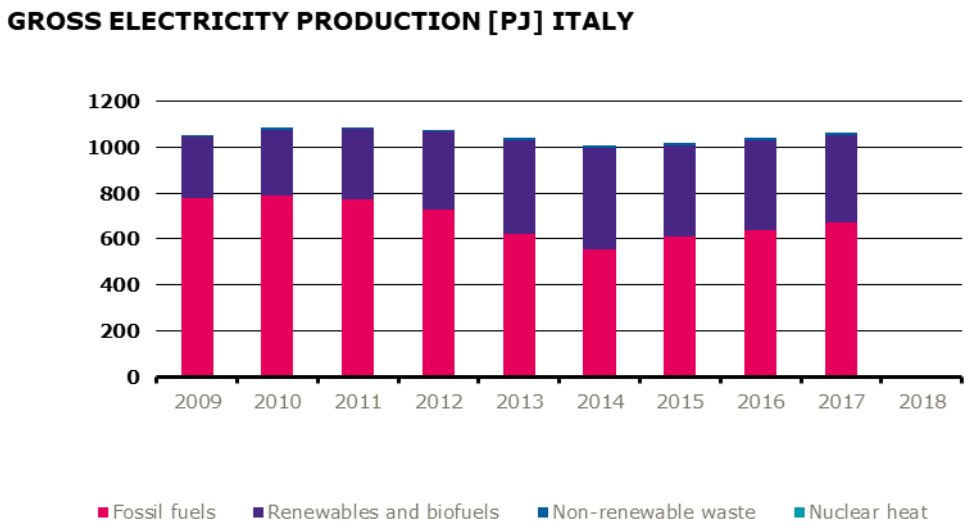


Figure 7-174: Gross electricity production by fuel type and year in Italy. Based on data from [2]

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7.15.5 District Heat

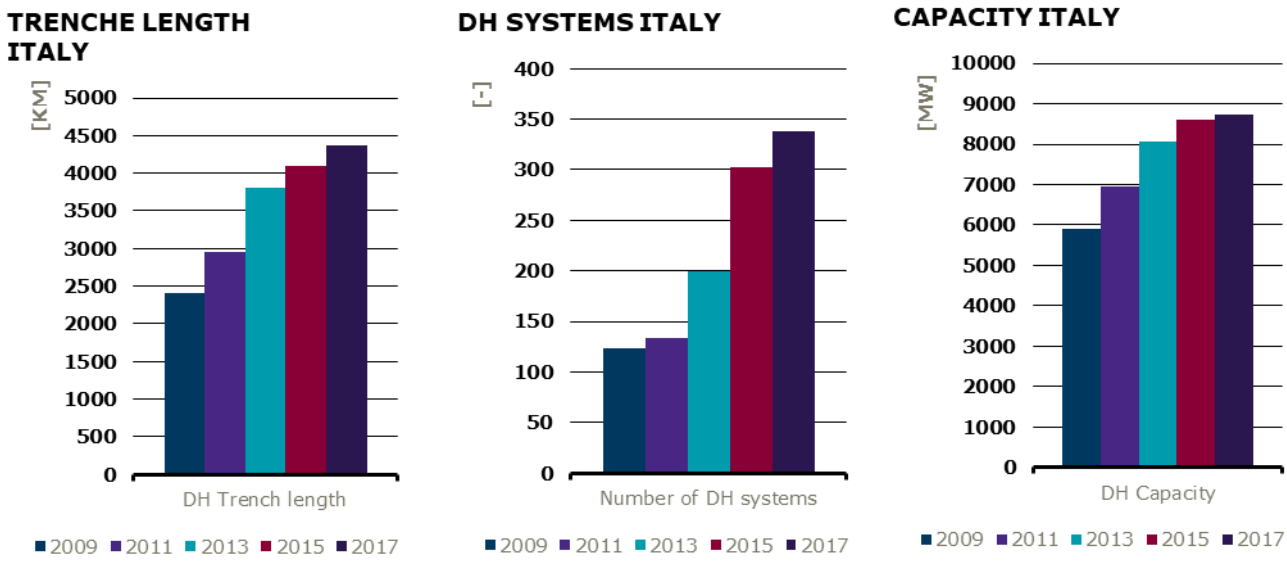


Figure 7-175: District heat indicators for Italy. Based on data from [2]

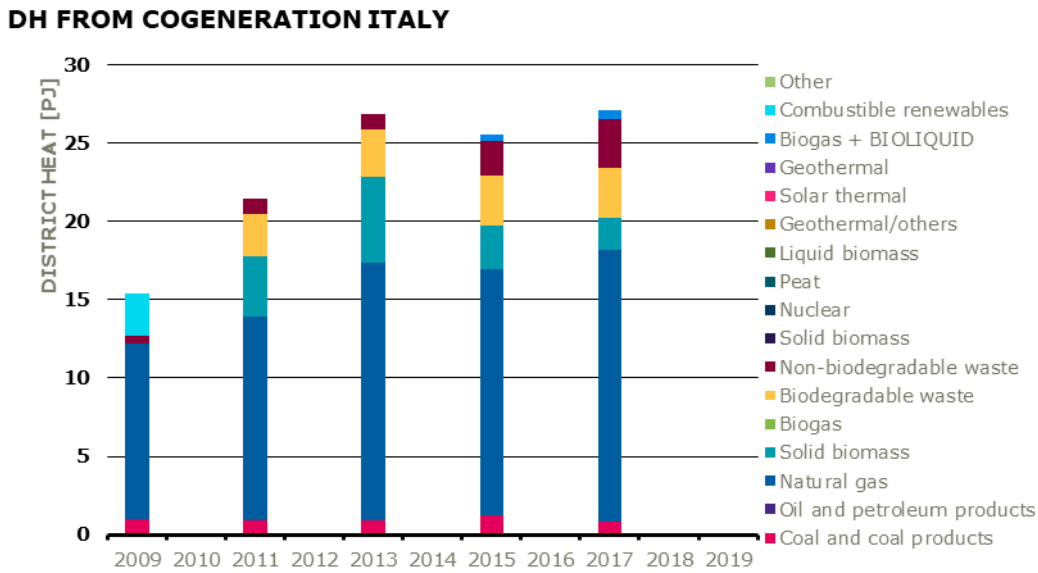


Figure 7-176: District heat generated in CHP plants by year and fuel in Italy. Based on data from [2], [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

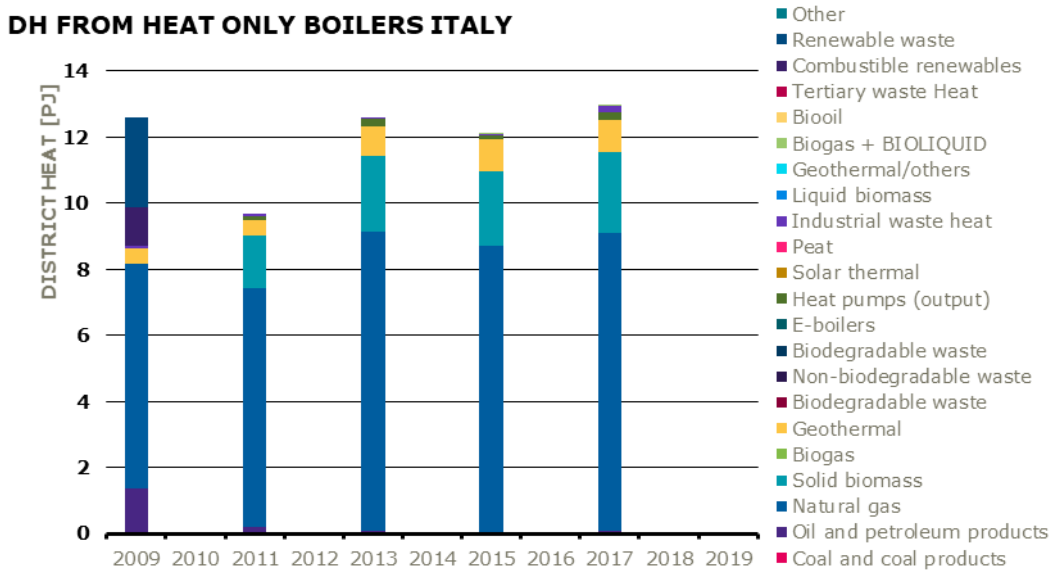


Figure 7-177: District heat generated in heat only boilers by year and fuel in Italy. Based on data from [2], [3]

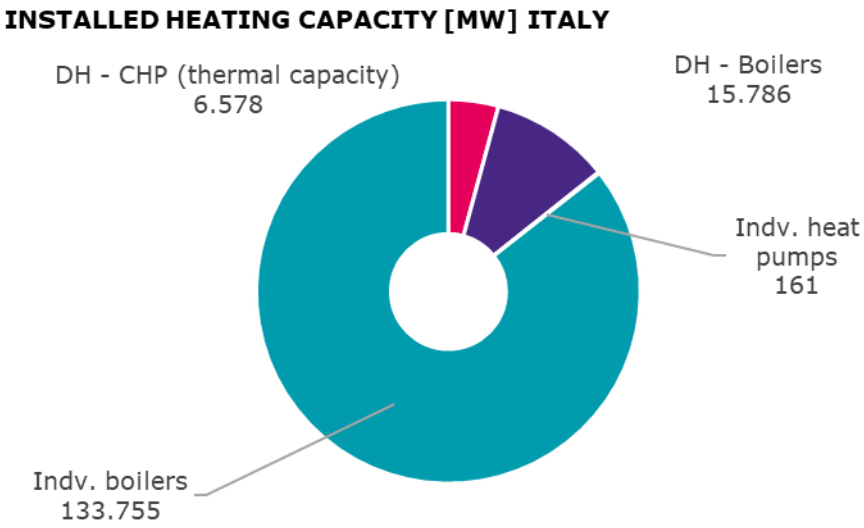


Figure 7-178: Installed heating capacity installed in Italy in 2015. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.15.6 Energy storage

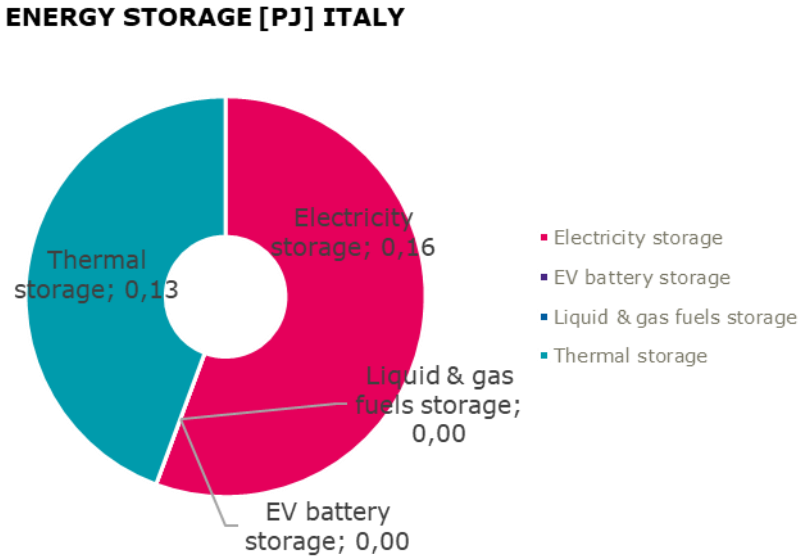
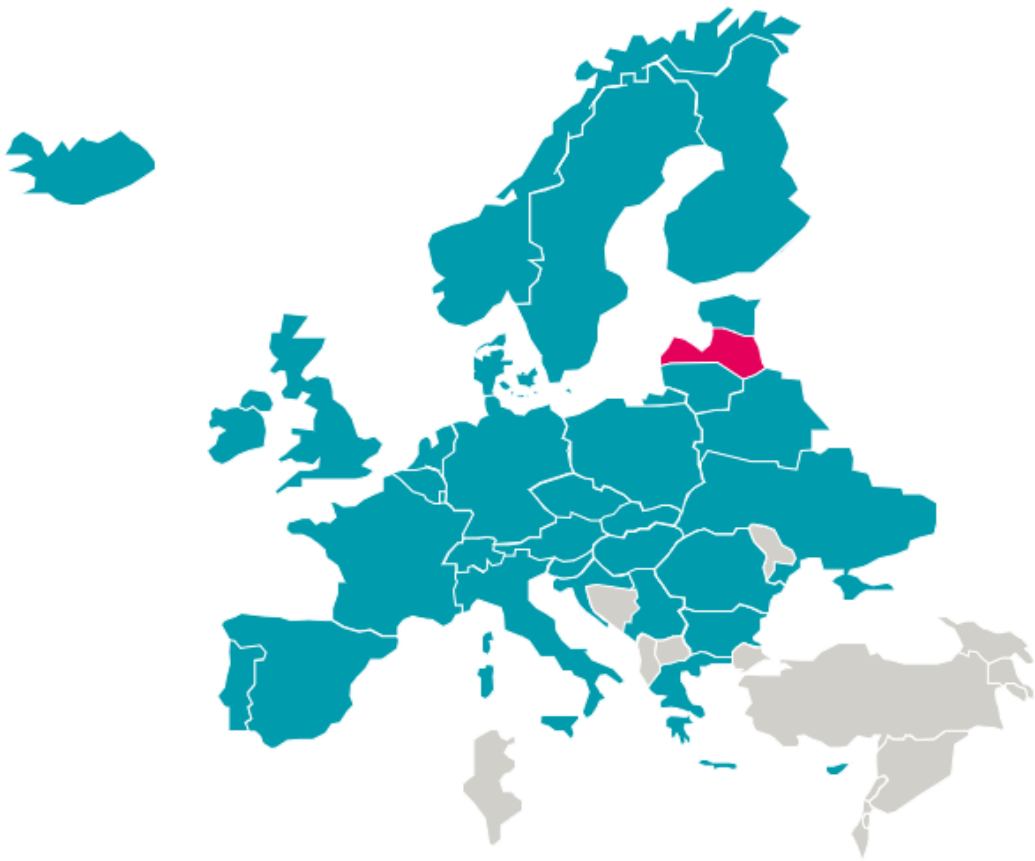


Figure 7-179: Stoage capacity in Italy in 2015. Based on data from [2]

7.16 Latvia

7.16.1 Country profile



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

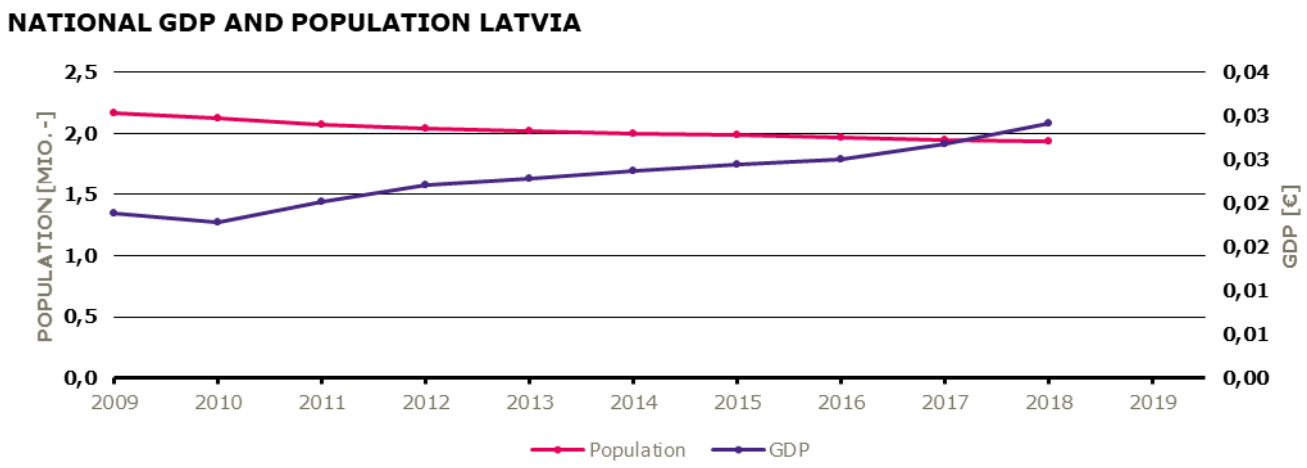


Figure 7-180: GDP and population development in Latvia. Based on data from [1]

7.16.2 Energy use

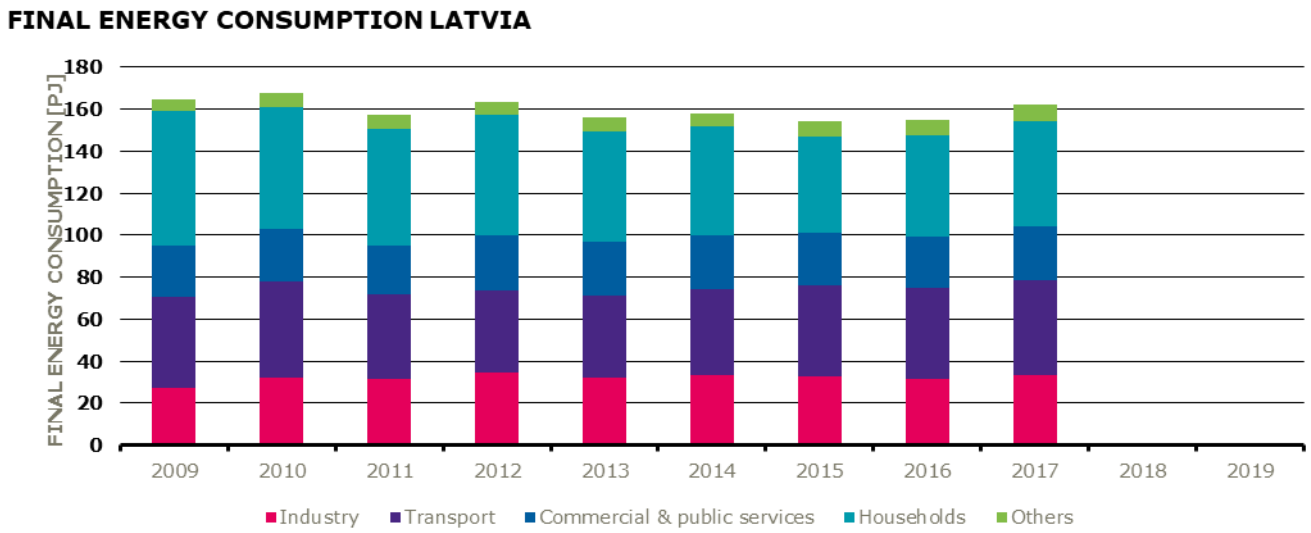


Figure 7-181: Final energy consumption by economic sector and year in Latvia. Based on data from [2]

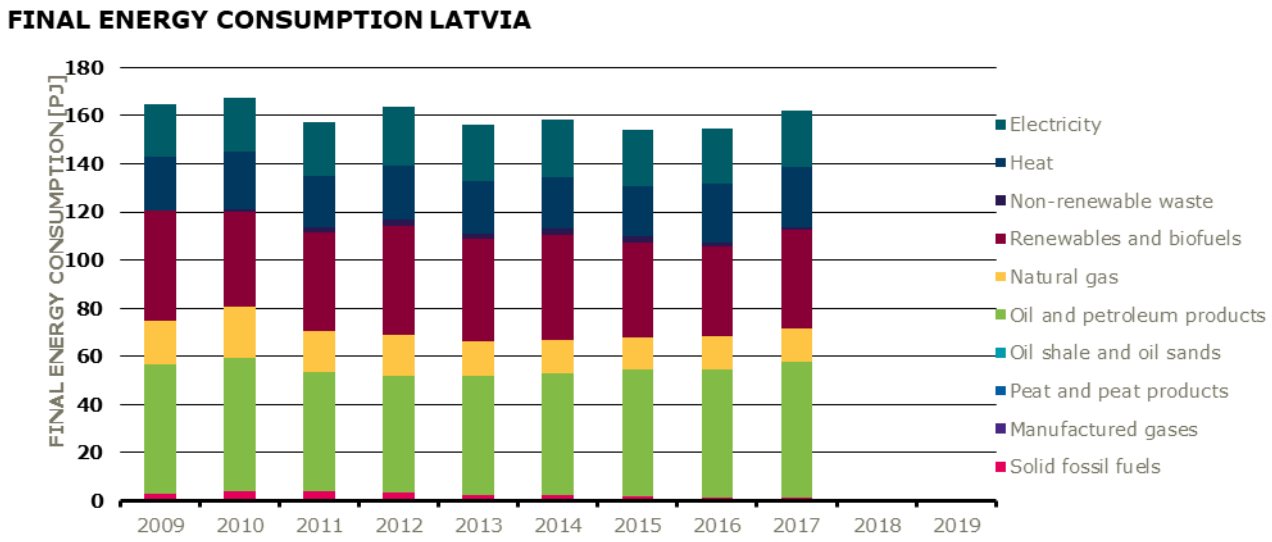


Figure 7-182: Final energy consumption by fuel and year in Latvia. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

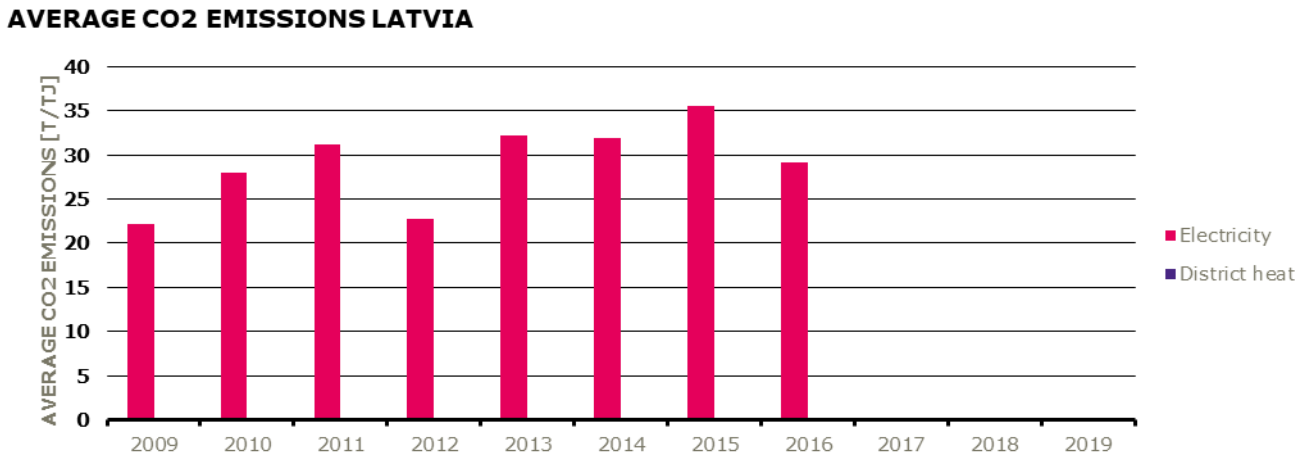


Figure 7-183: Average CO2 emissions in Latvia. Based on data from [3] & [4]

7.16.3 Heat Production

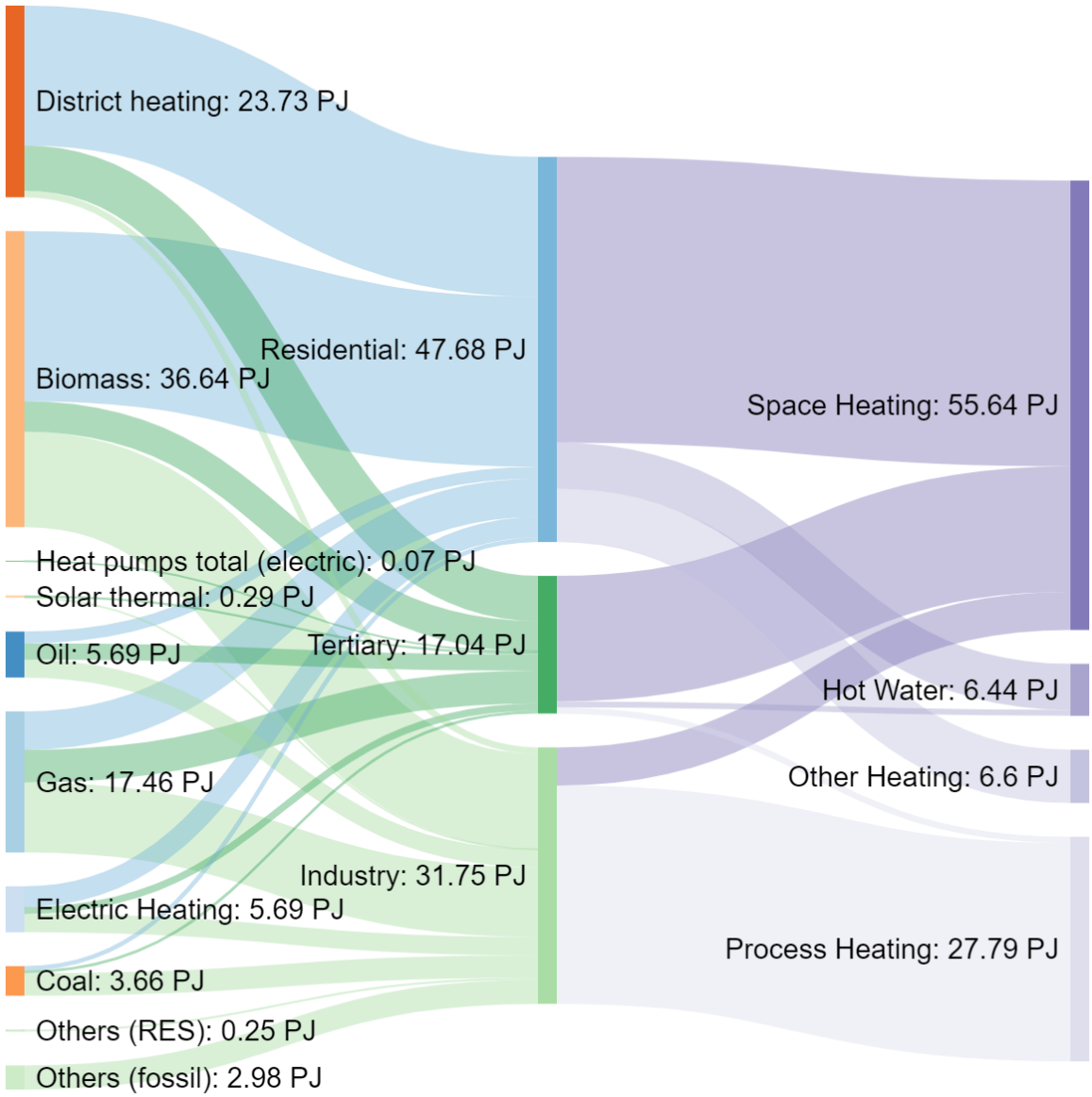


Figure 7-184: Sankey diagram of energy flows for heating purposes in Latvia in 2015. Based on data from [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

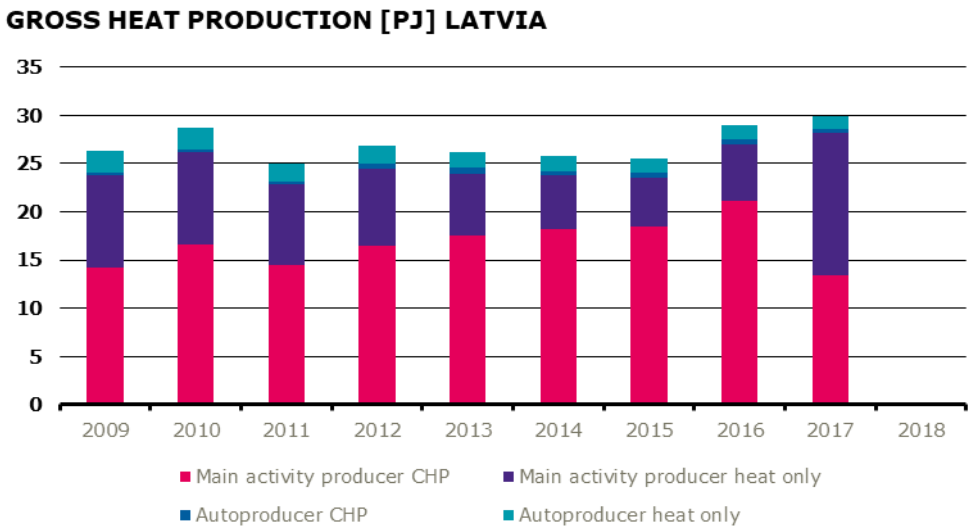


Figure 7-185: Gross heat production by producer type and year in Latvia. Based on data from [2]

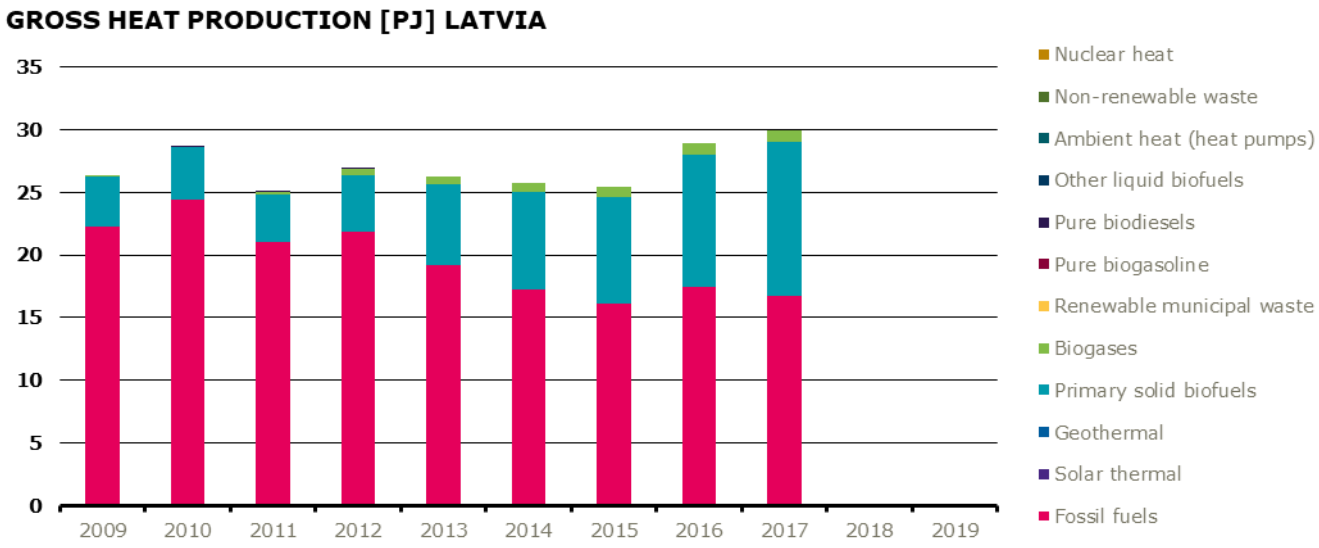


Figure 7-186: Gross heat production by fuel and year in Latvia. Based on data from [2]

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7.16.4 Electricity Production

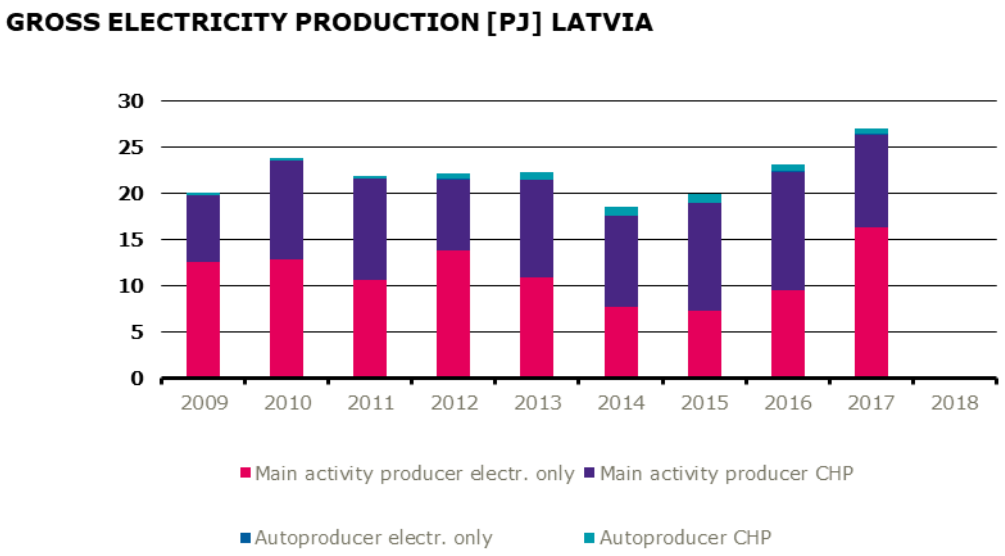


Figure 7-187: Gross electricity production by producer type and year in Latvia. Based on data from [2]

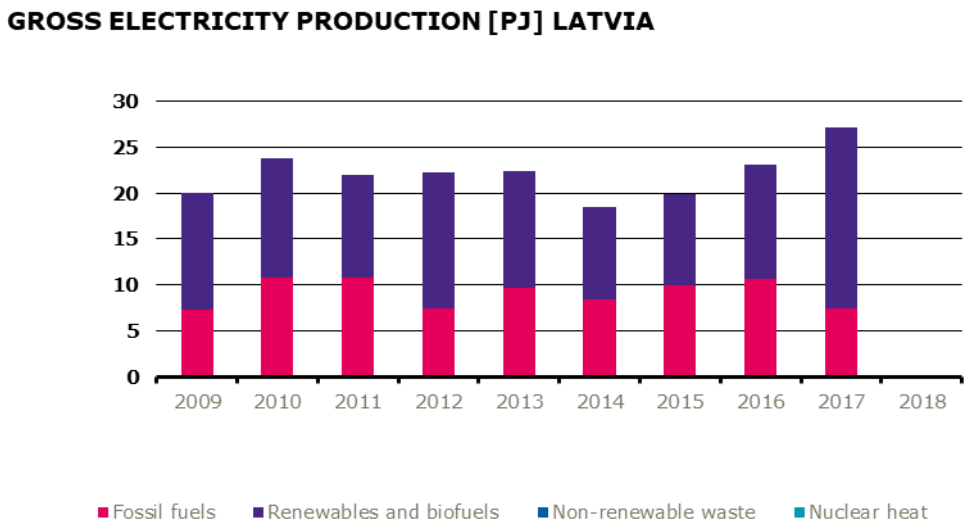


Figure 7-188: Gross electricity production by fuel type and year in Latvia. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.16.5 District Heat

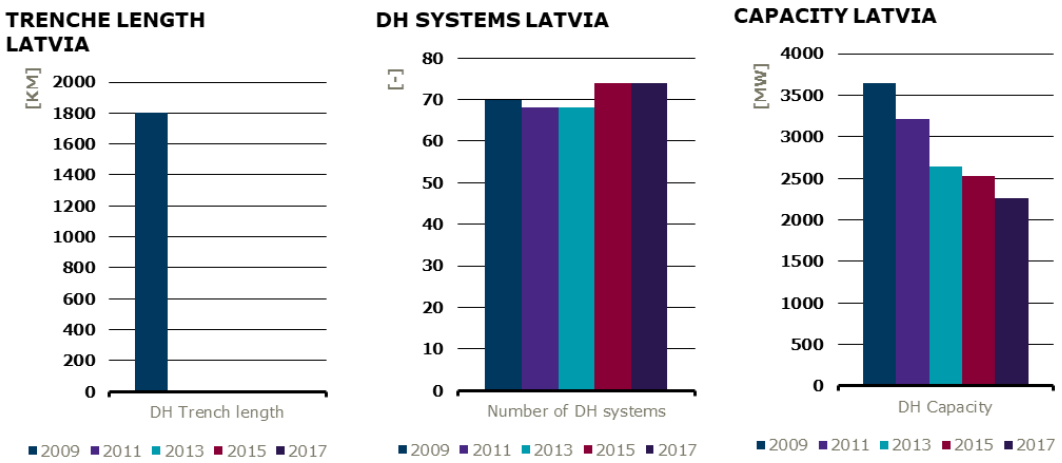


Figure 7-189: District heat indicators for Latvia. Based on data from [2]

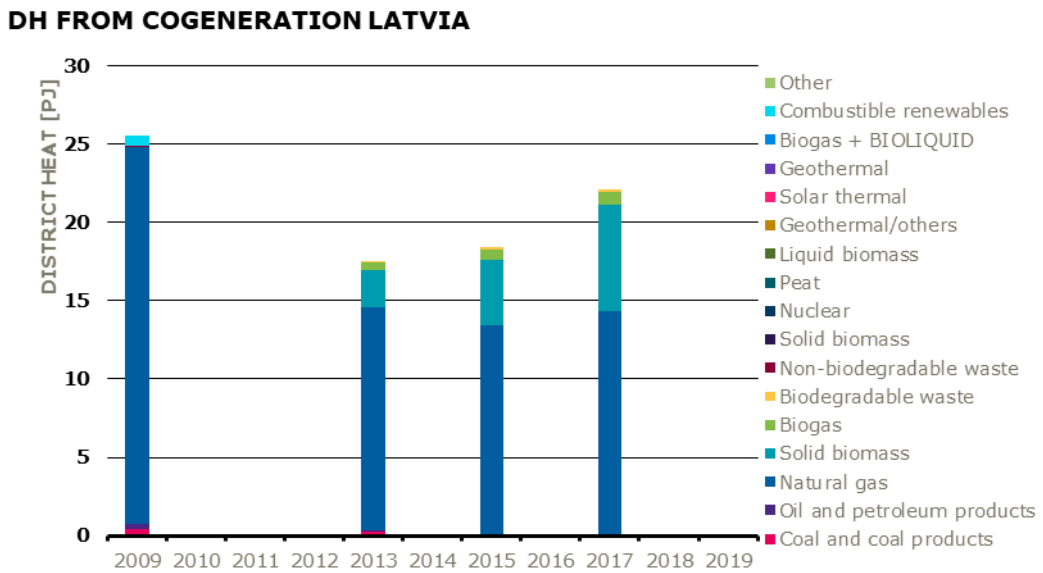


Figure 7-190: District heat generated in CHP plants by year and fuel in Latvia. Based on data from [2], [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

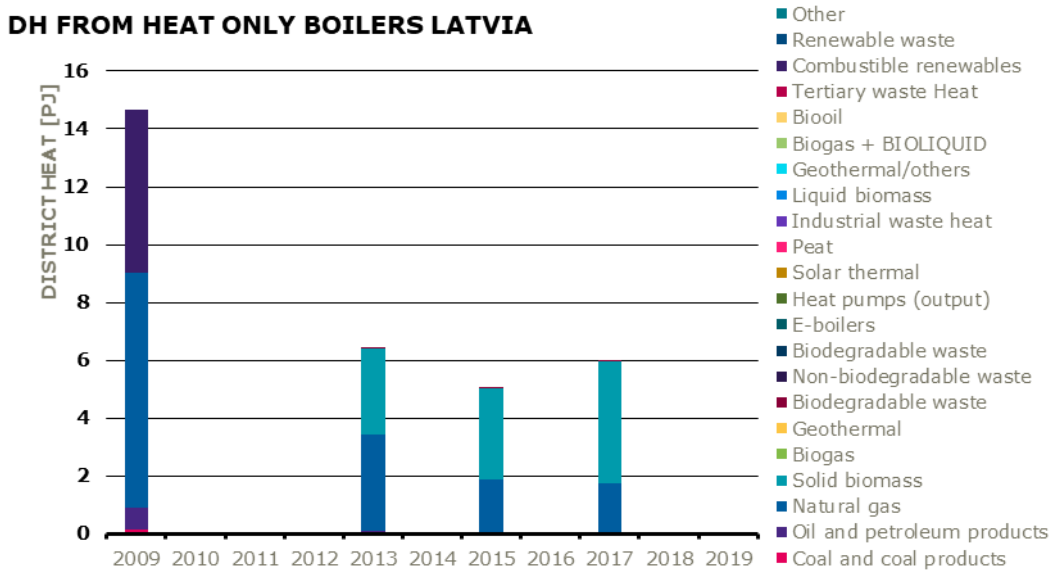


Figure 7-191: District heat generated in heat only boilers by year and fuel in Latvia. Based on data from [2], [3]

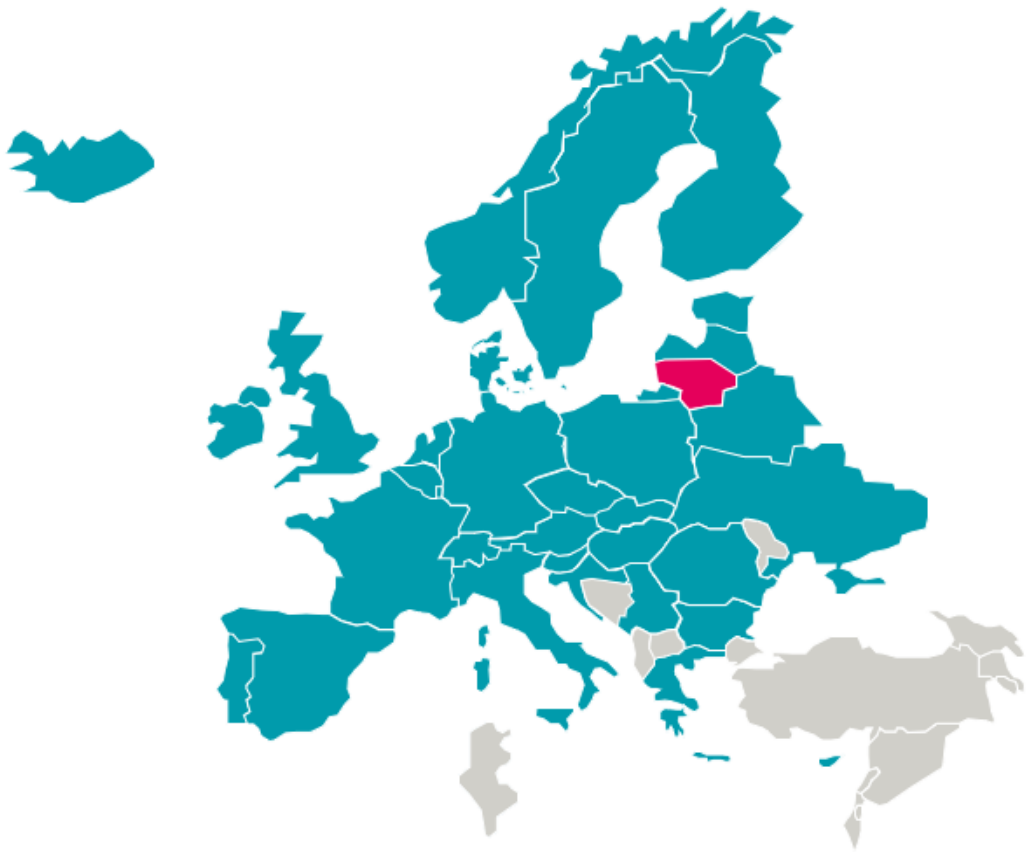
7.16.6 Energy storage

[*No data available*]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.17 Lithuania

7.17.1 Country profile



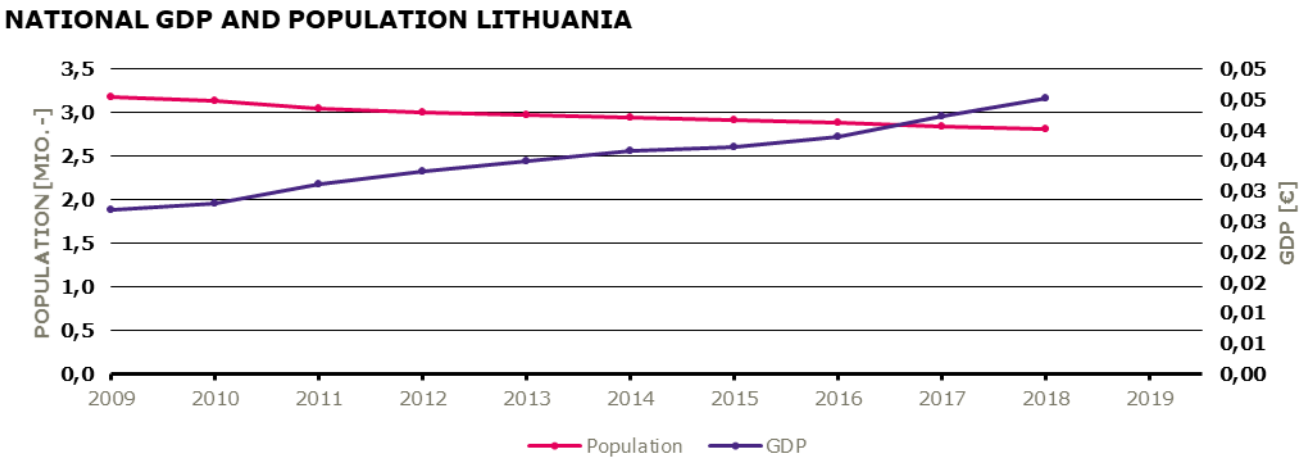


Figure 7-192: GDP and population development in Lithuania. Based on data from [1]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.17.2 Energy use

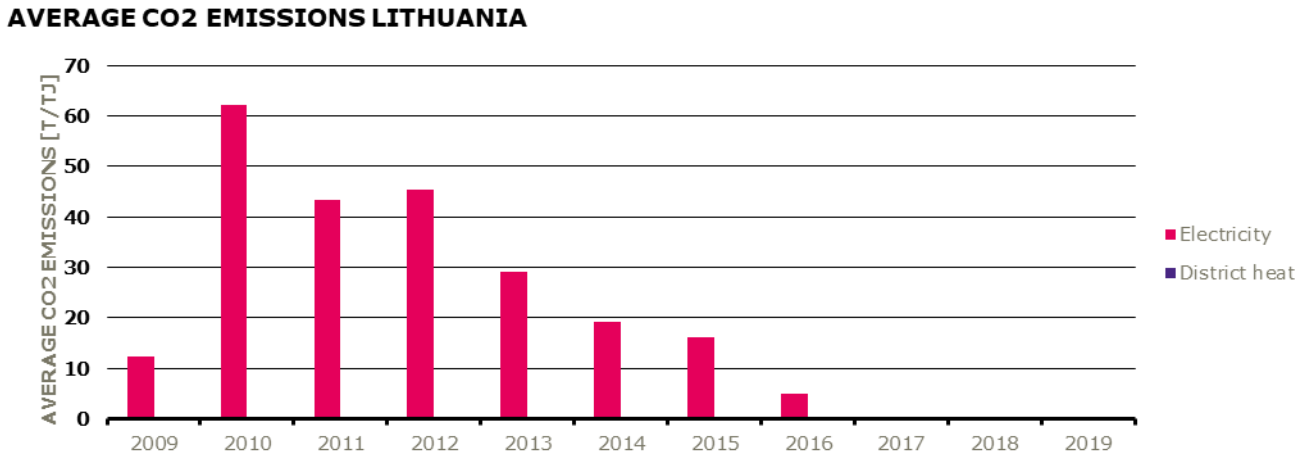


Figure 7-193: Average CO2 emissions in Lithuania. Based on data from [3] & [4]

7.17.3 Heat Production

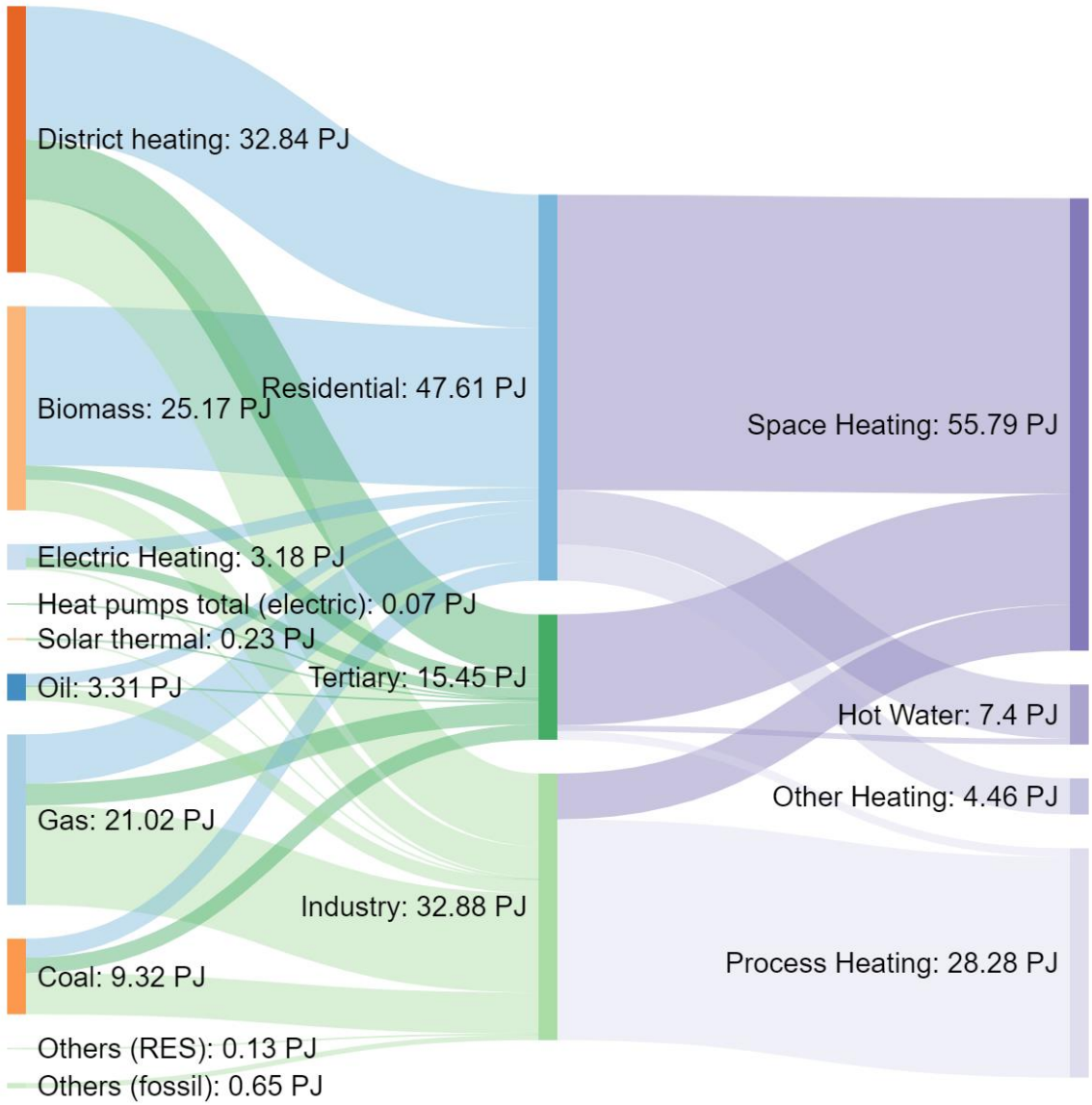


Figure 7-194: Sankey diagram of energy flows for heating purposes in Lithuania in 2015. Based on data from [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.17.4 Electricity Production

[*No data available*]

7.17.5 District Heat

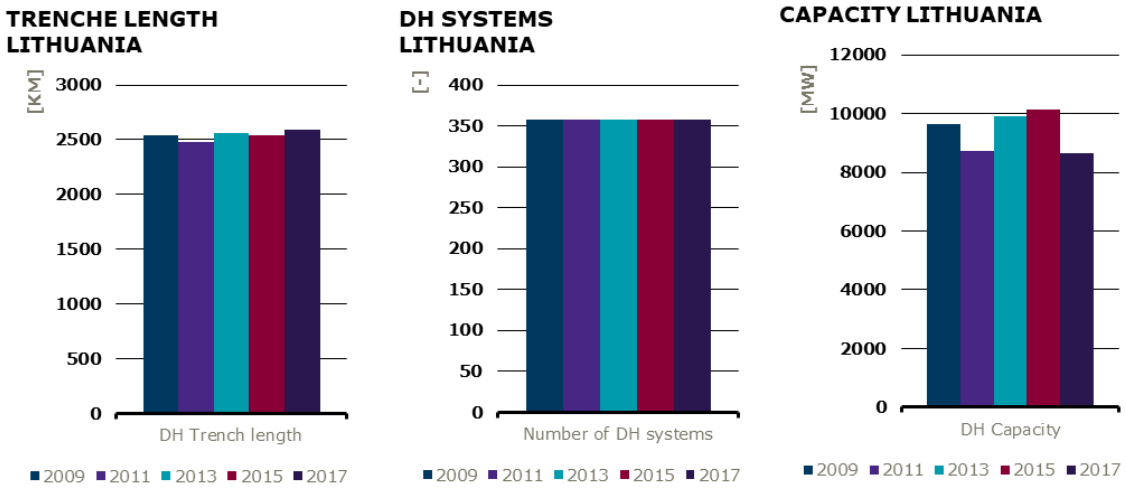


Figure 7-195: District heat indicators for Lithuania. Based on data from [2]

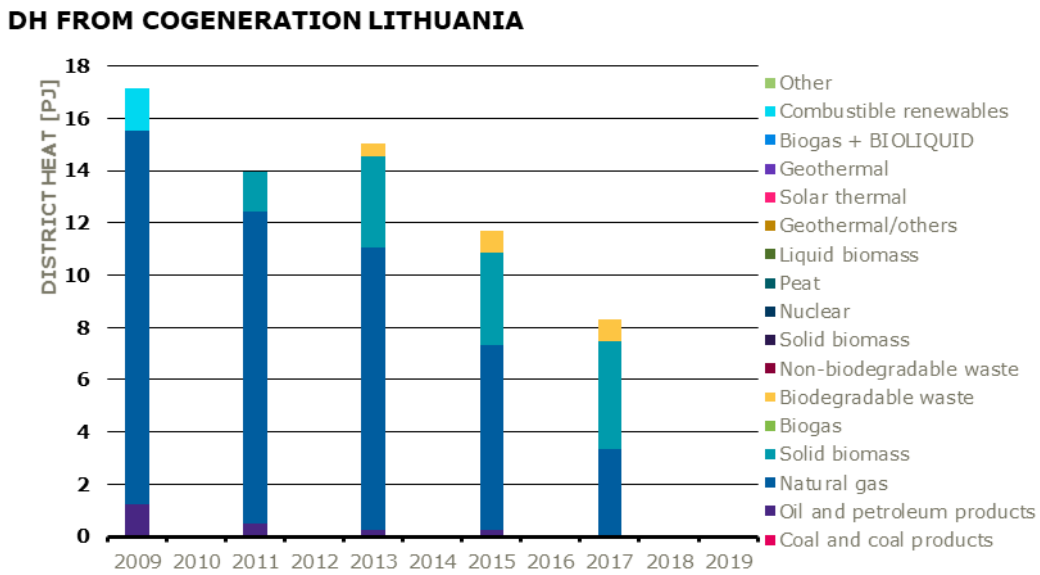


Figure 7-196: District heat generated in CHP plants by year and fuel in Lithuania. Based on data from [2], [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

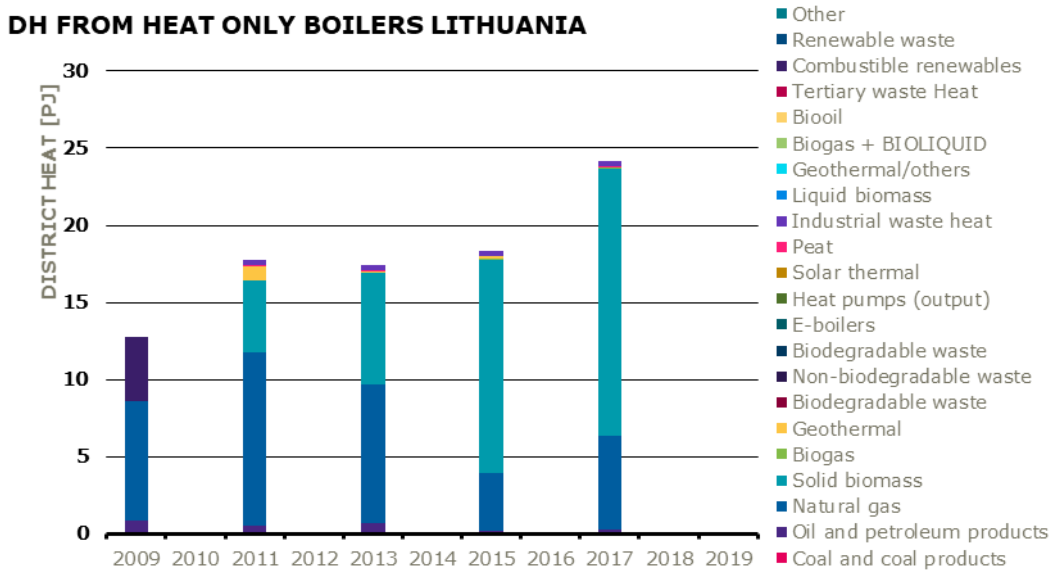


Figure 7-197: District heat generated in heat only boilers by year and fuel in Lithuania. Based on data from [2], [3]

7.17.6 Energy storage

[*No data available*]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.18 Luxembourg

7.18.1 Country profile

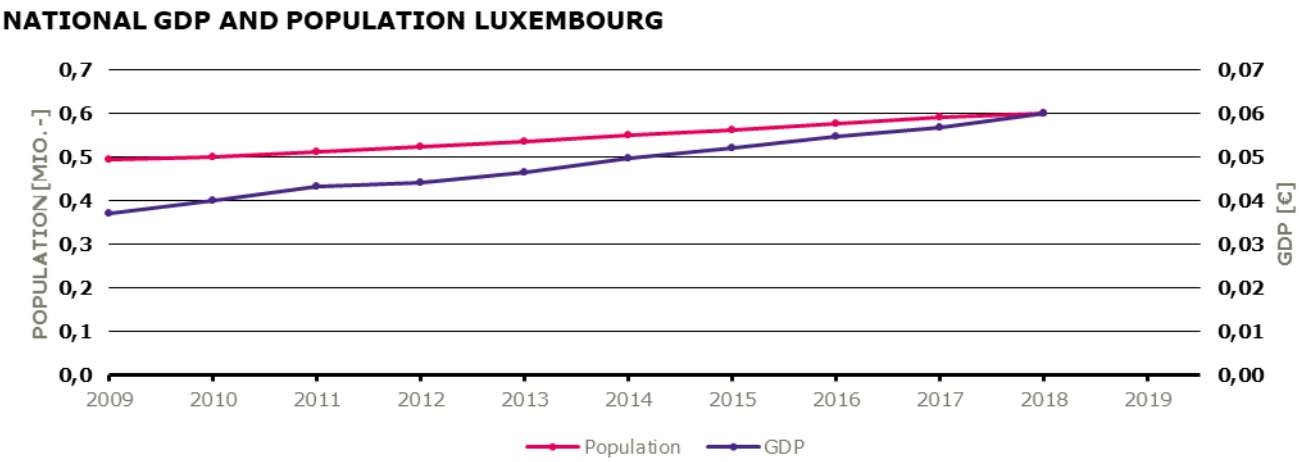


Figure 7-198: GDP and population development in Luxembourg. Based on data from [1]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.18.2 Energy use

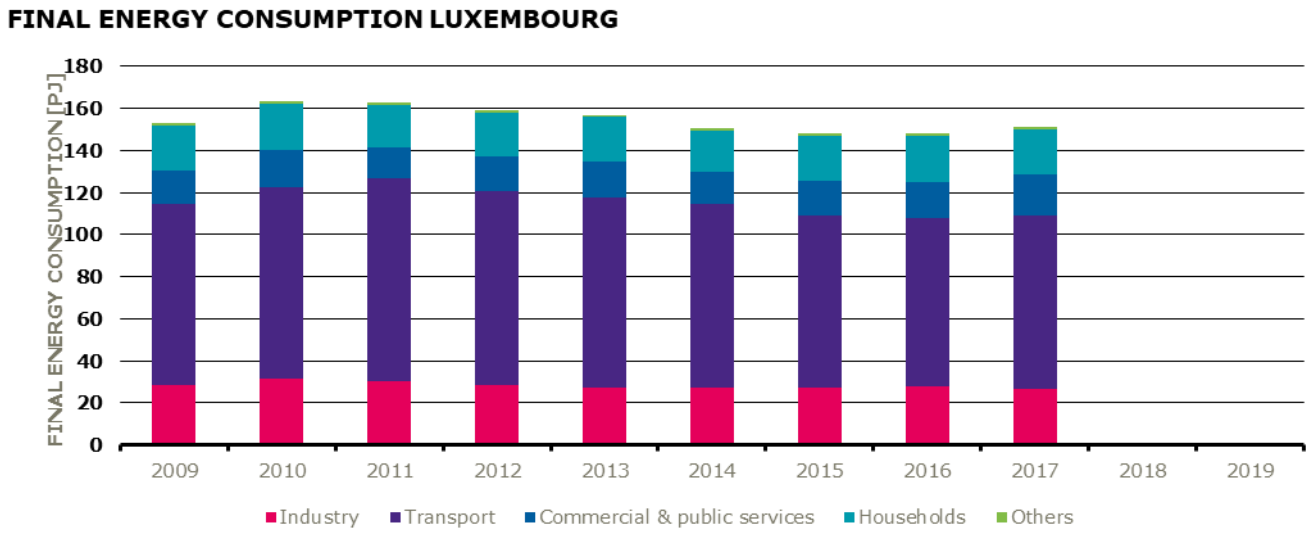


Figure 7-199: Final energy consumption by economic sector and year in Luxembourg. Based on data from [2]

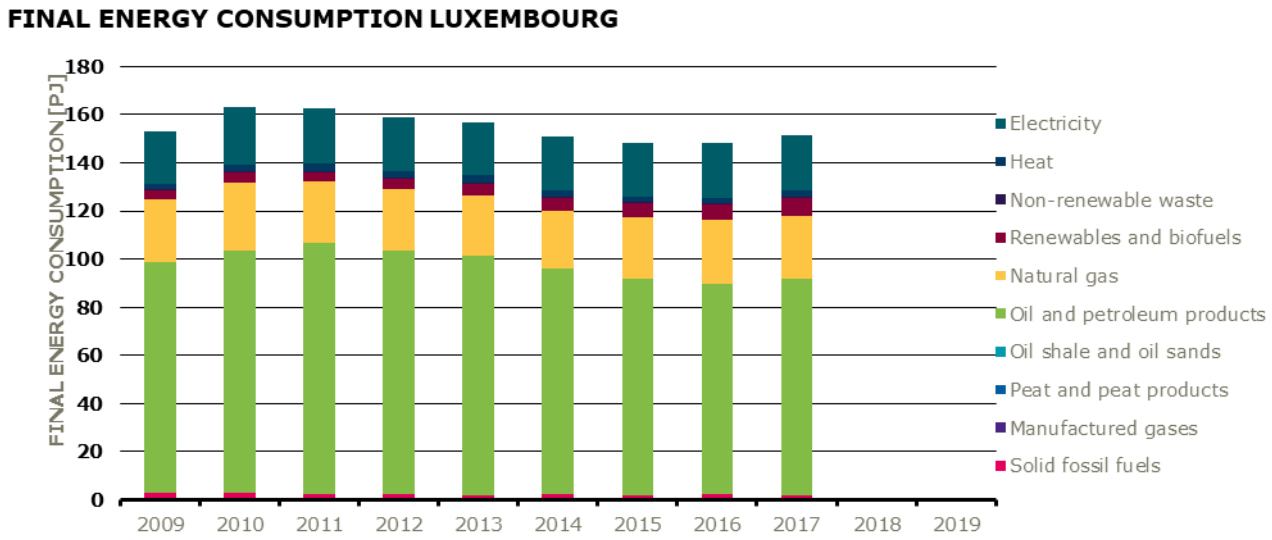


Figure 7-200: Final energy consumption by fuel and year in Luxembourg. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.18.3 Heat Production

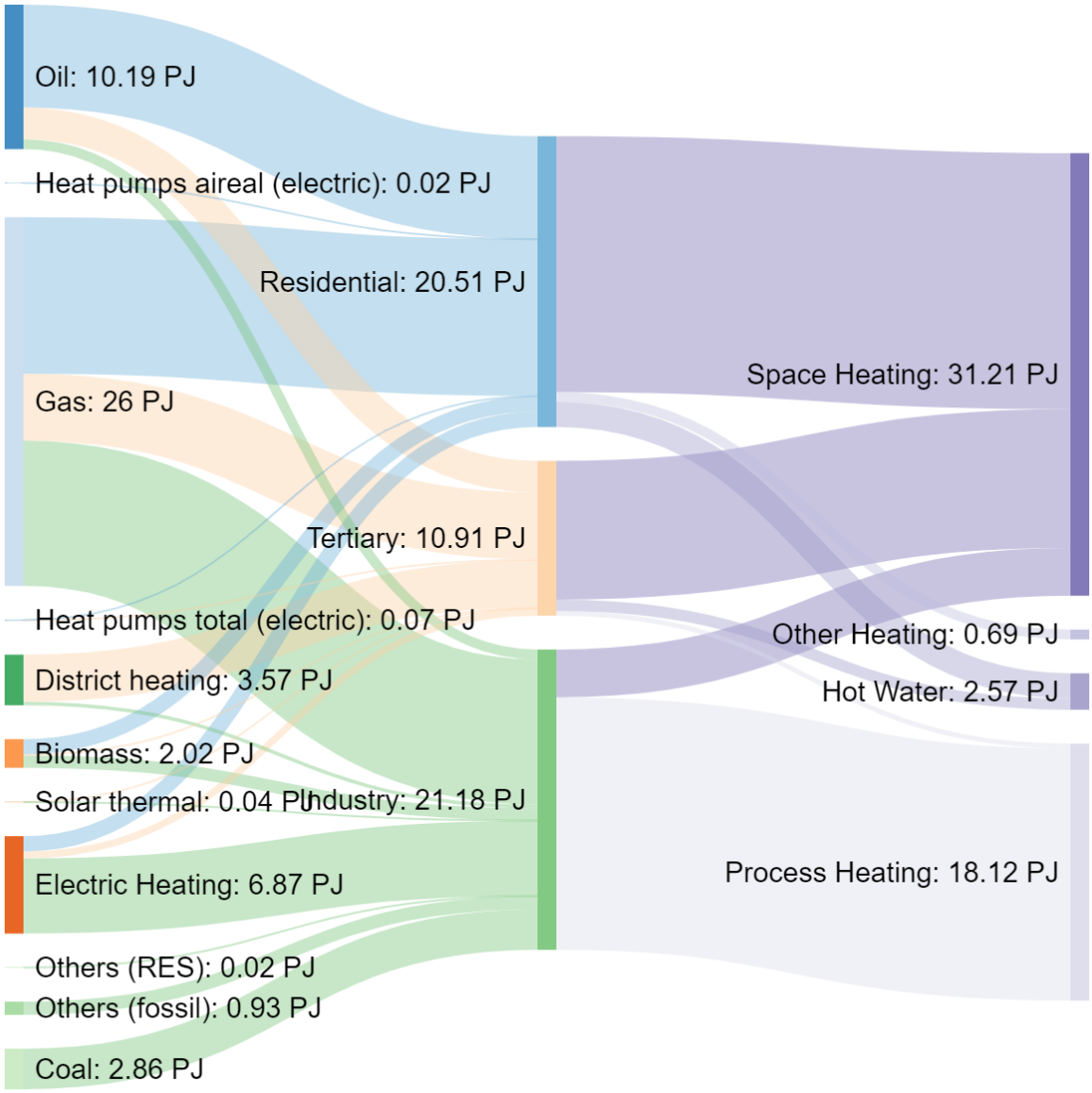


Figure 7-201: Sankey diagram of energy flows for heating purposes in Luxembourg in 2015. Based on data from [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

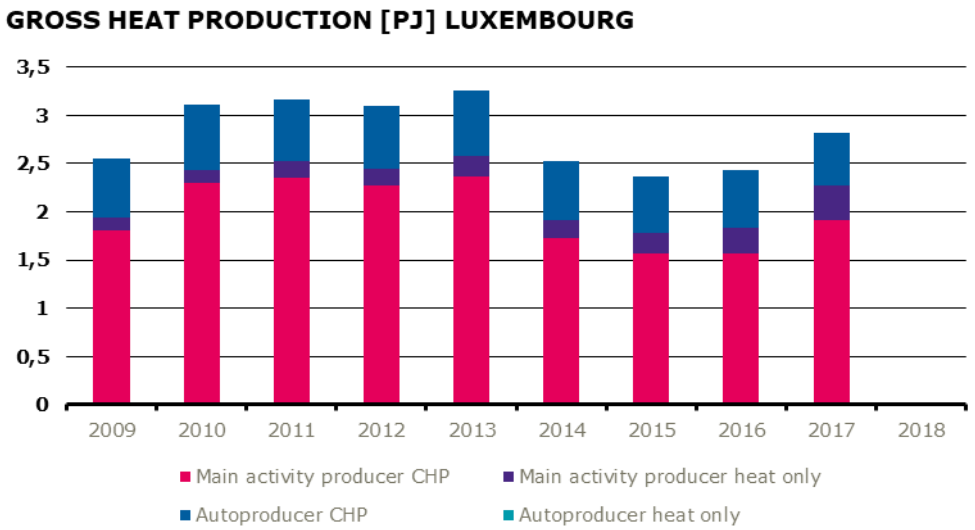


Figure 7-202: Gross heat production by producer type and year in Luxembourg. Based on data from [2]

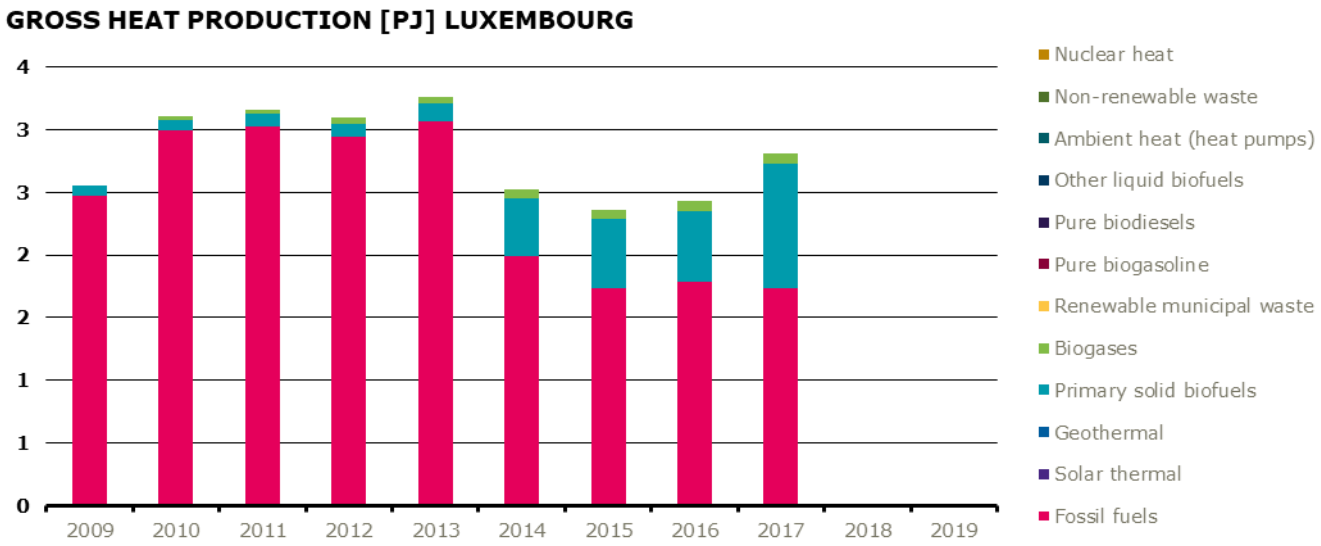


Figure 7-203: Gross heat production by fuel and year in Luxembourg. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.18.4 Electricity Production

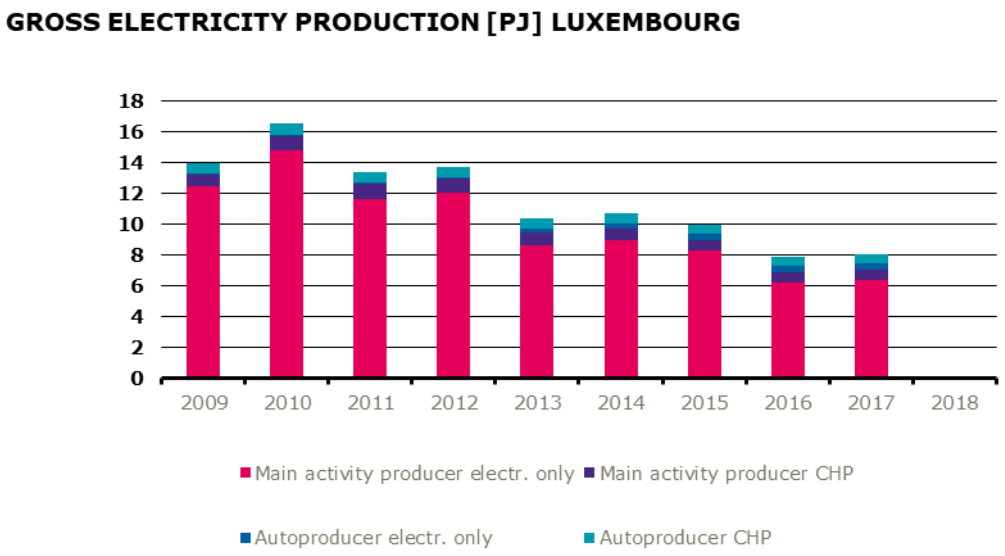


Figure 7-204: Gross electricity production by producer type and year in Luxembourg. Based on data from [2]

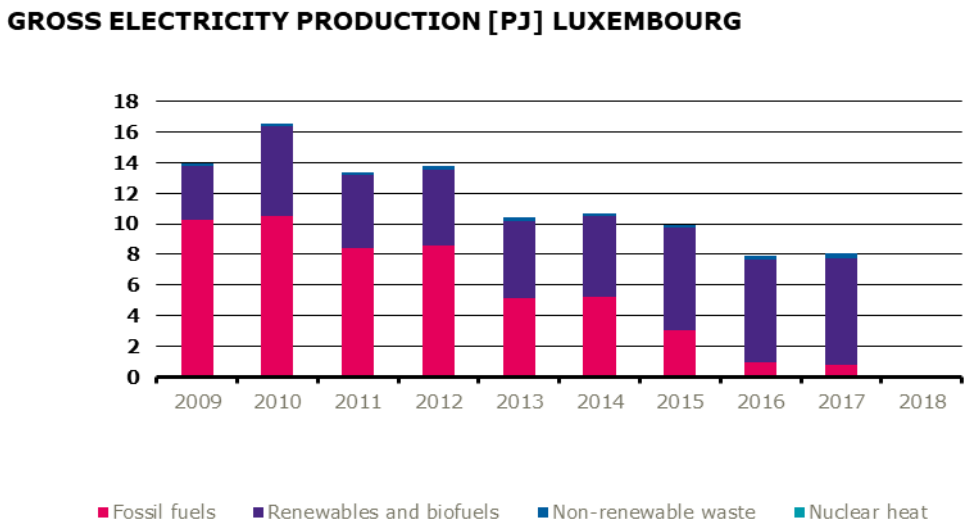


Figure 7-205: Gross electricity production by fuel type and year in Luxembourg. Based on data from [2]

7.18.5 District Heat

[*No data available*]

7.18.6 Energy storage

[*No data available*]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.19 Malta

7.19.1 Country profile

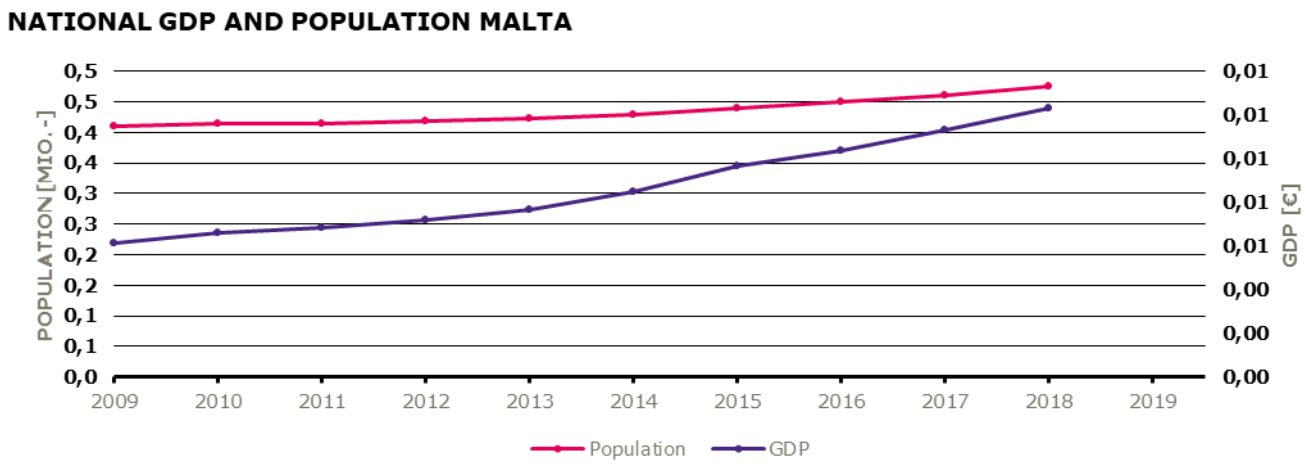


Figure 7-206: GDP and population development in Malta. Based on data from [1]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.19.2 Energy use

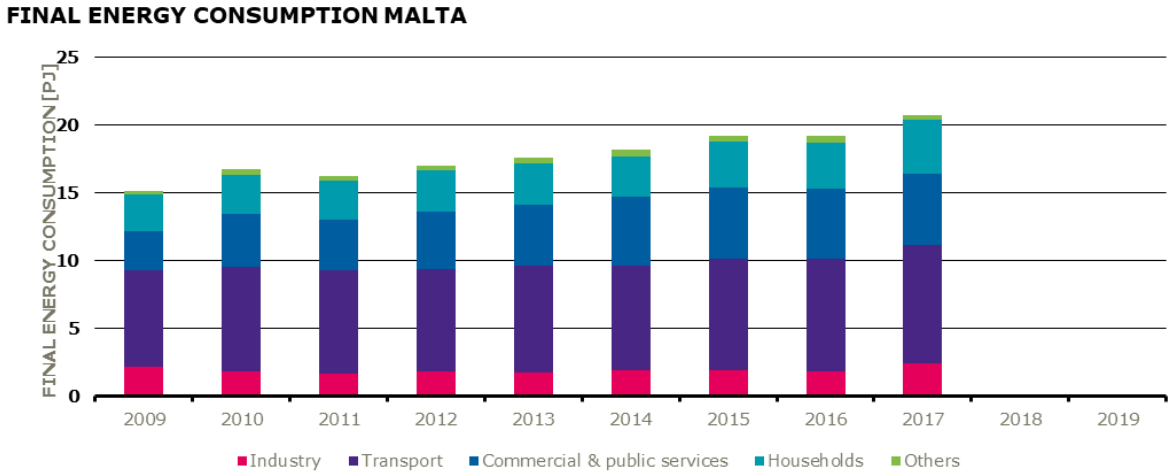


Figure 7-207: Final energy consumption by economic sector and year in Malta. Based on data from [2]

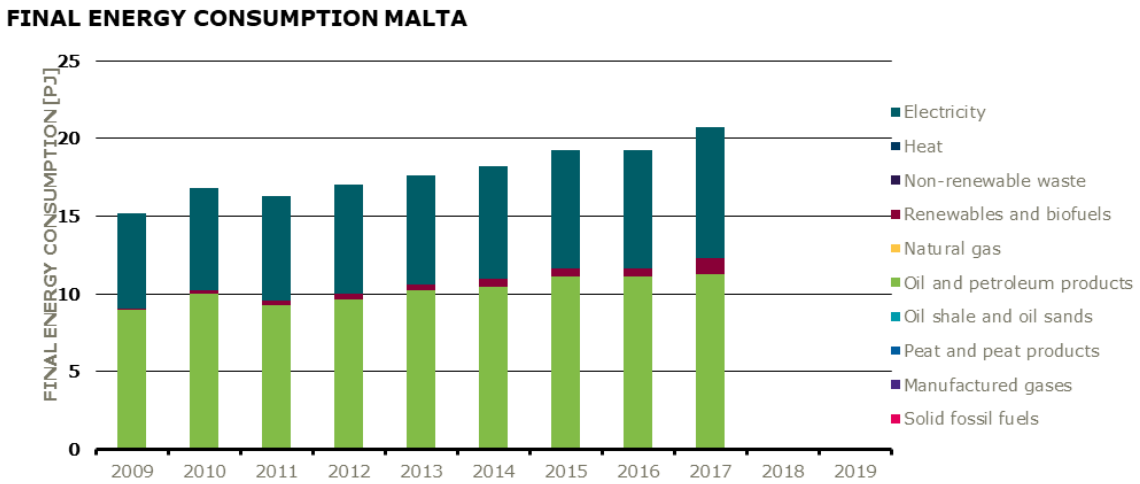


Figure 7-208: Final energy consumption by fuel and year in Malta. Based on data from [2]

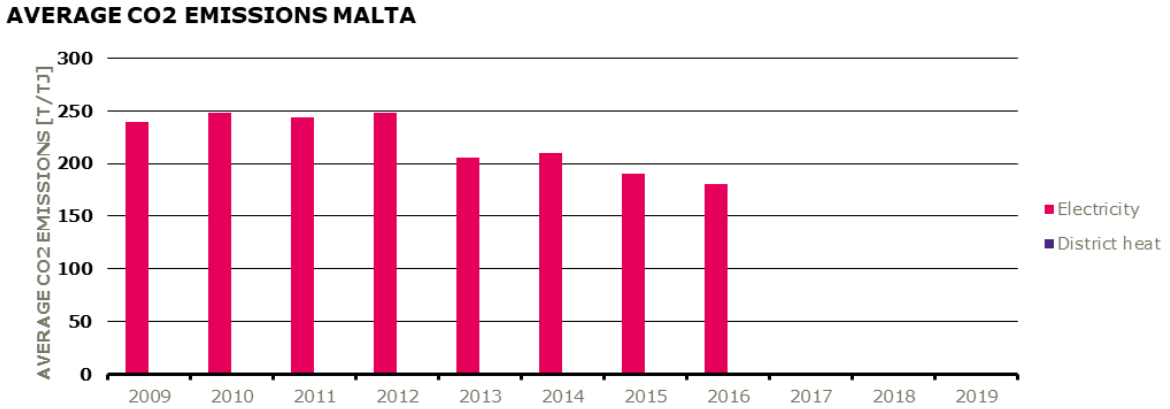


Figure 7-209: Average CO2 emissions in Malta. Based on data from [3] & [4]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.19.3 Heat Production

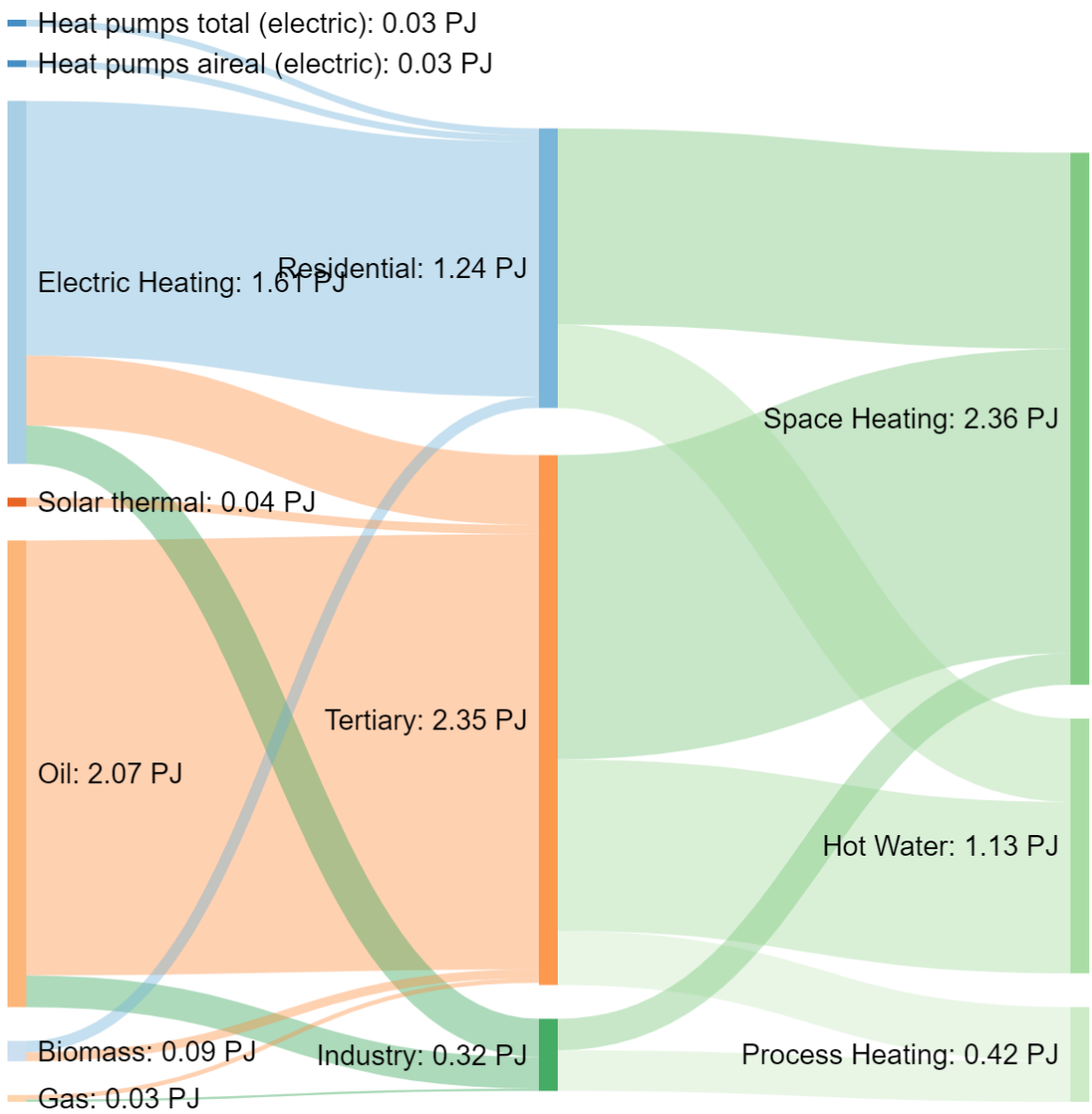


Figure 7-210: Sankey diagram of energy flows for heating purposes in Malta in 2015. Based on data from [3]

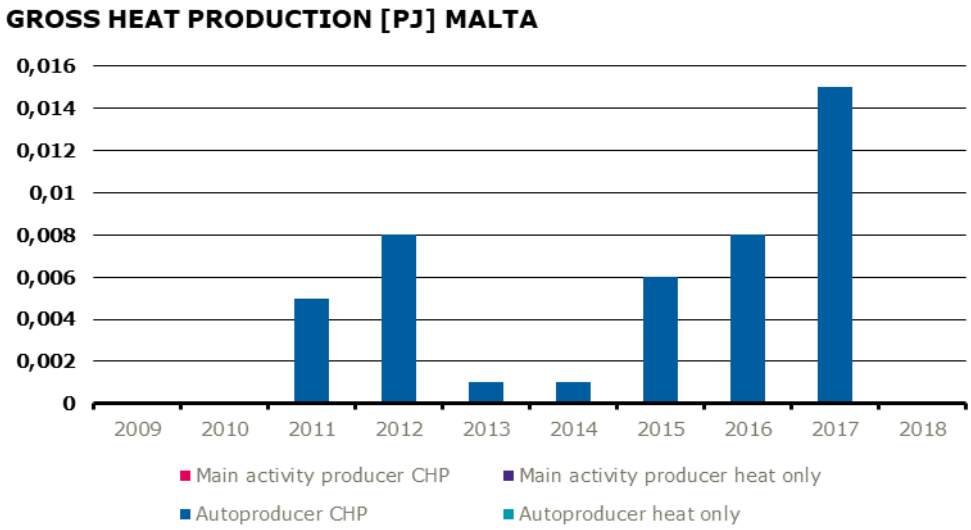


Figure 7-211: Gross heat production by producer type and year in Malta. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

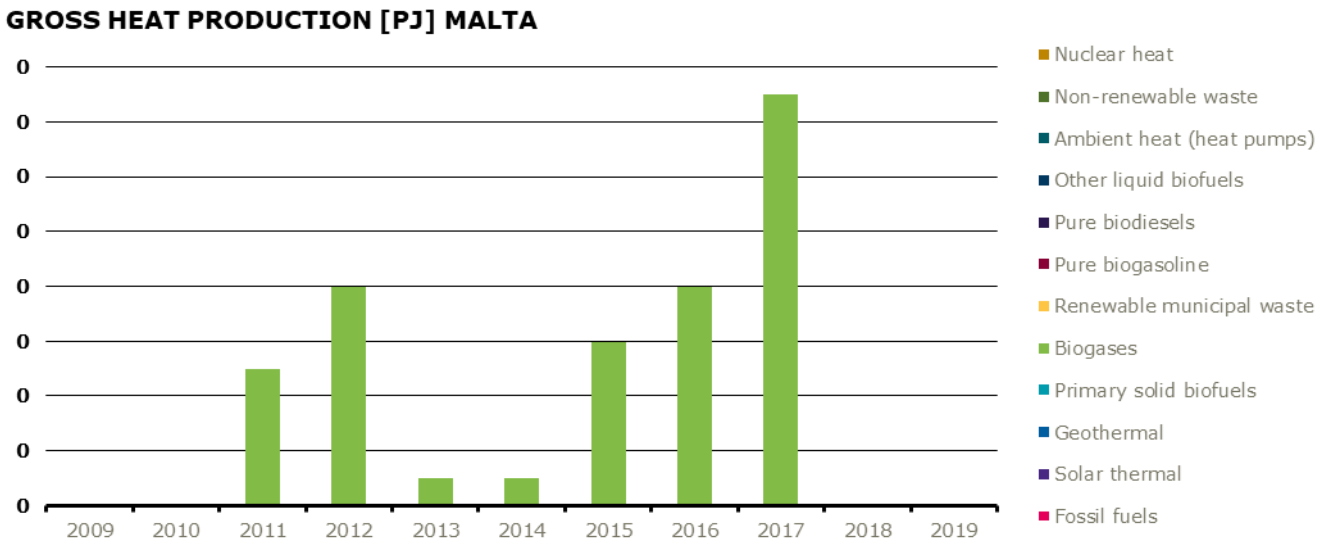


Figure 7-212: Gross heat production by fuel and year in Malta. Based on data from [2]

7.19.4 Electricity Production

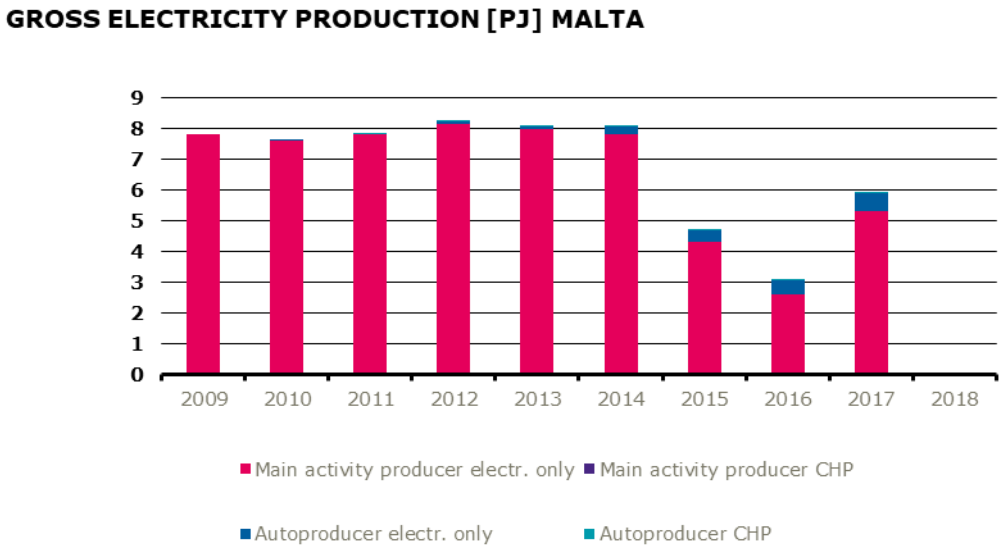


Figure 7-213: Gross electricity production by producer type and year in Malta. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

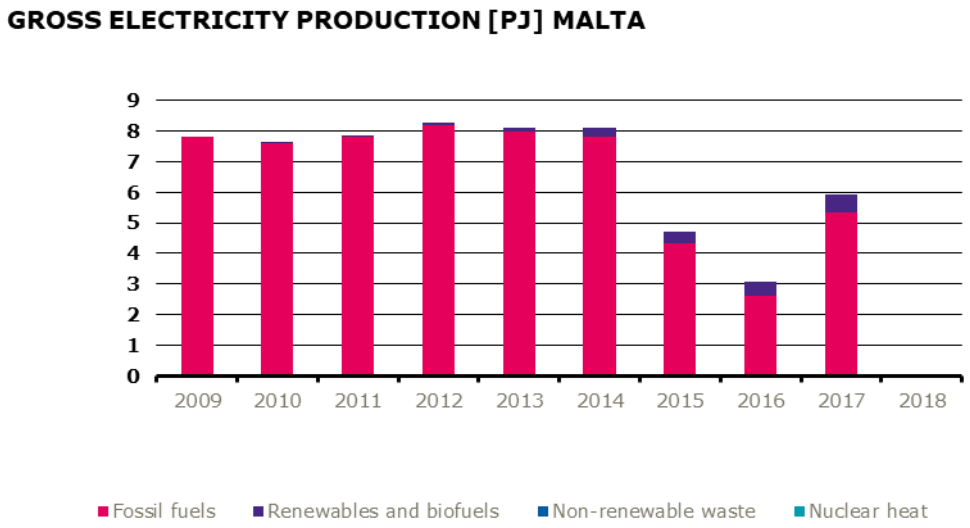


Figure 7-214: Gross electricity production by fuel type and year in Malta. Based on data from [2]

7.19.5 District Heat

[*No data available*]

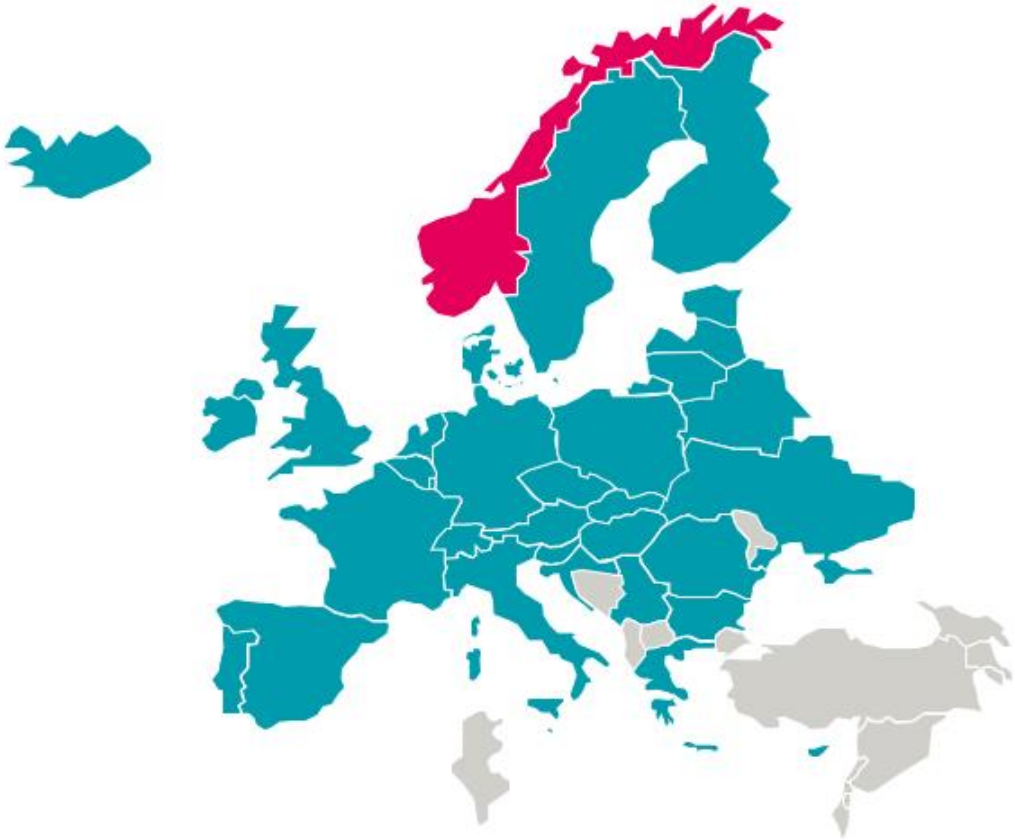
7.19.6 Energy storage

[*No data available*]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.20 Norway

7.20.1 Country profile



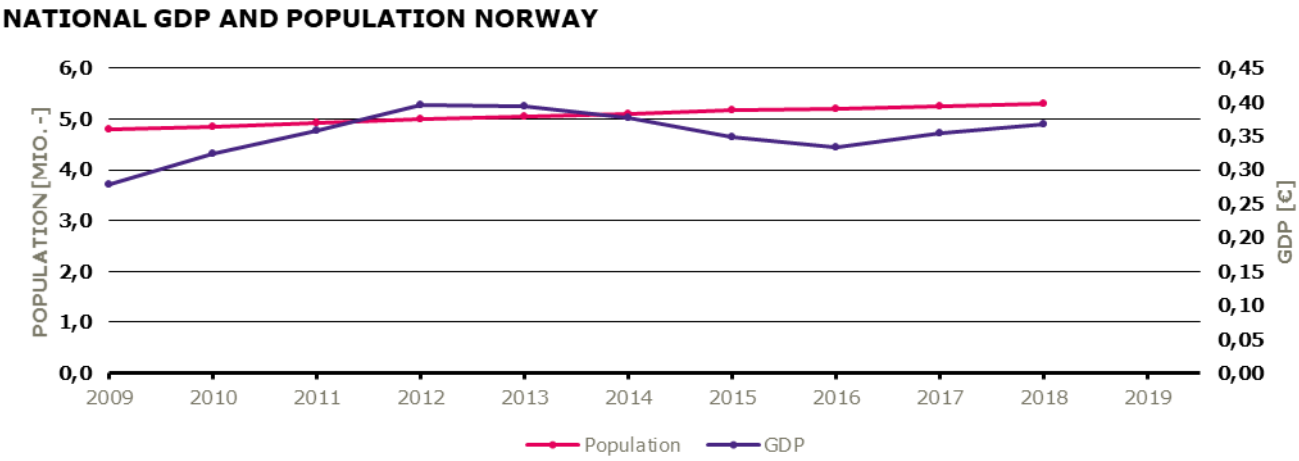


Figure 7-215: GDP and population development in Norway. Based on data from [1]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.20.2 Energy use

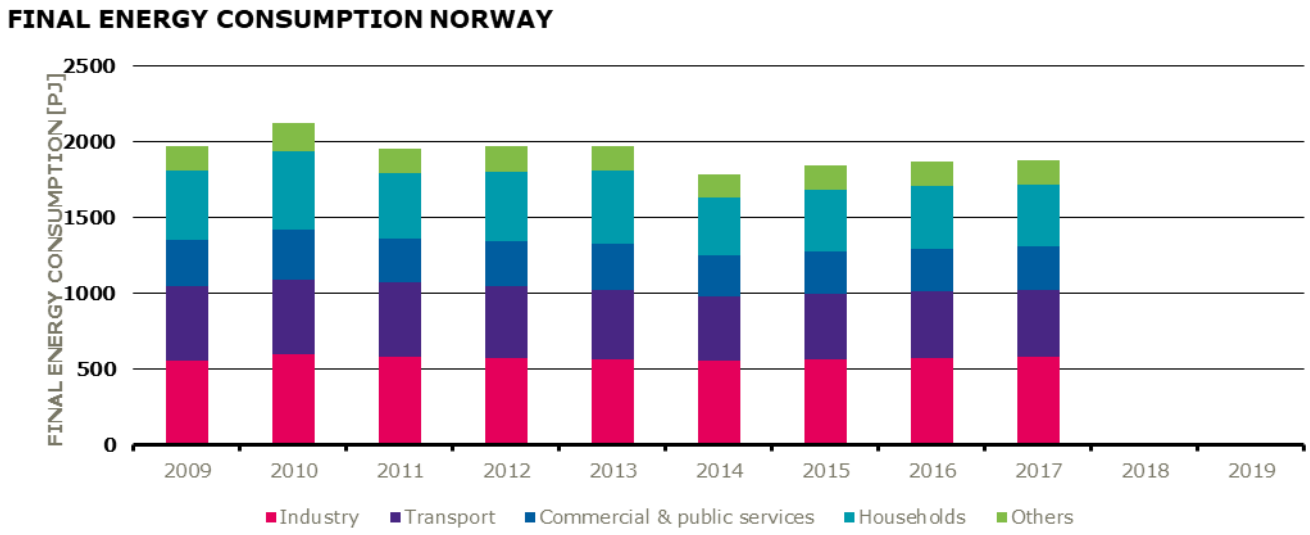


Figure 7-216: Final energy consumption by economic sector and year in Norway. Based on data from [2]

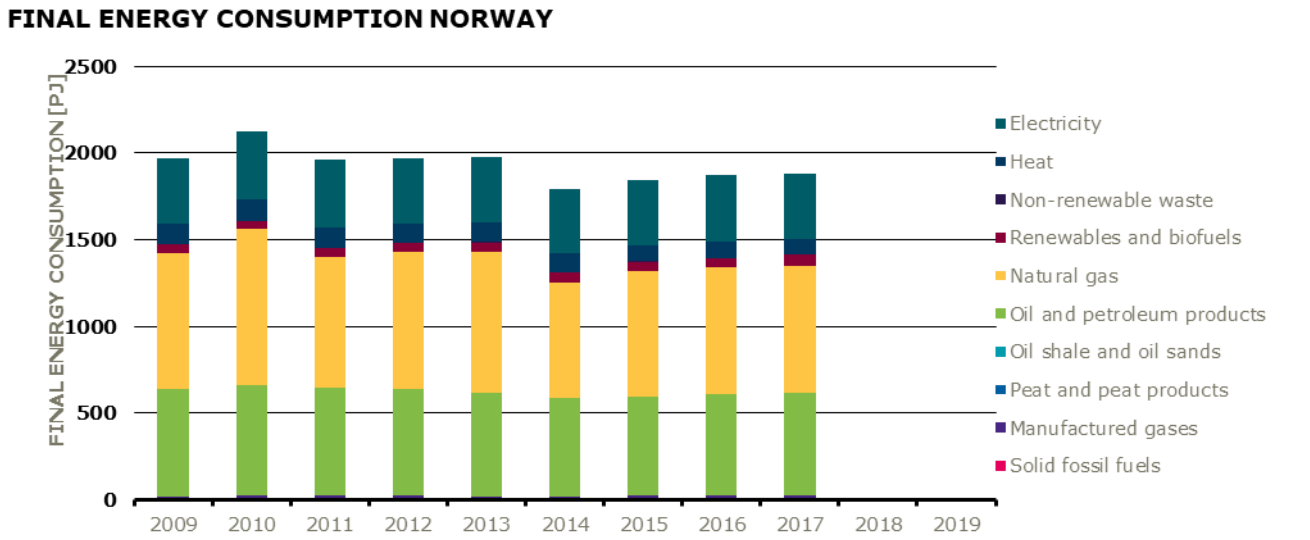


Figure 7-217: Final energy consumption by fuel and year in Norway. Based on data from [2]

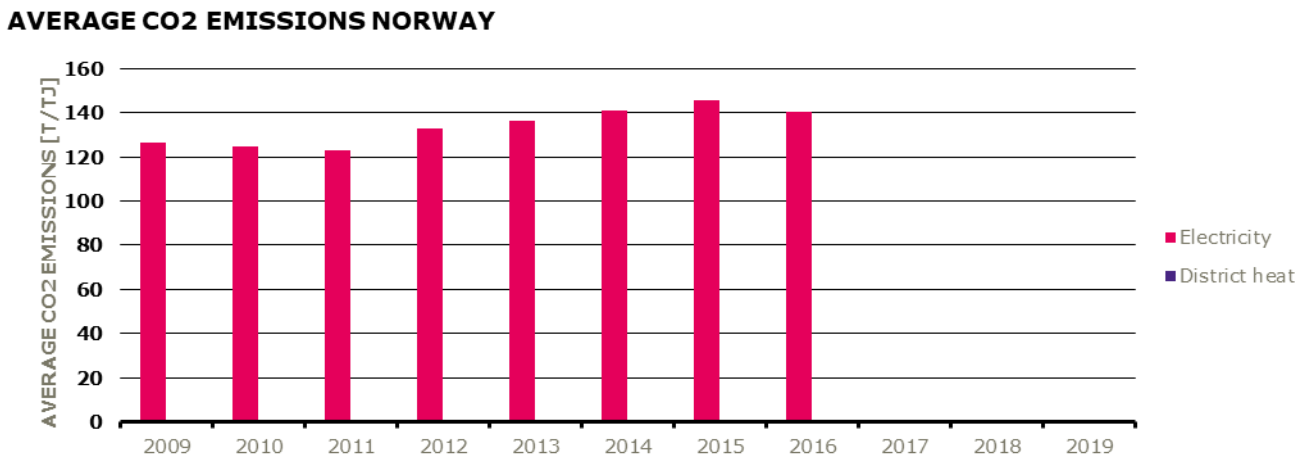


Figure 7-218: Average CO2 emissions in Norway. Based on data from [3] & [4]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.20.3 Heat Production

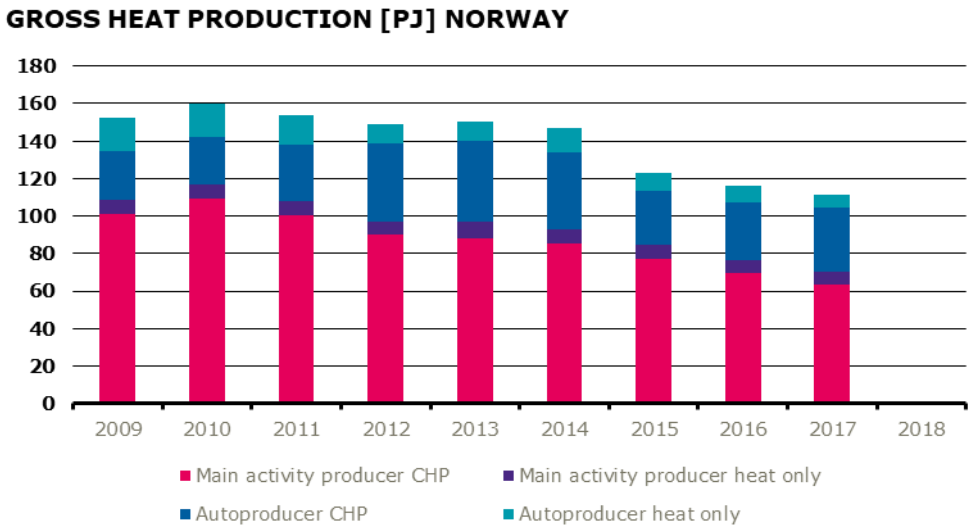


Figure 7-219: Gross heat production by producer type and year in Norway. Based on data from [2]

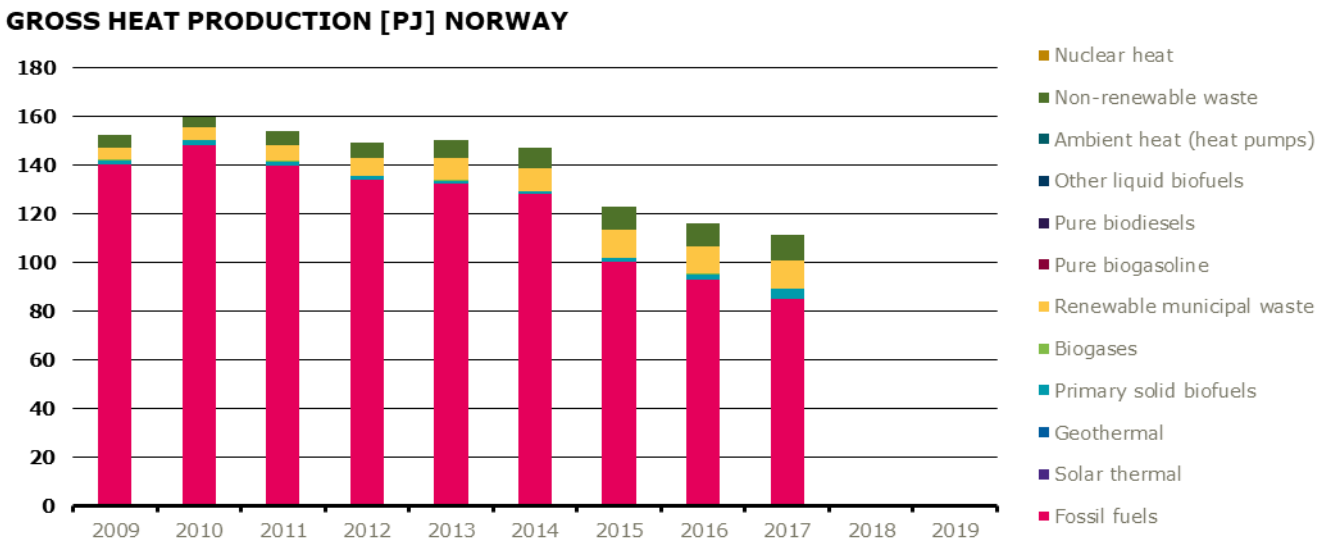


Figure 7-220: Gross heat production by fuel and year in Norway. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.20.4 Electricity Production

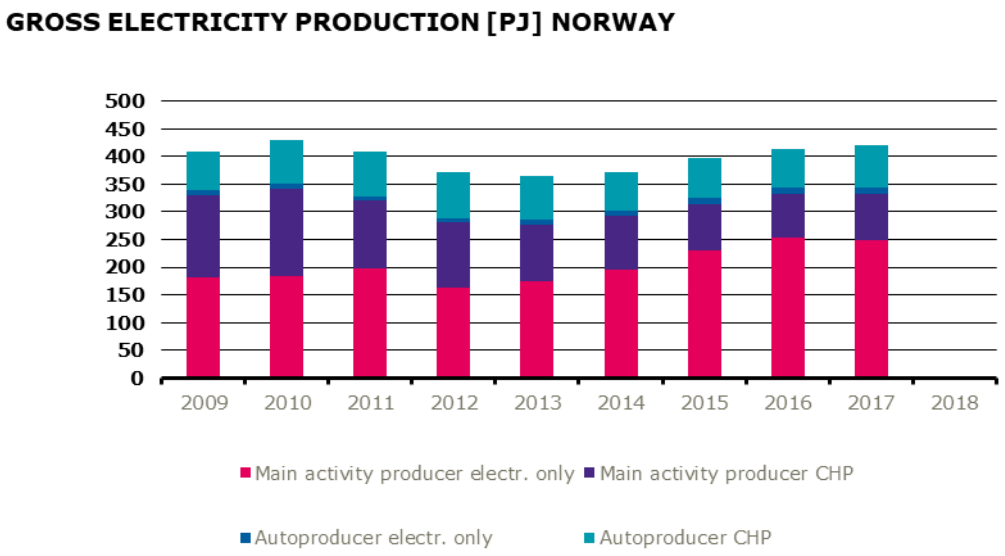


Figure 7-221: Gross electricity production by producer type and year in Norway. Based on data from [2]

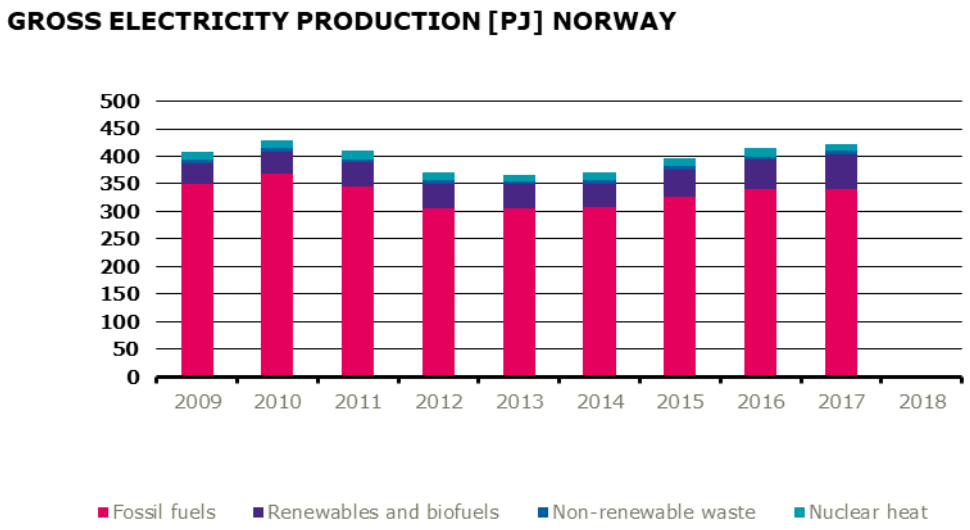


Figure 7-222: Gross electricity production by fuel type and year in Norway. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.20.5 District Heat

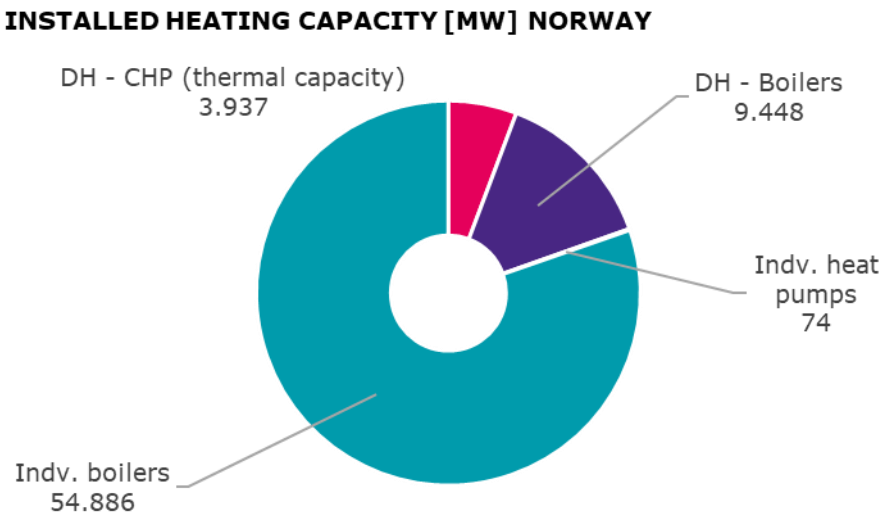


Figure 7-223: Installed heating capacity installed in Norway in 2015. Based on data from [2]

7.20.6 Energy storage

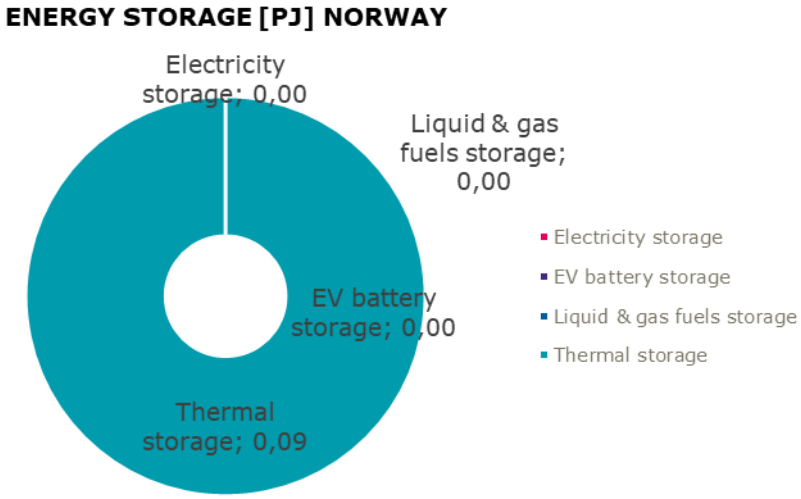
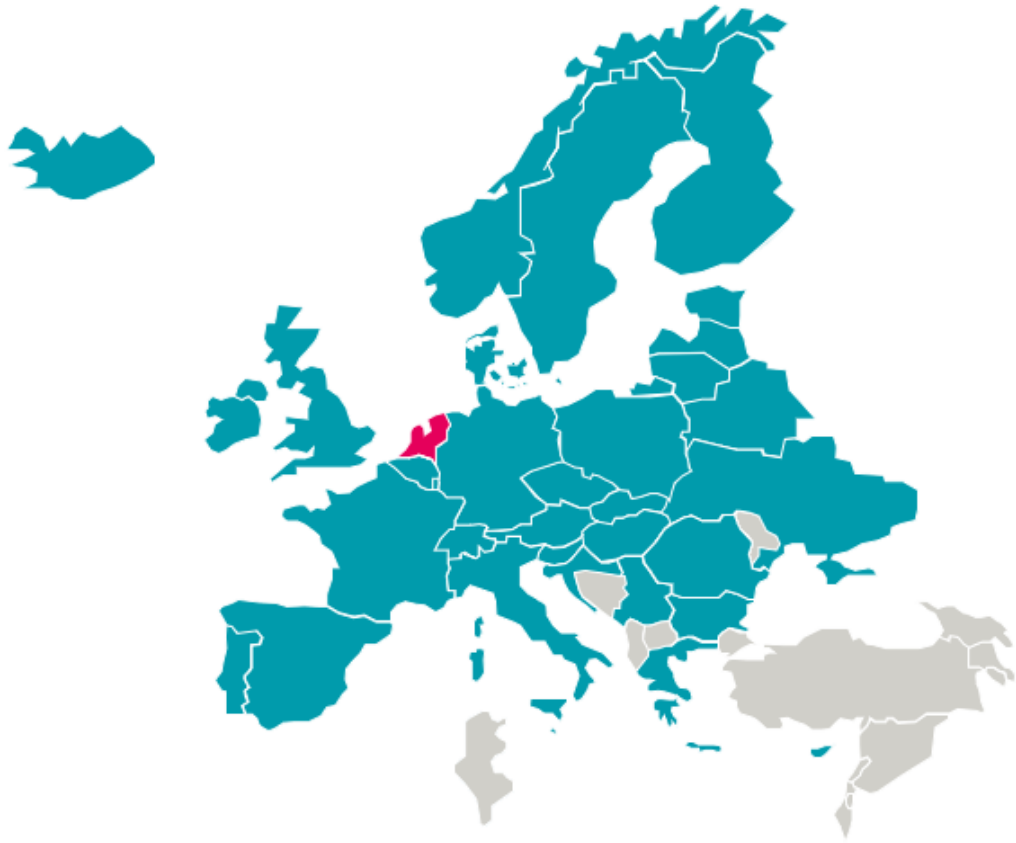


Figure 7-224: Stoage capacity in Norway in 2015. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.21 The Netherlands

7.21.1 Country profile



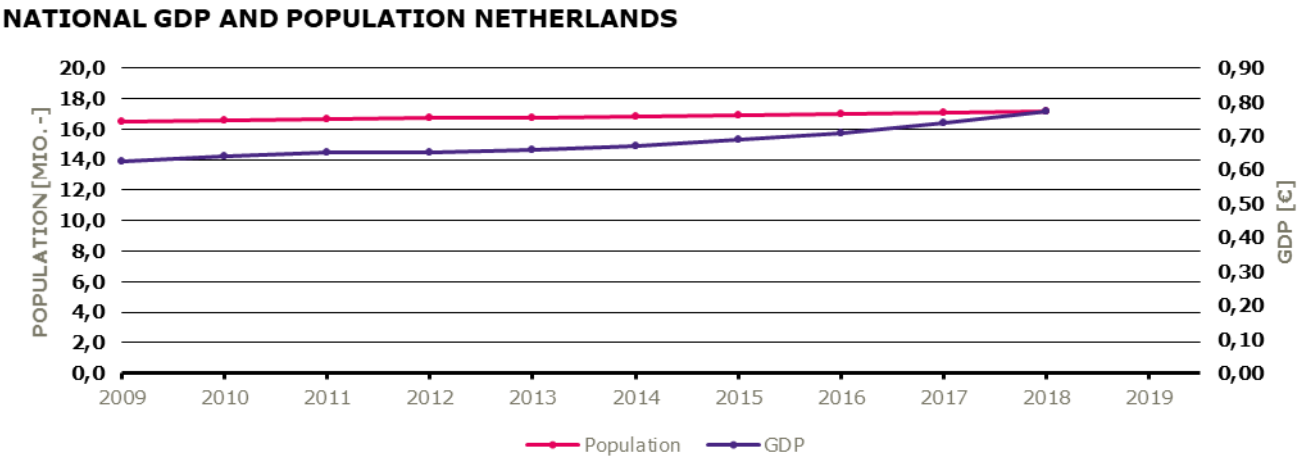


Figure 7-225: GDP and population development in The Netherlands. Based on data from [1]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.21.2 Energy use

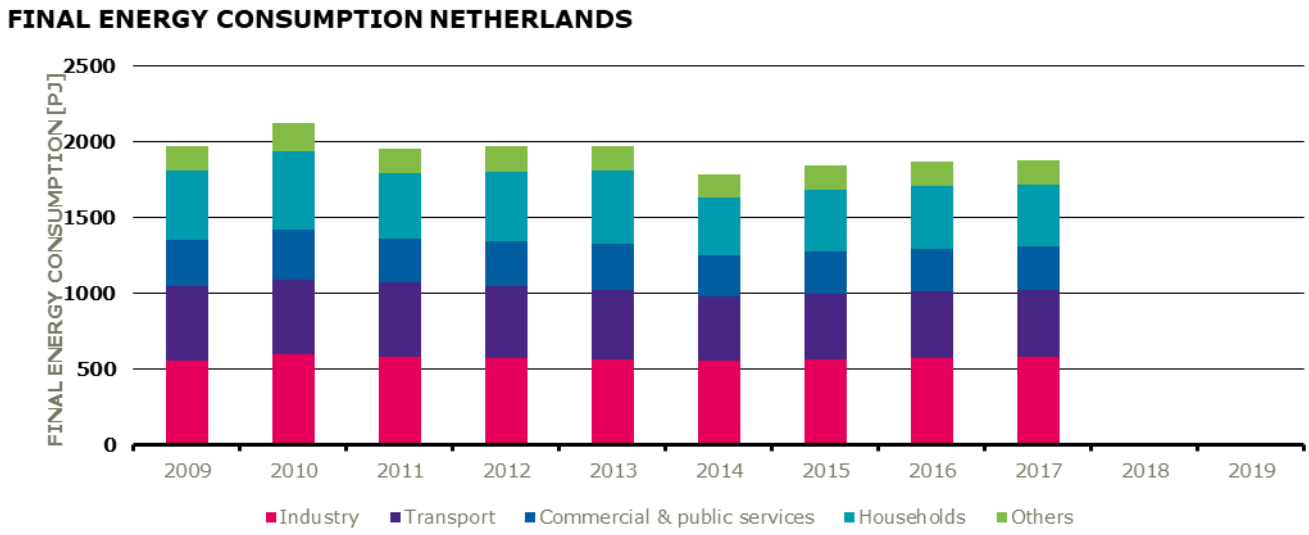


Figure 7-226: Final energy consumption by economic sector and year in The Netherlands. Based on data from [2]

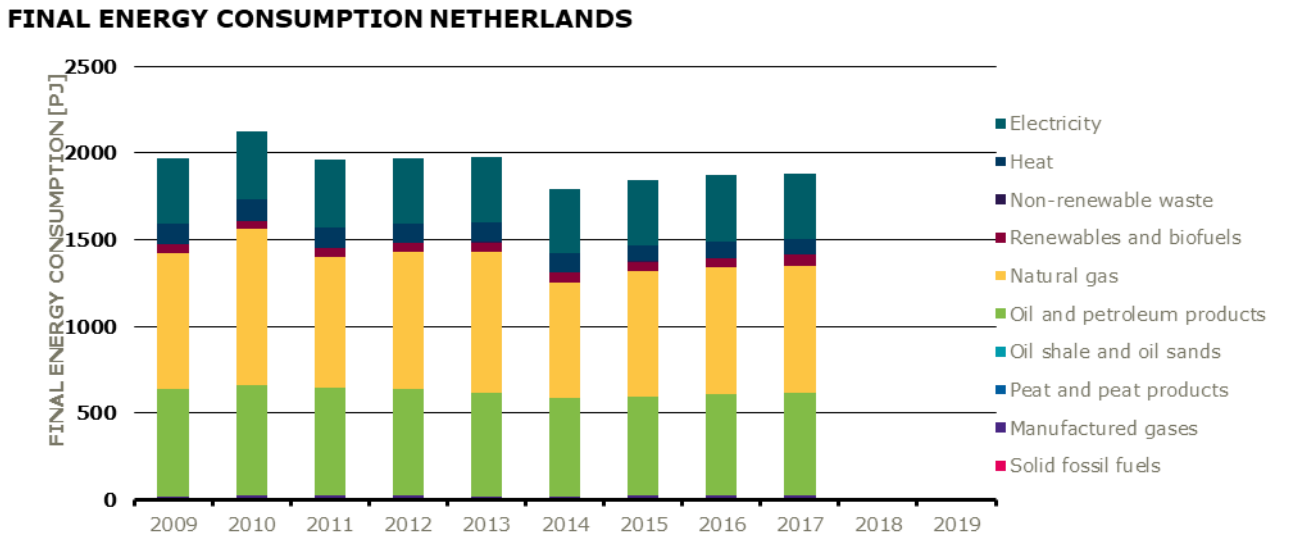


Figure 7-227: Final energy consumption by fuel and year in The Netherlands. Based on data from [2]

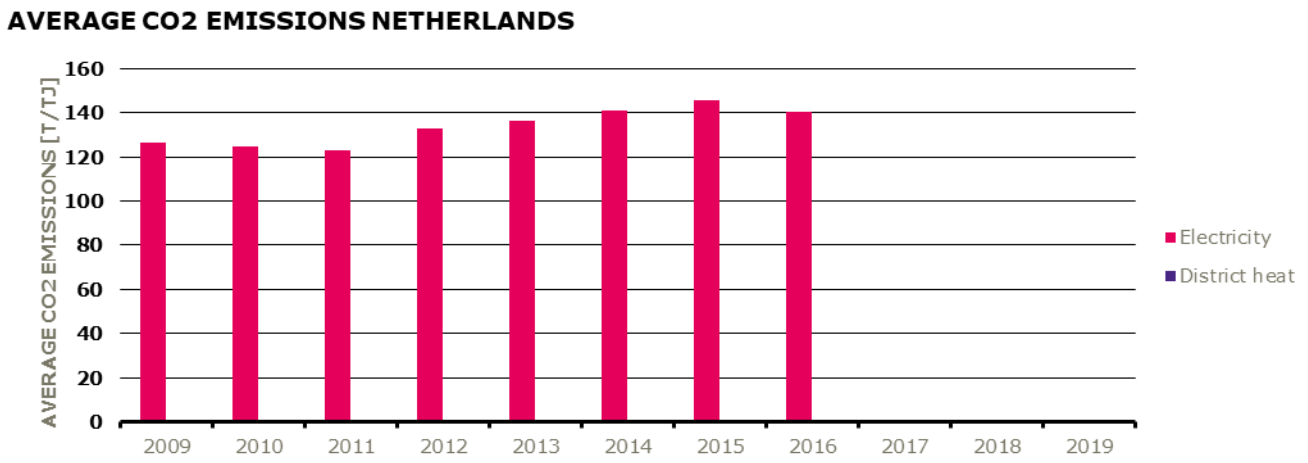


Figure 7-228: Average CO2 emissions in The Netherlands. Based on data from [3] & [4]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.21.3 Heat Production

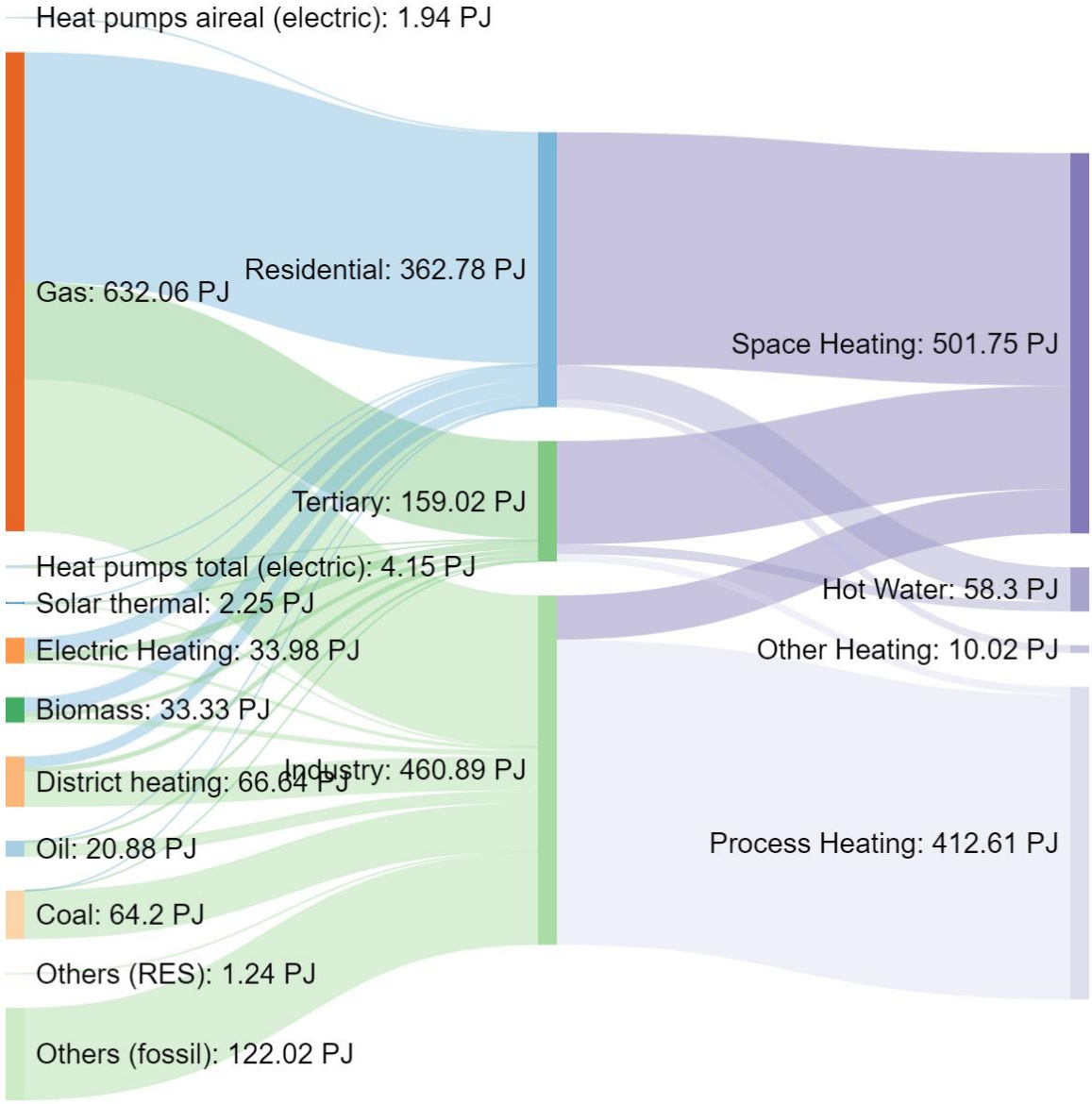


Figure 7-229: Sankey diagram of energy flows for heating purposes in The Netherlands in 2015. Based on data from [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

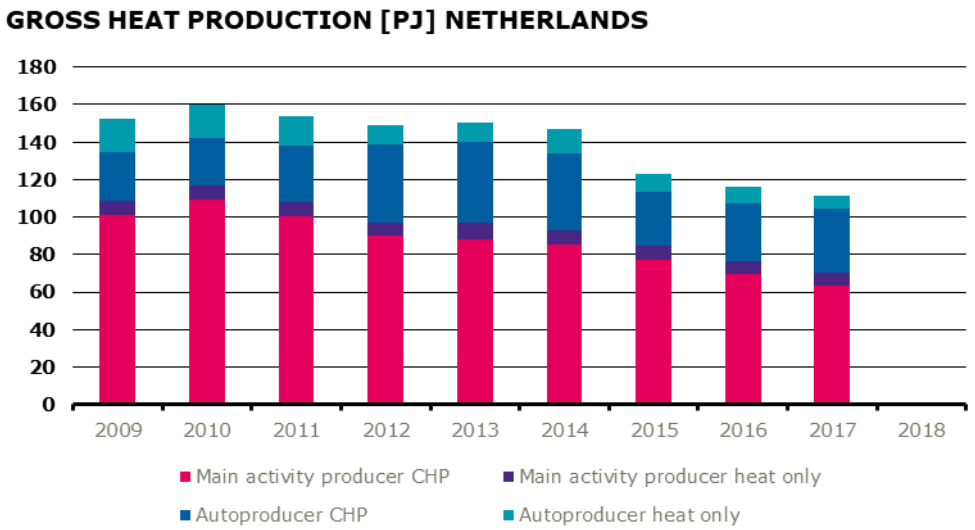


Figure 7-230: Gross heat production by producer type and year in The Netherlands. Based on data from [2]

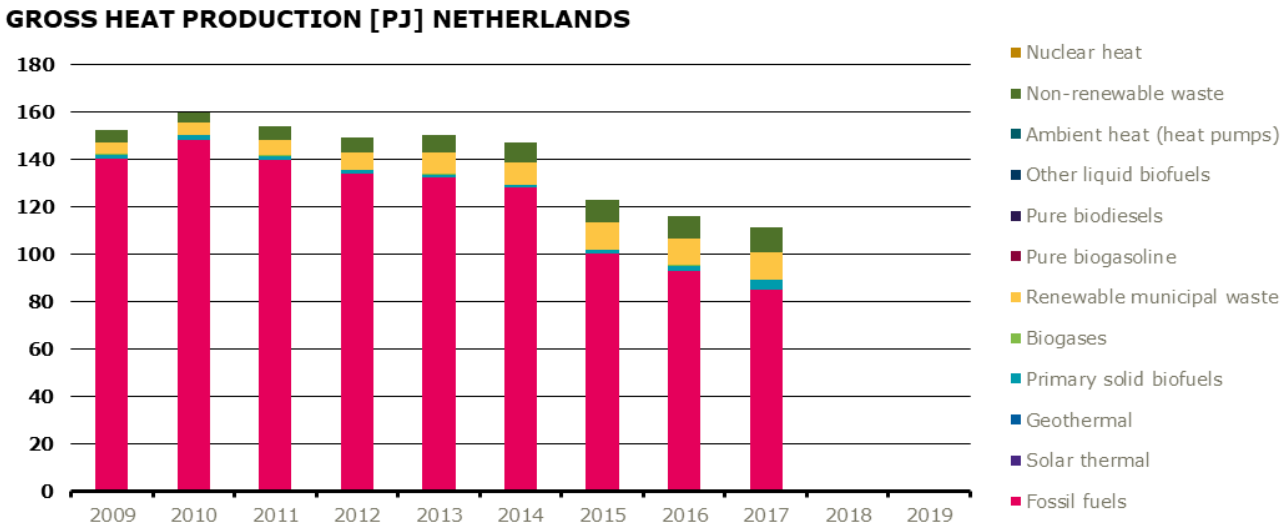


Figure 7-231: Gross heat production by fuel and year in The Netherlands. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.21.4 Electricity Production

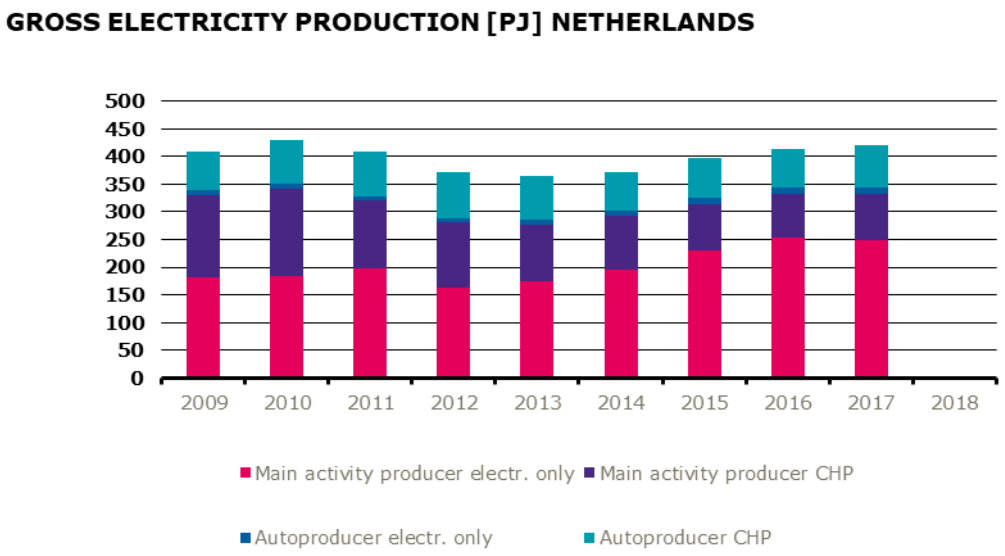


Figure 7-232: Gross electricity production by producer type and year in The Netherlands. Based on data from [2]

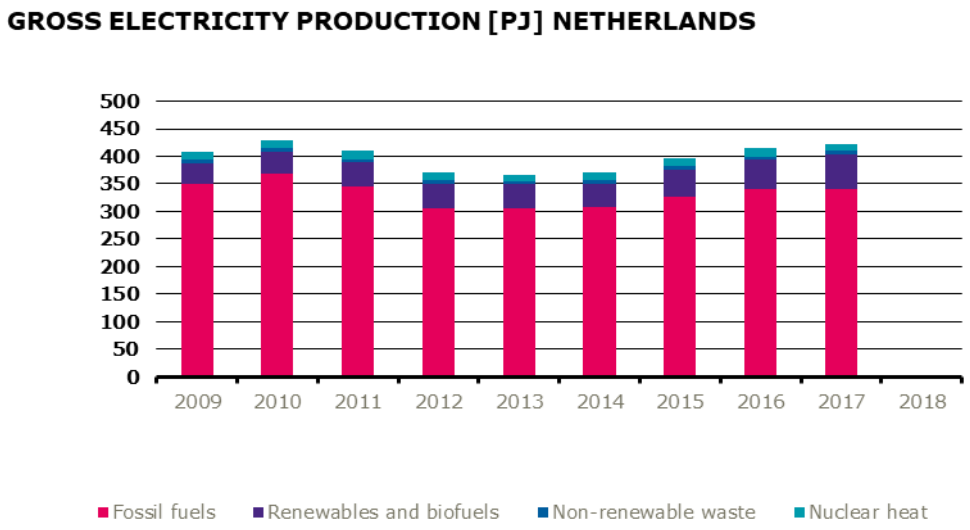


Figure 7-233: Gross electricity production by fuel type and year in The Netherlands. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.21.5 District Heat

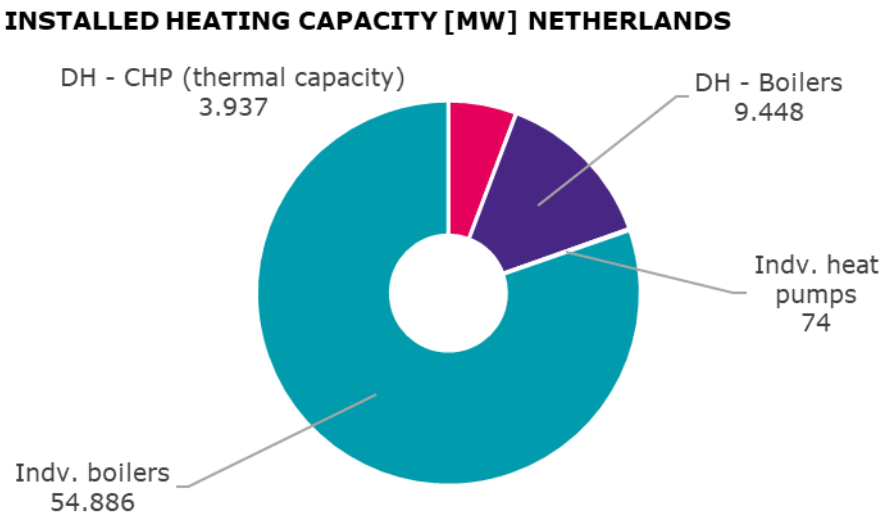


Figure 7-234: Installed heating capacity installed in The Netherlands in 2015. Based on data from [2]

7.21.6 Energy storage

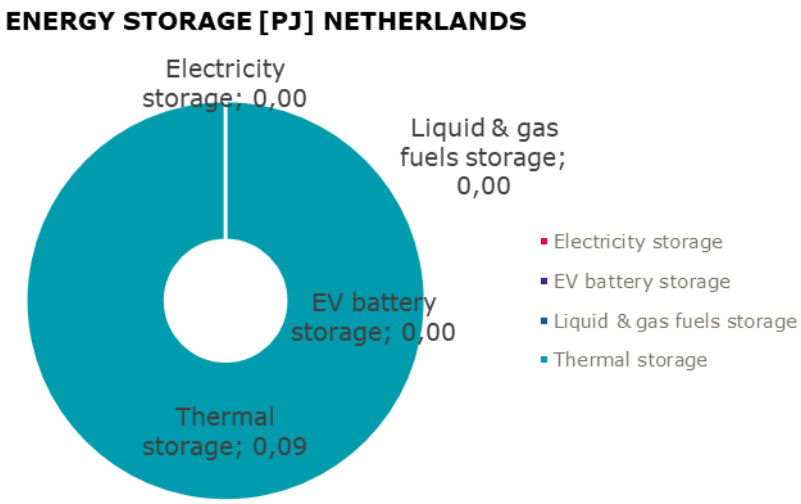
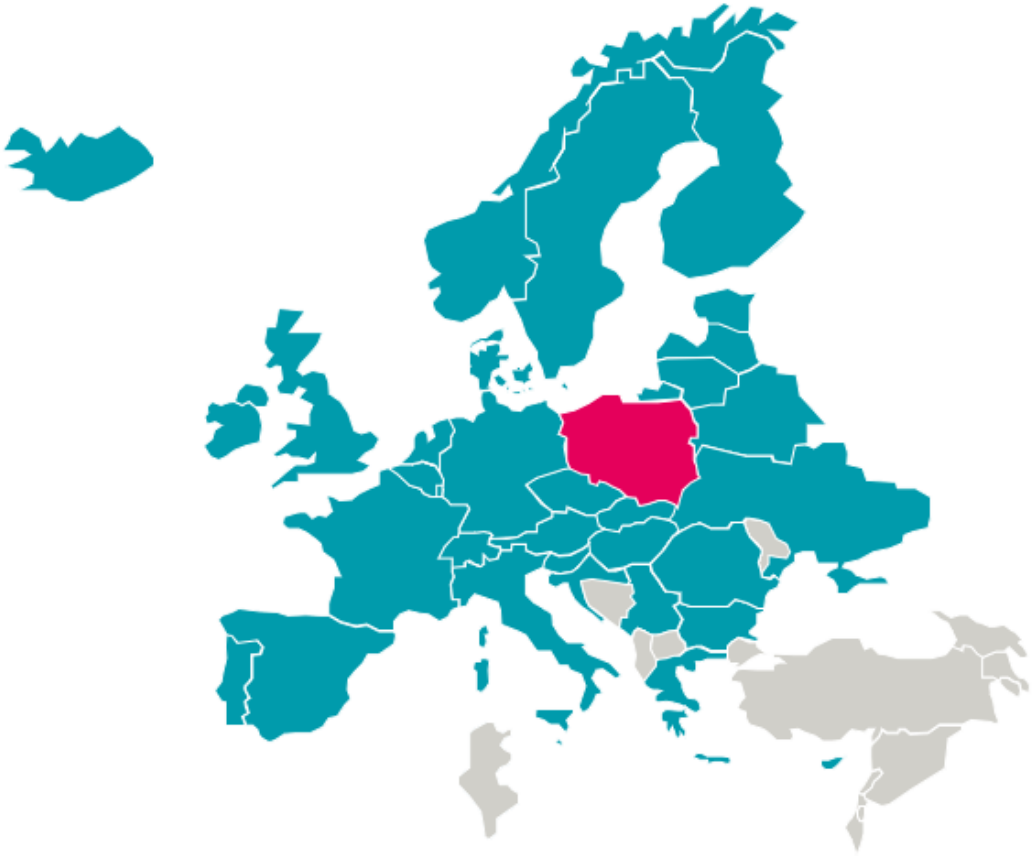


Figure 7-235: Stoage capacity in The Netherlands in 2015. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.22Poland

7.22.1 Country profile



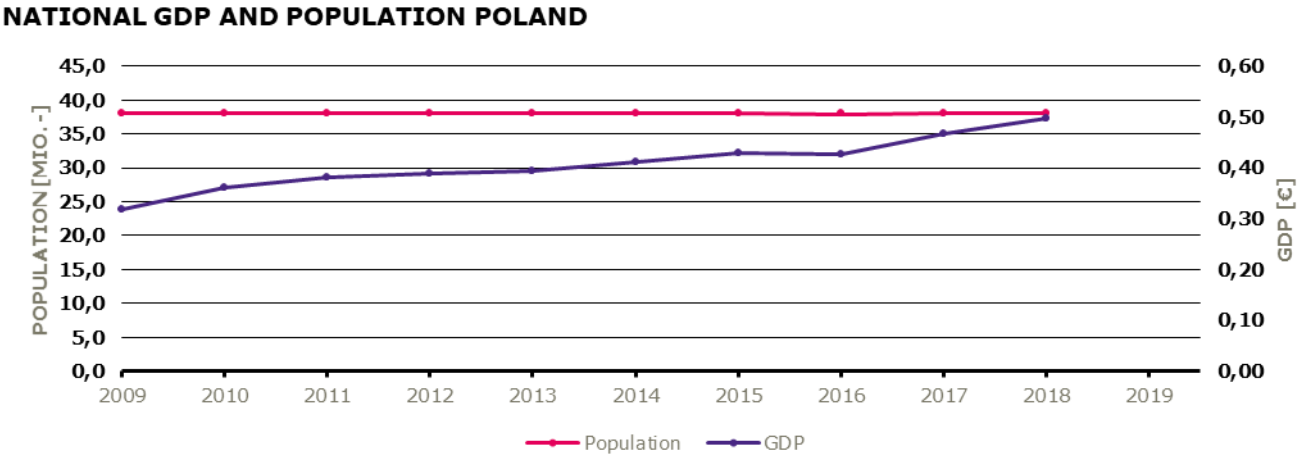


Figure 7-236: GDP and population development in Poland. Based on data from [1]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.22.2 Energy use

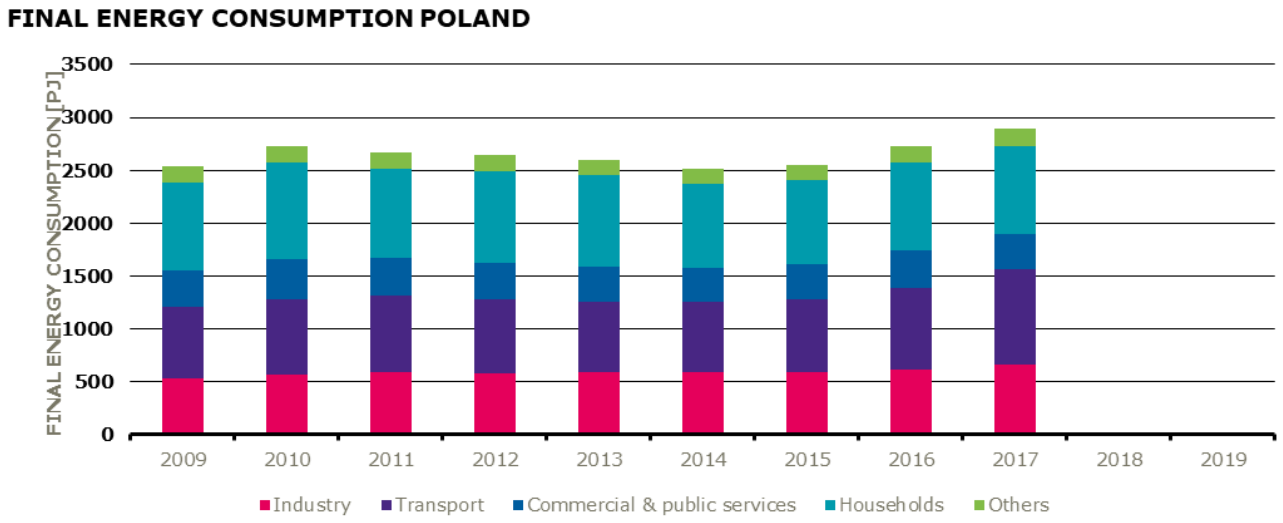


Figure 7-237: Final energy consumption by economic sector and year in Poland. Based on data from [2]

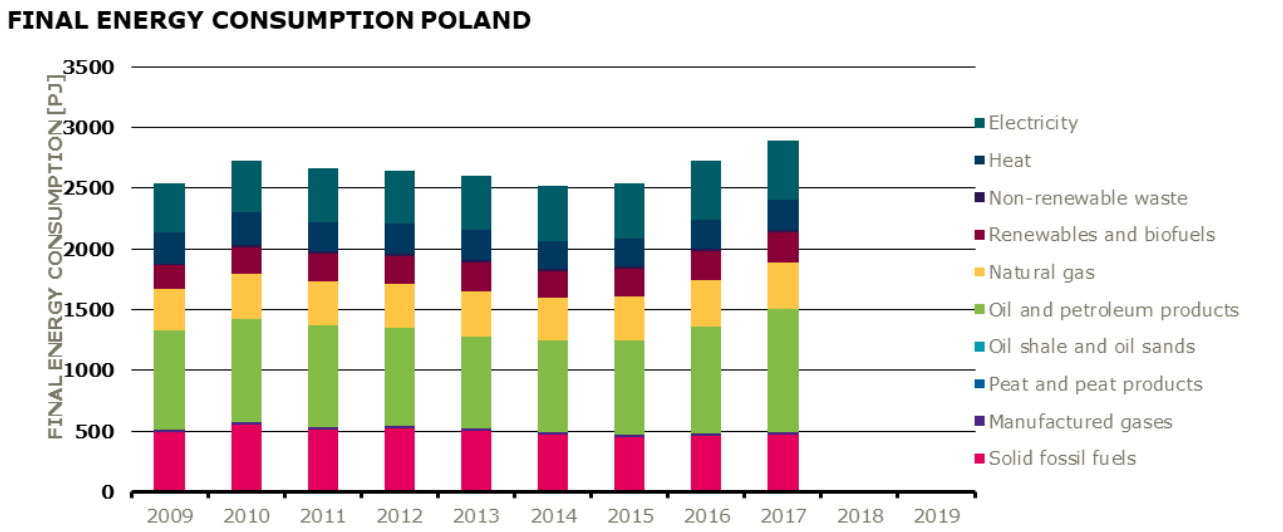


Figure 7-238: Final energy consumption by fuel and year in Poland. Based on data from [2]

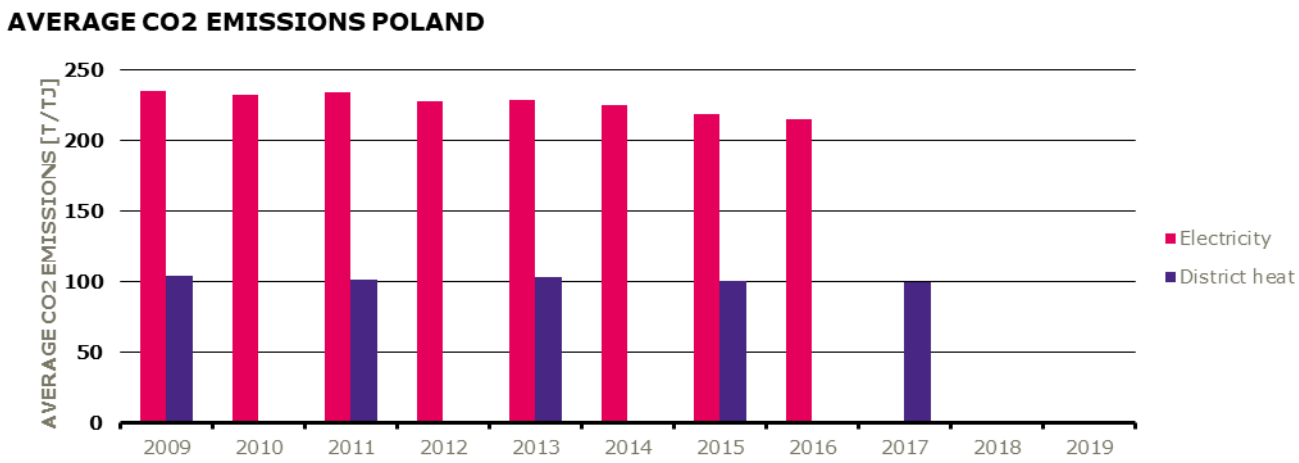


Figure 7-239: Average CO2 emissions in Poland. Based on data from [3] & [4]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.22.3 Heat Production

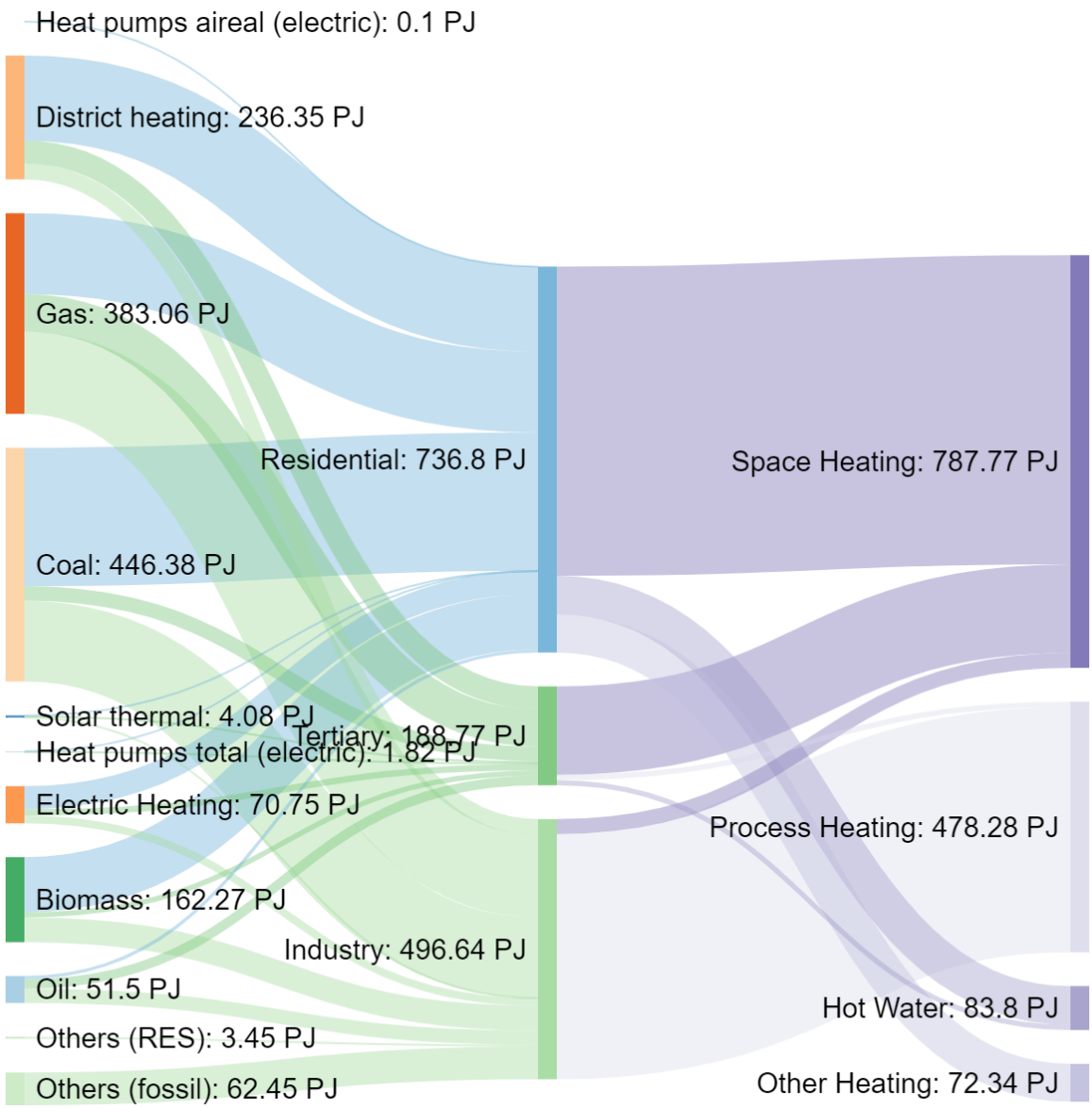


Figure 7-240: Sankey diagram of energy flows for heating purposes in Poland in 2015. Based on data from [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

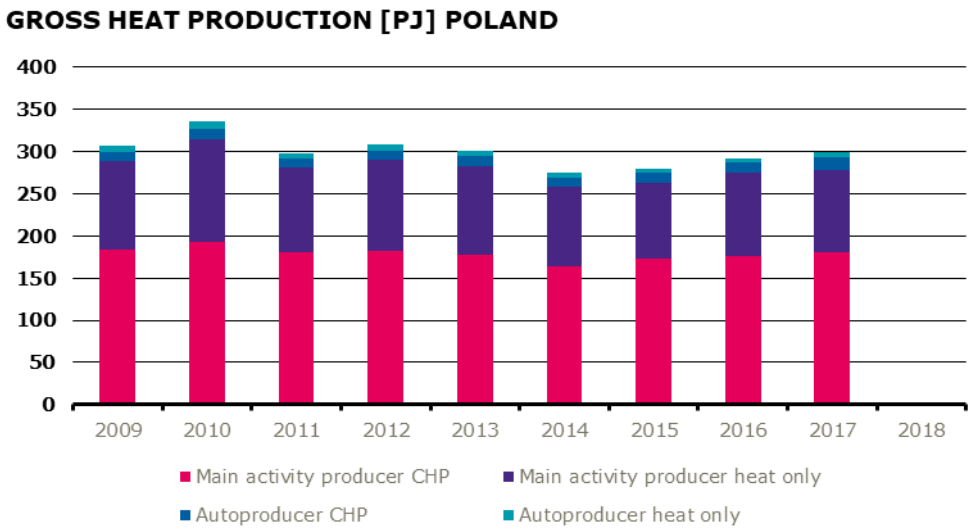


Figure 7-241: Gross heat production by producer type and year in Poland. Based on data from [2]

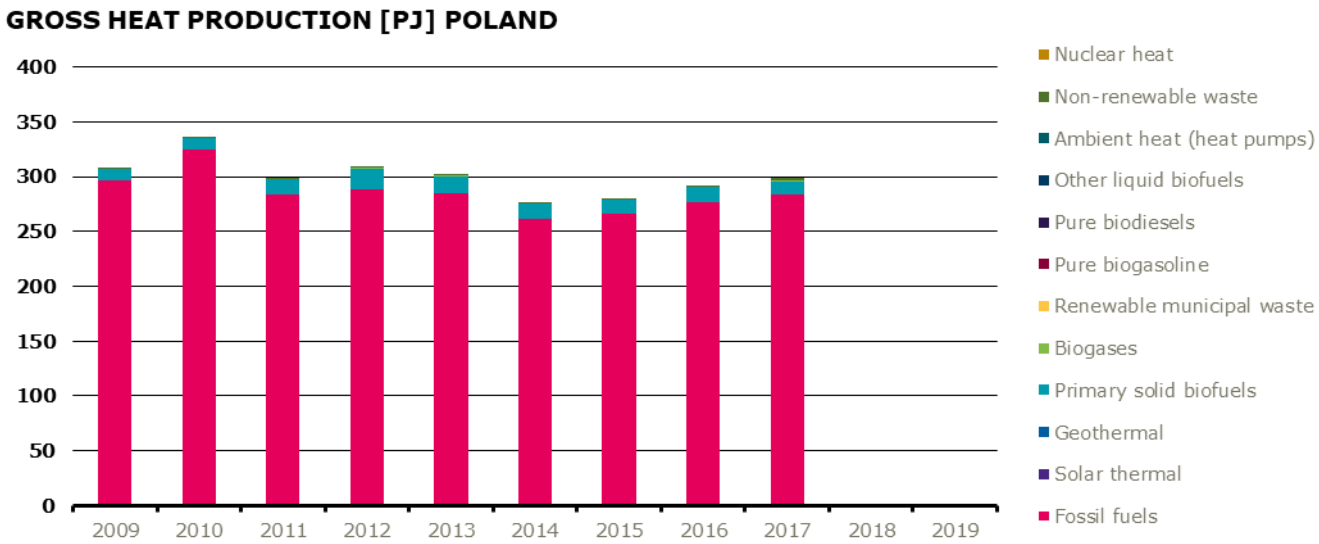


Figure 7-242: Gross heat production by fuel and year in Poland. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.22.4 Electricity Production

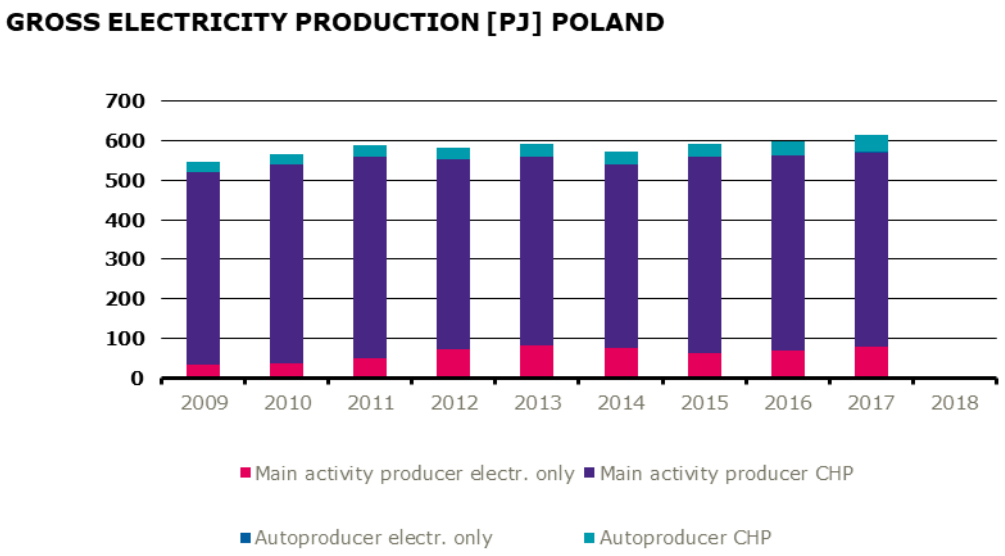


Figure 7-243: Gross electricity production by producer type and year in Poland. Based on data from [2].

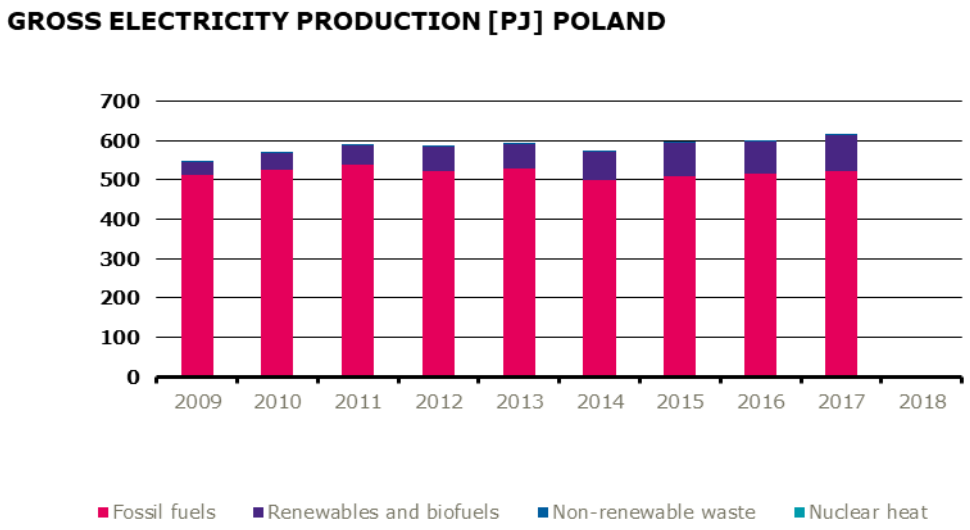


Figure 7-244: Gross electricity production by fuel type and year in Poland. Based on data from [2]

7.22.5 District Heat

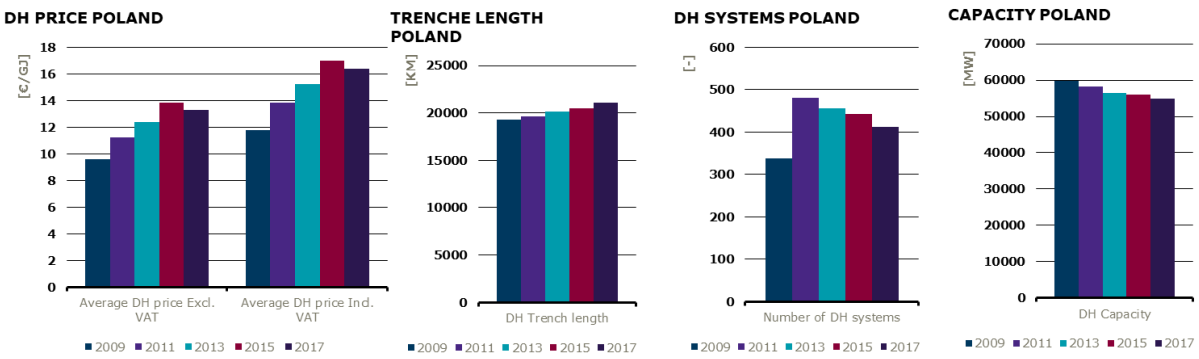


Figure 7-245: District heat indicators for Poland. Based on data from [2]

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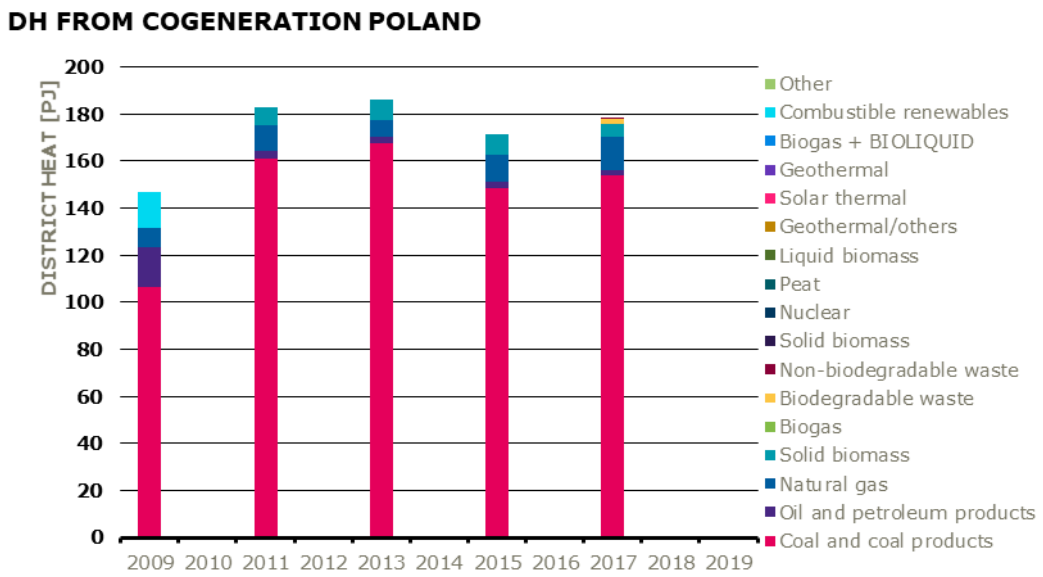

Figure 7-246: District heat generated in CHP plants by year and fuel in Poland. Based on data from [2], [3]

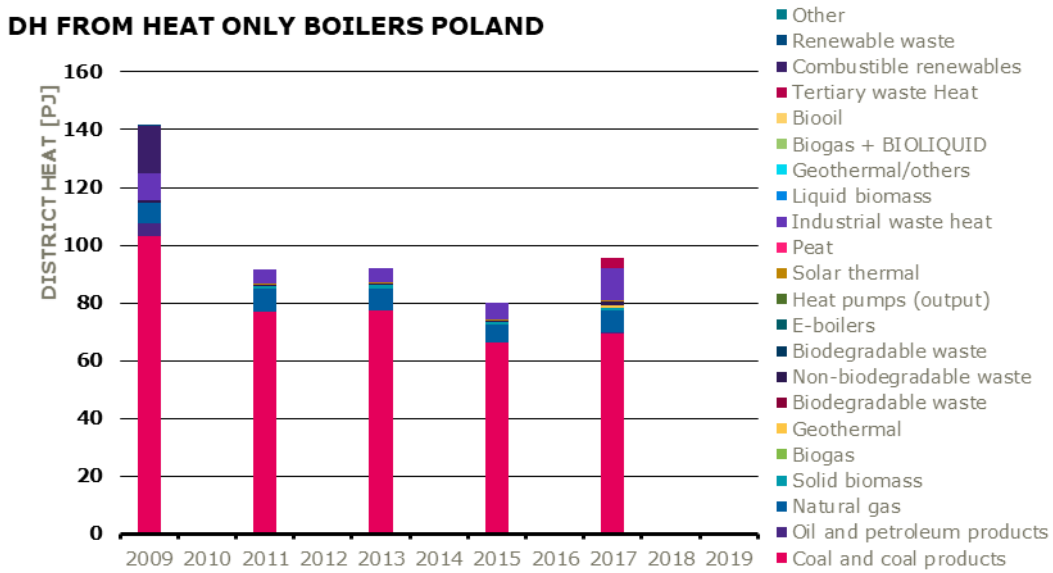

Figure 7-247: District heat generated in heat only boilers by year and fuel in Poland. Based on data from [2], [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

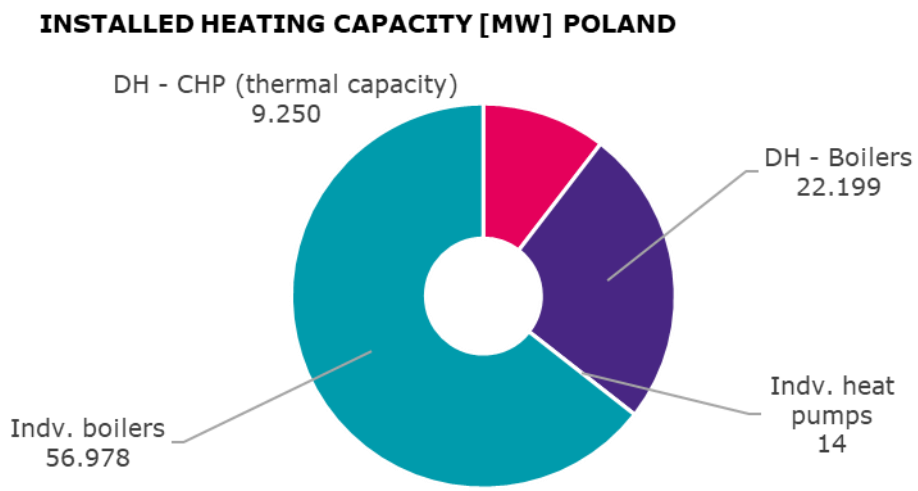

Figure 7-248: Installed heating capacity installed in Poland in 2015. Based on data from [2]

7.22.6 Energy storage

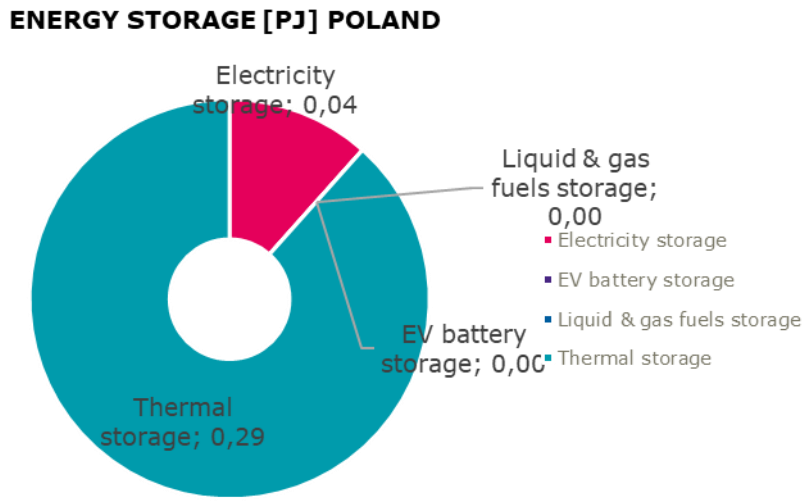

Figure 7-249: Stoage capacity in Poland in 2015. Based on data from [2]

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7.23 Portugal

7.23.1 Country profile

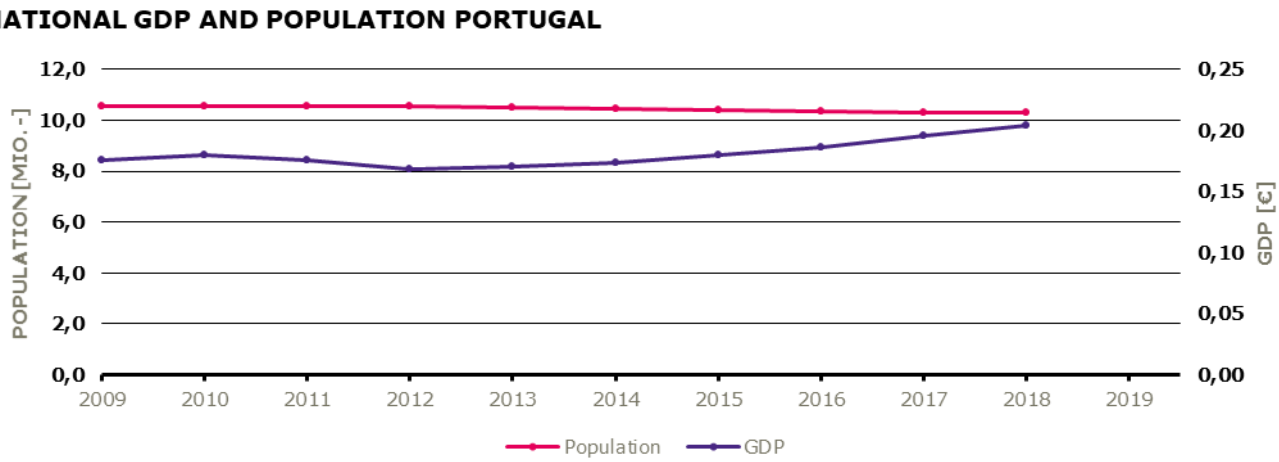

Figure 7-250: GDP and population development in Portugal. Based on data from [1]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.23.2 Energy use

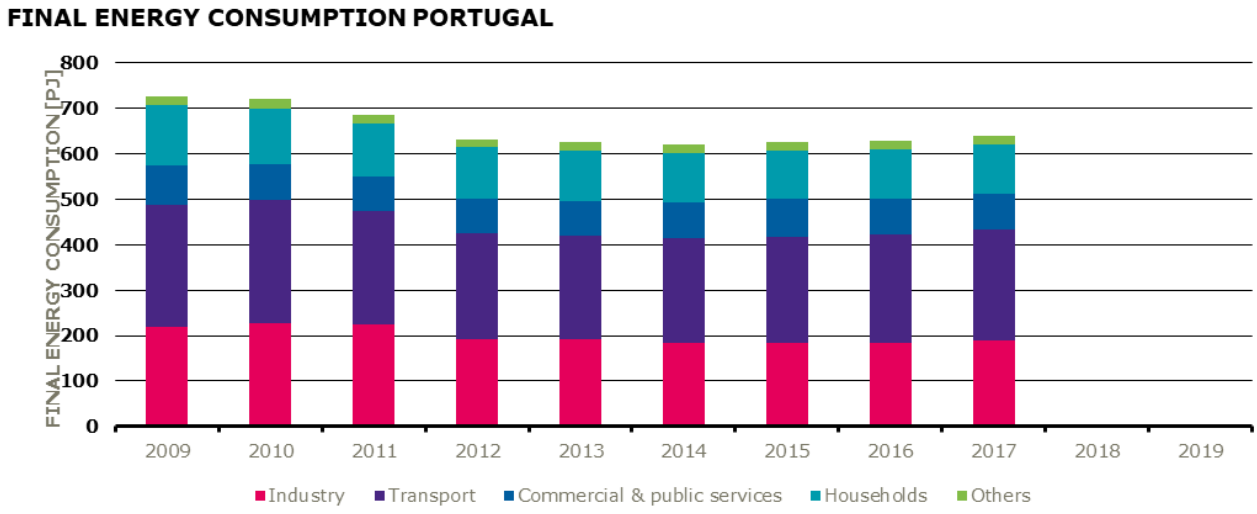

Figure 7-251: Final energy consumption by economic sector and year in Portugal. Based on data from [2]

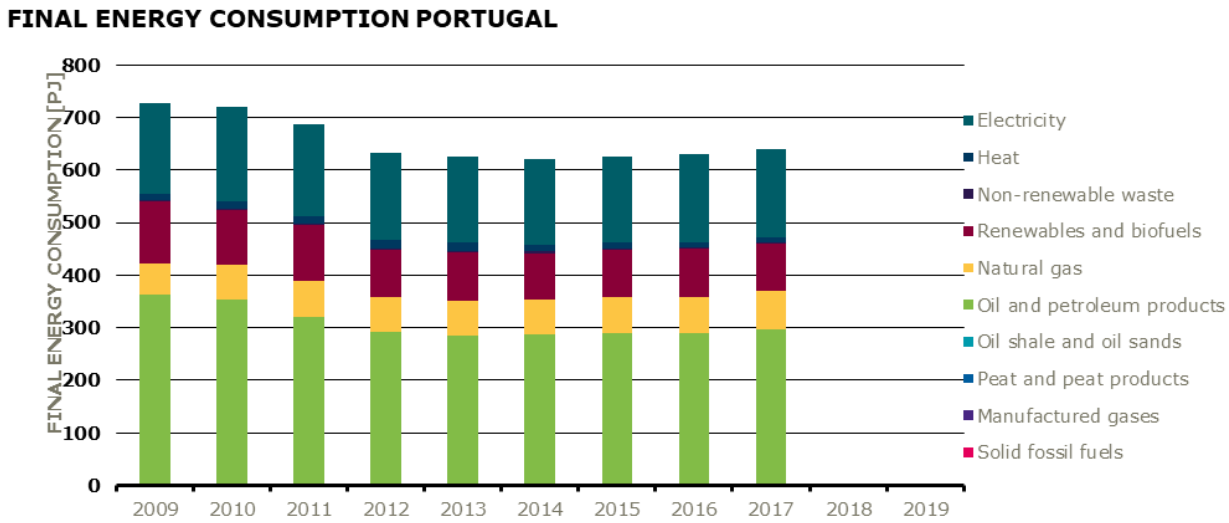

Figure 7-252: Final energy consumption by fuel and year in Portugal. Based on data from [2]

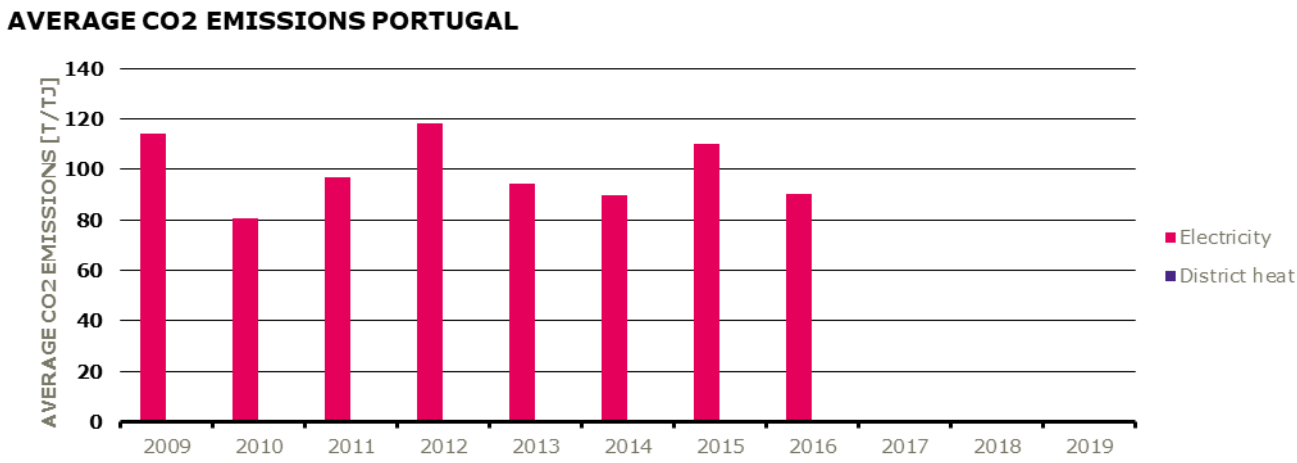

Figure 7-253: Average CO2 emissions in Portugal. Based on data from [3] & [4]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.23.3 Heat Production

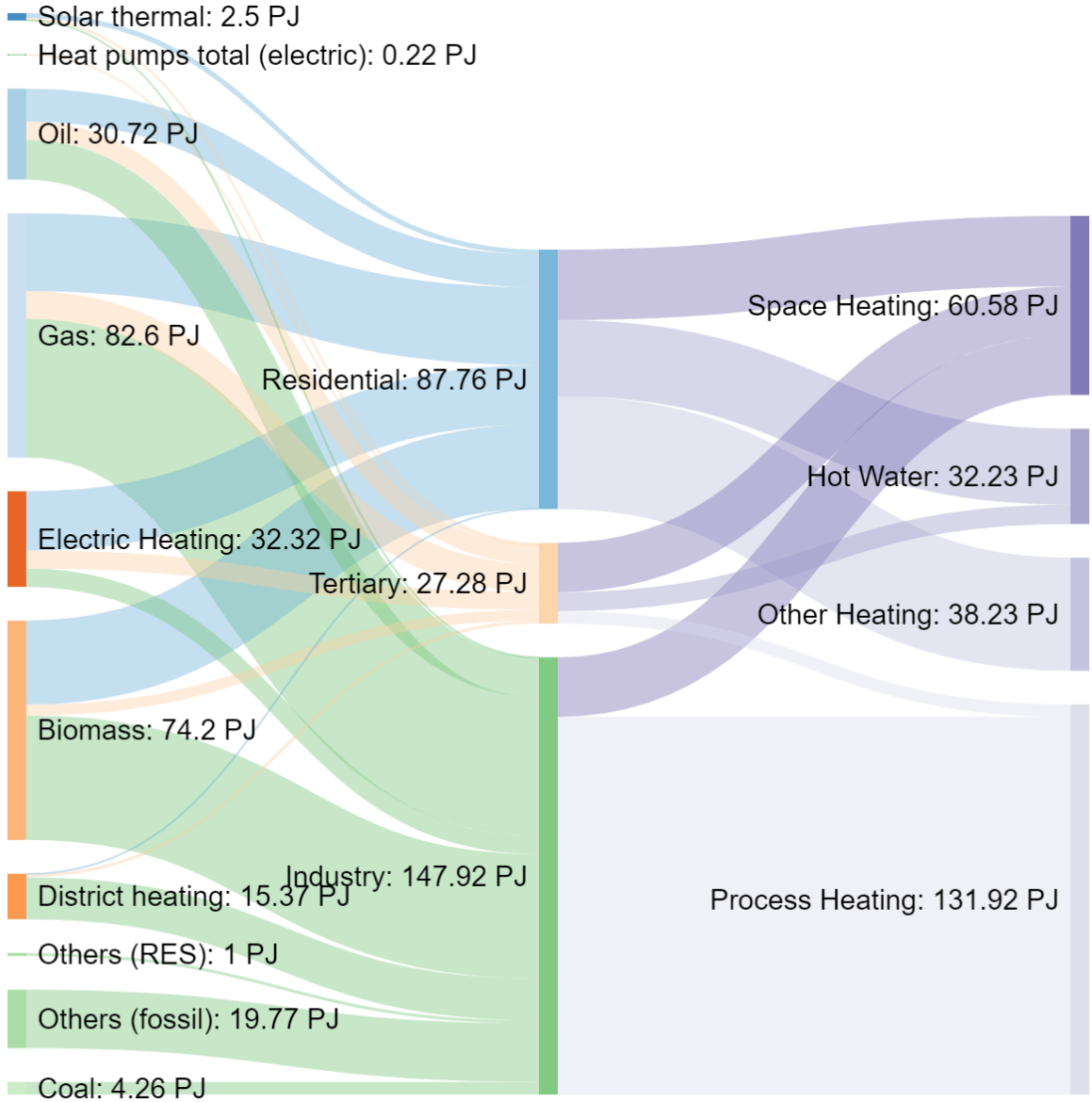

Figure 7-254: Sankey diagram of energy flows for heating purposes in Portugal in 2015. Based on data from [3]

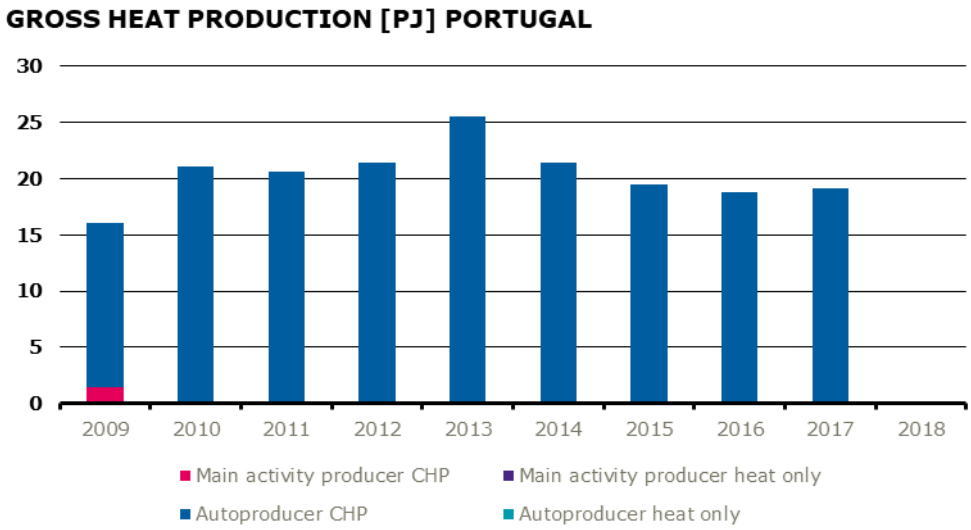

Figure 7-255: Gross heat production by producer type and year in Portugal. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

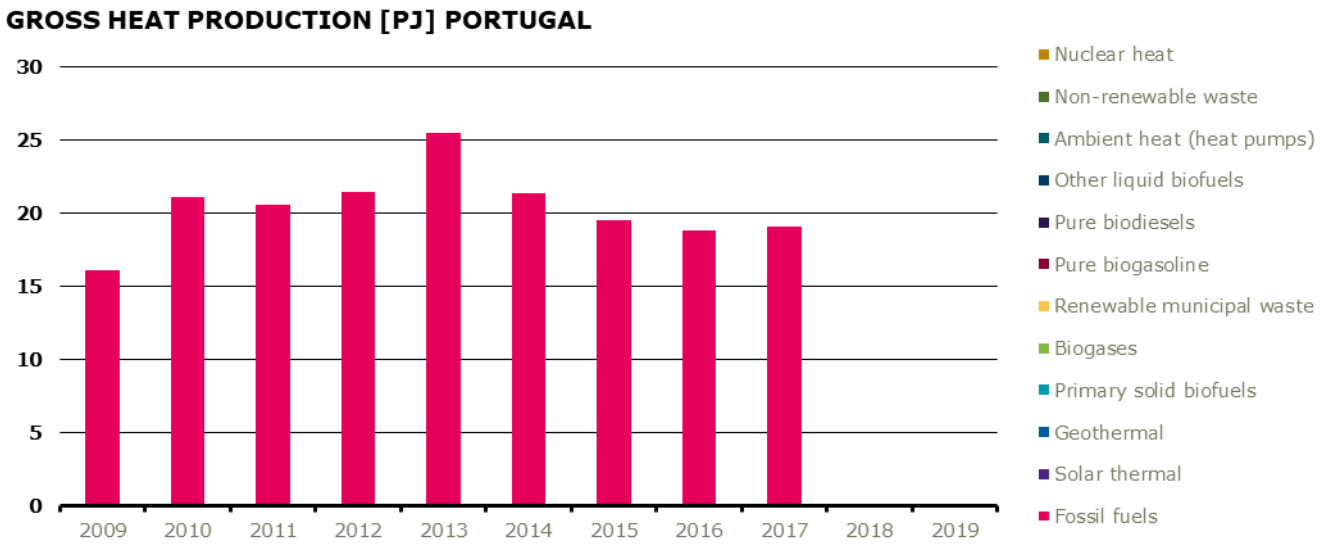

Figure 7-256: Gross heat production by producer type and year in Portugal. Based on data from [2]

7.23.4 Electricity Production

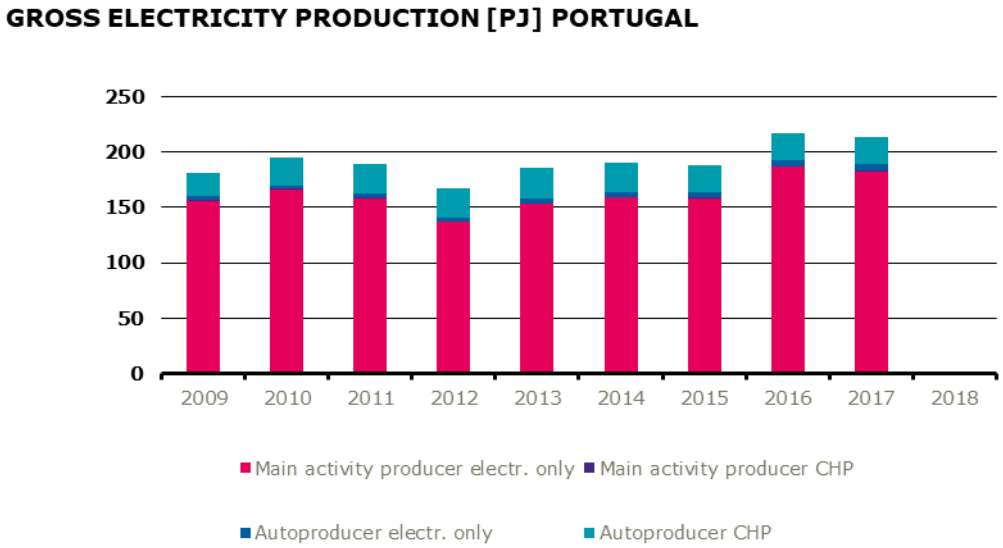

Figure 7-257: Gross electricity production by producer type and year in Portugal. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

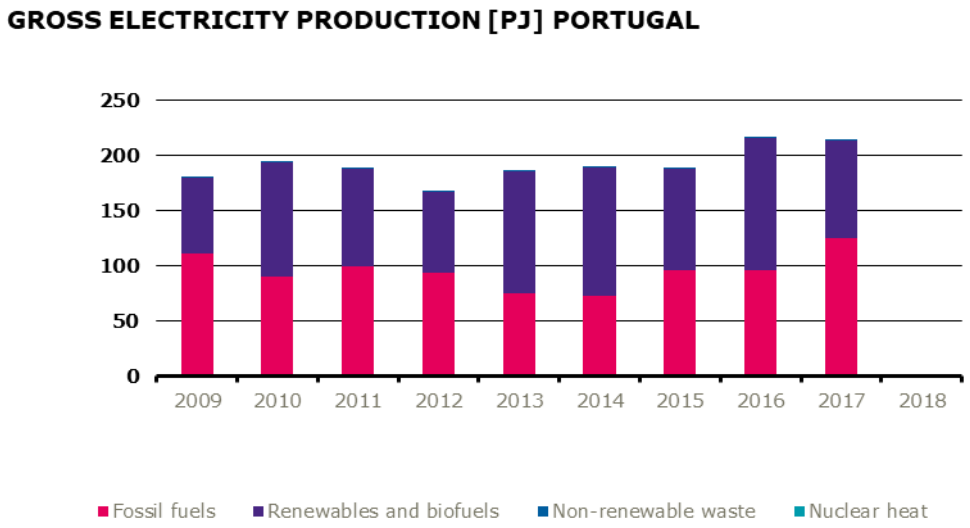

Figure 7-258: Gross electricity production by fuel type and year in Portugal. Based on data from [2]

7.23.5 District Heat

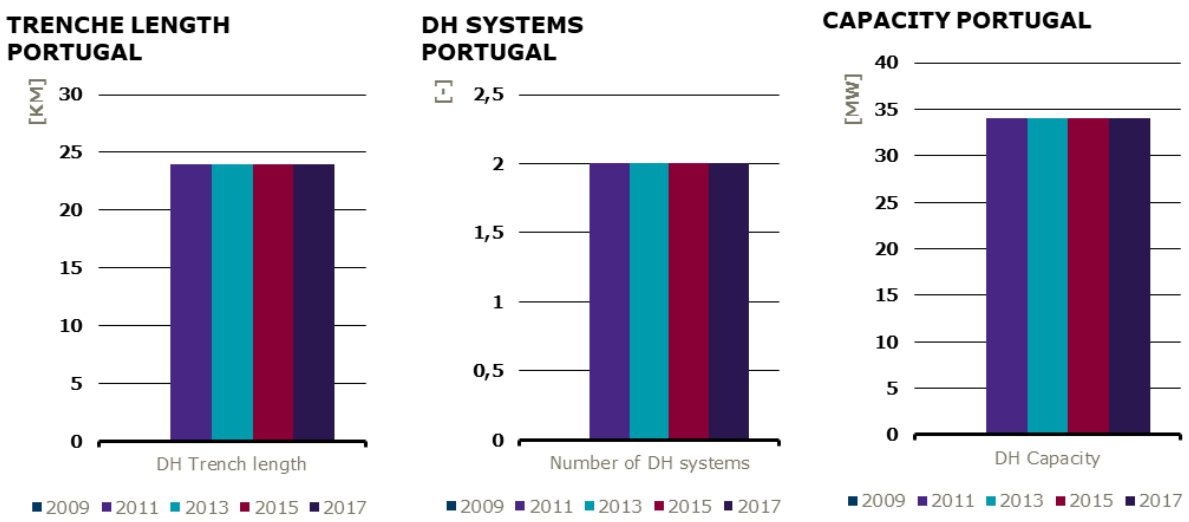

Figure 7-259: District heat indicators for Portugal. Based on data from [2]

7.23.6 Energy storage

[*No data available*]

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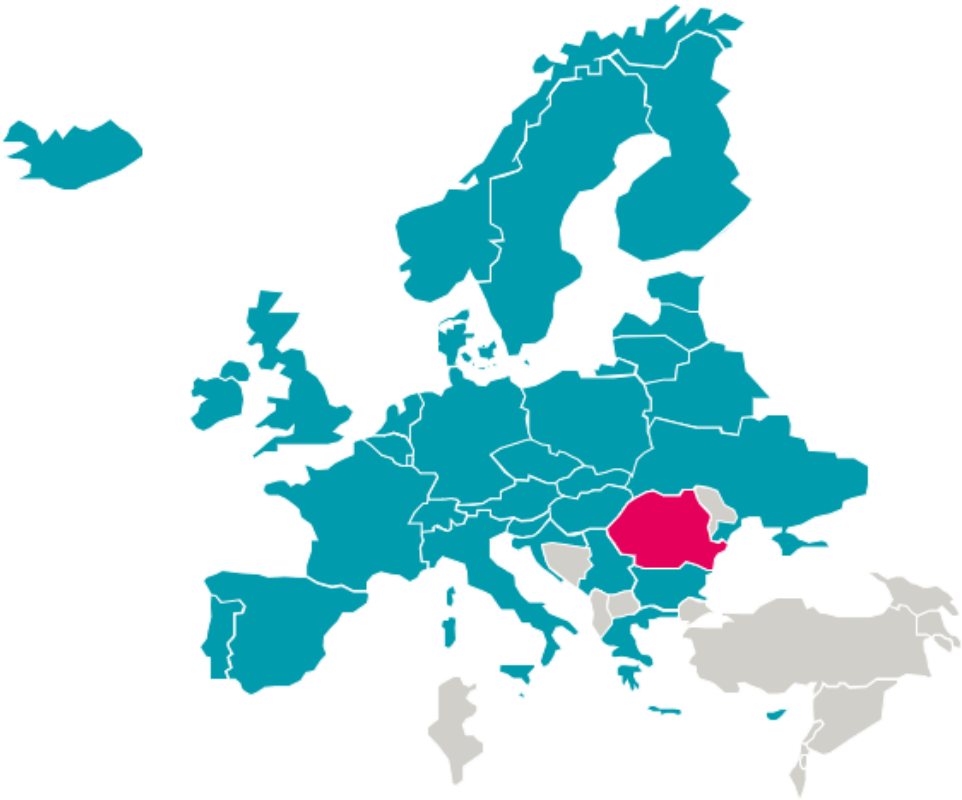
7.24Romania

7.24.1 Country profile



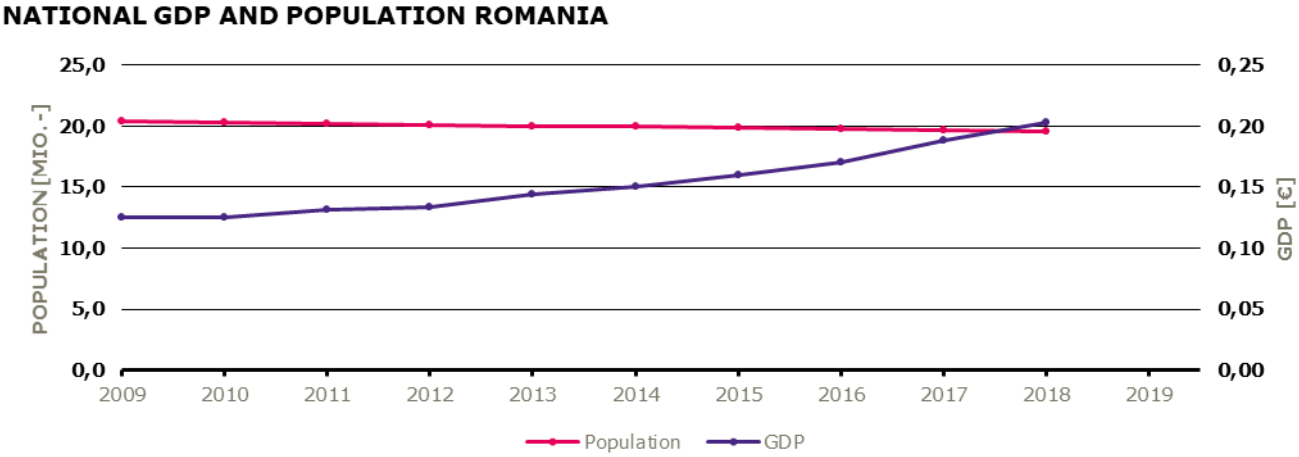


Figure 7-260: GDP and population development in Romania. Based on data from [1]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.24.2 Energy use

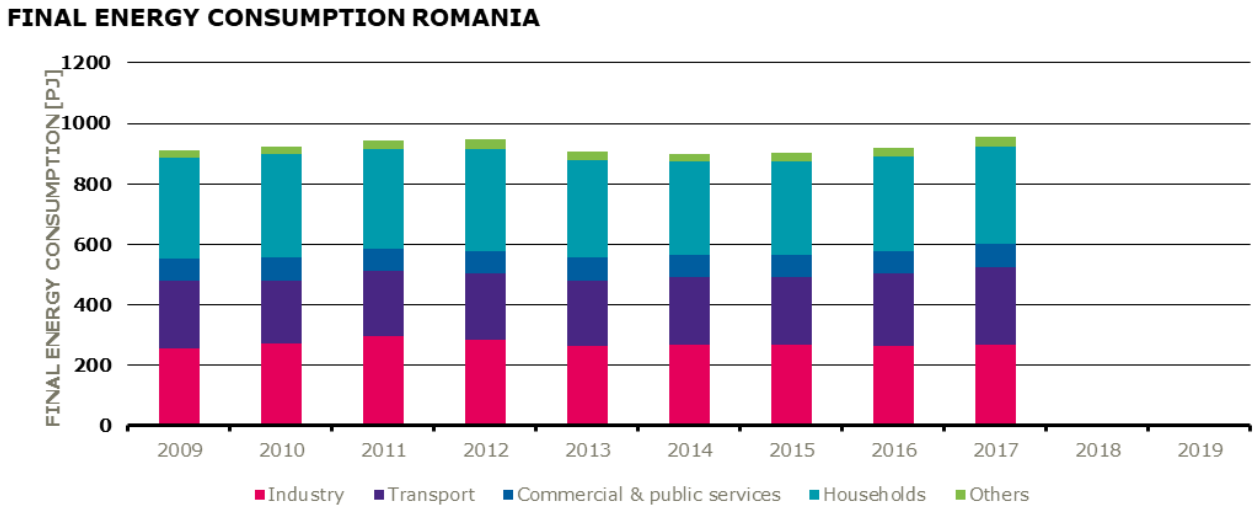


Figure 7-261: Final energy consumption by economic sector and year in Romania. Based on data from [2]

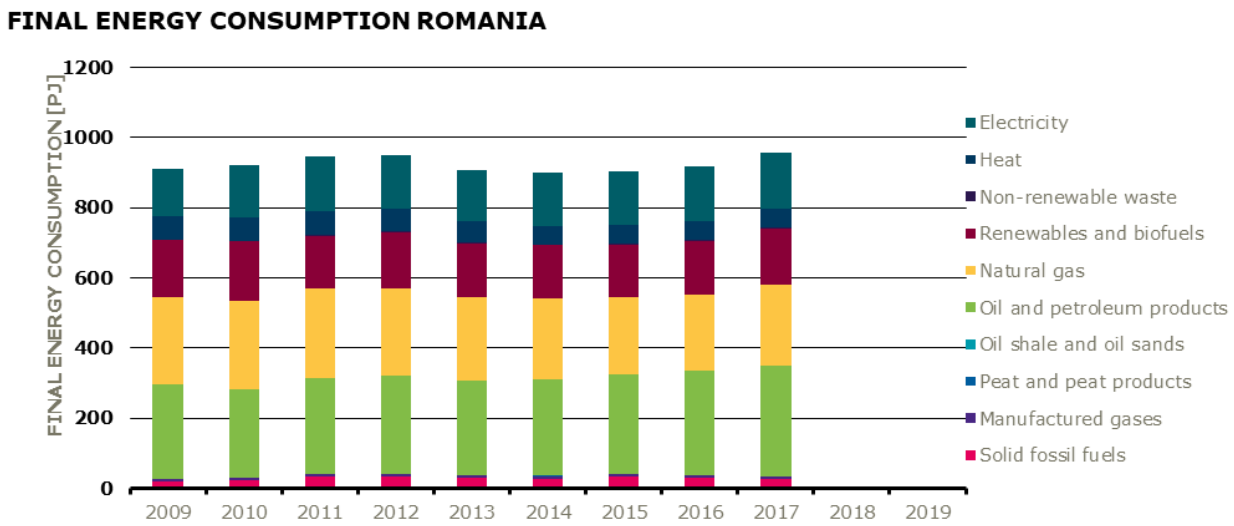


Figure 7-262: Final energy consumption by fuel and year in Romania. Based on data from [2]

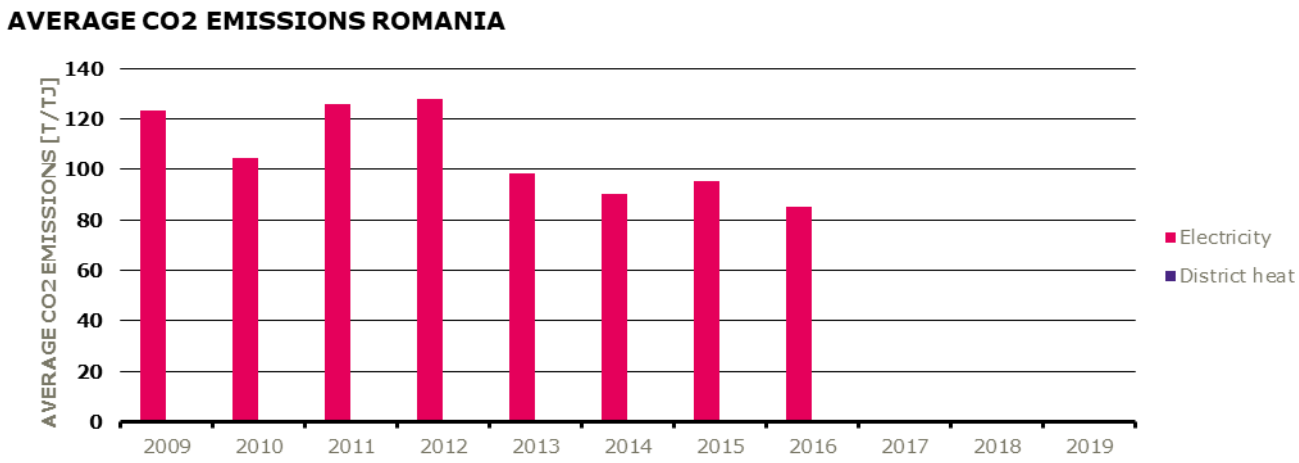


Figure 7-263: Average CO2 emissions in Romania. Based on data from [3] & [4]

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7.24.3 Heat Production

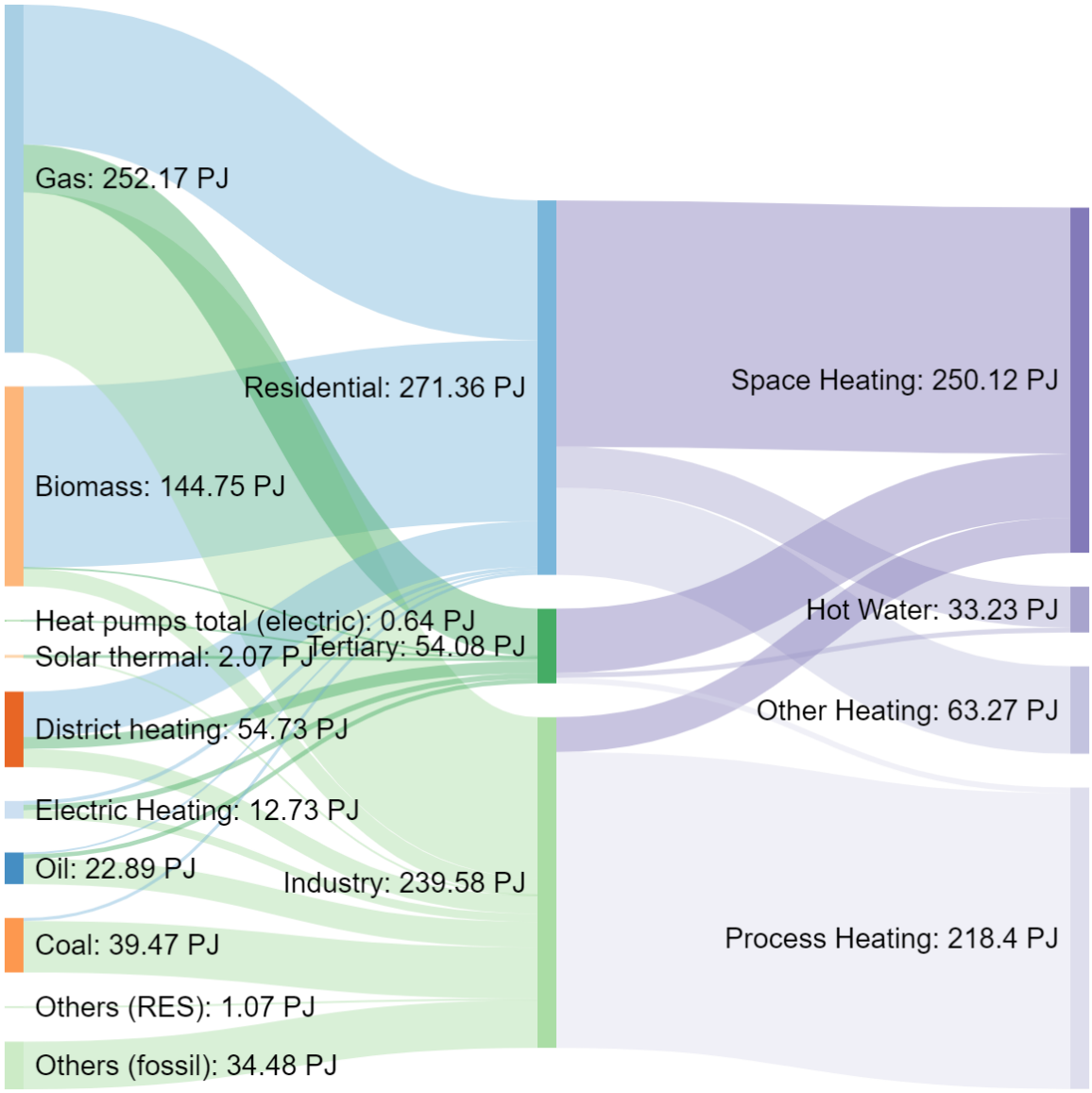

Figure 7-264: Sankey diagram of energy flows for heating purposes in Romania in 2015. Based on data from [3]

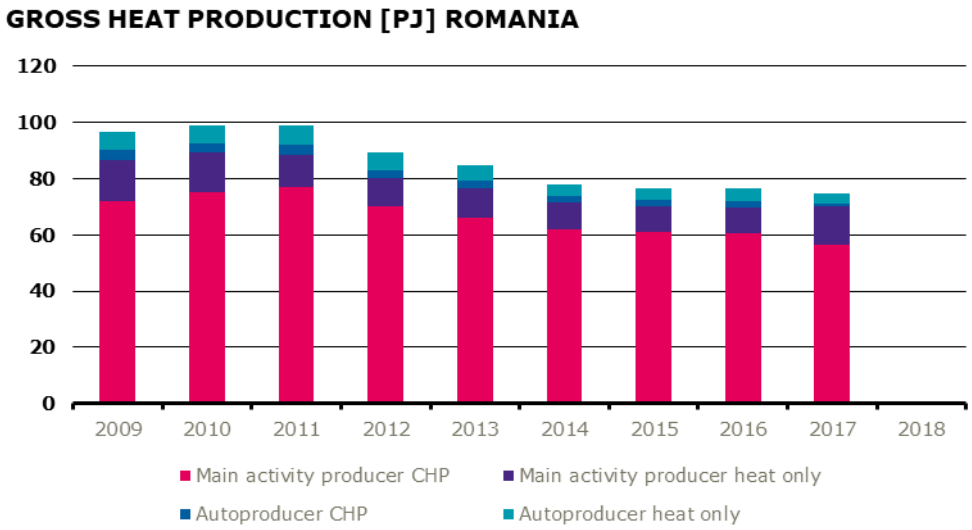

Figure 7-265: Gross heat production by producer type and year in Romania. Based on data from [2]

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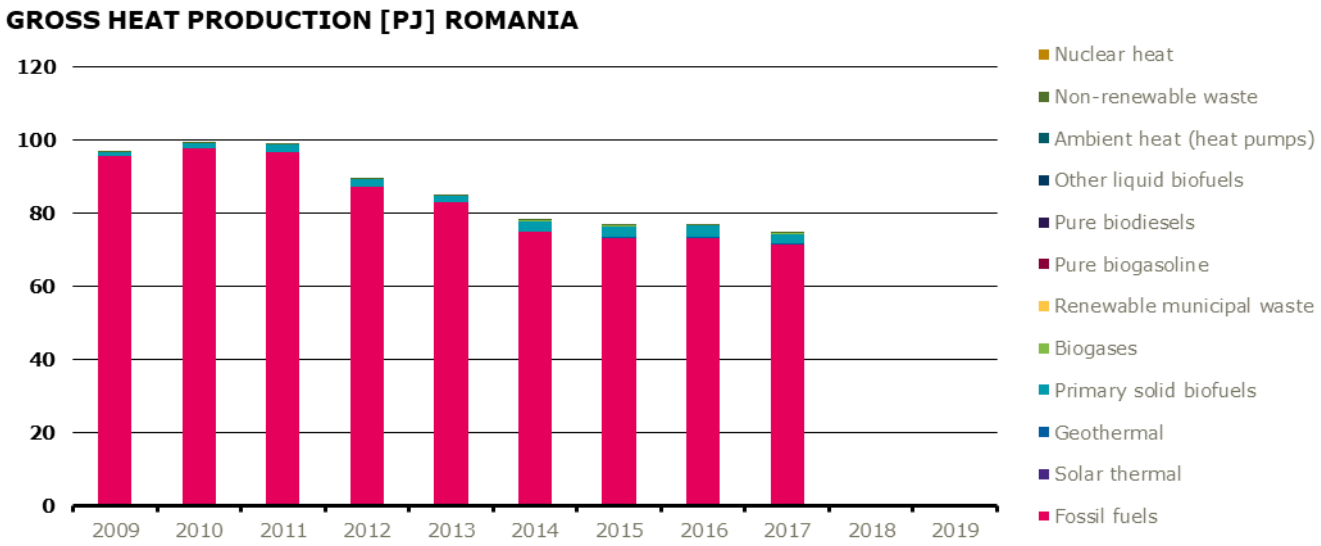

Figure 7-266: Gross heat production by fuel and year in Romania. Based on data from [2]

7.24.4 Electricity Production

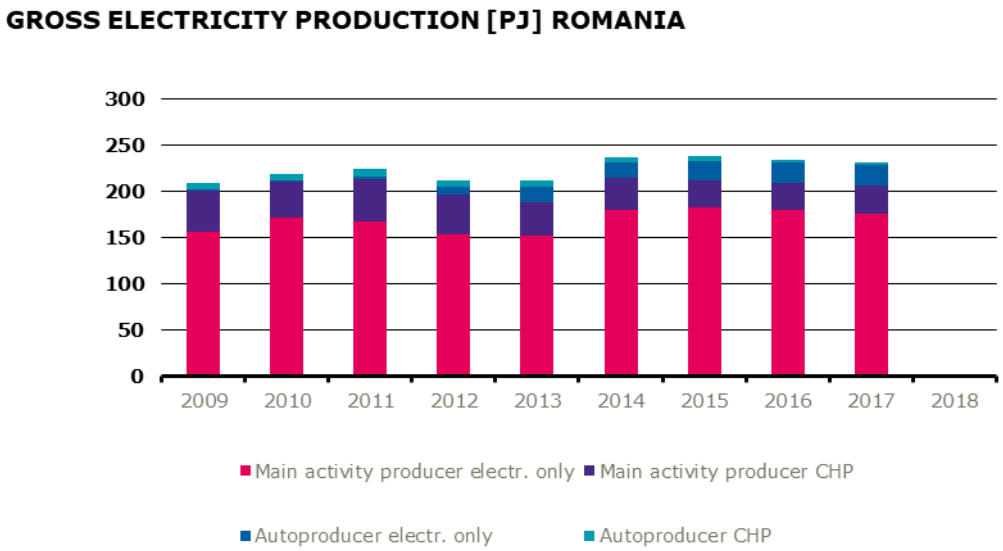

Figure 7-267: Gross electricity production by producer type and year in Romania. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

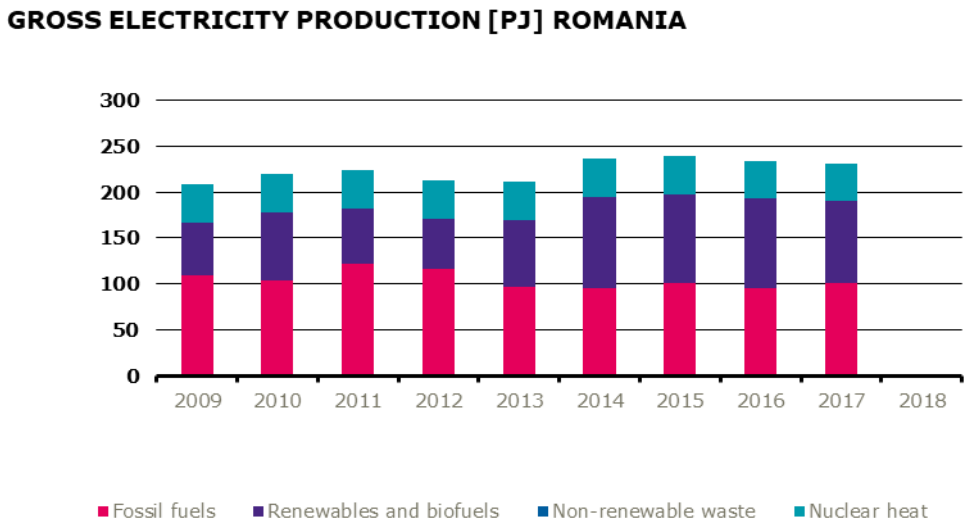

Figure 7-268: Gross electricity production by fuel type and year in Romania. Based on data from [2]

7.24.5 District Heat

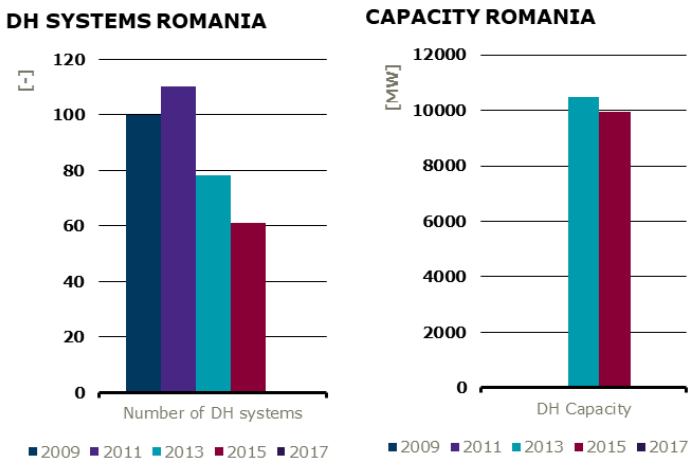

Figure 7-269: District heat indicators for Romania. Based on data from [2]

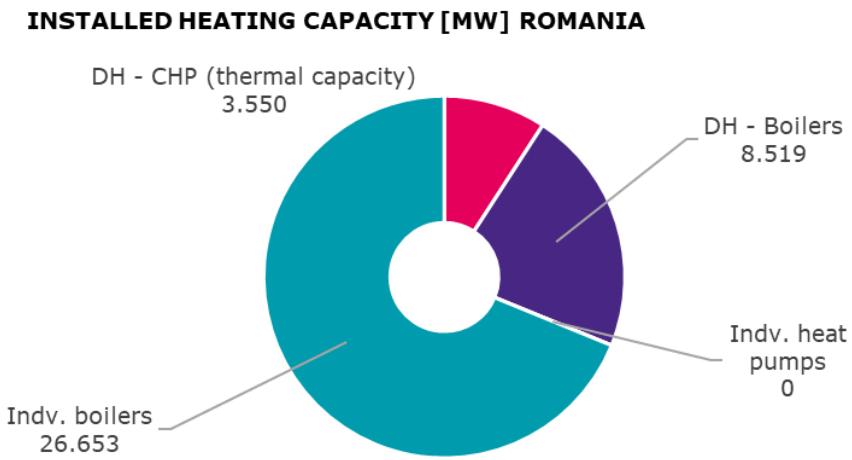

Figure 7-270: Installed heating capacity installed in Romaniain 2015. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.24.6 Energy storage

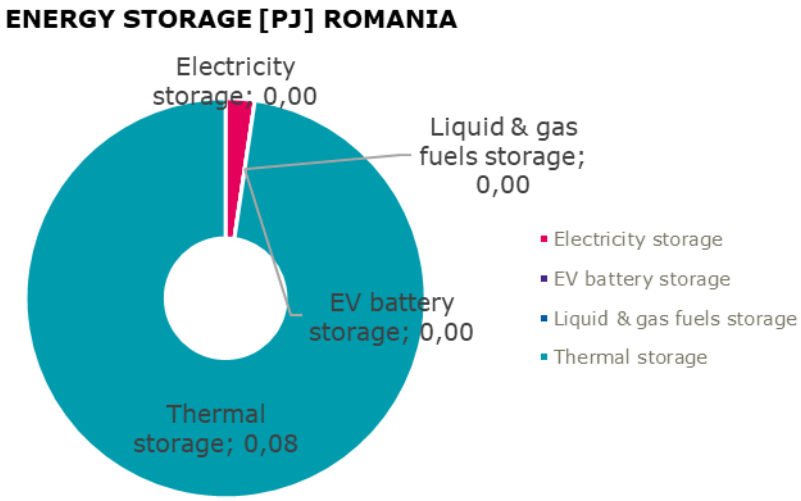

Figure 7-271: Stoage capacity in Romania in 2015. Based on data from [2]

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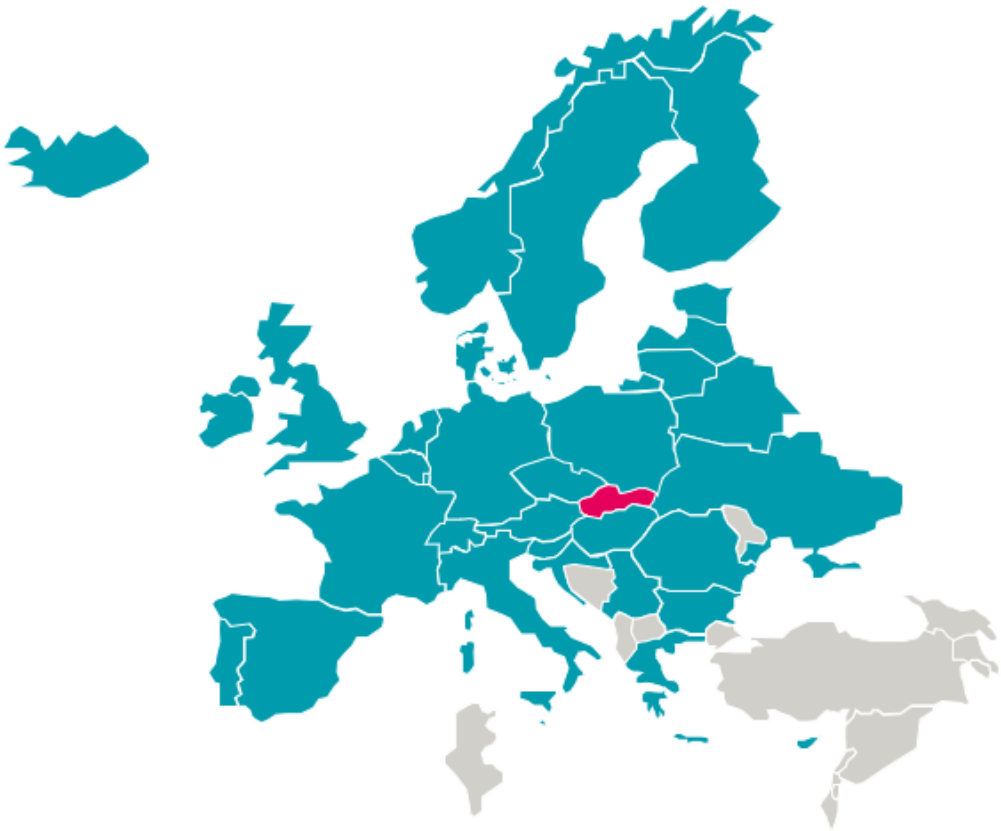
7.25 Slovakia

7.25.1 Country profile



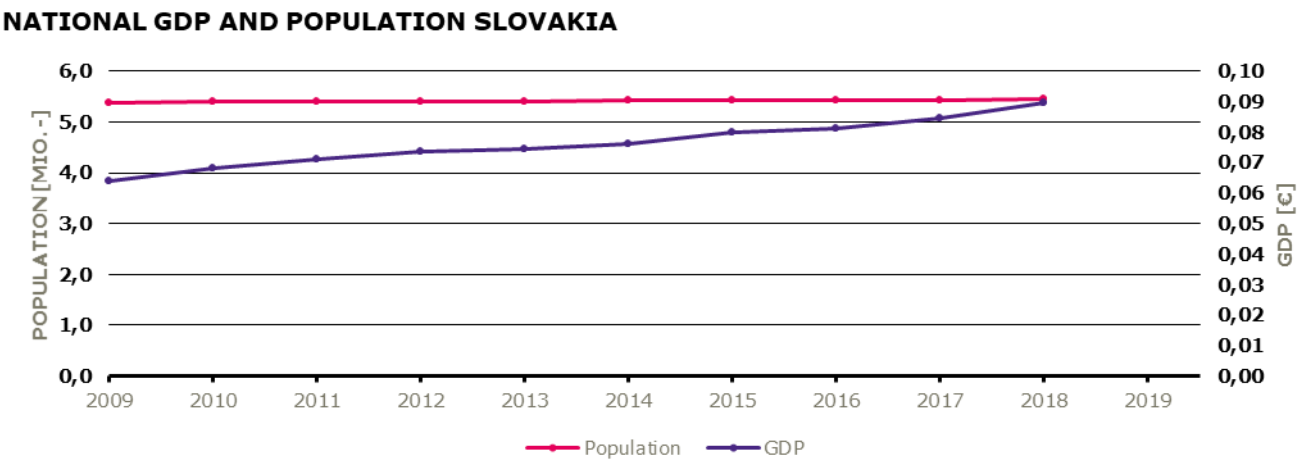


Figure 7-272: GDP and population development in Slovakia. Based on data from [1]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.25.2 Energy use

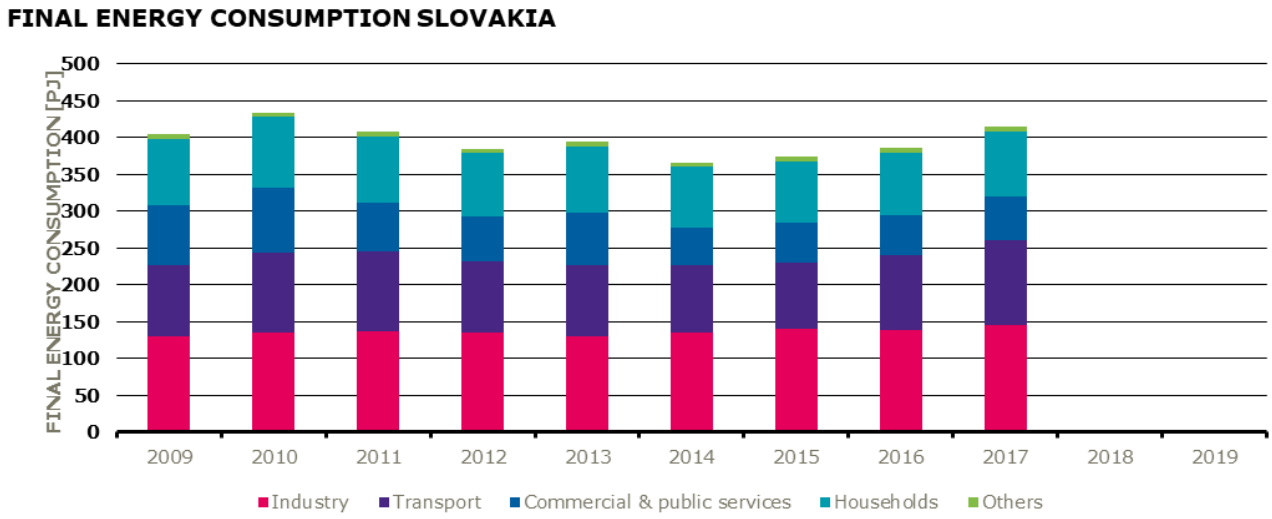


Figure 7-273: Final energy consumption by economic sector and year in Slovakia. Based on data from [2]

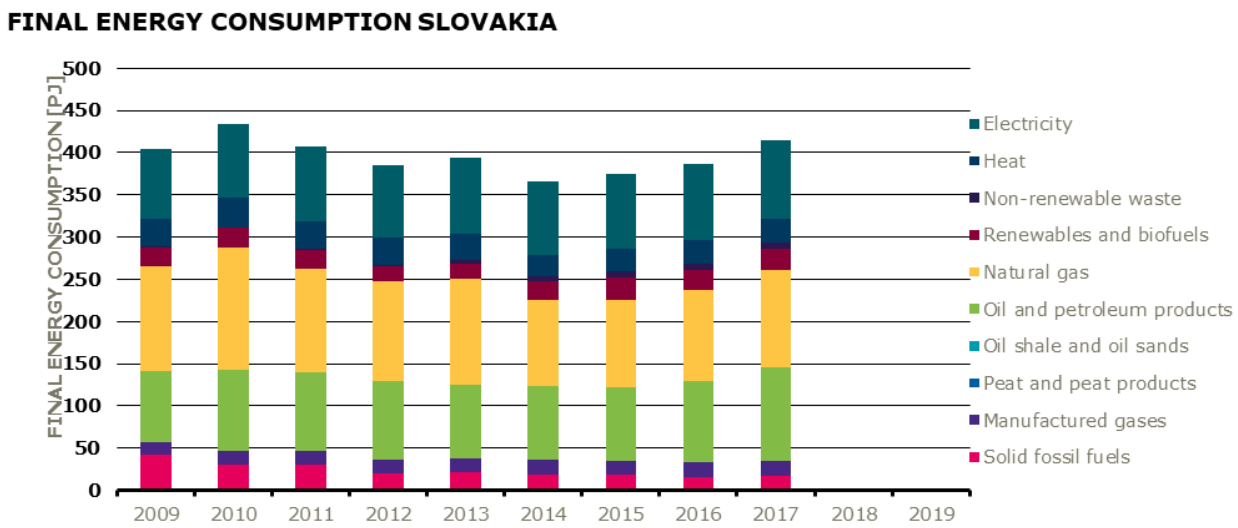


Figure 7-274: Final energy consumption by fuel and year in Slovakia. Based on data from [2]

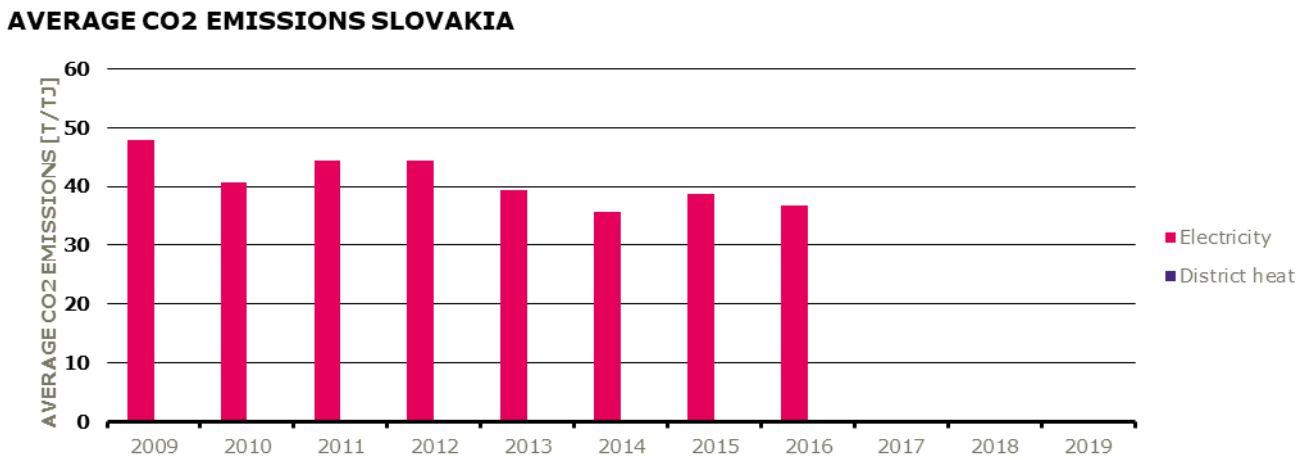


Figure 7-275: Average CO2 emissions in Slovakia. Based on data from [3] & [4]

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7.25.3 Heat Production

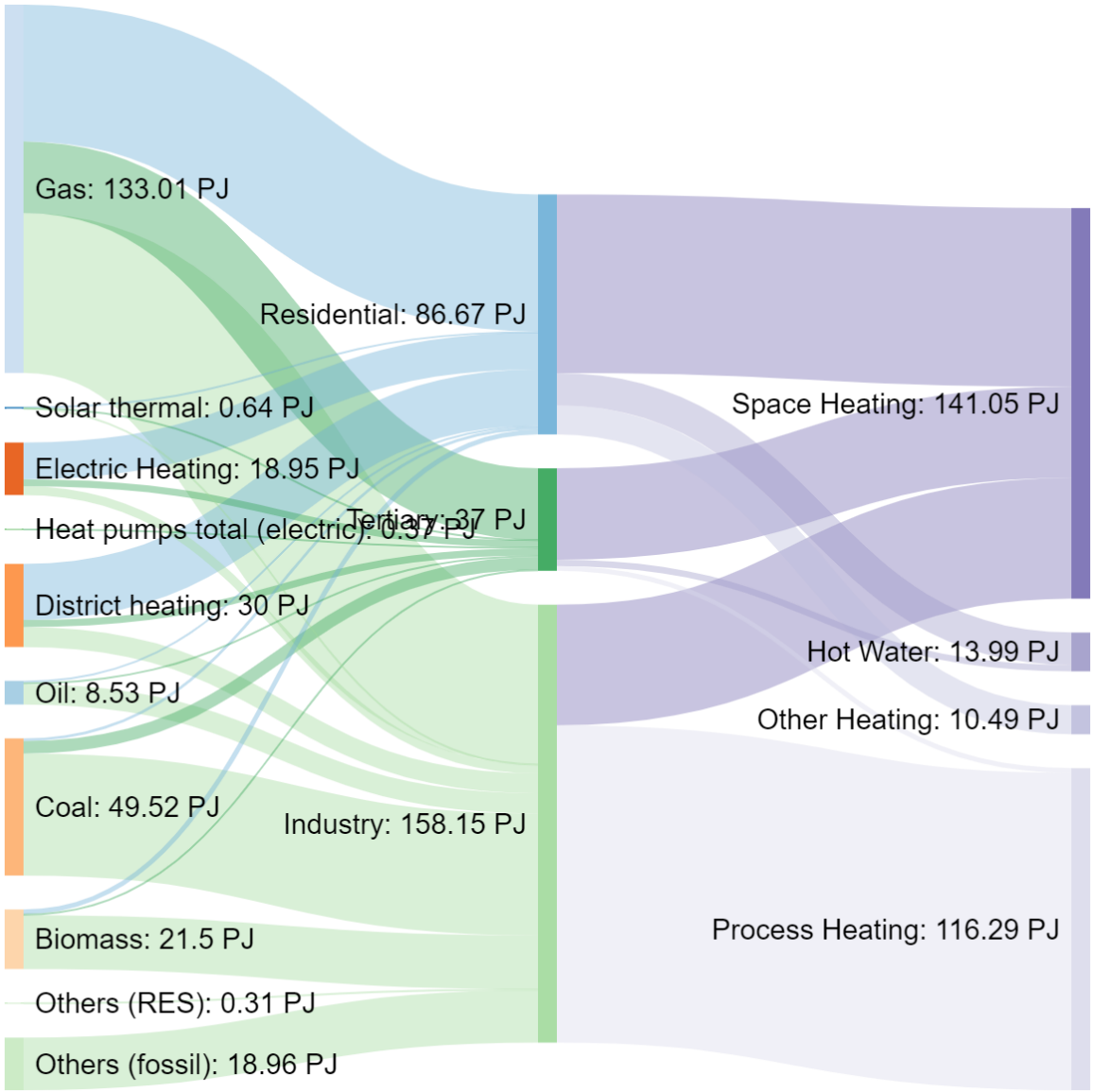


Figure 7-276: Sankey diagram of energy flows for heating purposes in Slovakia in 2015. Based on data from [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

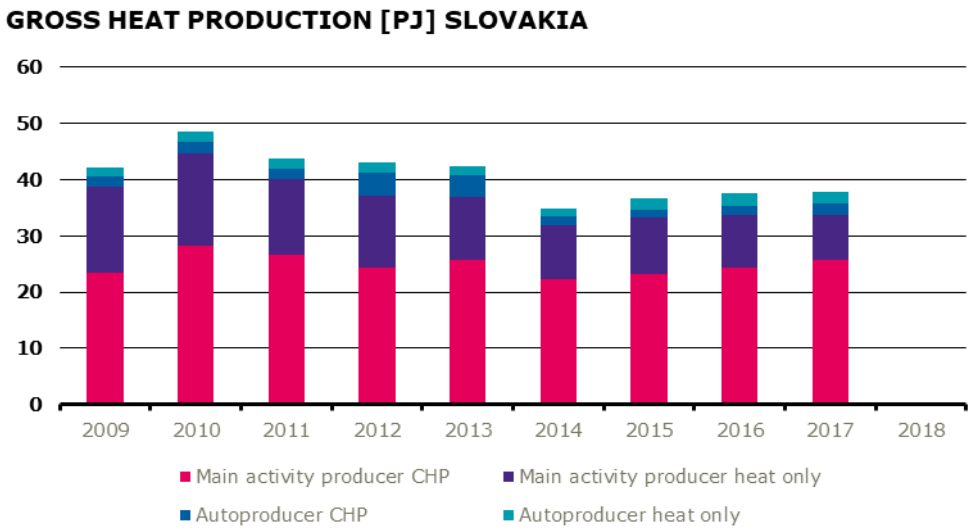


Figure 7-277: Gross heat production by producer type and year in Slovakia. Based on data from [2]

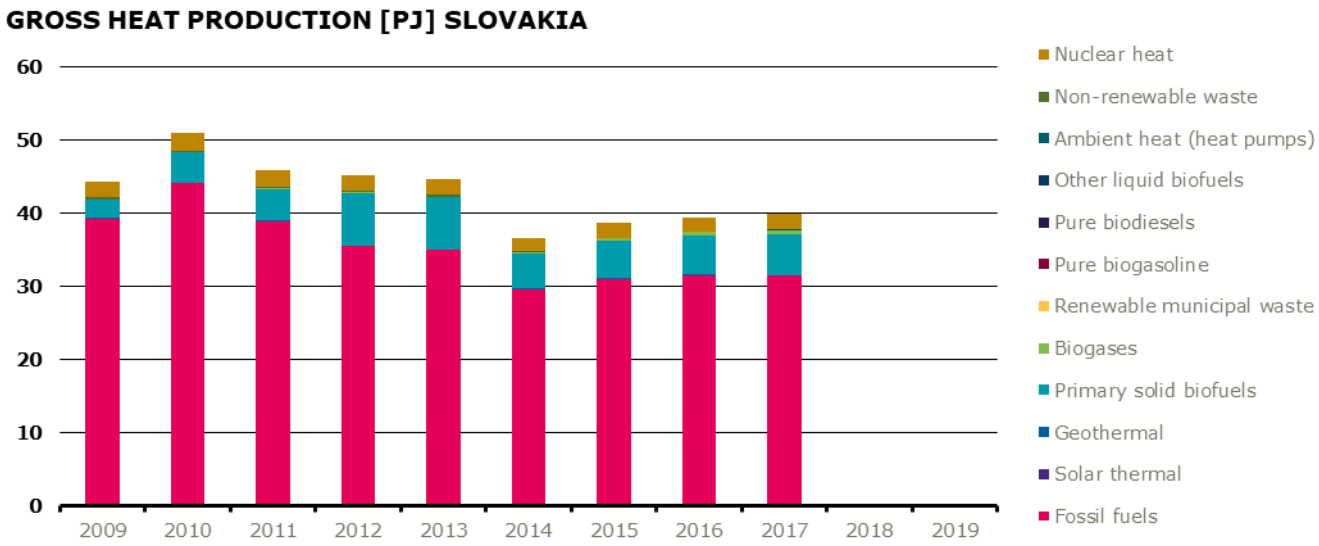


Figure 7-278: Gross heat production by fuel and year in Slovakia. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.25.4 Electricity Production

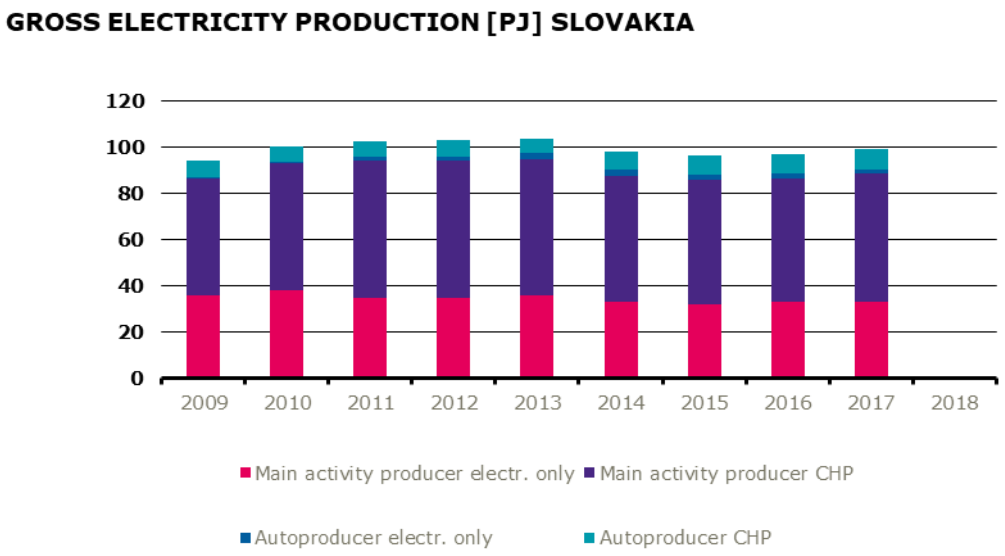


Figure 7-279: Gross electricity production by producer type and year in Slovakia. Based on data from [2]

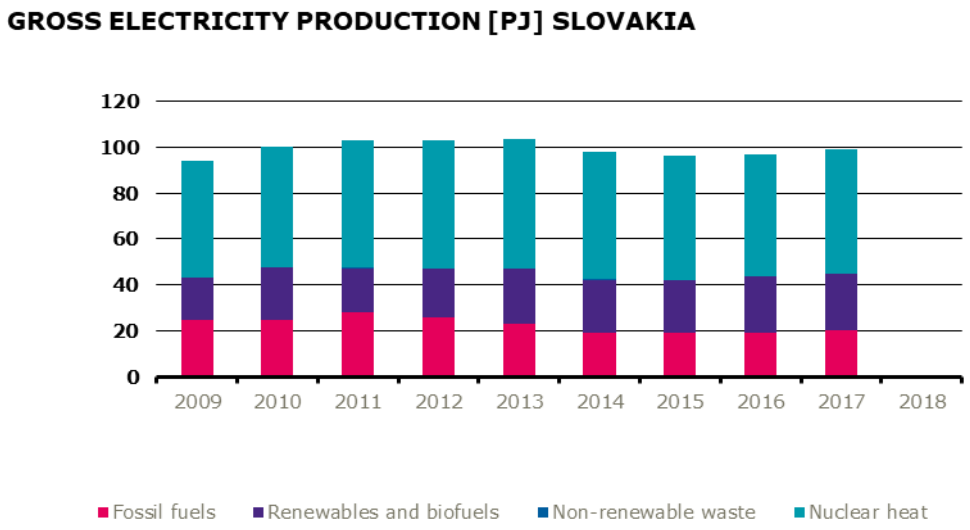


Figure 7-280: Gross electricity production by fuel type and year in Slovakia. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.25.5 District Heat

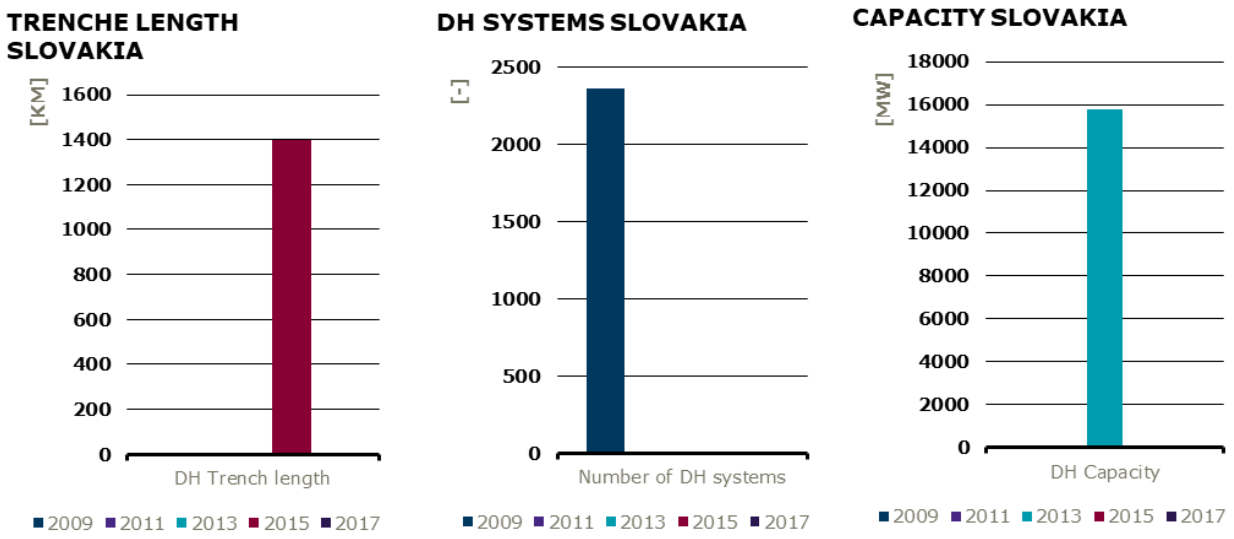


Figure 7-281: District heat indicators for Slovakia. Based on data from [2]

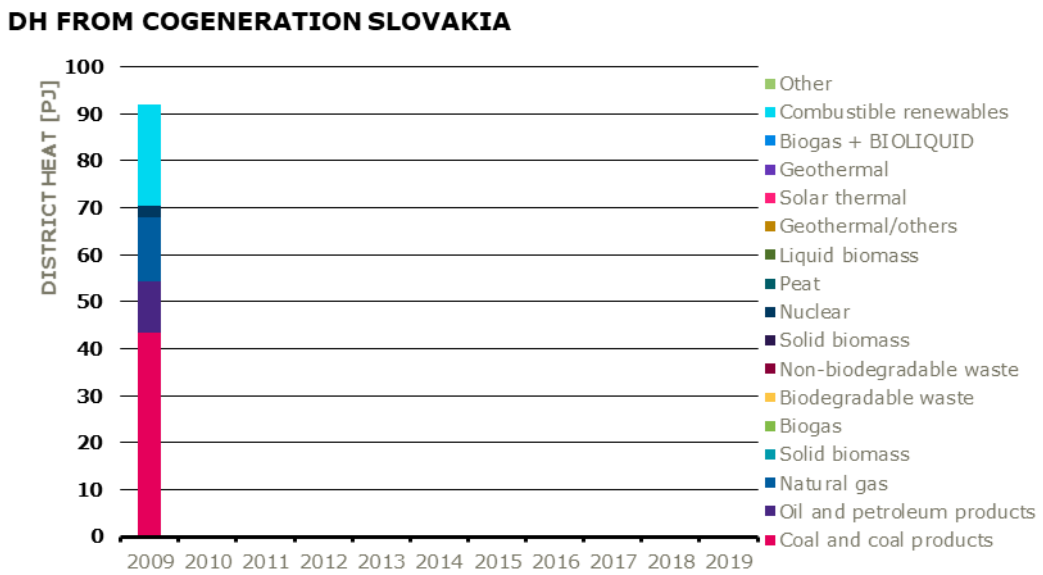


Figure 7-282: District heat generated in CHP plants by year and fuel in Slovakia. Based on data from [2], [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

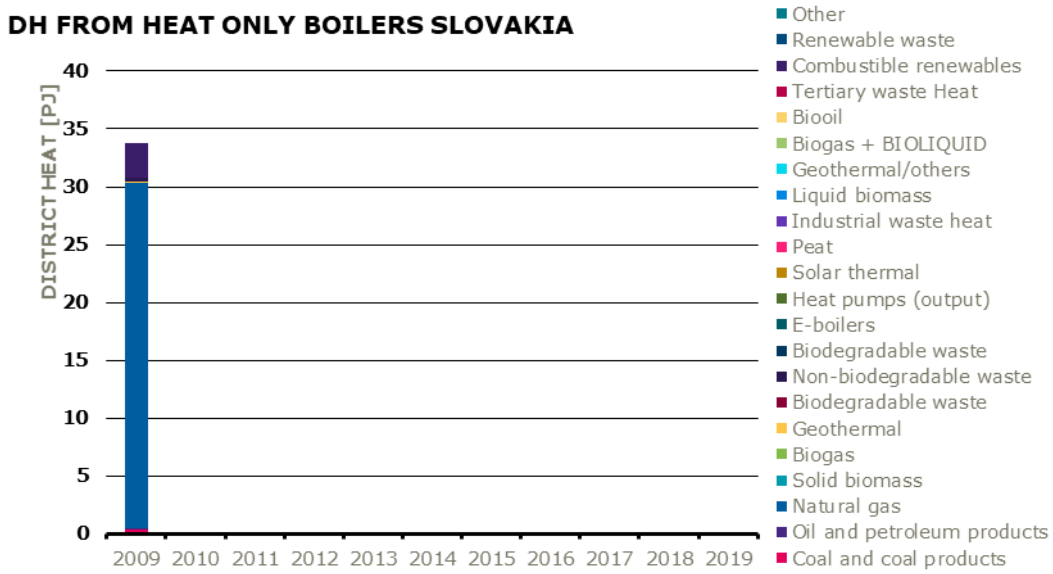


Figure 7-283: District heat generated in heat only boilers by year and fuel in Slovakia. Based on data from [2], [3]

7.25.6 Energy storage

[*No data available*]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.26 Slovenia

7.26.1 Country profile

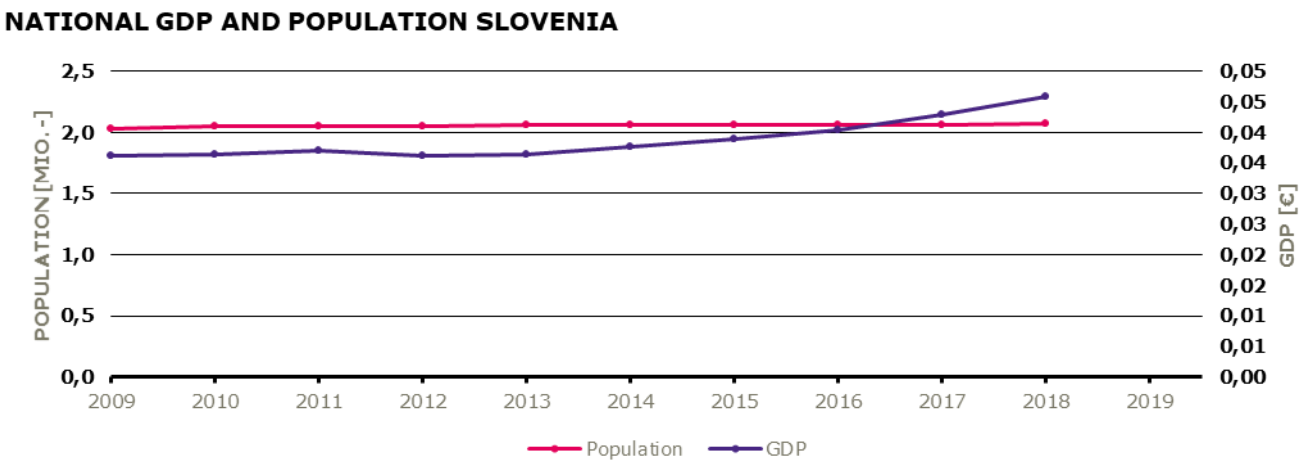


Figure 7-284: GDP and population development in Slovenia. Based on data from [1]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.26.2 Energy use

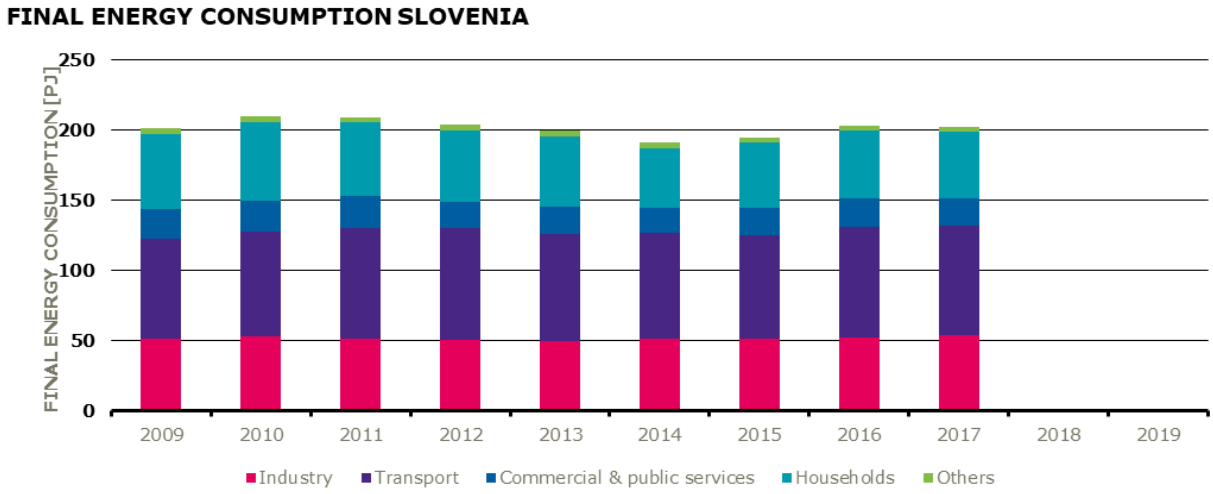


Figure 7-285: Final energy consumption by economic sector and year in Slovenia. Based on data from [2]

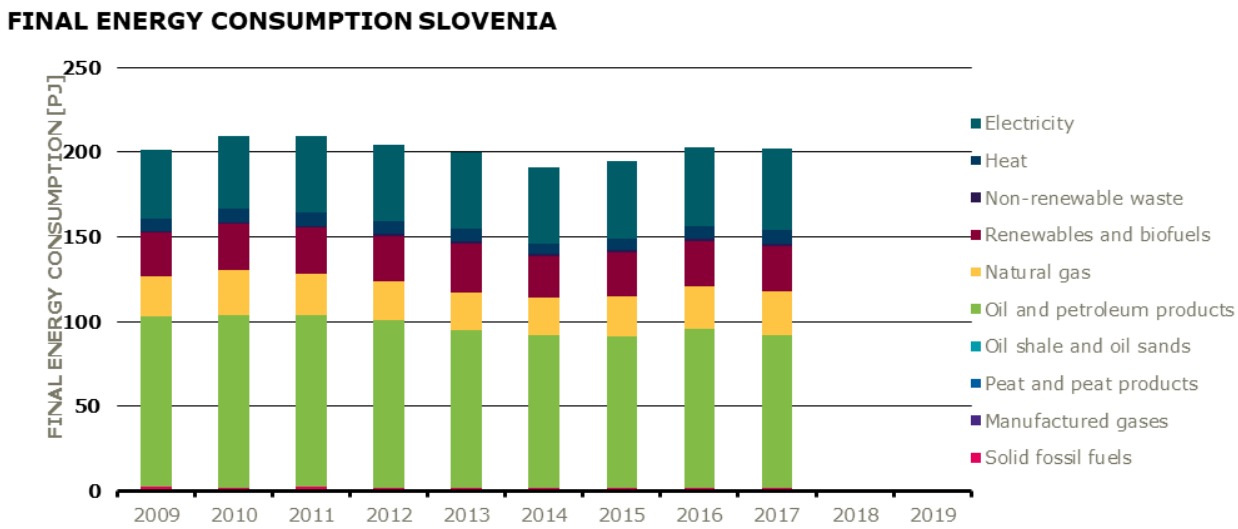


Figure 7-286: Final energy consumption by fuel and year in Slovenia. Based on data from [2]

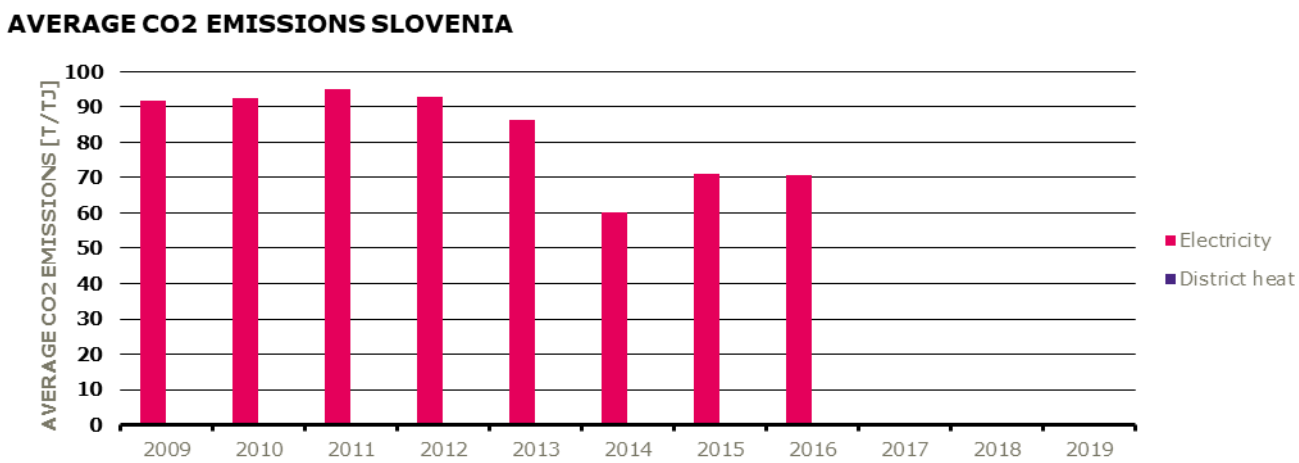


Figure 7-287: Average CO2 emissions in Slovenia. Based on data from [3] & [4]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.26.3 Heat Production

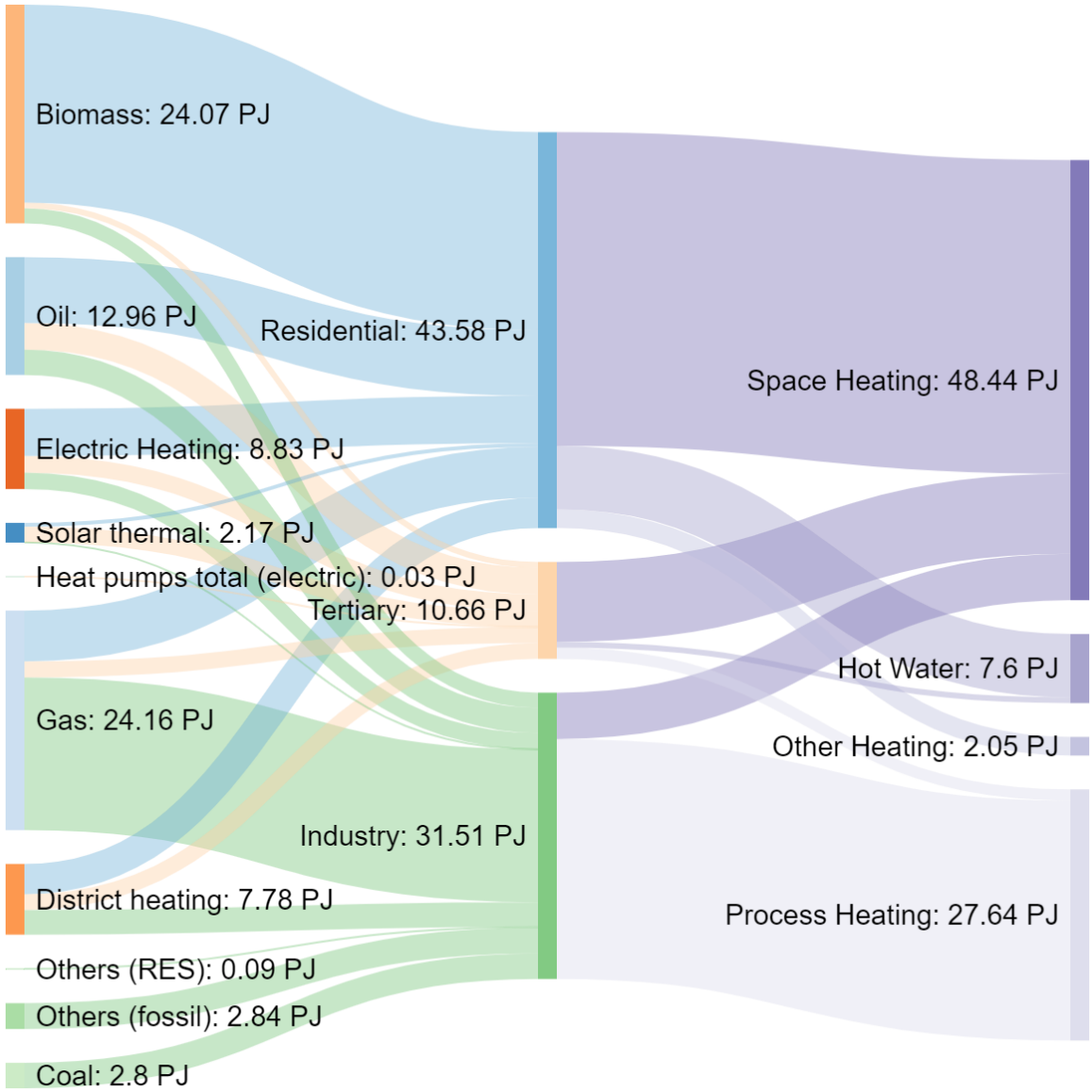


Figure 7-288: Sankey diagram of energy flows for heating purposes in Slovenia in 2015. Based on data from [3]

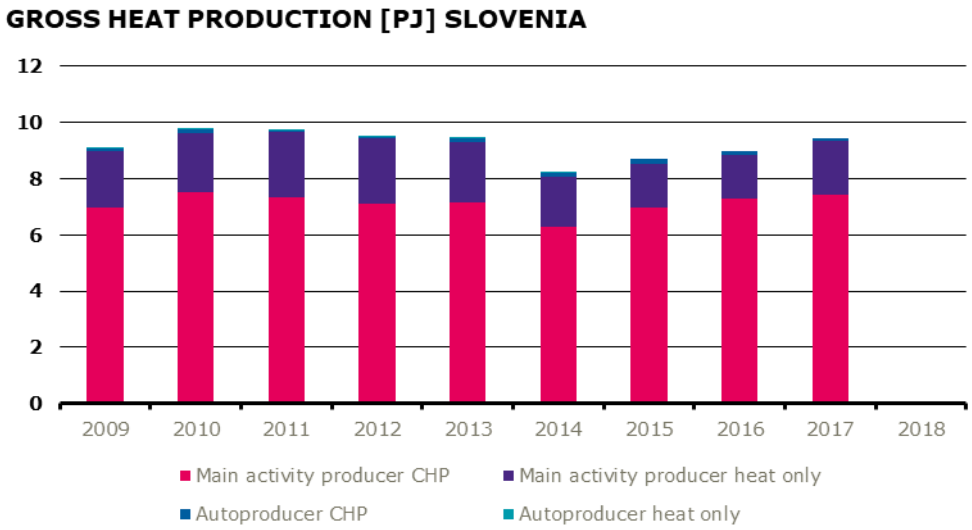


Figure 7-289: Gross heat production by producer type and year in Slovenia. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

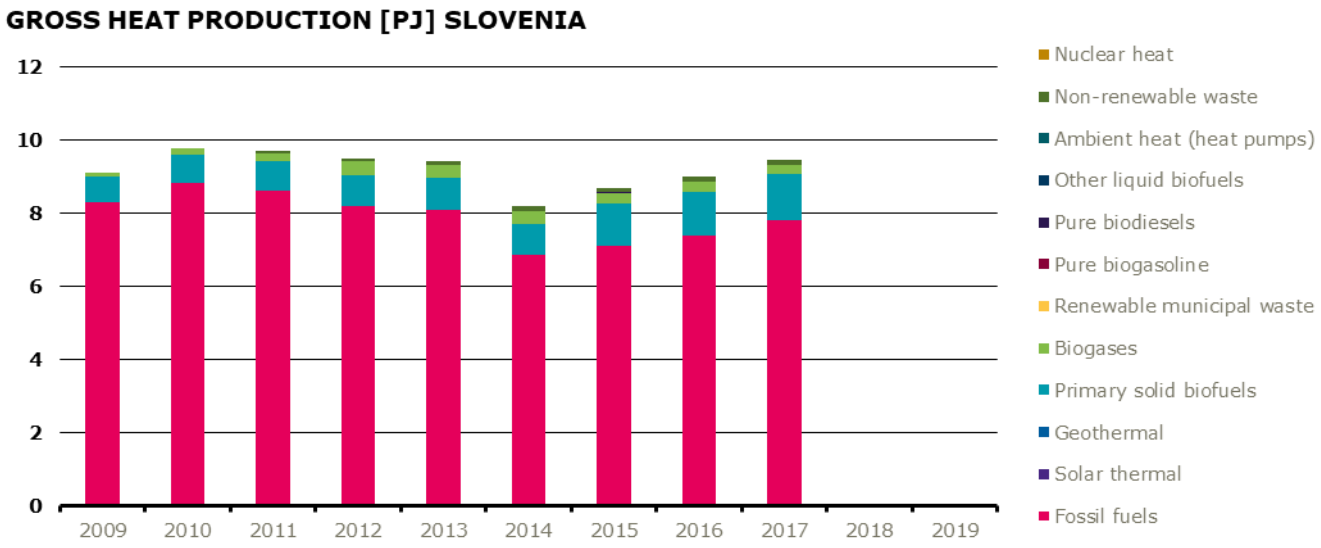


Figure 7-290: Gross heat production by fuel and year in Slovenia. Based on data from [2]

7.26.4 Electricity Production

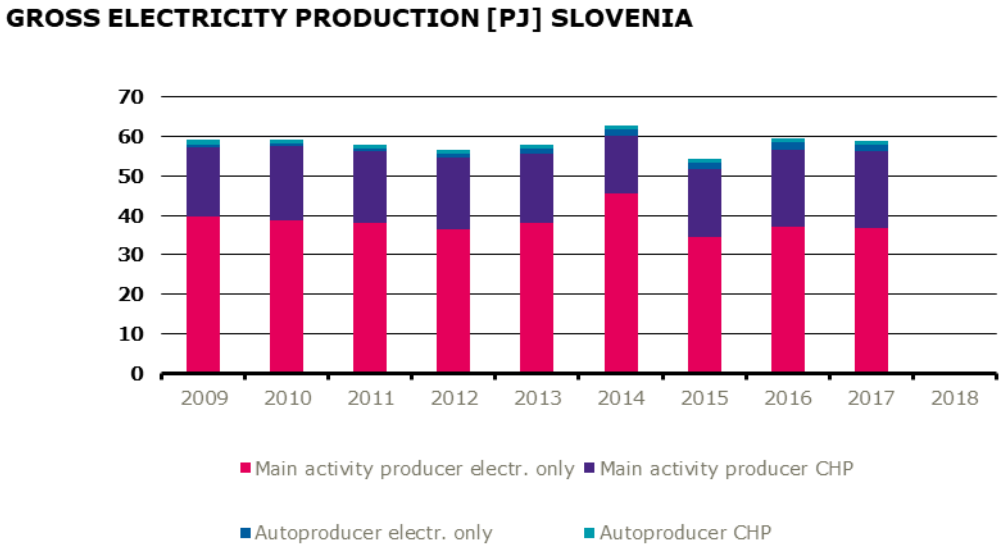


Figure 7-291: Gross electricity production by producer type and year in Slovenia. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

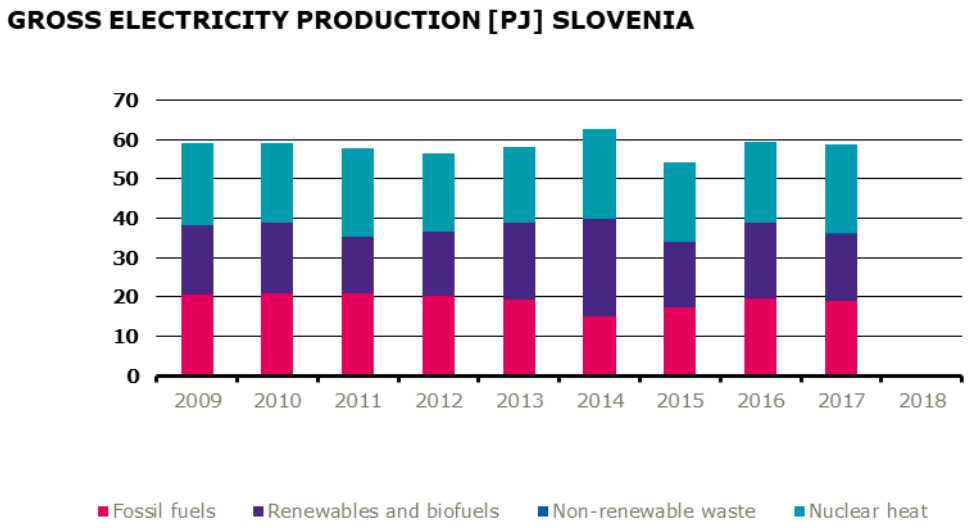


Figure 7-292: Gross electricity production by fuel type and year in Slovenia. Based on data from [2]

7.26.5 District Heat

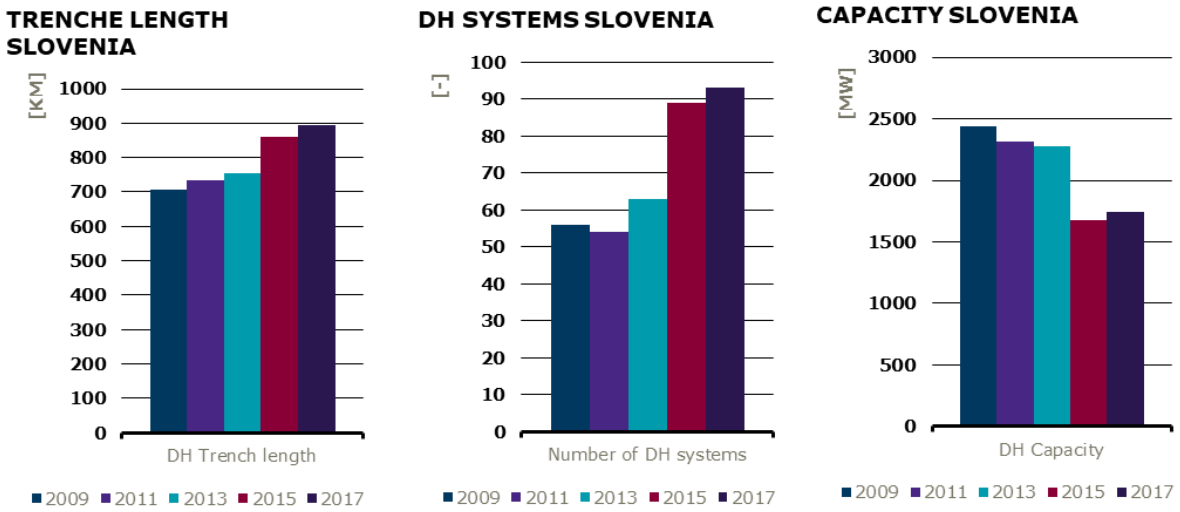


Figure 7-293: District heat indicators for Slovenia. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

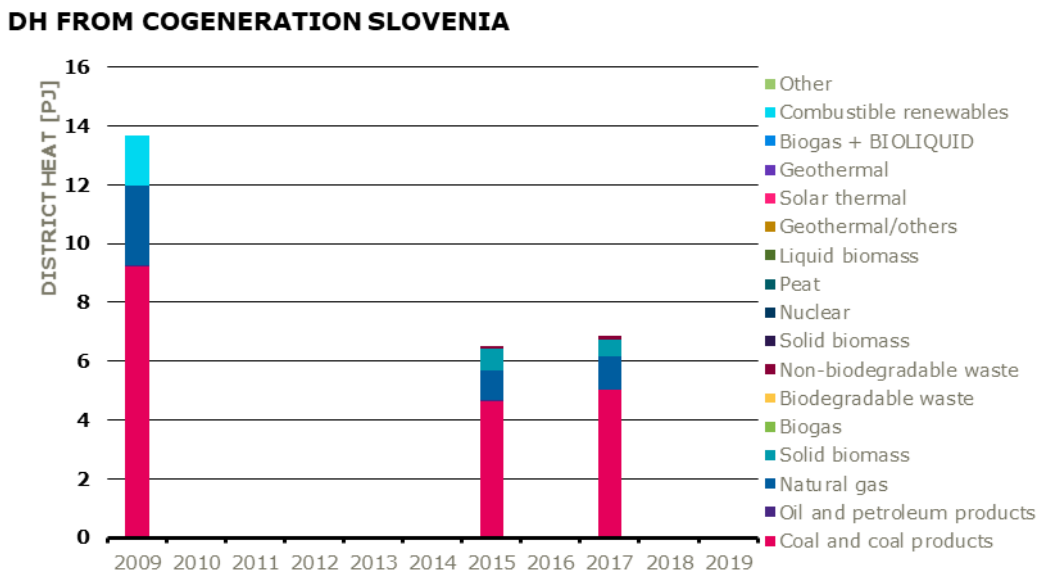


Figure 7-294: District heat generated in CHP plants by year and fuel in Slovenia. Based on data from [2], [3]

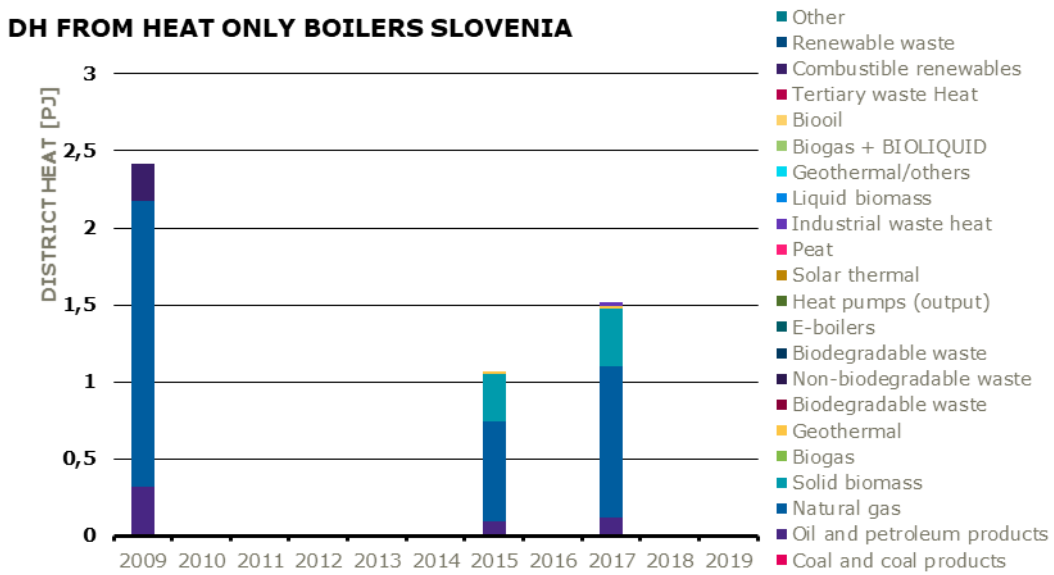


Figure 7-295: District heat generated in heat only boilers by year and fuel in Slovenia. Based on data from [2], [3]

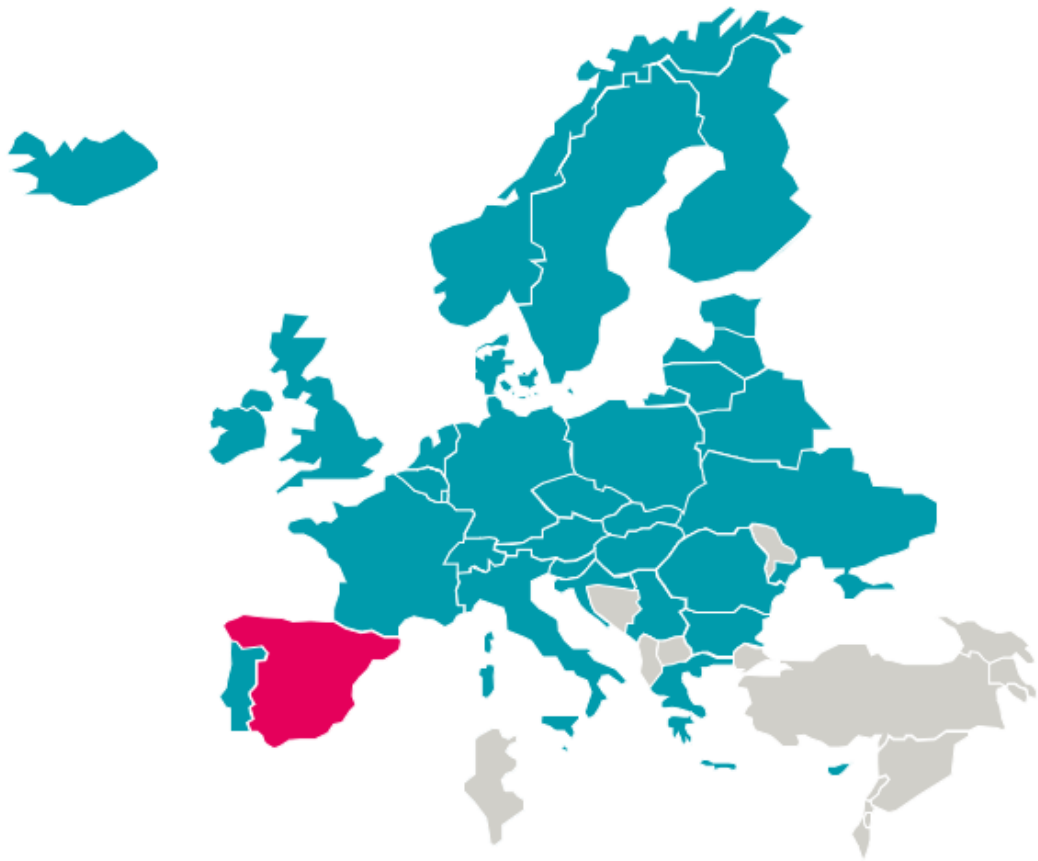
7.26.6 Energy storage

[*No data available*]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.27 Spain

7.27.1 Country profile



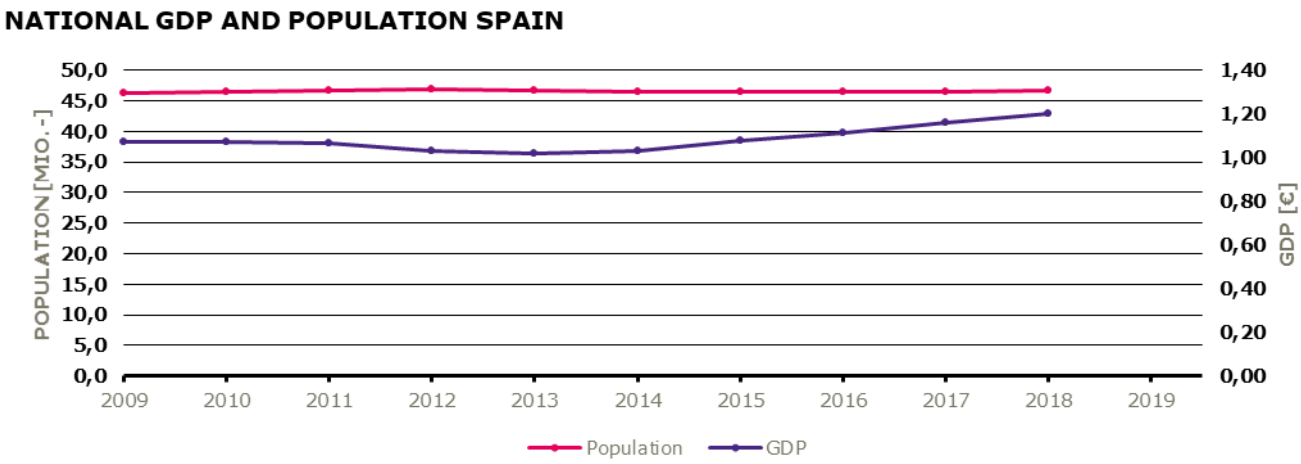


Figure 7-296: GDP and population development in Spain. Based on data from [1]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.27.2 Energy use

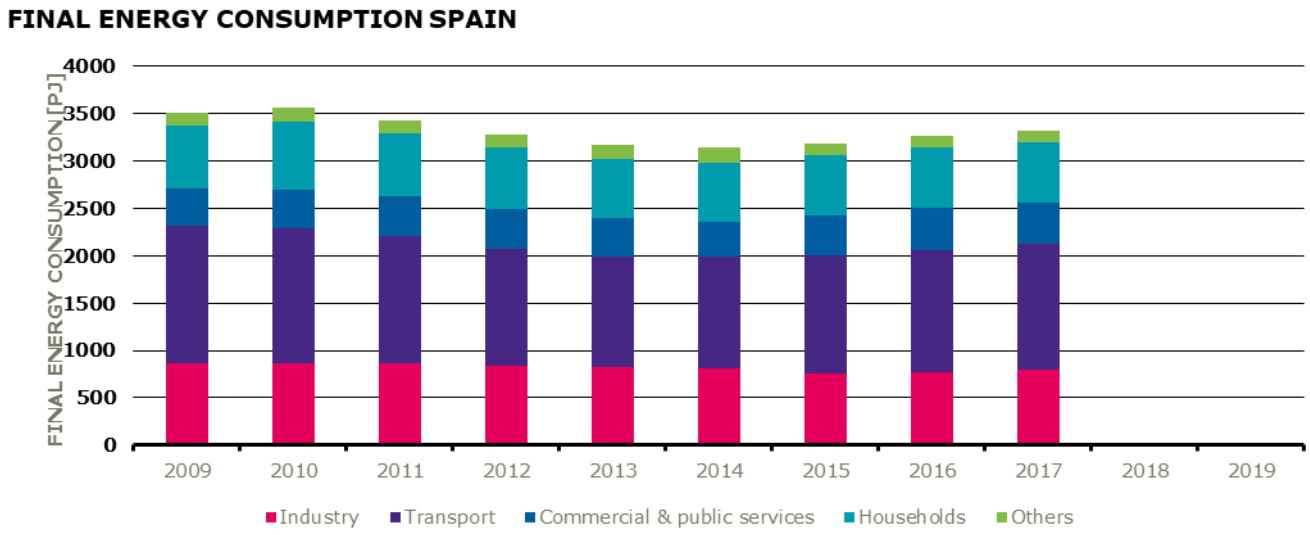


Figure 7-297: Final energy consumption by economic sector and year in Spain. Based on data from [2]

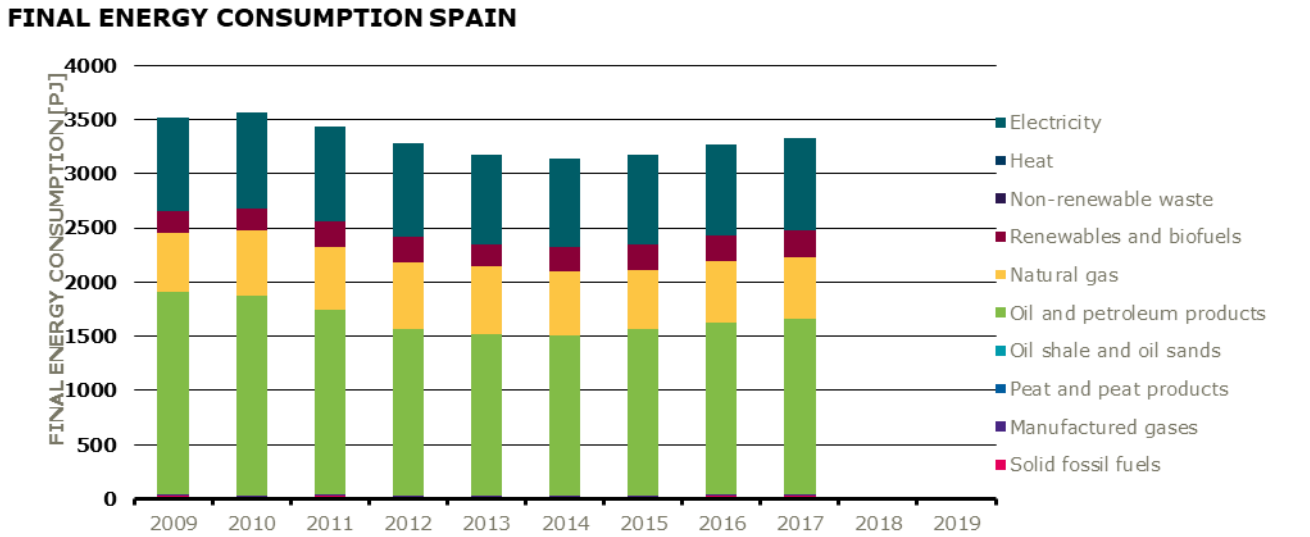


Figure 7-298: Final energy consumption by fuel and year in Spain. Based on data from [2]

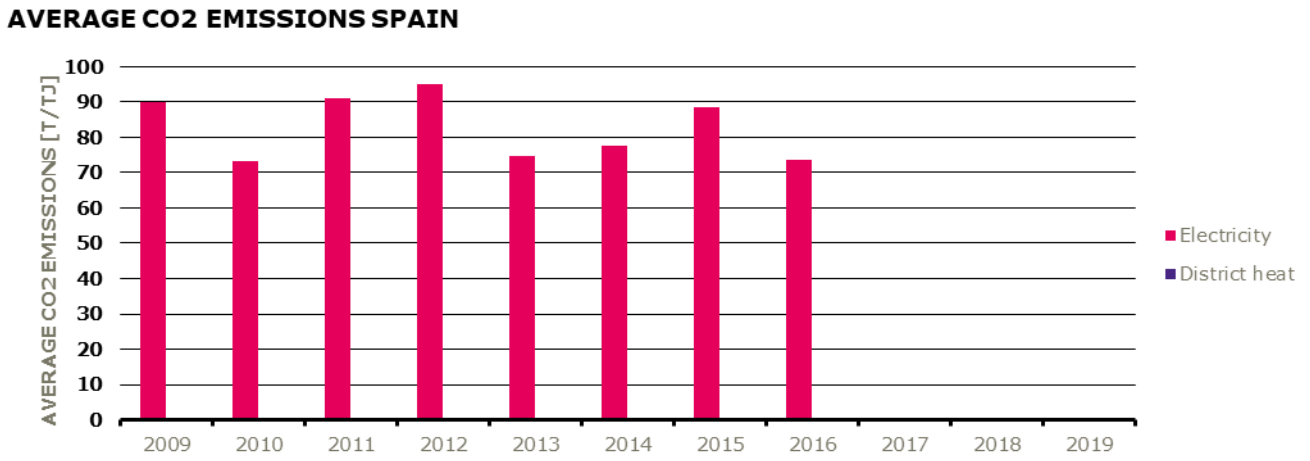


Figure 7-299: Average CO2 emissions in Spain. Based on data from [3] & [4]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.27.3 Heat Production

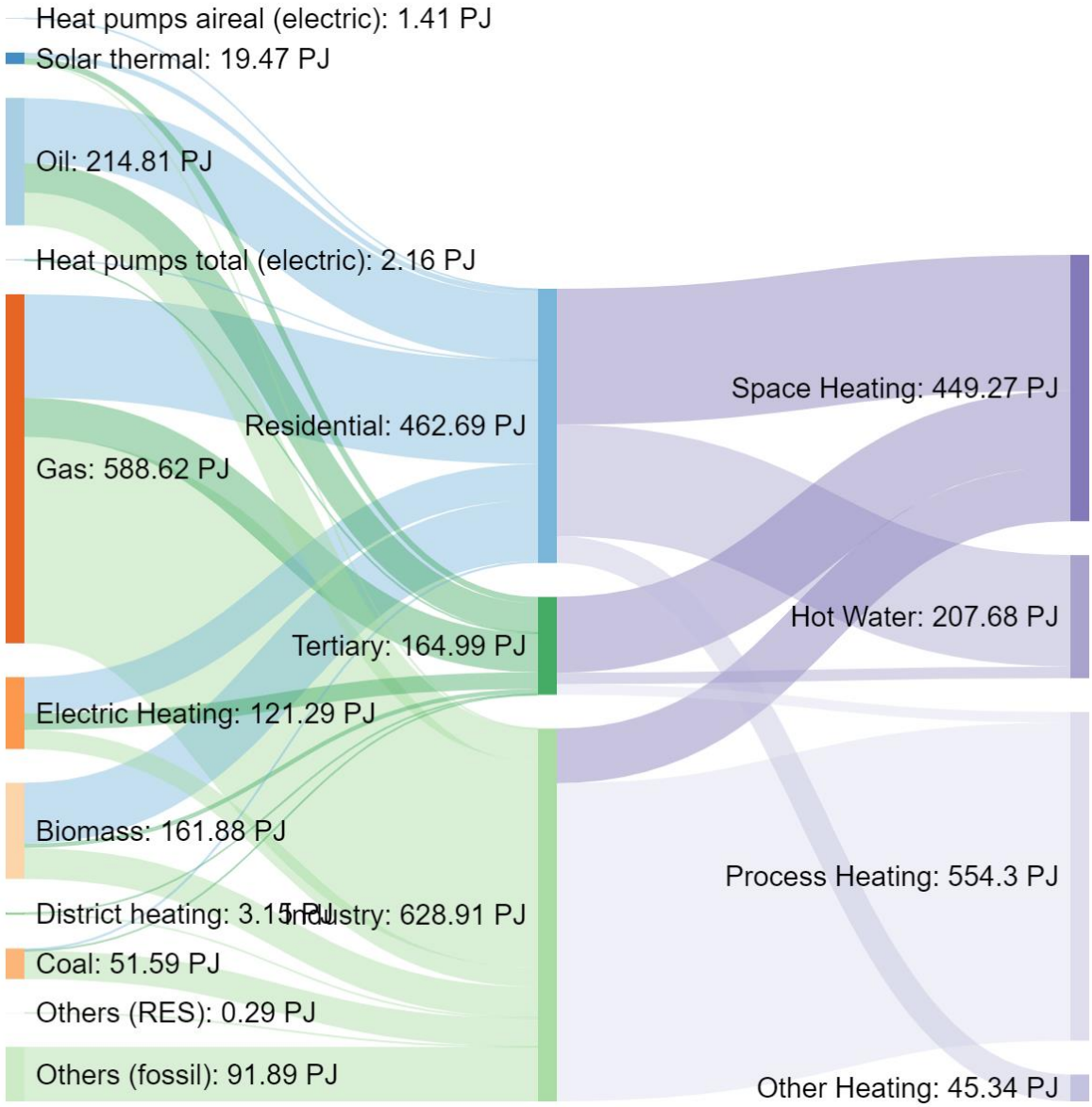


Figure 7-300: Sankey diagram of energy flows for heating purposes in Spain in 2015. Based on data from [3].

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.27.4 Electricity Production

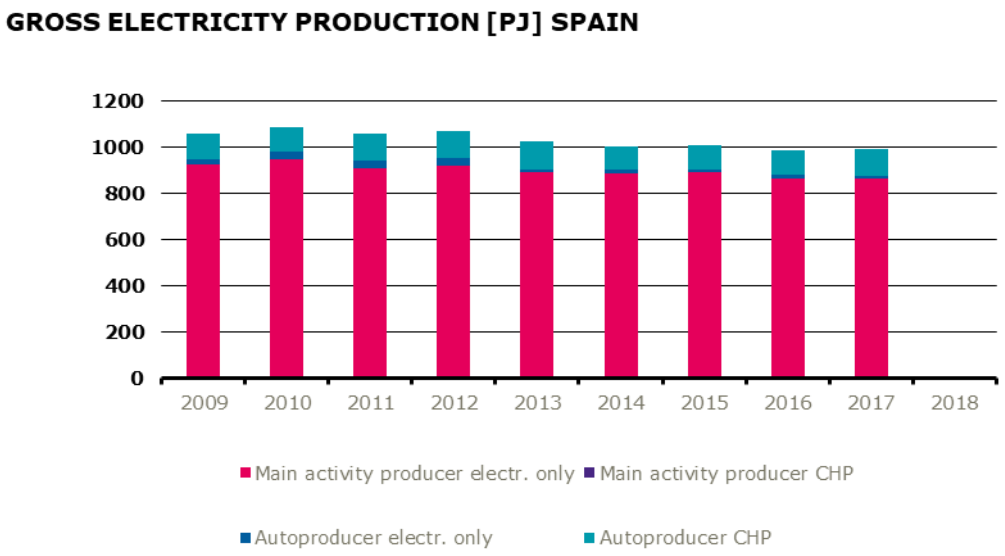


Figure 7-301: Gross electricity production by producer type and year in Spain. Based on data from [2]

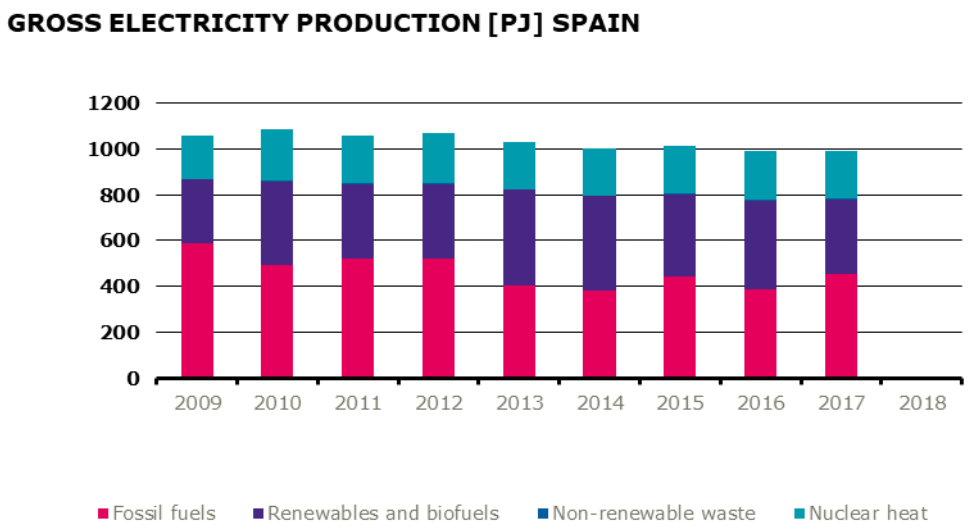


Figure 7-302: Gross electricity production by fuel type and year in Spain. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.27.5 District Heat

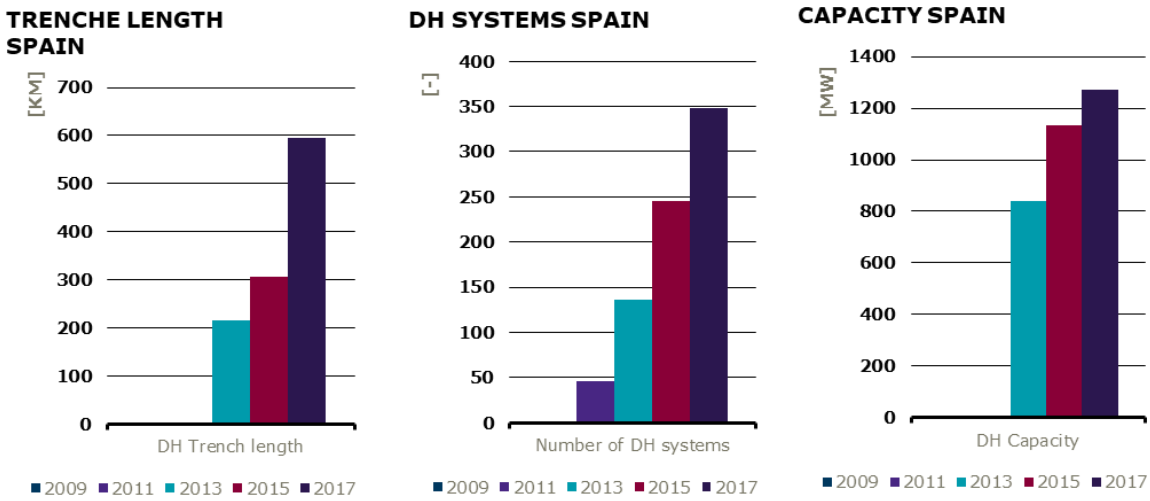


Figure 7-303: District heat indicators for Spain. Based on data from [2]

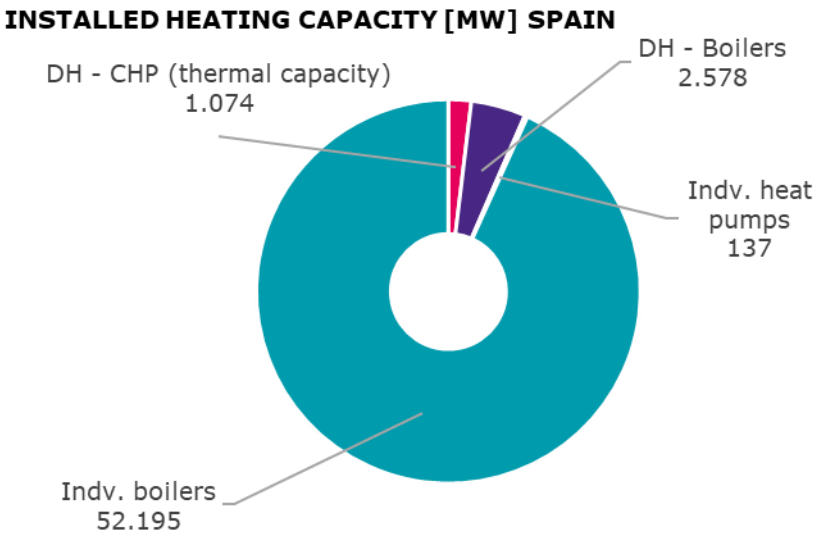


Figure 7-304: Installed heating capacity installed in Spain in 2015. Based on data from [10]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.27.6 Energy storage capacity

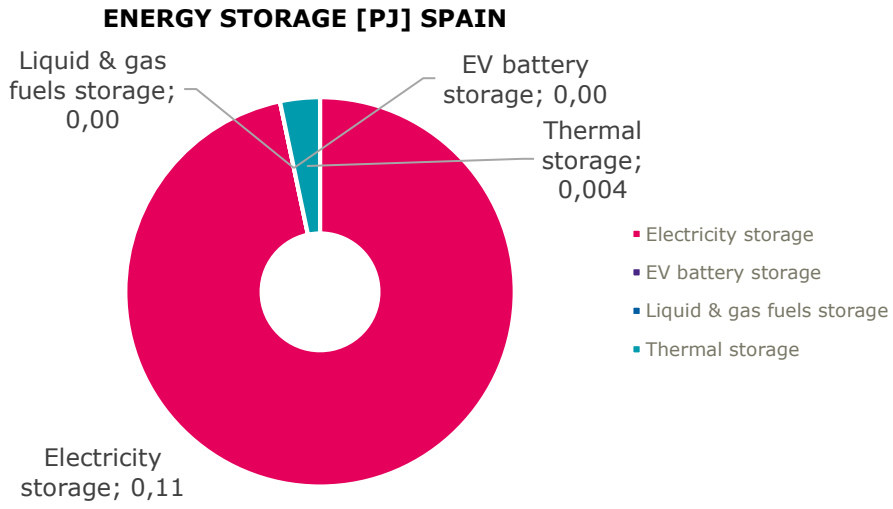
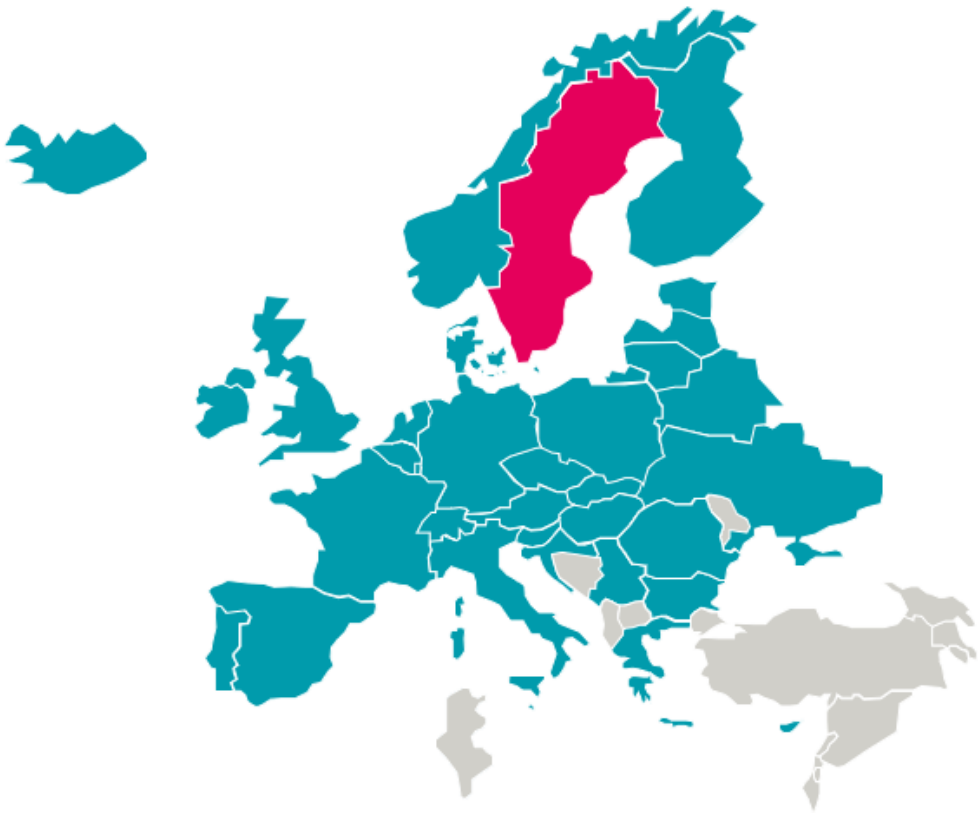


Figure 7-305: Storage capacity in Spain in 2015. Based on data from [2]

7.28 Sweden

7.28.1 Country profile



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

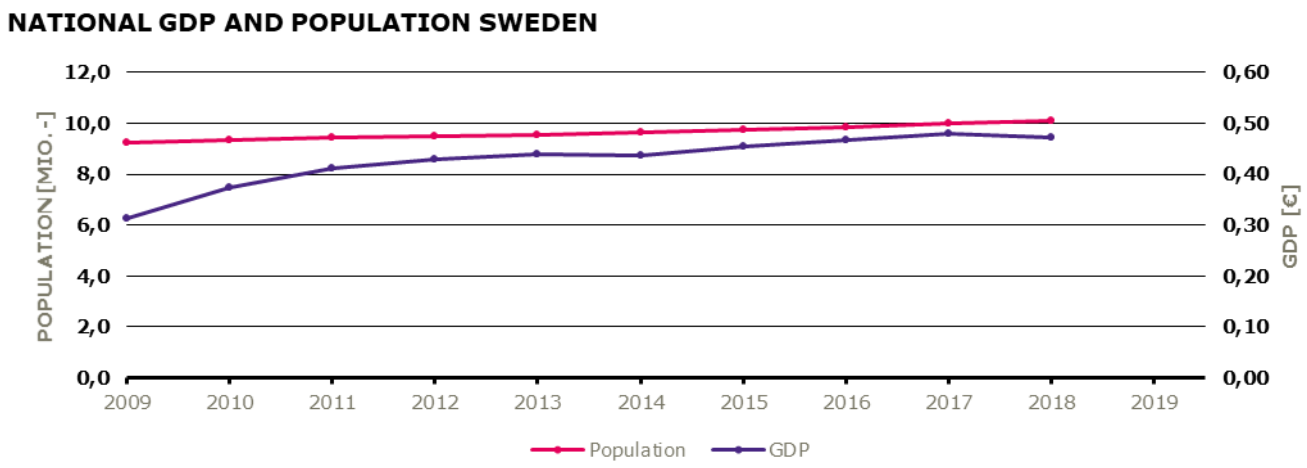


Figure 7-306: GDP and population development in Sweden. Based on data from [1]

7.28.2 Energy use

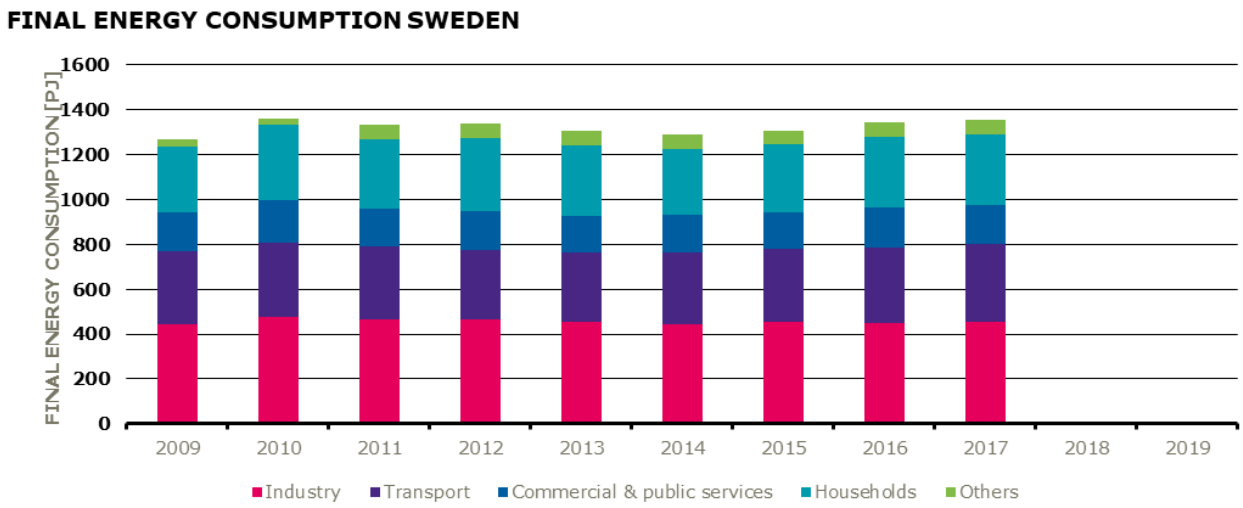


Figure 7-307: Final energy consumption by economic sector and year in Sweden. Based on data from [2]

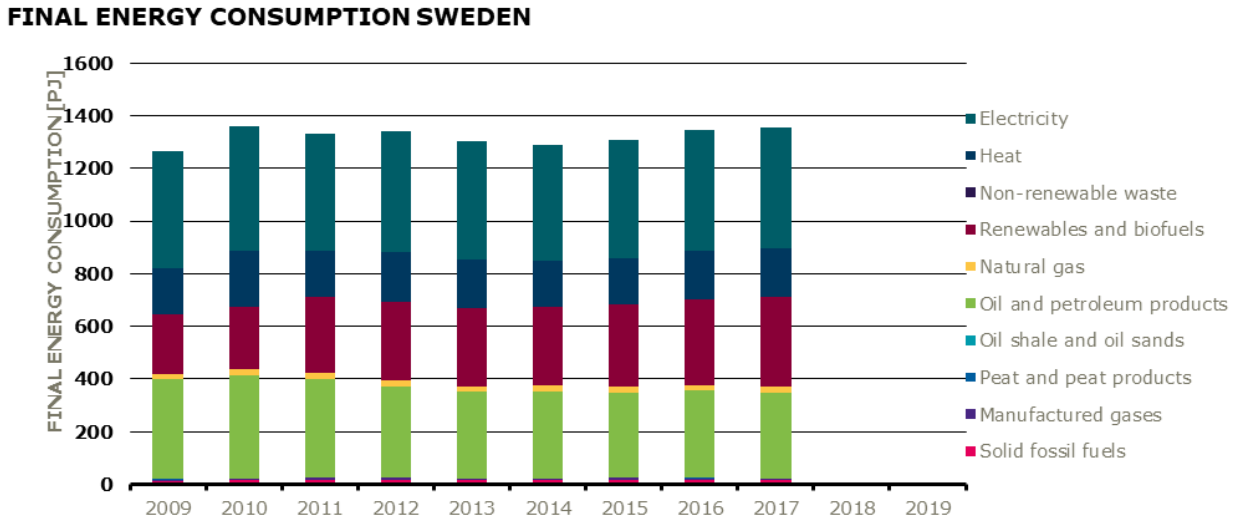


Figure 7-308: Final energy consumption by fuel and year in Sweden. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

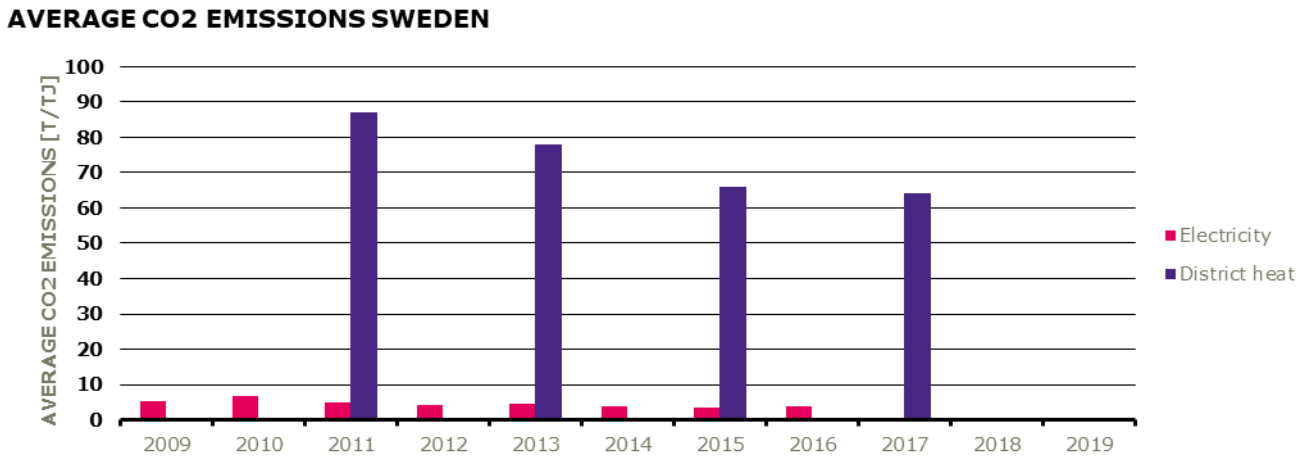


Figure 7-309: Average CO2 emissions in Sweden. Based on data from [3] & [4]

7.28.3 Heat Production

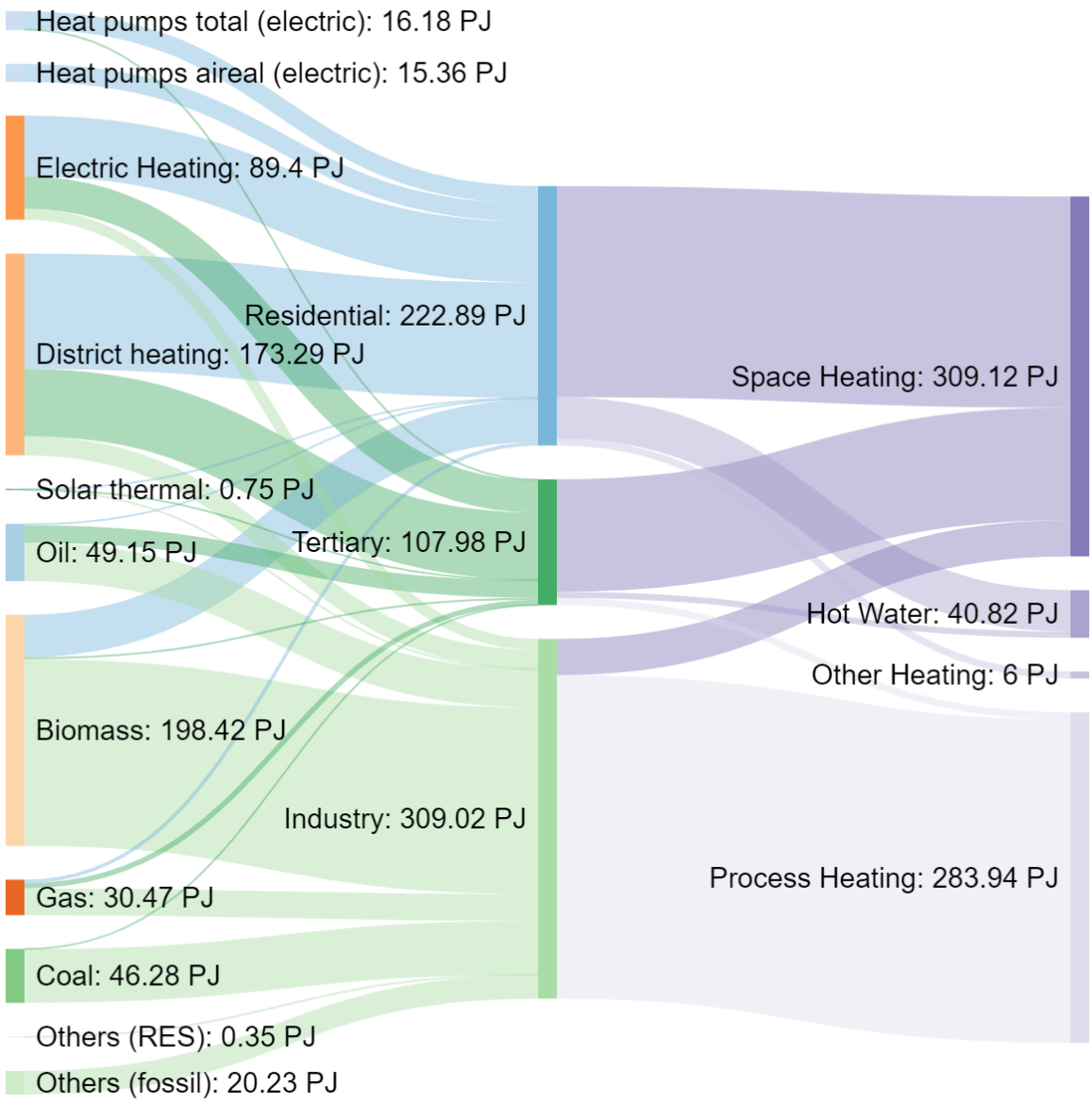


Figure 7-310: Sankey diagram of energy flows for heating purposes in Sweden in 2015. Based on data from [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

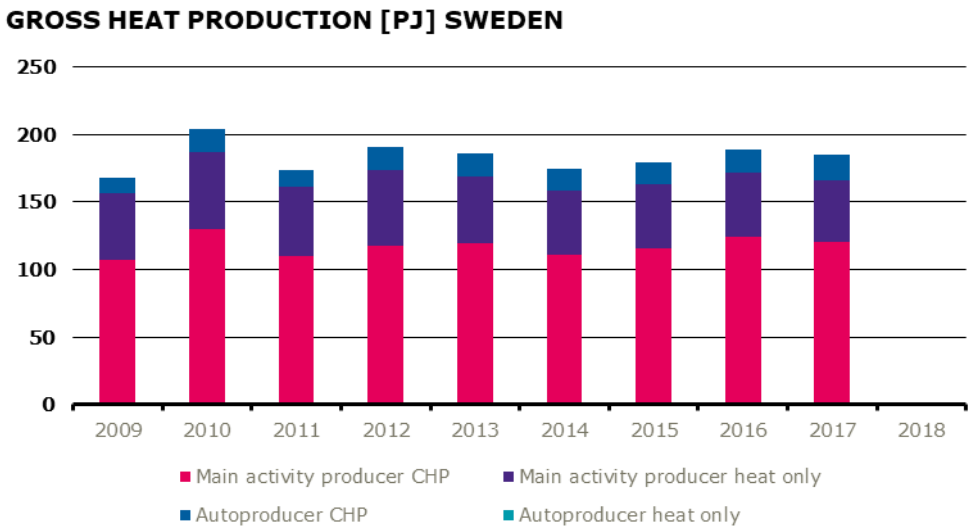


Figure 7-311: Gross heat production by producer type and year in Sweden. Based on data from [2]

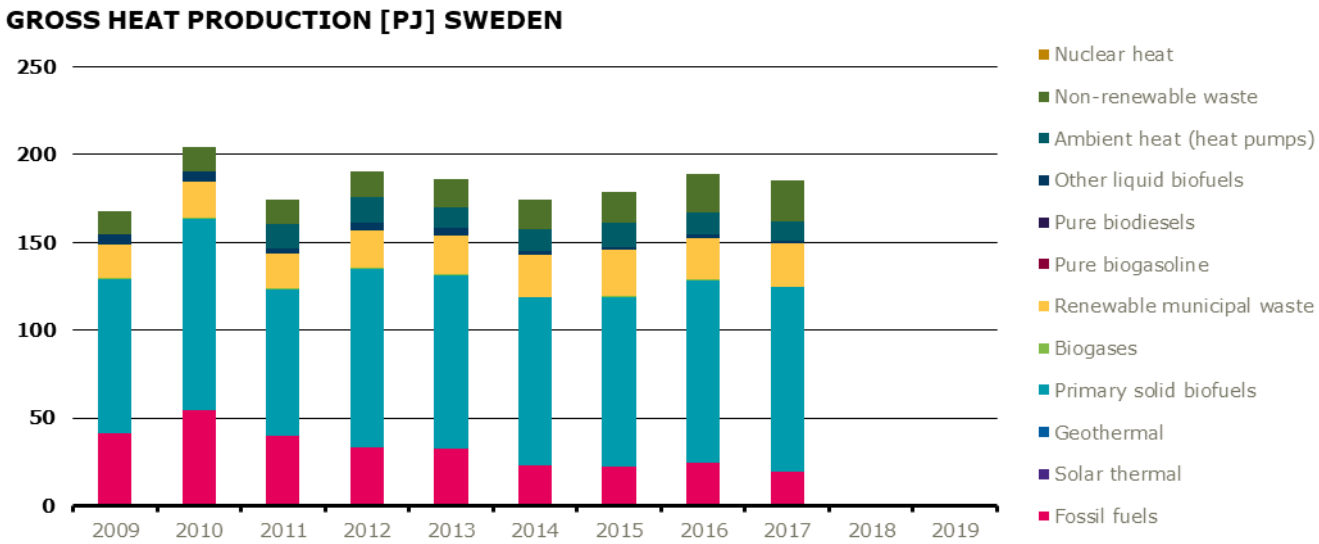


Figure 7-312: Gross heat production by fuel and year in Sweden. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.28.4 Electricity Production

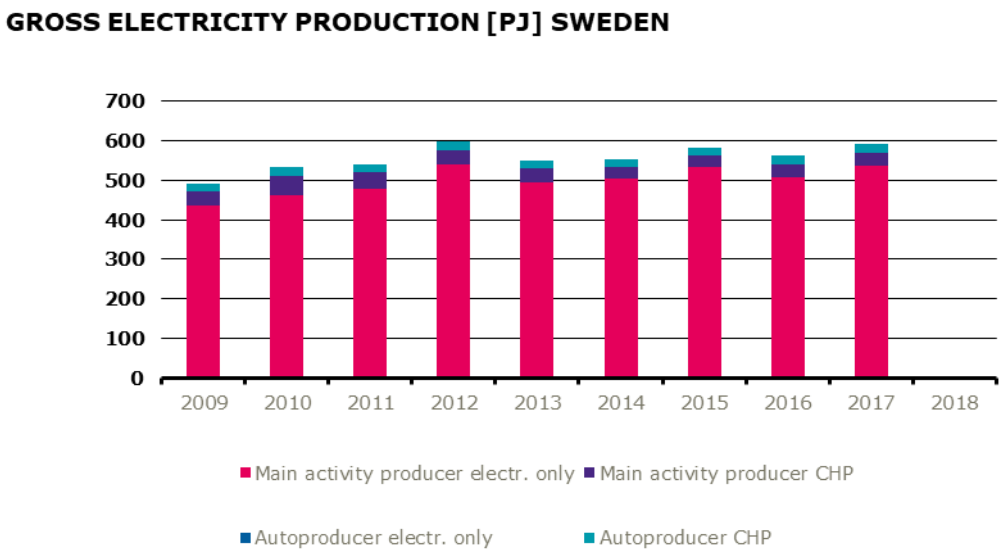


Figure 7-313: Gross electricity production by producer type and year in Sweden. Based on data from [2]

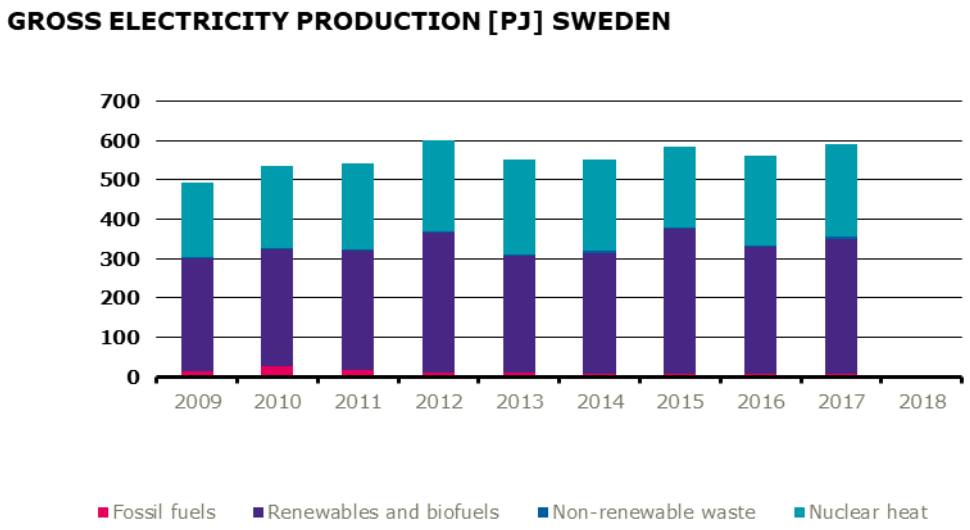


Figure 7-314: Gross electricity production by fuel type and year in Sweden. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.28.5 District Heat

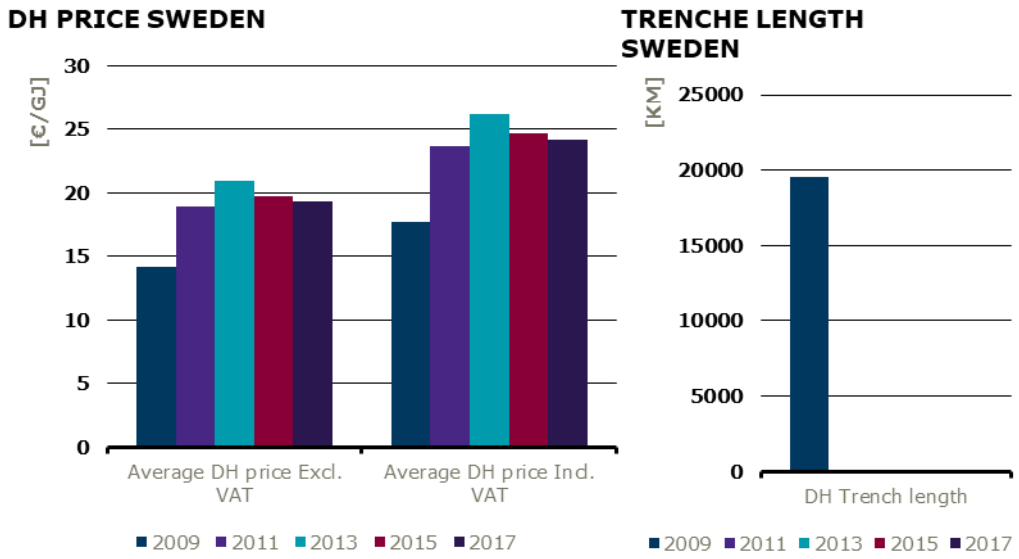


Figure 7-315: District heat indicators for Sweden. Based on data from [2]

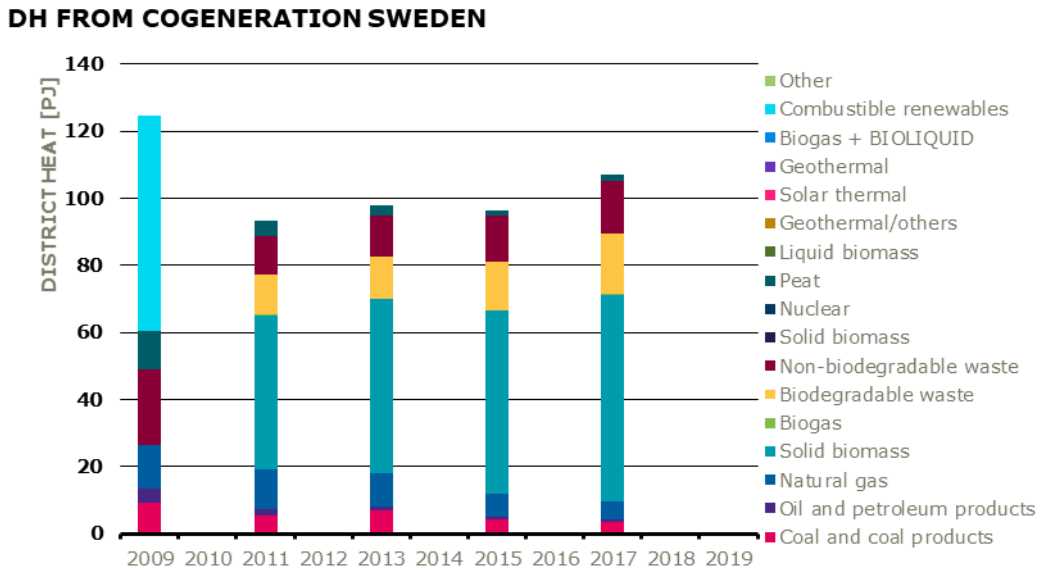


Figure 7-316: District heat generated in CHP plants by year and fuel in Sweden. Based on data from [2], [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

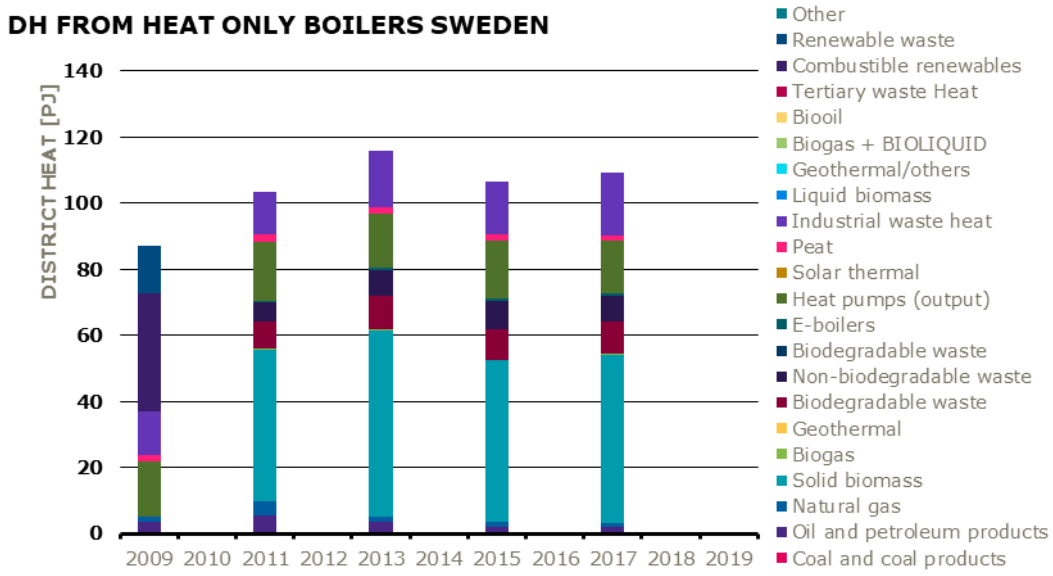


Figure 7-317: District heat generated in heat only boilers by year and fuel in Sweden. Based on data from [2], [3]

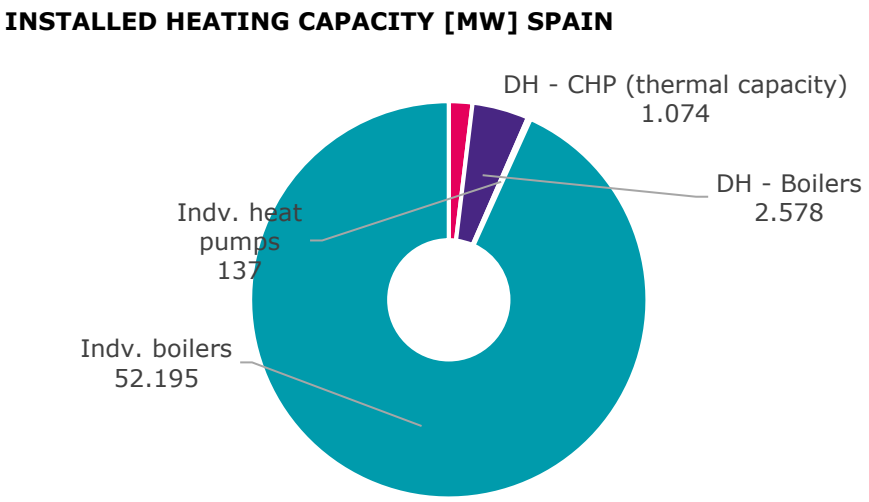


Figure 7-318: Installed heating capacity installed in Sweden in 2015. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.28.6 Energy storage

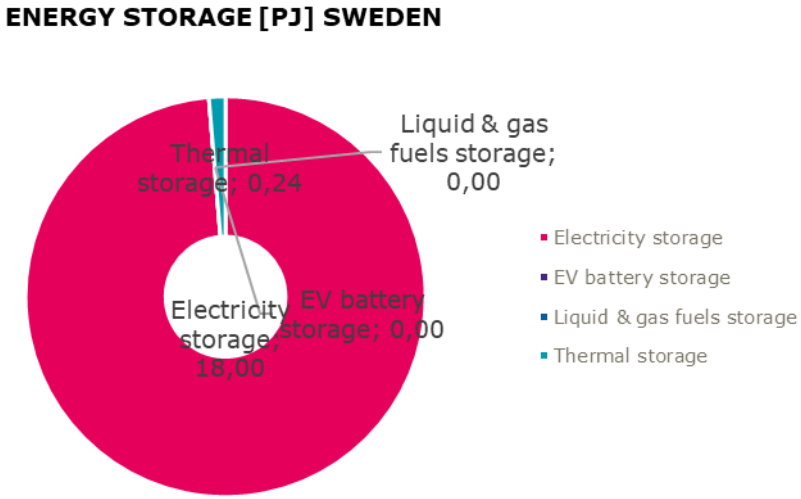
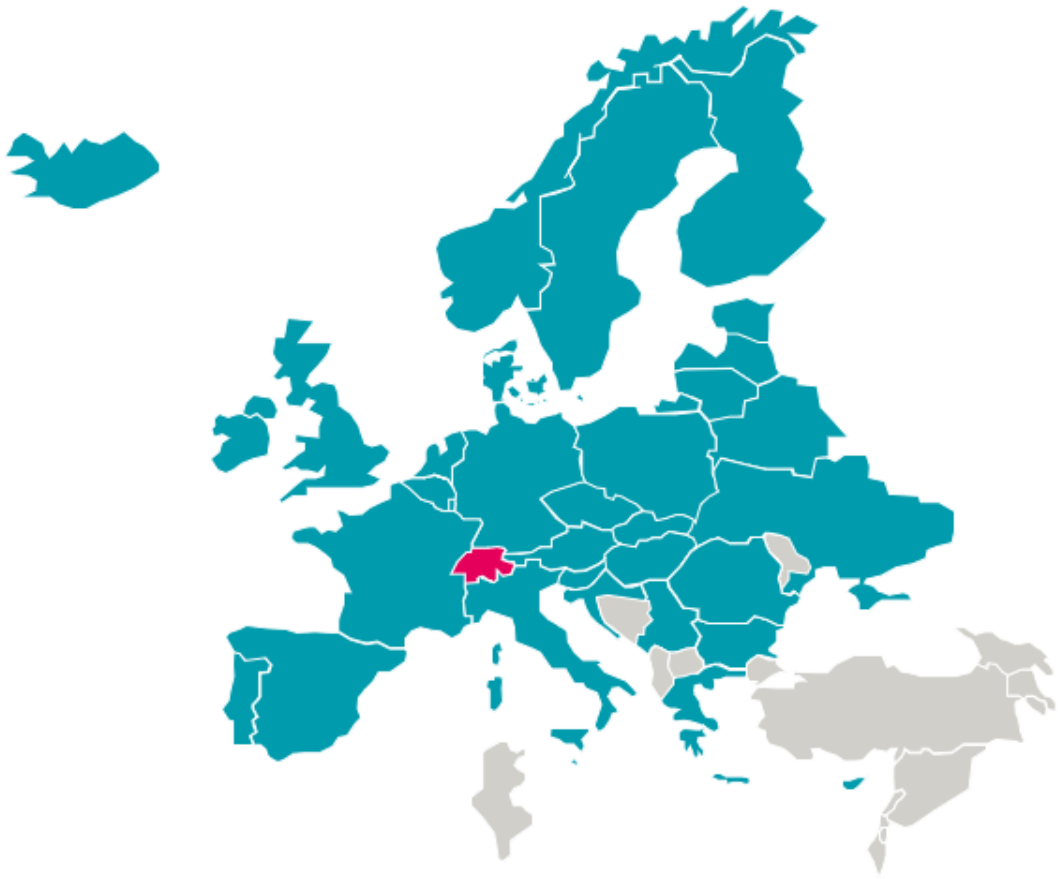


Figure 7-319: Stoage capacity in Sweden in 2015. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.29 Switzerland

7.29.1 Country profile



7.29.2 Energy use

[*No data available*]

7.29.3 Heat Production

[*No data available*]

7.29.4 Electricity Production

[*No data available*]

7.29.5 District Heat

[*No data available*]

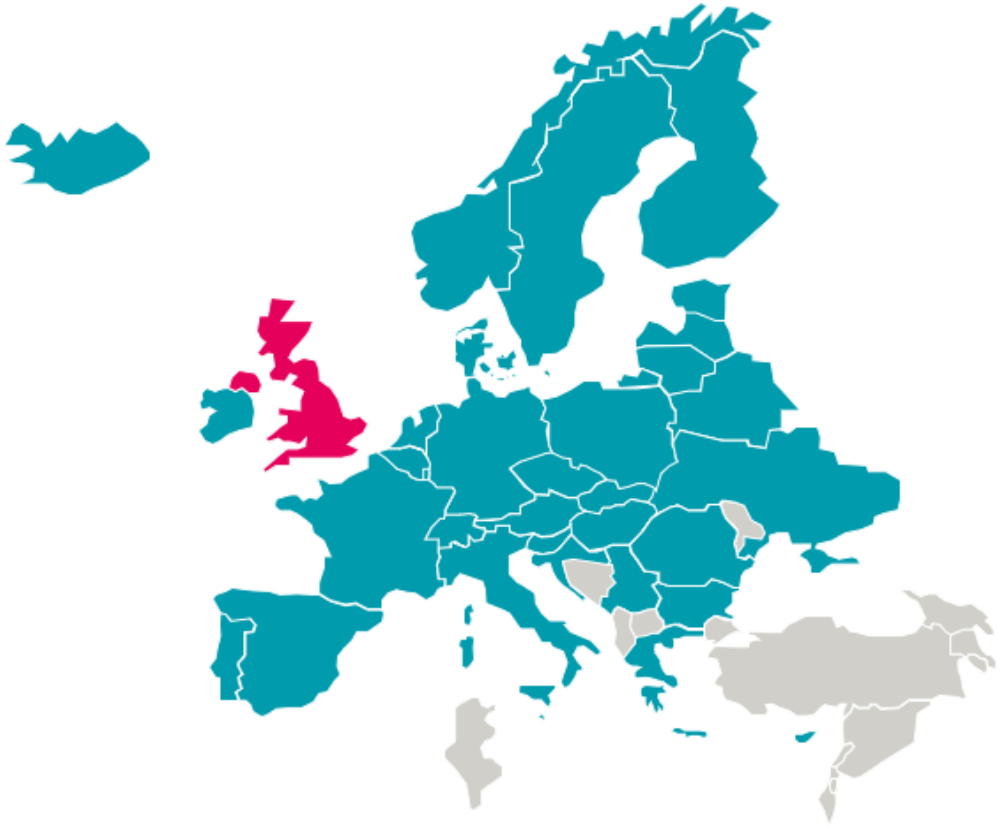
7.29.6 Energy storage

[*No data available*]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.30 United Kingdom

7.30.1 Country profile



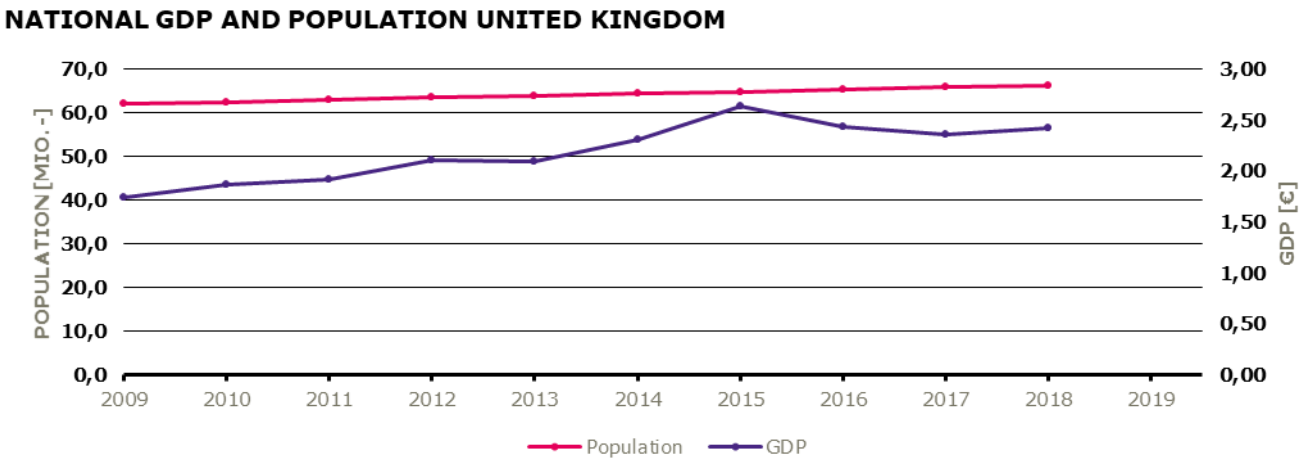


Figure 7-320: GDP and population development in United Kingdom. Based on data from [1]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.30.2 Energy use

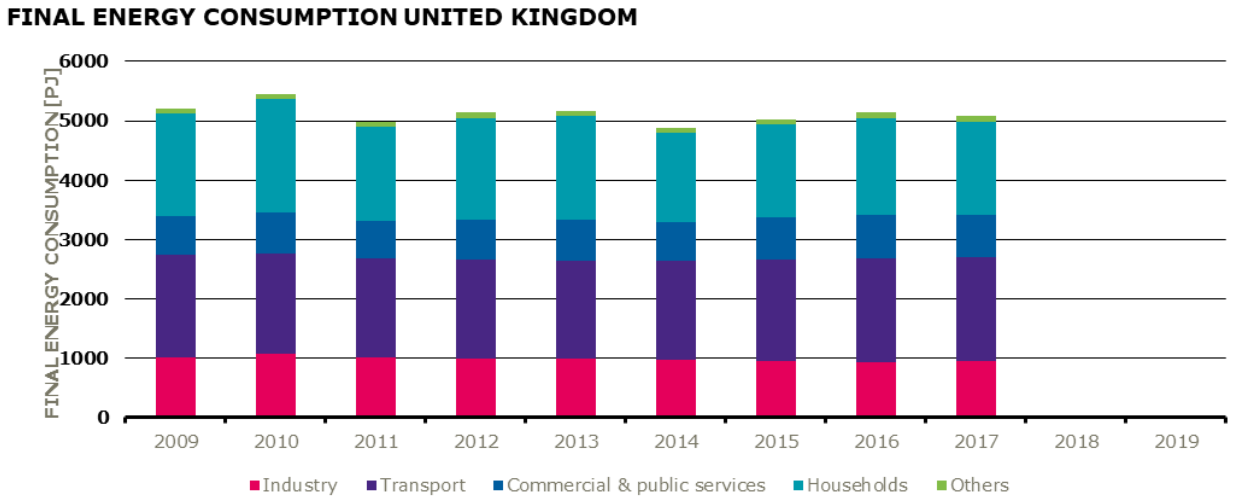


Figure 7-321: Final energy consumption by economic sector and year in United Kingdom. Based on data from [2]

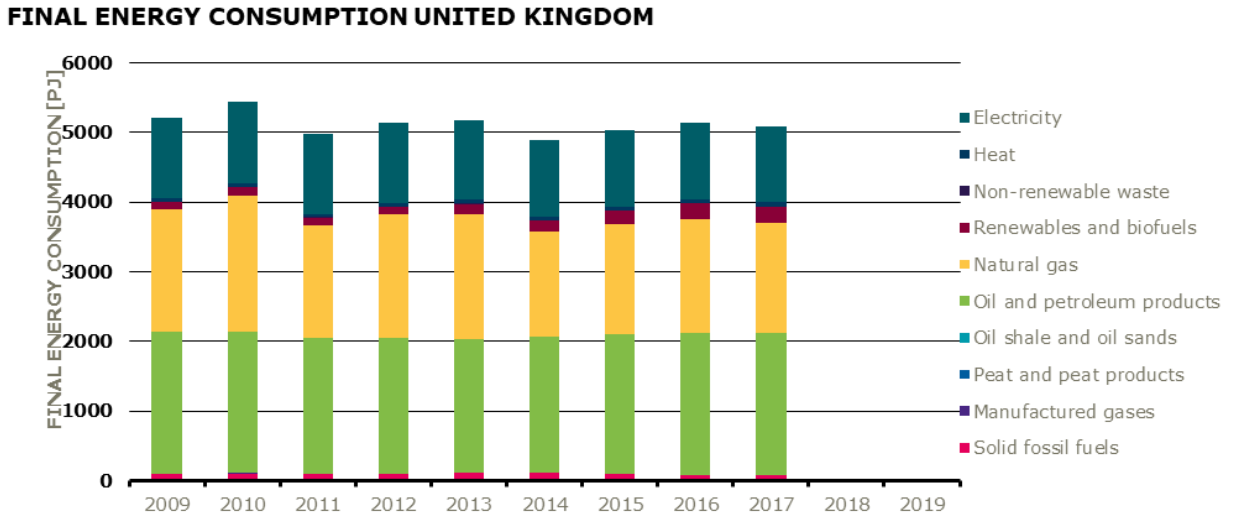


Figure 7-322: Final energy consumption by fuel and year in United Kingdom. Based on data from [2]

Figure 7-323: Average CO2 emissions in United Kingdom. Based on data from [3] & [4]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.30.3 Heat Production

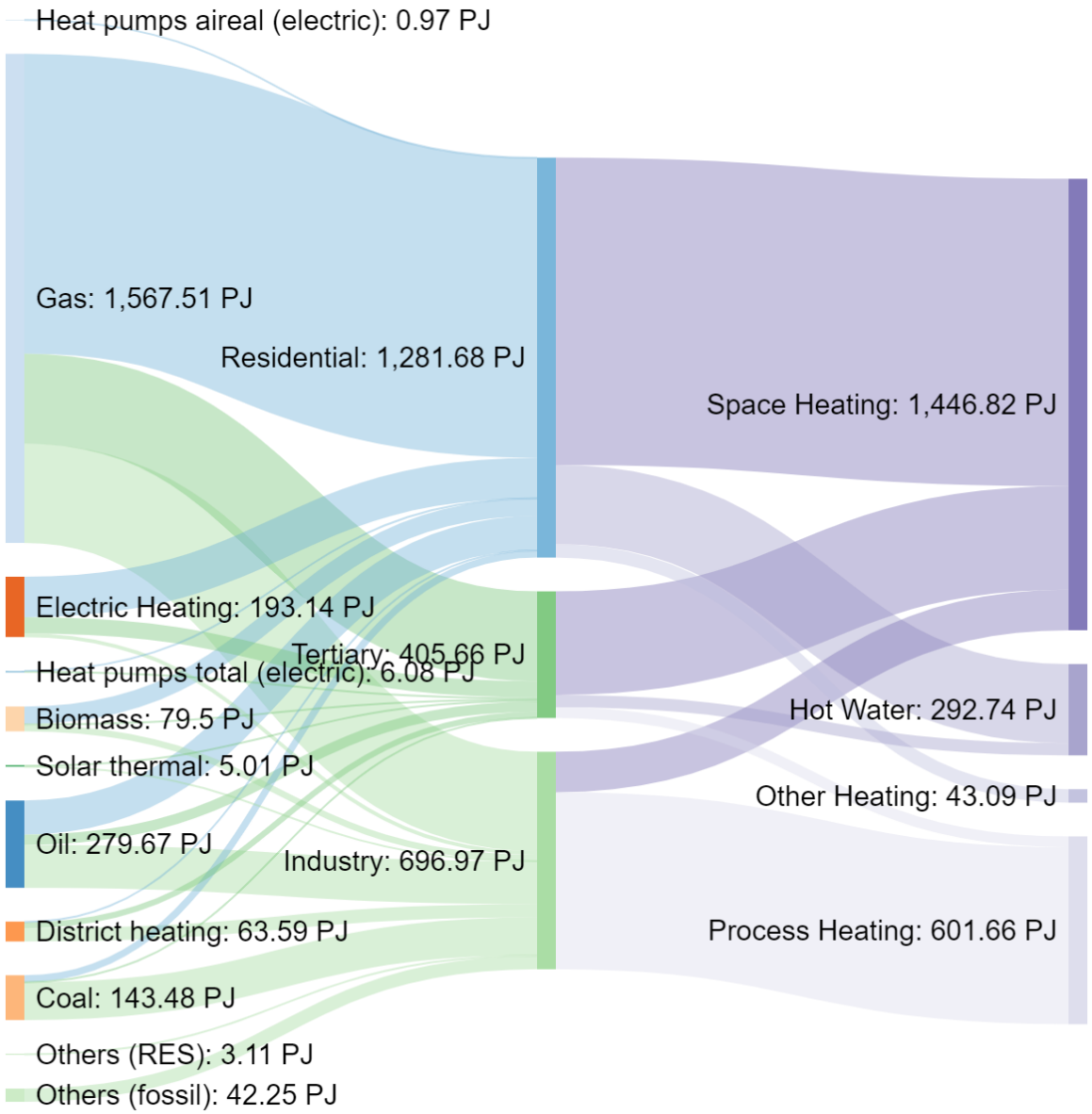


Figure 7-324: Sankey diagram of energy flows for heating purposes in United Kingdom in 2015. Based on data from [3]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

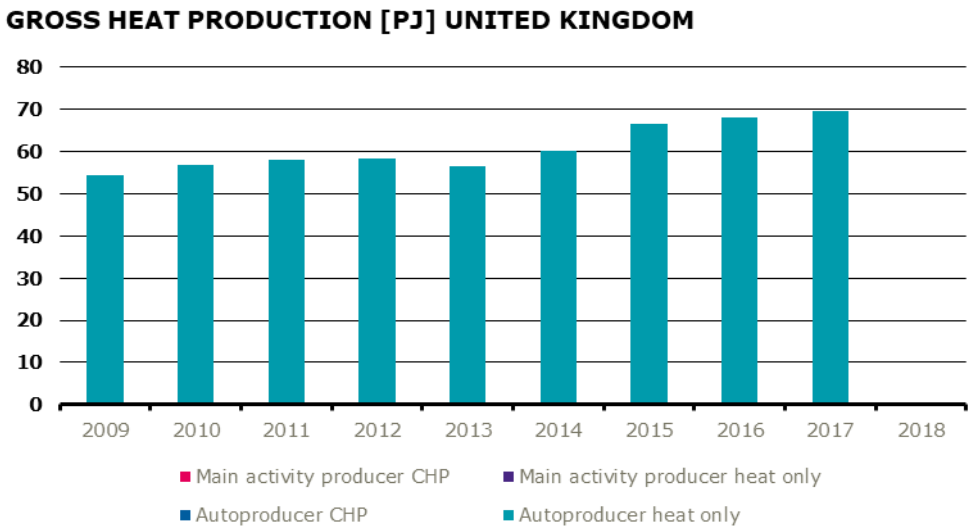


Figure 7-325: Gross heat production by producer type and year in United Kingdom. Based on data from [2]

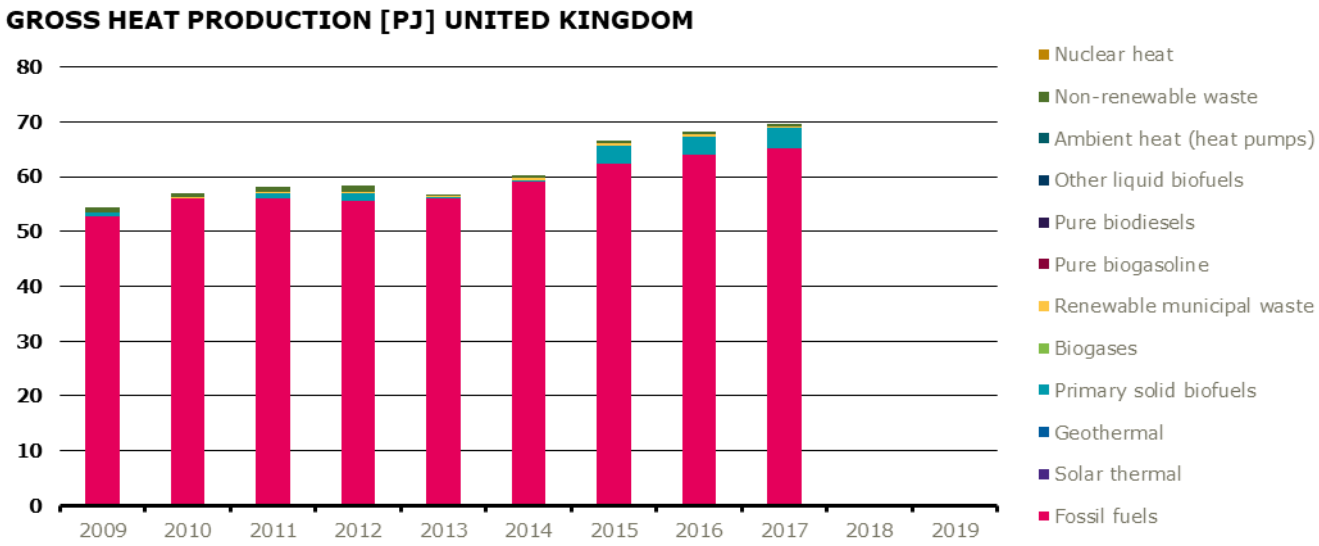


Figure 7-326: Gross heat production by fuel and year in United Kingdom. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.30.4 Electricity Production

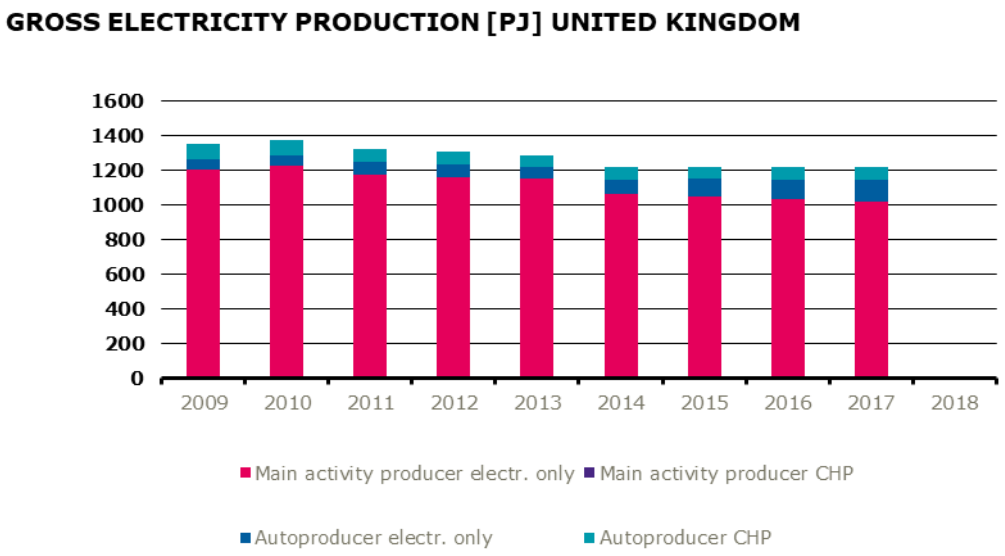


Figure 7-327: Gross electricity production by producer type and year in United Kingdom. Based on data from [2]

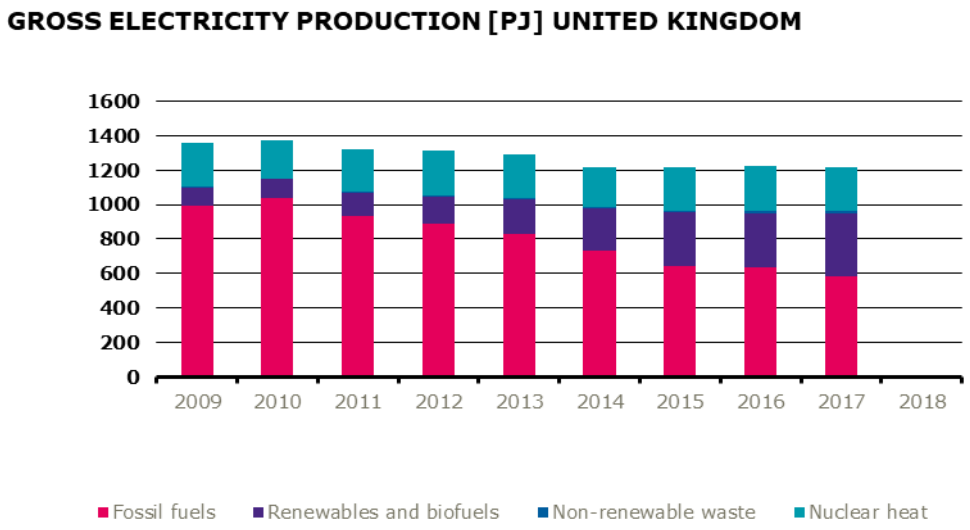


Figure 7-328: Gross electricity production by fuel type and year in United Kingdom. Based on data from [2]

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.30.5 District Heat

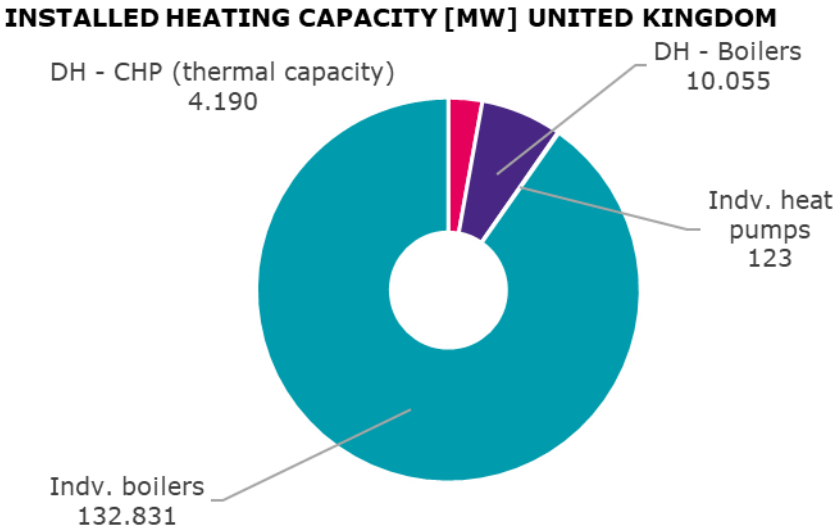


Figure 7-329: Installed heating capacity installed in United Kingdom in 2015. Based on data from [2]

7.30.6 Energy storage

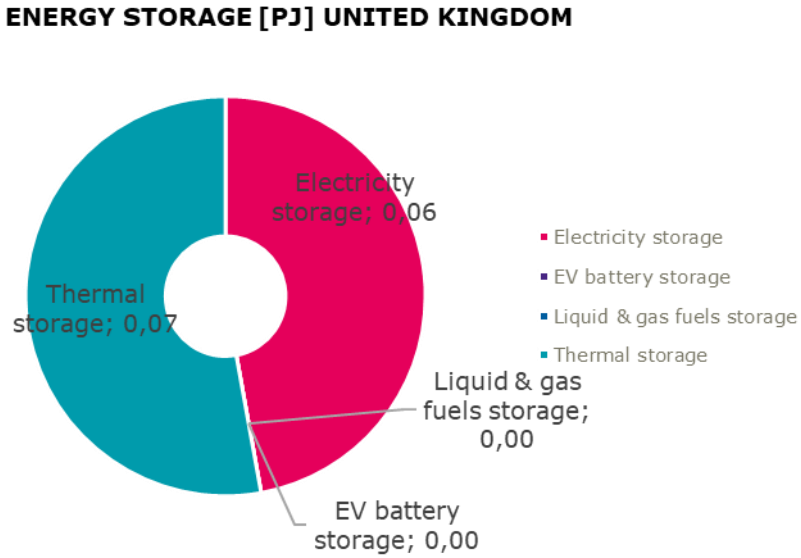


Figure 7-330: Stoage capacity in United Kingdom in 2015. Based on data from [2]

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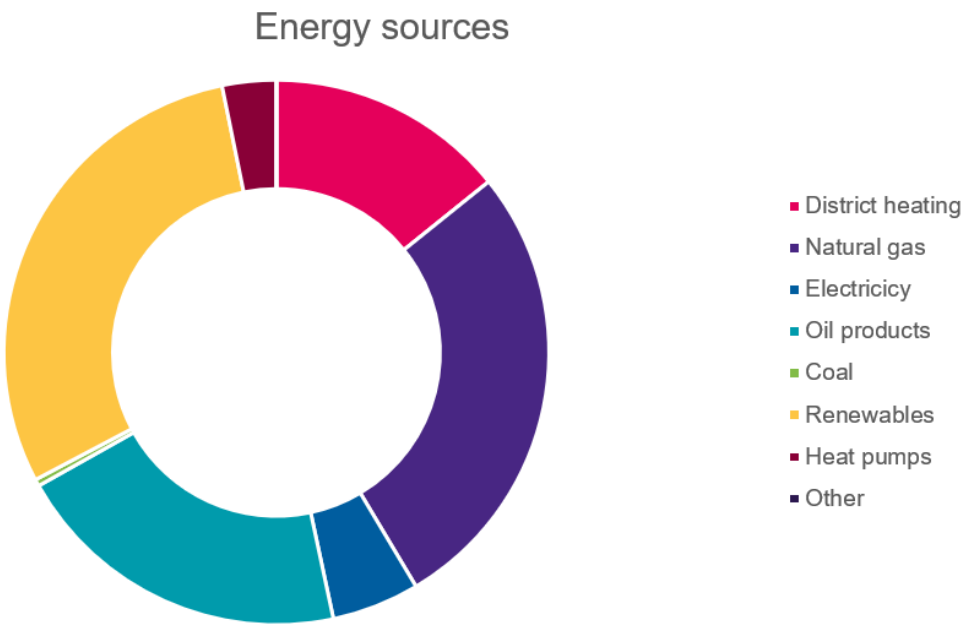
Annex 2. DHC Market Analysis country by country

7.31 Austria

Development of DH				
Category	**2013**	**2015**	**2017**	**Unit**
Total installed DH capacity	10,300	10,400	11,200	MW_{th}
Trench length	4,918	4,966	5,488	km
District heated floor space	66	70	75	Million m^2
Average DH price (Excl. VAT)	50.9	58.8	57.6	EUR/MWh
Average DH price (Incl. VAT)	61.0	70.5	69.2	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2017)	
Energy source	**Total (in %)**
District heating	14.2
Natural gas	27.2
Electricity	5.2
Oil / Petroleum products	20.2
Coal	0.4
Renewables*	29.5
Heat pumps	3.2
Other	0



*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal

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Barriers for further development of DH

Investments are often going to hot water electrode boilers instead of CHP and heating plants.
High gas prices and low electricity prices challenge CHP.
High (preliminary) investment cost.

Plans for further development of DH

National targets:

- Switch to RES and high-efficiency DH in the existing building stock;
- Although renewable energy is already very important, the heat market still depends heavily on imported fossil fuels. In order to mitigate that dependency, the use of biomass, solar heat and ambient heat will be developed by 2030, both as direct heating and as DH;
- Replacement of fossil fuels by renewable energy and efficient DH;
- Spatial planning is intended to identify areas with grid-bound energy infrastructure (e.g. DH areas) as soon as possible/2025;
- Supplying buildings and businesses with efficiently generated DH will continue to play an important role in the future, in particular in conurbations. Feed-in of waste heat from the plants where it is produced is also of major importance alongside the generation of energy from various RES (biomass, geothermal, solar thermal, photovoltaic, wind, etc.) and cogeneration. Austria is still far from fully exploiting its potential in this area. In future, increased incentives will be offered for using waste heat by way of energy spatial planning instruments;
- Grid densification is ongoing

Objectives for heating

Increase the share of renewables used by 2030 to 45% to 50% of the final gross energy consumption.
The heat requirement is to be covered 100% by renewable energies by 2050.

Market structure	
Obligation to connect DH	No, only in some parts in the cities of Linz and Graz*
Rules for connecting to and disconnecting from DH	Only technical rules*
Owner of DH companies	In the larger cities, DH companies are public owned. In the countryside, they are rather public cowned.
Other important information	
Status of DC	Capacity in 2017 of 134 MW Slowly increasing capacity Mostly present in the biggest cities

*K. Griessmair-Farkas from Association of Gas and District Heating Companies in Austria

Support schemes	
Subsidies for DH suppliers	Up to 30% of investment cost in subsidies for building new highly efficient CHP plants. Provinces have different schemes to subsidise investment costs of heating systems, often focusing on renewables and/or DH.
Subsidies for customers	No

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7.32 Belgium

Development of DH

Category	2013	2015	2017	Unit
Total installed DH capacity	N/A	N/A	N/A	MW_{th}
Trench length	N/A	N/A	N/A	km
District heated floor space	N/A	N/A	N/A	Million m^2
Average DH price (Excl. VAT)	N/A	N/A	N/A	EUR/MWh
Average DH price (Incl. VAT)	N/A	N/A	N/A	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2017)

Energy source	Total (in %)
District heating	N/A
Natural gas	N/A
Electricity	N/A
Oil / Petroleum products	N/A
Coal	N/A
Renewables*	N/A
Heat pumps	N/A
Other	N/A

*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal

Barriers for further development of DH

N/A

Plans for further development of DH

N/A

Objectives for heating

N/A

Market structure

Obligation to connect DH
Rules for connecting to and disconnecting from DH
Owner of DH companies
Other important information
Status of DC

Support schemes

Subsidies for DH suppliers
Subsidies for customers

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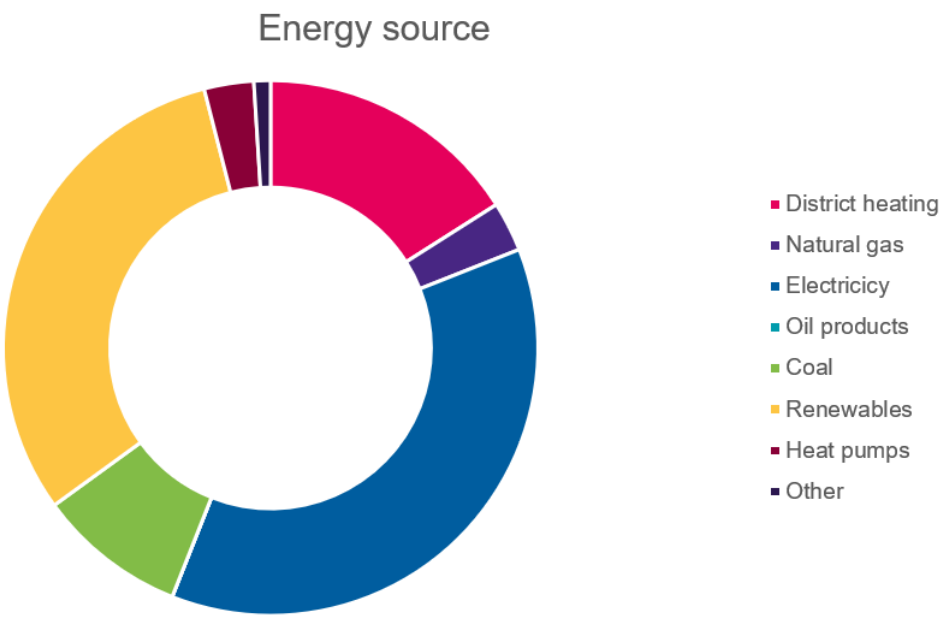
7.33 Bulgaria

Development of DH				
Category	**2013**	**2015**	**2017**	**Unit**
Total installed DH capacity	6,162	N/A	7,84	MW_{th}
Trench length	1,566	N/A	2,245	km
District heated floor space	38.2	N/A	N/A	Million m^2
Average DH price (Excl. VAT)	3.194	N/A	N/A	EUR/MWh
Average DH price (Incl. VAT)	3.833	N/A	N/A	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2013)	
Energy source	**Total (in %)**
District heating	16
Natural gas	3
Electricity	37
Oil / Petroleum products	0
Coal	9
Renewables*	31
Heat pumps	3
Other	1



*Renewables includes wood pellets, wood chips, biomass, firewood, geothermal, solar thermal

Barriers for further development of DH

New buildings are not required to connect to DH
The amount of DH-networks are decreasing

Plans for further development of DH

Bulgaria has a National Energy Strategy running until 2020, where there is a reference to the need for DH being developed and encouraged as a priority. The strategy contains a plan to stabilise and develop the DH sector, but this plan is yet to be confirmed by the

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government and no related measures are in force. Additionally, a European Commission report includes Bulgaria's progress in implementing measures which encourage the use of high-efficient CHP plants to generate electricity and heat. The increase of market share for CHP is highlighted as a key measure for achieving national energy efficiency goals.

Objectives for heating
There are no national targets for DH

Market structure	
Obligation to connect DH	It is not obligated to connect to DH.
Rules for connecting to and disconnecting from DH	No.
Owner of DH companies	Every DH company is privately owned except one which is owned by the municipality in Sofia.
Other important information	
Status of DC	DC is not used. Only one pilot project has tested it by using DH and an absorption chiller.

Support schemes	
Subsidies for DH suppliers	No
Subsidies for customers	No

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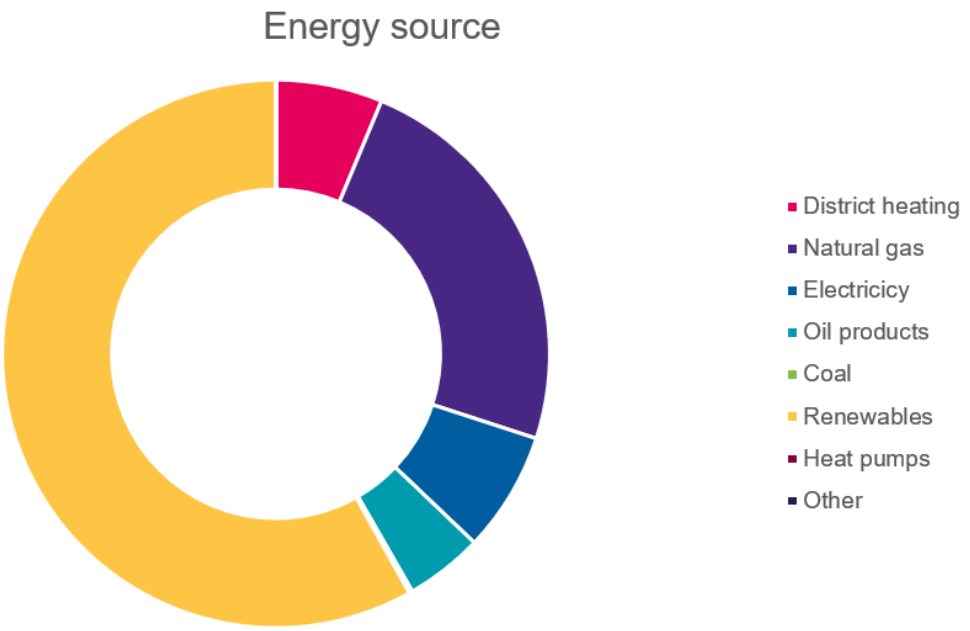
7.34 Croatia

Development of DH				
Category	**2013**	**2015**	**2017**	**Unit**
Total installed DH capacity	1,800	1,800	1,800	MW_{th}
Trench length	410	415	436	km
District heated floor space	11.7	11.6	11.7	Million m^2
Average DH price (Excl. VAT)	35.8	29.8	25.9	EUR/MWh
Average DH price (Incl. VAT)	44.7	37.3	32.4	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2017)	
Energy source	**Total (in %)**
District heating	6.3
Natural gas	23.7
Electricity	7.1
Oil / Petroleum products	4.6
Coal	0.2
Renewables*	58.1
Heat pumps	0
Other	0



*Renewables includes wood pellets, wood chips, biomass, firewood, geothermal, solar thermal

Barriers for further development of DH

Natural gas has a favorable price compared to DH
DH has aa very small market share

Plans for further development of DH

A DH strategy for Croatia has been postponed and there are today no plans or further

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development

Objectives for heating
Usage of renewable energy
Increase of energy efficiency
Improvement of regulatory framework
Distribution system loss reduction
Modernization of DH plants
Efficient usage of heat energy
Usage of information and communication technology in heating energy sector

Market structure	
Obligation to connect DH	There are possibilities for disconnecting from DH network.
Rules for connecting to and disconnecting from DH	In order to disconnect it is necessary to settle the debt for heating and then file a report, cancel the existing contracts. In order to connect to the system, there has to be agreement of 50% of residents of building that wants to be connected. After that, a residents' representative signs a contract with the company for heating energy delivery. The residents of the building share the expense for energy.
Owner of DH companies	They are mostly publicly owned by municipalities and national companies.
Other important information	DH tariffs are handled by Croatia's Energy Regulatory Agency.
Status of DC	There is no DC.

Support schemes	
Subsidies for DH suppliers	There are no subsidies for customers (it is worth mentioning that, in most cities, the price charge for customers is not sufficient for covering production expenses).
Subsidies for customers	There are subsidies defined with Act for electric energy production subsidies from RES and high-efficient cogeneration (NN 116/18).

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7.35 Cyprus

Development of DH

Category	2013	2015	2017	Unit
Total installed DH capacity	N/A	N/A	N/A	MW_{th}
Trench length	N/A	N/A	N/A	km
District heated floor space	N/A	N/A	N/A	Million m^2
Average DH price (Excl. VAT)	N/A	N/A	N/A	EUR/MWh
Average DH price (Incl. VAT)	N/A	N/A	N/A	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2017)

Energy source	Total (in %)
District heating	N/A
Natural gas	N/A
Electricity	N/A
Oil / Petroleum products	N/A
Coal	N/A
Renewables*	N/A
Heat pumps	N/A
Other	N/A

*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal

Barriers for further development of DH

N/A

Further development of DH

N/A

Objectives for heating

N/A

Market structure

Obligation to connect DH
Rules for connecting to and disconnecting from DH
Owner of DH companies
Other important information
Status of DC

Support schemes

Subsidies for DH suppliers
Subsidies for customers

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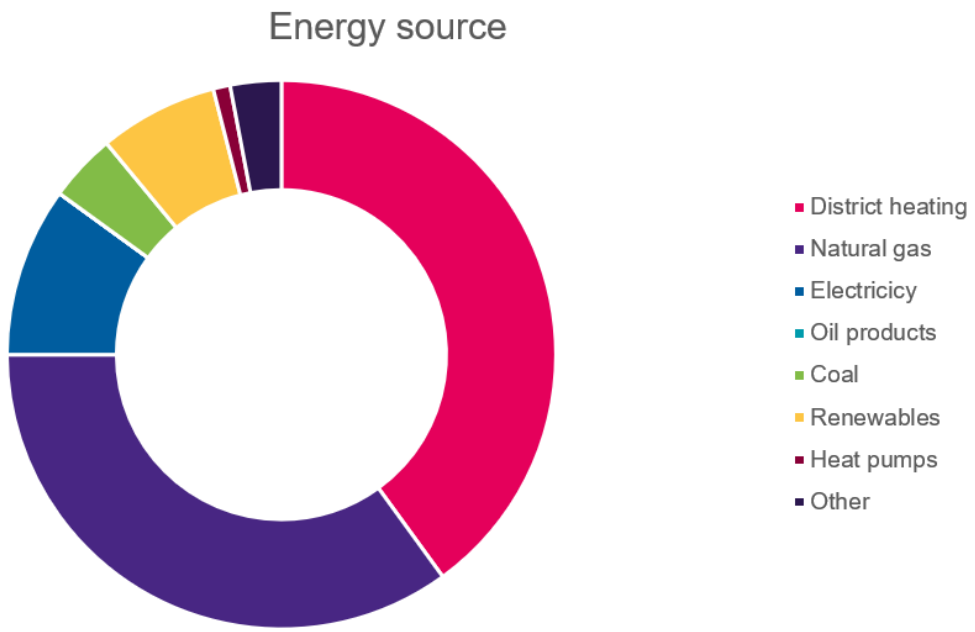
7.36 Czech Republic

Development of DH				
Category	**2013**	**2015**	**2017**	**Unit**
Total installed DH capacity	22,958	37,377	39,943	MW_{th}
Trench length	7,738	7,495	7,517	km
District heated floor space	145	148	153	Million m^2
Average DH price (Excl. VAT)	68.8	67.4	66.7	EUR/MWh
Average DH price (Incl. VAT)	79.2	77.5	76.7	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2017)	
Energy source	**Total (in %)**
District heating	40
Natural gas	35
Electricity	10
Oil / Petroleum products	0
Coal	4
Renewables*	7
Heat pumps	1
Other	3



*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal

Barriers for further development of DH

Lower heat demand because of less heavy and more efficient industry, as well as thermal improvements in households
DH production has to pay energy tax while individual heating do not

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Plans for further development of DH

In a State EnergyPolicy approved by the Government of the Czech Republic in 2015, one of the stipulated priorities were to make a restructuring of energetically and economically inefficient DH systems. This will make sure they will get supported whenever achievement of higher energy efficiency, higher flexibility of fuel use or better parameters from sustainable development point of view can be anticipated.

Objectives for heating

20% of DH must be covered by RES in 2040
At least 60% of heatprodution must come from CHP I 2040

Market structure

Obligation to connect DH	
Rules for connecting to and disconnecting from DH	Customer must pay the disconnection of DH.
Owner of DH companies	DH systems are mostly owned by municipalities or in combination with the private sector.*
Other important information	Prices for DH are regulated by the Energy regulatory office based on justified costs and reasonable profit. Investments from DH companies that result in price changes must be announced to the customers who then can choose to terminate their contract or not.
Status of DC	The DC market has slowly started. Since market paricipants are not obligated to report data about DC production, the Ministry of Industry and Trade estimates a DC supply of 300-400 TJ/year.

Support schemes

Subsidies for DH suppliers	No.
Subsidies for customers	Investment subsidies for new DH systems and retrofit subsidies exist but the requirements on applications are very complex.*

* Association for the District Heating of the Czech Republic (tscr), Jolana Buganova

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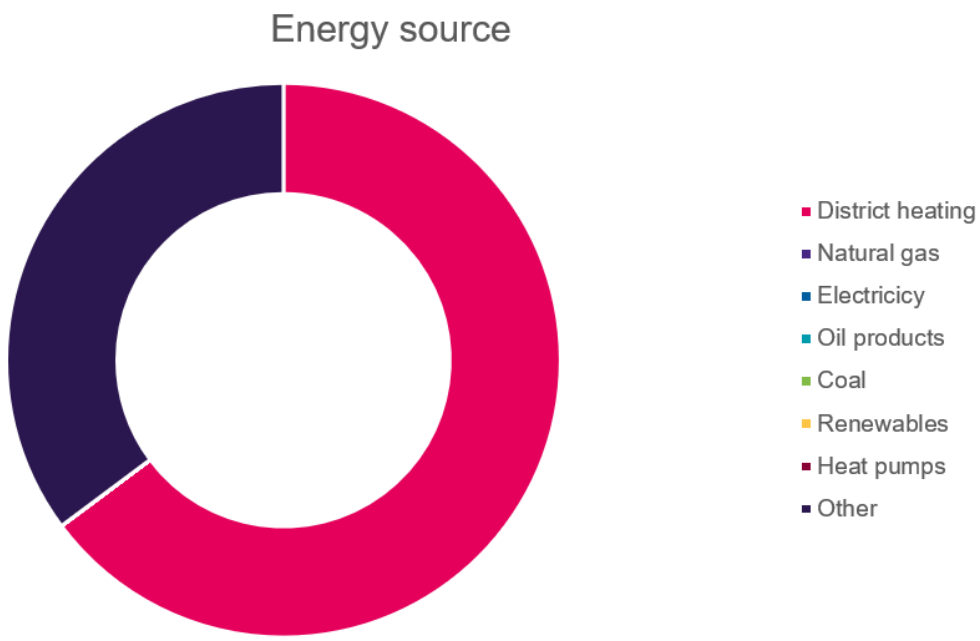
7.37 Denmark

Development of DH				
Category	2013	2015	2017	Unit
Total installed DH capacity	N/A	N/A	9,930 (+8,140 for peak load)*	MW_{th}
Trench length	30,510	30,780	30,800	km
District heated floor space	N/A	N/A	185	Million m^2
Average DH price (Excl. VAT)	100.4	79.7	79.0	EUR/MWh
Average DH price (Incl. VAT)	125.6	99.6	98.8	EUR/MWh

*Data from Rambøll [2020]

Distribution of energy sources used to satisfy heat demand in residential sector (2017)	
Energy source	**Total (in %)**
District heating	64.8
Natural gas	N/A
Electricity	N/A
Oil / Petroleum products	N/A
Coal	N/A
Renewables*	N/A
Heat pumps	N/A
Other**	35.2



*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal
**Other covers, in this case, all other energy sources

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Barriers for further development of DH

The DH-market is saturated
An increasing trend to implement individual solutions instead of DH

Plans for further development of DH

DH is becoming even better compared to individual oil or gas boilers which make further expansion more viable
If economical profitable, DH companies have an easy time financing expansion of the network

Objectives for heating

In 2030, 55% of the Danish energy production must come from RES
In 2030, 90% of DH consumption must be based on other than fossil fuels

Market structure

Obligation to connect DH	The municipality can decide if buildings in certain areas are obligated or not. However, they are not obligated to be supplied by DH.
Rules for connecting to and disconnecting from DH	
Owner of DH companies	Both private and public owned DH companies.
Other important information	DH companies must be non-profitable. The price of DH must only be reflected in the production cost.
Status of DC	DC is slowly getting traction in the larger cities.Today, six companies are selling DC to private companies and public institutions.

Support schemes

Subsidies for DH suppliers	There are subsidies for reneable electricity production which benefit CHP plants.
Subsidies for customers	

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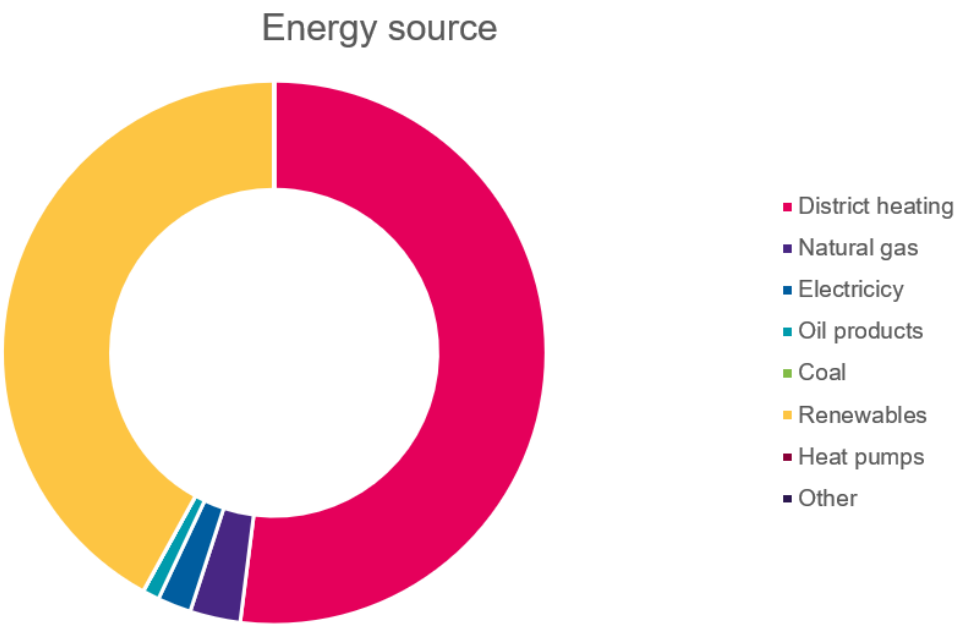
7.38 Estonia

Development of DH				
Category	**2013**	**2015**	**2017**	**Unit**
Total installed DH capacity	5,406	N/A	5,04 (2018)	MW_{th}
Trench length	1,450	N/A	1,524 (2018)	km
District heated floor space	31	N/A	N/A	Million m^2
Average DH price (Excl. VAT)	55.4	N/A	N/A	EUR/MWh
Average DH price (Incl. VAT)	66.5	N/A	N/A	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2013)	
Energy source	**Total (in %)**
District heating	52
Natural gas	3
Electricity	2
Oil / Petroleum products	1
Coal	0
Renewables*	42
Heat pumps	0
Other	0



*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal

Barriers for further development of DH

DH companies must pay CO2-taxes in opposite to individual boilers and small engines
Prices in the energy production are increasing because energy sources are being exported

Plans for further development of DH

DH development plans (0.5 mln eurot, 200 development plans)
Cogeneration

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•Heat storage
•District cooling
•Smart district heating networks

Objectives for heating
Reconstruction of customers local systems and installation of water based indoor heating systems. Smart measuring.

Market structure	
Obligation to connect DH	Every new building must connect if placed in established DH area.
Rules for connecting to and disconnecting from DH	DH customers have the right to disconnect from the DH network without being given a penalty.
Owner of DH companies	Public and Private Companies
Other important information	The DH market and prices are fully regulated by the state.
Status of DC	In 2014, the development of DC projects started and the first DC plant was commissioned in May 2016, becoming the first DC network in the Baltics and Eastern-Europe. Both DH and cooling networks are expected to continue growing. They are one of the main enablers of Tartu's environmental strategy.

Support schemes	
Subsidies for DH suppliers	CHP plants get a feed-in-tariff when using renewable fuels.
Subsidies for customers	No information.

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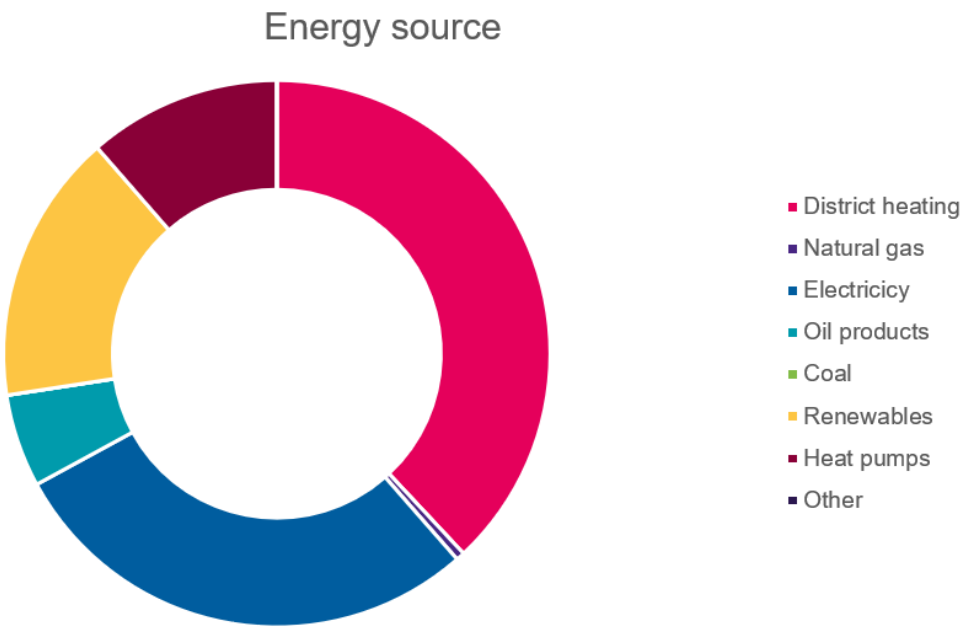
7.39 Finland

Development of DH				
Category	**2013**	**2015**	**2017**	**Unit**
Total installed DH capacity	22,480	22,790	23,390	MW_{th}
Trench length	13,850	14,610	14,920	km
District heated floor space	277	285	296	Million m^2
Average DH price (Excl. VAT)	58.7	61.1	61.9	EUR/MWh
Average DH price (Incl. VAT)	72.7	75.8	76.7	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2017)	
Energy source	**Total (in %)**
District heating	38
Natural gas	0.5
Electricity	28.5
Oil / Petroleum products	5.5
Coal	N/A
Renewables*	16
Heat pumps	11.4
Other	N/A



*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal

Barriers for further development of DH

New buildings are getting much more energy-efficient and older ones are getting renovated to cut down heat demand as well.

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Plans for further development of DH

Striving for carbon-neutral heat production

Objectives for heating

In 2030, DH will be nearly carbon neutral
In 2029, coal-fired energy production will be banned

Market structure

Obligation to connect DH	
Rules for connecting to and disconnecting from DH	Both customers can freely choose if they want to get connected to DH, but DH companies are not obligated to do so.
Owner of DH companies	The DH companies are independent but are most often owned by the municipalities[45]
Other important information	There are still regulations to protect the consumers from being dumped as customers and unreasonable prices.
Status of DC	DC is getting traction in the market. Especially for public and service buildings, but also residential buildings in high-density areas are starting to get connected to the DC network. 11 companies are delevring DC.

Support schemes

Subsidies for DH suppliers	Renewable energy production has been subsidised mainly with production subsidies for wind power and forest chips. In addition, investments in heat production in plants outside the emissions trading sector have also been subsidised.
Subsidies for customers	Non-regulation means that Finland does not have specific legislation concerning the selection or pricing of heating, cooling or heating and cooling methods. Competition between various solutions and service operators in the heating market ensures efficient operations, reasonable pricing and a high quality of services for customers.

[45] https://books.google.dk/books?id=ck6dBAAAQBAJ&pg=PA24&lpg=PA24&dq=DH+companies+in+finland+private+owned&source=bl&ots=a78ZURhQxN&sig=ACfU3U1n3XH3YWqihPOutWB82fyxNtNacg&hl=da&sa=X&ved=2ahUKEwilsKuUkcLoAhVumIsKHWVFCXIQ6AEwAHoECAkQAQ#v=onepage&q=munici&f=false

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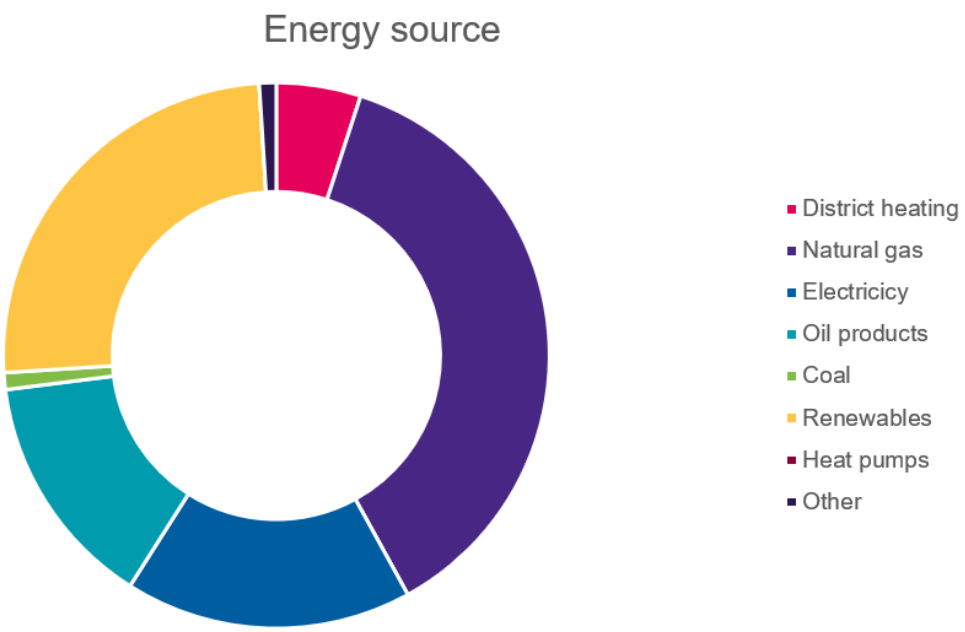
7.40 France

Development of DH				
Category	**2013**	**2015**	**2017**	**Unit**
Total installed DH capacity	21,230	22,319	24,707	MW_{th}
Trench length	3,725	4,738	5,397	km
District heated floor space		2.32 million housing units in 2016		
Average DH price (Excl. VAT)	67.5	67.6	70.0	EUR/MWh
Average DH price (Incl. VAT)	81	81.1	84	EUR/MWh

It has not been possible to find information on the number of m^2 heated by DH.

Distribution of energy sources used to satisfy heat demand in residential sector (2017)	
Energy source	**Total (in %)**
District heating	5
Natural gas	37
Electricity	17
Oil / Petroleum products	14
Coal	1
Renewables*	25
Heat pumps	0
Other	1



*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal

Barriers for further development of DH

There is a low awareness of DHC in France.
High investment cost and low competing fuel prices (oil and nuclear power) makes it difficult for DH to compete.

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Plans for further development of DH

No information

Objectives for heating

In 2030, the amount of energy produced on CHP plant must be five times higher.

Market structure

Obligation to connect DH	There is no obligation for the existing buildings to connect except if there is a major refurbishment. For new buildings (and when major refurbishment on existing buildings), it is an obligation to connect if the network has been "classified" (classement reseau in French) and if the building is within the Legal area/perimeter of the DH.
Rules for connecting to and disconnecting from DH	Rules are defined within the Contract of the ESCO (connection of new development if located within the legal perimeter, market development for existing buildings etc)
Owner of DH companies	Could be Borough, council, region, Esco, Associations
Other important information	Municipalities must produce masterplans for DHC before further development of the DHC network
Status of DC	There is low awareness of DC in France. However, it is found in the service sector like museums and offices.

Support schemes

Subsidies for DH suppliers	From the government through ADEME. The scheme is called "Fond Chaleur".
Subsidies for customers	DH consumers can benefit from a 5.5% reduced VAT-rate if the network uses at least 50% RES.

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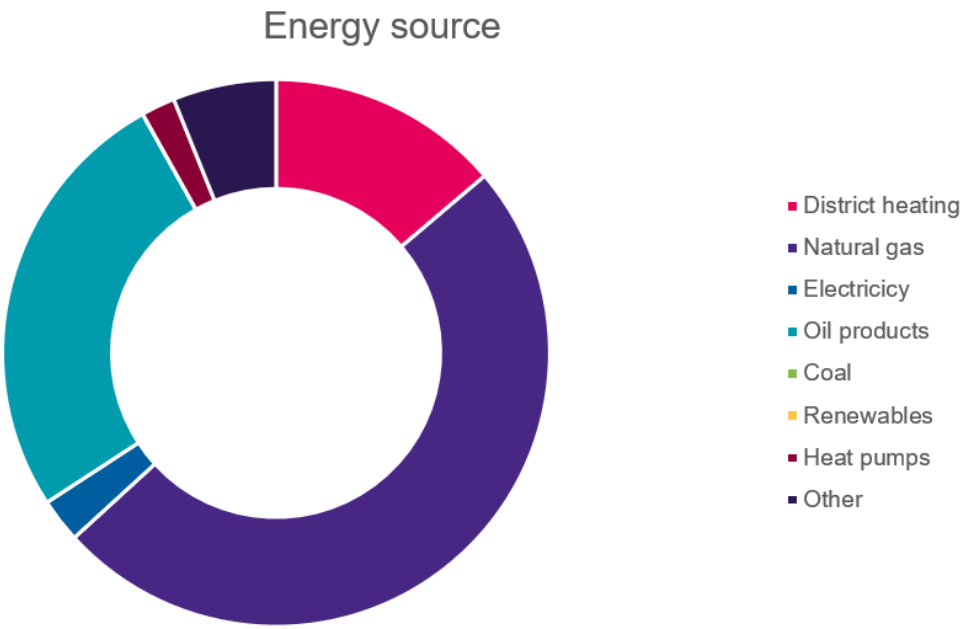
7.41 Germany

Development of DH				
Category	**2013**	**2015**	**2017**	**Unit**
Total installed DH capacity	49,691	49,455	49,475	MW_{th}
Trench length	20,219	21,269	21,610	km
District heated floor space	524	531.5	539.4	Million m^2
Average DH price (Excl. VAT)	76.46	73.97	72.08	EUR/MWh
Average DH price (Incl. VAT)	90.99	88.02	85.78	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2017)	
Energy source	**Total (in %)**
District heating	13.8
Natural gas	49.4
Electricity	2.6
Oil / Petroleum products	26.1
Coal	N/A
Renewables*	N/A
Heat pumps	2
Other	6.1



*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal

Barriers for further development of DH

Difficult to compete when CHP-plants must pay CO2 taxes and individual options for heat supply must not.
If introducing DH in rental buildings, the bill must not be higher than previously.

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Plans for further development of DH

Smalle scale DH networks are becoming more commn in dense urban areas.

Objectives for heating

In 2030, 30% of heat production must come from waste incineration.

Market structure

Obligation to connect DH	In general No. In some small DH network clients within that area are obligated to connect to it. So there might exist some. But at least at the moment it is rather difficult to force people to connect.
Rules for connecting to and disconnecting from DH	To protect customers, only with explicit consent from the customer can they be exempted.
Owner of DH companies	Mainly bigger utilities and more and more city (or partly) owned (e.g. Hamburg, where Vattenfall Wärme Hamburg became Wärme Hamburg, a city owned DH company). Cooperatives also exists but you would find them rather in rural areas.
Other important information	DH is not categorized as renewable per se, but if at least half of the production comes from RES or waste, it can be categorized as 'renewable energy'.
Status of DC	Only at the beginning. In Munich there is one project, where they installed DC in commercial areas, mainly in the city center. They have installed 14 km by now. There are also DC in some other cities, like Berlin, Chemnitz, Gera. An article from 2013 wrote about 90 km in total in Germany, but the actual numbers to day is not known. Focus is still commercial buildings.

Support schemes

Subsidies for DH suppliers	Yes. They focus mainly on the integration of renewable energies and low temperatures (which is < 95 °C). There exist some programs to support the investment when the network belongs to a DH systems which meets the requirements.
Subsidies for customers	There exist programs to support the connection to the DH network. There are more programs for renewable energies and cogeneration/efficient heat generation. There are many different funding programs, and also different from state to state.

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7.42 Greece

Development of DH

Category	2013	2015	2017	Unit
Total installed DH capacity	N/A	N/A	N/A	MW_{th}
Trench length	N/A	N/A	N/A	km
District heated floor space	N/A	N/A	N/A	Million m^2
Average DH price (Excl. VAT)	N/A	N/A	N/A	EUR/MWh
Average DH price (Incl. VAT)	N/A	N/A	N/A	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2017)

Energy source	Total (in %)
District heating	0.5
Natural gas	5.4
Electricity	26.8
Oil / Petroleum products	44.7
Coal	1.8
Renewables*	20.8
Heat pumps	N/A
Other	N/A

*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal

Barriers for further development of DH

N/A

Plans for further development of DH

N/A

Objectives for heating

N/A

Market structure

Obligation to connect DH
Rules for connecting to and disconnecting from DH
Owner of DH companies
Other important information
Status of DC

Support schemes

Subsidies for DH suppliers
Subsidies for customers

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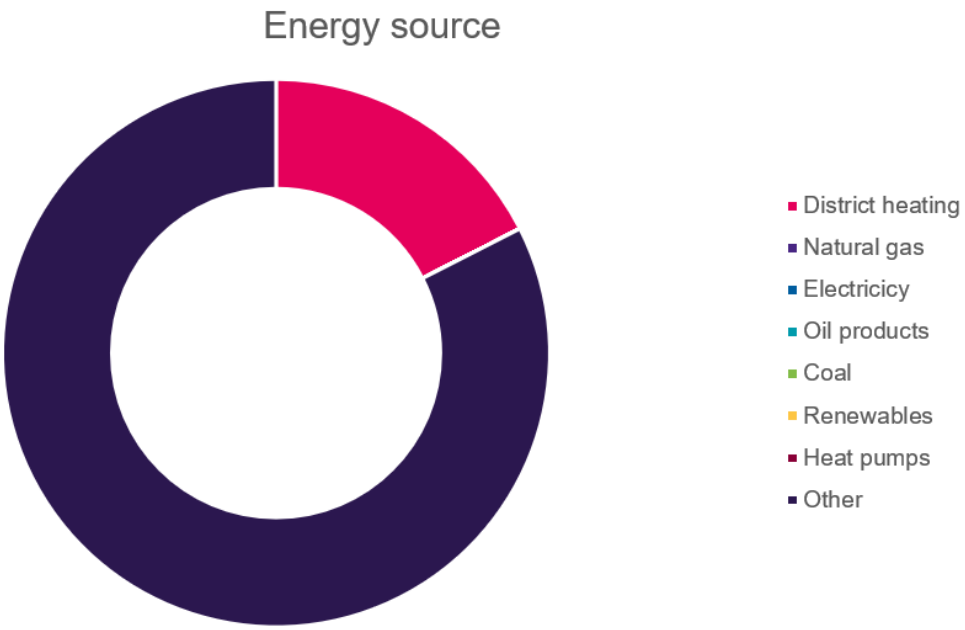
7.43 Hungary

Development of DH				
Category	**2013**	**2015**	**2017**	**Unit**
Total installed DH capacity	8,377	7,809	8,549	MW_{th}
Trench length	2,158	1,938	1,960	km
District heated floor space	597,985	599,980	600,364	Number of dwellings
Average DH price (Excl. VAT)	4.34	3.97	3.80	EUR/MWh
Average DH price (Incl. VAT)	4.56	4.2	4.0	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2017)	
Energy source	Total (in %)
District heating	17.5
Natural gas	N/A
Electricity	N/A
Oil / Petroleum products	N/A
Coal	N/A
Renewables*	N/A
Heat pumps	N/A
Other**	82.5



*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal
**Other covers, in this case, all other energy sources

Barriers for further development of DH

Current pipes are old and suffer a huge heat loss.
Low prices for natural gas makes it difficult to compete.
DH companies are limited for how much they can profit which makes it difficult to invest in

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further development of the DH network (or modernization).

Plans for further development of DH

Mainly commercial buildings and public institusions are getting connected to the DH network.

Objectives for heating

A national target is to reduce 52% to 85% of emission in 2050 compared to 1990 and DH is seen as an option to helt reach this goal.

Market structure

Obligation to connect DH	No obligation to connect to DH. The DH provider has a general public service contract obligation with the residential user. A general public service contract may be concluded for the provision of DH according to metering by a central heating system (heat receiving station) or by building.
Rules for connecting to and disconnecting from DH	The rules are regulated by XVIII Law on DH. The other user and the DH provider shall enter into an individual public service contract for the continuous and safe supply of DH and the payment of its consideration in accordance with the rules of civil law. The user may terminate the general public service contract by giving 30 days' notice in the manner specified in the Government Decree implementing this Act. The user bear the costs of the technical conversion of user equipment required as a result of the termination.
Owner of DH companies	Budapest Municipality is the owner of the DH company in Budapest.
Other important information	In most cases, bills are DH bills are calculated to the size of dwelling.
Status of DC	Cooling is today only provided with individual air conditions.

Support schemes

Subsidies for DH suppliers	The DH provider shall publish the conditions of any subsidies on its website.
Subsidies for customers	Customers only have to pay a 5% VAT for DH compared to 27% VAT for natural gas.

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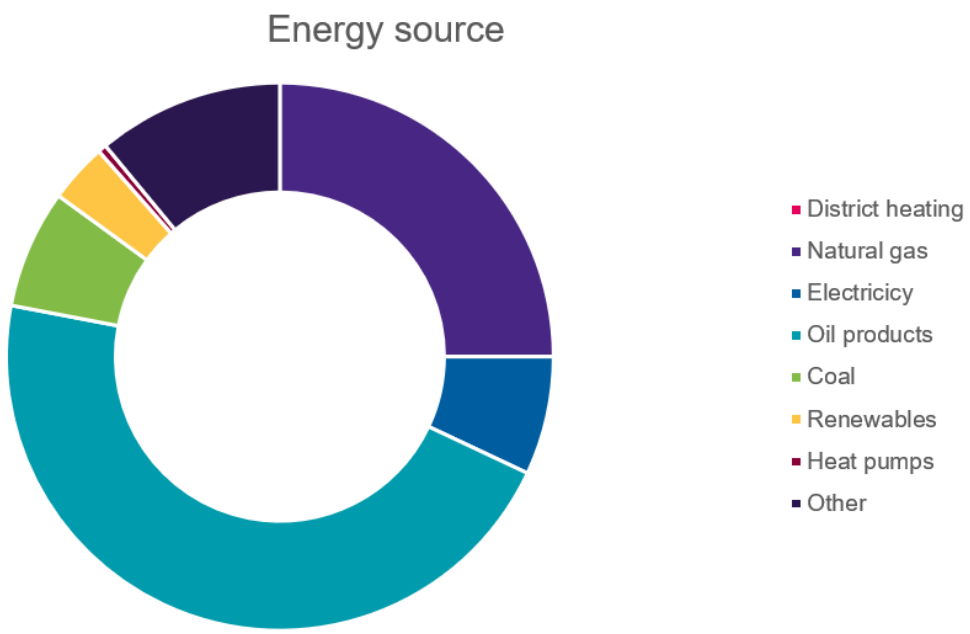
7.44 Ireland

Development of DH				
Category	**2013**	**2015**	**2017**	**Unit**
Total installed DH capacity	N/A	342	348	MW_{th}
Trench length	N/A	N/A	N/A	km
District heated floor space	N/A	N/A	N/A	Million m^2
Average DH price (Excl. VAT)	N/A	N/A	N/A	EUR/MWh
Average DH price (Incl. VAT)	N/A	N/A	N/A	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2017)	
Energy source	**Total (in %)**
District heating	N/A
Natural gas	25
Electricity	7
Oil / Petroleum products	46
Coal	7
Renewables*	3.5
Heat pumps	0.5
Other	11



*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal

Barriers for further development of DH

Has a very low market share.

Plans for further development of DH

Plan for introducing DH in Dublin is undergoing.

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Objectives for heating

There is currently no heat stregy in Ireland.

Market structure

Obligation to connect DH	
Rules for connecting to and disconnecting from DH	
Owner of DH companies	
Other important information	
Status of DC	There is no DC in Ireland today.

Support schemes

Subsidies for DH suppliers	
Subsidies for customers	

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7.45 Italy

Development of DH				
Category	**2013**	**2015**	**2017**	**Unit**
Total installed DH capacity	8,056	8,588	8,727	MW_{th}
Trench length	3,807	4,098	4,377	km
District heated Volume	302.1	329.8	350.5	Million m^3
Average DH price (Excl. VAT)	N/A	N/A	N/A	EUR/MWh
Average DH price (Incl. VAT)	N/A	N/A	N/A	EUR/MWh

The average DH price in 2011 in Italy amounted to 96.4 €/MWh (incl. VAT) and to 87.6 €/MWh (excl. VAT)[46].

For the following years, the average price is not available. The statistics dedicated to prices, after 2011, are available from each DH provider in different regions and they are not expressed on average terms. Taking into account, as example, the Regions of Lombardia and Piemonte, representing respectively 42.4% and 25.6% in terms of heated volume at National Level in 2018, the local utilities reported the following prices (Jan 2018; excl. VAT) for their residential customers:

- 75.9 €/MWht or 82.5 €/MWht in case of individual or centralised system (Brescia city)[47];
- 80.6 €/MWht in case of consumption lower than 350,000 Mcal/y (Torino city)

Distribution of energy sources used to satisfy heat demand in residential sector (2017)	
Energy source	**Total (in %)**
District heating	3
Natural gas	56
Electricity	6
Oil / Petroleum products	8
Coal	N/A
Renewables*	20
Heat pumps	N/A
Other	7

[46] Source : AGCM – Autorità Garante della Concorrenza e del Mercato, « Indagine conoscitiva sul settore del teleriscaldamento », April 2014. https://www.qualenergia.it/sites/default/files/articolo-doc/indagine%20teleriscaldamento.pdf

[47] https://www.ilteleriscaldamento.eu/pdf/a2a_brescia/a2a_bs_01_01_2018.pdf

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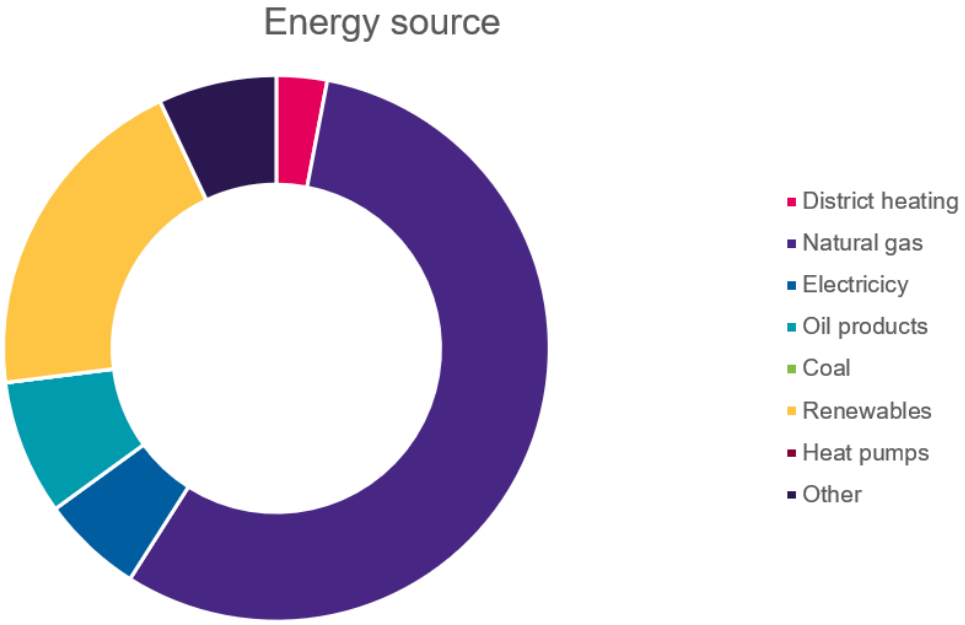

*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal

Barriers for further development of DH

Legislative barriers: The interruption of the previous main mechanism of subsidies (Titoli di Efficienza Energetica) occurred in 2015 and, since then, there is a lack of visibility on the introduction of alternative incentive scheme to support the investments in DH. The framework is also characterised by delays in the definition of implementing decrees linked to this subject. Eg. Delay by the Italian Ministry for the Economic Development in the definition of the access criteria to subsidies linked to cogeneration for DH[48].

Another interesting support was represented by a dedicated guarantee fund to cover long term lending to be invested in DH infrastructure; this kind of support was introduced in 2011[49], but later legislative actions extended its use to other energy efficiency measures that have been prioritised.

From an institutional point of view, the qualification process of DH installation was left to the local municipalities without a clear and strategic vision at National level.

Economic/financial barriers: payback time of the investments is long and uncertain. In the Northern region (eg: Po Valley), the PBT for small-medium installation is c. 15-17 years including the cost of capital, but it could be higher depending on the climatic conditions and the related heating need. The pick in winter temperature is similar to other Norther European countries, but the winter period could be very short with a consequent lower utilisation of the heating infrastructure. Furthermore, the cost and the complexity of the works for the installation of the network is sometimes considered too high by municipalities/citizens due to the configuration of the Italian cities usually characterised by a high density of buildings on the main road – lack of space for works and consequent blockade of main traffic.

Technological barriers:
In 2014, the Italian federation for energy efficiency (FIRE) identified as additional barrier, the

[48] Art. 19-decies, L. 4 dicembre 2017 n. 172 - https://www.gazzettaufficiale.it/eli/id/2017/12/5/17G00186/sg
[49] D.Lgs. 3 marzo 2011 n. 28, art. 22, comma 4

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lack of dedicated local know-how and specific R&D on DH bringing to a strong dependency on international more experienced companies. Furthermore, individual solutions for heating and energy efficiency interventions on building envelopes are often prioritized by environmental associations/consumers and also easily supported by fiscal benefits.

Plans for further development of DH

At the moment, only the 6% of the Italian population can benefit from DH supply. The average annual growth rate in the period 2000-2019 was 6.8%[50]. The further development of new DH network and generation plants strictly depends on the actions taken by the Government and by the Italian energy and environmental Authority (ARERA). ARERA in particular, during the seminar on the state and future development of DHC regulation held in Feb 2020, presented the main points of their 2019-2021 which included some promising work in progress from a regulatory point of view: i) the definition of technical-economic conditions to encourage the integration of local generation and heat recovery unit into the DH network; ii) definition of specific criteria to encourage the coordinated development of DH and gas network; iii) metering regulation and test of bi-directional heat supply/demand side management.

As highlighted by AIRU, the growth rate of the sector in 2018 and 2019 was decreasing both on existing and new network. Besides, the development happened in a very concentrated area; only in Torino and Milano areas.

All stakeholders involved in the sector still agree on the high potential of development in the country and the Government officially recognised the importance of DH, together with HPs, in the achievement of the National target for renewable thermal generation, but more legislative action is needed to allow concrete implementation.

In particular, the Integrated National Energy and Climate Plan (PNIEC), published in December 2019, reported that there will be a further development of DH in Italy and that "*it will be vitally important to take advantage of the synergies between the use of RES s and HEC (high-efficiency cogeneration)*". The feasible increase in thermal energy supplied via DH is expected to be close to 4,000 GWh correlated with approx. 900 km on the basis of the National plan for the next years.

In terms of energy sources the focus is placed, as a matter of priority, on natural gas, biomass and waste. The National Plan reported the intention to carry out an in-depth and broad spectrum analysis on the integration into DH networks of certain technologies that are currently marginal in a DHcontext, but have potential for high-density urban neighbourhoods, such as, for example, thermal solar energy, centralized HPs or the recovery of waste heat from installations located throughout Italy. The assessment of the potential of DH and HEC, and the integration of these technologies, will be updated and examined more closely with a view to 2030 (according to the provisions of Article 15 of RED II), with account being taken of a new generation of DH systems that are ready for use (fourth generation), characterised by a low temperature of the heat transfer fluid, and of the role that could be played by heating storage combined with solar installations, HEC systems and DH networks.

Objectives for heating

Italy plans to pursue the target of obtaining 30% of gross final consumption of energy from renewable sources in 2030 by defining a pathway of sustainable growth for renewable sources and the full integration thereof into the system. In particular, the target for 2030 projects a gross final consumption of energy of 111 Mtoe, with approximately 33 Mtoe of that coming from renewable sources[51].

The contribution of renewables to meet total gross final consumption by 2030 (30%) is expected to have the following distribution between the different sectors:

[50] ARERA – Seminar "Stato e prospettive della regolazione del settore del teleriscaldamento e teleraffrescamento", 6 February 2020

[51] Integrated National Energy and Climate Plan (PNIEC)

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- 55.0% renewables share in the electricity sector;
- 33.9% renewables share in the heating sector (for heating and cooling);
- 22.0% with regard to the incorporation of renewables in the transport sector.

The heating sector plays a very important role in attaining renewables targets: In absolute terms, consumption from renewables is expected to exceed 15 Mtoe in the heating and cooling sector, primarily linked to the increase in renewable energy provided by HPs.
Under the Paris Agreement (the Effort Sharing Regulation, ESR), Italy has a commitment for greenhouse emissions reduction of -33% compared with 2005 levels for non-ETS sectors. In order to achieve this target, a minimum cumulative reduction of emissions of approx. 142 $MTCO_{2eq}$ is needed in the period 2021-2030. This will primarily be achieved in the transport, civil and industrial sectors7.

Market structure	
Obligation to connect DH	No obligation
Rules for connecting to and disconnecting from DH	
Owner of DH companies	The profiles of the DH owners can vary, but the majority is represented by former public utilities which have been partially privatised (public control still at 51%). This is due to historical reasons as the first installations, built in the ’70-’80 and also in the following 20 years, have been built and operated by utilities companies belonging to municipalities. In the last years, some private companies started to enter the DH market; in many cases they are international companies. In general, the companies involved in DH market, manage the entire supply chain from production to the sale of heat, electricity and gas.
Other important information	N/A
Status of DC	At the end of 2017, there were 32 running DC networks in the country, distributed in 28 municipalities located in 8 Regions in Northern and Central Italy. The total extension of the network was 33,6 km and the total cooled volume reached almost 9 mln of m3. Lombardia Region is, by far, the main involved area as it includes 9 networks, corresponding to 56% of the total National extension and representing 36% of total volume. The second most interested area is Emilia Romagna Region counting 10 DC networks equal to 31% of total extension and representing 28% of the total volume. The contribution to DC in all the other Italian Regions is meaningless or null. The total power installed for DC in Italy is 203,9 MW in 2017 and 205,4 MW in 2018. The development of DC is stationary and there is no meaningful growth expectation

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	in the near future: the unit production cost is high in comparison with other single technology installed directly in buildings and the operating hours of functioning are too limited to justify the installed MW of capacity. The total cooled volume is mainly dedicated to the Tertiary sector (95%).
Support schemes	
Subsidies for DH suppliers	There are some mechanisms mainly based on fiscal benefits: reduced VAT applied on the cost of connection to DH; tax credit for DH investors in case of biomass and geothermal. In case of installation of solar thermal plants connected to the DH, municipalities, private companies and ESCO can have access to the incentive mechanism called “Conto Termico” managed by GSE[52].
Subsidies for customers	Tax deduction on a period of 10 years for residential buildings equal to 36% of the cost incurred for the connection to DH; reduced VAT on the supply of thermal energy for residentials.

[52]https://www.gse.it/documenti_site/Documenti%20GSE/Servizi%20per%20te/CONTO%20TERMICO/REGOLE%20APPLICATIVE/REGOLE_APPLICATIVE_CT.pdf

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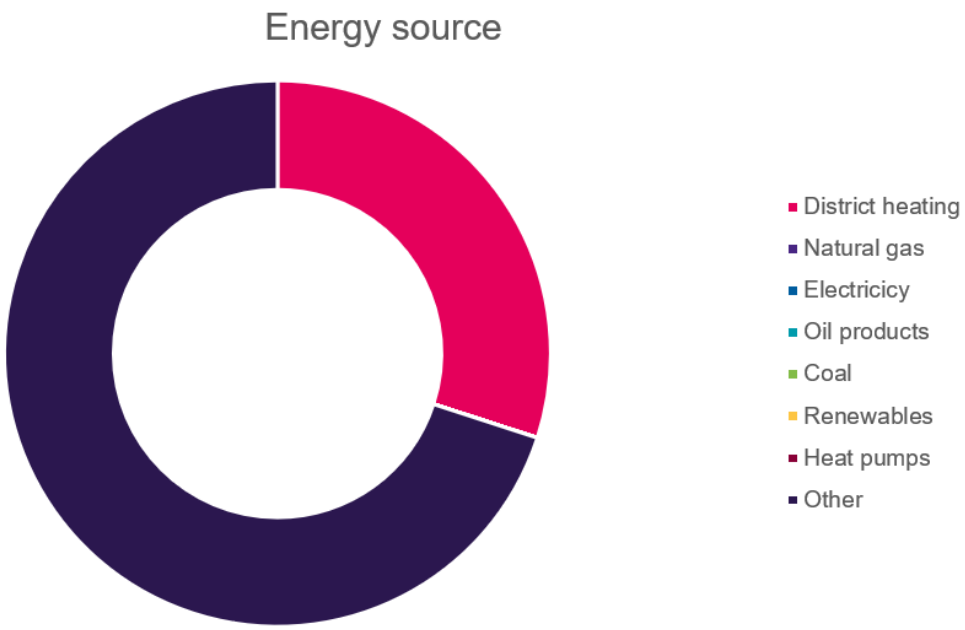
7.46 Latvia

Development of DH				
Category	2013	2015	2017	Unit
Total installed DH capacity	2,639	2,524.4	2,254.2	MW_{th}
Trench length	1700	N/A	N/A	km
District heated floor space	27	N/A	N/A	Million m^2
Average DH price (Excl. VAT)	54	44	36	EUR/MWh
Average DH price (Incl. VAT)	60.5	49.3	40.3	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2017)	
Energy source	Total (in %)
District heating	30
Natural gas	N/A
Electricity	N/A
Oil / Petroleum products	N/A
Coal	N/A
Renewables*	N/A
Heat pumps	N/A
Other**	70



*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal
**Other covers, in this case, all other energy sources

Barriers for further development of DH
A shrinking population leades to fewer potential customers
Big parts of the DH network is more than 25 years old and suffers huge heat losses
Big heat consumers often choose to build their own boiler houses
It is not allowed to offer different prices for DH to bigger potential customers

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The DH network is heavily dependant on natural gas prices, which results in high DH prices due to the fluctuating price of natural gas.

Plans for further development of DH
In general there is no state legislation demanding development of the DH system. Regional and local authorities have created policies that promote CHP and biofuel boilers operating on biomass. The Ministry of Economy intends to create a support scheme for new CHP plants operating on RES.

Objectives for heating
The accumulated energy consumption must decrease by 20,473 GWh from 2021 to 2030

Market structure	
Obligation to connect DH	No
Rules for connecting to and disconnecting from DH	Consumers can choose to disconnect the DH network for other heating sources
Owner of DH companies	Mainly local municipalities and State ownership.
Other important information	Substantial part of the heat in Riga is supplied by the electric utility company Latvenergo.
Status of DC	There is no DC in Latvia

Support schemes	
Subsidies for DH suppliers	In 2009 a feed-in-tariff was introduced, to increase the number of CHP being built
Subsidies for customers	No

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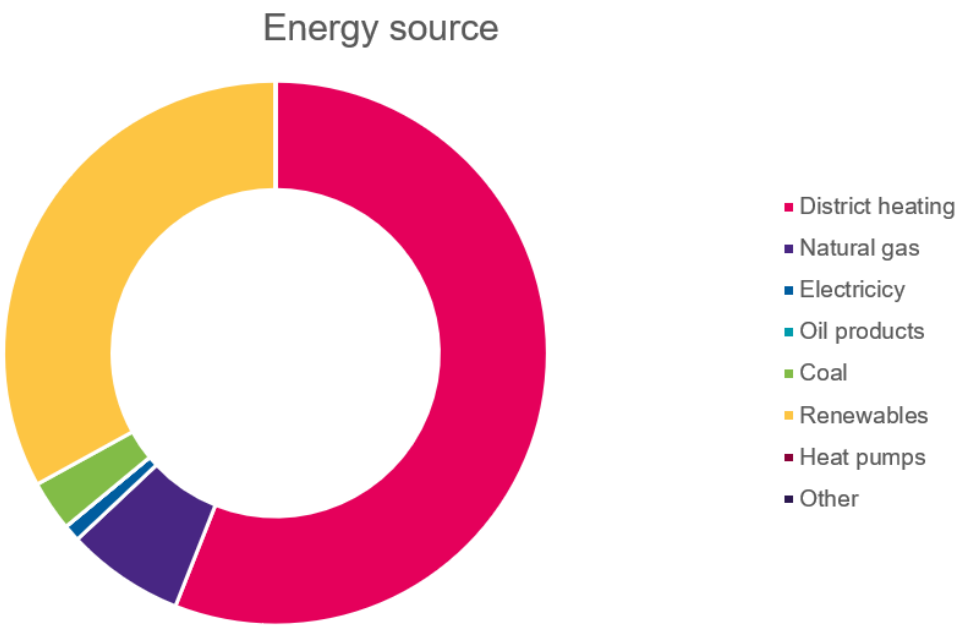
7.47 Lithuania

Development of DH				
Category	**2013**	**2015**	**2017**	**Unit**
Total installed DH capacity	9,920	10,147	8,645	MW_{th}
Trench length	2,565	2,540	2,592	km
District heated floor space	49.5	50.9	51.5	Million m^2
Average DH price (Excl. VAT)	72.4	57.5	47.5	EUR/MWh
Average DH price (Incl. VAT)	78.9	62.7	51.8	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2017)	
Energy source	**Total (in %)**
District heating	56
Natural gas	7
Electricity	1
Oil / Petroleum products	N/A
Coal	3
Renewables*	33
Heat pumps	N/A
Other	N/A



*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal

Barriers for further development of DH

New regulations make it possible for individual heat producers to sell heat directly to customers, where before DH companies could buy it for the DH grid. This can be a financial issue for DH companies.

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Plans for further development of DH

Local biomass in the form of wood in getting used in DH production which makes the DH price cheaper (three times cheaper than natural gas).

Objectives for heating

Lithuania wants to produce all its energy from RES by 2050, with subgoals of 70% in 2020 and 90% in 2030.
In 2050, 90 % of all buildings must be supplied by DH

Market structure

Obligation to connect DH	
Rules for connecting to and disconnecting from DH	Municipalities draw DH zones. If a DH-company is the only one providing in a zone, they must connect everybody who wants to be provided by DH.
Owner of DH companies	90% of the DH companies are owned by the municipalities while the remaining 10% are leased to foreign and domestic investors.
Other important information	DH companies that produced more than 10 GWh are regulated by the National Commission for Energy Control and Prices while smaller heat supply companies are regulated by the municipalities.
Status of DC	DC is not developed in Lithuania.

Support schemes

Subsidies for DH suppliers	
Subsidies for customers	- A reduced VAT rate of 9% to DH-supplied households - Low-income families are being paid compensation by the municipality

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7.48 Luxembourg

Development of DH

Category	2013	2015	2017	Unit
Total installed DH capacity	N/A	N/A	N/A	MW_{th}
Trench length	N/A	N/A	N/A	km
District heated floor space	N/A	N/A	N/A	Million m^2
Average DH price (Excl. VAT)	N/A	N/A	N/A	EUR/MWh
Average DH price (Incl. VAT)	N/A	N/A	N/A	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2017)

Energy source	Total (in %)
District heating	N/A
Natural gas	N/A
Electricity	N/A
Oil / Petroleum products	N/A
Coal	N/A
Renewables*	N/A
Heat pumps	N/A
Other	N/A

*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal

Barriers for further development of DH

N/A

Plans for further development of DH

N/A

Objectives for heating

N/A

Market structure

Obligation to connect DH
Rules for connecting to and disconnecting from DH
Owner of DH companies
Other important information
Status of DC

Support schemes

Subsidies for DH suppliers
Subsidies for customers

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7.49 Malta

Development of DH

Category	2013	2015	2017	Unit
Total installed DH capacity	N/A	N/A	N/A	MW_{th}
Trench length	N/A	N/A	N/A	km
District heated floor space	N/A	N/A	N/A	Million m^2
Average DH price (Excl. VAT)	N/A	N/A	N/A	EUR/MWh
Average DH price (Incl. VAT)	N/A	N/A	N/A	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2017)

Energy source	Total (in %)
District heating	N/A
Natural gas	N/A
Electricity	N/A
Oil / Petroleum products	N/A
Coal	N/A
Renewables*	N/A
Heat pumps	N/A
Other	N/A

*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal

Barriers for further development of DH

N/A

Plans for further development of DH

N/A

Objectives for heating

N/A

Market structure

Obligation to connect DH
Rules for connecting to and disconnecting from DH
Owner of DH companies
Other important information
Status of DC

Support schemes

Subsidies for DH suppliers
Subsidies for customers

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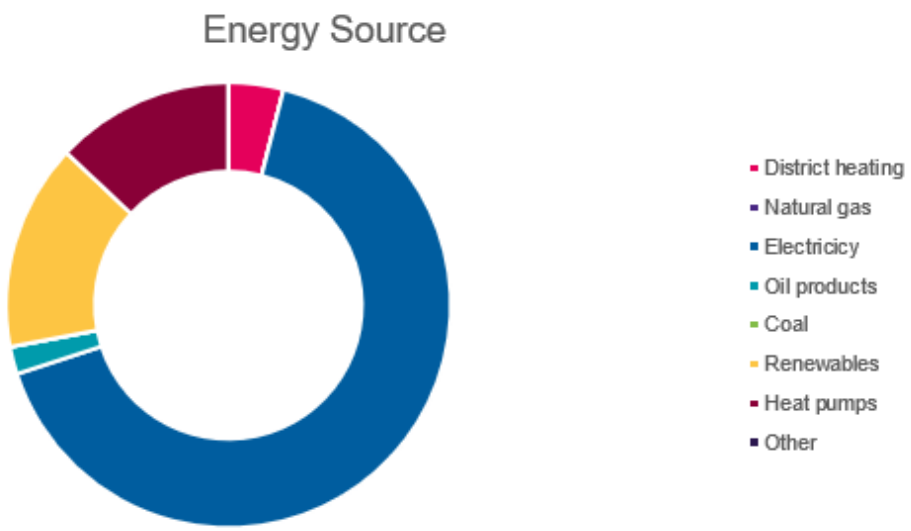
7.50 Norway

Development of DH

Category	2013	2015	2017	Unit
Total installed DH capacity	2,931	3,200	3,400	MW_{th}
Trench length	1,686	1,815	1,905	km
District heated floor space	N/A	N/A	N/A	Million m^2
Average DH price (Excl. VAT)	74	67	73	EUR/MWh
Average DH price (Incl. VAT)	92	83	91	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2017)

Energy source	Total (in %)
District heating	4
Natural gas	0
Electricity	66
Oil / Petroleum products	2
Coal	0
Renewables*	15
Heat pumps	13
Other	0



*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal

Barriers for further development of DH

There is a poor network of in-house waterbourne systems which makes is difficult to connect new customers to DH networks.
The Breeam systems favours on-site energy systems rather than DH.
DH is not a widely know or used concept in Norway.

Plans for further development of DH

Geothermal heat, large-scale HPs and hydropower are technologies which will be used in the future to provide DH in the future.

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Objectives for heating

N/A

Market structure

Obligation to connect DH	It is an obligation to connect to DH, if a building is located inside a DH area and has a waterbourne system.
Rules for connecting to and disconnecting from DH	
Owner of DH companies	
Other important information	Fossil fuels will be banned in buildings from 2020, and in industrial process it will be banned by 2023.
Status of DC	DC has been expanding the last couple of years in Norway. In 2017, 70 km trench and a capacity og 160 MW was installed.

Support schemes

Subsidies for DH suppliers
Subsidies for customers

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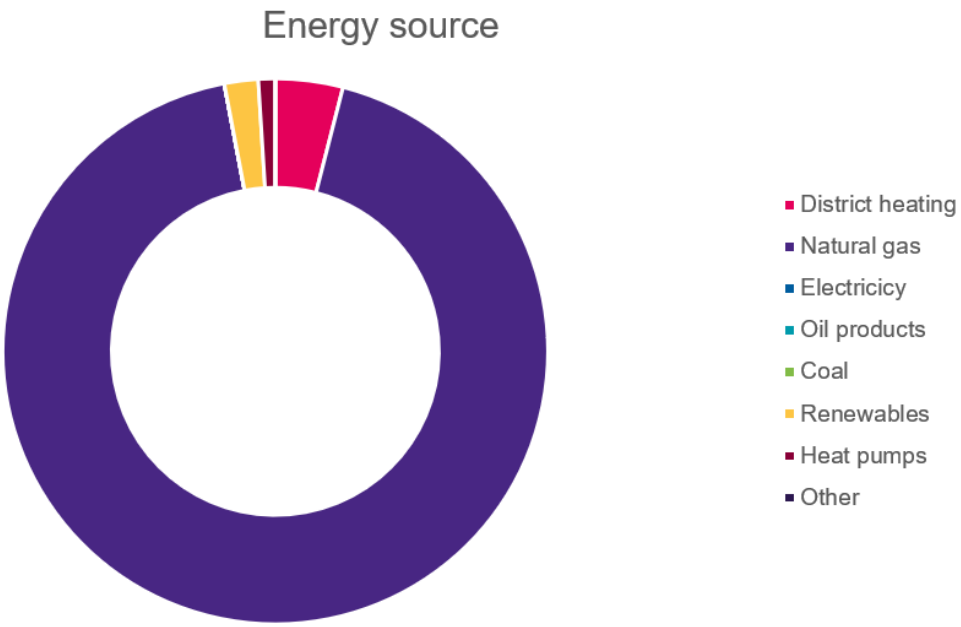
7.51 The Netherlands

Development of DH				
Category	**2013**	**2015**	**2017**	**Unit**
Total installed DH capacity	5,850	N/A	N/A	MW_{th}
Trench length	4,000	N/A	N/A	km
District heated floor space	41	N/A	N/A	Million m^2
Average DH price (Excl. VAT)	69.8	N/A	N/A	EUR/MWh
Average DH price (Incl. VAT)	84.4	N/A	N/A	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2013)	
Energy source	**Total (in %)**
District heating	4
Natural gas	93
Electricity	N/A
Oil / Petroleum products	N/A
Coal	N/A
Renewables*	2
Heat pumps	1
Other	N/A



*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal

Barriers for further development of DH

DH is competing with natural gas which has the majority market share because the Netherlands has a huge domestic reserve.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

Plans for further development of DH

N/A

Objectives for heating

N/A

Market structure

Obligation to connect DH
Rules for connecting to and disconnecting from DH
Owner of DH companies
Other important information
Status of DC

Support schemes

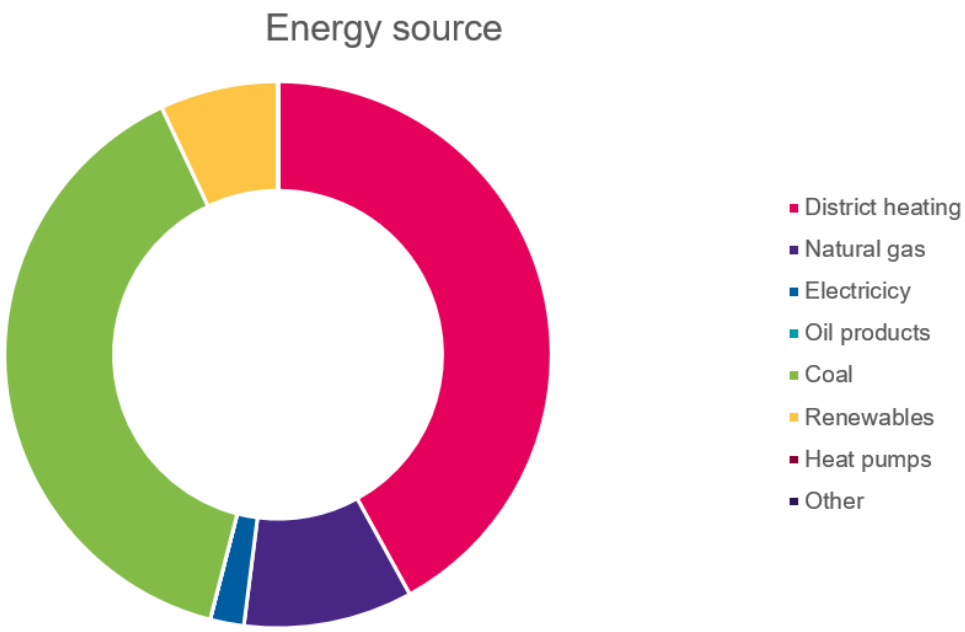
Subsidies for DH suppliers
Subsidies for customers

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°857801

7.52 Poland

Development of DH				
Category	**2013**	**2015**	**2017**	**Unit**
Total installed DH capacity	56,521	56,049	54,912	MW_{th}
Trench length	20,139	20,456	21,085	km
District heated floor space	266	312	390	Million m^2
Average DH price (Excl. VAT)	44.6	49.8	47.9	EUR/MWh
Average DH price (Incl. VAT)	54.9	61.2	58.9	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2017)	
Energy source	**Total (in %)**
District heating	42
Natural gas	10
Electricity	2
Oil / Petroleum products	N/A
Coal	39
Renewables*	7
Heat pumps	N/A
Other	N/A



*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal

Barriers for further development of DH

The tariff approval system limits the justification of cost for modernizing and extending the DH network.
High investment cost and low certainty, that customer remains connected*.
Lack of subsidy if a system is not efficient (defined in EED 2018/2002)*.

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New installation may collide with existing one (mostly large cities)*.

Plans for further development of DH

Extension and enhancement of efficiency of existing DH and building new DH and DC.
85 % of DH and DC, that power exceeds 5 MW is to be efficient by 2030. Following measures will be applied* **:
- Substitution of conventional heating with CHP
- Increase of RES share. It should grow 1.1 % annually
- Increase of waste usage in heat production (CHP mostly)
- Popularization of TES and smart DH systems
- Extension of obligation to DH connection and implementation of enforcement mechanism

70 % of all household is to be connected to DH (if DH is available) by 2030. In 2015 it was 61 %.* **
Enhancement of heat distribution efficiency. In 2018 average distribution efficiency for whole country was 86.6 % ***

Objectives for heating

Change of heat market policy - modification of heat price regulation mechanism, introduction of reference price and stimulus to the optimization of heat distribution cost*
Change of Energy Law in scope of responsibilities of local governments for heat, energy and gas distribution planning*
Development of national map of heat for planning purpose*
To reach 21 % of all energy coming from RES (gross) by 2030. It is predicted that RES share for heating should grow by 1.1 % annually*
Realization of commitments included in Directive 2009/29/EC *
Development of district cooling (both standalone and combined with heating)*

*'Energy Policy of Poland until 2040', Ministry of Economy, 2019
**'National Plan for Energy and Climate for years 2021-2030', Ministry of Energy, 2019
***'Heating Energy in Numbers – 2018', Energy Regulatory Office, 2019

Market structure

Obligation to connect DH	No, if one of following is met*: - DH or local heat source is already installed; - There is no technical condition to connect to DH; - Heat price in DH is higher or equals average price defined by Energy Regulatory Office; - Non-renewable primary energy factor does not exceed 0.8 for heat produced in the building; - HP or electrical heating is used; - DH is not efficient (DH is efficient if: 50 % of heat comes from RES, or 50 % of heat comes from waste, or 75 % of heat comes from CHP).
Rules for connecting to and disconnecting from DH	- Charge for installation is based on tariff which is depending on average annual investment, nominal power, connection length and its type; - There are no rules that regard disconnecting. If there is no obligation (specified above), DH might be disconnected.*

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Owner of DH companies	Mostly Limited Liability Companies, but also joint-stock companies, and a few local authorities and housing cooperatives.*
Other important information	DH companies must purchase heat produced from waste (such as biomass) and RES (n/a to multi-fuel combustion other than high-efficiency CHP), if: - Amount of purchased heat does not exceed total demand of customers; - The price is not higher than average, increased by an average annual consumer price index (if nonnegative); - DH system is not effective*.
Status of DC	No data on existing DC.

*KAPE

Support schemes	
Subsidies for DH suppliers	- 'District heating – pilot programme' - up to 50% subsidy for modernization or building new heat, CHP or geothermal plant, if local governments has at least 70 % shares of the company; - Goverments subsidies are given for CHP if a certain amount of electrical power is installed*.
Subsidies for customers	Subsidies are given for installing technology of heat usage to increase energy efficiency and reduce pollution.*

*KAPE

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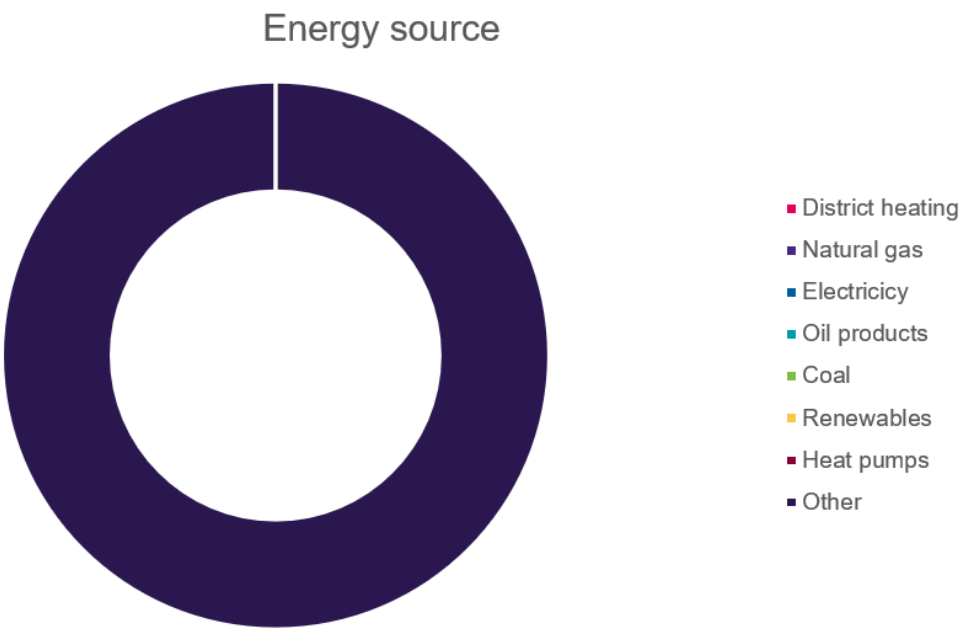
7.53 Portugal

Development of DH				
Category	**2013**	**2015**	**2017**	**Unit**
Total installed DH capacity	34	34	34	MW_{th}
Trench length	24	24	24	km
District heated floor space	N/A	N/A	N/A	Million m^2
Average DH price (Excl. VAT)	N/A	N/A	N/A	EUR/MWh
Average DH price (Incl. VAT)	N/A	N/A	N/A	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2017)	
Energy source	**Total (in %)**
District heating	0
Natural gas	0
Electricity	0
Oil / Petroleum products	0
Coal	0
Renewables*	0
Heat pumps	0
Other**	100



*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal
**Other covers, in this case, all other energy sources

Barriers for further development of DH

No culture for DH in Portugal and it is almost not existing

Plans for further development of DH

No

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Objectives for heating
N/A

Market structure	
Obligation to connect DH	No
Rules for connecting to and disconnecting from DH	
Owner of DH companies	
Other important information	
Status of DC	DC is found in the bigger of the two DH-networks in Portugal. Total installed capacity of 40 MWth.

Support schemes
Subsidies for DH suppliers
Subsidies for customers

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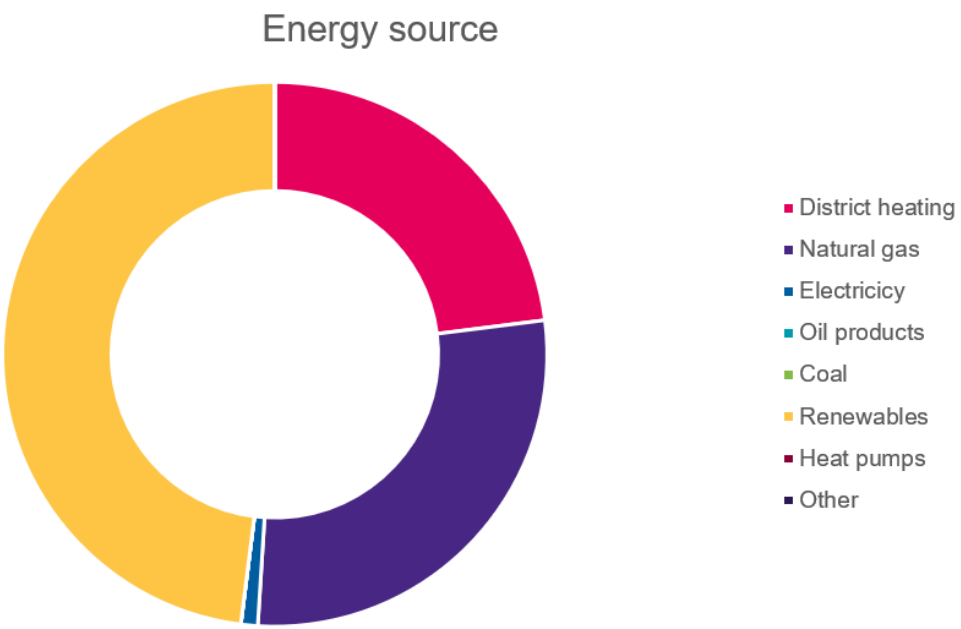
7.54 Romania

Development of DH				
Category	**2013**	**2015**	**2017**	**Unit**
Total installed DH capacity	10,480	9,962	N/A	MW_{th}
Trench length*	9,159	8,974	N/A	km
District heated floor space*	65.5	61.4	56.8	Million m^2
Average DH price (Excl. VAT)*	35	N/A	38.1	EUR/MWh
Average DH price (Incl. VAT)*	43.4	N/A	47.1	EUR/MWh

**Cristi Ionescu,*

Distribution of energy sources used to satisfy heat demand in residential sector (2015)	
Energy source	**Total (in %)**
District heating	23
Natural gas	28
Electricity	1
Oil / Petroleum products	0
Coal	0
Renewables*	48
Heat pumps	0
Other	0



*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal

Barriers for further development of DH

A support scheme for promoting highly efficient cogeneration units will end in 2023 which leaves no one to invest in new power plants.
Romania faces an over-capacity of energy since a support scheme made it attractive to produce renewable electricity and the consumption is decreasing.

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Plans for further development of DH

Both national plans and local strategies are made to expand the DH system in Romania*

Objectives for heating

It is wished to increase the share of renewable energy in the final energy consumption to 24% in 2020.**
Improving the efficiency in cogeneration units and the energy efficiency of DH supply systems.*
* *Cristi Ionescu,*
**https://unfccc.int/sites/default/files/6th_nccc_and_1st_br_of_romania%5B1%5D.pdf

Market structure

Obligation to connect DH	No.
Rules for connecting to and disconnecting from DH	There are only rules for disconnecting from the DH network which is set individually by each DH company.*
Owner of DH companies	DH systems are mainly operated by public entities.
Other important information	
Status of DC	DC is not found in Romania.

**Cristi Ionescu,*

Support schemes

Subsidies for DH suppliers	Support schemes for promoting highly efficient cogeneration units will end in 2023.
Subsidies for customers	The removal of subsidies for heating fuel has impacted the consumer bills by up to 30-50%.

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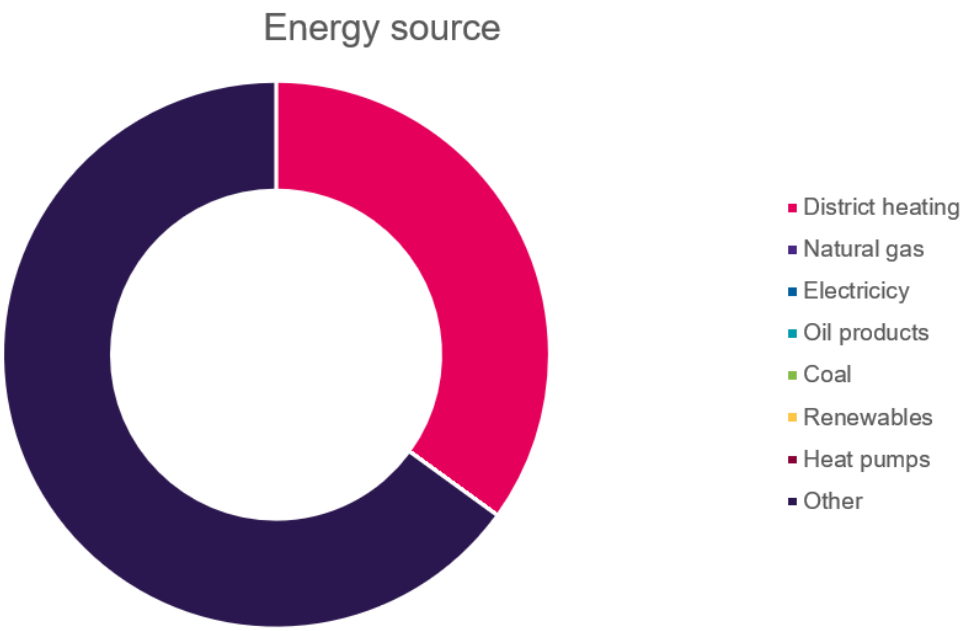
7.55 Slovakia

Development of DH				
Category	**2013**	**2015**	**2017**	**Unit**
Total installed DH capacity	15,793	N/A	N/A	MW_{th}
Trench length	4,984	N/A	2803	km
District heated floor space	49	N/A	N/A	Million m^2
Average DH price (Excl. VAT)	82.9	81.1	N/A	EUR/MWh
Average DH price (Incl. VAT)	99.5	97.3	N/A	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2017)	
Energy source	**Total (in %)**
District heating	53
Natural gas	0
Electricity	0
Oil / Petroleum products	0
Coal	0
Renewables*	0
Heat pumps	0
Other**	47



*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal
**Other covers, in this case, all other energy sources

Barriers for further development of DH

Most of the distribution system is 15-30 years old which has made it inefficient with huge heat loss
DH prices are over-regulated which can remove incentives to invest/optimize the DH system

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Long-term return on investment demands and lack of financial mechanism increases the difficulty of securing capital for modernization of the centralized heating system.

Plans for further development of DH

According to the 2014 Energy Plan the Ministry of Economy intends to create support schemes for investment in systems operating on RES, regulations so that electrical utilities move towards Co-generation plants operating on biomass, and to refurbish the existing distribution network.

Objectives for heating

Slovakia will focus on sustainable heat supply (both economic and sustainable)
The 2014 Energy Policy from the MoE states that in terms of the thermal energy issues, the objective is to increase the share of heat that is derived from local RES as well as improving the efficiency of the heating production and distribution. Further objectives are to develop efficient DH systems.

Market structure	
Obligation to connect DH	No
Rules for connecting to and disconnecting from DH	In order to disconnect certain conditions must be present. Firstly the customer and supplier must agree to switch. Secondly if the supplier does not fulfill essential criteria for heat supply, and finally the alternative heat supply must have a share of renewable energy that is 20% higher than the the share in the DH network.
Owner of DH companies	There are both private and public owned DH companies
Other important information	Heat consumers cannot choose between energy supplier - monopoly
Status of DC	DC is underdeveloped in Slovakia, currently limited to newer residential and industrial projects.

Support schemes

Subsidies for DH suppliers	
Subsidies for customers	No

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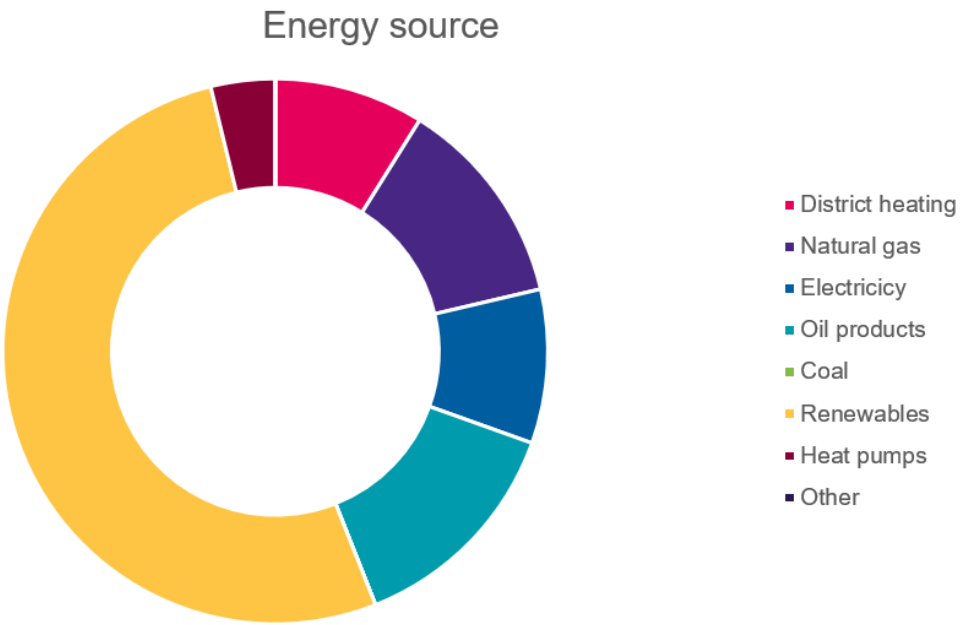
7.56 Slovenia

Development of DH				
Category	**2013**	**2015**	**2017**	**Unit**
Total installed DH capacity	2.276	1,677	1,739	MW_{th}
Trench length	753	861	893	km
District heated floor space	8,469	6,945	7,118	Million m^2
Average DH price (Excl. VAT)	47.7	62.6	59.9	EUR/MWh
Average DH price (Incl. VAT)	57.8	76.3	73.0	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2017)	
Energy source	**Total (in %)**
District heating	8.9
Natural gas	12.4
Electricity	9.1
Oil / Petroleum products	13.5
Coal	0
Renewables*	52
Heat pumps	3.8
Other	0



*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal

Barriers for further development of DH

Competing support schemes sometimes down-prioritize DH.

Plans for further development of DH:
Slovenia has developed a long term energy strategy, refered to as Energy Concept of

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Slovenia(ECS) with the intention of securing a reliable, sustainable and competitive energy sector.

A strategy for DHC has been developed, and is to be used as a guideline for developing efficient DHC networks and CHP usage. This has been performed on the basis of comprehensive spatial analysis and cost benefit analysis. To assist national and local project developers the 'Heat Map of Slovenia' is being developed, which contains relevant information on buildings, energy infrastructure, energy systems, demand etc.

Programmes for co-financing the construction and expansion of DH systems are made available if the DH companies plan to have the heat generation plants operating on RES.

Objectives for heating
Increase share of CHP and biomass boilers for heating demand. Ensure effective DH systems by demanding an obligatory share of heat deriving from RES. Utilize waste heat in the larger urban areas. Increase energy efficiency by refurbishment of existing networks and lowering of return temperatures of the network.

Market structure	
Obligation to connect DH	No.
Rules for connecting to and disconnecting from DH	
Owner of DH companies	DH can be both owned privately and publicly.
Other important information	The price for DH is regulated.
Status of DC	DC can only be found in Velenje and no development is seen in the rest of the country.

Support schemes	
Subsidies for DH suppliers	Yes, if heat producers supply heat deriving from RES, CHP or waste heat.
Subsidies for customers	Not known.

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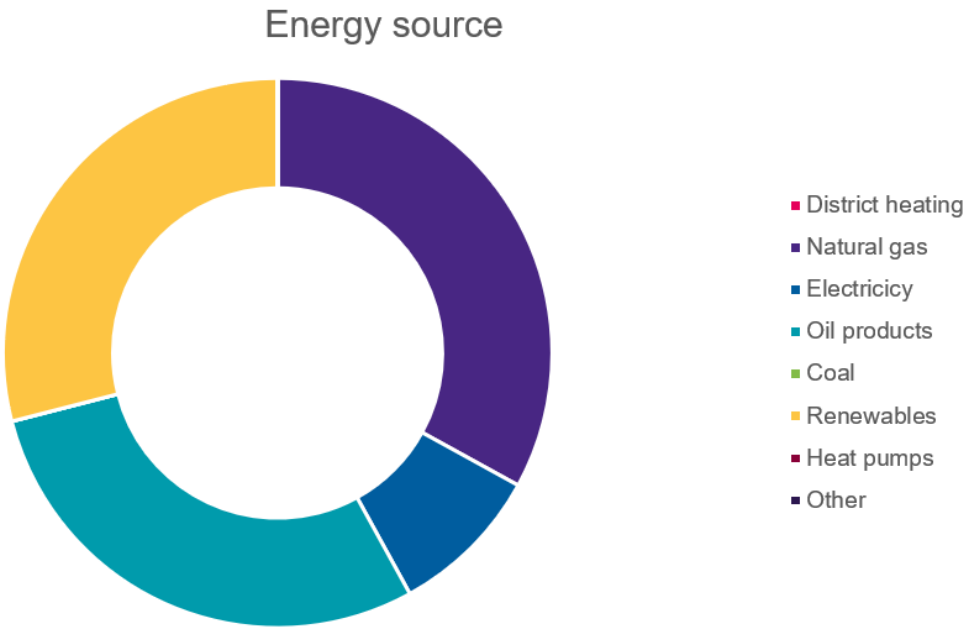
7.57 Spain

Development of DH				
Category	**2013**	**2015**	**2017**	**Unit**
Total installed DH capacity	839	1,132	1,273	MW_{th}
Trench length	215	304	594	km
District heated floor space	5	7	8.5	Million m^2
Average DH price (Excl. VAT)	N/A	N/A	50	EUR/MWh
Average DH price (Incl. VAT)	N/A	N/A	65.34	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2017)	
Energy source	**Total (in %)**
District heating**	0
Natural gas	33
Electricity	9
Oil / Petroleum products	29
Coal	0
Renewables*	29
Heat pumps	0
Other	0



*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal
**Data for DH is not included in this graph

Barriers for further development of DH

No legislative framework for DH.
An opposition of change and new technologies in sector by citizens.
Municipalities have little finicial capacity to develop DH.

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Plans for further development of DH

DHC census estimate that in the upcoming years private and joint ventures initiatives will duplicate the existing number of DHC.

Objectives for heating

To reduce emissions by increasing the rate of renewable energy in Spain's energy pool.

Market structure

Obligation to connect DH	None.
Rules for connecting to and disconnecting from DH	No specialized framework. According to the construction and operations licenses of each municipality and/or company's contract.
Owner of DH companies	Approximately 53% are owned by the public institutions, 44% private companies, and 3% by joint ventures.
Other important information	
Status of DC	There is no DC in Spain. It is mostly electric chillers that are used.

Support schemes

Subsidies for DH suppliers	Clima Project. Feder fundings. Efficient energy solutions subside (per municipality).
Subsidies for customers	None.

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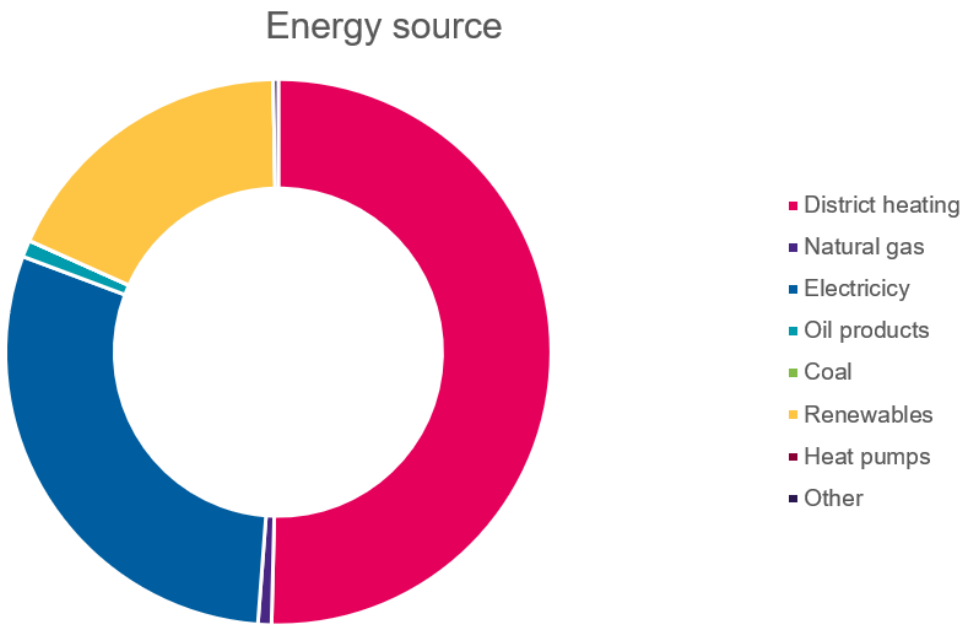
7.58 Sweden

Development of DH				
Category	**2013**	**2015**	**2017**	**Unit**
Total installed DH capacity	N/A	N/A	N/A	MW_{th}
Trench length	23,667	N/A	N/A	km
District heated floor space	N/A	N/A	N/A	Million m^2
Average DH price (Excl. VAT)	75.4	71.1	69.7	EUR/MWh
Average DH price (Incl. VAT)	94.3	88.9	87.1	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2017)	
Energy source	**Total (in %)**
District heating	50.4
Natural gas	0.8
Electricity	29.5
Oil / Petroleum products	1
Coal	0
Renewables*	18
Heat pumps	0
Other	0.3



*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal

Barriers for further development of DH

In mostly bigger cities, the market is saturated.
Electricity prices are low, which makes individual HPs compete with DH.

Plans for further development of DH

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High urbanization growth the potential market for DH

Objectives for heating
In the long term, Sweden will have 100% renewable energy*
*https://www.regeringen.se/pressmeddelanden/2015/09/regeringen-investerar-for-klimatet/

Market structure	
Obligation to connect DH	It is not obligated to connect to DH. In rare cases, the municipality can choose to obligatenew buildings to connect to the DH network.*
Rules for connecting to and disconnecting from DH	When DH companies change the price, consumers have the right to terminate their contract if no solution to negotiation is found
Owner of DH companies	In most cases, DH companies arr public companies and fully owned by the municipalities. In some cases, half of the companies are private owned.*
Other important information	
Status of DC	Sweden has the biggest DC market in Europe and in 2018, almost 1,800 GWh DC was supplied

*Mattias Vester, ICE

Support schemes	
Subsidies for DH suppliers	No
Subsidies for customers	No

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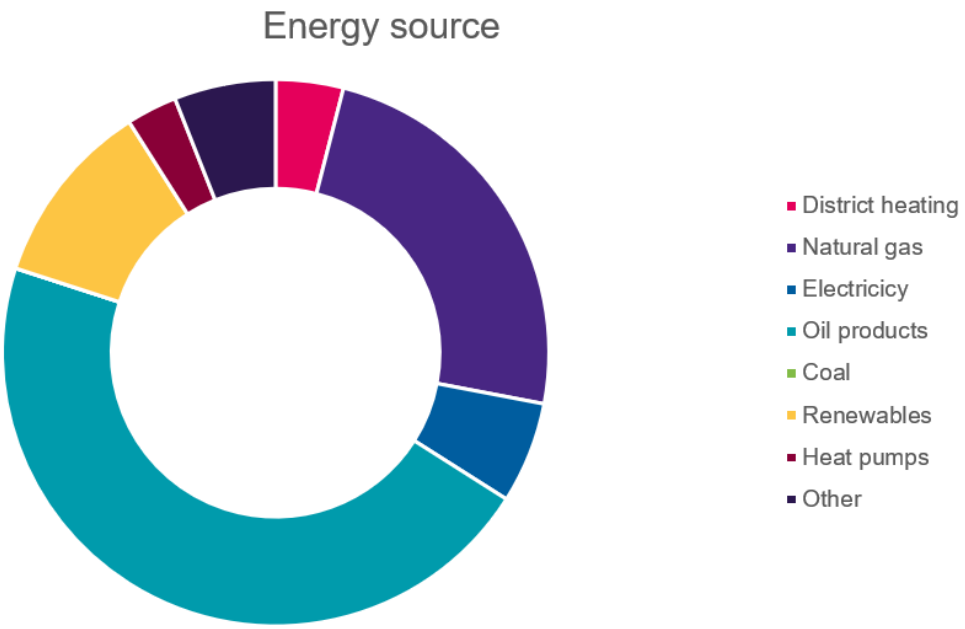
7.59 Switzerland

Development of DH				
Category	**2013**	**2015**	**2017**	**Unit**
Total installed DH capacity	2,466	2,792	N/A	MW_{th}
Trench length	1,432	1,468	N/A	km
District heated floor space	19	21.2	N/A	Million m^2
Average DH price (Excl. VAT)	61.01	70.73	N/A	EUR/MWh
Average DH price (Incl. VAT)	66.40	76.88	N/A	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2015)	
Energy source	**Total (in %)**
District heating	4
Natural gas	24
Electricity	6
Oil / Petroleum products	46
Coal	0
Renewables*	11
Heat pumps	3
Other	6



*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal

Barriers for further development of DH

Natural gas boilers replace fossil fuels in homes instead of DH because there is a more developed natural gas network.
DH is more expensive than fossil fuels and natural gas.

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Plans for further development of DH

N/A

Objectives for heating

N/A

Market structure

Obligation to connect DH	
Rules for connecting to and disconnecting from DH	
Owner of DH companies	
Other important information	
Status of DC	There is no DC in Switzerland.

Support schemes

Subsidies for DH suppliers	
Subsidies for customers	

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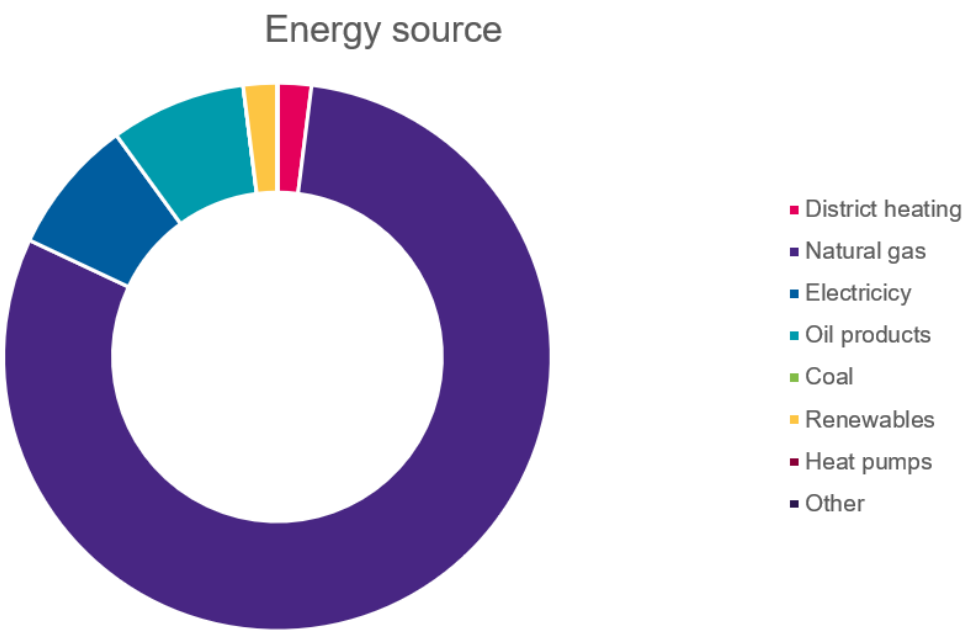
7.60 United Kingdom

Development of DH				
Category	**2013**	**2015**	**2017**	**Unit**
Total installed DH capacity	335	N/A	N/A	MW_{th}
Trench length	308	N/A	N/A	km
District heated floor space	N/A	N/A	N/A	Million m^2
Average DH price (Excl. VAT)	N/A	N/A	N/A	EUR/MWh
Average DH price (Incl. VAT)	N/A	N/A	N/A	EUR/MWh

Distribution of energy sources used to satisfy heat demand in residential sector (2013)	
Energy source	**Total (in %)**
District heating	2
Natural gas	80
Electricity	8
Oil / Petroleum products	8
Coal	0
Renewables*	2
Heat pumps	0
Other	0



*Renewables include wood pellets, wood chips, biomass, firewood, geothermal, solar thermal

Barriers for further development of DH

The market is highly dominated by natural gas.
The lack of regulation results in DH customers to pay higher taxes compared to other energy sources.

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Plans for further development of DH

N/A

Objectives for heating

In 2050 the British government has committed to reaching net-zero. Therefore, they has set a target that 17% of heat must come be produced as DH.

Market structure

Obligation to connect DH	
Rules for connecting to and disconnecting from DH	
Owner of DH companies	
Other important information	
Status of DC	No DC in the United Kingdom.

Support schemes

Subsidies for DH suppliers
Subsidies for customers

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