New Clean Energy Communities in a Changing European Energy System (NEWCOMERS)

Deliverable D3.1

Description of polycentric settings in the partner countries

Version: 1.1

WP 3

Authors: Jenny Palm, Katharina Reindl, Stephan Sommer, Sarah Darby, Nicolien van der Grijp, Laura-Charlotte Kaatz, Gaetano Maggio, Maša Mlinarič, Luka Nagode, Agatino Nicita, Gaetano Squadrito

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 837752.

Document information

Delivery Type	Report
Deliverable Number	D3.1
Deliverable Title	Description of polycentric settings in the partner countries
Due Date	29 May 2020
Submission Date	31 May 2020
WP/Task related	T3.1
Work package leader	Jenny Palm
Author(s)	Jenny Palm, Katharina Reindl, Stephan Sommer, Sarah Darby, Nicolien van der Grijp, Laura-Charlotte Kaatz, Gaetano Maggio, Maša Mlinarič, Luka Nagode, Agatino Nicita, Gaetano Squadrito,
Name (Partner organisation)	Lund University (LU)
Reviewer(s)	Stephan Sommer (RWI) Anna Svantesson (external)
Keywords	Polycentric setting; energy system, electricity system, heating system, emissions, country comparison
Dissemination level	Public
Project coordinator	Julia Blasch (VUA)
Project manager	Ruud van Ooijen (VUA)
Contact details	Ruud van Ooijen r.van.ooijen@vu.nl

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 837752.

Revisions

Version	Date	Author	Status
1.0	20 May 2020	Jenny Palm et al.	First draft
1.1	28 May 2020	Jenny Palm et al.	Final version

Reviews

Version	Date	Reviewer	Review Title
1.0	25 May 2020	Stephan Sommer	Review 1
1.0	25 May 2020	Anna Svantesson	Review 2

Statement of originality:

This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

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TABLE OF CONTENTS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 837752.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 837752.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 837752.

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Figures and Tables

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Abbreviations

Abbreviation	Explanation and translation
AEEGSI	The regulatory body Regulatory Authority for Electricity, Gas and Water, Autorità per l'Energia Elettrica, il Gas e il Sistema Idrico (Italy)
AU	Acquirente Unico, a subsidiary of Gestore dei Servizi Elettrici (Italy)
Autorità Garante della Concorrenza e del Mercato	The Competition Authority (Italy)
BEIS	Department for Business, Energy and Industrial Strategy United Kingdom)
Bioenergiedörfer	Bio Energy Villages (Germany)
BMU	The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germany)
BMWi	The Federal Ministry for Economic Affairs and Energy (Germany)
Bundesnetzagentur	The federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway (Germany)
Bundesrat	Federal council (Germany)
Bundestag	Federal parliament (Germany)
Bürgerenergie	Community energy or citizen energy (Germany)
c/kWh	Euro cents per kilowatt-hour
CBS	Statistics Netherlands
CCA	Climate Change Agreements (United Kingdom)
CCC	Committee on Climate Change (United Kingdom)
CCL	Climate Change Levy (United Kingdom)
CFD	Contracts for difference (United Kingdom)
CHP	Combined Heat and Power
CIPE	Inter-Ministerial Committee for Economic Planning (Italy)
CO2	Carbon dioxide
CPF	Carbon Price Floor
CPS	Carbon Price Support
CTE	The Inter-Ministerial Technical Committee for Emissions of GHGs (Italy)
DE	Germany
DENA	The German Energy Agency
DH	District heating
DNOs	Distribution network operators

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DSO	Distribution System Operators
E.ON	German electric utility company
ECS	Energy Concept of Slovenia
EDF	Électricité de France
EEC(s)	Energy Efficiency Certificate(s), called "certificati bianchi (Italy)
EEG	The Renewable Energy Sources Act (Germany)
ELES	A state-owned electricity transmission company of Slovenia, Elektro-Slovenija, ELES d.o.o.
EMR	Electricity Market Reform (United Kingdom)
EnBW	Energie Baden-Württemberg AG, publicly traded electric utilities company (Germany)
Energie Van Ons	'Energy owned by us' (the Netherlands)
Energiegenossenschaften	Energy cooperatives (Germany)
Energiekamer	The Dutch Office for Energy Regulation
Energiewende	German for energy transition
Energy intensity	Energy intensity is a measures of a nations the energy (in-) efficiency. It is measured with primary energy and GDP, namely the amount of energy used per unit of gross domestic product (GDP).
EPC(s)	Energy performance contract(s) (Germany)
ESD	Effort Sharing Decision (Germany)
ESO	Electricity System Operator
ETS	Emissions Trading System
EU	European Union
EU ETS	EU Emissions Trading System
EUR	Euro €
EV(s)	Electric vehical(s)
FiTs	Feed-in tariffs
GBP	Pound, £
GDP	Gross domestic product
GDP per capita ($)	Gross domestic product by its total population
GDP PPP	Gross domestic product based on purchasing power parity
GHG(s)	Greenhouse gas(es)
GJ	Gigajoule
GME	Gestore dei Mercati Energetici. The electricity marker operator (Italy)
GSE	Gestore dei Sistemi Energetici. A publicly owned company (Italy)

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GW	Gigawatt
GWh	Gigawatt hour
HSE	Holding slovenske elektrarne (Slovenia)
IAD	Institutional analysis and development framework
IEA	International Energy Agency
IGCC	The International Grid Control Co-operation
ISPRA	Institute for Environmental Protection and Research (Italy)
IT	Italy
Klimaat en Energieverkenning	Annual climate and energy outlook report (the Netherlands)
Klimaatplan	Climate policy plan (Germany)
Klimaschutzplan	Climate protection plan (Germany)
klimatklivet	Climate Leap (Sweden)
km2	Square kilometres
Ktoe	Thousand tonnes of oil equivalent
KVA	Kilovolt amperes
kW	Kilowatt
kWh	Kilowatt-hour
Länder	States (Germany)
LPG	Liquefied petroleum gas
LULUCF	Land use, land-use change, and forestry (Germany)
MATTM	The Ministry for the Environment, Land and Sea, Ministero dell'Ambiente e della Tutela del Territorio e del Mare (Italy)
Mercato di maggior tutela	The local DSO provide electricity according to a 'standard offer' regime (Italy)
Ministero dell'Economia e delle Finanze	Ministry of the Economy and Finance (Italy)
MSE	Ministry of Economic Development, Ministero dello Sviluppo Economico (Italy)
Mt	Million tonnes
MtCO2	Million tonnes of carbon dioxide
MtCO2-eq	Metric tons of carbon dioxide equivalent
MTE	Electricity market (Italy)
Mtoe	Million tonnes of oil-equivalent
MW	Megawatt
Mwe	Megawatt electric
MWth	Megawatt thermal
NAP	National Adaption Strategy (Slovenia)

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NAPE	National Action Plan on Energy Efficiency (Germany)
NECP	National Energy and Climate Plan (the Netherlands)
NEEAPs	The National Energy Efficiency Action Plans (Italy)
NES	National Energy Strategy (Italy)
NEWCOMERS	New Clean Energy Communities in a Changing European Energy System
NG	National grid
NGESO	National Grid Electricity System Operator (United Kingdom)
NGL	Natural Gas Liquids
NGO	Non-Governmental Organisation
NL	The Netherlands
NTC	Net transfer capabilities
Ofgem	Office of Gas and Electricity Markets (United Kingdom)
om nieuwe energie	Making the change to new energy (the Netherlands)
Participatiecoalitie	Participation Coalition
PBL	Netherlands Environmental Assessment Agency
PCE	Energy Accounts Platform, Piattaforma conti energia (Italy)
PJ	Petajoule
Politecnico di Milano	Polytechnic University of Milan is the largest technical university in Italy
postcoderoosregeling	The postal code scheme (the Netherlands)
PPP	Purchasing power parity
Protocol Monitoring Energiebesparing	Dutch protocol for monitoring energy saving
PV	Photovoltaics
R&D	Research and development
RED	Renewable Energy Directive
ReECS Motion	The Resolution on the Energy Concept of Slovenia
REGO	Renewable Energy Guarantees of Origin (United Kingdom)
RES	Renewable Energy Source(s)
RO	Renewable Obligations
ROCs	Renewables Obligation Certificates (United Kingdom)
ROT	ROT is a collective term for measures to renovate and upgrade existing residential properties (Sweden)
RVO	The Netherlands Enterprise Agency (Rijksdienst voor Ondernemend Nederland)
salderingsregeling	The net metering scheme (the Netherlands)

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SDE +	The Sustainable Energy Transition Scheme (the Netherlands)
SE	Sweden
SI	Slovenia
SODO	A state-owned company, SODO, d.o.o., supervises the electricity distribution system (Slovenia)
StBA	Federal Statistical Office (Germany)
Svenska kraftnät	The Swedish National Grid
TFC	Total final consumption
TFC	Total Final Consumption
Toe	Tonne of oil equivalent, defined as 107 kilocalories (41.868 gigajoules)
TPES	Total primary energy supply
TSO	Transmission System Operator
TWh	Terawatt-hour
UBA	Federal Environment Agency (Germany)
UK	United Kingdom
USD	US Dollar
Wet onafhankelijk netbeheer	The 2006 Network Unbundling Act (the Netherlands)
WP	Work package

1 EXECUTIVE SUMMARY

This deliverable maps the prevailing polycentric settings of six studied countries. The studied countries are the partner countries for the NEWCOMERS project, i.e. Germany, Italy, the Netherlands, Slovenia, Sweden and the United Kingdom. In this report, the countries' polycentric settings will be described in relation to the polycentric framework developed in WP 2, with specific focus on the technical system and actors. The factors in focus for the country descriptions are socio-economic conditions, technical system (electricity and heat), institutional arrangements as well as actors. Additionally, a description of energy communities in each country is presented, showing different developments in this area.

The research was conducted through a desktop research. Existing literature, reports as well as statistical information were gathered and then organised according to the factors chosen.

The aim in this delivery is to describe and understand the national polycentric settings as a first step to understand the emergence of new forms of energy communities. This deliverable is the basis for delivery 3.2, which will compare different polycentric national settings and delivery 3.3, which will evaluate what forms of energy communities work best in different polycentric setting and what are the potentials for learning between different polycentric settings.

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2 INTRODUCTION

The NEWCOMERS project aims to explore how new clean energy communities develop as well as under which polycentric settings energy communities evolve and under what conditions such initiatives are supressed. At a national level, the project will assess regulatory, institutional and social conditions, which support the emergence of new clean energy communities. The NEWCOMERS project applies a polycentric framework developed in WP 2[1] when analysing conditions in a country, which influence the emergence of new clean energy communities.

In the NEWCOMERS project research is carried out in six European Union Members states (NL, SE, UK, DE, IT, SI).These countries were selected because they differ in aspects, which can be assumed to be relevant for the presence of energy communities, such as energy generation, regulations, organisation of the electricity market and diversity of actors. In this report, the six different countries are described in relation to the polycentric framework developed in WP 2.

WP 2, deliverable 2.1, defines an analytical framework of the polycentric settings for our six studied countries, which is the institutional analysis and development framework (IAD).[2]

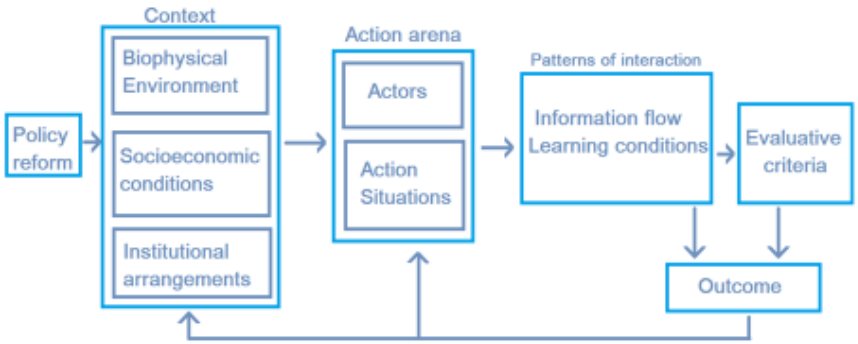

Figure 2.1 The institutional analysis and development framework (IAD)

In this report, the focus will be on the boxes related to context and action arena in order to describe the different (polycentric) settings in the six studied countries (see figure 2.1). In relation to context, the biophysical environment has been adapted to the energy field and instead of discussing it in terms of biophysical environment, we will describe the characterisation of the technical systems in the countries. Concerning the action arena, the focus in this report will be on the first box, namely actors. Thus, based on Figure 2.1, this deliverable focuses the country descriptions on socio-economic

[1] van der Grijp, N.M. et al. (2019). Theoretical framework focusing on learning in polycentric settings. Deliverable D2.1 developed as part of the NEWCOMERS project, funded under EU H2020 grant agreement 837752, December 2019.
[2] van der Grijp, N.M. et al. (2019). Theoretical framework focusing on learning in polycentric settings. Deliverable D2.1 developed as part of the NEWCOMERS project, funded under EU H2020 grant agreement 837752, December 2019.

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conditions, technical systems, institutional arrangements and actors. Additionally, the developments of energy communities so far in the different countries are also described (see Figure 2.2).

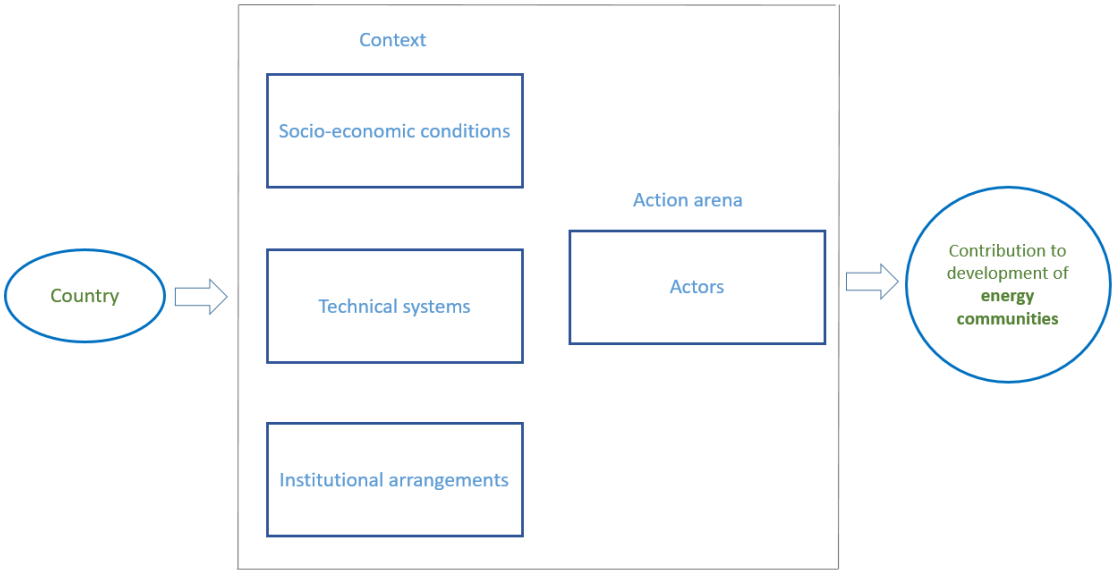

Figure 2.2 The boxes in focus in this report

2.1 Role of this deliverable in the project

This deliverable aims to map the prevailing polycentric settings of the six studied countries, focusing on the boxes presented in Figure 2.2 based on the IDA. These are socio-economic conditions, technical system, institutional arrangements as well as actors. Furthermore, a short overview of energy communities in different countries is presented. To describe and understand the national polycentric settings is a first step to understand the emergence of new forms of energy communities. This deliverable is the basis for the next steps: (i) to compare different polycentric national settings (D3.2) as well as (ii) to evaluate what forms of energy communities work best in different polycentric settings and what are the potentials for learning between different polycentric settings (D3.3).

2.2 Approach

The country description was conducted through desktop research. First, a review of existing literature and reports was conducted, focusing on existing statistics and country specific energy reports. Second, the data was organised in relation to the developed polycentric framework (see figure 2.2). Third, the description was reviewed and revised by the experts from each country in the NEWCOMERS project.

The report will be the basis for the coming comparison in deliverable 3.2 (D3.2) and the analysis of how different polycentric settings influence which energy communities are developed in a country in deliverable 3.3 (D3.3). The data collected needs to be comparable in order to allow for further comparison and identification of bottlenecks as well as issues at stake. The comparative method will provide opportunities to detect potential relationships. It allows us to understand in what conditions certain effects occur or fail to occur. With this in mind, we searched for data from similar sources or preferable the same source. Whenever possible information gathered and presented by the country

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reviews from the International Energy Agency (IEA) is used. The IEA has however not conducted such a report for Slovenia, but IEA's website and other sources (such as the energy agency in Slovenia and the European Commission) are used in the case of Slovenia. When IEA's review reports were already outdated or did not include all information, then the countries' chapters were also complemented with information from websites, national reports and statistics.

To enable comparison IEA has converted all data to a common energy unit, namely tonnes of oil equivalent (toe) defined as 10^7 kilocalories (41.868 gigajoules). We have kept the IEA's principle when reporting the countries figures. A common energy unit allows us to see the total amount of energy used and the relative contribution of each different source. The IEA uses an energy balance, which is an accounting framework depending on simplifications and generalisations. However, a positive aspects is the possibility to easily compare different data. This is the reason why we chose the units used in the IEA reports. The IEA discusses their methods used as well as its possibilities and restrictions on their website, for those who want to dig deeper into the data.[3]

In the report we also follow IEA's terminology including Total Primary Energy Supply (TPES) and Total Final Consumption (TFC) (see the index with abbreviations and their definitions in the beginning). TPES denotes the overall energy supply available for use in a country, while TFC shows the energy that is actually used by final consumers. The electricity output data shows the relative weights of all forms of energy in the generation mix, i.e. including electricity from different energy sources. TPES includes corresponding primary equivalent amount for each generation source.

For the socio-economic background, information from websites such as Worldometer[4], Statistics times[5] or Trading economics[6], were used for all six countries. Furthermore, the partners from each country provided additional national information.

2.3 Structure of the document

This deliverable is structured in the following way: Each country is presented with a similar outline, including the socio-economic conditions, the technical system, the institutional arrangements the actors as well as developments of energy communities in the specific country. The countries are presented in alphabetic order starting with Germany in Chapter 3, Italy chapter 4, The Netherlands in Chapter 5, Slovenia chapter 6, Sweden Chapter 7 and finally the United Kingdom in Chapter 8. Final Chapter 9 draws conclusions.

[3] https://www.iea.org/commentaries/understanding-and-using-the-energy-balance
[4] https://www.worldometers.info/
[5] http://statisticstimes.com/index.php
[6] https://tradingeconomics.com/

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3 Germany

In this chapter, the socioeconomic conditions, the energy system, the institutional setting and energy related actors in Germany will be described.

3.1 Context: Socioeconomic conditions

Table 3.1 presents socio-economic conditions for Germany.

Table 3.1 Socio-economic conditions

Population[7]	83,783,942
Urban population[8]	76%
Land area[9]	348,560 km^2
GDP 2019[10]	3,863.34 Billion USD
GDP per capita (2019)[11]	46,564.0 USD
GDP at purchasing power parity (PPP) (2019)[12]	53,566.9 USD
Employment rate (Sep/19)[13]	76.5
Unemployment rate (March/20)[14]	3.50

Germany has a population of around 83 million citizens on an area of 348 000 km^2. The unemployment rate is 3.5% (March/20), which is low compared to the rest of EU that has 6,2%.

3.2 Context: Technical systems

Here, Germany's energy system will be described, including energy production and consumption, the electricity system, the heating system and energy related emissions.

3.2.1 Energy production and consumption

In ted.

Table 3.2 the key figures for Germany's energy production and consumption are presented.

Table 3.2 Energy production and consumption[15]

TPES (2018)	298.3 Mtoe
TPES by source (2018)	Oil 32.8%, Natural gas 24.0%, Coal 22.5%, Bioenergy and waste 10.1%, Nuclear 6.6%, Wind 3.2%, Solar 1.6%, Hydro 0.5%,

[7] https://www.worldometers.info/population/countries-in-europe-by-population/
[8] https://www.worldometers.info/population/countries-in-europe-by-population/
[9] https://www.worldometers.info/population/countries-in-europe-by-population/
[10] http://statisticstimes.com/economy/countries-by-projected-gdp.php
[11] http://statisticstimes.com/economy/european-countries-by-gdp-per-capita.php
[12] http://statisticstimes.com/economy/european-countries-by-gdp-per-capita.php
[13] https://tradingeconomics.com/country-list/employment-rate
[14] https://tradingeconomics.com/country-list/unemployment-rate?continent=europe
[15] IEA (2020). Germany 2020 Energy Policy Review

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	Geothermal 0.1%, Electricity exports -1.4%
TPES per capita (2018)	3.6 toe/cap
Domestic energy production (2018)	111.6 Mtoe
Domestic energy production mix (2018)	Coal 33.7%, Biofuels and waste 26.8%, Nuclear 17.8%, Wind 8.6%, Natural gas 4.2%, Solar 4.2%, Oil 3.1%, Hydro 1.4%, Geothermal 0.2%
TFC (2017)	227.0 Mtoe
Consumption (delivered energy) by sector (2017)	Industry 35.0% Transport 25.4% Residential 24.5% Commercial 15.2%
TFC per capita (2017)	2.7 toe
Energy intensity (TFC/GDP PPP) (2017)	62.3 toe/USD million PPP

Despite substantial renewable energy source (RES) developments in Germany, the energy system still relies mainly on fossil fuels. In the TPES and TFC, oil and gas are the biggest sources. For power generation, coal is the major source. However, RES (bioenergy, wind and solar) are growing. Domestic oil and natural gas production is almost not existent; instead, the country depends heavily on imports.

The total domestic energy production in 2018 was 112 Mtoe, which accounts for just over one third of the TPES. The biggest source in the German energy production is coal. However, the domestic demand is so high, that almost half of the country's coal supply is in fact imported. One can differentiate between hard coal and lignite. The hard coal is imported, while lignite is a local resource. Bioenergy and waste are the second biggest source in domestic production. Half of it accounts for heat and power generation and the other half accounts for final consumption (biofuels in transport (8%) of total bioenergy supply, for heating in residential and commercial buildings (28%), or for industry purposes (13%)). In 2018 the TPES amounted to 298 Mtoe, thereby oil, natural gas and coal contributed to 80% of the TPES. The TPES per capita is 3.6 toe, which is below the IEA average of 4.1 toe. In 2017 the TFC constituted 227 Mtoe (oil 41%, natural gas 24%, electricity 20%). The consumption of the residential and commercial sector was 40%, the industry sector 35% and the transport sector 25%.[16]

The energy supply mix has changed from mainly coal and oil to a system that is more diversified. Nuclear power started to be used in the 1970s and the share of nuclear of the TPES was 13%. The plan is now to phase out nuclear power by 2022. There is a trend of more RES in the energy system, which is also in agreement with Germany's energy transition targets. The planned date for a coal phase-out for electricity generation (80% of the TPES) is in 2038. The phase-out extends over a long period and e.g. until 2022 the capacity of hard coal and lignite shall be 15 GW each.[17]

[16] IEA (2020). Germany 2020 Energy Policy Review
[17] https://www.bundesregierung.de/breg-de/aktuelles/kohleausstiegsgesetz-1716678

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RES and their growth have mainly been used to substitute nuclear power, which is also a low-carbon energy source. The fossil fuel share has been about 80% in the last decade, which equals the median of all IEA members. Between 2008 and 2018, renewable energy grew from 7% to 12%, with a share of 3% in 2000. It started with a growth in bioenergy supply. In 2018, the share of bioenergy was 8.7% of the TPES (solid biofuels, biogas, renewable waste, transport biofuels). About half of the bioenergy use can be attributed to heat and power generation as well as residential boilers. Recently the bioenergy growth has stabilized, and the main growth of renewable energy can be observed for solar and wind power.[18]

Regarding the domestic energy production, the production of fossil fuels decreased by one third and the nuclear production was cut in half between 2008 and 2018. This reduction was largely compensated by renewable energy production. In total, the domestic production declined by 16%. In 2018, the production of renewables and waste was 41%. The increase in renewable energy production made it possible for Germany to keep a steady level of energy self-sufficiency (approx. 40%).[19]

TFC in 2017 was 227 Mtoe. In the last 10 years the TFC lied between 215 Mtoe and 229 Mtoe (6% total difference).

The industry sector consumes most energy, one third of the TFC. The consumption of the industry sector decreased in 2009 due to the financial crisis but reached quickly pre-crisis levels. The residential sector was on second place regarding the TFC but was overtaken in 2014 by the transport sector. The highest variation has been in the residential sector, as it correlates with outdoor temperature. Heating is responsible for the biggest share of energy demand. In the last five years, the transport sector has experienced an 8% growth and if this trend remains the 2030 targets will not be achieved (15-20% reduction compared to levels in 2005). The commercial sector is the smallest energy consumer with 15%.[20]

Fossil fuels consumption amounted to two-thirds of the total TFC in 2017. The residential and commercial sector consume mainly natural gas and oil for heating. The transport sector is highly dependent on oil fuels and biofuels, while electricity and natural gas only have small shares. Growth in transport is however covered entirely with diesel consumption.[21]

The energy intensity decreased during the last decade, which is induced in the energy efficiency strategy and climate strategy. The GDP grew from 2000 to 2017, however, the TFC remained stable. This points to a decoupling of economic growth and energy consumption. In contrast, the TFC per capita was rather steady.[22]

Due to the decrease in energy intensity during the last decade, Germany was in the 19th place in 2017 compared to other IEA members regarding the TFC per GDP. This is around 19% lower compared to the IEA average on 73.9 toe/USD PPP. TFC per capita was 2.7 toe, 5% below the IEA average of 2.9 toe. The primary energy consumption decreased by more than 10% between 2008 and 2018. However, as it looks now, Germany will not be able to meet their energy efficiency targets from the 2010 Energy Concept, which aims for a reduction of primary energy consumption by 20% until 2020 and 50% until

[18] IEA (2020). Germany 2020 Energy Policy Review
[19] IEA (2020). Germany 2020 Energy Policy Review
[20] IEA (2020). Germany 2020 Energy Policy Review
[21] IEA (2020). Germany 2020 Energy Policy Review
[22] IEA (2020). Germany 2020 Energy Policy Review

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2050 (in comparison to 2008). There is a need for all sectors to develop more specific energy efficiency policies and regulatory frameworks.[23]

During the last decade, the energy consumption was rather steady. Precisely, there was a 2% decrease compared to 2000 and a 3% increase compared to 2007.

3.2.2 The Electricity system

In Table 3.3, the electricity generation and consumption is displayed.

Table 3.3 Electricity generation and consumption

Electricity generation (2018 provisional)[24]	644 TWh
Electricity generation mix (2018 provisional)[25]	Coal 37.5% Nuclear 11.8% Natural gas 13.2%, Wind 17.3%, Bioenergy and waste 9.1% Solar 7.4% Hydro 2.8%. Oil 0.8%, Geothermal 0.03%
Electricity net exports: (2018 provisional)[26]	48.7 TWh
Imports (2018 provisional)[27]	31.7 TWh
Exports (2018 provisional)[28]	-80.5 TWh
Installed capacity (2017)[29]	215.5 GW
Electricity consumption (2017)[30]	531 TWh
Electricity consumption by sector (2017)[31]	Industry 42.9% Commercial 28.4% Residential 24.1% Transport 2.3%, Other energy 2.3%)
Electricity consumption/pop (kWh/capita) (2016)[32]	6 947 kWh
Electricity price (2017) Households average price per 100 kWh[33]	28.7 EUR
Share of taxes and levies in average price[34]	54%

[23] IEA (2020). Germany 2020 Energy Policy Review
[24] IEA (2020). Germany 2020 Energy Policy Review
[25]IEA (2020). Germany 2020 Energy Policy Review
[26] IEA (2020). Germany 2020 Energy Policy Review
[27] IEA (2020). Germany 2020 Energy Policy Review
[28] IEA (2020). Germany 2020 Energy Policy Review
[29] IEA (2020). Germany 2020 Energy Policy Review
[30] IEA (2020). Germany 2020 Energy Policy Review
[31] IEA (2020). Germany 2020 Energy Policy Review
[32] IEA (2019). Key World Energy Statistics
[33] https://ec.europa.eu/eurostat/documents/2995521/8489679/8-29112017-AP-EN.pdf/600c794f-c0d8-4b33-b6d9-69e0489409b7
[34] https://ec.europa.eu/eurostat/documents/2995521/8489679/8-29112017-AP-EN.pdf/600c794f-c0d8-4b33-b6d9-69e0489409b7

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Fossil fuels still dominate the electricity generation in Germany. Together oil (very small share), natural gas and coal made up 52% of the electricity generation in 2018. Compared to the other IEA countries, Germany lies in the middle regarding the share of fossil fuels in the electricity generation. The average share of fossil fuels in IEA countries is 47%. Coal (mainly lignite) accounts for the highest share of electricity generation in 2018 with 38%, but it is declining (previously 50% a decade ago). In the last decade, nuclear energy decreased by half and was substituted mainly with renewable energy (supported by feed-in tariffs (FiTs)). The renewable energy share was 15% in 2008 and 35% in 2018. The increase of wind has been exponentially (doubled in the last five years). There was also a strong increase of solar power and bioenergy in the last decade.[35]

There is a big impact of the energy transition on the electricity generation with the aim to end nuclear power in 2022 and coal in 2038. This will affect the growth of renewable energy. The electricity generation lied at around 630 TWh over the last decade. There was however a switch from nuclear energy to renewables.[36]

The German power market is interconnected with its neighbouring countries. Due to the fast growth in renewable energy, Germany is a net exporter of electricity. In 2018 the export amounted to 80 TWh and the import to 32 TWh, adding up to a net export of 49 TWh. Electricity was mainly exported to the Netherlands, Austria and Poland and impetrated mainly from France.[37]

The installed capacity of RES rose by 32% between 2010 and 2017, largely due to increases in wind and solar power (wind from 27 GW to 56 GW and solar from 18 GW to 42.3 GW). In this period the capacity in power plants using combustible fuels also rose by 25% (76.4 GW to 95.1 GW), especially from new bioenergy plants. In that period nuclear generation capacity was reduced by half while hydro capacity remained more or less unchanged.[38]

There is a peak in power generation in the winter, when the heating demand rises. This is true also for the neighbouring countries. Thus, Germany's export increases during winter. The supply of solar power is higher in the summer whereas in winter the supply from wind power is higher, which is in line with the demand.[39]

Electricity consumption has been rather steady over the last 10 years, around 530 TWh. 52% of the TFC comes from the residential and commercial sector, 43% from industry and only a small share is transportation. From 2007 to 2017, the electricity consumption decreased in all sectors except the commercial sector. The commercial sector increased electricity consumption by 10%, the residential sector decreased consumption by 8% and the industry sector by 5%.[40]

3.2.2.1 Electricity from renewable energy

During the past 10 years, renewable energy grew from minor levels to 14% of the TPES and TFC. The largest growth was for electricity generation, which grew from 5% in 1998 to 35% in 2018.

[35] IEA (2020). Germany 2020 Energy Policy Review
[36] IEA (2020). Germany 2020 Energy Policy Review
[37] IEA (2020). Germany 2020 Energy Policy Review
[38] IEA (2020). Germany 2020 Energy Policy Review
[39] IEA (2020). Germany 2020 Energy Policy Review
[40] IEA (2020), Germany 2020 Energy Policy Review

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In the last 10 years the share of renewable energy grew fast due to strong policy support. In 2018, 35% of the electricity generation came from renewable sources (15% in 2008). The FiTs has supported the renewable growths, promoting wind (and all other RES) since the 2000s. From 2009 to 2012, photovoltaics (PV) installations boomed, especially distributed generation plants in the commercial sector. Afterwards, the PV installations grew much slower due to government interventions to control subsidy costs. Since 2015 it lies steady around 40 TWh (=6% of the total generation), with record levels in 2018 and 46 TWh. Also, bioenergy electricity production increased fast in the beginning of the 2000s and is now stable at just under 60% (=8% of the total electricity generation).[41]

Wind power is the dominant RES with the largest share at 112 TWh in 2018 (doubling in four years). Wind and solar combined have a share of electricity generation of 25% in 2018 which is the fourth highest share among the IEA countries.[42]

Germany is one of the world leaders in biogas, with an output of 8 Mtoe per year. Germany is furthermore on second place worldwide behind the People's Republic of China and Germany is the largest producer compared to other IEA members. [43]

Currently, it is unlikely that Germany will reach its 2030 goal of 30% renewable energy in TFC. What is needed is a clear strategy for more renewable energy in the transport, building and industry sectors. One possibility is to have more renewable electricity for decarbonising for instance heating and transport, but developments in this area are still slow. The plans for phase-out of nuclear as well as coal power will make renewable energy developments even more important. This will put more pressure on the power system and infrastructure improvements and policy development to integrate these sources in a reliable and efficient way.[44]

3.2.3 The electricity grid and smart grids

Germany has four Transmission System Operators (TSOs) that plan and maintain Germany's ultra-high voltage grid and regulate grid operations. In 2013 Germany had 880 Distribution System Operators (DSOs) of which 75 served more than 100 000 customers.[45]

Of the 1.8 million kilometres electric cables in Germany 80% run underground. This is a relatively high portion by international standards and has aided to provide power with minimal interruptions.

The ultra-high voltage electricity grid must grow to manage the shift to an energy system primarily based on renewables, as is recognised by the German government. The government's target to source 65% of power from RES by 2030 depends on an expansion of the grid. Thus, the government is prioritising grid expansion and almost 8 thousand km of grid expansions, among others four major north-south high-voltage direct current lines, have been adopted into law.[46]

Network constraints are related to the fact that most wind capacity is located in northern Germany while most demand arises in metropolitan and industrial areas in the south and west. Northern states are facing power surplus while southern states are experiencing deficits. These imbalances are

[41] IEA (2020), Germany 2020 Energy Policy Review
[42] IEA (2020), Germany 2020 Energy Policy Review
[43] IEA (2020), Germany 2020 Energy Policy Review
[44] IEA (2020), Germany 2020 Energy Policy Review
[45] https://publications.jrc.ec.europa.eu/repository/bitstream/JRC113926/jrc113926_kjna29615enn_newer.pdf
[46] IEA (2020). Germany 2020 Energy Policy Review

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worsening with the phase-out of nuclear power and the establishment of new offshore wind farms. This has led to substantial re-dispatch measures: in the south grid operators order power stations to ramp up and in the north grid operators curtail wind power. The imbalances create loop flows to neighbouring countries, which have had to invest in grid enforcement. Grid expansions in Germany are also facing delays generating congestion management cost. Costs for grid expansions are borne by users. The users pay grid charges, which are subject to revenue cap for grid operators. Industrial customers receive exemptions, while households pay a larger share. In 2018, grid fees accounted for around 25% of total electricity prices. Under the Grid Charge Modernisation Act from July 2017, transmission grid fees are gradually harmonised across the country. This will be finalised by January 2023. [47]

In order to correct the bottlenecks in the grid between the German north and south, the European Commission might force Germany to split the power market into two market-bidding zones by 2025. However, the German government prefers a single electricity market and will address the grid challenges by 2025. German TSOs have been involved in the setup of cross-border co-operation on balancing services, partly to avoid a split of the market. The four TSOs have worked together in the context of the Grid Control Co-operation. Since 2011, TSOs from Austria, Belgium, the Czech Republic, Denmark, France, Germany, the Netherlands and Switzerland have cooperated and implemented a cross-border, regional imbalance netting process (the International Grid Control Co-operation, IGCC). A mandatory platform is in use since 2017 for the procurement of automatic and manual frequency restoration reserves and replacement reserves. The IGCC was chosen by the European Network of TSOs for Electricity to be the future European platform. [48]

In 2017, the Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway (Bundesnetzagentur) changed the design of balancing energy procurement, from weekly to daily auctions and adjusted the period of delivering energy to four hours. This is expected to benefit wind and solar generators. The minimum capacity to participate was also lowered from 5 to 1 MW, which supports smaller renewables installations.[49]

The Energy Efficiency Strategy emphasises the role which digitalisation may play regarding the reduction of energy consumption and reaching efficiency targets. The European Union's third internal market directive on gas and electricity states that member states should provide 80% of their consumers with smart meters by 2020. The federal parliament passed the Act on the Digitalisation of the energy transition (in German Energiewende) in 2016 regarding the smart meters. In the first stage larger consumers and generation facilities should be equipped (consumers with an energy consumption exceeding 6 000 kWh per year). On average, a household in Germany consumes 3500 kWh per year. (consumers who have an energy consumption that is higher than 6 000 kWh per year).

Building the smart meter infrastructure is called Smart Meter Gateway. Data security is a big concern in Germany, and it has the most stringent data protection rules in Europe (Acto on Digitalisation of the "Energiewende", the federal parliament (Bundestag)). In addition, a certification of smart meters by the Federal Office for Information Security is included. The smart meter roll-out is slow due to technology development delays as well as technology certifications.

[47] IEA (2020). Germany 2020 Energy Policy Review
[48] IEA (2020). Germany 2020 Energy Policy Review
[49] IEA (2020). Germany 2020 Energy Policy Review

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In 2016 the Energy-Saving Meter pilot programmes started. Its aim is to enable and help the development of digital metering systems. In this programme the Federal Office of Economics and Export Control offers EUR 1 million funding for each project in which companies equip customers with metering infrastructure, energy data and energy saving advice. In the end of February 2019, the second phase started which will run until 2022.

3.2.4 The heating systems

In Table 3.4, the heating system with its consumption and production is described.

Table 3.4 Heat production and consumption

Energy supply in residential space heating (2016)[50]	Natural gas 53% Coal 2% District heating (DH) 10% Oil and oil products 26% Biofuels 6% Electricity 3%
TFC heat (2017)[51]	9 897 ktoe
DH production (2017)[52]	140 TWh
DH consumption (2017)[53]	124 TWh
DH production by fuel[54]	Natural gas 44% Coal 26% Oil 1% Biofuels, renewable waste, solar thermal and geothermal 14% Industrial surplus heat 7%

Germany made progress regarding the decarbonisation of the electricity sector and long-term plans for achieving more emission reductions in the power sectors. However, progress is still needed in other sectors such as heating for achieving the carbon reduction targets of the Climate Action Plan 2050. Heating is responsible for more than 50% of final energy consumptions and 40% of emissions. The government is still working on the formulation of a decarbonisation plan.[55] There are about 10 million heating systems (mainly residential and commercial) which are more than 15 years old and often rather inefficient. Around 25% of the heating systems are oil based. New buildings do however not get oil boilers. Rebuilding properties will reduce oil boilers in the long run. Only around 2% of the buildings use heat pumps, however their installation is growing in new buildings.

The German heating sector is highly dependent on fossil fuels. In 2016, 81% of the direct heat supply in residential space heating was based on fossil fuels. Moreover, a big part of district heating (DH) and electricity production comes from fossil energy sources, adding up to only 10% of renewable energy in residential space heating. For the residential and commercial sector (over 80% of the energy consumption accounts for space and water heating) natural gas has a share of 36%,[56] electricity 27%

[50] IEA (2020). Germany 2020 Energy Policy Review
[51] https://www.iea.org/data-and-statistics/data-tables?country=GERMANY&energy=Balances&year=2017
[52] IEA (2020). Germany 2020 Energy Policy Review
[53] IEA (2020). Germany 2020 Energy Policy Review
[54] IEA (2020). Germany 2020 Energy Policy Review
[55] IEA (2020). Germany 2020 Energy Policy Review
[56] IEA (2020). Germany 2020 Energy Policy Review

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and oil 21%. Biomass for heating has risen and has a share of 10% of the total energy use in residential and commercial buildings. As of 2017, DH decreased and has a share of 6% of residential and commercial consumption. [57] Increasing efficiency and renewable energy in the heating system will contribute a lot to the decarbonisation in Germany. Renewable energy for heating can be provided directly or indirectly (direct: solar heating, biomass, geothermal heat or biogas; indirect: district heating, electric heating produced from renewables).

DH is not as spread in Germany in comparison to other European countries, but it is getting more important in urban areas. In 2017, the total DH production accounted for 140 TWh and the net DH consumption was 124 TWh. Fossil fuels are dominant in Germany's DH production (44% natural gas, 26% coal and 1% oil, non-renewable waste 8%). Renewable energy has a share of 14% (mainly biofuels and renewable waste, a little amount of solar thermal and geothermal heat). The final 7% are provided by industrial waste heat.[58]

3.2.5 Energy related emissions

In Table 3.5 emissions related to the energy sector are shown.

Table 3.5 Energy related emissions[59]

CO_2 emissions (Mt of CO_2) (2017)	718.8
CO_2/TPES (tCO_2/toe) (2017)	2.31
CO_2/Pop (tCO_2/capita) (2017)	8.,70
CO_2/GDP ($kgCO_2$/2010 USD) (2017)	0.19
CO_2/GDP (PPP) ($kgCO_2$/2010 USD) (2017)	0.20

Germany has outlined ambitious goals for GHG emission reduction in its 2010 Energy Concept. The aim is to achieve a total emission reduction of at least 40% by 2020 and 55% by 2030 in comparison with 1990 levels. Renewable electricity generation grew quickly (38% of gross electricity consumption in 2018), however emissions have not decreased as much. In 2017, the share of total GHG emission reduction was 28% compared to levels of 1990. Despite this reduction, Germany is far away from reaching its goals in 2020. The share of energy-related emissions (power generation, transport, energy use in buildings and industry) is at 80% of the total emissions.[60]

There are national and EU targets (EU Emission Trading System (ETS) for emission reduction in Germany. Additionally, the target is to reduce non-ETS emissions by 14% by 2020 compared to levels in 2005 and 38% by 2030. Germany does not appear to be able to meet the targets (in 2017 emissions were just 1.5% below 2005).

What is needed are expanded and new policies and measures for reaching its goals. Germany's plan for the nuclear- and coal- phase out and thus the increased focus on more renewable power and the participation in the EU ETS shall support progress in the power sector.[61]

[57] IEA (2020). Germany 2020 Energy Policy Review
[58] IEA (2020). Germany 2020 Energy Policy Review
[59] IEA (2019). Key World Energy Statistics
[60] IEA (2020). Germany 2020 Energy Policy Review
[61] IEA (2020). Germany 2020 Energy Policy Review

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Besides the power sector, a focus on transport and heating will also be needed. This could comprise carbon pricing in order to stimulate consumers' choices for low carbon options and other regulatory options.[62] Carbon pricing for the building and transport sector will be implemented starting from 2021: starting with 25 EUR per ton CO2.

Energy-related CO_2 emissions decreased in the last decades. Emissions were 729 $MtCO_2$ in 2017, which is 9% below 2005's value, and 24% below 1990's value. The largest source of energy related CO_2 emissions is power and heat generation in Germany, which in 2017 represented 42% of total emissions. It was followed by transport (22%), industry (12%), residential (12%), commercial (6%), and other energy business (3%). In recent years there has been a reduction of emissions in most sectors, the residential sector in particular, where a 21% decrease since 2005 has occurred, mainly owed to energy efficiency improvements and fuel switching. This has led to a reduction in oil consumption for heating. In addition, power and heat generation has been improved, resulting in 15% less emissions since 2005. However, the nuclear phase-out might affect these gains. The transportation sector is the exception, where emissions have increased by 5% between 2005 and 2017.

The power sector is relying on coal and this is reflected in the emissions per energy source. In 2017, coal (including blast furnace gas and other recovered gases) represented 39% of all power generation in Germany and approximately 40% of all CO_2 emissions from energy production. Oil represents 34% of all emissions, and natural gas 24% (2017).

3.3 Context: Institutional setting

Under institutional settings, political goals, policies, subsidies and tax schemes as well as the construction of electricity prices will be discussed.

3.3.1 Political goals and national energy agreements to reduce emission

In Germany, the "Energiewende" is a significant plan to change the energy system to be mostly supplied by RES. The "Energiewende".[63] The energy transition strategy is summarized in these three main objectives: (1) All sectors must reduce energy consumption (the principle is "efficiency first"), (2) Use renewable energy directly when economically and ecologically sensible; and (3) Remaining energy need is supplied by electricity from RES.[64]

The federal government adopted the Energy Concept document in 2010. This document plans Germany's energy policy until 2050 and specifically sets measures for RES and energy efficiency. The decision to phase out nuclear power entirely by 2022 was added in 2011. The Energy Concept emphasises the three goals of affordability, energy security and environmental protection. The target according to the document is to reduce emissions at least by 80%, by 2050 compared to levels in 1990. The concept focuses on substantial expanding renewable energy and fast improvements in energy efficiency.[65] The target for 2020 for renewable energy is 18% of the gross final energy consumption, which is in line with the EU target. Further, the target is to have a share of renewables of 30% by 2030 as well as 45% by 2040 and 60% by 2050. It is expected that the major renewable sources will be wind and solar and then biomass and hydropower. The goal for electricity generation is a share of 35% renewables of the gross electricity consumption in 2020. Furthermore, the share of renewables in

[62] IEA (2020). Germany 2020 Energy Policy Review
[63] IEA (2020). Germany 2020 Energy Policy Review
[64] IEA (2020). Germany 2020 Energy Policy Review
[65] IEA (2020). Germany 2020 Energy Policy Review

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electricity shall be 50% in 2030, 65% in 2040 as well as 80% in 2050. The new coalition later on agreed on a more ambitious goal of 65% renewable electricity until 2030 depending on the expansion in grid capacity.[66]

In 2002, the decision was made by the government to phase out the commercial use of nuclear power for generation when power plants accomplish their legally defined residual electricity production volumes. After the 2009 parliamentary election, the federal government implemented a modified energy policy, which regarded the use of nuclear energy as a "bridging technology" on the way to more RES generation. After the Fukushima incident in 2011, the situation changed and Germany reassessed the risk associated with nuclear power. The decision was made to speed up the process of phasing out commercial nuclear power plants with the enactment of the 13th Act Amending the Atomic Energy Act. All facilities should be closed in the end of 2022.[67]

The climate protection policies are enclosed in many different national laws and decisions, EU regulations as well as international agreements. The national climate strategy is established in the Climate Action Plan 2050, describing to reduce sector-specific emissions with a long-term pathway, in the Energy Concept. The aim is to accomplish a 40% reduction in GHG emission by 2020 and 55% by 2030, 70% by 2040 as well as 80-95% by 2050 compared to 1990. In 2050, the country is expected to be more or less GHG-neutral. The EU climate policies framework, i.e. the 2020 climate package and the 2030 climate framework, also guides the German climate policy. For achieving the GHG reduction targets by 2020 the 2020 Climate Action Programme was implemented in 2014 by the federal government. This Programme includes over 110 measures.[68] The key policy strategy can be found in the National Action Plan on Energy Efficiency (NAPE).

As mentioned above Germany struggles meeting targets. There is uneven progress in the different sectors and especially the transport sector is struggling. Thus, the aim is to cut as many emissions as possible until 2020 and then focus on the target for 2030 instead, namely to cut 55% of the emissions compared to 1990 levels. For the aim to meet the aspiring targets to reduce GHG emissions until 2030, the government introduced a climate cabinet in March 2019. This climate cabinet is led by the chancellor and includes ministers from relevant ministries, as the Federal Ministry for Economic Affairs and Energy (BMWi) and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety BMU, as well as the transport, interior, agriculture and finance ministries. This cabinet published a measure package (Climate Action Programme 2030), which comprises a phased carbon pricing system for the buildings and transport sectors, banning oil-based heating in buildings from 2026, higher subsidies for electric vehicles (EVs), increasing incentives for retrofitting of buildings, and greater public investments in public transport. Furthermore, a proposal from the climate cabinet is to lower costs for households and companies giving relieved and reduced taxes and fees on electricity prices (even though the financial support for renewables is not lowered).[69]

The climate Action Plan 2050 was implemented in 2016 and acknowledges again the emission targets from the Energy Concept, with the long-term goals to be more or less GHG neutral (80-95% emission reduction). The plan also contains targets for 2030 for different sectors (energy, industry, buildings, transport, agriculture, land use and forestry) applying a linear pathway to manage the 2050 goals.

[66] IEA (2020). Germany 2020 Energy Policy Review
[67] IEA (2020). Germany 2020 Energy Policy Review
[68] IEA (2020). Germany 2020 Energy Policy Review
[69] IEA (2020). Germany 2020 Energy Policy Review

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Included in the plan are initial adoption measures as well as monitoring and updating policies and measures every five years (which is also in line with the Paris Agreement).[70]

Energy efficiency is important in the "Energiewende" in order to lower GHG emissions, to save costs for households and companies but also to boost the global competitiveness of German industry. There is progress made regarding boosting energy efficiency as well as decoupling energy demand and economic growth. However, the 2020 targets will most likely not be met (20% reducing in 2020 compared to 2008). The goal is further to reduce primary energy consumption by 50% until 2050. NAPE was a crucial step towards reducing energy demand for several reasons. First, consumer information was provided with advice on energy efficiency. Secondly, there was the promotion of targeted investment in energy efficiency with the help of incentives. Thirdly, more action was demanded by large companies doing energy audits, having new standards for appliances as well as newly constructed buildings.[71]

The government aims to have a cross-sectoral Energy Efficiency Strategy and NAPE 2.0 to plan specific efficiency measures between 2021 and 2030. The plan is now a definition of concrete measures for 2021 to 2030 in order to meet the 2030 goals as part of a new National Action Plan on Energy Efficiency 2.0 and additionally to fulfil the EU Energy Efficiency Directive.[72]

A main source to finance energy efficiency measures is the Energy and Climate Fund, founded by federal law in 2010 and financed with revenues from permit auctions under the EU ETS. There exist different kinds of programmes, for instance from direct financial support to information, communication measures and advisory services. In 2018 EUR 2.6 billion of auction revenues as well as EUR 2.8 billion federal budget were assigned to the fund.[73]

Furthermore, a roadmap is planned in support of the national target to reduce primary energy consumption by half until 2050 compared to levels in 2008 (especially focussing on heating sector and buildings).[74]

Additionally, Germany is also a leading market for energy performance contracts (EPCs), supported with establishing standardised model EPC contracts, which contain different pre-approved providers as for instance the German Energy Agency (DENA) or the Berlin Energy Agency. Various organisations offer model contracts and the Federal Bureau for Energy Efficiency has a list of different model contracts. Furthermore, the government has advisory programmes where consultants check on companies as well as municipalities to decide if EPCs could support them achieving energy efficiency gains.[75]

3.3.2 Performance on EU 2020 energy targets

The climate policy is guided and influenced by the EU climate policies framework, namely the 2020 climate package as well as the 2030 climate framework. Big combustion facilities in the power and industry sectors are included in the EU ETS. Non-ETS emissions belong to the Effort Sharing Decision (ESD). About half of the emissions arise in the EU-ETS system and the other half in sectors of the ESD.

[70] IEA (2020). Germany 2020 Energy Policy Review
[71] IEA (2020). Germany 2020 Energy Policy Review
[72] IEA (2020). Germany 2020 Energy Policy Review
[73] IEA (2020). Germany 2020 Energy Policy Review
[74] IEA (2020). Germany 2020 Energy Policy Review
[75] IEA (2020). Germany 2020 Energy Policy Review

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In accordance with the Paris Agreement, the EU stated to cut GHG emissions by 40% until 2030 compared to levels in 1990. Germany as well as other countries do not have a Nationally Determined Contribution as part of the Paris Agreement. Additionally Germany must also consider the land use, land-use change, and forestry (LULUCF) Regulation, which binds EU member states to keep and improve their anthropogenic climate balance from LULUCF from 2021 to 2030.[76]

Germany will not be able to meet their energy efficiency targets from the 2010 Energy Concept, which aims for a reduction of primary energy consumption by 20% until 2020 and 50% until 2050 (in comparison to 2008).

Germany will most likely not achieve its 2020 renewable targets, i.e. 25% of renewables of the TFC.

Germany's goal was to achieve a total emission reduction of at least 40% by 2020, which most likely will not be reached). In 2017, the share of total GHG emission reduction was 28% compared to levels of 1990.

3.3.3 Electricity market, policy and law

The German electricity market was fully liberalised in 1998. The most significant market reform after that was the Act on the Further Development of the Electricity Market, adopted in July 2016. The goal with the act was to make the electricity market suitable to accommodate growing shares of renewables and adjust the regulation for competition between flexible supply, flexible demand and storage. A gradual process has then been in place to eliminate distortions in the regulatory framework and include guarantee competition-based free price formation, known as the Electricity Market 2.0.

The focus in Germany lies on the "Energiewende" or energy transformation, which was introduced above. One key element of it is to eliminate current use of nuclear power by 2022. The policy includes phasing out nuclear power, the progressive replacement of fossil fuels by renewables and lowering overall electricity demand (though a shift towards electrification in transport and heating can offset the effects of efficiency and demand-side management measures).

An important instrument to expand renewable energy in the electricity sector is the Renewable Energy Sources Act (EEG). The first step of the EEG was released in 2000. This included guaranteed grid connection, access to renewables priority dispatch, compensation for curtailment and financial support for 20 years (FiTs and feed-in premiums). This was based on the size of the project, the technology and its location. An EEG surcharge on electricity consumption made it possible to finance the subsidy for renewables. Energy-intensive industries are exempt from the surcharge to protect their international competitiveness. There was an escalation of RES cost support, which led to a reformation of the Renewable Energy Sources Act in 2014 with an introduction of market premiums for newly installed RES over a minimum threshold and auctions to determine the level of financial support for RES in 2017 latest. The first auctions were held in 2015 for ground-mounted PV. The Renewable Energy Sources Act 2017 led to a paradigm shift regarding funding for renewable energy in the direction of more competition, greater cost efficiency as well as limited previous cost system of fixed funding rates for smaller installations. Now, the RES with large capacities (on-, offshore wind, large PV systems as well as biomass) compete at auctions. At these auctions, it is the cheapest offers that win.[77]

[76] IEA (2020). Germany 2020 Energy Policy Review
[77] IEA (2020). Germany 2020 Energy Policy Review

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In a simple way, the deployment of renewable capacities in Germany can be shown in three phases. First, the early phase of FiTs, promoting onshore wind increasingly PV; second during the PV boom, regulation struggled to deal with very quick technology cost reductions and fast installation volumes, which caused a sizeable rise in the EEG surcharge and third the deployment of renewables based on competitive auctions.

The electricity market in Germany consists of various trading markets, namely wholesale and balancing, day-ahead, intraday and futures. Electricity generation and consumption are informed by price signals from these markets. Those generation sources that have the lowest variable cost are prioritised to meet demand. The final wholesale price is defined based on a single price zone and also on the basis of the most expensive generation source in the market, or the marginal power plant. Marginal costs are mainly affected by fuel costs, power plant efficiency and carbon prices. Renewable power is usually placed first in the merit order, given near-zero marginal costs.[78]

The introduction of large volumes of renewable power has increased volatility in wholesale prices. When an abundance of wind generation occurs in periods of low demand, prices can plummet and even turn negative. When the opposite happens, prices can surge.

Several countries neighbouring Germany are connected to the German electricity market. The day-ahead market that is based on net transfer capabilities, NTC, is connected to 18 countries (Austria, Belgium, Denmark, Estonia, Finland, France, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Norway, Portugal, Slovenia, Spain, Sweden, the United Kingdom, and Poland via cable to Sweden). The intraday market that is based on NTC is connected to 14 countries (Austria, Belgium, Denmark, Estonia, Finland, France, Latvia, Lithuania, Luxembourg, the Netherlands, Norway, Portugal, Spain, and Sweden). In the day-ahead market that is based on flows, six countries can be traded with (Austria, Belgium, France, Luxembourg, and the Netherlands).

Electricity is traded on exchanges in Germany. These exchanges include the European Energy Exchange, and the European Power Exchange. However, supply contracts are often made directly between companies and providers. Trading occurs on forward, day-ahead, and intraday markets, where forward contracts last for up to six years, and day-ahead and intraday contracts are based on auctions on the spot market.

3.3.4 Subsidies, tax schemes

The energy taxation is synchronised with the 2003 EU Energy Taxation Directive. It was implemented into national law with the Energy Duty Act in 2006 as well as the Electricity Duty Act of 1999. In the EU directive, there are minimum exercise duty rates on energy products. Germany chose to have higher national rates (for instance for gasoil/diesel, petrol, liquefied petroleum gas (LPG) and natural gas).[79]

There is an energy tax on oil products, natural gas as well as coal and coke products. The rates are different depending on the product's end use in transport or for heating and other applications. According to the Energy Duty Act, there exist tax concessions. These are based on environmental and economic policy rationale. For example, there is no tax on fuels when used for electricity generation and at power plants with capacities greater than 2 MW or when meeting particular co-generation

[78] IEA (2020). Germany 2020 Energy Policy Review
[79] IEA (2020). Germany 2020 Energy Policy Review

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requirements with heat and power. There is also a relief in taxes for heating fuels or electricity when used by manufacturing industries and in agriculture. Agriculture also gets tax relief on diesel. Natural Gas and LPG[80] also have reduced taxes. There had been also biofuels tax incentives, which are now abolished. Since 2015, biofuels are subsidised solely through EU biofuel targets. There are values for different biofuels categories on the basis of their GHG reduction potential.[81]

Germany is also a participant in the EU ETS. This is a cap-and-trade programme, which generates a carbon price for obligated participants, for power generators, large industrial facilities and airlines for flights within the European Union. Germany has lately also adopted a carbon tax for emissions in non-ETS sectors (i.e. buildings and transport).[82]

There is the Ecological Tax Reform, which implemented taxation of electricity and increased taxation on energy products in different steps between 1999 and 2003. This was done of financial reasons and in order to encourage ecological behaviour.[83]

There is a tax relief made available by the government for heating fuels used by the manufacturing, agriculture and forestry sectors. Many energy-intensive industries receive at least partial exemptions from charges, levies and the electricity tax, which gives in turn a higher share of costs for households. The EEG surcharge lied at 6.79 euro cents per kilowatt-hour (c/kWh) in 2018 (this is 23% of the electricity price). Since 2014, the range for it was between 6.2 c/kWh and 6.9 c/kWh. Supporting renewables together with the ETS prices raises the financial burden for overall CO_2 reduction, which is much higher in electricity consumption compared other energy modalities. Because of the missing additional taxes for heating fuels,[84] the disproportionate surcharges on electricity hinder changing from fossil fuel-based heating systems to heat pumps using electricity (which is more and more supplied by renewables). [85]

3.3.5 Electricity prices

In the EEG, an extra surcharge was introduced to the consumers' (industry and household) electricity bills. This is in proportion with the power consumption (as a per kilowatt-hour rate), to pay for subsidies for renewable facilities. Most energy-intensive industries are suitable to receive partial exemptions from the charges. This pushes higher costs on households. This EEG surcharge comprises the market premiums and FiTs which are then paid to renewable technologies and the average trading price for electricity. Due to the high FiTs from the early time of the EEG, the price for electricity for households is the third highest compared to the IEA member countries. Levies, charges and taxes, including the EEG surcharge, represent about half of the total price. [86]

There is no regulation for end-use prices. [87]

In comparison to neighbouring IEA countries, the German electricity price increased the most in the last 10 years. There was a price drop in 2015 but otherwise the prices increased by 10% in industry

[80] IEA (2020). Germany 2020 Energy Policy Review
[81] IEA (2020). Germany 2020 Energy Policy Review
[82] IEA (2020). Germany 2020 Energy Policy Review
[83] IEA (2020). Germany 2020 Energy Policy Review
[84] IEA (2020). Germany 2020 Energy Policy Review
[85] IEA (2020). Germany 2020 Energy Policy Review
[86] IEA (2020). Germany 2020 Energy Policy Review
[87] IEA (2020). Germany 2020 Energy Policy Review

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and household sector in the last 10 years.[88] The price for household electricity was 0.310 EUR/kWh in Germany in June 2019. This includes all components such as the cost for power, grid tariffs and taxes. [89] Among EU countries, Denmark and Germany are the most expensive.[90] 53% of the price were politically determined parts such as taxes, levies and surcharges. 7.39 cents was regulated grid fees including metering and associated services.[91]

Of all households in 2017, 41.2% had contracts with the default supplier, compared to 27% for metered non-households. The switching rate for households and non-households was 15% and 7.2%, respectively.

3.4 Action arena: Actors

In this section the main public and market actors are described. The section ends with a brief overview of the number of energy communities.

3.4.1 Institutional actors

Germany is constitutionally the Federal Republic of Germany. It is a federal parliamentary, representative democratic republic led by a chancellor. Federal legislative power rests in the parliament consisting of the "Bundestag" and the federal council (Bundesrat). The "Bundestag" is elected through direct elections. The "Bundesrat" consist of representatives of the governments of the sixteen federate states. The president is the head of the state and has mainly representative responsibilities.

The central environmental protection agency is called Federal Environment Agency (UBA) and is in charge of collecting data on the state of the environment, investigating drivers as well as interrelationships influencing the environment and publish projections on environmental trends. It works with waste avoidance, climate protection and pesticides approval[92]

The German Environment Agency collects environmental data, makes projections, and gives policy advice to other federal bodies, e.g., BMWi.

The German Emissions Trading Authority is in charge of administering the participation of Germany in the EU ETS as well as emissions trading and licensing of United Nations-led Joint Implementation and Clean Development Mechanism projects.[93]

Both the federal government and the states "Länder" are responsible in the field of energy policy. The federal government's responsibilities are mainly to establish legislations on energy policy. The "Länder" help towards shaping energy policies with the "Bundesrat". There they participate in federal legislation. Germany can be described as a social market economy. Thus, the principle for energy policy is that interventions by the government shall be reduced and only exerted when a market mechanism does not exist or does not work.[94]

[88] IEA (2020). Germany 2020 Energy Policy Review
[89] https://www.globalpetrolprices.com/Germany/electricity_prices/
[90] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Electricity_price_statistics#Electricity_prices_for_household_consumers
[91] https://www.cleanenergywire.org/factsheets/power-grid-fees-unfair-and-opaque
[92] IEA (2020). Germany 2020 Energy Policy Review
[93] IEA (2020). Germany 2020 Energy Policy Review
[94] IEA (2020). Germany 2020 Energy Policy Review

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The BMWi is in charge of the federal energy policy, energy transition and climate policy aspects of energy. The BMWi also administers industries. Thus, it also makes sure that the energy transition does not put at risk the competitiveness of the industry. Additionally, the BMWi is responsible of the policy for the market start of renewables, energy efficiency, as well as emergency planning for oil, gas and electricity. The BMWi represents Germany in the EU and internationally when it comes to energy policy. Recently, the BMWi has requested reports on energy projections and scenarios from independent academic institutes.

The federal government manages central funding instruments, such as the EEG, the Renewable Energies Heat Act, while the "Länder" handle regional planning and approval procedures. The states are responsible for implementing the Renewable Energies Heat Act.

Regarding energy conservation in buildings, the BMWi as well as the Federal Ministry of the Interior, Building and Community are in charge.[95]

The BMU is in charge of environment and climate change policies. This ministry was founded in 1986 as a reaction to the Chernobyl nuclear disaster. As a ministry, they deal with environmental issues. It is responsible for the protection of the public from environmental toxins and radiation, ensuring efficient use of raw materials, moving climate action forward, and encouraging using natural resources for the conservation of biodiversity and secure habitats.[96] The BMU creates not only legislation in its subject areas, but it is also associated with research and development (R&D) promoting environmental technologies as well as with national and international co-operation.[97]

The Federal Ministry of Transport and Digital Infrastructure is in charge of the fuel strategy of the government and for co-ordinating the energy transition in the transport sector.[98]

The "Bundesnetzagentur" works as an independent federal authority. It works with the BMWi and with the authorisation to assure more liberal and deregulated markets in telecommunications, postal, railway, and energy sectors.[99] It is in charge of grid regulation, i.e., network access and prices for third parties, systems integration, and network planning and granting of permissions for high-voltage transmission lines. The "Bundesnetzagentur" is in charge of "larger" system operators, comprising TSOs as well as large DSOs that operate in more than one state. Generally, regional authorities regulate small DSOs with less than 100 000 customers. Additionally, the "Bundesnetzagentur" monitors the equalisation between TSOs and DSOs on one side, and the electricity suppliers on the other.[100]

The DENA is a centre of experts in the area of energy efficiency and RES. Additionally, DENA has two equal shareholders, which are the federation and the state-owned KfW banking group.[101]

The Federal Statistical Office (StBA) and the Statistical Offices of the German "Länder" provide important services, in which they gather energy data as described in the Energy Statistics Act.[102]

[95] IEA (2020). Germany 2020 Energy Policy Review
[96] IEA (2020). Germany 2020 Energy Policy Review
[97] IEA (2020). Germany 2020 Energy Policy Review
[98] IEA (2020). Germany 2020 Energy Policy Review
[99] IEA (2020). Germany 2020 Energy Policy Review
[100] IEA (2020). Germany 2020 Energy Policy Review
[101] IEA (2020). Germany 2020 Energy Policy Review
[102] IEA (2020). Germany 2020 Energy Policy Review

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The Working Group on Renewable Energies Statistics is responsible for creating reliable data on the use of renewable energies. It is formed by the BMU, BMWi, Federal Ministry of Food and Agriculture, StBA, the Working Group on Energy Balances, UBA, business associations in the field of renewables and research institutes.[103]

3.4.2 The market

There are hundreds of power providers in Germany. Over 50% of the conventional electricity comes from the four largest providers: E.ON, RWE, Vattenfall, and EnBW. 25% is provided by public utilities operating at the regional or city level. For RES, there is a large and more innovative group of producers, e.g., project developers, power companies, municipal utilities, and households and farmers. Larger scale solar and offshore wind projects are most commonly developed by professional developers.

There are four TSOs that together make up the transmission system in Germany: Amprion, TenneT, 50Hertz, and TransnetBW. Over 800 DSOs operate in Germany, and the majority have less than 100 000 customers; the smaller DSOs serve on average around 30 000 customers.

The market share for the four largest companies on the retail level is large, but still less than 40%. End-users had 143 providers in their network to choose from in Germany in 2017, and households could choose from 124 providers.

3.4.3 Energy communities

In Germany, there is no single definition of energy communities. Moreover, the terms community energy or citizen energy (Bürgerenergie) are more widely used.[104]

For more than two decades, citizens have banded together in various forms of ownership to own renewably capacity and generate energy. At the end of 2016, 1,747 energy communities were registered in Germany. The registration of energy communities increased moderately until 2007 (between 5 and 35 new communities per year), but rapidly rose afterward. Alone in 2013, 267 energy communities were founded. Yet, since then the speed of new energy communities has decreased again.[105] Most of the communities registered between 2009 and 2012 focus on the production of solar energy, while wind power has become more important afterward.[106]

Most projects of community energy are so-called energy cooperatives (Energiegenossenschaften), which take the legal form of limited liability companies. These provide less than one percent of total renewable electricity supply but are crucial in terms of public support.[107] There are more than 1000 energy cooperatives[108] with on average 296 members.[109]

Besides this business model, there are about 100 communities that additionally operate their own electricity grid, e.g. Bio Energy Villages (Bioenergiedörfer).[110] For instance, Jühnde is the first Bioenergiedorf, and since 2005 it gets all of its electricity and more than half of its heat from a biogas

[103] IEA (2020). Germany 2020 Energy Policy Review
[104] https://www.unendlich-viel-energie.de/media/file/3591.89_Renews_Spezial_Community_energy_LECo.pdf
[105] https://www.buendnis-buergerenergie.de/fileadmin/user_upload/wpbl27_BEG-Stand_Entwicklungen.pdf
[106] https://www.buendnis-buergerenergie.de/fileadmin/user_upload/wpbl27_BEG-Stand_Entwicklungen.pdf
[107] https://www.unendlich-viel-energie.de/media/file/3591.89_Renews_Spezial_Community_energy_LECo.pdf
[108] https://www.buendnis-buergerenergie.de/fileadmin/user_upload/wpbl27_BEG-Stand_Entwicklungen.pdf
[109] https://www.unendlich-viel-energie.de/media/file/3591.89_Renews_Spezial_Community_energy_LECo.pdf
[110] https://www.buendnis-buergerenergie.de/fileadmin/user_upload/wpbl27_BEG-Stand_Entwicklungen.pdf

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plant that is powered with local crops. Moreover, the residents co-financed a district heat network and replaced their existing heating systems.[111]

[111] https://www.unendlich-viel-energie.de/media/file/3591.89_Renews_Spezial_Community_energy_LECo.pdf

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4 Italy

In this chapter the socioeconomic conditions, the energy system, institutional setting and energy related actors in Italy will be described.

4.1 Context: Socioeconomic conditions

In Table 4.1 a summary of some of Italy's socio-economic conditions is displayed. Italy has a population of 60 400 000 citizens on an area of 294 000 km^2. The unemployment rate is 9.3% (March 2020), which is above the EU average on 6.2%.

Table 4.1 Socio-economic conditions

Population[112]	60,493,700
Urban population[113]	69%
Land area[114]	294,140 km^2
GDP 2019[115]	1988,64 Billion USD
GDP per capita (2019)[116]	32,946.5 USD
GDP PPP[117]	40,470.3 USD
Employment rate (March/2020)[118]	58.9%
Unemployment rate (March/2020)[119]	9.3%

4.2 Context: Technical systems

In the following, Italy's energy system will be described, including energy production and consumption, the electricity system, the heating system and energy related emissions.

4.2.1 Energy production and consumption

In Table 4.2 below is key figures relating to Italy's energy production and consumption are shown.

Table 4.2 Energy production and consumption

TPES (2016)[120]	151 Mtoe
TPES by source (2016)[121]	Natural gas 38.5% Crude oil, natural gas liquid and oil products 34.1% Coal 7.3% Waste (non-renewable) 0.8% Renewable energy, bioenergy 8.7% Renewable energy, other 8.5% Electricity imported 2.1%
TPES/capita (2015)[122]	2.5 toe

[112] https://www.worldometers.info/population/countries-in-europe-by-population/
[113] https://www.worldometers.info/population/countries-in-europe-by-population/
[114] https://www.worldometers.info/population/countries-in-europe-by-population/
[115] http://statisticstimes.com/economy/countries-by-projected-gdp.php
[116] http://statisticstimes.com/economy/european-countries-by-gdp-per-capita.php
[117] http://statisticstimes.com/economy/european-countries-by-gdp-per-capita.php
[118] https://tradingeconomics.com/country-list/employment-rate
[119] https://tradingeconomics.com/country-list/unemployment-rate?continent=europe
[120] https://www.iea.org/data-and-statistics/data-tables?country=ITALY&energy=Balances&year=2016
[121] https://www.ieabioenergy.com/wp-content/uploads/2018/10/CountryReport2018_Italy_final.pdf
[122] IEA (2016). Energy Policies of IEA countries. Italy Review

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Domestic energy production (2015)[123]	35.5 Mtoe
Domestic energy production mix (2015)[124]	Biofuels and waste 32.2% Geothermal 15.4% Hydro 10.6% Solar 6.6% Wind 3.6% Crude oil 15.9% Natural gas 15.6%
TFC (2014)[125]	116.6 Mtoe
Consumption delivered energy by sector (2014)[126]	Transport (31.7%) Residential (25.3%) Industry (27.9%) Commercial and public services, including agriculture and fishing (15.1%)
TFC/capita (2014)[127]	1.92
Energy intensity (TFC/GDP PPP) (2016)[128]	59.9 toe/USD million PPP

In 2016 the energy production was 35.5 Mtoe. Since 2001 the energy production has steadily increased with a 17.7% increase from 2005 to 2015. The production growth is mainly based on the development of renewable energy. Biofuels and waste accounted for 32.2%, geothermal (15.4%), hydro (10.6%), solar (6.6%) and wind (3.6%).

In recent years, solar, wind, biofuels, and waste have developed the most, where solar energy has had the strongest development due to substantial subsidies. Around one third of the energy production is based on crude oil (15.9%) and natural gas (15.6%). Coal production lies only at 0.1%. Both natural gas and oil production were much lower compared to 10 years ago. Among the IEA member countries, Italy is thirteenth-highest regarding the share of fossil fuels in the TPES (this is similar to the USA).

The TPES amounted to 150.9 Mtoe in 2018, in 2005 it was 186.4 Mtoe. Hence, it decreased by almost 20% during 10 years. The TPES decreased even though there was an increase in energy production. This is due to a reduced domestic demand.[129]

Energy supply per capita was 2.5 toe, which is below the IEA average of 4.5 toe. The energy intensity in Italy is sixth lowest compared to other IEA member countries (higher than Ireland, Switzerland, the United Kingdom, Denmark and Luxembourg). The energy intensity was 14.6% lower in 2015 than in 2005.[130]

The TFC lies at 116.6 Mtoe in 2014. The TFC is about 79% of the TPES. The remainder is used in power generation and other energy industries. The TCF decreased 10.8% from 2004 to 2014. The sectors transport (31.7%), household (25.3%) and industry (27.9%) have a similar energy demand. The

[123] IEA (2016). Energy Policies of IEA countries. Italy Review
[124] IEA (2016). Energy Policies of IEA countries. Italy Review
[125] IEA (2016). Energy Policies of IEA countries. Italy Review
[126] IEA (2016). Energy Policies of IEA countries. Italy Review
[127] IEA (2016). Energy Policies of IEA countries. Italy Review
[128] IEA (2016). Energy Policies of IEA countries. Italy Review
[129] IEA (2016). Energy Policies of IEA countries. Italy Review
[130] IEA (2016). Energy Policies of IEA countries. Italy Review

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commercial and service sector (plus agriculture and fishing) has an energy demand of 15.1%. Demand in transport and industry reduced in the decade 2004 to 2014.[131]

4.2.2 The Electricity system

In Table 4.1 is the electricity generation and consumption described.

Table 4.3 Electricity generation and consumption

Electricity generation (2015)[132]	280.7 TWh
Electricity generation mix (2015)[133]	Natural gas 38.3%, Coal 16.6%, Hydro 15.6%, Solar 9.3%, Biofuels and waste 7.8%, Wind 5.2%, Oil 4.8%, Geothermal 2.2%
Net imports (2015)[134]	46.4 TWh
Imports (2015)[135]	50.8 TWh
Exports (2015)[136]	4.5 TWh
Installed capacity (2014)[137]	117.7 GW
Electricity consumption (2014)[138]	Industry 38.8%, Commercial and other services 32.2%, Residential 22.1%, Transport 3.6%, Other energy 3.3%
Electricity consumption/pop (kWh/capita) (2017)[139]	5202 kWh
Electricity price (2017) Households average price per 100 kWh[140]	21.4 EUR
Share of taxes and levies in average price[141]	38%

The electricity generation was at 313.5 TWh in 2008. It decreased by 8% during the economic recession in 2009 and grew again by 4.2% in 2010/2011 and decreased again with 6.6% in 2012-2015.

The electricity mix consists of natural gas 38.3%, coal 16.6% and oil 4.8%. In total the fossil fuel share is 59.7%. Hydro as a RES accounted for 15.6%, non-hydro renewables had a share of 24.6% of generation, with solar 9.3%, biofuels and waste 7.8%, wind 5.2% and geothermal 2.2%. In 2005 fossil fuels, natural gas, coal and oil accounted for 82.8% of the total generation. The remainder was RES,

[131] IEA (2016). Energy Policies of IEA countries. Italy Review
[132] IEA (2016). Energy Policies of IEA countries. Italy Review
[133] IEA (2016). Energy Policies of IEA countries. Italy Review
[134] IEA (2016). Energy Policies of IEA countries. Italy Review
[135] IEA (2016). Energy Policies of IEA countries. Italy Review
[136] IEA (2016). Energy Policies of IEA countries. Italy Review
[137] IEA (2016). Energy Policies of IEA countries. Italy Review
[138] IEA (2016). Energy Policies of IEA countries. Italy Review
[139] IEA (2019), Key World Energy Statistics
[140] https://ec.europa.eu/eurostat/documents/2995521/8489679/8-29112017-AP-EN.pdf/600c794f-c0d8-4b33-b6d9-69e0489409b7
[141] https://ec.europa.eu/eurostat/documents/2995521/8489679/8-29112017-AP-EN.pdf/600c794f-c0d8-4b33-b6d9-69e0489409b7

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hydro 12.2%, biofuels and waste 2.1%, geothermal 1.8%, wind 0.8% and solar 0.4%. Solar, wind, and biofuels and waste have increased drastically by 2182%, 526% and 256% over which period. Solar energy grew the fastest due to lower systems costs combined with favourable government incentives. Compared to the other IEA member countries, Italy's share of fossil fuels in electricity generation was at place 12. Oil is the fourth highest and natural gas the sixth highest. Regarding the share of solar in the electricity generation, Italy is at the first place. The share of geothermal is the third highest.[142]

Italy can be characterised as an electricity net importer. The net imports were 46.4 TWh in 2015. This corresponds to 15% of the electricity consumption. The imports lied at 50.8 TWh while the exports were 4.5 TWh. In 2015 the net imports decreased by 9% compared to 2003. The imported electricity comes from Switzerland (54%), France (33.8%), Slovenia (11.6%), Austria (3.4%) and with a net export to Greece (-2.8%).

Most electricity in Italy is consumed by the industry (38.8%) in 2014. The commercial sector and others lied at 32.2% in 2014 increasing since 2004. Electricity consumption in the residential sector decreased by 3.5% in the last ten years, with a consumption of 22.1% of the total demand. The demand in the transport sector increased with 9% in comparison with 2004 with a 3.6% consumption of the total electricity demand.

4.2.2.1 Electricity from renewable energy

RES grew fast in recent years, even more than the government targets. Especially solar PV developed rapidly. Thus, the share of renewable energy almost doubled in the decade from 2005 to 2015 from 7.9% to 18.2% of the TPES. All sectors show growth in the use of RES (heating, cooling, electricity, transport).

Different schemes were used in support of RES, with varying degrees of effectiveness regarding the stimulation of deployment with at the same time contained costs.[143]

The electricity from renewable sources amounted to 112.8 TWh in 2015. This equates to around 40% of the total generation. In 2005, the generation of electricity from renewables was 17.2%. The increase took place due to developments in solar and wind power as well as biofuels and waste.[144]

There was a support of growth of RES in the electricity, which occurred between 2009 and 2012, due to support mechanisms. These support schemes were changed and updated in 2013. The schemes spurred an extensive deployment, especially solar PV grew more than the government targets.[145]

4.2.3 The electricity grid and smart grids

Terna is the name of the TSO in Italy. Its main operational responsibility lies in electricity emergency response. The DSOs support the TSO in case of a network crisis. Due to more variable renewables in the electricity supply information sharing, robust communication and coordination of real-time power system management between the TSO and DSOs is crucial.[146] There are 144 DSOs and three of these have more than 100 000 customers.[147]

[142] IEA (2016). Energy Policies of IEA countries. Italy Review
[143] IEA (2016). Energy Policies of IEA countries. Italy Review
[144] IEA (2016). Energy Policies of IEA countries. Italy Review
[145] IEA (2016). Energy Policies of IEA countries. Italy Review
[146] IEA (2016). Energy Policies of IEA countries. Italy Review
[147] https://publications.jrc.ec.europa.eu/repository/bitstream/JRC113926/jrc113926_kjna29615enn_newer.pdf

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Over the years, emergency operation procedures have been developed with all neighbouring countries to handle emergency events.[148] A custom protection scheme automatically handles emergency conditions with a state-owned electricity transmission company of Slovenia (ELES, Elektro-Slovenija, d.o.o.). There is a bilateral agreement with all neighbours for mutual assistance in emergency situations to supply real-time service. [149]

Until 2015 there has been a comprehensive deployment of smart grid with almost 32 million installed smart meters in homes as well as businesses. The smart meters have a wide variation of technologies and they can be used for many different things, including remote metering, monitoring of outage, fraud detection, switching retail-provider, EV charging, and integrating variable renewables. [150]

Enel Distribuzione is the second largest distribution company in Europe. It has a total market share of 85% in Italy. Furthermore, it has been leading in the smart grid deployment. The TSO Terna also deployed smart grid technologies. This is to help manage energy flows, with real-time system optimisation, perform real-time system monitoring as well as predict variable renewable generation. For Terna smart grids are also crucial for storage, as this might ease transmission constraints.[151]

At the distribution level, the main drivers for deploying the smart grid are improved service as well as cost reduction. Enel estimates that between 2001 and 2013 the service quality (number of minutes of interruption per year) improved by 65%. Additionally, expenses for operation and maintenance decreased by 40%, which means a reduction per customer from 80€ to 51€. In the same period, due to these measures and other efficiency improvements, the retail tariffs costs (assigned to distribution) were reduced by 35%.[152]

A common customer management platform is also developed for the smart grid infrastructure. Creating an independent database system needs constant data collection in a consistent way. This also means smart grid data being available to third parties. Thus, there might be a risk for privacy violations, fraud or other abuse.[153]

4.2.4 The heating systems

In Table 4.4 is the heating system with its consumption and production described.

Table 4.4 Heat production and consumption

Heat generation (2015)[154]	62 TWh +15.8% since 2005
Heat generation mix (2015)[155]	Natural gas 63.6%, Biofuels and waste 19.5%, Oil 14.7%, Coal 1.8%, Geothermal 0.4%
Installed capacity (2015)[156]	1 368 MWth, 929 MWe

[148] IEA (2016). Energy Policies of IEA countries. Italy Review
[149] IEA (2016). Energy Policies of IEA countries. Italy Review
[150] IEA (2016). Energy Policies of IEA countries. Italy Review
[151] IEA (2016). Energy Policies of IEA countries. Italy Review
[152] IEA (2016). Energy Policies of IEA countries. Italy Review
[153] IEA (2016). Energy Policies of IEA countries. Italy Review
[154] IEA (2016). Energy Policies of IEA countries. Italy Review
[155] IEA (2016). Energy Policies of IEA countries. Italy Review
[156] IEA (2016). Energy Policies of IEA countries. Italy Review

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Heat consumption (2014)[157]	Industry 70.2%, Residential 21.8%, Commercial and public services, including agriculture 8.0%

The establishment of DH systems started in the 1970s in Northern Italy. This continued also in the 1980s and 1990s, including networks of limited size as well as others that were part of specific residential developments. The connected heating volume saw a rise at an average annual rate of 7.5%, increasing from 110 million m³ to 260 million m³ between 2000 and 2011. According to an estimation by the Italian Association of District Heating at the end of 2011, at least 200 DH networks were in operation. About 90 of those 200 DH networks were mainly or fully powered by biomass (excluding municipal waste). Around 5% of the population is connected to DH networks. Most commonly these networks are small or medium sized, which means a connected volume of less than 5.0 million m³, with varying heat technologies in use, often combined. There are more biomass-fired networks, but they are normally smaller. Natural gas co-generation is usually used in larger DH networks, followed by solid municipal waste incineration.[158]

Around half of the heat generation comes from fossil fuel-fired co-generation plants (30% of the installed capacity). Around one-fifth comes from renewable sources and heat pumps (10% of the available capacity) and 25% are provided by integration, reserve and base boilers powered by fossil fuels (60% of installed capacity). It is common that operators are subsidiaries of the municipalities, there are however also private ones.[159]

4.2.5 Energy related emissions

In Table 4.5 is emissions related to the energy sector shown.

Table 4.5 Energy related emissions[160]

CO_2 emissions ($MtCO_2$) (2017)	321.5
CO_2/TPES (tCO_2/toe) (2017)	2.10
CO_2/Pop (tCO_2/capita) (2017)	5.31
CO_2/GDP ($kgCO_2$/2010 USD) (2017)	0.15
CO_2/GDP (PPP) ($kgCO_2$/2010 USD) (2017)	0.16

The greenhouse gas (GHG) emissions have decreased since 2008. This decrease took place due to various different factors such as increased use of natural gas and RES in the power sector as well as improved energy efficiency. Another contribution was the economic recession. [161]

The energy sector is responsible for 81.2% of the total GHG emissions (agriculture and industrial processes, 7.2% each as well as waste and solvents, 4.3%). In 2016, energy-related CO_2 accounted for 325.7 million tonnes (Mt). These emissions are around 17% lower compared to 1990 and 29% lower in comparison to a peak of 456.3 Mt in 2005. Emissions have been reducing due to falling energy supply,

[157] IEA (2016). Energy Policies of IEA countries. Italy Review
[158] IEA (2016). Energy Policies of IEA countries. Italy Review
[159] IEA (2016). Energy Policies of IEA countries. Italy Review
[160] IEA (2019), Key World Energy Statistics
[161] IEA (2016). Energy Policies of IEA countries. Italy Review

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the economic downturn, shrinking manufacturing sector, and an increasing percentage of renewables, especially in the power sector.[162]

The power generation sector was the second-largest emitter in 2014 (used to be the largest) with 32.3% of the total share. The transport sector emitted 33% of the total emissions, thereby being the largest emitter. Households emitted 13.1%, the manufacturing and construction sector 11.2%, commercial and other services sector (including agriculture and fisheries) 7.1% and other energy industries (including refining) 3.2% of the total. Since 1990, emissions in power generation, manufacturing and construction, other energy industries and from households decreased. However they increased from commercial services and transport. Since the peak in 2005, one can however see a decline in all sectors.[163]

In 2013, 45.5% of the energy-related CO_2 emissions came from oil and oil-products, natural gas accounted for 36.7% and coal was at 16.2%. Additionally, industrial and non-renewable municipal waste accounted for 1.6% of the total energy-related emissions.[164]

CO_2 emissions decreased due to reduced oil and natural gas consumption. Oil emissions are 40.5% lower as in 1990 and 35.9% as in 2005. Coal emissions declined by 8.4% compared to 1990 and 18.8% in comparison to 2005. Natural gas emissions on the other hand rose by 34.7% compared to 1990, however they decreased by 27.8% since 2005.[165]

The carbon intensity was 0.16 tonnes of CO_2 per USD 1 000 PPP in 2016, which is lower compared to the IEA average which is 0.3 and lower than the IEA Europe average, which is 0.23 tCO_2/USD 1 000 PPP.[166]

4.3 Context: Institutional setting

Under institutional settings political goals, policies, subsidies and tax schemes as well as the construction of electricity prices will be discussed.

4.3.1 Political goals and national energy agreements to reduce emissions

In 1998/1999 the liberalisation process of the electricity and natural gas market started. In 2013, the National Energy Strategy (NES) was published. This NES contains objectives, key policies and priority measures for the energy sector including medium as well as long-term elements (2020, 2050). The NES focuses on fostering sustainable growth, which will be achieved through strengthening the competitiveness of the Italian economy. Additionally, it emphasises that consequences of climate change shall be addressed and at the same time also guarantees secure as well as accessible energy for all citizens.[167]

The NES includes four goals as well as seven priorities of actions plus expected results.

The goals are:

- Align energy prices in Italy with rest of Europe.

[162] IEA (2016). Energy Policies of IEA countries. Italy Review
[163] IEA (2016). Energy Policies of IEA countries. Italy Review
[164] IEA (2016). Energy Policies of IEA countries. Italy Review
[165] IEA (2016). Energy Policies of IEA countries. Italy Review
[166] IEA (2016). Energy Policies of IEA countries. Italy Review
[167] IEA (2016). Energy Policies of IEA countries. Italy Review

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- Meet and surpass the objectives set by EU Climate and Energy Package 2020 and decrease GHG emissions by 19% compared to the 18% target.
- Reduce energy imports from 84% in 2013 to 67% in 2020, saving EUR 14 billion annually.
- Foster sustainable economic growth in the energy sector.

The most significant priorities are the following:

- Improved energy efficiency will absorb a substantial portion of expected increases in energy demand by 2020, in terms of both primary supply and final consumption.
- Sustainable development of renewable energy.
- Develop electricity infrastructure and the electricity market.
- Restructure the refining industry and the fuel distribution sector.
- Sustainable production of domestic hydrocarbons.

The role of technology is also highlighted in the strategy, as investments in advanced technologies R&D are mentioned as necessary for a progressive decarbonisation.[168]

The strategy for 2020 entails the achievement of a 24% reduction in primary energy consumption in relation to a 2007 "business-as-usual" projection. This was aimed to be accomplished through energy efficiency measures. The 2050 strategy aims to decouple economic growth from energy consumption and achieve a reduction of 17-26% compared to 2010.[169]

The climate change policy in Italy developed in line with the EU framework for climate and energy policies. The central government is responsible for climate policy (at the domestic level) but there are also increased policy making and implementation responsibilities by the regions. Additionally, there is a framework for the Covenant of Mayors, including about 1300 local administrations to work with plans and measures to achieve a local contribution to reduce emissions.[170]

The National Energy Efficiency Action Plans (NEEAPs), is set by member states of the European Union. It included estimated energy consumption, planned energy efficiency measures and expectations of improvements which each member state is expected to achieve. The NEEAP 2014 established energy efficiency targets, the needed policy measures and progress made.[171]

A National Action Plan for the Reduction of Greenhouse Gases for 2013-2020 was set in 2013.[172] Italy mainly uses economic instruments in its climate mitigation policy. The EU-ETS covers about 40% of Italy's GHG emissions. This is less than other large EU economies, leaving most emission abatements to be achieved by domestic measures in the non-ETS sectors. Italy has heavily relied on renewable energies and energy efficiency mechanisms (notably tradable white certificates, and tax rebates and capital funding) to achieve climate mitigation goals. The core of the renewable and policy mix has been renewable certificates and feed-in tariffs.[173]

[168] IEA (2016). Energy Policies of IEA countries. Italy Review
[169] IEA (2016). Energy Policies of IEA countries. Italy Review
[170] IEA (2016). Energy Policies of IEA countries. Italy Review
[171] IEA (2016). Energy Policies of IEA countries. Italy Review
[172] IEA (2016). Energy Policies of IEA countries. Italy Review
[173] IEA (2016). Energy Policies of IEA countries. Italy Review

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4.3.2 Performance on EU 2020 energy targets

The Renewable Energy Action Plan in Italy started in 2010 with the goal to reach 17% of final energy consumption from RES by 2020. A priority in Italy's energy policy is the increase of RES and energy efficiency. The policy aims to focus on energy supply security, lower energy costs for consumers, promotion of innovative new technologies, environmental protection (including lower GHG emissions). In the medium to long term, Italy aims to decrease its dependency on imported fossil fuels. In 2018 Italy had a share of 17.8% renewable in gross final energy consumption.[174]

Greenhouse gas emissions–excluding land use, land-use change and forestry–decreased by 17.2% between 1990 and 2018[175] (passing from 516 to about 427 $MtCO_2$-eq). Hence, it seems like the country is on a good track to achieve the goal (Italy, as a member state of EU, committed to reducing GHG emissions by 20% by 2020 compared to 1990). The most important greenhouse gas, CO_2, which accounts for 81.4% of total emissions in CO_2 equivalents, decreased by 20.5% between 1990 and 2018.[176] Under the Paris Agreement, signed in 2016, Italy promised to reach a new target: a GHG emission reduction of 30% compared to a 2005 baseline (587 $MtCO_2$-eq), by 2030.[177]

The fourth National Energy Efficiency Action Plan, submitted in 2017, sets the final end-use energy savings target of 15.5 Mtoe in final energy for 2020. To reach this energy efficiency goal, several measures have been planned: i.e., Energy Efficiency Certificates (EECs; called "certificati bianchi"), tax deductions, thermal energy account ("conto termico"; an incentive for renewable thermal energies, introduced in 2012), normative standards, and investments on mobility (see Table 4.5). Greater amounts of savings are expected from the adoption of EECs (5.45 Mtoe) and normative standards (5.23 Mtoe). While, considering the effects on the different energy-consuming sectors, the largest savings are expected from the transport (5.50 Mtoe) and the industry sectors (5.10 Mtoe), followed by residential (3.67 Mtoe) and tertiary sectors (1.23 Mtoe). More details can be found in the literature[178].

Table 4.6 Energy efficiency objectives in end-use final energy (Mtoe/year) for 2020[179]

Sector	**Measures foreseen in the period 2011-2020**					**Expected savings**
	EECs	**Tax deductions**	**Thermal energy account**	**Normative standards**	**Investments on mobility**	
Residential	0.15	1.38	0.54	1.60		**3.67**
Tertiary	0.10		0.93	0.20		**1.23**
P.A.	*0.04*		*0.43*	*0.10*		*0.57*
Private	*0.06*		*0.50*	*0.10*		*0.66*
Industry	5.10					**5.10**
Transport	0.10			3.43	1.97	**5.50**
Total	**5.45**	**1.38**	**1.47**	**5.23**	**1.97**	**15.50**

[174] https://ec.europa.eu/info/business-economy-euro/economic-and-fiscal-policy-coordination/eu-economic-governance-monitoring-prevention-correction/european-semester/european-semester-your-country/italy/europe-2020-targets-statistics-and-indicators-italy_en
[175] ISPRA, Italian Greenhouse Gas Inventory 1990-2018. National Inventory Report 2020.
[176] ISPRA, Italian Greenhouse Gas Inventory 1990-2018. National Inventory Report 2020.
[177] https://www.climatescorecard.org/2018/06/italys-national-energy-strategy/
[178] J. Malinauskaite et al., "Energy efficiency in industry: EU and national policies in Italy and the UK", Energy 172 (2019) 255-269.
[179] https://ec.europa.eu/energy/sites/ener/files/documents/it_annual_report_2018_it.pdf.

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In the European Commission's Climate and Energy Policy Framework for 2030 a 30% energy saving target for 2030 is stated. This target was designed with already achieved targets in mind, namely that new buildings use half the energy compared to 1980s and that industry is around 19% less energy-intensive compared to 2001. An indicative target of 27%, which will be reviewed in 2020, was however, endorsed by the European Council.[180]

4.3.3 Electricity market, policy and law

In relation to IEA Europe, Italy has the fourth largest electricity market. As mentioned above the liberalisation of the electricity market started 1998/1999. The country is making progress regarding market liberalisation and infrastructure development.

There are six primary geographic zones and four "poles of limited production", (generating units that have interconnected capacity with the grid smaller than their installed capacity) over which wholesale prices are computed in Italy. Additionally, an hourly national single price is calculated from the prices (PUN, prezzo unico nazionale) in these zones. This is simply the average price per zone weighted by total volume traded.[181]

There are three retail markets in Italy: the safeguarded market; the enhanced protection market; and the open market. The safeguarded market targets final customers that do not qualify for the enhanced protection market and may not have an electricity supplier. Approximately 93000 customers are served by two companies. Fewer and fewer customers are in this category, as more move to the open market. Customers must make an active decision to move to the open market. Customers that do not make a decision are provided electricity form the enhanced protection market.[182]

The spot electricity market in Italy consists of a day-ahead market and an intraday market, both managed by the electricity market operator, gestore dei Mercati Energetici (GME). Additionally, there is an ancillary services market where Terna, the TSO, acts as an important counterpart. Additionally, GME operates a forward electricity market (MTE). There were 223 participants registered on the spot markets in 2014 (23 in 2012), but only 23 participants on the MTE (25 in 2013). Also, suppliers can enter bilateral contracts, that must be registered in the Energy Accounts Platform, Piattaforma conti energia (PCE), or Energy Accounts Platform. There were 287 participants on the PCE in 2013 (259 in 2012).[183]

In 2013, the spot market exchange accounted for 42% of electricity supply. Thus, it was the largest clearinghouse for delivered electricity. Approximately 28% of electricity supplied was cleared through the PCE, compared to 12% through foreign power exchanges. The remaining 17% was provided by the publicly owned company Gestore dei Sistemi Energetici (GSE), that is developing renewable resources and energy efficiency. Currently, the Italian government is uniting GSE's operations role from its accounting role, such that it becomes more independent.[184]

[180] IEA (2016). Energy Policies of IEA countries. Italy Review
[181] IEA (2016). Energy Policies of IEA countries. Italy Review
[182] IEA (2016). Energy Policies of IEA countries. Italy Review
[183] IEA (2016). Energy Policies of IEA countries. Italy Review
[184] IEA (2016). Energy Policies of IEA countries. Italy Review

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The share of conventional thermal power plants (i.e., gas, coal, and oil) in power generation decreased from 80% in early 2012 to 54% in August 2014. This decrease has been offset by a growing share of renewables, mostly solar energy. The growing share of renewables and lower gas prices contributed to lower wholesale power prices in Italy. There has also been a shift from over-the-counter (bilateral) trades to an exchange trade on the Energy Accounts Platform.[185]

Recently, there has been an increase in the trading volume on the forward market. This type of market offers participants an opportunity to hedge against price volatility. Likely, the importance of this market will grow in the future.[186]

4.3.4 Subsidies, tax schemes

The European Union Directive 2003/96/EC provides common rules for the taxation of energy products and additionally strives for a reduction of distortions of competition between EU member states, which have divergent rates of tax on energy products as well as between mineral oils and other energy products. The Italian energy tax is set within the framework of the directive. Tax rates are mostly higher than the minimum rates from the EU directive.[187]

- Natural gas for transportation is an exception being at the minimum rate level.
- Fuel taxes for transportation are different depending on the fuel type. Taxes for heating and process fuel are defined according to the user. Regarding transport, exempts are for instances taxes for aviation and shipping (transport) and taxes for rail are reduced.
- Heating and process fuel has a lower tax for commercial and industrial use compared to residential use.
- For agriculture and fishing gasoline, diesel oil and LPG have a lower tax.
- The natural gas tax is different depending on geographical location and consumption level.
- There is a different tax for electricity consumed by business and non-business users.
- Electricity produced by fuels as a quite low tax (almost nil) compare to other uses.
- There is a tax exemption for electricity used for transportation.
- Waste, biomass and other renewable energy is exempt from taxes if it is used for heat or electricity.
- Also, no tax has heat consumption.

In 2008, after a period of increasing energy taxes, a new energy tax was introduced. The objective of this tax was to capture some of the higher profits of the energy sector. The tax (called "Robin Hood tax") was introduced at a rate of 5.5%, 6.5% in 2010 and 10.5% for 2011 to 2013. It was then also used for companies with an annual turnover larger than EUR 3 million as well as taxable income at EUR 300 000. In 2015, this tax was said to be illegal (Constitutional Court), however not retroactive.[188]

Energy consumption in Italy has high taxation. Additionally, carbon prices implied in energy tax rates applied to industrial processes, heating and other non-transport uses are higher compared to competing economies like France or Germany. On the contrary, industrial users of fuels have benefits from certain tax exemptions, and consuming fuel in the agriculture sector has benefits from a reduction

[185] IEA (2016). Energy Policies of IEA countries. Italy Review
[186] IEA (2016). Energy Policies of IEA countries. Italy Review
[187] IEA (2016). Energy Policies of IEA countries. Italy Review
[188] IEA (2016). Energy Policies of IEA countries. Italy Review

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of the rate of taxation on diesel. Compared to the European Union, Italy has one of the highest taxes on fuel. [189]

4.3.5 Electricity prices

In 2014, in order to achieve more affordable electricity, especially for small enterprises, the government adopted specific provisions for a cost reduction. The cost of incentives for renewables is paid through additional charges on customers' bills, so the government reduced remuneration for renewables producers amongst others. The intention with this progressive tariff system (called "inclining block rates") is to provide incentives for using electricity more efficiently. This system works well when it comes to energy efficiency measures as replacing high-consuming appliances with low-consuming ones. However, it is a system that provides disincentives or energy efficiency measures that involve fuel switching. Thus, the regulator tests an explicit incentive regarding the tariff consumer using heat pumps as a heating system. Finally, Legislative Decree No. 102/2014 which implements the Directive 2012/27/EC on Energy Efficiency, allows a gradual removal of the progressive tariff system for domestic consumers.[190]

AU (Acquirente Unico), a subsidiary of Gestore dei Servizi Elettrici, has the mission (by law) to secure efficient and reasonable priced electricity supply for households as well as small businesses Electricity is purchased by AU on good terms and is then sold to distributors or retailers on the standard offer market (named "mercato di maggior tutela"). This is done to supply small consumers who did not switch to the open market. The electricity market was fully opened-up on 1 July 2007. Since that time, AU has been buying electricity in order to cover the requirements of the standard offer market, meaning households and small business consumers, who are connected with a low voltage and less than 50 employees and yearly turnover that is not higher than EUR 10 million, and who did not select a new provider in the open market. Additionally, it manages an energy consumers' helpdesk and offers public bidding procedures in order to choose providers of last resort. How the AU procures, electricity is defined in the Decree of the Minister of Productive Activities of 19 December 2003.[191]

- For volumes less than 25% of the overall yearly forecast demand of the captive market, make over-the-counter contracts (for the power exchange).
- Participate in allocation procedures for the transmission capacity, such that electricity can be imported and, based on allocated capacity, make contracts with foreign suppliers.
- To cover the remaining requirements, procure electricity on the market after making financial contracts to minimize sensitivity to price volatility.

AU also does bidding procedures, identifying providers of the last service ("servizio di salvaguardia"). This service is offered to end-customers not qualifying for the standard offer market and who are temporarily without an electricity supplier.[192]

The price for household electricity was 0.234 EUR/kWh in Italy in June 2019. This includes all components such as the cost of power, grid tariffs and taxes. [193] This is 28% above the average in other

[189] IEA (2016). Energy Policies of IEA countries. Italy Review
[190] IEA (2016). Energy Policies of IEA countries. Italy Review
[191] IEA (2016). Energy Policies of IEA countries. Italy Review
[192] IEA (2016). Energy Policies of IEA countries. Italy Review
[193] https://www.globalpetrolprices.com/Italy/electricity_prices/

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EU countries. While Denmark and Germany have the highest electricity rates, Italy has the sixth highest rate.[194]

In 2018, the household price for a typical family (maximum connected load of 3 kW and average electricity consumption of 2,700 kWh a year) comprised energy material costs 43.8% (35% for energy supply, 8.8% for retail marketing), transport and meter management costs 20.4%, system charges cost (set by law) 22.4%, and taxes 13.3% (including value added tax 10.0%, and excise duties).[195]

Between 2007 and 2013, the rate of customers switching to the openmarket was ten times greater than the rate of customers switching from the free market. This suggests that the free market provides competitive pricing and additional value to consumers. Thus, the enhanced protection market has been shrinking continuously, however, it is still 23% of all electricity consumed.[196]

It is hard to switch between retail providers compared to switch between market categories. Very little data is required to be shared, thus switching between providers requires a lot of time and effort. Italy is improving this by requiring AU to implement an Integrated Information System. This acts as a common platform to manage all retail customers. AU has also a role of common customer support, as it tracks and responds to customer complaints.[197] In Italy, consumers that do not choose a supplier remain with a default supplier, the local DSO. They provide electricity according to a 'standard offer' regime (the mentioned "mercato di maggior tutela"). In 2012 a majority, 80% of the households were served on the base of this standard offer.[198] In 2017, this percentage decreased to about 61%[199]; while at the end of 2019, according to Authority for Energy, Networks and Environment[200], there were 53.5% of the households still served by the standard offer.

4.4 Action arena: Actors

In this section, the main public and market actors are described. The section ends with a brief overview of the number of energy communities.

4.4.1 Government and Authorities

Italy is a unitary parliamentary republic. The parliament government is based on a mixed proportional and majoritarian voting system. The parliament is bicameral with two houses, the chamber of Deputies and the Senate of the Republic. The two houses have the same power, with the important role of discussing and approving laws.

The Ministry of Economic Development (MSE, Ministero dello Sviluppo Economico) is in charge to formulate and implement energy policy.

The Ministry for the Environment, Land and Sea (MATTM, Ministero dell'Ambiente e della Tutela del Territorio e del Mare) is responsible to co-ordinate climate policy issues. Additionally, they are co-signing policy measures encouraging renewable energy efficiency with the MSE.

[194] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Electricity_price_statistics#Electricity_prices_for_household_consumers
[195] https://www.arera.it/allegati/com_stampa/18/180329eng.pdf.
[196] IEA (2016). Energy Policies of IEA countries. Italy Review
[197] IEA (2016). Energy Policies of IEA countries. Italy Review
[198] https://ec.europa.eu/energy/sites/ener/files/documents/2014_countryreports_italy.pdf
[199] https://www.qualenergia.it/articoli/elettricita-e-gas-aumenta-la-quota-dei-clienti-sul-mercato-libero.
[200] https://www.ilsole24ore.com/art/luce-e-gas-piu-salato-mercato-libero-ecco-come-risparmiare-ACU9DP5.

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The Inter-Ministerial Committee for Economic Planning (CIPE) is responsible for national policies, including climate change, and it approves national GHG emissions reduction programmes. The Inter-Ministerial Technical Committee for Emissions of GHGs (CTE) supports the CIPE's climate work. The MATTM chairs the CTE.

The CTE is made up of representatives of all relevant ministries and of the Presidency of the Council of Ministers. The CTE is responsible for monitoring implementation of policies and measures identified in the NES and their impacts on emission trends, as well as for identifying further measures to meet targets.

The Institute for Environmental Protection and Research (ISPRA) is in charge for reporting national emissions to the EU and the United Nations Framework Convention on Climate Change (UNFCCC).

The regulatory body Regulatory Authority for Electricity, Gas and Water (AEEGSI, Autorità per l'Energia Elettrica, il Gas e il Sistema Idrico) is independent from the government and regulates and oversees the electricity, natural gas, and water sectors. The commissioner is nominated by the Parliament, and sets tariffs, the definition of service quality standards as well as the economic and technical conditions that governs network access and interconnectivity. The funding for the AEEGSI comes from a mandatory annual contribution from the service provider.[201] Additionally, the AEEGSI has different responsibilities for renewable energy, as providing and securing fair grid access conditions as well as getting support for the cost of renewable energy in a variety of consumer groups. They surveille the wholesale energy markets.

The Competition Authority (Autorità Garante della Concorrenza e del Mercato) is independent. It enforces rules to protect against anticompetitive agreements between undertakings, joint ventures that may be detrimental to competition, dominant positions that are abused and mergers and acquisitions.

The company GSE is owned by the state encouraging and supporting RES. They are auctioning the Italian share of EU-ETS allowances.[202] The organisation of GSE is that of a private company and the sole shareholder is the Ministry of the Economy and Finance (Ministero dell'Economia e delle Finanze).

The Italian Carbon Fund (ICF) is in charge of purchasing carbon credits.

GME organises and manages the economics of the electricity market neutrally, transparently, and objectively. It aims to foster competition among producers and ensure available reserve capacity. Additionally, it is responsible for the management of green certificates and energy efficiency certificates (so called "Certificati Bianchi" or "White Certificates").

The subsidiary of GSE, AU, is by law given the task of procuring continuous, secure, and efficient, and reasonably priced electricity supply for households and small business. The AU buys electricity in the market,

4.4.2 Market actors

There are three retail markets in Italy: the safeguarded market; the enhanced protection market; and the open market.

[201] IEA (2016). Energy Policies of IEA countries. Italy Review
[202] IEA (2016). Energy Policies of IEA countries. Italy Review

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There are 236 suppliers in the enhanced protection service, however, most consumers (85%) are served by Enel Servizio Elettrico. The three largest providers (Acea Energia, A2A Energia, and Iren Mercato) together serve 9.3%, while the remaining 132 providers serve less than 5% of the standard offer market. As of end of 2013, 22 million households and four million small-medium sized enterprises were in the enhanced protection market.[203]

Central to the enhanced protection market is a single purchaser, AU, which has legislative mandate to provide proper service to the "enhanced protection" market, as well as consumers that have not yet switched to an alternative supplier. AU uses the wholesale market to buy and sells to standard offer retailers, who resells at a regulated price.[204]

There has been a form of free market in Italy for over 10 years; however, the introduction of retail competition was finished in 2007. The market has the largest number of retail providers (336). Total number of resellers has been increasing, with as much as 50 between 2012 and 2013. [205]

Enel is again the largest retailer, though its relative share is less than in the enhanced protection market. Enel serves 35% of the free market; significantly more than all competitors. This figure is even misleadingly low, because it includes all customer classes. Enel supplies 76% of delivered electricity in the domestic (residential) category. Enel is also the largest provider in the non-residential, low-voltage, category (43% of the load). However, Enel has fallen from first place in the medium- and high-voltage categories, where Edison and Green Network Luce and Gas, respectively, are now in the lead. Despite this, Enel has a unique position as it dominates the enhanced protection market and the free domestic markets.[206]

Terna is the TSO. Thera are 144 DSOs and of those three have more than 100 000 customers.[207]

4.4.3 Energy communities

In Italy, the initiatives relating to the development of energy communities are at an early stage. At the moment, the only initiatives that involve citizens and offer alternatives to the usual players in the electricity market are energy cooperatives.

The first energy cooperatives date back to the 1900s, when hydro-electricity cooperatives were founded in the northern regions of Trentino and South Tyrol. The objective of these cooperatives was to favour the development of the mountain population of the Alps through the production and distribution of electricity. Some of these historical hydro and thermal cooperatives still exist, but they have been reconfigured after the nationalisation of the electric energy production and distribution in Italy (1962) and other legislative measures that in practice hindered their development.

Energy cooperatives expanded significantly after 2006, as a part of a generalised growth of the renewable energies in Italy. They include a variety of initiatives with shared interest in RES (generation or consumption), with different organizational forms.

[203] IEA (2016). Energy Policies of IEA countries. Italy Review
[204] IEA (2016). Energy Policies of IEA countries. Italy Review
[205] IEA (2016). Energy Policies of IEA countries. Italy Review
[206] IEA (2016). Energy Policies of IEA countries. Italy Review
[207] https://publications.jrc.ec.europa.eu/repository/bitstream/JRC113926/jrc113926_kjna29615enn_newer.pdf

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Today in Italy there are about 30 energy cooperatives (34 have been surveyed in recent literature)[208, 209]. These cooperatives are mostly concentrated in the north of Italy. An exception is the one in the municipality of Melpignano (Lecce, Puglia region), in the southern part of Italy; founded in 2011 in order to install and manage PV systems on the roof of inhabitants' houses. The most important Italian cooperatives are compared in Table 4.7 Main energy cooperatives in Italy.Additional details can be found in the literature.[210,]

Table 4.7 Main energy cooperatives in Italy[211]

	Enercoop	Somenergia	WeForGreen	Energia Positiva	Énostra
Number of members	52 000	44 000	590	154	2 796
Produced energy (GWh/year)	260	5	7.2	0.6	0.6
Sold energy (GWh/year)	250	100			4.3
Production	Yes	partially	Yes	yes	partially
Distribution	Yes	Yes	No	no	yes

With regard to energy communities, however, as mentioned above, Italy is in the initial stages. But interest and initiatives aimed at the establishment of energy communities are constantly growing. With Law no. 8 of 28 February 2020, Italy began the process of adopting the European Renewable Energy Directive (Directive 2018/2001/EU) which will be implemented by the Italian government in 2021. In particular, Article 42 of this law specifies that consumers may establish renewable energy communities. The people, involved in the energy communities, must produce energy for their own consumption with plants powered by renewable sources, with a total power not exceeding 200 kW. The communities are allowed to use existing distribution networks to share the energy produced.

In addition, the same law also allows the establishment of energy communities in condominiums that represent a great potential for the development of community renewable energy plants. According to the Energy@Home association (founded on July 2012 by Electrolux, Enel, Indesit Company and Telecom Italia) there are 2.6 million condominiums in Italy potentially interested in the installation of PV systems for energy communities with around 29 GW of potentially installable PV power and 6-9 GW PV installations for self-consumption by 2025.
In addition to legislative measures at national level, local and regional initiatives are beginning to develop the first interesting projects.

[208] C. Candelise, G. Ruggieri, "Community energy in Italy: Heterogenous institutional characteristics and citizens engagement", IEFE, Center for Research on Energy and Environmental Economics and Policy, Università Bocconi, Milano, Italy.
[209] R.J. Hewitt et al., "Social innovation in community energy in Europe; a review of the evidence", Frontiers in Energy Research 7:31, 2019.
[210] N. Magnani, G. Osti, "Does civil society matter? Challenges and strategies of grassroots initiatives in Italy's energy transition", Energy Reserach and Social Science 13 (2016), 148-157; C. Candelise, G. Ruggieri, "Status and evolution of the community energy sector in Italy", Energies (2020) 13, 1888.
[211] N. Magnani, D, Patrucco, "Le cooperative energetiche rinnovabili in Italy: tensioni e opportunità in un contesto in trasformazione", In: G. Osti, L. Pellizzoni (eds.) "Energia e innovazione tra flussi globali e circuiti locali", EUT, Edizioni Universitò di Trieste, 2018, pp. 187-207.

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The Piedmont Region, in line with the European and National Directives on energy and climate policies, has recently approved the first Regional Law in Italy (Regional Law 12/2018, approved on July 25th, 2018) for the constitution of "Energy Communities".[212] This law identifies energy communities as homogenous territorial area that, in order to overcome the use of fossil fuels, produce and exchange energy generated from RES, promoting measures of energy savings and energy efficiency. In this context, the Piedmont Region has published a call for proposals for municipalities to finance the development of energy communities. In addition, the Piedmont region is also supporting a group of municipalities. These formed a consortium to set up the first Oil Free Zone in Italy where an energy community will be created, based on-site production, self-consumption and self-exchange of clean energy.

Another region, Puglia, in southern Italy, has also chosen to speed up the transition to renewable energy by supporting the creation of energy communities. In this regard, the region has enacted a specific law issued in August 2019, which provides guidance to municipalities that intend to establish or support the creation of energy communities.

It is easy to predict that in the coming years, thanks to the support of both local and national institutions and a wider awareness of citizens, the number of energy communities in Italy will follow a positive trend. According to a forecast made by the Politecnico di Milano (Polytechnic University of Milan is the largest technical university in Italy), almost 100 000 energy communities are expected to be built in Italy by 2030, with a turnover of EUR 160 billion (on average over EUR 10 billion per year).[213]

[212] G. Mutani, V. Todeschi, A. Tartaglia, G. Nuvoli, "Energy Communities in Piedmont Region (IT). The case study in Pinerolo territory", 2018 IEEE International Telecommunications Energy Conference (INTELEC), October 7-11, 2018, Torino, Italy.
[213] Energy & Strategy Group, Smart Grid Report, Politecnico di Milano, 2014.

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5 The Netherlands (NL)

In this chapter the socioeconomic conditions, the energy system, institutional setting and energy related actors in the Netherlands will be described.

5.1 Context: Socioeconomic conditions

In Table 5.1the socioeconomic conditions for the Netherlands is described. Located at the delta of the rivers Rhine, Ijssel and Meuse, 20% of the country lies below and 50% less than one metre above sea level.[214] The Netherlands is densely populated, with approximately 17 000 000 citizens on an area of 33 720 km².

Table 5.1 Socio-economic conditions

Population[215]	17,134,872
Urban population[216]	92%
Land area[217]	33,720 km²
GDP 2019[218]	902,333 Billion USD
GDP per capita (2018)[219]	52,931 USD
GDP PPP 2019[220]	1,005.270 USD
Employment rate (March/2020)[221]	78.4%
Unemployment rate (March/2020)[222]	2.9%

In the world, the Netherlands is ranked as number 17 when comparing countries' GDP and as number 28 in relation to GDP at PPP. In Europe it has the eighth highest GDP per capita. The employment rate is 78.4% (March 2020), slightly above the EU level of 73.2. The unemployment rate is much lower than the rest of the EU, only 2.9% (EU has 6,2%).

5.2 Context: Technical systems

Below the Dutch energy system will be described, including energy production and consumption, the electricity system, the heating system and energy related emissions.

5.2.1 Energy production and consumption

Table 5.2 provides figures related to energy production and consumption for the Netherlands.

Table 5.2 Energy production and consumption

TPES (Total Primary Energy Supply) (2018)[2233]	71.7 Mtoe
TPES by source (2017)[224]	Coal 13% Oil 37,8%

[214] IEA (2014), Energy Policies of IEA Countries. The Netherlands. 2014 Review
[215] https://www.worldometers.info/population/countries-in-europe-by-population/
[216] https://www.worldometers.info/population/countries-in-europe-by-population/
[217] https://www.worldometers.info/population/countries-in-europe-by-population/
[218] http://statisticstimes.com/economy/countries-by-projected-gdp.php
[219] http://statisticstimes.com/economy/european-countries-by-gdp-per-capita.php
[220] http://statisticstimes.com/economy/countries-by-projected-gdp.php
[221] https://tradingeconomics.com/country-list/employment-rate
[222] https://tradingeconomics.com/country-list/unemployment-rate?continent=europe
[223] https://www.iea.org/data-and-statistics/data-tables?country=NETHLAND&energy=Balances&year=2018
[224] https://www.ieabioenergy.com/wp-content/uploads/2018/10/CountryReport2018_Netherlands_final.pdf

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	Natural gas 40,3% Nuclear 1,4% Waste 1,2% Bioenergy 3,8% Renewable energy, other 3,1%
TPES/capita (2017)[225]	4.33
Domestic Energy production (2012)[226]	64.7 Mtoe
Domestic energy production mix (2012)[227]	Natural gas 88.8% Biofuels and waste 6.1% Oil for 2.8%. Nuclear, wind, solar and geothermal, 2%
TFC (2017)[228]	64.5 Mtoe
Consumption (delivered energy) by sector (2018)[229]	Industry and construction 46% Transport 18% Households 17% Services, waste and water 12% Agriculture and fishery 7%
TFC/capita (2018)[230]	4.2 toe
Energy intensity (TFC/GDP PPP) (2015)[231]	90.19 toe/USD million PPP

The Dutch energy supply is characterised by high shares of natural gas, which accounts for 83% of the energy mix. Since the discovery of large gas reserves in Slochteren in 1959, the Netherlands has been a net exporter of natural gas, exporting over 60% of its production.[232] This changed in 2013 due to earthquakes in the province of Groningen. Most imports were from Norway, followed by Germany and Great Britain.[233]

Therefore, the Netherlands is no longer a major exporter of natural gas.[234] After more than 50 years of net exports, the Netherlands became a small net importer in 2018. After 2021, net imports will presumably increase further. Dutch natural gas production has been declining since 2013. In 2018, it was only half of the average production over 2010–2013 and, in 2024; this amount will likely be halved again. Moreover, it has recently been decided to reduce production from the Groningen field even faster. The Netherlands has a relatively low share of renewables. Renewable energy comes mainly from wind, biofuels, waste and solar. Geothermal and hydro energy only play minor roles in the country.

[225] IEA (2019), Key World Energy Statistics
[226] IEA (2014), Energy policies of IEA countries. The Netherlands Review.
[227] IEA (2014), Energy policies of IEA countries. The Netherlands Review.
[228] https://ec.europa.eu/eurostat/documents/2995521/9549144/8-07022019-AP-EN.pdf/4a5fe0b1-c20f-46f0-8184-e82b694ad492
[229] https://www.ebn.nl/wp-content/uploads/2018/04/EBN-poster-numbers2016.pdf;
[230] https://estore.enerdata.net/netherlands-energy.html
[231] https://tradingeconomics.com/netherlands/total-final-energy-consumption-tfec-wb-data.html;
[232] Kooij, H-J, Oteman, M, Veenman, S, Sperling, K, Magnusson, D, Palm, J & Hvelplund, F (2018) Between grassroots and treetops: Community power and institutional dependence in the renewable energy sector in Denmark, Sweden and the Netherlands, *Energy Research & Social Science,* 37, pp 52-64
[233] https://www.cbs.nl/en-gb/news/2018/16/energy-consumption-hardly-changed-in-2017
[234] https://www.pbl.nl/sites/default/files/downloads/pbl-2019-climate-and-energy-outlook-2019-summary-3825.pdf

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In 2017, the main energy carriers in relation to the total energy consumption were natural gas (41%), petroleum (39%), coal (12%) and renewables, nuclear energy and waste were together 8%.[235]

The Dutch energy intensity is slightly above average. The energy intensity has fallen gradually since 1996. The TFC per capita 2018 was 40% higher than the EU average, which is explained by the large refining and petrochemical industries.[236]

The Netherlands has a large energy-intensive industry sector, accounting for 46% of the TFC in 2018. Industrial energy consumption has decreased in recent years, mainly thanks to more energy efficient production processes. Around half of the energy is generated using petroleum raw material and products. The chemical and pharmaceutical industry accounted together for 63% of industrial energy consumption.[237].Transport is the second largest energy user (18%), followed by the household sector (17%).

Approximately half (53%) of final energy consumption in 2018 was used for heating, about one quarter (27%) as motor fuel, and one-fifth (20%) as electricity consumption.[238] Most energy is consumed in the built environment (36%), closely followed by industry (29%) and transport and mobility (27%), and much less in agriculture (7%).

Energy consumption per capita decreased between 1990 and 2018 by 19% from 32.8 to 26.5 GJ.[239] The share of natural gas was relatively stable over these years, accounting for nearly 75%, whereas the share of electricity increased from 11.6 to 17.0%. The share of renewable energy in total energy consumption amounted to 7,4% in 2018 compared with 6,6% in 2017.[240]

5.2.2 The Electricity system

In Table 5.3 the electricity generation and consumption is described.

Table 5.3 Electricity generation and consumption

Electricity generation (2019)[241]	121 TWh
Electricity generation mix[242]	Gas 59%, Coal 14%, Fossil 3%, Nuclear 3%, Wind 10%, Biomass 5%, Solar 4%, Hydro 0%,
Electricity net imports (2018)[243]	8 TWh
Electricity import (2018)[243]	26.8 TWh

[235] https://longreads.cbs.nl/trends18-eng/economy/figures/energy/
[236] https://estore.enerdata.net/netherlands-energy.html
[237] https://longreads.cbs.nl/trends18-eng/economy/figures/energy/).
[238] https://www.pbl.nl/sites/default/files/downloads/pbl-2019-climate-and-energy-outlook-2019-summary-3825.pdf
[239] https://www.clo.nl/indicatoren/nl0035-energieverbruik-door-de-huishoudens
[240] https://www.clo.nl/indicatoren/nl0385-verbruik-van-hernieuwbare-energie?ond=20881
[241] https://www.cbs.nl/en-gb/figures/detail/80030eng
[242] https://www.cbs.nl/en-gb/figures/detail/80030eng; https://www.cbs.nl/en-gb/figures/detail/82610ENG
[243] https://www.iea.org/data-and-statistics/data-tables?country=NETHLAND&energy=Electricity&year=2018)

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Electricity export (2018)243 above[243]	-18.8 TWh
Installed capacity (2017)[244]	34 GW
Electricity consumption (2017)[245]	115.4 TWh
Electricity consumption by sector (2012)[246]	Commercial and public services 33,7% Agriculture and forestry 6.7% Industry 35.5% Residential sector 22.5% Transport 1.6%
Electricity consumption/pop (kWh/capita) (2017)[247]	6 734
Electricity price (2017) Households average price per 100 kWh[248]	15.6 EUR
Share of taxes and levies in average price[249]	27%

Electricity production amounted to 121.0 TWh in 2019. The main resources for electricity were fossil fuels, especially natural gas. The production from coal sources saw a sharp decline from over 27 billion kWh in 2018 to over 17 billion kWh in 2019.[250] In the same period, electricity production using natural gas rose from nearly 58 billion kWh to 71 billion kWh. Low natural gas prices as well as high carbon prices contributed to this development. The country has one nuclear plant in Borssele, generating 3% of electricity.

In 2019, total electricity production from renewable sources amounted to 21.8 billion kWh in 2019, versus 18.5 billion kWh in 2018.[251] Wind turbines occupied the largest share at 49%, although this represented a decline compared with 2018 (54%). Biomass accounted for 26%, while solar power accounted for 24% of total renewable electricity production. Electricity production from solar energy in particular increased in 2019, according to new and provisional figures on renewable electricity, released by Statistics Netherlands (CBS).

In 2018, total electricity consumption amounted to 121 billion kWh, being more or less the same since 2005.[252] Electricity consumption is dominated by the commercial and public services sector, including agriculture and forestry. In 2012 40% was consumed by this sector, which was an increase by over 6 percentage points since 2002. Industry is also a major consumer with 35.5%. The industrial electricity usage declined by 14% between 2002 and 2012, but it was mainly related to the economic recession in 2009. The residential sector accounts for approximately 22% of the total consumption.[253]

[244] https://www.eia.gov/international/data/country/NLD/electricity/electricity-capacity?pd=2&p=0000000000000000000007vo7&u=0&f=A&v=mapbubble&a=-&i=none&vo=value&&t=C&g=none&l=249--160&s=283996800000&e=1483228800000
[245] IEA (2019), Key World Energy Statistics
[246] IEA (2014), Energy policies of IEA countries. The Netherlands Review
[247] IEA (2019), Key World Energy Statistics
[248] https://ec.europa.eu/eurostat/documents/2995521/8489679/8-29112017-AP-EN.pdf/600c794f-c0d8-4b33-b6d9-69e0489409b7
[249] https://ec.europa.eu/eurostat/documents/2995521/8489679/8-29112017-AP-EN.pdf/600c794f-c0d8-4b33-b6d9-69e0489409b7
[250] https://www.cbs.nl/en-gb/news/2020/12/electricity-production-at-record-high
[251] https://www.cbs.nl/en-gb/news/2020/10/sharp-rise-in-green-electricity-production
[252] https://longreads.cbs.nl/trends19-eng/economy/figures/energy/
[253] IEA (2014), Energy policies of IEA countries. The Netherlands Review

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Energy consumption per capita decreased between 1990 and 2018 with 19% from 32.8 to 26.5 GJ.[254] The share of natural gas was relatively stable over these years, accounting for nearly 75%, whereas the share of electricity increased from 11.6 to 17.0%. The share of renewable energy in total energy consumption amounted to 7.4% in 2018 compared with 6.6% in 2017.[255]

Per capita electricity consumption was around 6 500 kWh in 2016, which is 20% above the EU average. Electricity consumption has been relatively stable over the years with its highest level in 2008 with 124 TWh. The consumption was almost 6% higher in 2016 than in 2000. [256]

The Netherlands' electricity network is interconnected with Germany, Belgium, Norway and the UK [257] Electricity net import amounted to 8 TWh in 2018.

5.2.2.1 Electricity from renewable energy

The Netherlands is dependent on fossil fuel for more than 80% of the country's electricity supply. RES has however increased and in 2016 wind power met 8.4% of the Netherlands' electricity demand.[258] In 2019, the Netherlands generated 18% more electricity from renewables compared with the previous year. Wind, solar and biomass accounted for 18% of the country's need in 2018 according to CBS.[259] Wind turbines accounted for 49% of the total, solar panels 24% and biomass installations 26%.

5.2.3 The electricity grid and smart grids

The Dutch electricity grid has interconnections with Belgium, Germany, Norway and the UK. The Netherlands has been a net importer of electricity since 1982. Between 2002 and 2012 the import grew by 206% and export increased by 149%.[260]

The high voltage transmission network is operated by the TSO TenneT. The transmission network has a total length of 10 118 km.[261] There are eight DSOs, where the three biggest, Liander, Enexis and Stedin, serve the bulk of the country.[262]

TenneT is also operating the balancing mechanism that is market-based. The balancing mechanism obliges all consumers, also renewable installations, to balance their net trade position and offer surplus capacity of above 60 MW to the balancing market. Demand side providers and non-contracted parties can also participate. Permanent reserve capacity is procured.

In 2014, the Dutch government decided on a rollout of smart meters to every home. In the end of 2016, nearly three million households were equipped with a smart meter. Thus, the Netherlands is on track to reach the target mentioned in EU Directive 2009/72/EC, i.e. that 80% of households have a

[254] https://www.clo.nl/indicatoren/nl0035-energieverbruik-door-de-huishoudens
[255] https://www.clo.nl/indicatoren/nl0385-verbruik-van-hernieuwbare-energie?ond=20881
[256] https://longreads.cbs.nl/trends18-eng/economy/figures/energy/
[257] https://www.tennet.eu/our-grid/international-connections-2/?tx_kesearch_pi1%5Bfilter%5D%5B-2%5D%5B%5D=syscat66
[258] https://windeurope.org/about-wind/campaigns/amsterdam/
[259] https://www.cbs.nl/en-gb/news/2020/10/sharp-rise-in-green-electricity-production
[260] IEA (2014), Energy policies of IEA countries. The Netherlands Review
[261] https://www.globaltransmission.info/archive.php?id=26063
[262] https://www.statista.com/statistics/878534/electricity-dso-market-share-in-the-netherlands/

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smart meter by 2020.[263] Customers do not need to accept a smart meter offered, but can choose one with standard reading, or with detailed readings, no readings at all or to refuse a smart meter.[264]

The 2006 Network Unbundling Act (Wet onafhankelijk netbeheer) required full ownership unbundling of electricity and gas distribution networks from supply activities by 1 January 2011. It also prohibited network companies from being part of a vertically integrated group, from engaging in other commercial activities and from being privatised.[265]

5.2.4 The heating systems

In Table 5.4 the heating system with its consumption and production is described.

Table 5.4 Heat production and consumption

Heat production (2014)[266]	Total 40,8 TWh
Heat production by source (2014)[267]	Coal 0,93 TWh, 2,3% Oil 5,9 TWh, 14,5% Gas 28,7 TWh, 70,2% Biofuels O,3 TWh, 0,7% Waste 5 TWh, 12,3%
Heat consumption (2017)[268]	Gas 76% Renewables 5,7% Other 18%
Energy consumption for space heat and hot water in buildings[269]	473,7 PJ
Energy consumption for space heat and hot water in buildings by fuel	Natural gas 411.1 PJ DH 20.7 PJ Biomass 20.4 PJ Electricity 9.7 PJ Heat pump 7.1 PJ Oil 3.5 PJ Solar 1.1 PJ

The infrastructure for gas, including for domestic heating, spans the entire country and was established in the 1970s. The majority of heating in the Netherlands is met through natural gas domestic boilers. Heat supply from DH schemes represents a relatively small proportion of total heat supply. In 2013 around 4.4% of dwellings were connected to one of the 400 DH schemes. 90% of this DH was

[263] Van Aubel, P., & Poll, E. (2019). Smart metering in the Netherlands: what, how, and why. International Journal of Electrical Power & Energy Systems, 109, 719-725
[264] IEA (2014), Energy policies of IEA countries. The Netherlands Review
[265] IEA (2014), Energy policies of IEA countries. The Netherlands Review
[266] International Energy Agency. Statistics by country. 2017; Available from: http://www.iea.org/statistics/statisticssearch/; Kooij, H-J, Oteman, M, Veenman, S, Sperling, K, Magnusson, D, Palm, J & Hvelplund, F (2018) Between grassroots and treetops: Community power and institutional dependence in the renewable energy sector in Denmark, Sweden and the Netherlands, *Energy Research & Social Science,* 37, pp 52-64
[267] International Energy Agency. Statistics by country. 2017; Available from: http://www.iea.org/statistics/statisticssearch/
[268] https://www.cbs.nl/nl-nl/achtergrond/2019/23/warmtemonitor-2017

[269] https://www.cbs.nl/nl-nl/achtergrond/2019/23/warmtemonitor-2017

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generated from direct renewable sources and recycled heat. Four main DH companies own the majority of the 4,000 km of transport and distribution infrastructure.[270]

The final energy consumption for heating is projected to decrease from 1008 petajoules in 2017 to 903 PJ by 2030.[271] The national heat supply will continue to be dominated by natural gas; its share will decrease slightly from 76% in 2017 to an expected 68% by 2030 (under established and proposed policy). The share of renewable energy is projected to double from just under 6% in 2017 to around 13% by 2030. Therefore, up to 2030, the growth rate of renewably generated heat will be far slower than that of renewable electricity (the latter share will be over two thirds, by 2030).
The share of renewable energy in DH is projected to increase from 20% in 2017 to more than 50% by 2030. The scale of DH in the Netherlands is limited and amounts to only a few per cent of the total final energy used for heating.

5.2.5 Energy related emissions

Table 5.5 shows emissions related to the energy sector.

Table 5.5 Energy related emissions[272]

CO_2 emissions ($MtCO_2$) (2017)	155.6
CO_2/TPES (tCO_2/toe) (2017)	2.10
CO_2/Pop (tCO_2/capita) (2017)	9.08
CO_2/GDP ($kgCO_2$/2010 USD) (2017)	0.17
CO_2/GDP (PPP) ($kgCO_2$/2010 USD) (2017)	0.19

Electricity and heat generation are the largest CO_2-emitting sectors in the Netherlands, corresponding to around 30% of the total emissions. Manufacturing and construction are also major emitters, followed by transport.[273] Within manufacturing, chemical and petrochemical industry and wood and wood products saw substantial increases in their CO_2 emissions since 2002.

CO_2 intensity is measured as kilograms of CO_2 emissions per unit of gross domestic product at purchasing power parity using 2010 USD prices. In 2016, the Dutch carbon intensity in the Netherlands was 0.2, which is lower than the IEA average. Since 2002, the carbon intensity in the Netherlands has decreased. With regard to carbon intensity of energy supply (TPES) the Netherlands is around average with its 2.10 tonnes of CO_2 emissions per tonne of oil-equivalent (tCO_2/toe) in 2017. Also, this ratio is shrinking.[274] The ratio of CO_2 emissions per capita was 9.23 in 2016.

5.3 Context: Institutional setting

In this section political goals, policies, subsidies and tax schemes as well as the construction of electricity prices will be discussed.

[270] https://www.euroheat.org/knowledge-hub/district-energy-netherlands/
[271] https://www.pbl.nl/en/publications/climate-and-energy-outlook-2019
[272] IEA (2019), Key World Energy Statistics
[273] IEA (2014), Energy policies of IEA countries. The Netherlands Review
[274] IEA (2014), Energy policies of IEA countries. The Netherlands Review

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5.3.1 Political goals and national energy agreements to reduce emissions

The current targets for RES were initially set during the first Rutte government in 2011, aiming for an 80-95% CO_2 reduction in 2015, compared to 1990 levels. The 2012 Rutte-Asscher cabinet set the target for RES at 16% in 2020, but already decreased this level to 14% in 2020 and 16% RES in 2023 in the 2013 Energy Agreement. Current projections estimate the 2020 share to be around 13%.[275]

The government relies on the following instruments, amongst others:

- EU ETS
- Energy taxation and green tax incentives such as energy investment allowances
- Subsidy on renewable energy (SDE + = the new Sustainable Energy Incentive Scheme, expanded to SDE ++ in 2020) as surcharge on the consumers energy bill to achieve a share of 14% renewable in 2020
- Energy efficient measures including voluntary agreements with industry

New energy policies were initiated by the 2013 Energy Agreement for Sustainable Growth.[276] These goals are laid down in the Climate Act of May 28, 2019. The Climate Plan[277], the National Energy and Climate Plan (NECP)[278] and the National Climate Agreement[279] contain the policy and measures to achieve these climate goals.

The National Climate Agreement[280] from 2019 was concluded in a major multi-stakeholder effort and is meant as the successor of the previous Energy Agreement for Sustainable Growth from 2013. The new agreement contains actions to attain the 2030 greenhouse gas emissions reduction target of 49% by 2030 compared to 1990. It targets the sectors of electricity, built environment, industry, agriculture, and transport.

Under the new Climate Agreement, the government and other parties have identified a number of general policy measures for energy efficiency in various sectors, which will be continued beyond 2020.[281] Many measures will have to be worked out in more detail in the coming period. According to the National Climate Agreement, one of the ambitions is to realise 50% of local ownership in wind and solar projects by 2030. Its implementation will take place through the development of 30 Regional Energy Strategies that will be negotiated in multi-stakeholder processes and will be updated every two years. The deadline for the finalisation of the strategies was set at 1 June 2020 but has been postponed until 1 October 2020 due to the COVID-19 crisis.

In addition to the National Climate Agreement, a new Climate Act was adopted in 2019 by the parliament. This Act gives a long-term legal framework for government and climate policies. There will be an annual climate and energy outlook report (Klimaat en Energieverkenning) as a joint responsibility

[275] Kooij, H-J, Oteman, M, Veenman, S, Sperling, K, Magnusson, D, Palm, J & Hvelplund, F (2018) Between grassroots and treetops: Community power and institutional dependence in the renewable energy sector in Denmark, Sweden and the Netherlands, *Energy Research & Social Science,* 37, pp 52-64
[276] https://www.eesc.europa.eu/ceslink/resources/docs/netherlands---agreement-on-energy-policy-in-practice.pdf
[277] https://rwsenvironment.eu/publish/pages/126866/the-agreement-on-energy-policy-in-practice_2015.pdf
[278] https://ec.europa.eu/energy/sites/ener/files/documents/nl_final_necp_main_en.pdf
[279] https://www.government.nl/documents/reports/2019/06/28/climate-agreement
[280] https://www.government.nl/documents/reports/2019/06/28/climate-agreement
[281] https://www.iea.org/policies/7986-climate-agreement

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of the Netherlands Environmental Assessment Agency (PBL), National Institute for Public Health and the Environment, the Netherlands Enterprise Agency (Rijksdienst voor Ondernemend Nederland (RVO)), and the Energy Research Centre of the Netherlands part of Netherlands Organisation for Applied Scientific Research with information on realized effects and projected effects. The government will also periodically update its climate policy plan (Klimaatplan). The Climate Act calls for a 49% reduction in GHG emissions by 2030 compared to 1990 and a 95% reduction by 2050.[282]

The Sustainable Energy Transition Scheme (SDE++) will be opened in 2020. This is the successor of the previous SDE and SDE+ schemes,[283] which are seen as the most important instruments for stimulating the generation of renewable energy.

Since 2011, the main support instrument for new renewable electricity, gas and heat projects is the SDE+ scheme, a tender-based feed-in premium scheme.[284] From 2003 to 2005 the MEP scheme, a fixed feed-in premium scheme, and from 2007 up to 2010 the SDE support scheme, a floating feed-in premium scheme, was in force. Over the past two decades the Netherlands has been a testing ground for renewable energy support schemes with cumulative learning from previous support scheme flaws. Each year a sequel of tender rounds are organized by RVO. Before the start of each annual tender sequel, for each SDE+ eligible technology a reference cost of energy, i.e. the maximum cost per unit of energy (called "base rate") is determined, as well as the maximum subsidy-eligible number of full load hours and the projected long-term market value per unit of energy. For each tender round a maximum reference cost of energy ("maximum base amount") and a funding budget limit is specified. The maximum base amount rises with each consecutive tender round of the annual sequel.

The SDE+ scheme will be replaced by the SDE++ scheme from 2020 onwards.[285] Under the new scheme, sustainable energy techniques will no longer compete on the basis of produced sustainable energy but on the avoidance of CO_2 emissions.[286] The techniques that are most cost-effective will be the first to be considered for the subsidy. A large part (currently 45%) of Dutch CO_2 emissions is covered under the EU-ETS cap-and-trade system, which was set up in 2003 for the implementation of the Kyoto Protocol by the Directive 2003/87/EC and started in 2005. In phase III (2013-2020) there were some changes such as the setting of an overall EU cap, with allowances then allocated to the EU members, limiting banking of allowances between phase II and III and a move from allowances to auctions. In the third trading period 2013-20, the Netherlands allocated on average 46 million allowances per year.[287] Phase IV will start on 1 January 2021 and finish on 31 December 2030.

Under the EU Effort Sharing Decision (406/2009/EC), the Netherlands has a binding national target of 16% emission reduction from 2005 levels in 2020 for those sectors not in the ETS, which correspond to 105 Mt CO_2-eq. The non-ETS sectors represented 55% of GHG emissions in 2011. This included transport, housing, waste disposal, agriculture and forestry, aquaculture and some areas of industry.[288]

[282] https://www.iea.org/policies/8632-climate-act
[283] https://english.rvo.nl/subsidies-programmes/sde
[284] https://www.pbl.nl/sites/default/files/downloads/pbl-2019-climate-and-energy-outlook-2019-summary-3825.pdf
[285] https://www.rvo.nl/actueel/nieuws/sde-opent-29-september-2020
[286] Peuchen, R., Gamboa Palacios, S., and Dreijerink, L. (2019). Public support and public participation in land based photovoltaic solar parks in the Netherlands. TNO report P10360.
[287] IEA (2014), Energy policies of IEA countries. The Netherlands Review
[288] IEA (2014), Energy policies of IEA countries. The Netherlands Review

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5.3.2 Performance on EU 2020 energy targets

The Dutch energy policy is based on the EU 20-20-20 targets, which call for the reduction of 20% in GHG emissions, a 20% increase in energy efficiency and a total share of 20% of renewable energy in 2020. Those objectives were translated into national targets and the Netherlands has national target of 14% of renewable energy in TFC, a binding reduction of GHG emissions by 16% in 2020 (for the non-ETS sector), below 2005 levels and 20% of energy savings, which has been translated into a 1.5% annual improvement in terms of energy efficiency.

The country seems to meet its national targets when it comes to GHG emissions.[289] In 2018, total GHG emissions were 15% below those of 1990. PBL et al. (2020) estimate that, by 2020, emissions will be 23% below 1990 levels, with a range of 19% to 26%.[290]

However, a 20% GHG emissions reduction was not considered as enough by the Urgenda Foundation in the Netherlands, which sued the Dutch state. Urgenda demanded a reduction in Dutch emissions by at least 25% in 2020 compared to 1990 levels and the The Hague District Court agreed with Urgenda. The court in 2015 ordered the state to reduce GHG emissions by 25% by 2020 and this order was later confirmed by the The Hague Court of Appeal in 2018. The Supreme Court rejected the Dutch state's cassation appeal against the decision.[291]

The targets for renewables (14%) will not be met in 2020.[292] In the Climate and Energy Outlook 2019, it is estimated that the share of renewable energy will amount to 11.4% in 2020. However, the same document projects a sharp increase in the share of renewable energy, from 7.4% in 2018 to approximately 25% by 2030.[293] Especially in the electricity sector, renewable energy will grow spectacularly; from 15% in 2018 to over two thirds by 2030. The result is that, by 2030, the Dutch electricity system will be dominated by wind and solar power, backed up with gas-fired power stations that operate mainly when there is less wind or sunshine. Emissions from the electricity sector will decrease sharply, because of these developments.

With respect to the Energy Efficiency Directive, the Netherlands aims for a primary energy consumption of 2 541 PJ in 2020 and a final energy consumption of 2 186 PJ in 2020.[294] Based on present policies, the expectation is that the target for primary energy consumption will not be met, whereas the target for final energy consumption will (2,080 PJ).

When considering the energy efficiency target of 20% in terms of an annual 1.5% increase of energy savings, it is expected to be nearly missed.[295] The rate of saving, according to Dutch protocol for

[289] https://ec.europa.eu/clima/sites/clima/files/strategies/progress/docs/nl_factsheet_en.pdf
[290] https://www.pbl.nl/sites/default/files/downloads/pbl-2019-climate-and-energy-outlook-2019-summary-3825.pdf
[291] https://www.rechtspraak.nl/Organisatie-en-contact/Organisatie/Hoge-Raad-der-Nederlanden/Nieuws/Paginas/Dutch-State-to-reduce-greenhouse-gas-emissions-by-25-by-the-end-of-2020.aspx
[292] https://ec.europa.eu/info/business-economy-euro/economic-and-fiscal-policy-coordination/eu-economic-governance-monitoring-prevention-correction/european-semester/european-semester-your-country/netherlands/europe-2020-targets-statistics-and-indicators-netherlands_en#share-of-renewable-energy
[293] https://www.pbl.nl/sites/default/files/downloads/pbl-2019-climate-and-energy-outlook-2019-summary-3825.pdf
[294] https://www.pbl.nl/sites/default/files/downloads/pbl-2019-klimaat-en-energieverkenning-2019-3508.pdf
[295] https://www.pbl.nl/sites/default/files/downloads/pbl-2019-climate-and-energy-outlook-2019-summary-3825.pdf

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monitoring energy saving (Protocol Monitoring Energiebesparing) is expected to be around 1.5% over the 2013–2020 period, but was with 1.1% considerably lower between 2000 and 2010.

5.3.3 Electricity market, policy and law

The liberalisation of the Dutch electricity market started in the 1990s and followed an energy only market model. The liberalised Electricity Law came in force 1998 and was later enshrined in 2003 by the creation of a national regulatory authority for energy, the Dutch Office for Energy Regulation (Energiekamer), the legal unbundling of networks from competitive generation and supply activities, third-party access to the networks and the gradual liberalisation of the retail market.[296]

The retail market was opened in 2002 for industry and in 2004 for households. In 2007, full ownership unbundling of the electricity transmission and distribution networks was implemented. The generation was privatised, while the network maintained being regulated under public ownership. Group prohibition is in place for network operators, i.e. network operators are not allowed to be part of a company engaged in supply, production or trading of gas and electricity. Ownership unbundling is partly limited if considering the Dutch state's shareholding in electricity transmission and in the supply of gas through TenneT, Energie Beheer Nederland and GasTerra.[297]

The electricity policy and regulations are based on European regulations and directives. The first energy law in the Netherlands was the Dutch Electricity Act which was an implementation of the first line of European directives in 1998.[298] The Electricity Act is the main source of energy regulation, but is currently reviewed in relation to the ongoing transition to renewable energy and the latest Electricity Directive.[299] The country has also the national 20-20-20 targets mentioned above, combined with the more ambitious goals that followed from the court decision to reduce CO_2 emissions with 25% in 2020.

In 2013, 47 organisations signed the Agreement on Energy for Sustainable Growth including four goals: e.g., a 14% share of renewable energy in the Netherlands by 2020, and a 16% by 2023, an average energy efficiency saving of 1.5% per year and creating at least 15,000 additional jobs by 2020, compared to 2013.

The Climate Act includes long-term goals of a decrease of 49% in CO_2 emissions by 2030 and 95% by 2050 compared to 1990.[300]

5.3.4 Subsidies and tax schemes

Support scheme for renewable energy is currently SD+, SDE, ++, the postal code scheme and the net metering scheme described above. It also includes subsidies e.g. for energy efficiency measures. The focus will be primarily on CO_2 reduction instead of generation of renewable energy. In addition, policy instruments such as the net metering scheme (salderingsregeling), SDE+, and the postal code scheme (postcoderoosregeling) will remain in place for several years to come.

The country uses a system of environmental taxation and after Denmark the Netherlands had the second highest environmental tax revenues per capita in 2012. Starting in 1996 the country has applied

[296] IEA (2014), Energy policies of IEA countries. The Netherlands Review
[297] IEA (2014), Energy policies of IEA countries. The Netherlands Review
[298] IEA (2014), Energy policies of IEA countries. The Netherlands Review
[299] https://gettingthedealthrough.com/area/12/jurisdiction/17/electricity-regulation-2020-netherlands/
[300] https://gettingthedealthrough.com/area/12/jurisdiction/17/electricity-regulation-2020-netherlands/

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energy tax on mineral oils (not including motor fuel), electricity and natural gas. The tax has increased over time. Energy products and fuels used to generate electricity, except for coal, is exempted from the energy tax and the same holds for natural gas use in combined heat and power and in the horticultural sector (greenhouses). Fossil fuels are subsidies indirectly in form of an exemption from the energy tax for energy intensive industries.

5.3.5 Electricity prices

The price for electricity for household was 0.221 EUR/kWh in the Netherlands in June 2019. This includes all components such as the cost for power, grid tariffs and taxes.[301] This is 28% above the average in other EU countries. Most expensive are Denmark and Germany and the Netherlands is 3 cents below them.[302]

In the second half of 2019, the household price was divided between energy tax 45%, value added tax 17%, the cost of supply 29%, and storage 9%.[303]

Starting in 2020, the energy tax for gas will be annually increased in order to stimulate the transition from gas to electricity use.[304]

Since the market opened for the households in 2004, 64% of the consumers have switched suppliers or the contract they have with their supplier. The country has a high switching rate compared to other countries within EU.[305]

5.4 Action arena: Actors

In this section, the main public and market actors are described. The section ends with a brief overview of the number of energy communities.

5.4.1 Government and Authorities[306]

The Netherlands is a constitutional monarchy with a parliamentary democracy. The Netherlands has a tradition of coalition governments and no single party has held a majority in Parliament since the 19th century.

The Ministry of Economic Affairs and Climate Policy has the overall responsibility for Dutch energy policy, including policies for renewable energy, energy transition and bio-based economy. The RVO is inter alia responsible for implementing policies and regulations relating to climate and energy. The Ministry of Infrastructure and Environment is responsible for policies on environment, transport, water and public works. It supervises the administrative procedures under the Dutch Environmental Management Act.

The regional governments are responsible for granting environmental licences and permits.

[301] https://www.globalpetrolprices.com/Netherlands/electricity_prices/
[302] https://www.dutchnews.nl/features/2019/05/after-a-e30-rise-in-january-dutch-energy-prices-among-highest-in-eu/
[303] https://energiecijfers.databank.nl/dashboard/energieprijzen
[304] https://www.rijksoverheid.nl/onderwerpen/belastingplan/belastingwijzigingen-voor-ons-allemaal/energiebelasting
[305] IEA (2014), Energy policies of IEA countries. The Netherlands Review
[306] IEA (2014), Energy policies of IEA countries. The Netherlands Review

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The responsibility for energy efficiency is shared among several ministries and implementing agencies. The Ministry of Economic Affairs is in charge of overall energy policy, including energy efficiency, and measures in agriculture and industrial sectors. The Ministry of Infrastructure and Environment is responsible for energy efficiency in transport policy and the Ministry of the Interior and Kingdom Relations is responsible for energy efficiency in buildings.

The Netherlands Authority for Consumers and Markets supervises electricity and natural gas markets as well as DH markets.

In 2014, the Dutch government created a single nuclear safety authority, the Authority for Nuclear Safety and Radiation Protection.

The Statistical Office, the CBS is collecting and processing national statistics.

The PBL has a key role in implementing environmental policy and monitoring the implementation of national energy and climate objectives and develops long-term scenarios.

5.4.2 Market actors

Essent, Vattenfall, Eneco and Engie are currently the main players in terms of power generating capacity.[307]

The Dutch wholesale market has several submarkets: 1) the commodity market for trade in bilateral contracts, 2) the day ahead physical and financial trading on the power exchanges and, 3) the balancing market for control and reserve power operated by TenneT.[308]

The Dutch retail market remains fairly concentrated and several retail companies use multiple-brand strategies such as Oxxio which is part of Eneco and Essent/RWE owns EnergieDirect.[309] The three largest are Essent, Vattenfall, and Eneco and they (together with the affiliated brands) serve about 80% or the market.[310] Other entrants have been (partially) acquired by one of the incumbents (Oxxio, Greenchoice).[311]

Each year, consumer and environmental organisations compare energy suppliers in terms of sustainability performance.[312]

5.4.3 Energy communities

The first energy communities emerged in the late 1980s when ownership of wind turbines through a cooperative or legal association was established. This was enabled by the 1989 Electricity Act that gave these actors grid access and guaranteed a standard price. The cooperatives did not have licenses to supply electricity to its members and sold their product to large suppliers.[313] The liberalization of the energy market in 2004 increased the opportunities for energy communities. In addition, policy

[307] https://www.energievergelijk.nl/onderwerpen/welke-energieleveranciers-zijn-er
[308] IEA (2014), Energy policies of IEA countries. The Netherlands Review
[309] https://www.energievergelijk.nl/wp-content/uploads/2018/06/Energieleveranciers_April2019.jpg
[310] Mulder, M., Willems, B. (2019). The Dutch retail electricity market. Energy Policy, 127, pp. 228-239
[311] Mulder and Willems 2019
[312] https://wisenederland.nl/sites/default/files/images/WISE_ODNS_rapport_A4_2019.pdf
[313] Kooij, H-J, Oteman, M, Veenman, S, Sperling, K, Magnusson, D, Palm, J & Hvelplund, F (2018) Between grassroots and treetops: Community power and institutional dependence in the renewable energy sector in Denmark, Sweden and the Netherlands, *Energy Research & Social Science,* 37, pp 52-64

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instruments such as the "salderingsregeling" since 2004, SDE+[314] since 2011, and the "postcoderoosregeling" since 2013, were important stimuli.[315]

Currently, energy communities are flourishing in the Netherlands. According to the latest assessment by Hier opgewekt in early 2020, the number of energy cooperatives amounted to 582, compared to 248 in 2015.[316] Trends in the past years include the major increase in both solar and wind capacity. At the same time, several energy cooperatives started to be engaged in other activities, such as heat production, car sharing, etc. With the commitment of 50% local ownership established in the Climate Agreement, the expectation is that energy communities will continue to grow in the years to come. To help achieving this 50% goal, the bottom up Participation Coalition (Participatiecoalitie)[317] has offered to support municipalities and regions with the implementation of the Regional Energy Strategies under the National Climate Agreement.

More recently, energy cooperatives have started to also focus on supply. Since 2013, two cooperatively owned energy suppliers have been active on the market: Energie Van Ons ('energy owned by us') and Om Nieuwe Energie ('making the change to new energy').[318] Both were awarded the highest ranking as green suppliers in the Netherlands in 2018 as well as 2019. More than 130 energy cooperatives are associated with these cooperative suppliers. Other cooperatives work with green commercial suppliers such as Greenchoice, and Huismerk Energie. Large wind parks, such as Krammer, sell their electricity directly to larger companies, effectively introducing citizen-to-business trade.

Energie Samen is the Dutch umbrella organization for energy communities, being the result of a merger of existing organisations.[319] Hier opgewekt is the knowledge platform for local sustainable energy initiatives.[320] The Nederlandse Vereniging Duurzame Energie represents more than 6 000 companies involved in the renewable energy sector.[321]

[314] Kooij, H-J, Oteman, M, Veenman, S, Sperling, K, Magnusson, D, Palm, J & Hvelplund, F (2018) Between grassroots and treetops: Community power and institutional dependence in the renewable energy sector in Denmark, Sweden and the Netherlands, *Energy Research & Social Science,* 37, pp 52-64
[315] Kooij, H-J, Oteman, M, Veenman, S, Sperling, K, Magnusson, D, Palm, J & Hvelplund, F (2018) Between grassroots and treetops: Community power and institutional dependence in the renewable energy sector in Denmark, Sweden and the Netherlands, *Energy Research & Social Science,* 37, pp 52-64
[316] https://www.hieropgewekt.nl/uploads/inline/Lokale%20Energiemonitor%202019_DEF_feb2020_2.pdf
[317] https://departicipatiecoalitie.nl/
[318] https://www.hieropgewekt.nl/local-energy-monitor
[319] https://energiesamen.nu/
[320] https://www.hieropgewekt.nl/
[321] http://www.nvde.nl/

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6 Slovenia

In this chapter the socioeconomic conditions, the energy system, institutional setting and energy related actors in Slovenia will be described.

6.1 Context: Socioeconomic conditions

In Table 6.1, the socioeconomic conditions for Slovenia are described. Slovenia has a population of 2 078 938 citizens on an area of 20 140 km². The urbanisation rate is relatively low as only 55% live in urban areas. The unemployment rate in September 2019 amounted to 7.7% and thus was slightly higher compared to the rest of the EU (6.2%).

Table 6.1 Socio-economic conditions

Population[322]	2,078,938
Urban populations[323]	55%
Land area[324]	20,140 km²
GDP 2019[325]	54,154 Billion USD
GDP per capita (2019)[326]	26,170.3 USD
GDP PPP (2019)[327]	38,462.4 USD
Employment rate (Sep/19)[328]	72.5%
Unemployment rate (Jan/20)[329]	7.7%

6.2 Context: Technical systems

Slovenia's energy system will be described below, including energy production and consumption, the electricity system, the heating system and energy related emissions.

6.2.1 Energy production and consumption

Table 6.2 presents energy production and consumption for Slovenia.

Table 6.2 Energy production and consumption

TPES (2018)[330]	6.905 Mtoe
TPES by source (2017)[331]	Oil 33% Nuclear 24% Coal 17% Natural gas 11% Biofuels, waste 10% Hydro 5% Geothermal, wind, solar 1%

[322] https://www.worldometers.info/population/countries-in-europe-by-population/
[323] https://www.worldometers.info/population/countries-in-europe-by-population/
[324] https://www.worldometers.info/population/countries-in-europe-by-population/
[325] http://statisticstimes.com/economy/countries-by-projected-gdp.php
[326] http://statisticstimes.com/economy/european-countries-by-gdp-per-capita.php
[327] http://statisticstimes.com/economy/european-countries-by-gdp-per-capita.php
[328] https://tradingeconomics.com/country-list/employment-rate
[329] https://tradingeconomics.com/country-list/unemployment-rate?continent=europe
[330] https://www.iea.org/countries/Slovenia
[331] OECD 2019, Fossil Fuel Support Country Note. Slovenia, http://stats.oecd.org/wbos/fileview2.aspx?IDFile=bd2dc92f-1480-46d3-bd55-850d267aeb8d

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TFC (2018)[332]	5,073. Mtoe
Consumption by sector (2018)[333]	Transport 40% Industry and construction 27% Households 21% Agriculture and other use 12%
TFC/capita[334]	2.42 toe
Energy-intensity TFC/capita (2015)[335]	4.9 toe

Slovenia's total production energy supply was 6.9 Mtoe in 2018. The biggest energy source was oil, followed by nuclear, coal and natural gas. The share of renewables was 16%. Slovenia is dependent on energy imports; 46.9% of the energy consumption was imported in 2018. The country imports all of its oil derivates, hard coal, coke fuel and natural gas needs.[336] The import dependency declined by 3.8% between 2005 and 2015.[337] 60% of the natural gas share is imported from Russia.[338] There is no refinery in Slovenia and therefore no crude oil is imported. The only thermal coal power plant takes most of the hard coal from local coalmines of brown coal, so the import of hard coal was very limited. [339]

The primary energy consumption declined by almost 8% between 2005 and 2017. The largest decline occurred in the transport sector with 40%, followed by industry and construction at 27%, households at 21% and 12% other use (including agriculture). During the same period, there was also a decrease of final energy consumption by 1.2% from 5,096 Mtoe to 5,037 Mtoe. In 2015 Slovenia had already reached the 2020 energy goals (7.3 Mtoe in primary energy consumption and 5.1 Mtoe in final energy consumption). The primary energy intensity has declined since 2005, however it is higher than the EU average, is also reducing slower. Regarding the Slovenian energy intensity, it lies also over the EU average, however decreasing faster; on average 3.3% in the period from 2005 to 2015. Moreover, also the energy intensity in the residential and service sector is above the EU average.[340]

6.2.2 The electricity system

In Table 6.3, the electricity generation and consumption are described.

[332] https://pxweb.stat.si/SiStatDb/pxweb/en/30_Okolje/30_Okolje__18_energetika__01_18179_bilanca_kazalniki/1817902S.px/table/tableViewLayout2/
[333] https://www.stat.si/StatWeb/en/News/Index/8424
[334] https://pxweb.stat.si/SiStatDb/pxweb/en/30_Okolje/30_Okolje__18_energetika__01_18179_bilanca_kazalniki/1817902S.px/
[335] https://unstats.un.org/unsd/energystats/pubs/documents/2018pb-web.pdf
[336] https://www-pub.iaea.org/MTCD/Publications/PDF/cnpp2019/countryprofiles/Slovenia/Slovenia.htm
[337] http://kazalci.arso.gov.si/en/content/energy-import-dependency-2
[338] https://www-pub.iaea.org/MTCD/Publications/PDF/cnpp2019/countryprofiles/Slovenia/Slovenia.htm
[339] Commission staff working document (2017). Energy Union Factsheet Slovenia. Report, European Commission. Brussels
[340] Commission staff working document (2017). Energy Union Factsheet Slovenia. Report, European Commission. Brussels

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Table 6.3 Electricity generation and consumption

Electricity generation (2018)[341]	16.3 TWh
Electricity generation mix (2018)[342]	Conventional thermal 28.4% Nuclear 35.4% Hydro 30% Solar 1.6% Other: 4.6%
Electricity net imports (2018)[343]	502 GWh
Electricity import (2018) [344]	8930 GWh
Electricity export (2018)[345]243 above	-9432 GWh
Installed capacity (2017)[346]	34 GW
Electricity consumption (2018)[347]	14.9 TWh
Average household electricity consumption (2018)[348]	4.084 kWh
Electricity consumption/pop (kWh/capita) (2017)[349]	7220 kWh
Electricity price (2017) Households average price per 100 kWh[350]	16.1 EUR
Share of taxes and levies in average price[351]	31%

In 2017 the electricity production in Slovenia was 16.3 TWh and a third was generated by renewables. The major sources are nuclear power, hydro and thermal power. The major source of renewables was hydro power (32%). The country has one nuclear power plant in commercial operation since 1981, the Krško Nuclear Power Plant with a rated capacity of 696 MW. 82.9% of electricity consumption came from domestic production and 17.1% were imported in 2017. The electricity import dependency has varied greatly. For instance, in the past 8 years (from 2017) it fluctuated between 1.8% and 18.2%.[352]

Final electricity consumption is dominated by the industrial sector, buildings and by 49.6%. 24.4% of electricity was consumed by households, 1.7% by transport, 0.7% for energy sector and 23.7% for other.[353]

[341] https://www.iea.org/data-and-statistics?country=SLOVENIA&fuel=Energy%20supply&indicator=Electricity%20generation%20by%20source
[342] https://www.iea.org/data-and-statistics?country=SLOVENIA&fuel=Energy%20supply&indicator=Electricity%20generation%20by%20source
[343] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Electricity_production_and_supply_statistics&oldid=59327#Production_of_electricity, data from the excel file
[344] https://www.energetika-portal.si/fileadmin/dokumenti/publikacije/energetska_bilanca/ebrs_2019.pdf
[345] https://www.energetika-portal.si/fileadmin/dokumenti/publikacije/energetska_bilanca/ebrs_2019.pdf
[346] https://www.energetika-portal.si/fileadmin/dokumenti/publikacije/energetska_bilanca/ebrs_2019.pdf
[347] https://www.iea.org/countries/Slovenia
[348] https://www.stat.si/StatWeb/en/News/Index/8424
[349] IEA (2019), Key World Energy Statistics
[350] https://ec.europa.eu/eurostat/documents/2995521/8489679/8-29112017-AP-EN.pdf/600c794f-c0d8-4b33-b6d9-69e0489409b7
[351] https://ec.europa.eu/eurostat/documents/2995521/8489679/8-29112017-AP-EN.pdf/600c794f-c0d8-4b33-b6d9-69e0489409b7
[352] Agencija za energijo (2017). Report on the energy sector in Slovenia 2017
[353] https://www.energetika-portal.si/fileadmin/dokumenti/publikacije/energetska_bilanca/ebrs_2019.pdf

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6.2.2.1 Electricity from renewable energy

The share of electricity generated in hydro power plants as well as facilities using RES fluctuates annually, but has always been around 30%. The share depends on hydrological and other conditions. Electricity produced from fossil fuel plants accounts for 30% and from Krško nuclear power plant 40%.[354] There is a national target of 39.3% share of renewable electricity in the gross final energy demand by 2020, set in the national action plan for renewable energy for 2010–2020.

According to estimations, the share of RES in the gross final consumption in 2017 was 21.6%, which is slightly below their expected target for that year.[355]

In 2017, there were more than 2 500 RES producers and in total roughly 3 900 facilities, predominantly hydro and solar power plants. Solar power plants still have the largest share with 3 312 facilities, which is more than 85%. There are 380 Combined Heat and Power (CHP) installations, which are using fossil fuels.[356] Total installed capacity of RES and CHP is about 500 MW. [357] Most of the solar power plants started their operation in 2010, 2011 and 2012, when investments were favourable. However, the solar power support stopped in the end of 2012 and resulted in a rapid reduction of the number of new solar power plants From 2013–2015, there were somewhat more CHP installations using fossil fuels entering the support scheme.[358]

6.2.3 The electricity grid and smart grids

The key legislative framework are the Energy Act and the Energy Concept for Slovenia. The Third Energy Package was approved in parliament 2014.[359] This led to that the regional distribution companies were obliged to unbundle their distribution and supply activities and several new companies were formed.

The electricity distribution system is owned by five distribution companies, owned mainly by the state. State-owned ELES, d.o.o. operates the electricity transmission network and another state-owned company, SODO, d.o.o., supervises the electricity distribution system.

The power market operator is Borzen d.o.o, which e.g. manages the Slovenian balance scheme. Balancing services incur costs to the TSO; these costs must be paid by the party responsible for costs. For this purpose, in Slovenia the balance scheme is established, which consists of balance groups, within which an unlimited number of subgroups are active. Balance group and subgroups are the members of the balance scheme represented by the balance group leader.

The electricity network is interconnected with neighbouring countries - Italy, Croatia and Austria. A connection with Hungary is in the preparation phase of construction.

[354] Agencija za energijo (2017). Report on the energy sector in Slovenia 2017
[355] https://www.eea.europa.eu/data-and-maps/indicators/renewable-gross-final-energy-consumption-4/assessment-4
[356] Agencija za energijo (2017). Report on the energy sector in Slovenia 2017
[357] https://www.borzen.si/en/Home/menu1/Centre-for-RES-CHP/new-Centre-for-RES-CHP
[358] Agencija za energijo (2017). Report on the energy sector in Slovenia 2017
[359] https://ec.europa.eu/energy/sites/ener/files/documents/2014_countryreports_slovenia.pdf

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At the end of 2017, as many as 57% of consumers on the distribution system were already equipped with smart meters. The range of smart grid projects has increased as well. Thus, Slovenia is part of the leading countries in Europe regarding introducing advanced metering.[360]

In December 2015 Slovenia adopted a decree on the self-supply of electricity from renewables that regulated a net-metering programme, which came in force in January 2016. The net-metering support scheme is available for households and small enterprises. The policy encourages electricity production for self-consumption. This has been done in order to avoid export to the grid because Slovenia faces the problem that more electricity is sent to the grid than acquired. All renewable energy installations are eligible to participate. The installations participating are not allowed to benefit from FiTs and premium support (see under 6.3.4 below).[361]

The number of households with two-tariff metering rose on average by 1.3% in 2017. On the other hand, the number of households with single tariff metering is steadily decreasing. There is an increase in the share of consumers having two-tariff metering. They can regulate their consumption and have the opportunity to use electricity during the low tariff with lower costs. Thus, when more advanced metering equipment with built-in control device is used, it will be possible for a consumer to use lower tariff rates between 10:00pm and 6:00am as well as during weekends and holidays.[362]

6.2.4 The heating systems

Table 6.4 shows the heating system with its consumption and production.

Table 6.4 Heat production and consumption[363]

Heat generation (2017)	2,466 GWh
Heat distribution (2017)	2,332 GWh
Consumption by sector	Losses 14,9% Households 36,2% Business and other consumers 28,9% Industry 14,5%
Production by fuel	Coal 56% Natural gas 26,5% Oil 1% Renewables 12,8% (mainly wood biomass)
Energy consumption for space heat and hot water households	892,3 GWh

In 2017, the heat was supplied from 93 distribution systems by 55 heat suppliers in 64 municipalities. In total, Slovenia has 212 municipalities. The heat systems' total length was 893.2 km. Heat distribution was in 37 cases carried out as an optional local service of general economic interest. In nine cases it is a commercial distribution, and in 15 cases it was a private distribution system. Private distribution systems in the municipalities of Kranj, Koper, Maribor, and Žalec are large distribution systems and

[360] Agencija za energijo (2017). Report on the energy sector in Slovenia 2017
[361] https://www.iea.org/policies/5958-slovenia-net-metering-system-uredbo-o-samooskrbi-z-elektricno-energijo-iz-obnovljivih-virov-energije
[362] Agencija za energijo (2017). Report on the energy sector in Slovenia 2017
[363] Agencija za energijo (2017). Report on the energy sector in Slovenia 2017

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supply 10 053 consumers, among which 9931 were households. The major part was the optional local service of general economic interest and supplied 89.3% of all consumers, and the share of delivered heat was 93.6%. In total, 106,292 consumers were supplied and the delivery of heat was 1,963.1 GWh (excluding losses). Earlier, there was a downward trend regarding DH, which stopped in 2017 and there was rather an increase of 5.4%.[364]

The share of heat produced to supply distribution systems from cogeneration was 86.8% of all generated heat. The heat supply is heavily dependent on fossil fuels, only 12.8% is produced by renewables. The biggest consumers are households, followed by businesses and other users as well as the industry.

In 2017, there were two big distribution systems in operation, with a total installed capacity of 3.88 MW of cooling units. These deliver mostly to business and industrial consumers.[365]

There is a support for RES for heating. This is achieved with loans, grant subsidies and building obligations.[366]

6.2.5 Energy related emissions

In Table 6.5 emissions related to the energy sector are shown.

Table 6.5 Energy related emissions[367]

CO_2 emissions ($MtCO_2$) (2017)	13.4
CO_2/TPES (tCO_2/toe) (2017)	1.94
CO_2/Pop (tCO_2/capita) (2017)	6.49
CO_2/GDP ($kgCO_2$/2010 USD) (2017)	0.25
CO_2/GDP (PPP) ($kgCO_2$/2010 USD) (2017)	0.21

Energy supply and transportation are the largest CO_2-emitting sector in the Slovenia. 15.6 million tonnes of CO_2 emissions were generated in 2017, which is 2.5% more than the previous year, but compared to 2008, emission decreased by 17.1% The main contributor is the transport sector and also the main barrier to reach EU's 2030 goals. Slovenia is a transit country connecting many European countries. The share of renewable energy in transport is one of the lowest in the EU. The share is 1.6%, while the EU average is 7.1%.[368] The share of RES in the gross final consumption in 2017 was 21.6%,[369] which is higher than the European average of 17%.

[364] Agencija za energijo (2017). Report on the energy sector in Slovenia 2017
[365] Agencija za energijo (2017). Report on the energy sector in Slovenia 2017
[366] Commission staff working document (2017). Energy Union Factsheet Slovenia. Report, European Commission. Brussels
[367] IEA (2019), Key World Energy Statistics
[368] https://www.eiu.com/industry/article/1966927180/slovenia-struggles-to-meet-2030-greenhouse-gas-targets/2018-07-12
[369] https://www.eea.europa.eu/data-and-maps/indicators/renewable-gross-final-energy-consumption-4/assessment-4

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CO_2 intensity (CO_2/GDP PPP) was 0.23, which is similar to the IEA average (0.237), but above IEA EU average at 0.173. CO_2 emission per capita is 6.58, which is above the IEA EU average 6.3 tCO_2/capita.[370]

6.3 Context: Institutional setting

In this section political goals, policies, subsidies and tax schemes as well as the construction of electricity prices will be discussed.

6.3.1 Political goals and national energy agreements to reduce emissions

When it comes to legislation and policies, Slovenia follows the EU goals and the Energy Agency of Slovenia refers to EU directives.[371] The goals include e.g. to achieve 25% of RES in the gross final energy consumption and 10% in transport until 2020 (this the same as in other EU member states).[372] The Energy Act from 2014 incorporates EU directives on electricity, energy efficiency and RES.

There is a national renewable energy action plan 2010-2020 which has been under consideration in 2017. There were some changes with the result of a goal of achieving a RES gross final energy 38.6% and a share of RES for heating and cooling of 34.5%.[373]

There is also the National Adaption Strategy (NAP) in Slovenia. The NAP takes into consideration national risk assessment, additionally, a measure action plan shall come on the basis of a comprehensive national Climate Change Vulnerability Assessment. Areas, which pay most attention to adapting to climate change are water management (and associated risks of flood and drought), agriculture and forestry. As of 2017, no monitoring and reporting framework existed. There is a system reviewing adaptation action periodically and was established in the framework of the NAP.[374]

The Energy Concept of Slovenia (ECS) will serve as the basic development document in the energy field and will define the objectives of the reliable, sustainable and competitive energy supply for the next 20 years (and tentatively for the next 40 years). The ECS is supposed to be adopted through a resolution by the National Assembly. On March 1, 2018, the Government submitted the Resolution on the Energy Concept of Slovenia (ReECS Motion) to the parliament. The parliament was however not able to put the ReECS Motion on the agenda before the early elections. The latest plan is that it will be adopted in 2020.[375]

In the EU commissions draft for the Integrated National Energy and Climate Plan for Slovenia (NECR), the following objectives are included:[376]

- reducing GHG emissions by 2030 in accordance with the Burden Sharing Regulation by 15% in comparison to 2005;
- ensuring that there will be no net emissions produced from the LULUCF sectors by 2030, i.e. the emissions in LULUCF sectors will not exceed the sinks;

[370] https://www.iea.org/data-and-statistics?country=EU28&fuel=CO2%20emissions&indicator=CO2%20emissions%20per%20capita
[371] https://www.agen-rs.si/web/en/direktive-eu
[372] Agencija za energijo (2017). Report on the energy sector in Slovenia 2017
[373] Agencija za energijo (2017). Report on the energy sector in Slovenia 2017
[374] Commission staff working document (2017). Energy Union Factsheet Slovenia. Report, European Commission. Brussels
[375] https://cnpp.iaea.org/countryprofiles/Slovenia/Slovenia.htm
[376] https://ec.europa.eu/energy/sites/ener/files/documents/ec_courtesy_translation_si_necp.pdf

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- indicative sectoral targets for reducing GHG in sectors that are not included in the Emissions Trading Scheme by 2030 include e.g. that energy will reduce GHE by 16%,
- reducing greenhouse-gas emissions in buildings by at least 70% by 2030 relative to 2005;
- achieving a 27% share of renewable sources in final energy consumption by 2030;
- increasing the efficient use of energy (and, consequently, reducing its use) as the first and key measure towards a low-carbon society.

6.3.2 Performance on EU 2020 energy targets

The national target for energy efficiency follows the EU target with a reduction by 20%. This equals that primary energy consumption should not exceed 7 120 Mtoe. The total energy consumption was 4 980 Mtoe in 2017.[377]

The goal for GHG emissions is to achieve 21% reduction for the EU ETS. For the non-EU ETS Slovenia can increase its emissions by 4% compared to 2005, according to the Effort Sharing Decision (ESD).[378] According to the government, Slovenia has met these targets.[379]

The goal for RES is to achieve 25% of RES in the balance of gross final energy consumption by 2020. The share of renewables was 21.6% in 2017.[380]

6.3.3 Electricity market, policy and law

Since 2001, the Slovenian electrical energy markets have been gradually deregulated. The purchases of electrical energy at the organized stock exchange started in 2001.[381] The markets were opened to all non-household customers in July 2004, representing a volume of market opening of 75% and 90%, respectively. Both markets have been fully open since 1 July 2007.[382]

For Slovenia, the key legislative frameworks are the Energy Act and the Energy Concept. As mentioned above, the Third Energy Package was approved in the parliament in 2014. This led to the unbundling of the regional distribution companies. After the unbundling GEN-I d.o.o. (GEN-I) and Petrol Energetika d.o.o. (Petrol) entered the electricity supply market and acquired market shares of approximately 22% and 5% respectively. The market is fully liberalised, but it is still small and vertically integrated and it is difficult for new suppliers to enter.[383]

In the electricity wholesale market, electricity is traded on the market via bilateral contracts. Trading is organized by Borzen. Power plants are divided into four groups, depending on the installed power: micro power plants (up to and including 36 kW); small power plants (from 36 kW to 1 MW); medium power plants (from 1 MW to 10 MW); and large power plants (above 10 MW).[384] In 2017, there were 21 active suppliers in the Slovenian retail market, delivering electricity to final consumers.[385] The

[377] https://www.iea.org/data-and-statistics/data-tables?country=SLOVENIA
[378] https://ec.europa.eu/clima/sites/clima/files/strategies/progress/reporting/docs/sl_2014_en.pdf
[379] https://www.gov.si/en/news/2019-06-13-slovenia-hits-greenhouse-gas-emission-targets/
[380] https://www.eea.europa.eu/data-and-maps/indicators/renewable-gross-final-energy-consumption-4/assessment-4
[381] Stefan Bojnec & Drago Papler, 2019. "The analysis of liberalisation of the electricity market in Slovenia,"Managerial Economics, AGH University of Science and Technology, Faculty of Management, vol. 20(1), pages 7-26.
[382] https://www-pub.iaea.org/MTCD/Publications/PDF/cnpp2019/countryprofiles/Slovenia/Slovenia.htm
[383] https://www.lexology.com/library/detail.aspx?g=b3111e42-5b5d-405d-81a9-8be2473c05e8
[384] https://www-pub.iaea.org/MTCD/Publications/PDF/cnpp2019/countryprofiles/Slovenia/Slovenia.htm
[385] OECD Fossil Fuel Country Report. Slovenia. 2019

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quantity and the time profile of supply of contractual volumes of electricity which are set in advance so that the price does not depend on the actual realization of the contracts. The wholesale market participants conclude their business by the bilateral transactions or at the exchanges in Slovenia and abroad. [386]

6.3.4 Subsidies, tax schemes

One crucial climate energy policy for Slovenia (and the EU), is the "support scheme for RES and CHP", with the aim to promote electricity production from RES and CHP. The scheme is supposed to increase the investments in environmentally friendly electricity-production technology. However, there was a disproportionate increase of support scheme costs, which were passed on the consumers through their energy bills. Subsequently, this became a burden for consumers. Thus, the support scheme was a change and an implementation with the new Energy Act in 2014 (EA-1) followed. The aim was to achieve a control of the costs of the support scheme and support investment in new RES and CHP projects. However, these will not be more than the maximum value permitted and determined by the European Commission guidelines.[387]

Rules and conditions of the support scheme should be compatible with the European Commission. The new support scheme started in 2016 and in line the European Commission and internal market. In the support scheme hydro energy, wind, solar energy, geothermal energy, biomass, biogas, energy from landfill gas and sewage treatment plants and energy from biodegradable waste are included.[388]

Since 2002, RES for electricity have been encouraged in Slovenia with a FiT and a premium tariff. Both are granted via a tender procedure. Electricity producers can select either a guaranteed FiT or a bonus (premium) on top of the free market price for electricity. The amount of wind energy in Slovenia has been small, even though there would be good conditions for it, particularly in the West. The support scheme is financed via a supplement to the electricity price.[389]

6.3.5 Electricity prices

In June 2019, the price for electricity for household in Slovenia was 0.164 EUR/kWh. This includes all components such as the cost for power, grid tariffs and taxes.[390]. This is slightly above the average in other EU countries, which was 0.1251 EUR/kWh in 2019.[391]

In first half of 2019, share of taxes and levies paid by household consumer for the electricity was a bit more than 30%. [392]

Since the market opened for the households in 2004, 64% of the consumers have switched suppliers or the contract they had had with their supplier.

[386] Agencija za energijo (2017). Report on the energy sector in Slovenia 2017
[387] Agencija za energijo (2017). Report on the energy sector in Slovenia 2017
[388] Agencija za energijo (2017). Report on the energy sector in Slovenia 2017
[389] Commission staff working document (2017). Energy Union Factsheet Slovenia. Report, European Commission. Brussels
[390] https://www.globalpetrolprices.com/Slovenia/electricity_prices/
[391] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Electricity_price_statistics#Electricity_prices_for_household_consumers
[392] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Electricity_price_statistics

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6.4 Action arena: Actors

In this section the main public and market actors are described. The section ends with a brief overview of the number of energy communities.

6.4.1 Government and Authorities

Slovenia is a parliamentary democracy republic with a multi-party system. The head of the state is the president who is elected for five years. The president has mainly a representative role. It is a bicameral parliament, characterised by an asymmetric duality. The major power is by the National Assembly, while the National Council has limited advisory and control power.

Slovenia became part of the EU in 2004.

The Ministry of Infrastructure, Directorate for Energy is responsible for drawing up energy policy and legislation, preparing and implementing national policy and encouraging energy efficiency and renewables.[393]

Local authorities are responsible for providing the construction and maintenance of municipal energy supply and regulation and maintaining power supply facilities.

The Energy Agency is a regulatory authority ensuring the operation of the energy market. The agency is politically and financially independent and financed by network charges.[394] The Energy Agency carry out administrative and other tasks related to the Energy Act. The tasks include regulation of the network activities, regulation of the supply of heat, ensuring reliable supply of natural gas, promoting renewables in the electricity system, promoting energy efficiency, monitoring the electricity and natural gas market and protecting the right of consumers.[395]

6.4.2 The market actors

In Slovenia most actors in the electricity market are directly or indirectly controlled by the government.

The organizer of the electricity market is Borzen d.o.o, TSO ELES d.o.o. operates the Slovenian transmission network and state-owned company SODO, Ltd. oversees the electricity distribution system.

In 2017, nine companies were operating large facilities with a capacity of over 10 MW.

Production companies in Slovenia differ in their generation and primary energy sources for electricity generation. Companies DEM[396], SEL[397], HESS[398], and SENG[399], generate electricity in hydro power plants, TEŠ[400] in thermal power plant, TEB[401] and holding slovenske elektrarne (HSE). ED Trbovlje[402]

[393] https://portal.cor.europa.eu/divisionpowers/Pages/Slovenia-Energy.aspx
[394] https://www.agen-rs.si/web/en/about-the-agency
[395] https://www.agen-rs.si/web/en/tasks-of-the-energy-agency
[396] Dravske elektrarne Maribor
[397] Savske elektrarne Ljubljana
[398] Hidroelektrarne na spodnji Savi
[399] Soške elektrarne Nova Gorica
[400] Termoelektrarna Šoštanj
[401] Termoelektrarna Brestanica
[402] Energetska družba Trbovlje

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are operating on liquid and gaseous fuel, NEK[403] in a nuclear power plant, and JPEL[404] cogenerates heat and electricity in a cogeneration process using coal and wood biomass.

Most of the major actors in electricity production are owned by the two parent companies, HSE and GEN Energija. HSE also has majority ownership of the lignite mine in Velenje. NEK (that is operating the nuclear plant) is owned in equal shares by the Slovenian and Croatian legal successors of the founders of the power plant. The Slovenian owner is the company GEN Energija, which is 100% state owned.[405]

6.4.3 Energy communities

In Slovenia, the concept of energy communities is still in its infancy. There are two known energy cooperatives active; Krajcarca in Gorensjka and Zadruga Soncnih Elektrarn Slovenije, and some other decentralized renewable energy projects in which local communities are engaged. In Nova Gorica and Luče, energy community projects are currently being set up. The renewable energy community Luče in Slovenia (COMPILE project) has been enriched with nine solar power plants, with the total power of 102 kW, and these are connected to the grid since August 2019. With this step, the village Luče is approaching the goal of lowering cost of electrical energy, solving problems concerning repetitive interruptions and becoming the first self-sufficient energy community in Slovenia.[406] In Nova Gorica, a PV power plant will be put on the roof of the municipality building or a kindergarten. Yet there is a lack of knowledge and experience with community projects and lack of funds for their implementation. Both represent a key barrier for an expansion of community practices. [407]

[403] Nuklearna elektrarna Krško
[404] Javno podjetje Energetika Ljubljana
[405] https://cnpp.iaea.org/countryprofiles/Slovenia/Slovenia.htm
[406] https://www.compile-project.eu/news/installation-and-connection-of-pv-in-luce-slovenia/
[407] http://www.energise-project.eu/node/1229

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7 Sweden

In this chapter the socioeconomic conditions, the technical system in the energy field, the institutional setting, energy related actors and an overview of energy communities in Sweden will be described.

7.1 Context: Socioeconomic conditions

In Table 7.1 the socioeconomic conditions for Sweden are described.

Table 7.1 Socio-economic conditions

Population[408]	10.099.265
Urban population[409]	88%
Land area[410]	410,340 km^2
GDP 2019[411]	528.9 Billion USD
GDP per capita (2018)[412]	53,867 USD
GDP PPP 2019[413]	563.8 USD
Employment rate (March/2020)[414]	67.1%
Unemployment rate (March/2020)[415]	7.1%

Sweden has a population of around 10 000 000 citizens on an area of 410 000 km^2. Sweden is ranked 24th in terms of countries' GDP and 40th in terms of GDP PPP. In Europe Sweden has the seventh highest GDP per capita. The employment rate is lower than the EU (EU has 73.2)[416], while the unemployment rate is slightly higher compared to the rest of the EU (EU has 6,2%).

7.2 Context: Technical systems

Below Sweden's energy system is described, including energy production and consumption, the electricity system, the heating system as well as energy related emissions.

7.2.1 Energy production and consumption

In Table 7.2 figures related to energy production and consumption for Sweden are described.

Table 7.2 Energy production and consumption

TPES (Total Primary Energy Supply) (2018)[417]	47.9 Mtoe
TPES by source (2017)	Nuclear 34.9% Bioenergy and waste 26.3% Oil 21.2% Hydro 11.4% Coal3.9% Wind 3.1% Natural gas 1.9%

[408] https://www.worldometers.info/population/countries-in-europe-by-population/
[409] https://www.worldometers.info/population/countries-in-europe-by-population/
[410] https://www.worldometers.info/population/countries-in-europe-by-population/
[411] http://statisticstimes.com/economy/countries-by-projected-gdp.php
[412] http://statisticstimes.com/economy/european-countries-by-gdp-per-capita.php
[413] http://statisticstimes.com/economy/countries-by-projected-gdp.php
[414] https://tradingeconomics.com/country-list/employment-rate
[415] https://tradingeconomics.com/country-list/unemployment-rate?continent=europe
[416] https://ec.europa.eu/eurostat/statistics-explained/index.php/Employment_statistics
[417] https://www.iea.org/data-and-statistics/data-tables?country=SWEDEN&energy=Balances&year=2018

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	Heat 0.3% Peat 0.3 5
TPES/capita 2016[418]	4,96 (Toe/capita)
Domestic primary energy production (2018)[419]	35.1 Mtoe
Domestic energy production mix (2017)[420]	Nuclear 47.6% Bioenergy and waste 31.8% Hydro 15.6% Wind 4.2% Heat 0.4% Peat 0.3%
TFC (2017)[421]	33.5 Mtoe
Consumption by sector (2017)[422]	Industry 39.9% Transport 24.5% Residential 22.4% Commercial 13.1%
TFC per capita (2017)[423]	3.3 toe (IEA average 2.9 toe)
Energy intensity (TFC/GDP PPP) (2017)[424]	73.7 toe/USD million PPP

Sweden's energy supply is characterised by high shares of hydropower, nuclear power and bioenergy. These account for 95% of the domestic energy production and over 70% of the TPES. These three sources contribute to Sweden's overall self-sufficiency of over 70%, despite its almost non-existent domestic fuel production (a small supply of peat exists). The largest imported energy source is oil (84% of total energy import). However, the uranium fuel for the nuclear power plants is not included in that figure.

Nuclear power is a large source of primary energy although it has declined during the last decade. One nuclear reactor closed in 2019 and another one is closing in 2020.[425]. The share of nuclear power in TPES is the second highest after France.[426]

Renewable energy, especially wind power, has increased in the last decade. The share of fossil fuels in Sweden's TPES is the lowest among IEA's member countries. Biomass-based fuel and waste is high, the third highest after Denmark and Finland. The share of coal is 4% and mainly used in the steel and cement industry. The share of natural gas is relatively low in Sweden with 1.4% of TPES and the supply consist of a network that only covers the southwest of Sweden.

Sweden is relatively energy intensive. Since peaking at 36.8 Mtoe in 1996, the TFC has slowly declined to 33.5 Mtoe in 2017. Still, Sweden's TFC per capita is the ninth highest among IEA countries and 14% above IEA average. When it comes to energy intensity of the economy (TFC/GDP), Sweden is more in the middle and slightly below the IEA average. Electricity is the largest source of TFC (one-third)

[418] IEA (2018), Global Energy & CO_2 Status Report
[419] https://www.iea.org/data-and-statistics/data-tables?country=SWEDEN&energy=Balances&year=2018;
[420] IEA (2019). Energy Policies of IEA Countries. Sweden 2019 review
[421] IEA (2019). Energy Policies of IEA Countries. Sweden 2019 review
[422] IEA (2019). Energy Policies of IEA Countries. Sweden 2019 review
[423] IEA (2019). Energy Policies of IEA Countries. Sweden 2019 review
[424] IEA (2019). Energy Policies of IEA Countries. Sweden 2019 review
[425] https://group.vattenfall.com/se/var-verksamhet/ringhals/produktion/avveckling-ringhals-1-och-2
[426] IEA (2019). Energy Policies of IEA Countries. Sweden 2019 review

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followed by oil, biomass-based fuels and waste, and DH. Energy use is generally efficient, largely due to the wide use of electricity and DH. Electricity use per capita is however one of the highest in the world.

Sweden has a large energy-intensive industry sector and it accounts for 40% of the TFC. The high-energy intensity is related to processing of domestic resource like wood and iron ore. The pulp and paper industry is also a big energy consumer, but this sector is more or less self-sufficient thanks to its by-products and waste wood for heat and power generation. The industrial use has however decreased the last two decades from 16 Mtoe to 13 Mtoe, mainly due to improved energy efficiency in the processes and structural changes such as switching from mechanical pulp production to chemical pulp.[427] Transport is the second largest energy user and the only sector still dependent on fossil fuels. Sweden is large by area, which contributes to a high-energy demand for transport.

The electricity for the residential and commercial sectors stands for more than half of the total consumption. The use of heat pumps and electrical heating is one important explanation to that. DH is another main source for heat in the residential sector and DH is among the highest of all IEA members. The demand for heat is high in Sweden due to the cold winters.

7.2.2 The Electricity system

In Table 7.3 the electricity generation and consumption is described.

Table 7.3 Electricity generation and consumption

Electricity generation (2018)[428]	159.288 TWh
Electricity generation mix (2017)[429]	Nuclear 39% Hydro 40% Wind 11% Bioenergy and waste 9% Others 1%(with solar 0.1%)
Electricity net export (2018)[430]	17.2 TWh
Electricity imports (2018)[431]	12.2 TWh
Electricity exports (2018)[432]	-29.4 TWh
Installed capacity (2017)[433]	39 991 MW
Peak demand (2017)[434]	26 616 MW
Electricity consumption (2016)[435]	136,7 TWh
Electricity consumption by sector (2018) [436]	Industry 39% Residential sector 35% Commercial 22% Transport 2%

[427] IEA (2019). Energy Policies of IEA Countries. Sweden 2019 review
[428] https://www.iea.org/data-and-statistics/data-tables?country=SWEDEN&energy=Electricity&year=2018
[429] Swedish Energy Agency (2019). Energy in Sweden. Facts and Figures 2019. Eskilstuna: Swedish Energy Agency
[430] https://www.iea.org/data-and-statistics/data-tables?country=SWEDEN&energy=Electricity&year=2018
[431] https://www.iea.org/data-and-statistics/data-tables?country=SWEDEN&energy=Electricity&year=2018
[432] https://www.iea.org/data-and-statistics/data-tables?country=SWEDEN&energy=Electricity&year=2018
[433] IEA (2019). Energy Policies of IEA Countries. Sweden 2019 review
[434] IEA (2019). Energy Policies of IEA Countries. Sweden 2019 review
[435] IEA (2018), Global Energy & CO_2 Status Report
[436] IEA (2019). Energy Policies of IEA Countries. Sweden 2019 review

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	Others 2%.
Electricity consumption/pop (kWh/capita) (2016)[437]	13 755.79 kWh/capita
Electricity price (2017) Households average price per 100 kWh[438]	19.4 EUR
Share of taxes and levies in average price[439]	24%

Sweden has the second-lowest share of fossil fuels in electricity generation among all IEA member countries (after Switzerland). Since the commissioning of nuclear power plants in the 1970s and 1980s, the annual electricity generation has been stable around 150 TWh. In 2018, the total electricity generation was 159 TWh. The electricity mix is mainly based on nuclear and hydropower. For a long time this mix was half nuclear and half hydropower. Since the 2000s wind, biofuels and waste have increased their shares. Especially wind power has grown since the 2000's mainly due to the electricity certificate system that has supported investments in renewables. In the last years, the electricity mix has remained the same, with 40% shares for both nuclear and hydropower, 10% for wind and mainly bioenergy and the remaining share for waste. The production from nuclear power and hydropower exhibit a big variability over the years. During the period 2008-2017, hydropower production ranged from 61 TWh to 79 TWh and nuclear power production from 52 TWh to 66 TWh.

Electricity demand has declined in the past decades and Sweden has become a large net exporter. In 2018 the net exports were 17 TWh. Sweden is interconnected through land cable to Norway and Finland and through high-voltage sea cables to Finland, Denmark, Germany, Poland and Lithuania. Sweden mainly exports to Finland and imports from Norway.[440]

Sweden is an electricity-intensive country. Electricity consumption was 136 TWh in 2016 and has been quite stable around 13 MWh per capita since 2015.[441] Sweden has the fifth highest electricity/capita consumption among the IEA members.

Sweden has a large energy intensive industry. Sweden also has a tradition of relatively low electricity prices, which has also contributed to widespread use of electric heating in detached houses.[442] The industry is the largest electricity consumption sector with 39%, followed by the residential sector 35%, commercial 22%, followed by transport 2% and others 2%.[443]

The highest load in 2017 occurred on 5 January and amounted to 26.6 GW. The load is always correlating to outside temperature in Sweden. In periods with low temperatures, the load increases due to more electric heating.

[437] IEA (2018), Global Energy & CO_2 Status Report
[438] https://ec.europa.eu/eurostat/documents/2995521/8489679/8-29112017-AP-EN.pdf/600c794f-c0d8-4b33-b6d9-69e0489409b7
[439] Swedish Energy Agency (2019). Energy in Sweden. Facts and Figures 2019. Eskilstuna: Swedish Energy Agency
[440] Swedish Energy Agency (2019). Energy in Sweden. Facts and Figures 2019. Eskilstuna: Swedish Energy Agency
[441] Swedish Energy Agency (2019). Energy in Sweden. Facts and Figures 2019. Eskilstuna: Swedish Energy Agency
[442] IEA (2019). Energy Policies of IEA Countries. Sweden 2019 review
[443] IEA (2019). Energy Policies of IEA Countries. Sweden 2019 review

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7.2.2.1 Electricity from renewable energy

The power mix has the second-lowest share of fossil fuels among the IEA member countries (Switzerland has the lowest). Hydropower has a stable share with roughly 40%. Since the 2000s wind, biofuels and waste have increased their shares and wind has now 11% and biofuel and waste 9%. The electricity certificate system has contributed to this development. Wind power has more than doubled since 2015, and was 17.6 TWh in 2017. Even though solar power is increasing in Sweden, it is still below 1%.[444]

7.2.3 The electricity grid and smart grids

The Swedish electricity market was deregulated in 1996. Sweden is also part of a common Nordic/Baltic electricity market, which includes Norway, Sweden, Denmark, Finland, Estonia, Lithuania and Latvia.

Sweden has a 15 000 km high voltage transmission network, running from the north where the hydropower and most wind power are located to the south where the consumption rates are the highest. The nuclear power plants are also all located in the south. A major challenge in Sweden for the moment is that the TSO needs to increase both the national and the north-south capacity as well as the cross border capacity.[445] Sweden faces many bottlenecks in the grid and several transmissions lines are old and need to be replaced.

Electricity transmission and supply are separated through ownership unbundling, while distribution network operators are functionally unbundled. There are around 170 distribution network companies. In many of those, production, distribution and trade are carried out within the same corporate group, but they are unbundled in different legal entities. Distribution network companies that have more than 100 000 customers must be functionally separated from companies that produce or trade electricity.

Network-access tariffs for electricity transmission and distribution are regulated ex ante, while the price of electricity supply is not regulated. The customers are free to choose their supplier.

Everyone has the right to be connected to the grid. The DSOs set their own price, but the regulator must approve the pricing method. Sweden has around 5.4 million customers.

A former barrier in the Swedish system complicating the connection of renewables was the so-called threshold effect. This meant that when a generator wanted to be connected to the grid and the grid lacked the capacity to accommodate the load, the generator was forced to pay the cost for upgrading the grid's capacity. This was only a one-time cost, i.e. the following generators did not have to pay additional upgrading costs. However, in 2015 the government introduced a transitional solution where the DSOs may recoup the entire investment cost for upgrading the grid. Instead, the generators that connect only pay for the additional share of the grid cost.

Sweden is in the process of rolling out smart meters by the end of 2024. All DSOs will install smart meters, and this will be monitored by Energy Market Inspectorate.

7.2.4 The heating systems

In Table 7.4 is the heating system with its consumption and production described.

[444] Lindahl J. (2019). IEA-PVPS National Survey Report of PV power applications in Sweden 2018. Technical report, IEA-PVPS
[445] IEA (2019). Energy Policies of IEA Countries. Sweden 2019 review

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Table 7.4 Heat production and consumption[446]

Heat generation (2017)	5.3 Mtoe/62.0 TWh
DH production by fuel	Biofuels and waste 76.2%, Industrial surplus heat 7.8% Heat pumps 7.2% Coal and peat 3.0% Natural gas 3.0%, Oil 2.3% Electric boilers 0.5%
Energy consumption for space heat and hot water in buildings	6.9 Mtoe / 80.5 TWh
Energy consumption for space heat and hot water in buildings by fuel	DH 57.6% Electricity 25.9% Biofuels and waste 14.2% Oil 1.3% Natural gas 1.0%

DH supplies 90% of heat demand in multifamily buildings, 77% of non-residential buildings and 17% of detached one- and two-dwelling houses.[447] DH supplies 58% of the total heat demand. Most DH is produced in co-generated plants, where both heat and electricity is produced. In 2016, co-generation accounted for 73% of the total DH generation and 10% of the total electricity generation in Sweden. Municipal waste is an important source for fuel and incineration with energy recovery is an accepted waste treatment method. Electricity accounted for 26% in 2016, and this figure has been stable over the past three decades. A change that has occurred is however that most houses have replaced their electric boiler with heat pumps for improved efficiency. [448]

Space and water heating in building accounts for two thirds of the total energy consumption in the residential sector but is also a major share in commercial and public buildings. There are over 100 000 heat pumps installed, where half of them are air-to-air pumps and one third are ground-source heat pumps. Electricity accounts for half of the total heating demand in detached houses.[449] Wood and pellets account for 14% of the total heat demand in building and of one-third in detached houses.

7.2.5 Energy related emissions

In Table 7.5 emissions related to the energy sector are presented.

Table 7.5 Energy related emissions[450]

CO_2 emissions ($MtCO_2$) (2017)	37.6
CO_2/TPES (tCO_2/toe) (2017)	0.77
CO_2/Pop (tCO_2/capita) (2017)	3.74
CO_2/GDP ($kgCO_2$/2010 USD) (2017)	0.07
CO_2/GDP (PPP) ($kgCO_2$/2010 USD) (2017)	0.08

[446] IEA (2019). Energy Policies of IEA Countries. Sweden 2019 review
[447] IEA (2019). Energy Policies of IEA Countries. Sweden 2019 review
[448] IEA (2019). Energy Policies of IEA Countries. Sweden 2019 review
[449] IEA (2019). Energy Policies of IEA Countries. Sweden 2019 review
[450] IEA (2019), Key World Energy Statistics

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Sweden's energy related CO_2 emissions fell rapidly in the late 1970s when oil use was replaced with electricity from the, at that time, new nuclear power plants. The emissions have continued to decline during the 2000s but have stalled since 2013. In 2016, the CO_2 emissions amounted to 38 Mt. The transport sector stood for more than half of these emissions, namely 20 Mt. The second largest was from heat and power generation with a 19% share. Further, the manufacturing industry stood for 17%, oil refineries for 7% and commercial and residential sector together represent 4%.[451] Sweden's CO_2 intensity in heat and power generation is the second lowest among the IEA countries, after Norway. Between 1990 and 2017, Sweden's GDP per capita increased by 51% and the population grew by 18%, but the CO_2 emissions were reduced by 28%.

7.3 Context: Institutional setting

In this section political goals, policies, subsidies and tax schemes, national energy agreements to reduce emissions as well as the construction of electricity prices, will be discussed.

7.3.1 Political goals and national energy agreements

In 2015, the government appointed a Parliamentary Committee, the Energy Policy Commission, to propose a broad agreement on energy policy with focus on the conditions for electricity supply after 2030. In June 2016, the Framework Agreement on Energy Policy was reached between five parties, namely the Social Democratic Party, the Moderate Party, the Swedish Green Party, the Centre Party and the Christian Democrats, representing a majority in the parliament. The goals were the net-zero GHG emission by 2045 mentioned above, by 2030, Sweden's primary energy use per GDP shall be 50% more efficient than in 2005, and by 2040 the electricity generation shall be 100% renewable. This last goal is however not seen as a deadline for banning nuclear power. The future for nuclear power in Sweden was excluded from the Energy Policy Agreement.

As part of the Energy agreement, the electricity certificate system was prolonged to 2030. The electricity certificate system has been in place since 2003 and the current target is the deployment of 28.4 TWh of new RES until 2020 (compared with 2011). Energy agreement from 2016 said that additional 18 TWh will be deployed until 2030.

In 2017, the parliament adopted a national Climate Policy Framework including the Energy Agreement target for GHG, but also to reduce GHG emissions in non-European Union Emissions Trading System (EU-ETS) sectors by at least 63% in 2030 and by at least 75% in 2040 from 1990 values.

In 2017, the Swedish Parliament adopted the national Climate Framework (Bill 2016/17:146), containing National climate targets, a Climate Act and a Climate policy council.

One climate target is to have net-zero GHG emissions by 2045 and thereafter negative emissions. This target is set five years earlier than the EU roadmap target. The goal is to reduce domestic emissions by at least 85% from 1990 and have the remaining 15% from carbon capture and storage and emission reduction outside Sweden via international projects or mechanisms.

For the non-ETS emissions, Sweden's target is to reach a 63% reduction until 2030 (compared to 1990) and 75% reduction until 2040. The EU target is 40% until 2030. Thus, Sweden's own target is more ambitious.

[451] IEA (2019). Energy Policies of IEA Countries. Sweden 2019 review

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The Swedish Climate Act (2017:720) includes that climate policy must be based on the climate goals and the government must present a climate report every year in its Budget Bill. Further, every four years the government must draw up a Climate Policy Action Plan and Climate policy goals and budget policy must be mutually consistent.

The Climate Policy Council has eight members from different academic institutions. Their task is to support the government by doing an annual independent assessment of whether the overall policy is compatible with the climate targets. The council can give recommendation, but the government is not obligated to follow them.

In January 2019, the Liberals and the Centre party came to an agreement with the Social Democrats and the Green Party. The agreement made it possible for a re-election of the government with the Social Democrats and the Green Party. This agreement, the "January Agreement", contains a list of 73 policy statements across different areas that the government promised to follow. This list is under constant critique, both internally and externally. The list contains mostly agreements relating to the transport sector.

7.3.2 Performance on EU 2020 energy targets

Sweden's 20/20/20 targets are

- at least 50% of renewable energy in the gross final consumption of energy
- at least 10% of renewable energy in the transport sector
- 20% more efficient use of energy compared to 2008
- 17% GHG emissions by 2020 and 40% by 2030 (compared to 2005 values)

According to the Swedish Environmental Protection Agency current forecasts, it seems like Sweden will reach these goals.[452]

7.3.3 Electricity market, policy and law

The electricity market was deregulated in 1996. The customers are free to choose their own supplier and the price of electricity supply is not regulated. Electricity transmission and supply are separated through ownership unbundling and DSOs are functionally unbundled. Network-access tariffs for electricity transmission and distribution are regulated ex ante. Distribution networks are regulated at a return rate with a regulatory period of four years and a revenue cap of one year.

The electricity certificate system was introduced in 2003. The increase of renewable electricity generation had to be achieved with other sources than large hydropower, because most of the remaining rivers in Sweden are protected. The present goal is to have 18 TWh more renewables from 2020 to 2030. The market design is that electricity generators receive one electricity certificate for each MWh of renewable electricity produced over 15 years. The demand for electricity certificates arises as electricity suppliers are obliged by law to buy electricity certificates to meet a certain quota of their calculation-relevant electricity supply. Certain large customers must also buy electricity certificates to meet a certain share of their calculation-relevant electricity consumption.[453]

[452] https://www.naturvardsverket.se/Sa-mar-miljon/Klimat-och-luft/Klimat/Tre-satt-att-berakna-klimatpaverkande-utslapp/Sa-foljer-vi-upp-klimatmalen/
[453] IEA (2019). Energy Policies of IEA Countries. Sweden 2019 review

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The responsibility for the security of electricity supply is divided between the market and the government. The market should develop adequate generation and distribution capacity. The SEMI is responsible for supervision. The TSO is responsible for preparedness, supervision and market development. The TSO can contract strategic reserves in an annual procurement process. These reserves will be in place until 2025, and then it can be replaced with e.g. a market-based solution. The Swedish system prioritizes users that is considered as important to society. Prioritised users are identified by the municipalities and counties together with the grid owner.

7.3.4 Subsidies and tax schemes

Sweden has a long tradition of energy taxation. The CO_2 tax is highest in the world at USD 140/tCO_2-eq in 2017. Switzerland is second highest with USD 87/tCO_2-eq. In 1991, Sweden introduced the CO_2 tax on fossil fuels to complement the energy taxation. The CO_2 taxes and the energy tax complement each other to form a total tax level on fuel consumption. From 2004 onwards, the CO_2 tax was adjusted annually with the inflation and from 2017 onward an additional 2% annual increase was introduced. In 2018, the CO_2 taxes for gasoline and diesel were reduced parallel to the introduction of the emission reduction obligation system.[454]

Some industries have tax reductions such as diesel consumption in mining and agriculture. A lower energy tax is levied on heat in all co-generation plants and if they are part of the EU-ETS a lower CO_2 tax is applied. The CO_2 tax has influenced the relative competitiveness of biofuels and DH.[455]

The climate investment support – the Climate Leap (klimatklivet) – was introduced in 2015. It is a subsidy programme supporting local and regional infrastructure investments reducing GHG emissions. The programme has been extended to at least 2023. Around 1 900 projects have been funded and on an average the Climate Leap provides 44% of the project cost. Swedish Environmental Protection Agency estimates that the project saves 0.88 MtCO_2/year.

An investment aid of 20% for PVs is in place and since 2019. Homeowners can choose to use ROT-tax deduction. "ROT" is a collective term for measures to renovate and upgrade existing residential properties. The ROT-tax deduction usually equals 9% of the investment cost.[456] The production is also eligible for participation in the certificate system. Microgeneration of PV is also supported through tax reduction and prosumers who are net buyers from the grid are exempted from the network charges for the electricity they feed into the network. Households may also receive subsidies for investing in storage.

Biogas production from manure is supported by a subsidy of a maximum of SEK 0.4/kWh of biogas produced.

7.3.5 Electricity prices

The Nordic market area is managed on the basis of countertrading or market splitting through the creation of price areas. Sweden is divided into four bidding areas. The SE1 area is the Luleå bidding area in the north. Sundsvall bidding area is the SE2, Stockholm SE3 and Malmö SE4. The areas in the north, SE 1 and 2 have a generation surplus, while the two in the south (3 and 4) have a generation

[454] IEA (2019). Energy Policies of IEA Countries. Sweden 2019 review
[455] IEA (2019). Energy Policies of IEA Countries. Sweden 2019 review
[456] Palm (2018) Palm, J (2018). Household installation of solar panels - motives and barriers in a 10-year perspective, Energy Policy, vol 113, pp 1-8; http://dx.doi.org/10.1016/j.enpol.2017.10.047

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 837752.

shortage. The price differences between the areas are expected to encourage increased generating and transmission capacity.

The Swedish end-user market has around 5.4 million customers, served by around 120 suppliers. The largest suppliers are Vattenfall, E.ON and Forutum. Suppliers are free to decide what product to offer, but variable price contracts (monthly based) are the most common among household customers. There are 10-years contracts available, but most common is a 1-3 year contract. Mixed contracts are available and contracts with winter/summer tariffs. Most suppliers offer only one type of tariff to customers with low electricity consumption. These single tariffs mean that the customers pay the same price per kWh regardless of the time of use during the day. Some companies offer an alternative time-of-use tariff. In 2017, 9.5% of the end-users switched supplier. This is representative for how many in Sweden usually are changing supplier during a year.

Electricity prices are low, especially for the industry. In 2017, industry paid on an average USD 62.5/MWh, the second lowest among all IEA member states. This is due to low wholesale prices but also that taxes accounted for only around 1% of the industry electricity price. Swedish households pay more, on an average 178.3 USD/MWh, where 38% are taxes. This is around median among the IEA members. The price differences between the four price areas were small in 2016 and 2017.[457]

7.4 Action arena: Actors

In this section, the main public and market actors are described. The section ends with a brief overview of the number of energy communities.

7.4.1 Government and Authorities[458]

Sweden is a constitutional monarchy where the king has a representative role. The parliament (Riksdagen) is a single-chamber parliament. Sweden is a unitary state with 21 administrative counties. The development of energy policy is the government's responsibility. Sweden joined the EU in 1995, but has kept the Swedish currency (SEK).

The Ministry of Environment and Energy is responsible for energy policies.

The Swedish Energy Agency is under the Ministry of Environment and Energy and is the government agency in charge of implementing most energy policies.

The Swedish Energy Markets Inspectorate is the national regulator for the electricity, natural gas and DH markets.

The Swedish National Grid (Svenska kraftnät) is the TSO. It owns and operates the national high-voltage electricity grid and is responsible for the electricity system's short-term balance.

The Swedish Competition Authority works to safeguard and increase competition.

The National Board of Housing, Building and Planning is the national agency for planning, management of land and water resources, urban development, building and housing. It is responsible for promoting the efficient use of energy in buildings.

[457] IEA (2019). Energy Policies of IEA Countries. Sweden 2019 review
[458] IEA (2019). Energy Policies of IEA Countries. Sweden 2019 review

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The Swedish Environmental Protection Agency has the responsibility for Sweden's regular climate reporting to the United Nations Framework Convention on Climate Change and the European Union. They are responsible for projections and reports related to climate change, GHG emissions and climate policies and measures.

The Swedish Radiation Safety Authority works proactively and preventively on nuclear safety, radiation protection and nuclear non-proliferation.

7.4.2 Market actors[459]

The largest network companies are Vattenfall Eldistribution AB (owned by the Swedish state), Ellevio AB and E.ON Energidistribution AB – each have more than 800 000 customers. The smallest network companies have less than 1 000 customers. The companies are a mix of co-operative economic associations, privately owned companies and municipalities.

The electricity generation is dominated by a few large generators: Vattenfall generates 40% of the total. The three biggest Vattenfall, Fortum and Uniper (47% ownerd by Fortum) generate 73% of the total. These three companies also own the nuclear power capacity. Around 95% of the power trade takes place at Nord Pool. There were 380 market participants of various sizes in 2017.

7.4.3 Energy communities

There is no database over existing energy communities in Sweden and no umbrella organisation exists. In a mapping performed in 2017, searching e.g. the Swedish Energy Agency's database 'Cesar', covering organizations registered in the Swedish electricity certificate system, around 140 energy communities were identified. The total generating capacity of the organizations was 160 MW. Most of them where wind cooperatives (78 active and 20 discounted). The second largest were eco-villages (32), followed by 10 small-scale heating organisations, 9 PV communities and 8 rural communities (Magnusson and Palm 2019).[460]

[459] IEA (2019). Energy Policies of IEA Countries. Sweden 2019 review
[460] Magnusson, D., Palm, J., (2019). Come together-the development of Swedish energy communities. Sustainability (Switzerland) 11:4, 1056.

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8 United Kingdom (UK)

In this chapter the socioeconomic conditions, the energy system, institutional setting and energy related actors in United Kingdom will be described.

8.1 Context: Socioeconomic conditions

In Table 8.1the socioeconomic conditions for the UK are described.

Table 8.1 Socio-economic conditions

Population[461]	67,593,030
Urban population %[462]	83%
Land area[463]	241,930 km^2
GDP 2019[464]	2,743.59 Billion USD
GDP per capita (2018)[465]	42,261 USD
GDP at purchasing power parity (PPP) 2019[466]	3131.2 USD
Employment rate (Jan/2020)[467]	76.6%
Unemployment rate (Feb/2020)[468]	4%

The UK has the sixth largest economy in the world in nominal GDP and the ninth largest in relation to GDP at PPP. In Europe it has the 15th highest GDP per capita. The employment rate is higher than the EU level of 76.6% and unemployment rate is lower (EU has 6,2%).

8.2 Context: Technical systems

Below the UK's energy system will be described, including energy production and consumption, the electricity system, heating arrangements and energy related emissions.

8.2.1 Energy production and consumption

Figures related to energy production and consumption are shown in Table 8.2

Table 8.2 Energy production and consumption

TPES (2018)[469]	176.8 Mtoe
TPES by source (2017)[470]	Natural gas 38.6% Oil 34.5% Nuclear 10.4% Biofuels and waste1 7.1% Coal 5.4% Wind 2.4% Electricity 0.7% Solar 0.6

[461] https://www.worldometers.info/world-population/uk-population/
[462] https://www.worldometers.info/world-population/uk-population/
[463] https://www.worldometers.info/world-population/uk-population/
[464] http://statisticstimes.com/economy/countries-by-projected-gdp.php
[465] http://statisticstimes.com/economy/european-countries-by-gdp-per-capita.php
[466] http://statisticstimes.com/economy/countries-by-projected-gdp.php
[467] https://tradingeconomics.com/country-list/employment-rate
[468] https://tradingeconomics.com/country-list/unemployment-rate?continent=europe.
[469] https://www.iea.org/data-and-statistics/data-tables?country=UK&energy=Balances&year=2018
[470] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review

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	Hydro 0.3%)
TPES/capita (2016)[471]	2.73 toe per capita]
Domestic primary energy production (2018)[472]	124.1 Mtoe
Domestic energy production mix (2017)[473]	Oil 40% Natural gas 30% Nuclear 15% Biofuel and waste 8% Wind 4% Coal 2% Solar 1% Hydro 0,4% ,
TFC[474]	127.3 Mtoe
Consumption (delivered energy) by sector[475]	Transport 32.6% Residential 29.0% Industry 23.8% Commercial 14.6%
TFC per capita (2017)[476]	1.9 toe (IEA average: 2.9 toe),
Energy intensity (TFC/GDP PPP) (2017)[477]	49.0 toe/USD million PPP (IEA average: 73.9), -20% since 2007]

In 2017, the United Kingdom's total primary energy production was 124 Mtoe. Compared to the peak in 1999 of 282 Mtoe this indicates a decrease by over 50%. Both oil and gas production have fallen since then and renewable energy production has increased. The industry sector reduced its oil consumption by over 20% between 2007 and 2018.

Coal production in the country has fallen sharply over the past four decades and most mines have closed. Consequently, the UK has become more dependent on fuel imports. Since 2004, the UK has been a net importer of gas, and two-thirds of the imports come via pipelines from Norway. Most of the remaining part comes from Qatar as liquid LNG. The UK also imports gas from the Netherlands and Belgium and exports to Belgium and Ireland.[478]

The supply of renewable energy was, in 2017, 17.7 Mtoe, 10% of the TPES. The UK has the eleventh lowest share of renewable energy in the TPES among the IEA member countries. Bioenergy and waste were in 2017 the largest source of renewable energy in TPES at 7.1%. These categories include primary solid biofuels (54%), biogas (22%), wastes (17%), and transport biofuels (7%).[479]

The transport sector is the largest energy-consuming sector (33% of the TFC in 2017); the residential sector is the second largest (29%) and industry the third (24%). Oil is the largest energy source in the final energy consumption with 43% of TFC in 2016. Natural gas is the second-largest source, mostly used in the residential sector. Electricity accounts for a considerable share in all the sectors.

[471] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[472] https://www.iea.org/data-and-statistics/data-tables?country=UK&energy=Balances&year=2018;
[473] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[474] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[475] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[476] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[477] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[478] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[479] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review

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Energy efficiency improvements, as well as de-industrialisation and a warming climate have played major parts in decoupling UK final consumption of energy from its economic growth and increasing population.[480] Overall consumption of electricity and natural gas have fallen steadily since around 2005.

8.2.2 The Electricity system

The electricity system is described in Table 8.3.

Table 8.3 Electricity generation and consumption

Electricity generation (2017)[481]	335.5 TWh
Electricity generation mix (2017)[482]	Natural gas 40.8% Nuclear 21.0% Wind 14.9%, Biofuels and waste 10.7% Coal 6.9% Solar 3.4% Hydro 1.8% Oil 0.5%
Electricity net imports (2018)[483]	19 TWh (imports 18.2 TWh, exports 3.4 TWh)
Electricity export (2018)[484]	-2.3 TWh
Electricity import (2018)[485]	21.3TWh
Installed capacity (2017)[486]	103.5 GW
Electricity consumption (2016)[487]	327 TWh
Electricity consumption by sector (2018)[488]	Domestic 30% Industry 26% Commercial 21% Losses 8% Fuel industry 7% Public administration 5% Transport 1% Agriculture 1%
Electricity consumption/pop (kWh/capita) (2016)[489]	4951
Electricity price (2017). Households average price per 100 kWh[490]	17.7 EUR
Share of taxes and levies in average price[491]	24%

[480] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review; https://www.gov.uk/government/statistics/digest-of-uk-energy-statistics-dukes-2019, accessed 3 May 2020
[481] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[482] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[483] https://www.iea.org/data-and-statistics/data-tables?country=UK&energy=Electricity&year=2018)
[484] https://www.iea.org/data-and-statistics/data-tables?country=UK&energy=Electricity&year=2018)
[485] https://www.iea.org/data-and-statistics/data-tables?country=UK&energy=Electricity&year=2018)
[486] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[487] IEA (2019), Key World Energy Statistics
[488]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/820708/Chapter_5.pdf
[489] IEA (2019). Key World Energy Statistics
[490] https://ec.europa.eu/eurostat/documents/2995521/8489679/8-29112017-AP-EN.pdf/600c794f-c0d8-4b33-b6d9-69e0489409b7
[491] https://ec.europa.eu/eurostat/documents/2995521/8489679/8-29112017-AP-EN.pdf/600c794f-c0d8-4b33-b6d9-69e0489409b7

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The UK's electricity generation peaked in 2003 when 395 TWh was generated.[492] Since then it has declined steadily, to 333 TWh in 2018, although total supply (including imports) was 352 TWh. The UK is interconnected with France, Belgium, Ireland, and the Netherlands through five interconnectors with a total capacity of 5 000 MW. In 2018 the UK imported 21.3 TWh and exported 2.3 TWh. Almost all trade is with France and the Netherlands.

Natural gas accounted for 40% of electricity generation (a high proportion in international terms). Renewables were the second largest element in the supply mix, accounting for 33% of generation in 2018. Nuclear plants contributed 20% of generation; coal, 5%.[493] According to the IEA, coal-fired power generation declined by 83% between 2007 and 2017: this has been the single greatest factor in decarbonisation of the electricity sector.

Investment is greatly below the UK government's target of 16 GW of new nuclear capacity by 2030. There is only one project, the Hinkley Point C (HPC) of 3.2GW underway.[494]

Electricity accounted for 17% of the UK's TFC of energy in 2018.[495] In that year, final electricity consumption was 300 TWh, with a further 53 TWh of demand accounted for by the energy industry itself and losses in transmission and distribution.[496]Residential, commercial, and industry sectors each accounted for around one-third of final consumption. Electricity demand has fallen steadily over the past 15 years and IEA figures show that since 2007 industrial consumption has decreased by 18%, the residential sector by 14% and the commercial sector by 4%.[497]

8.2.2.1 Electricity from renewable energy

Renewable Energy Supply (RES) has increased over the past decades, especially wind and biofuels. In 2017 the total installed capacity of variable renewable energy (i.e., not including hydropower) was 32.7 gigawatts (GW), of which 61% was wind and 39% solar PV. This places the UK around the median among the IEA members. In 2017, wind generated 50 TWh, providing 14.9% of the total electricity generation, and the UK was the largest market for offshore wind energy in the world with an installed capacity of 7.9 GW. Onshore wind capacity was 12.2. GW.

In November 2018, the total renewable electricity capacity from wind, solar, and biomass (42 GW) overtook the capacity of coal and gas generation (40.6 GW),[498]

8.2.3 The electricity grid and smart grids

Great Britain is a single energy market with a single price zone. The wholesale electricity market is based on "self-dispatch", where suppliers and generators contract to buy and sell power and have to pay balancing costs if they under- or over-deliver. GB also has a capacity market. Generation and supply

[492] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[493] https://www.gov.uk/government/statistical-data-sets/historical-electricity-data
[494] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[495] Digest of UK Energy Statistics (DUKES) 2019: https://www.gov.uk/government/statistical-data-sets/historical-electricity-data, accessed 3 May 2020
[496][496] https://www.gov.uk/government/statistical-data-sets/historical-electricity-data
[497] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[498] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review

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are unbundled from transmission and distribution and from the system operation. The National Electricity Transmission System is owned and maintained by different regional transmission companies.

A process of legal separation is underway to split the transmission function from the Electricity System Operator (ESO) role of national grid electricity Transmission. In April 2019, separate legal companies within the NG Group were created (ESO and Electricity Transmission), stopping short of full separation. [499]

Offshore transmission networks are owned by a variety of offshore transmission owners, which follow a framework devised by the Office of Gas and Electricity Markets (Ofgem), the UK energy regulator. There are 14 licensed Distribution Network Operators (DNOs), each responsible for planning, constructing, operating, and maintaining the network in their geographical areas. There are also 14 licensed independent DNOs responsible for network extensions in commercial areas.

Great Britain[500] is in the process of rolling out smart meters for both electricity and gas in homes and small businesses on a voluntary basis, having carried out trials between 2007-2011 and started the full-scale rollout in 2016. The original planned end-date of 2020 has now been extended to 2024. Over 50 energy suppliers will install smart meters and the process is monitored by the Department for Business, Energy and Industrial Strategy (BEIS). As smart meters are not rolled out everywhere, many consumers' usage is still 'settled' in the market based on a profile of an average consumer.

8.2.4 The heating systems

Heating in the UK is largely supplied through individual gas boilers; changes in space- and water-heating practices will be crucial in meeting climate change targets.

Heat sources are itemised in Table 8.4, showing the very limited contributions from renewables-based heating, DH (primarily from natural gas and small cogeneration plants) and the relatively small role of electric heating. There is a lively debate over whether policy should move in the direction of full electrification of heating, relying primarily on heat pumps, or repurposing the gas network to supply hydrogen and biogas rather than fossil methane. Energy efficiency considerations are an important factor here, as there is plenty of scope to reduce heating demand by improving the poor state of the UK building stock.[501] The final consumption of heat sold has been quite stable since 2005.[502]

Table 8.4 Sources of space and water heating

Heat sources (residential sector) (2019)[503]	Gas (central heating) 85% Electric (not storage) 4% Oil 4% Electric (storage) 3% Electric (portable heaters) 1%

[499] https://www.capgemini.com/gb-en/2019/05/legal-separation-opportunities-for-the-et-customers/
[500] Note that Northern Ireland has separate arrangements, not least because it shares a wholesale market as with the Republic of Ireland. Semi-smart metering was introduced there during the 1990s and fully smart meters (with two-way communications) are now being rolled out.
[501] See Eyre and Baruah (2015) Uncertainties in future energy demand in UK residential heating. Energy Policy 87, 641-653
[502] https://www.statista.com/statistics/554300/energy-final-consumption-heat-uk/, accessed 3 May 2020
[503] https://www.statista.com/statistics/426988/united-kingdom-uk-heating-methods/, accessed 3 May 2020

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Final consumption of heat sold[504]	1,207 Ktoe

8.2.5 Energy related emissions

Emissions related to the energy sector are shown in Table 8.5

Table 8.5 Energy related emissions[505]

CO_2 emissions ($MtCO_2$) (2017)	371.1
CO_2/TPES (tCO_2/toe) (2017)	2.04
CO_2/Pop (tCO_2/capita) (2017)	5.43
CO_2/GDP ($kgCO_2$/2010 USD) (2017)	0.13
CO_2/GDP (PPP) ($kgCO_2$/2010 USD) (2017)	0.14

Energy related GHG emissions account for about 81% of the total. UK energy-related CO_2 emissions have declined by 35% compared to 1990 levels, and total greenhouse gases (GHGs) are down by 40%, reaching some of the lowest levels recorded since 1888 (IEA 2019). Power and heat, which were once the number one source of energy-related CO_2 emissions in the United Kingdom, have declined significantly (to 25% of the total), far below those of transport (34%). Industry is estimated to account for 18% and commerce 6%.[506] As noted above, reductions in emissions from power generation have played a major part in the overall reductions, as a result of energy efficiency and the displacement of coal by natural gas and renewable sources.

In 2017, oil (45%) and natural gas (44%) were the two largest sources of energy-related CO_2 emissions. These figures highlight the significance of transport (oil), heating (gas) and power generation (gas) in energy transition.

8.3 Context: Institutional setting

In this section political goals, policies, subsidies and tax schemes, as well as the construction of electricity prices, will be discussed.

8.3.1 Political goals and national energy agreements to reduce emissions

The United Kingdom adopted the Climate Change Act in 2008, the first piece of legislation to set legally-binding targets for government. Accordingly, the UK had to reduce GHG emissions from 1990 levels by at least 80% by 2050. To achieve long-term national emission targets the government has established the Committee on Climate Change (CCC), an expert body with strong advisory powers that sets five-year caps on emissions, so-called carbon budgets.[507] These are prepared 12 years in advance. The CCC advises the UK government and also the devolved governments/administrations for Scotland, Wales and Northern Ireland (see below).

[504] https://www.statista.com/statistics/554300/energy-final-consumption-heat-uk/, accessed 3 May 2020
[505] IEA (2019), Key World Energy Statistics
[506] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[507] https://www.gov.uk/government/organisations/committee-on-climate-change

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Following the 2015 Paris Agreement, the CCC advised the UK government to set a net zero greenhouse gas target for 2050.[508]

In 2016, the government adopted the fifth carbon budget (for the period 2028-32), which targets a 57% reduction in GHG emissions relative to 1990 levels.[509] The first and second carbon budgets were met – it was relatively easy to cut emissions from the power sector – and the third one was almost met in 2018. The IEA reports on a gap between ambitions and set targets in the fifth budget.[510]

The carbon budgets do not provide for sectoral targets and are designed for technology neutrality. The Clean Growth Strategy adopted in 2017 set out policies by sector and outlined a number of proposals to meet the fifth carbon budget. This included to improve energy efficiency in business and industry by at least 20% by 2030. Energy efficiency in homes is to be supported by providing investment support to one million homes through an Energy Company Obligation. Other measures are to foster the roll-out of low-carbon heating by reforming Renewable Heat Incentives. By 2025 all remaining unabated coal-fired power generation is to be phased out. A voluntary public sector target of 30% of reduction in carbon emissions by 2021 is also introduced among many other measures.[511]

The key challenges to meet the targets, according to the IEA, are 1) to decarbonise beyond the power sector (transport, heat and industry), 2) deliver affordable energy, and 3) establish a post-Brexit framework.

In the Industrial Strategy of 2017, the government built long-term strategic partnership with businesses, called sector deals. In the same year, the Clean Growth Strategy consisted of a list of policy actions and funding programmes but did not set quantitative emissions targets. According to the IEA the Clean Growth Strategy and Industrial Strategy have focused UK energy policy on competitiveness and affordability, and the UK has adopted a long-term roadmap to minimise business and household energy costs. (By implication, climate considerations have become less significant in government thinking.)

The Carbon Price Floor (CPF) is a UK Government policy implemented to support the EU ETS. The CPF was introduced on 1 April 2013 to underpin the price of carbon at a level that drives low carbon investment. The price floors are paid for by energy generators as 1) The EU ETS allowance price and as 2) the Carbon Price Support (CPS). All revenues from the CFP is collected by the Treasury.

Community energy was originally to play a significant part in meeting emissions targets and a Community Energy Strategy was set out in 2014. At the time, there were some 5,000 community energy groups in the UK. However, following the 2015 election, government support for community energy has lessened considerably and it faces considerable challenges.[512]

Scotland, Wales, and Northern Ireland have separate climate change policies. The Scottish government, the most ambitious, has pledged to set a net zero emissions target by 2045. Wales passed the Environment Wales Act in 2016, which include an 80% reduction in GHG emission by 2050 (compared with 1990 levels). Wales also has five-yearly carbon budgets.

[508] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[509] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[510] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[511] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[512] Rydin and Turcu (2019) Revisiting urban energy initiatives in the UK: declining local capacity in a shifting policy context. Energy Policy 129, 653-660

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The Northern Ireland Executive has a target to reduce its GHG emissions by at least 35% by 2025 (compared to 1990 levels).

8.3.2 Performance on EU 2020 energy targets

The EU CO_2 target is to have a 20% reduction compared to 1990 levels by 2020 and the UK met this, with a reduction of 37%.[513] The UK's 2050 climate change target had been to reduce emissions by at least 80%, compared to 1990 levels, but the CCC advocated a net zero target and this was adopted by Prime Minister Theresa May just before she left office in 2019.[514], [515]

The EU Renewable Energy Directive (RED, 2009/28/EC) supported a renewable energy target of 20% of gross final consumption by 2020. The UK national target was to achieve 15% of final energy consumption from renewables in electricity generation, heating, and transport. In 2018 the UK share was 11% renewables.[516] In the first National Renewable Energy Action Plan in 2010, the government stated that it would aim at 30% renewable share of electricity generation (already surpassed, see above), 12% in heat and 10% in transport. Due to Brexit, the European Commission stated in March 2018 that RED would no longer apply to the UK. UK's participation in the second RED, with targets for 2030, is not clear.[517]

In the electricity system RES have increased rapidly, particularly wind and biofuels, and in 2017 they accounted for 30% of generated electricity (compared to 5,5% in 2007). This is in line with the national electricity from RES target under the EC Renewable Energy Directive (2009/28/EC). Together with nuclear power, the share of low-carbon power generation is over 50%. Renewables progress in heating and transport sector has been more challenging. The innovative Renewable Heat Incentive and the Renewable Transport Fuel Obligation have provided mixed results and IEA recommend a review of these policies for Horizon 2030/50.[518]

Under the 2012 Energy Efficiency Directive (2012/27/EU) the UK had a target to reduce final energy consumption by 18% to a level of 129.2 Mtoe in 2020, which equals a 20% reduction in primary energy consumption to 177.6 Mtoe, which was reached.[519]

8.3.3 Electricity market, policy and law

The Electricity Market Reform (EMR) of 2013 started as a supply-side reform, but has been encouraging also for the power sector transition. The EMR, or the Energy Act 2013, introduced four mechanisms to support investment in low-carbon electricity generation: a carbon price floor, an emission performance standard, a capacity market and Contracts for Difference (CFD) between current and

[513] https://ec.europa.eu/info/business-economy-euro/economic-and-fiscal-policy-coordination/eu-economic-governance-monitoring-prevention-correction/european-semester/european-semester-your-country/united-kingdom/europe-2020-targets-statistics-and-indicators-united-kingdom_en.
[514] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/774235/national_energy_and_climate_plan.pdf
[515] https://www.bbc.co.uk/news/science-environment-48596775
[516] https://ec.europa.eu/info/business-economy-euro/economic-and-fiscal-policy-coordination/eu-economic-governance-monitoring-prevention-correction/european-semester/european-semester-your-country/united-kingdom/europe-2020-targets-statistics-and-indicators-united-kingdom_en#greenhouse-gas-emissions
[517] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[518] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[519] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review

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contracted prices paid to suppliers. In addition, the government announced in 2015 the closure of all coal fired power plants without carbon capture and storage by 2025.

The EMR was created as a series of targeted interventions to manage the transition to a decarbonised electricity market. The EMR supplemented the energy-only market with a new design that included the Great Britain capacity market, CFD for low-carbon electricity, a CPF of GBP 18.08 per tonne of carbon dioxide, and an emissions performance standard (EPS) of 450 g/ CO_2/kWh.

The increase of electricity generation from renewables has according to IEA mainly been driven by three support schemes. The Renewables Obligation was introduced in 2002 and closed to new applications in 2017; FiTs were used to encourage small-scale renewable electricity generation, introduced in 2010 and closed in 2019; and CFDs were introduced as part of the Electricity Market Reform of 2013 with auctions held in 2015 and 2017. The annual costs of the three support schemes are estimated at GBP 8.6 billion in 2021/22, and these are paid through additional charges on customers' bills. According to the IEA the CFDs led to a boom in renewable investment through competitive allocation. However, the end of the RO leaves onshore wind or solar PV projects of over 5 MW in limbo, and the closure of the FiTs from 2019 means there will be no government support for any solar projects.

It has been announced that CFD auctions will be run every two years after the auctions in May 2019. Around 10 GW wind capacity is planned for the 2020s, with 2 GW) of new offshore wind capacity every year, provided costs continue to fall.[520]

The CPF underpinned the value of carbon in the power sector to supplement the EU Emissions Trading System and drove coal-to-gas switching, while the EPS restricted the prospects for new coal power plants. CPF will stay at the current level until 2021.[521]

The power system will have an increase in renewables due to a final phase out of remaining coal-fired capacity and closure of the oldest nuclear reactors by 2025 (which is half of the total capacity of 8.9 GW). Another six reactors will be closed by 2030. Electricity security has been a priority in the UK and the reliability standard is set to a 5% capacity margin or loss of load expectation of 3 hours per year.

The capacity market places value on security of supply through an auction process. This has brought down prices, encouraged capacity remunerations for existing plants, smaller-scale new build plants and flexibility sources.

8.3.4 Subsidies and tax schemes

The United Kingdom has three major support schemes for electricity generation based on RES: a Renewable Obligations (RO) that has existed since 2002, FiTs were introduced in 2010, and CFD in 2013. The CFD scheme is the main mechanism for supporting new large-scale renewable energy generation.

The RO required UK electricity suppliers to have Renewables Obligation Certificates (ROCs) for each MWh of electricity supplied. Ofgem issued ROCs to generators who could sell those to suppliers or traders. The value of a ROC was negotiated between the generators and suppliers and there was a

[520] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[521] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review

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certificate trading exchange. If a supplier could not show compliance with the obligation they had to make a payment per ROC into a buy-out-fund. The money from the buy-out-fund was recycled on a pro-rata basis to suppliers who presented ROCs, which encouraged suppliers to choose ROCs over the fund. The cost of the RO to suppliers was passed on to customers through their energy bills. The RO has been replaced by the CFD (see below for more information about the CFD).

The FiTs support scheme started in April 2010 to encourage deployment of small-scale, low-carbon electricity generation. FiTs supports solar PV, onshore wind, hydropower, anaerobic digestion up to 5 MW and micro co-generation with a capacity up to 2 kW. Under the FiTs scheme, generators received payment for every kWh generated and an additional payment for every kWh exported to the local electricity network. Generators also reduced their energy bills when they used their own electricity on site. Electricity suppliers paid the FiTs to generators and passed these costs to customers through the bill. Since 2010 the FiTs scheme supported over 800 000 installations, with a total capacity of 6 GW. Most of these were solar (80% of capacity). The FiTs support scheme closed April 2019.[522]

The Contracts for Difference (CFD) scheme was introduced together with the Electricity Market Reform in 2013. This scheme supports new large-scale low-carbon generation projects, renewables as well as nuclear, (though with more favourable terms to nuclear). A CFD is a private law contract between a low-carbon electricity generator and the government-owned Low Carbon Contracts Company. The winning generators are guaranteed a certain electricity price in a long-term contract. The CFD payments are raised through a levy on all UK electricity suppliers who then pass the costs on to customers. This has contributed especially to investments in offshore wind. In the auction in 2017, solar PV and onshore wind were excluded.

Until 2017 the UK had a levy control framework (LCF) in place. This was linked to the annual budget process and was a way to control the costs of low-carbon electricity support schemes, which are levied on energy bills through wholesale prices. It related only to electricity, not transport or heat, and included the costs of the CFD, the RO and the FiTs schemes. In the autumn of 2017, the Control for Low Carbon Levies (the Control) replaced the LCF. The Control covers all existing and new low-carbon electricity levies. The government has however decided to not introduce any new low-carbon electricity levies until costs fall, which in practice means there will be no new levies until 2025.

The Total Carbon Price (TCP) for energy generation in GB is made up of the EU Emission Trading System ETS price and the CPS rate of the Climate Change Levy (CCL). The Carbon Price Support was implemented to support the EU ETS, and underpins the price of carbon by taxing fossil fuels used to generate electricity (CPS does not apply in Northern Ireland). The CCL is levied on the supply to business and public sector consumers per unit of electricity, gas, coal and liquefied petroleum gas. Households, charities and small businesses are exempted. Energy-intensive industries have a discount if they meet negotiated energy efficiency targets through voluntary Climate Change Agreements (CCA). These provide a 90% discount on the levy on electricity and 65% on gas and other taxable fuels. Businesses with CCAs cannot take part in other energy efficiency and carbon reduction schemes.[523]

[522] https://www.ofgem.gov.uk/system/files/docs/2018/12/essential_guide_to_closure_0.pdf
[523] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review

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The CPS has a cap at 18 GBP/tCO_2 (at least to 2020/21) to limit the competitive disadvantages faced by businesses and reduce energy bills for consumers.

With the EMR in 2013, several mechanisms were introduced such as the CPS rate as a supplement to EU ETS, which increased the cost of emitting CO_2. An emission performance standard on fossil fuel was introduced along with CFD for low-carbon power generation. There are also FiTs for small-scale renewable power and a renewable heat incentive.

The Clean Growth Strategy of 2017 set out policies and government funding of GBP 2.5 billion for innovation and low-carbon investment up to 2021. Together with Canada, the UK launched the Powering Past Coal Alliance, which commits them to the rapid phase out of unabated coal.[524]

Carbon pricing applies to electricity (with the CPF), industry is exempt if they implement energy efficiency agreements).[525]

In accordance with EU's Renewable Energy Directive (2009/28/EC), the UK has a Renewable Energy Guarantees of Origin (REGO) scheme, which gives transparency to consumers about the share of renewables in a supplier's electricity generation. Ofgem issues one REGO certificate per MWh of eligible renewable output. The European Commission stated in March 2018 that the UK's guarantees of origin will no longer be recognised by the EU-27 if it is not subject to any transitional arrangement. The UK government has legislated to ensure the REGO in EU countries will be recognised in a 'no deal' Brexit situation, to allow electricity suppliers to continue to use EU REGOs. [526]

8.3.5 Electricity prices

The Electricity Market Reform changed the wholesale market design. Wholesale electricity prices in Great Britain were low between 2012 and 2016 but have increased since then. Prices are in general higher than European average. Another factor influencing electricity price is that UK has limited interconnection to continental Europe. In 2017, the UK's electricity price for industries was the seventh-highest and the households (GBP 193/MWh) was the tenth highest price among IEA member countries.

The final electricity retail price is composed of wholesale energy costs, which account for almost 50%, transmission and system operation costs (25%), environmental and social costs (15%), and retail cost (20%).

A focus on the energy poor and vulnerable consumers is strong in the UK, where 2.5 million households were estimated to live in fuel poverty in 2017.[527] The figures has varied however over the years. Fuel poverty depends on a combination of income, energy unit costs and efficiency of the home and its appliances. People can move over the threshold in either direction from year to year very easily. There are around 5m households on regulated prices with three types of price cap in place. Around 4m customers have prepayment meters and since 2017, a price cap, a so-called safeguard tariff, is in place for them. Since 2018, this also include 1m vulnerable customers who receive a warm home discount. In 2019, another default price cap entered into force which applies to 6m customers on

[524] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[525] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[526] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[527] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/754361/Committee_on_Fuel_Poverty_Annual_Report_2018.pdf

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standard electricity and gas tariffs. In total 11million households were under the price cap during 2019. The cap is planned to be temporary until a better-functioning competitive market is in place.[528]

The Energy Switch Guarantee, launched in 2016, provided consumers with the right to switch suppliers within 21 days of signing a new contract. In 2018 around 18.4% of the consumers switched suppliers, which is a large share compared to other IEA countries. However, more than 60% have only switched once or never and 54% have been on default tariffs for more than three years. [529]

8.4 Action arena: Actors

In this section the main public and market actors are described. The section ends with a brief overview of the number of energy communities.

8.4.1 Government and Authorities

The UK is a constitutional monarchy, where the reigning monarch makes no political decisions. There is devolution of varying powers (administrative, executive or authority) to the parliaments in Scotland, Wales and Northern Ireland. These devolved administrations have either exclusive or shared competence when it comes to issues such as small-scale generation, climate change and energy efficiency. Energy in the UK has been governed by EU law; at the time of writing, it is not clear what the post-Brexit legal situation will be.[530]

The central government of the UK leads on overall energy policy, although the Scottish government sets its own, more innovative, policy. The UK BEIS is responsible for ensuring secure, clean, and affordable energy supplies. The Department for Environment, Food and Rural Affairs (DEFRA) works with other departments to make sure that energy policies are aligned with their environmental objectives.[531]

Ofgem is the main regulator of the UK gas and electricity networks. Ofgem's role is to protect consumer interests, which include reducing GHG emissions, ensuring security of supply, and regulating competitive markets in gas and electricity supply and retail. Ofgem is accountable to the UK Parliament and funded by annual licence fees paid by licensed companies.[532]

The Competition and Markets Authority is the United Kingdom's competition and consumer authority. It is responsible for carrying out investigations into mergers, markets, and regulated industries.

The Nuclear Decommissioning Authority owns 17 civil nuclear legacy sites and is a non-departmental public body. The Office for Nuclear Regulation is the independent nuclear regulatory authority.[533]

National Grid plc is a British multinational electricity and gas utility company that owns and operates the gas and electricity transmission networks and (partly) the interconnectors. In April 2019 the National Grid Electricity System Operator (NGESO) was established. NGESO is legally separate from

[528] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[529] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[530] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[531] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[532] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[533] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review

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the transmission owner, NG Electricity Transmission. The separation will allow the ESO to play a more proactive role in managing the electricity system.[534]

The Low Carbon Contracts Company and the Electricity Settlements Company are both private limited companies to deliver on the decarbonisation of the UK electricity sector.[535]

8.4.2 Market actors

The wholesale electricity market has been dominated for about 20 years by six vertically integrated companies (active in generation and retail). These are: Centrica/British Gas, Électricité de France (EDF), Uniper (the fossil fuel arm of E.ON) RWE Npower, Scottish and Southern Energy, and Scottish Power. In 2017 these six owned approximately 50% of the total installed capacity of around 100 GW. EDF accounted for 24% of the GB electricity supply, RWE Npower for 14%; Scottish Power for 8%, Drax for 7%, Centrica for 5% and E.ON UK for 5%. There have however been many new entrants to the market over the past 10 years, mostly niche suppliers. The wholesale market is moderately concentrated as eight generators provide 71% of the volumes in 2017.

All of the 'Big Six' electricity suppliers also supply gas.

8.4.3 Energy communities

According to the UK government website, there were over 5 000 energy communities in the UK in 2015.[536] Examples are:

- Community-owned renewable electricity installations such as solar PV panels, wind turbines or hydroelectric generation.
- Members of the community jointly switching to a renewable heat source such as a heat pump or biomass boiler.
- A community group supporting energy saving measures such as the installation of cavity wall or solid wall insulation, which can be funded wholly or partly by the Green Deal.
- Working in partnership with the local DNO to pilot smart technologies.
- Collective purchasing of heating oil for off gas-grid communities
- Collective switching of electricity or gas suppliers.

As indicated above, however, UK government support for community energy has fallen since 2010, especially since 2015. The latest initiative has been 'Prospering from the Energy Revolution', a major programme of research and development aimed at developing and demonstrating clean, smart local energy systems and services.[537] The approach is primarily technical and economic rather than community-based, but there are some links with energy communities. In Scotland, the level of government support is more favourable to community energy.

Non-financial support for new initiatives in England, where about 85% of the UK population live, comes from Community Energy England; Scotland and Wales have similar organisations. Some local government bodies and other NGOs have also played an important role in developing and supporting

[534] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[535] IEA (2019), Energy policies of IEA countries. United Kingdom 2019 Review
[536] https://www.gov.uk/guidance/community-energy
[537] https://www.gov.uk/government/news/prospering-from-the-energy-revolution-full-programme-details

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local energy initiatives: examples are the Centre for Alternative Technology, the Centre for Sustainable Energy (Bristol), National Energy Action and the Transition Towns movement.

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9 Final remarks

The aim of this delivery was a mapping of the polycentric settings in the six studied countries, Germany, Italy, the Netherlands, Slovenia, Sweden and the United Kingdom. For each country the socio-economic conditions, the technical system (electricity and heat), institutional arrangements and actors are described. Furthermore, the developments of each country regarding energy communities are presented. This delivery serves as a basis for delivery D3.2 where the aim is to compare different national polycentric settings. It will also feed in to delivery D3.3 that aims to evaluate what forms of energy communities work best in different polycentric setting and what the potentials for learning between different polycentric settings are.

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