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WORLD COALITION

An overview of the Global Cogeneration Market

Produced by Challoch Energy for the COGEN World Coalition

November 2022

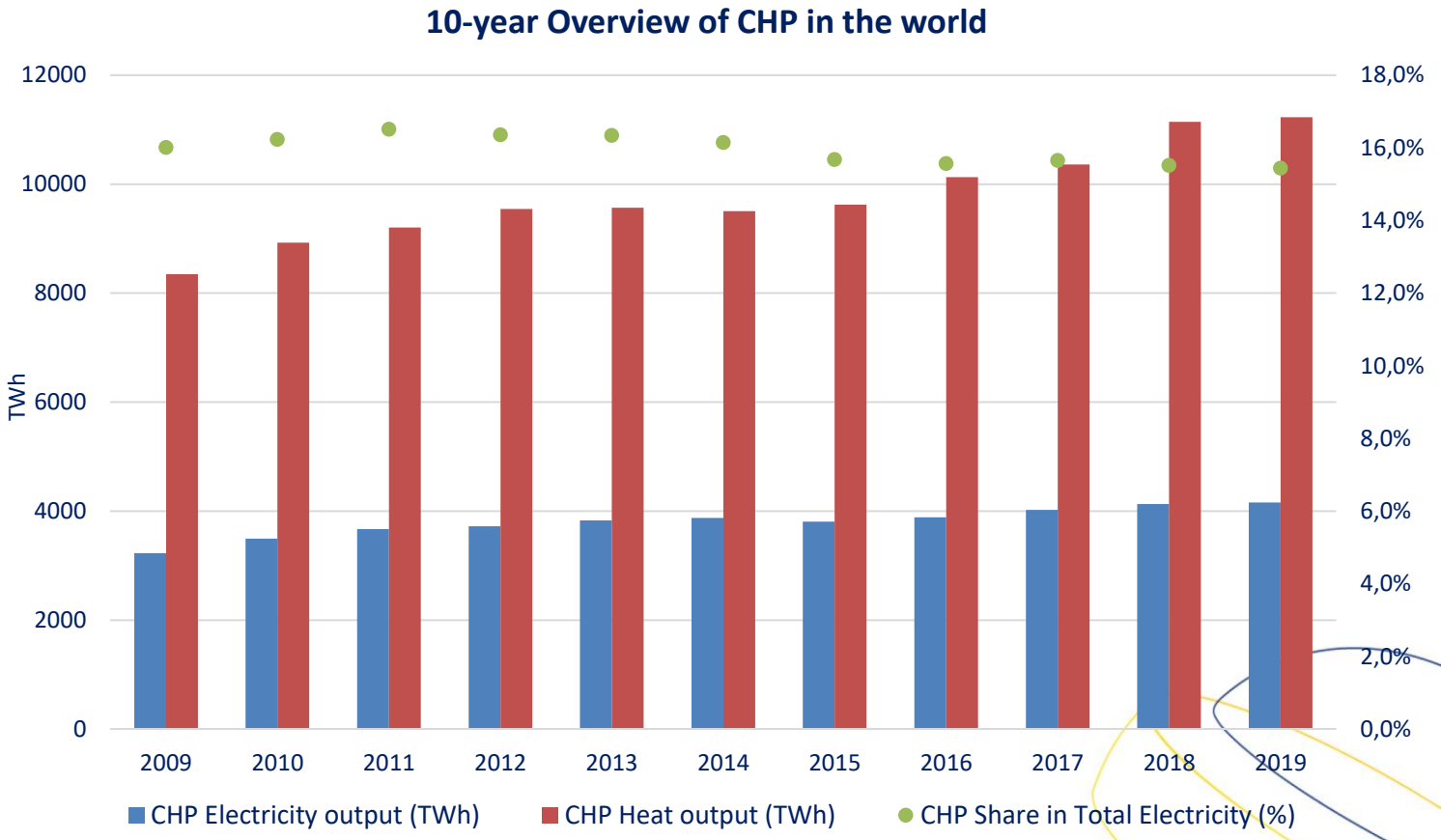
World Overview

World

Electricity produced by CHP plants in 2019:

4,159TWh

- Electricity generation values from IEA database include condensing parts which may lead to overestimated values.
- We can observe an **increase of the CHP electricity output of almost 1,000TWh between 2009 and 2019.**
- During the given period, **CHP Heat output went up from 8400TWh to 11200TWh.**
- On the contrary, **the share of CHP in the total electricity generation has slightly decrease.**



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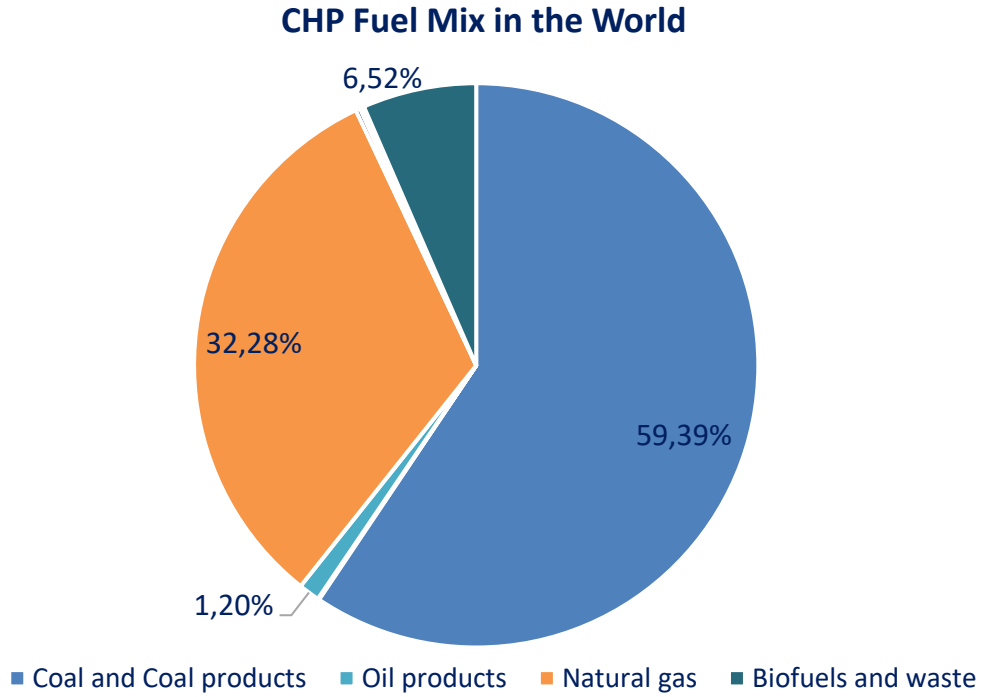
CHP Fuel Mix



Commentary:

- Fossil fuels continue to dominate with coal leading at 60%
- Biofuel is a growing share, now at ~6%
- 95% of the fuel mix share is held by 3 fuels: coal, natural gas and biofuels and waste.

Future trends:

- Gradual phaseout of coal
- Electrification of industry
- Hydrogen CHP technology gradually gaining ground → acceptance is rising, but economics not yet.

Proportion of the other fuels:

- Peat and peat products 0.08%
- Oil shale and oil sands 0.01%
- Nuclear 0.27%
- Geothermal 0.12%
- Solar/Wind/other 0.11%

EUROPE

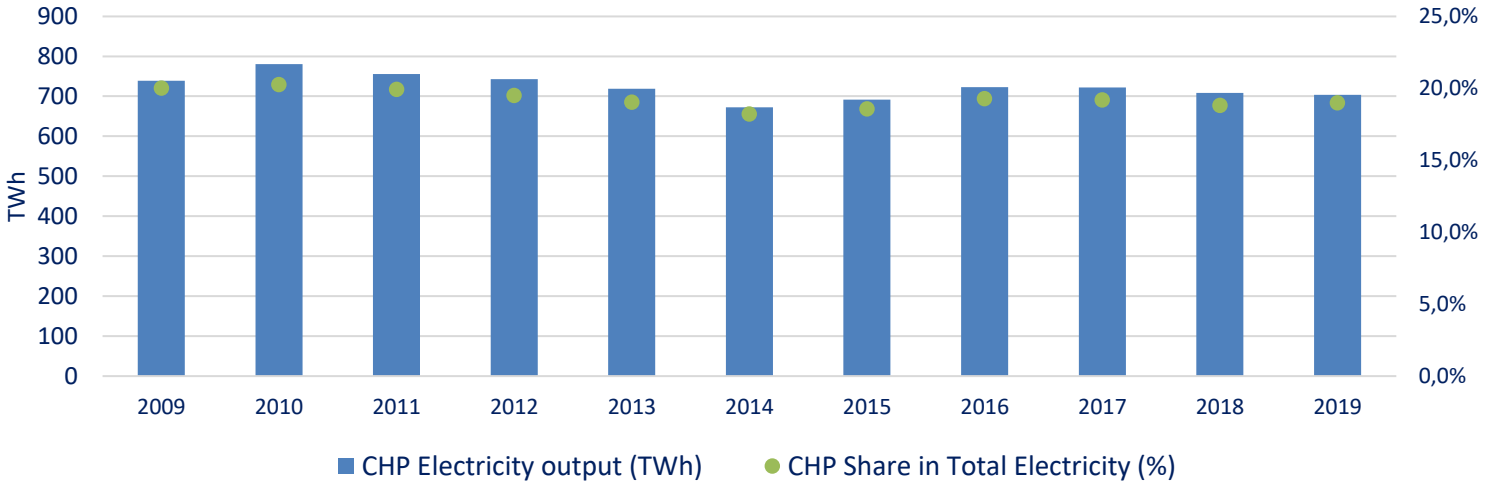
Europe

Electricity produced by CHP plants in 2019:

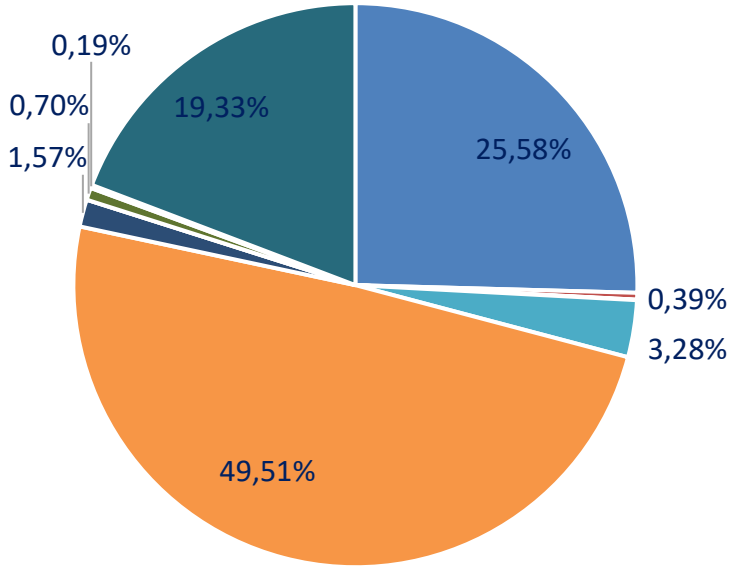
704TWh

- CHP represents 20% of the electricity produced in Europe
- Minor variations in electricity generation during the last 10 years **(between 700 and 800 TWh)**.
- CHP's share of total electricity production stays stable at **~19%.**
- The main fuels are **natural gas and coal**, followed by biofuels and waste.
- High share of solar, wind, other relative to the global fuel mix.

10-year Overview of CHP in Europe



CHP Fuel Mix in Europe



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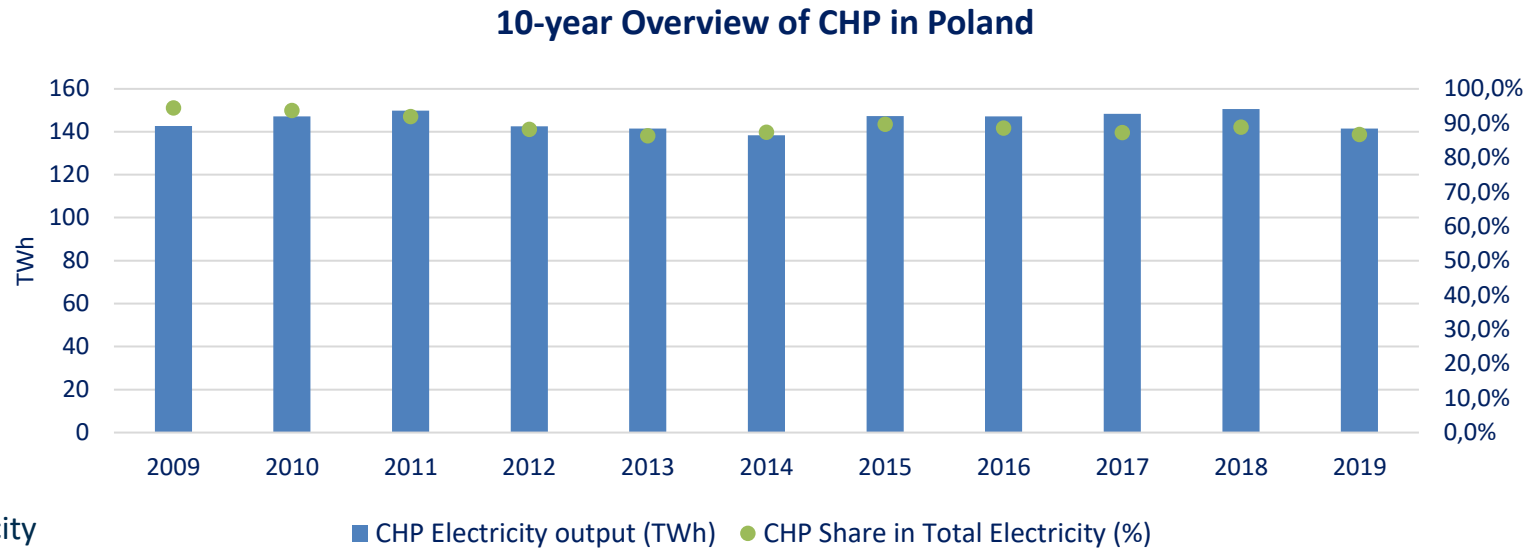
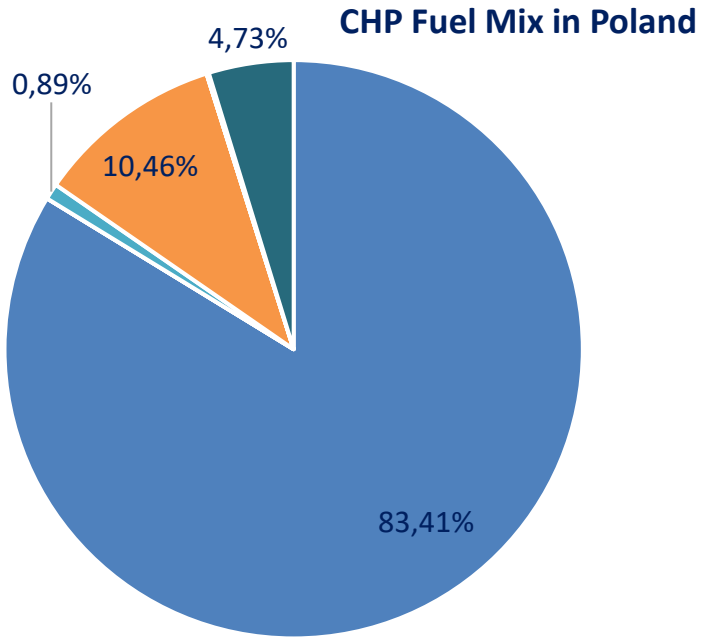
Poland

Electricity produced by CHP plants in 2019:

141TWh

- CHP represents 90% of the electricity produced in Poland
- Stable evolution of the electricity output **(between 140 and 150 TWh).**
- Very high share of CHP electricity in total electricity generation **(~90%)**. This is due to the method of calculation used by the IEA. In comparison, Eurostat estimates the share of CHP in the electricity generation at 17%.
- CHP fuel mix of Poland is largely dominated by **coal.**





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Germany and Italy

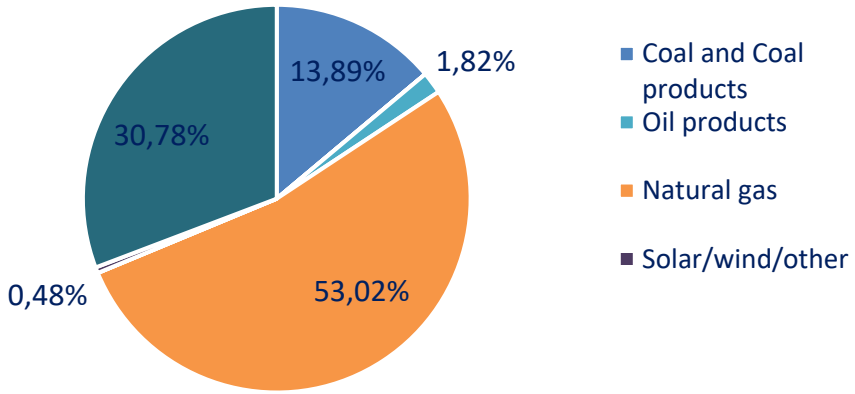
GERMANY

Electricity produced by CHP plants in 2019:

120TWh

→ 17% of the electricity produced by CHP in Europe

CHP Fuel Mix in Germany



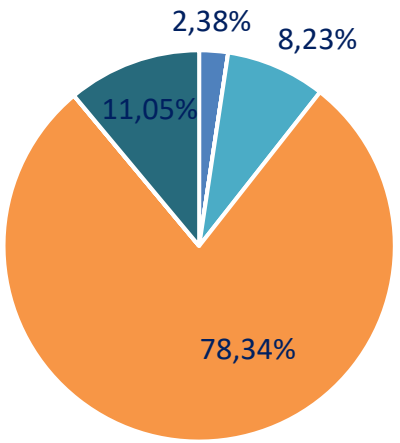
ITALY

Electricity produced by CHP plants in 2019:

105TWh

→ 15% of the electricity produced by CHP in Europe

CHP Fuel Mix in Italy



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IEA and Eurostat Databases Comparison: Germany

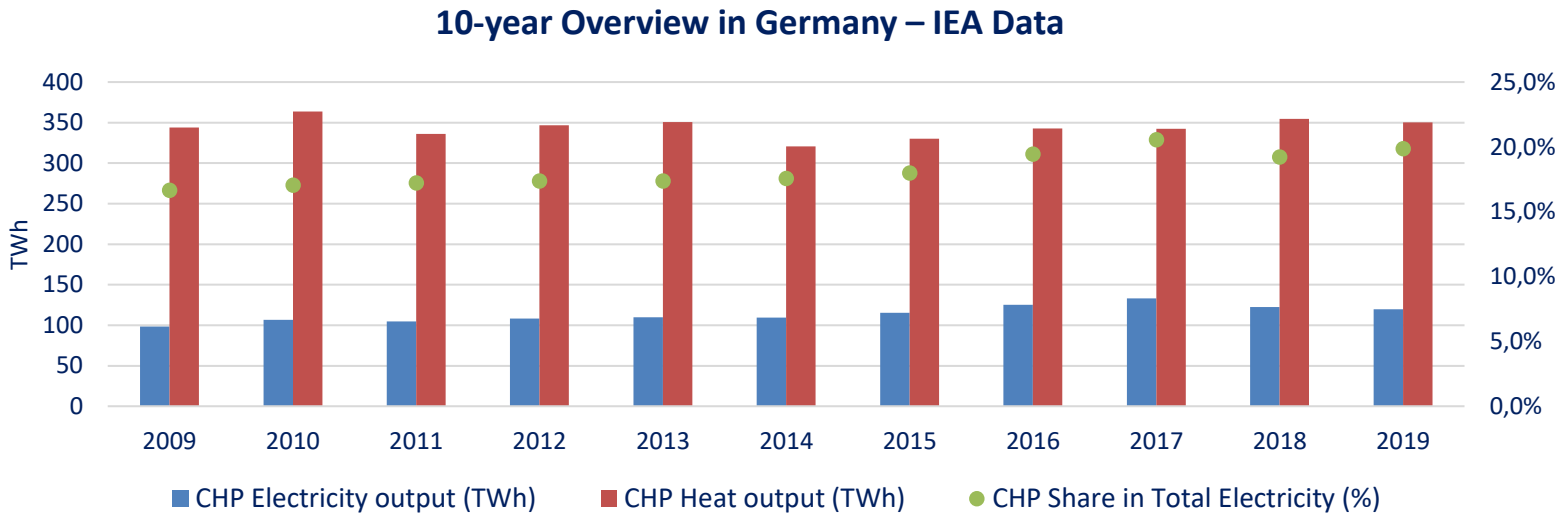
IEA Database

CHP Electricity Output in 2019

120TWh

CHP Heat Output in 2019

350TWh



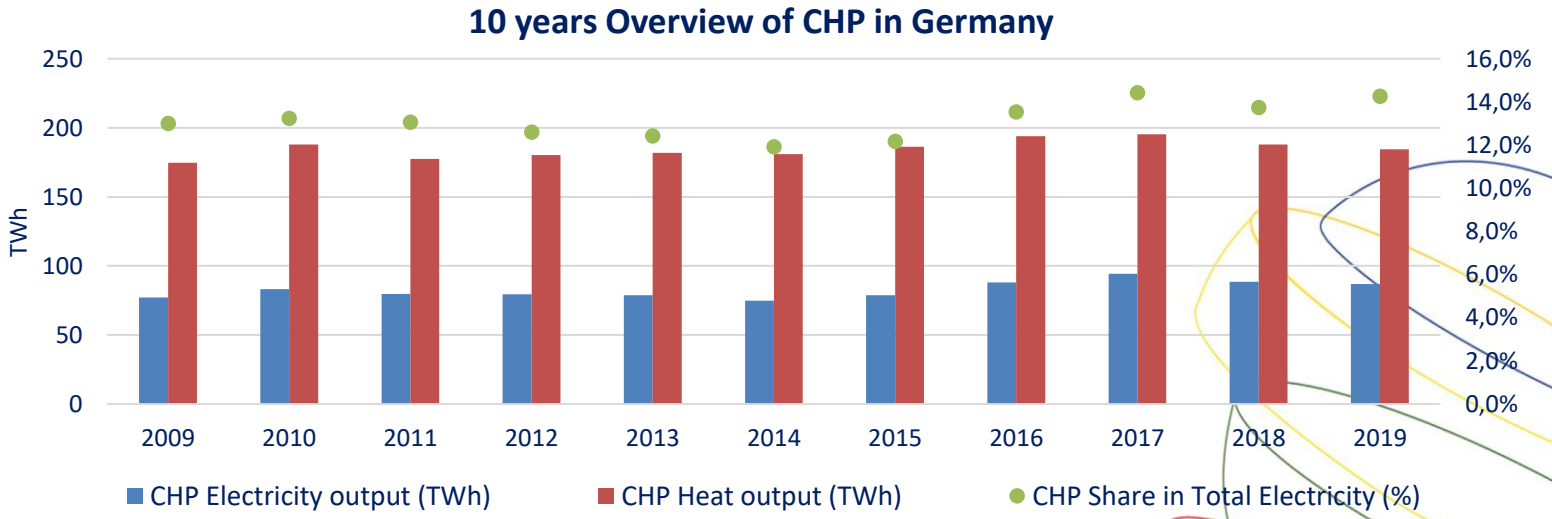
Eurostat Database

CHP Electricity Output in 2019

87TWh

CHP Heat Output in 2019

184TWh



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IEA and Eurostat Databases Comparison

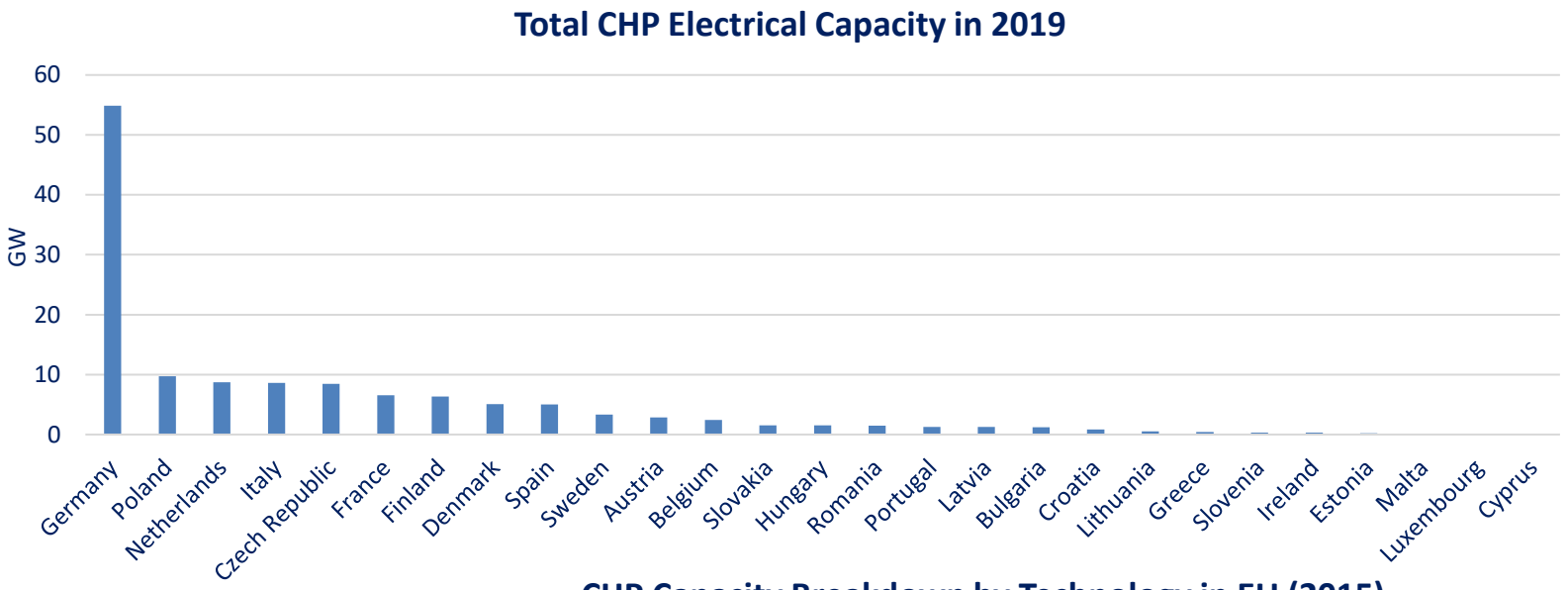
Commentary on the previous slide:

- The two databases do not have the same values concerning CHP electricity and heat output.
- We can observe a gap between the electricity values, mainly because IEA and Eurostat do not use the same methodology to calculate these values.
- Eurostat data on CHP are generally more accurate.

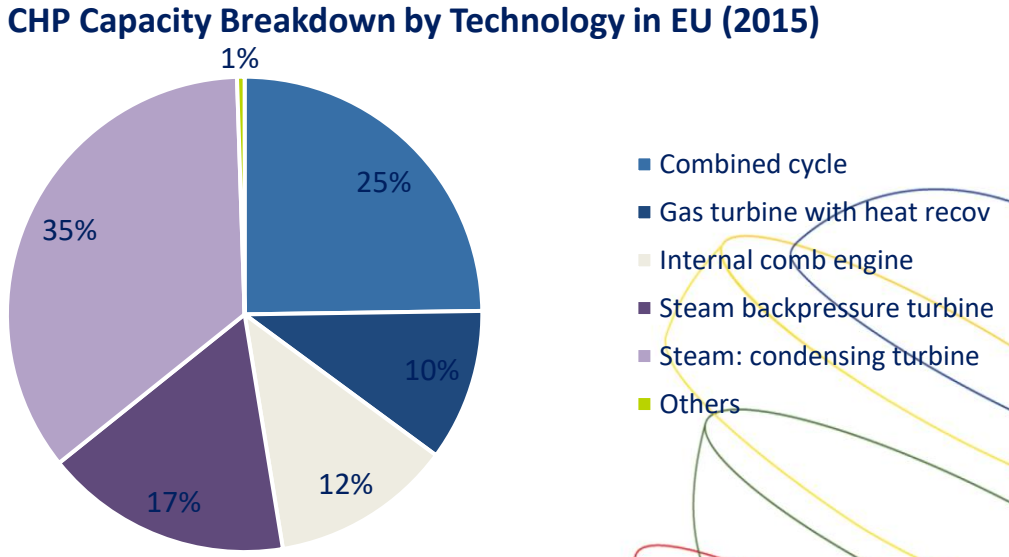
Additional details on EU27

CHP Installed Capacity in 2019

133GW



- **Germany** has the largest CHP Installed capacity among the 27 countries of the EU.
- **Steam turbine** dominates the CHP market in EU with 52% of the CHP capacity. It is followed by combined cycle power plants and gas turbine.



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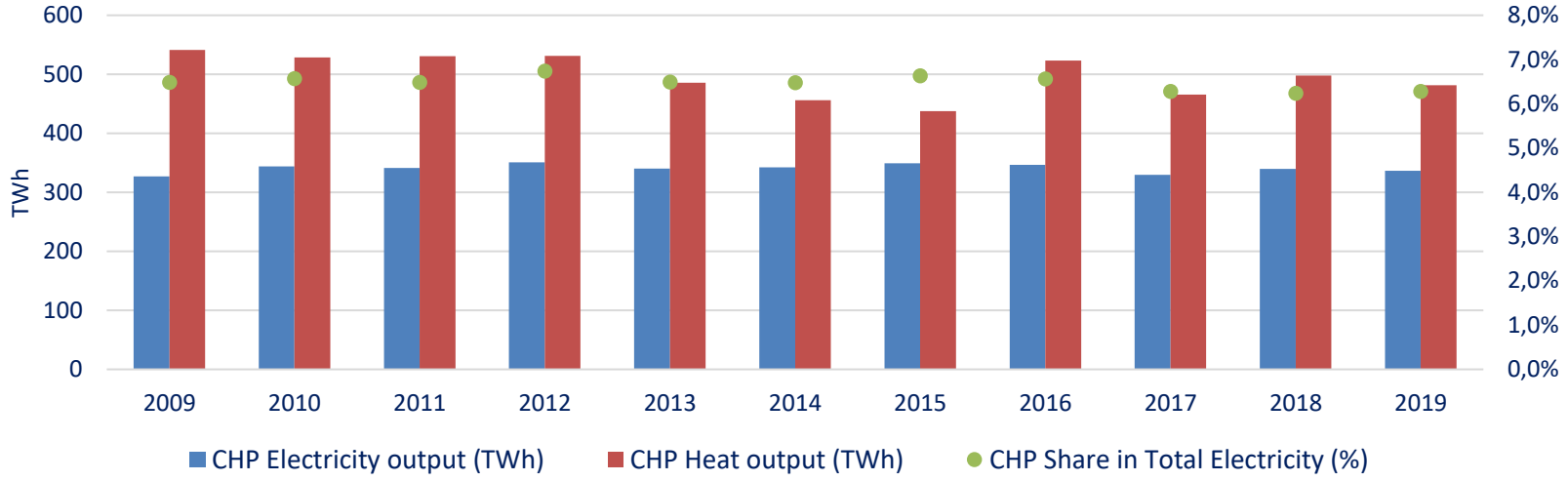
NORTH AMERICA

North America

Electricity produced by CHP plants in 2019:

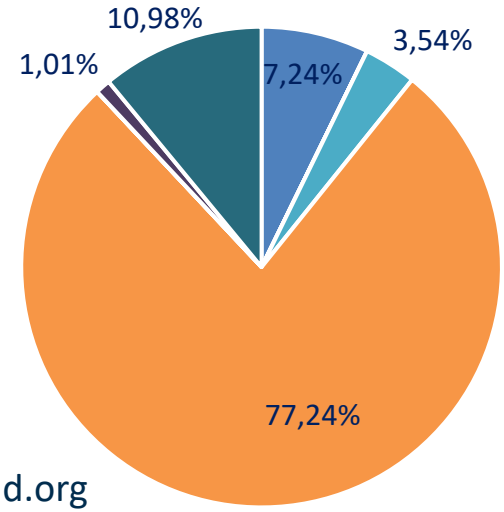
336TWh

10-year Overview of CHP in North America



- Little variation of the electricity output **(between 325 and 350TWh).**
- CHP's electricity share remains stagnant at **~6.5%** since 2008
- The main fuel used for CHP in North America is **natural gas**, followed by biofuels and waste, and coal. We can notice a small share of solar/wind/other in the CHP fuel mix.

CHP Fuel Mix in North America



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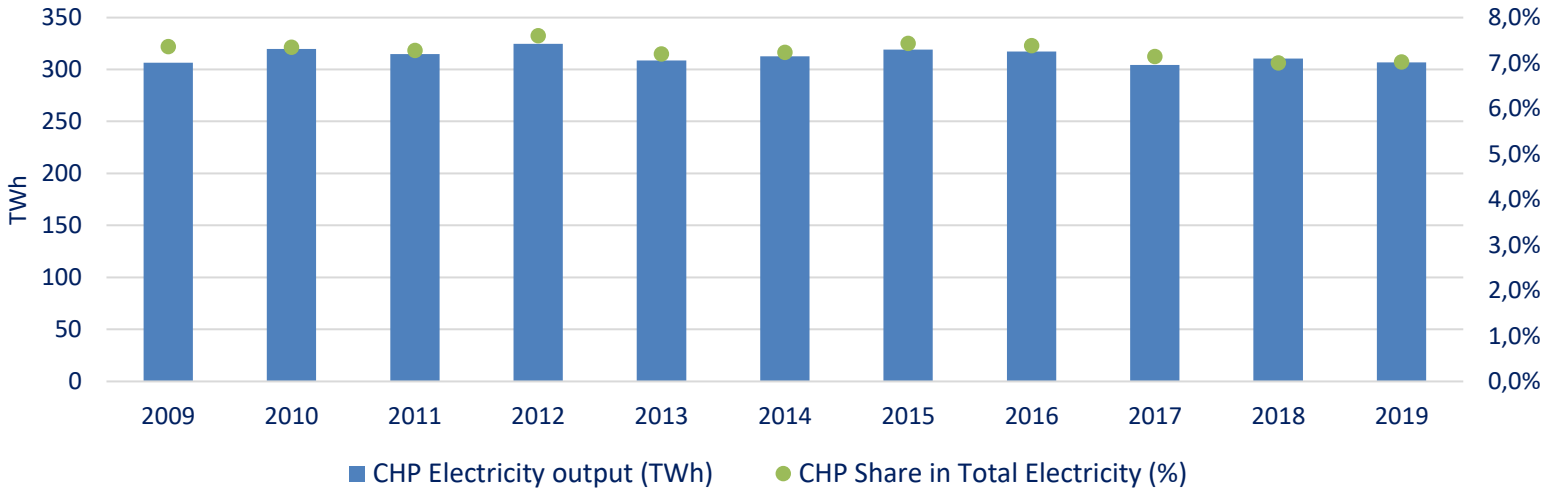
USA

Electricity produced by CHP plants in 2019:

306TWh

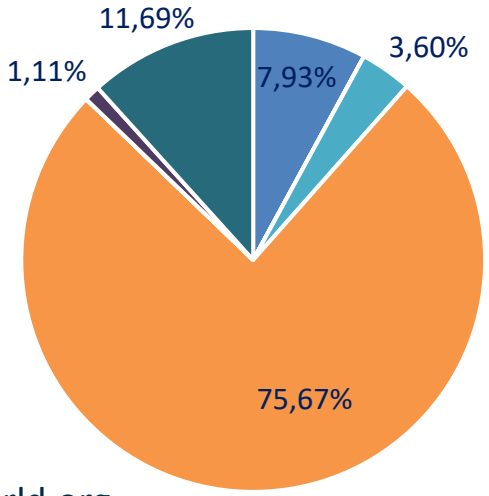
→ 91% of the electricity produced by CHP in North America

10-year Overview of CHP in the USA



- Little variation of the electricity output **(between 300 and 325TWh).**
- Stable evolution of the CHP electricity share **(~7.5%).**
- As the U.S. is the main producer of electricity by CHP in North America, its fuel mix is almost the same as the North American one. **Natural gas** is the main fuel.

CHP Fuel Mix in the USA



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Additional details on the USA

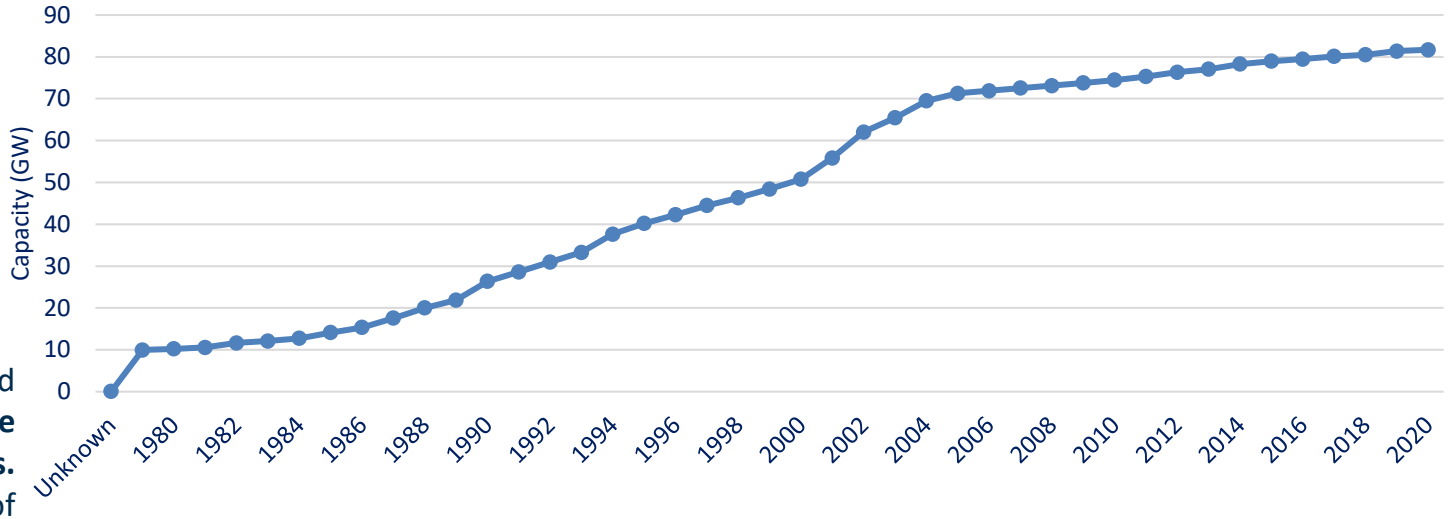
CHP Installed Capacity in 2020

- The rate of the CHP capacity installed was the fastest between **the end of the 80s and the beginning of the 2000s.** This was partly due to the PURPA1 of 1978 (legalization of the sale of non-utility-generated electricity to the grid) and the Energy Policy Act of 1992 (furtherance of the energy efficiency).

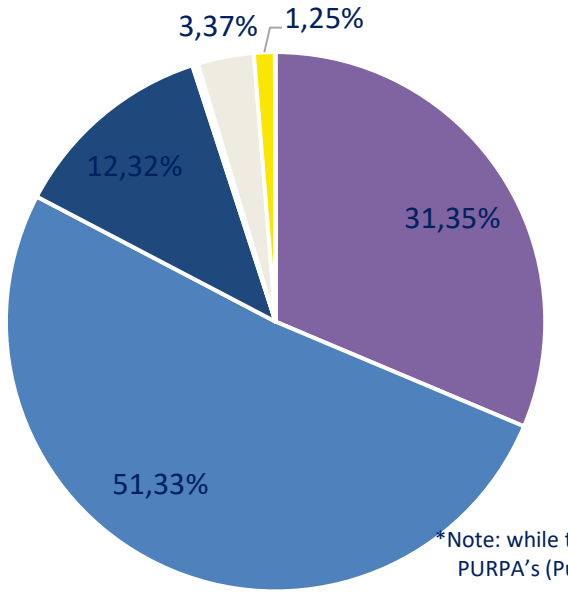
- **Combined cycle** dominates the CHP market in the U.S. with 51% of the CHP capacity. It is followed by boiler/steam turbines and gas turbines.

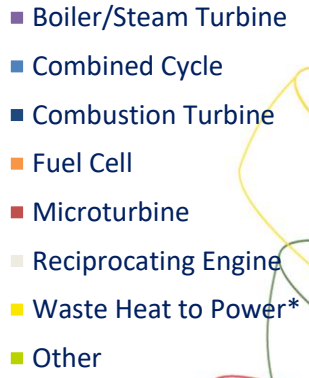
[1]Public Utility Regulatory Policies Act

Current CHP Installations - Total Installations by Year, 1980-2020



Current CHP Installations – Share of Technology by Capacity





*Note: while these systems are waste heat to power, they may not all meet PURPA's (Public Utility Regulatory Policies Act) definition of cogeneration

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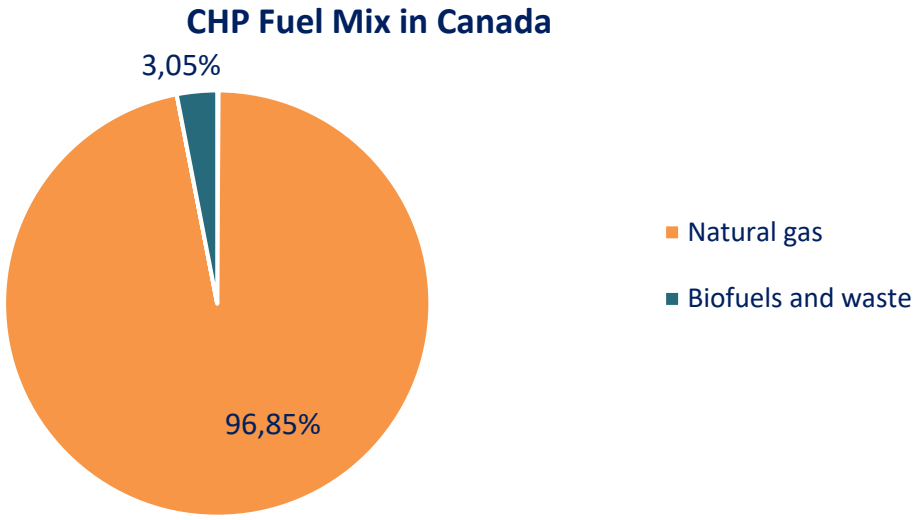
Canada

Electricity produced by CHP plants in 2019:

10TWh

→ 3% of the electricity produced by CHP in North America



- According to the IEA, natural gas is virtually the only fuel used to power cogeneration plants in Canada and Mexico.

CENTRAL / SOUTH AMERICA

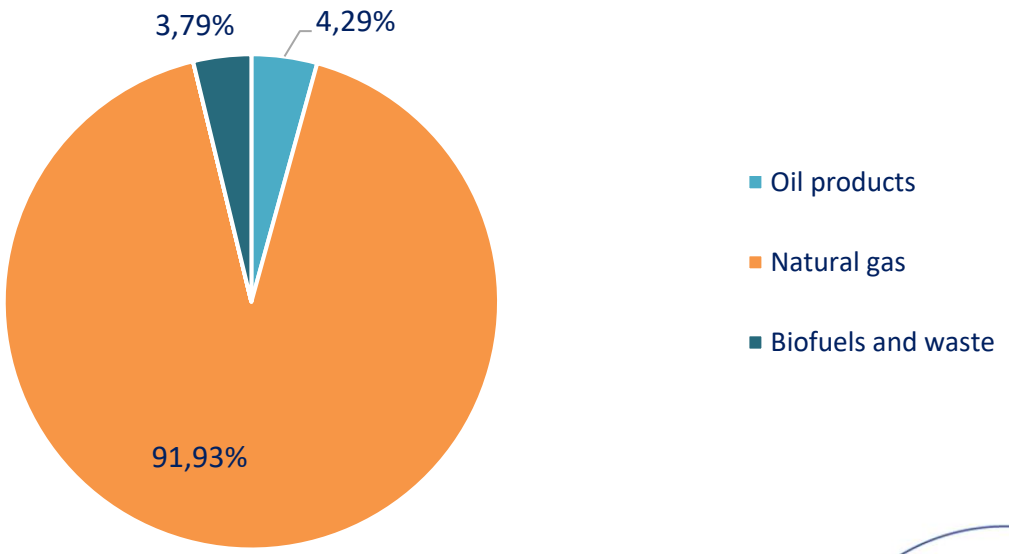
Mexico

Electricity produced by CHP plants in 2019:

20TWh

→ 6% of the electricity produced by CHP in North America

CHP Fuel Mix in Mexico



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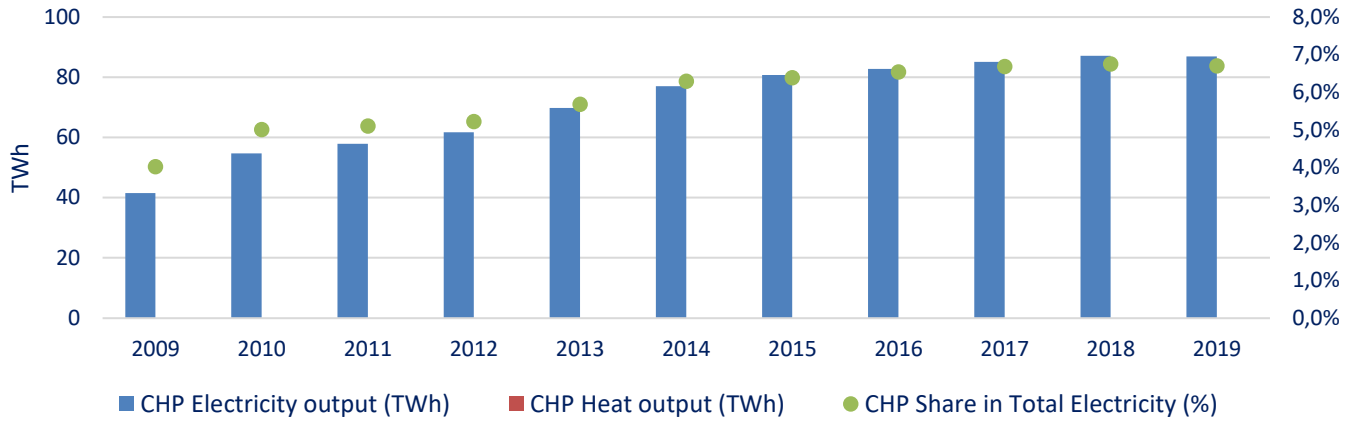
South America

Electricity produced by CHP plants in 2019:

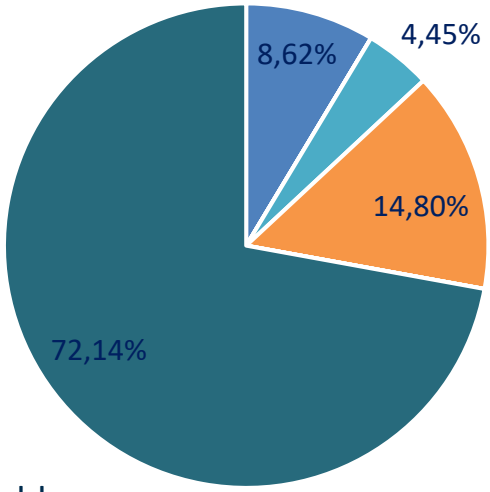
87TWh

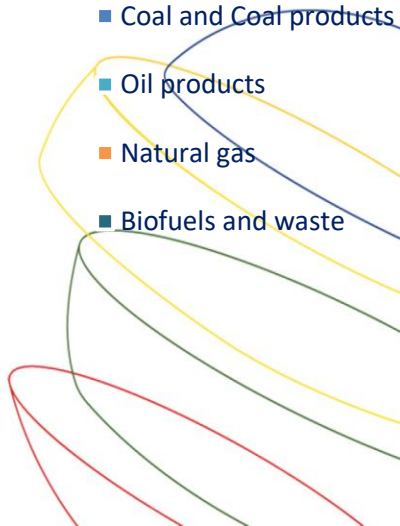
10-year Overview of CHP in South America



- In ten years, the CHP electricity output of South America doubled **from 40TWh to 87TWh**.
- During the same time, the share of CHP electricity gained 3%. In 2019 it was **6.7%.**
- **Biofuels and waste** category clearly dominates the CHP fuel market in South America. It is followed by natural gas and coal.
- According to IEA data, South America experienced the largest growth rate in the world in term of CHP electricity output during the given period (2009-2019).

CHP Fuel Mix in South America





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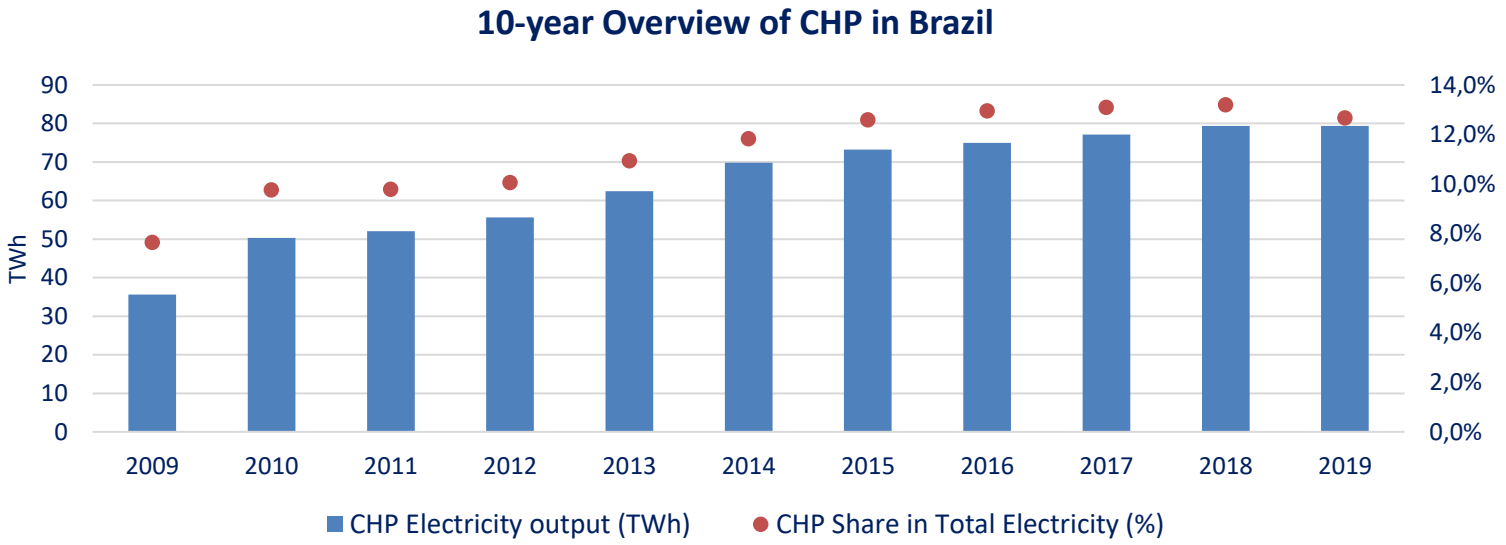
Brazil

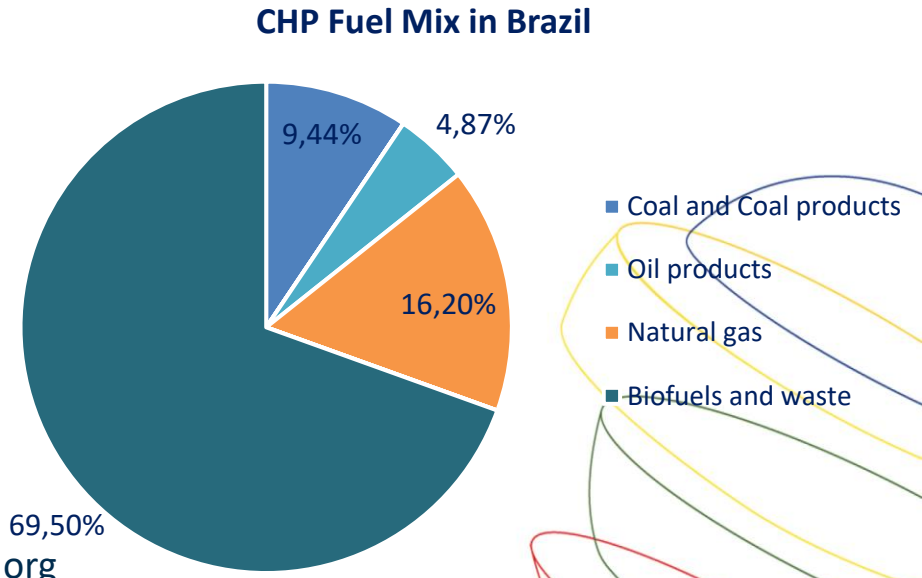
Electricity produced by CHP plants in 2019:

79TWh

- Brazil = ~90% of CHP electricity produced in South America.



- As Brazil produces 90% of the electricity produced by CHP in South America, the electricity output as well as the fuel mix follow the same trends than the region.
- CHP electricity output over 10 years increased **from 34TWh to 79TWh**, an annual growth rate of 13%.
- CHP's share of electricity was almost **13%** in 2018.
- The main fuel used to power CHP is **biofuels and waste**.



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Chile and Uruguay

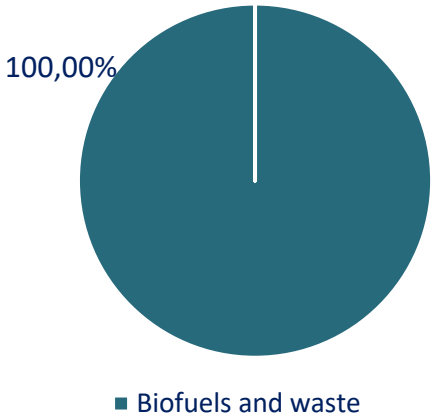
CHILE

Electricity produced by CHP plants in 2019:

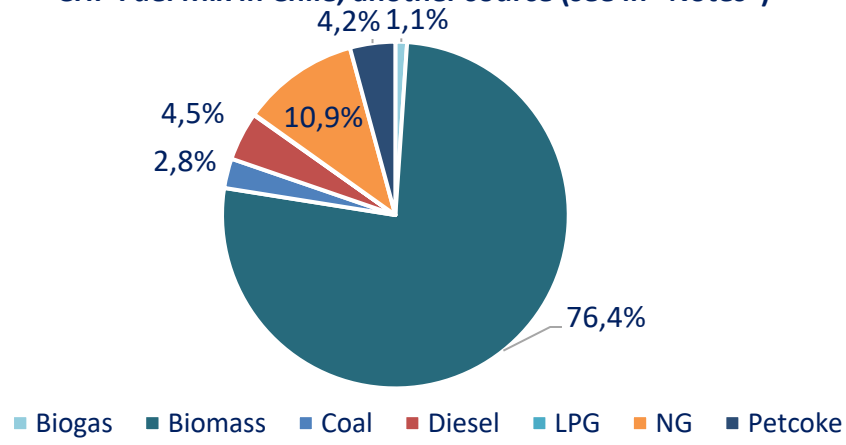
5.4TWh

→ 6.5% of the electricity produced by CHP in South America.

CHP Fuel Mix in Chile, according to IEA



CHP Fuel Mix in Chile, another source (see in "Notes")



➢ According to the IEA data, Chile only uses biofuels and waste to power its CHP plants. However, according to other sources, Chile has a wider CHP fuel mix. This shows the limits of the IEA database that can sometime be incomplete.

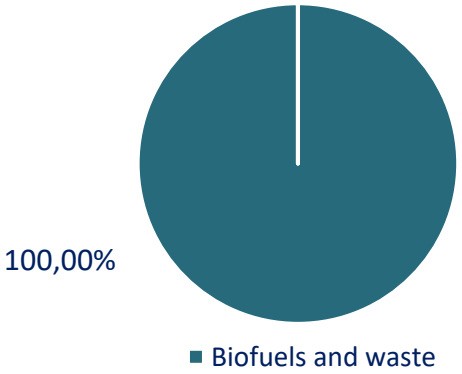
URUGUAY

Electricity produced by CHP plants in 2018:

1.7TWh

→ 2% of the electricity produced by CHP in South America.

CHP Fuel Mix in Uruguay, according to the IEA data



➢ As for Chile, Uruguay data from IEA seem limited. However, no other data have been found to compare and check their accuracy.

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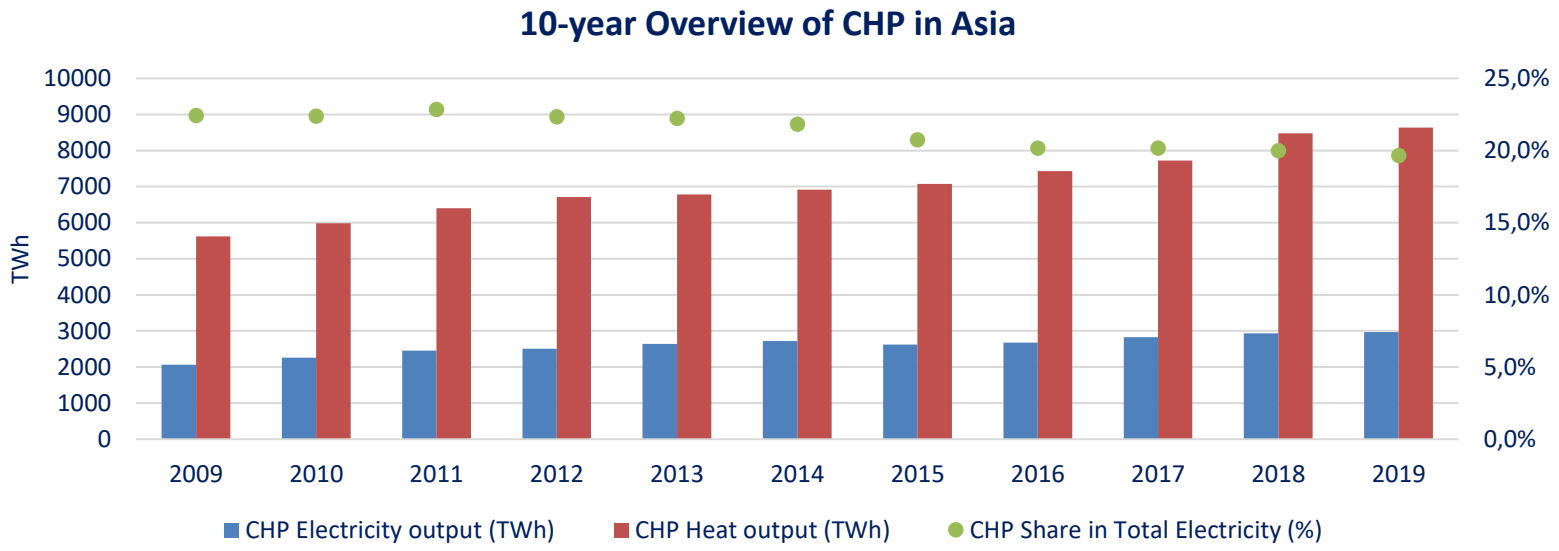
ASIA

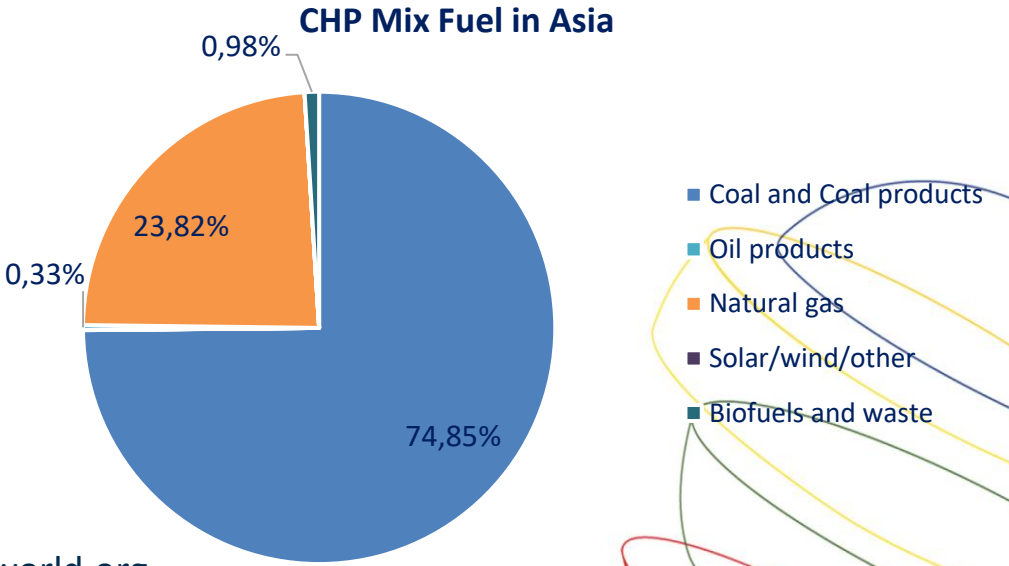
Asia

Electricity produced by CHP plants in 2019:

2,971TWh



- Increase of the electricity output **from 2,000 TWh to almost 3,000TWh.**
- Despite an increase in output, CHP's share of electricity has decreased steadily since 2013 **from 22% to 19%.**
- Asian electricity markets are prioritising other technologies for development.
- Asia's main fuel remains **coal, and this is due to China's very high consumption of coal to power CHP**. The rest of the fuel used in Asia is almost exclusively natural gas.



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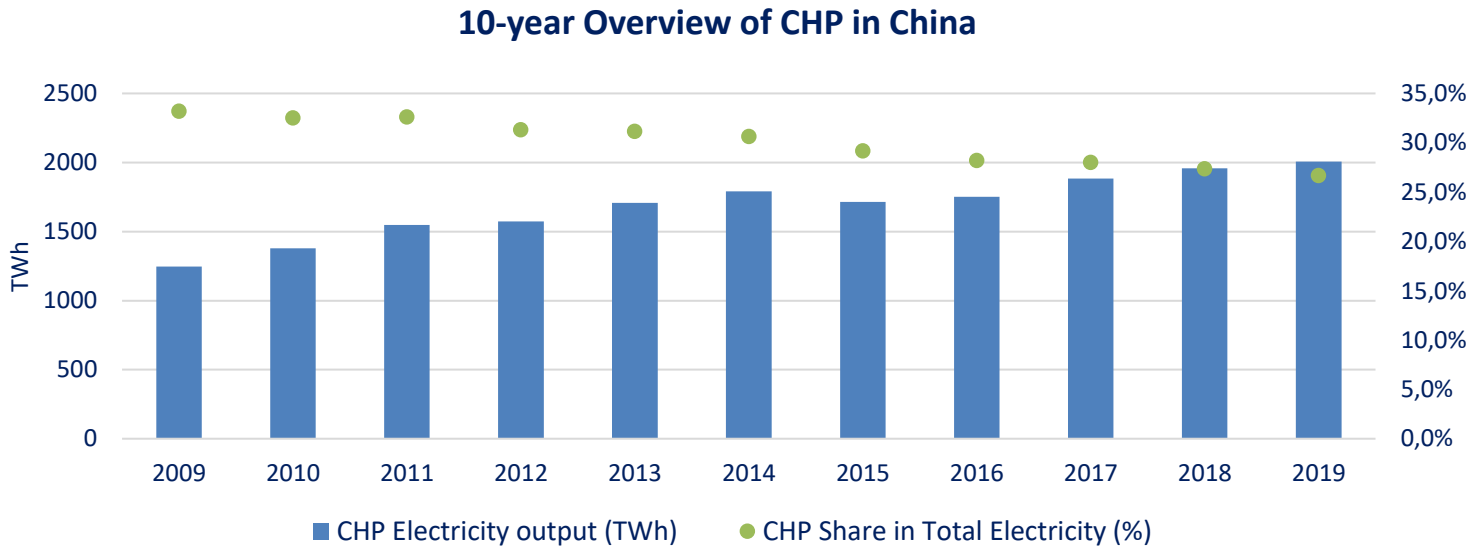
China

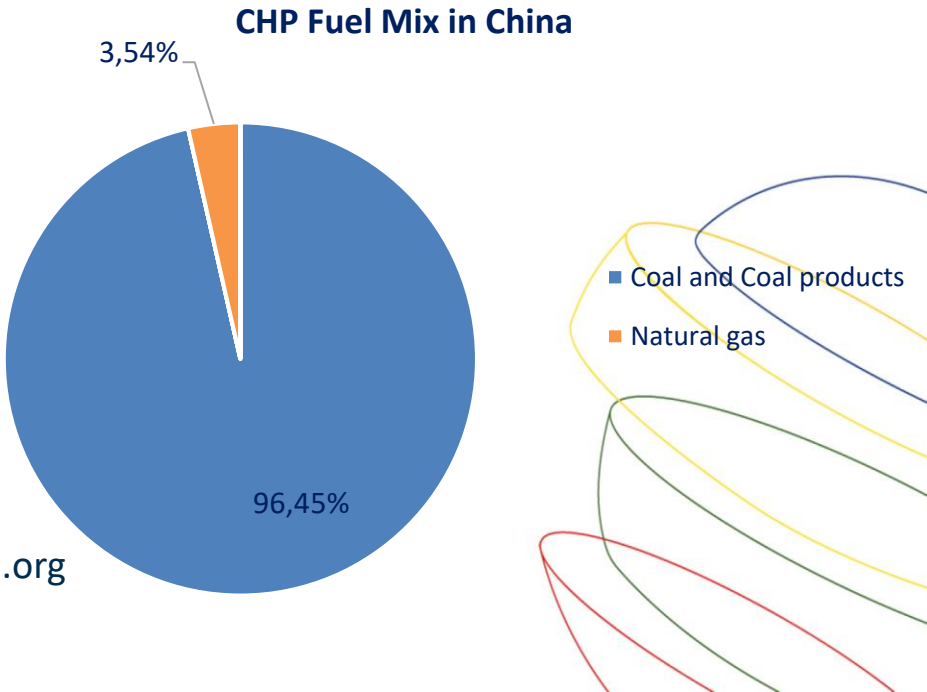
Electricity produced by CHP plants in 2019:

2,006TWh

China represents **68%** of all CHP electricity produced in Asia.



- Increase of the electricity output **from 1,100TWh to 2,000TWh.**
- Small decrease of the CHP electricity share in the total electricity generation **(from 33% to 27%).**
- China does not seem to develop its CHP capacity at the same rate as its electricity demand. This suggests than China prioritises other technologies.
- **Coal** largely dominates the CHP fuel market in China. Natural gas has only a share of less than 4%.



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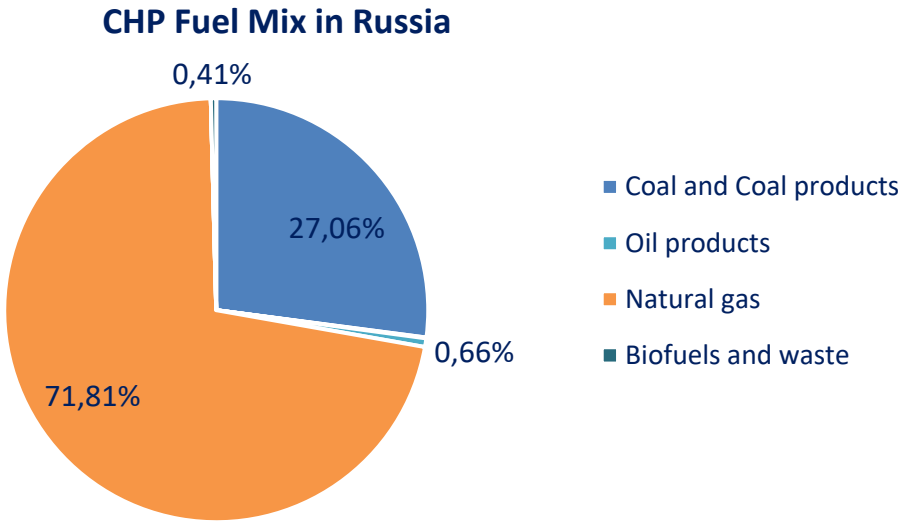
Russia and India

RUSSIA

Electricity produced by CHP plants in 2019:

694TWh

→ 26 % of the electricity produced by CHP in Asia

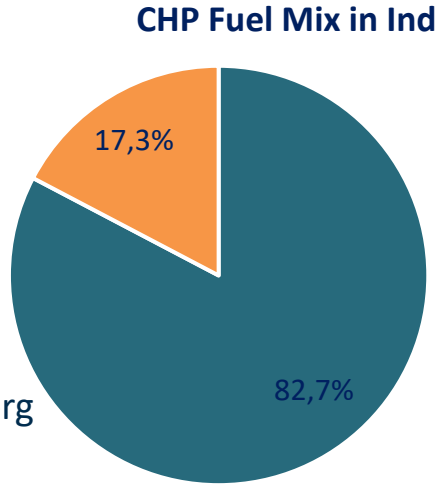


INDIA

IEA has very scarce data for India, information came from the country's Ministry of Renewable Energy, as well as from GEM Gas Plant Tracker. It is known that India has several coal power plants operating as CHP plants, though they are not accounted for, as data were limited.

CHP Installed Capacity in 2021:

12.3GW



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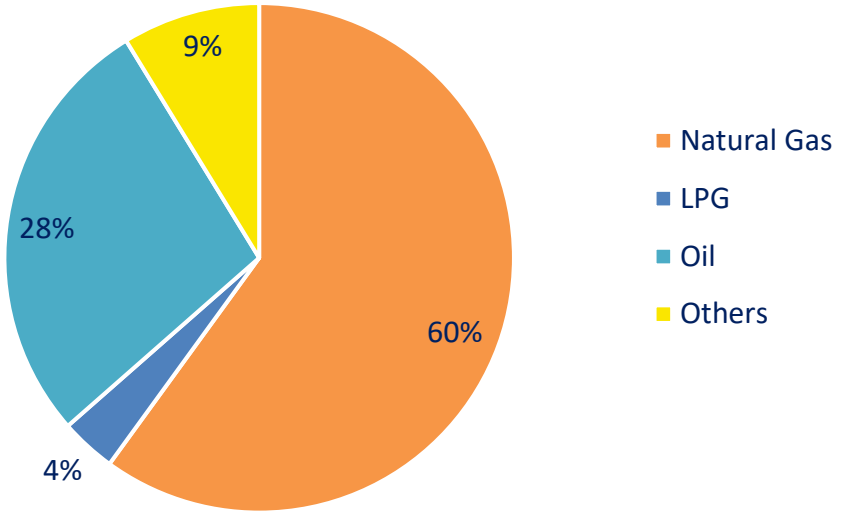
Japan

CHP Installed Capacity in 2021

13.2GW

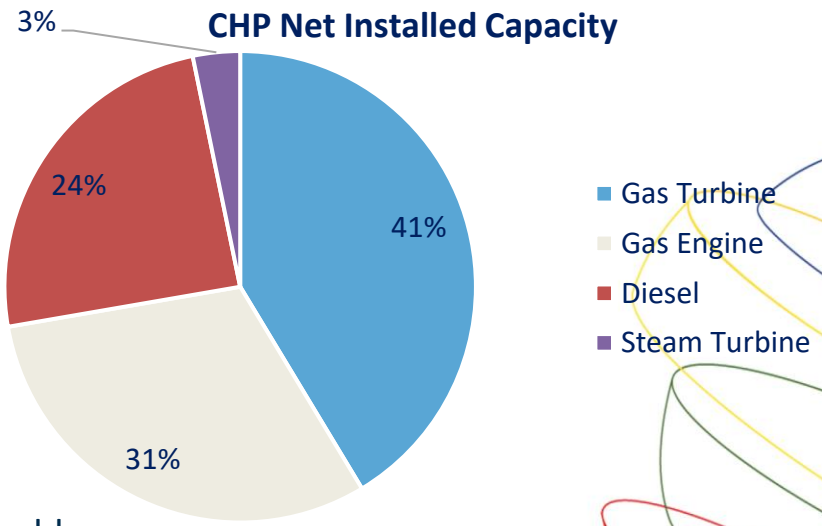
No data from IEA for Japan. Values come from the Advanced Cogeneration and Energy Utilization Center of Japan.

CHP Fuel Mix in Japan



- Japan uses mainly **natural gas**. Its use of oil as a CHP fuel is also quite high, especially compared to the world average (1.3%)
- The two technologies with the most capacity installed in the country are **gas turbines and gas engines.** Diesel engines are also frequently used and that is in line with the high share of oil in the fuel mix.

CHP Net Installed Capacity



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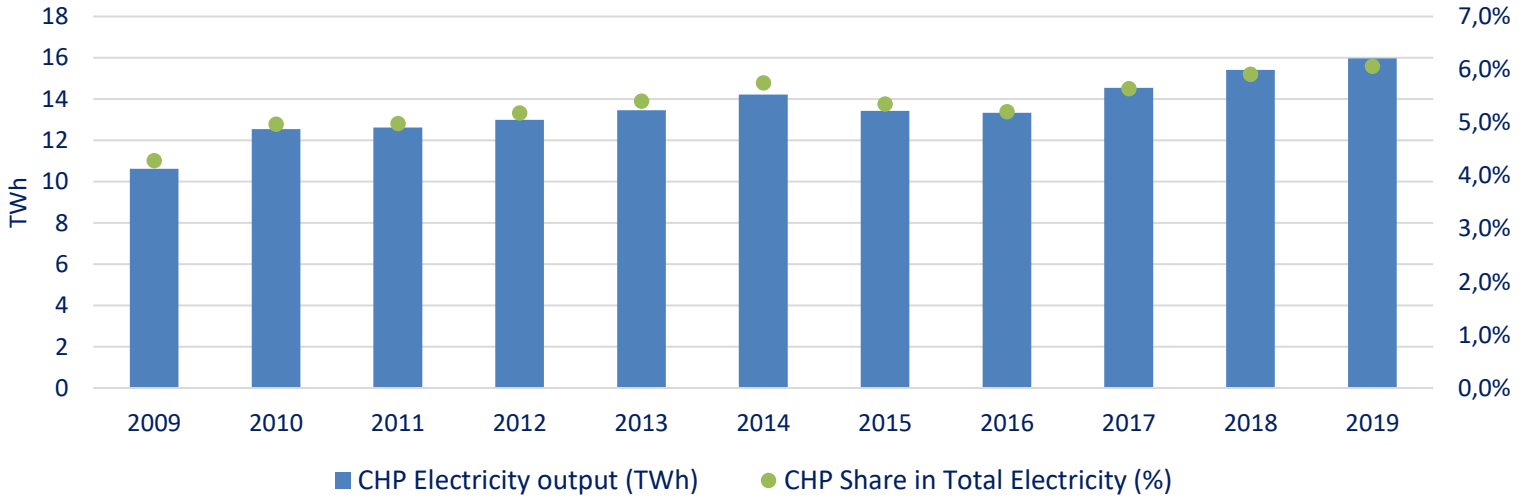
AUSTRALIA / NEW ZEALAND

Australia

Electricity produced by CHP plants in 2019:

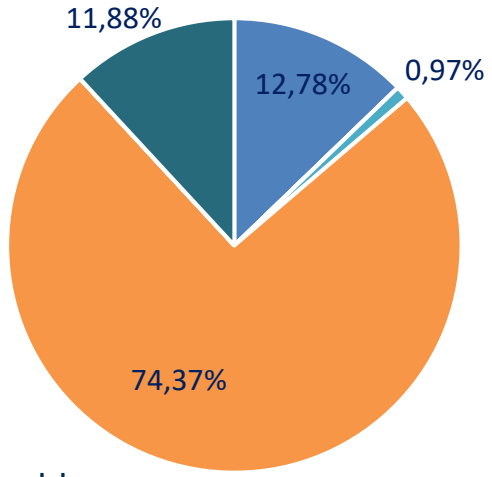
16TWh

10-year Overview of CHP in Australia



- Small variations of CHP electricity output **(between 10.6 and 16TWh).**
-
- CHP's share of electricity remains constant **(4-6%).**
- High share of **natural gas** in CHP fuel mix. Coal, biofuels and waste are used in the same proportions.

CHP Fuel Mix in Australia



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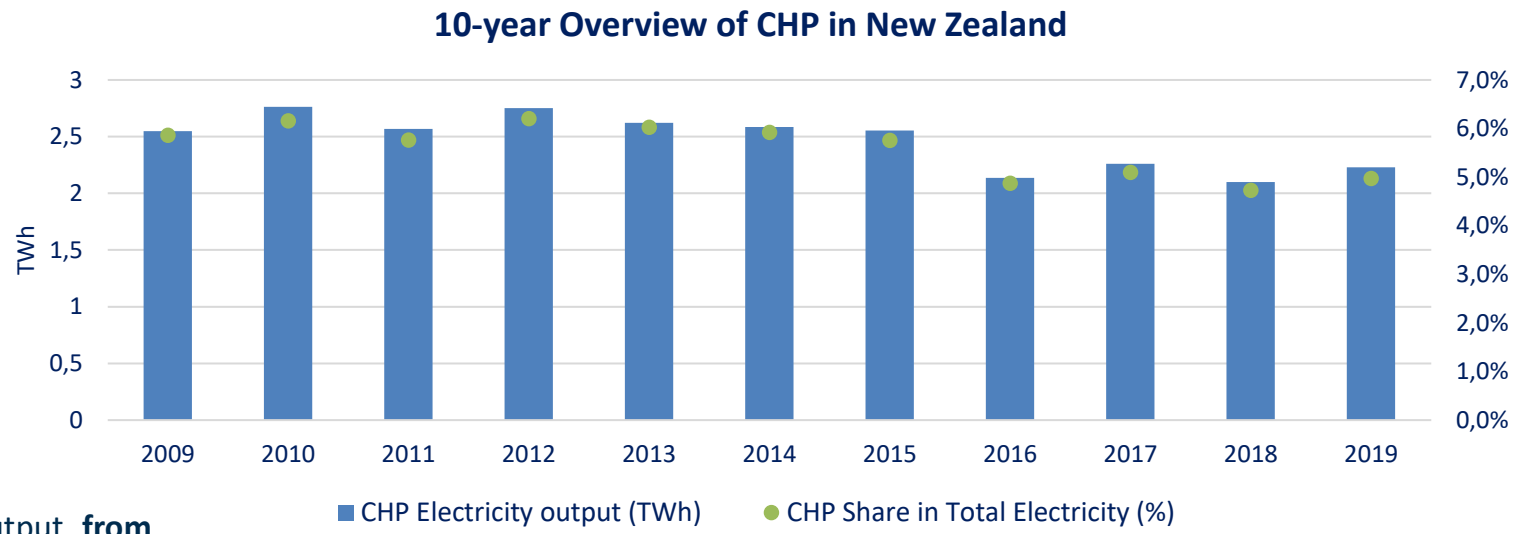
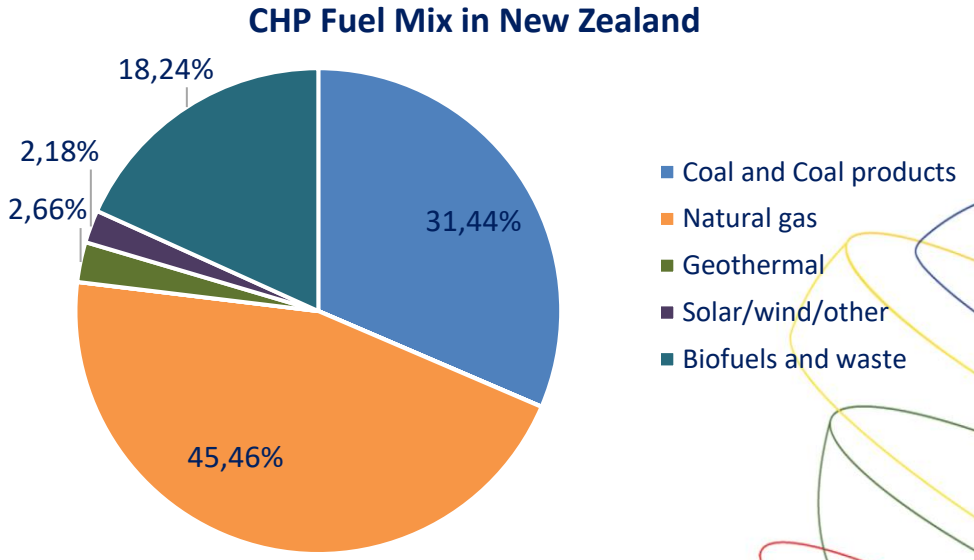
New Zealand

Electricity produced by CHP plants in 2019:

2TWh



- Decrease of CHP electricity output **from 3.2TWh to 2.2TWh.**
- The share of CHP electricity lost 2.5 percentage points. In 2019 it was at **5%**.
- **Natural gas** is the main fuel used to power CHP in New Zealand, followed by coal, biofuels & waste.
- The country has a relatively high share of geothermal and solar/wind/other compared to the world average.



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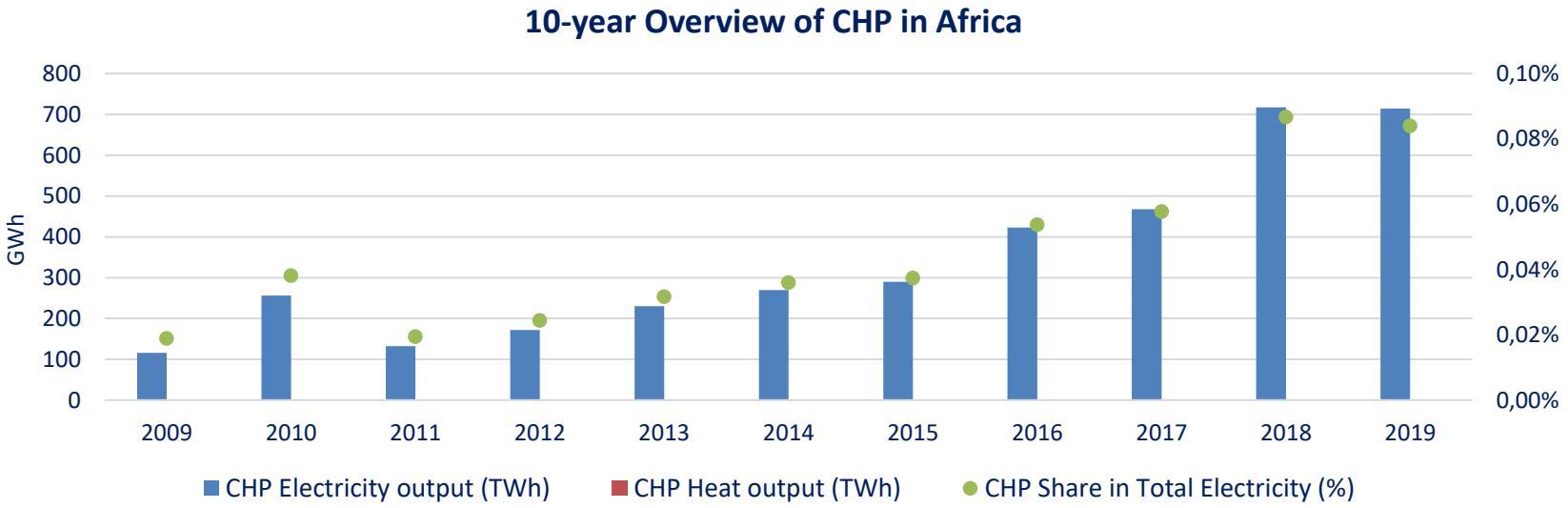
AFRICA

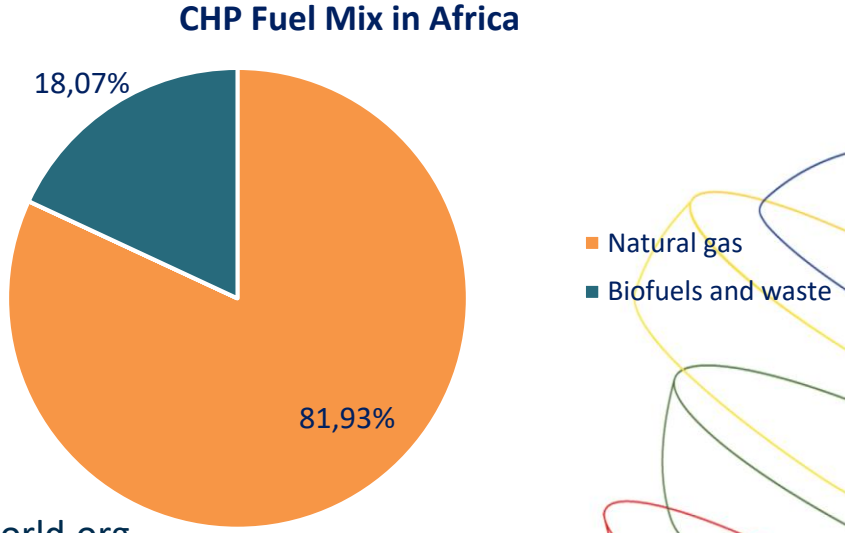
Africa

Electricity produced by CHP plants in 2019

714GWh



- Increase of the CHP electricity output **from 110GWh to 714GWh.**
-
- The share of CHP electricity output in the African electricity generation is insignificant. In 2019 it was **c.0.08%.**
- According to the Energy balance table of Africa (IEA), CHP is powered with **biofuels and waste and natural gas**.
- No complete data from the IEA to do analysis by African countries.



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Current and future trends of the CHP Market

Current and future trends of the CHP Market

	Geography	Technology	Fuel	Size	End-Users
Current situation	Asia Pacific accounted for a 55.7% share of the CHP market in 2020. Europe and North America have also a developed CHP market.	Gas and steam turbines are the two main technologies on the market.	Natural gas and coal are currently the most used fuels in the world.	Large capacity plants dominate the market because of the important use of CHP in the industrial sector.	Industries such as chemicals or pulp and paper are currently the main end-users of cogeneration. Commercial and residential facilities (hospitals, universities, district heating) in lesser measure.
Forecast	Growth in India and China due to the industrial expansion and technological innovations. A growth in South America, particularly in Brazil, is expected to continue.	Fuel cells are expected to be increasingly used in the next years, as it is a technology with clean by-products (water and heat). Micro-CHP fuel cell have already emerged on the market. Larger CHP fuel cells begin to be installed in the US, Japan and South Korea.	A transition from coal-based generation to cleaner powered generation is assumed. Gas should still have an important part to play because of its relatively low greenhouse emissions compared to other fuels. However, some part of the world such as the EU are establishing greenhouse emissions regulations which could be a barrier for new CHP running on fossil fuels. Consequently, it is expected to observe an increase of the use of renewable resources like solar, geothermal or biofuels. Hydrogen should experience a rapid growth linked to the fuel cell emergence in the CHP sector.	High demand for up to 10MW capacity from residential and commercial end-users. Use of Micro-CHP to replace domestic boilers.	Increase in the commercial and residential CHP installations: CHP as a key technology for city and district level utilities. Power or Heat produced by utilities can be used on-site, distributed to the local facilities or transmitted to the grid/district heating.

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