Electricity generation and use in Finland – fuels and CO_{2e} emissions

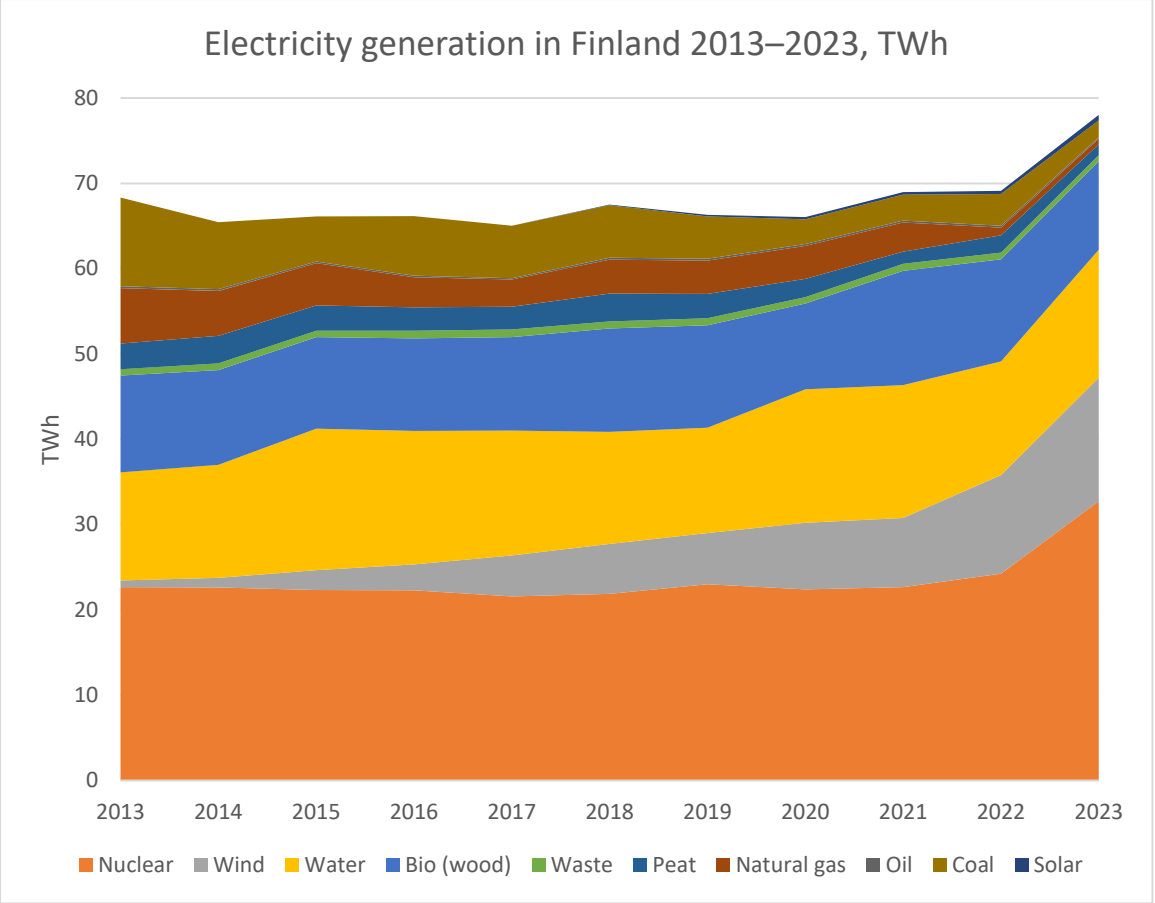
Years 2013–2023

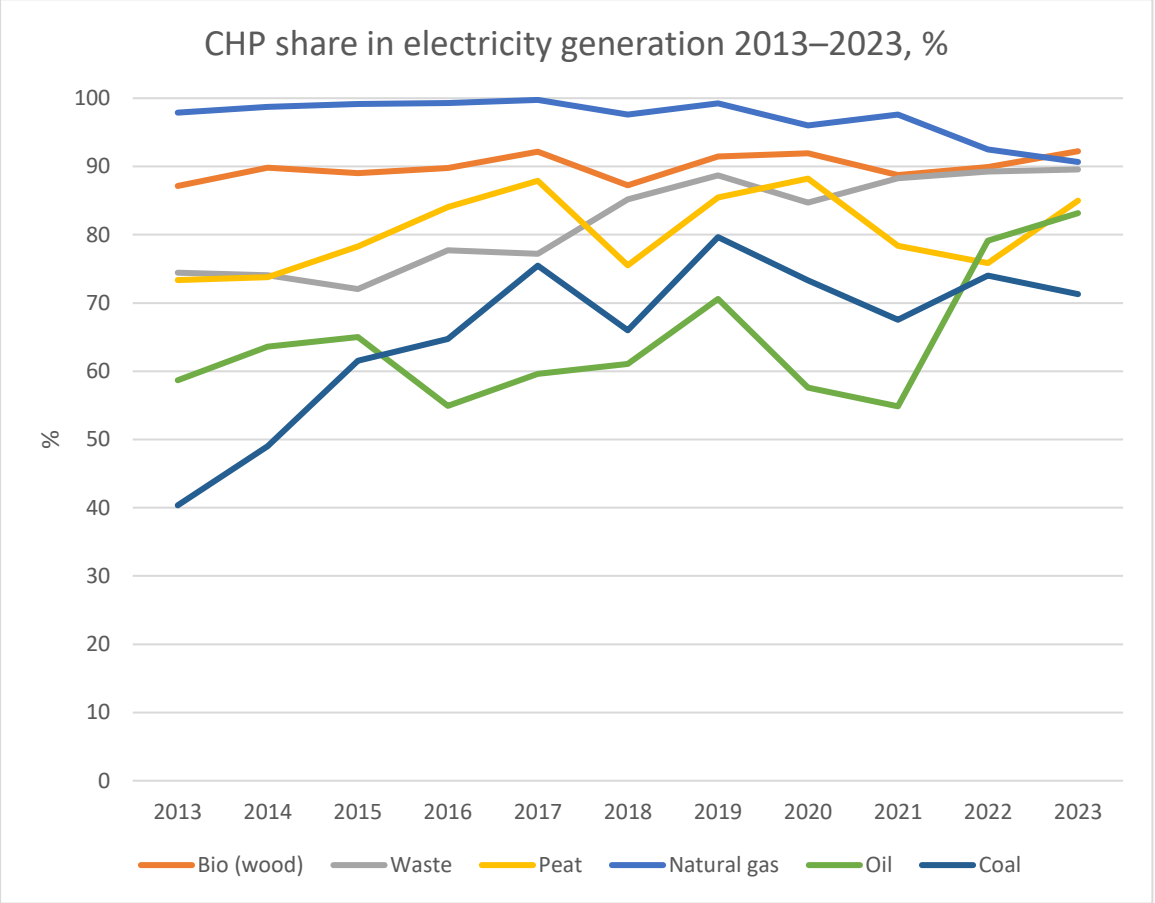
Cleanfi Oy 2024

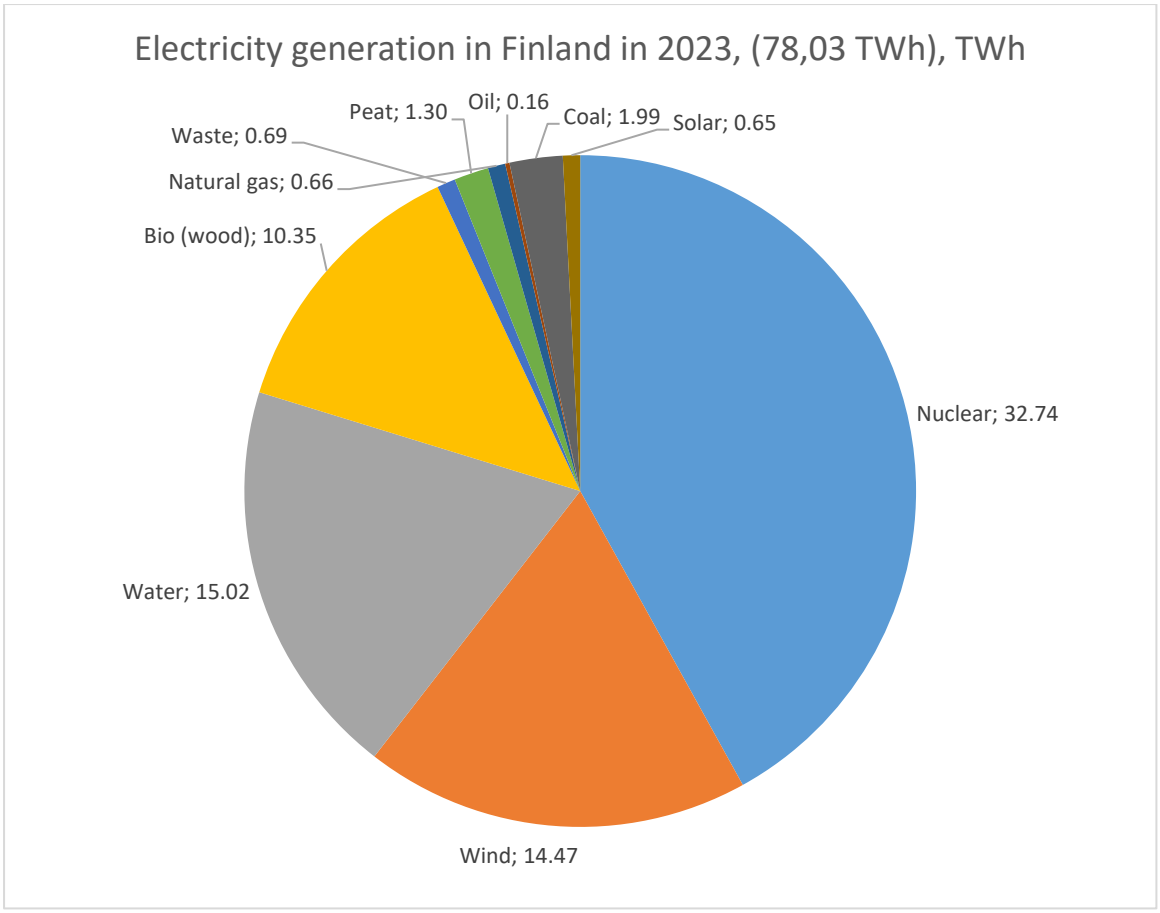
14.6.2024

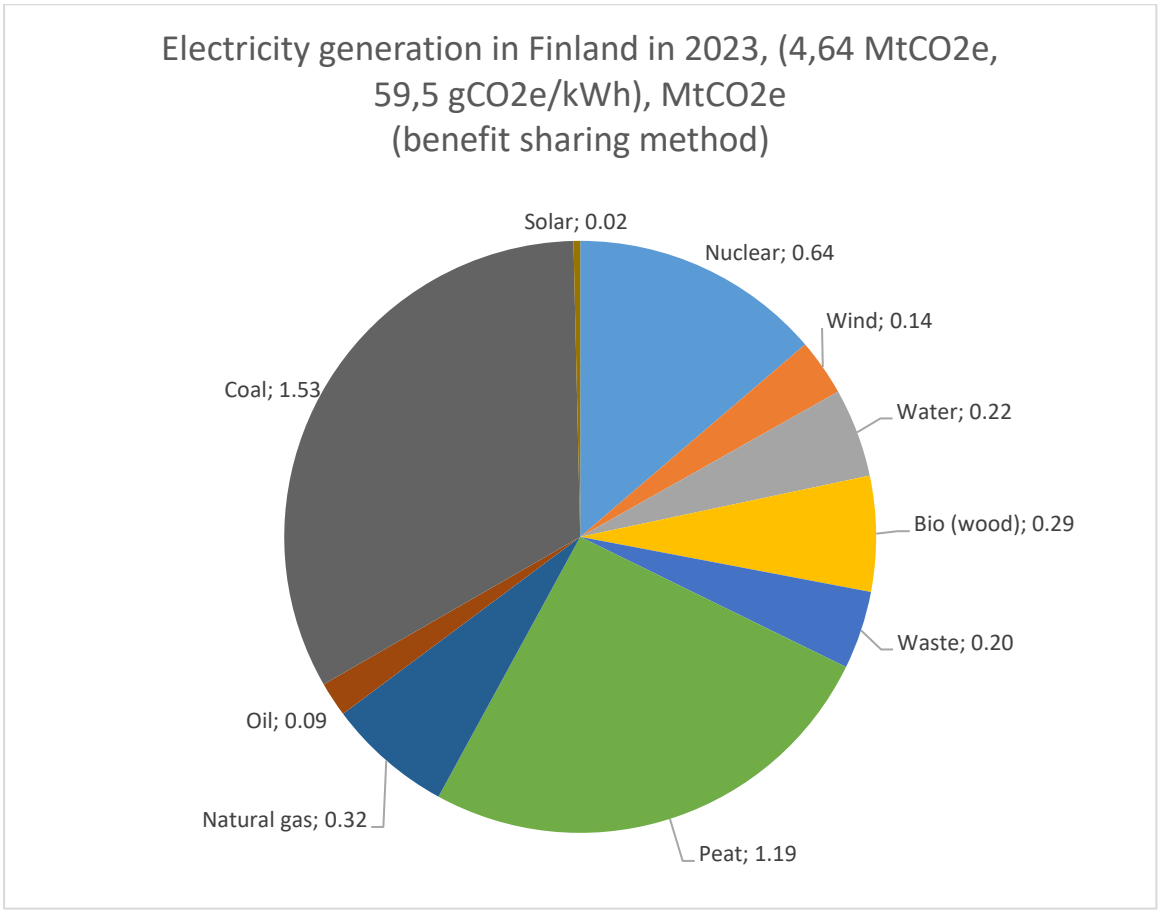
Table 1. Finland's electricity generation mix in 2023. Exports and imports are not taken into account. (Finnish Energy 2024)

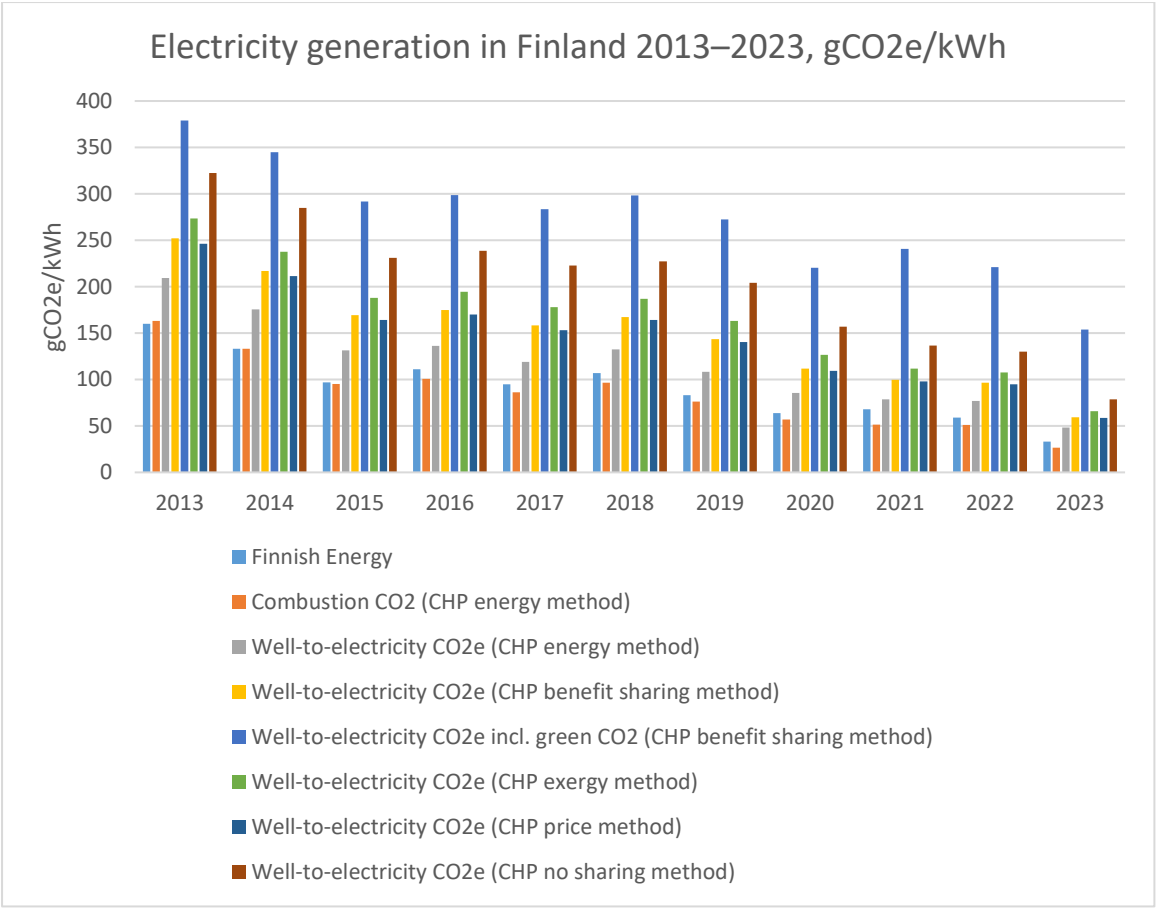
Electricity source	Electricity share (%)	CHP share (%)
Natural gas	0.84	90.66
Coal	2.55	71.29
Anthracite	0.00	0.00
Lignite	0.00	0.00
Manure biogas	0.00	0.00
Sub-bituminous coal	0.00	0.00
Coking coal	0.00	0.00
Petroleum coke	0.00	0.00
Oil shale	0.00	0.00
Residual fuel oil	0.21	83.16
Diesel oil	0.00	0.00
Peat	1.67	84.98
Wood chips (Finnish softwood)	13.27	92.23
Wood chips (Finnish softwood) small	0.00	0.00
Wood pellets (Finnish softwood)	0.00	0.00
Wood pellets (Finnish softwood) small	0.00	0.00
Wood sawdust to pellets	0.00	0.00
Wood sawdust to pellets, small	0.00	0.00
Waste	0.89	89.56
Hydroelectric	19.25	
Wind	18.54	
Nuclear	41.96	
Solar PV	0.83	
Geothermal	0.00	

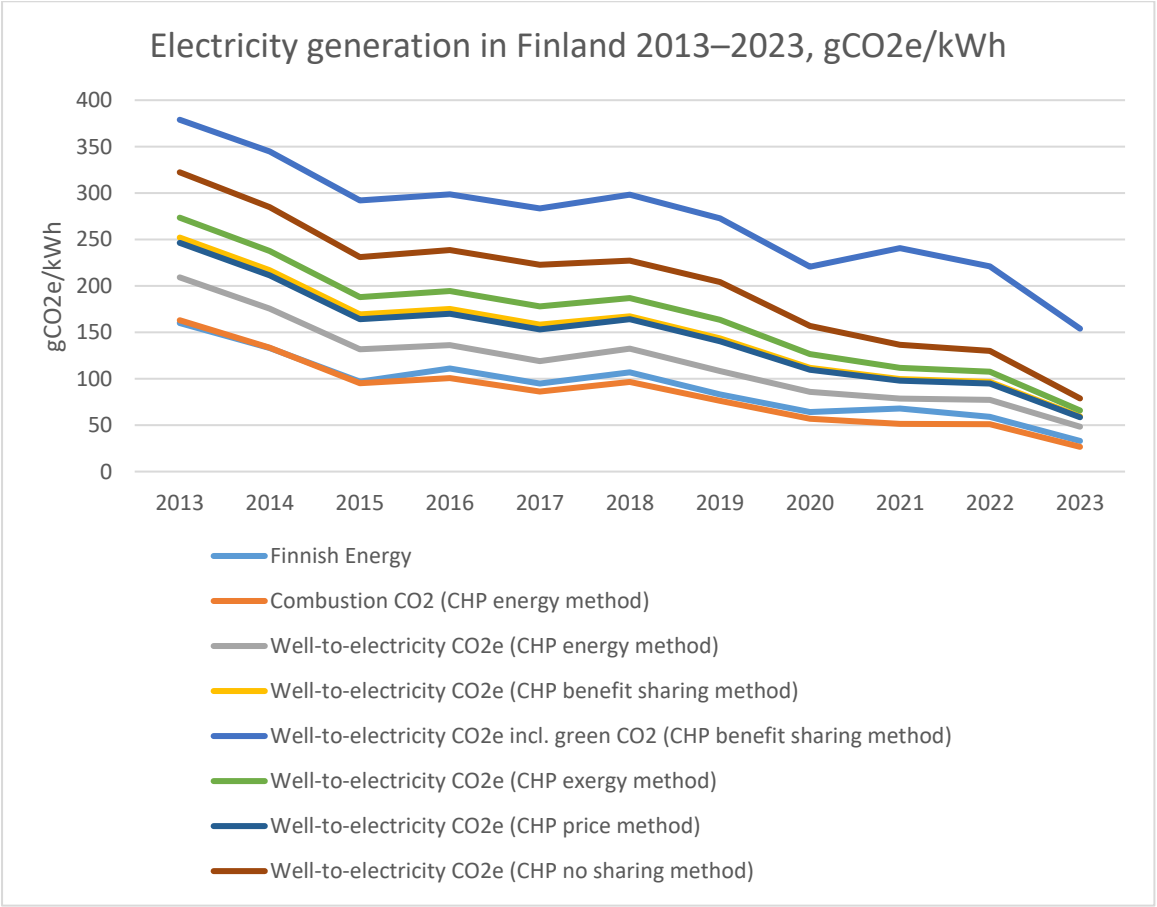

Electricity generation in Finland 2013–2023, TWh
TWh
80
70
60
50
40
30
20
10
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Nuclear
Wind
Water
Bio (wood)
Waste
Peat
Natural gas
Oil
Coal
Solar

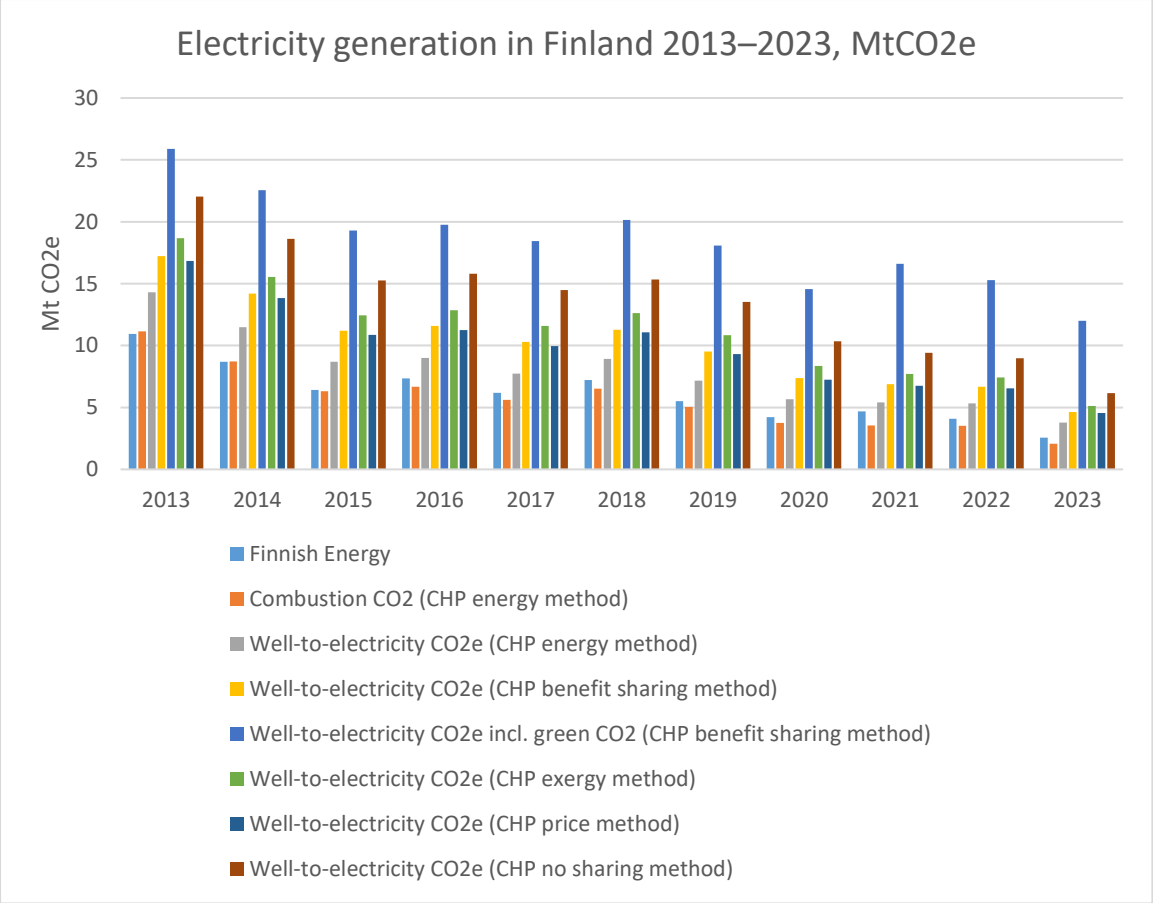

CHP share in electricity generation 2013–2023, %
%
100
90
80
70
60
50
40
30
20
10
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Bio (wood)
Waste
Peat
Natural gas
Oil
Coal

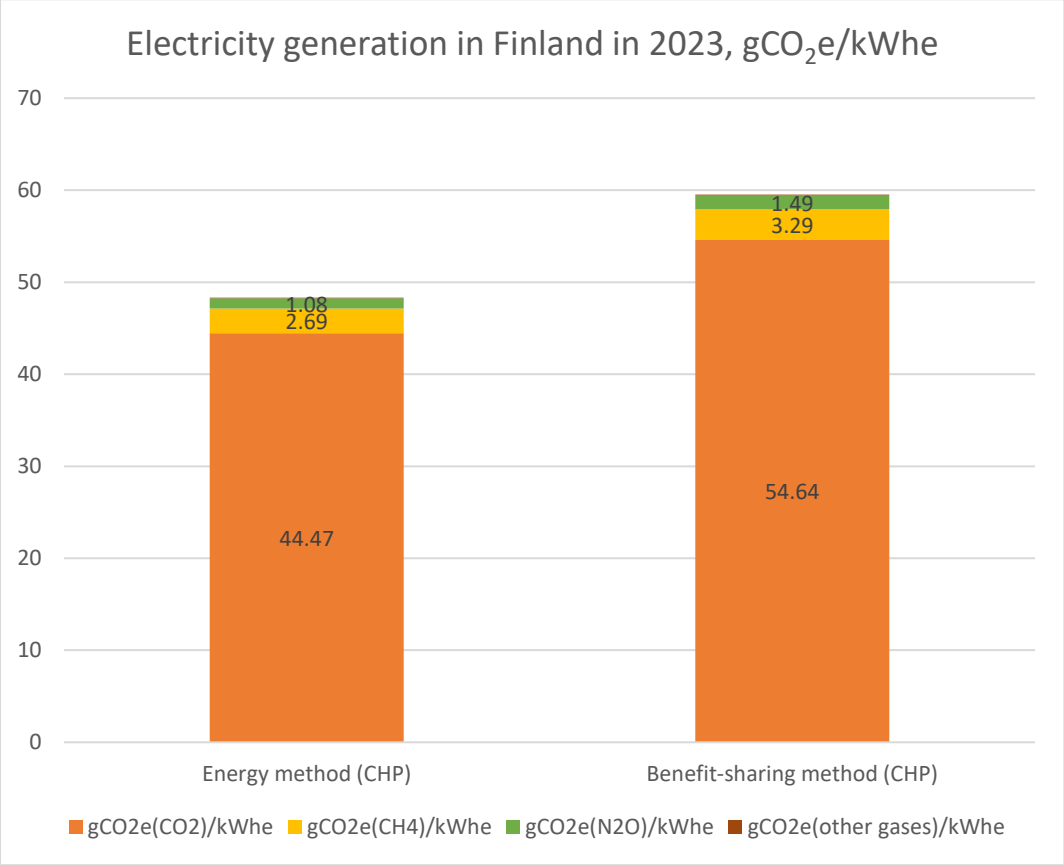

Electricity generation in Finland in 2023, (78,03 TWh), TWh
Peat; 1.30
Oil; 0.16
Coal; 1.99
Solar; 0.65
Waste; 0.69
Natural gas; 0.66
Bio (wood); 10.35
Nuclear; 32.74
Water; 15.02
Wind; 14.47

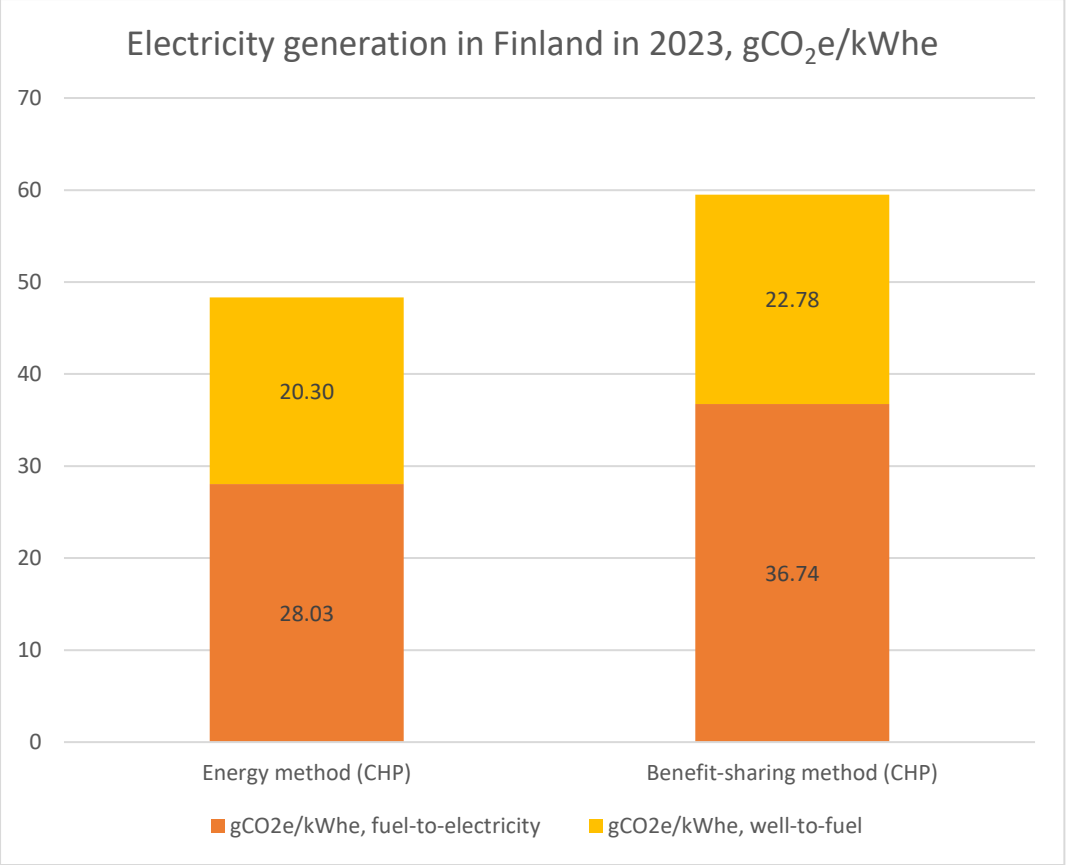

Electricity generation in Finland in 2023, (4,64 MtCO2e, 59,5 gCO2e/kWh), MtCO2e
(benefit sharing method)
Solar; 0.02
Nuclear; 0.64
Wind; 0.14
Coal; 1.53
Water; 0.22
Bio (wood); 0.29
Waste; 0.20
Oil; 0.09
Natural gas; 0.32
Peat; 1.19

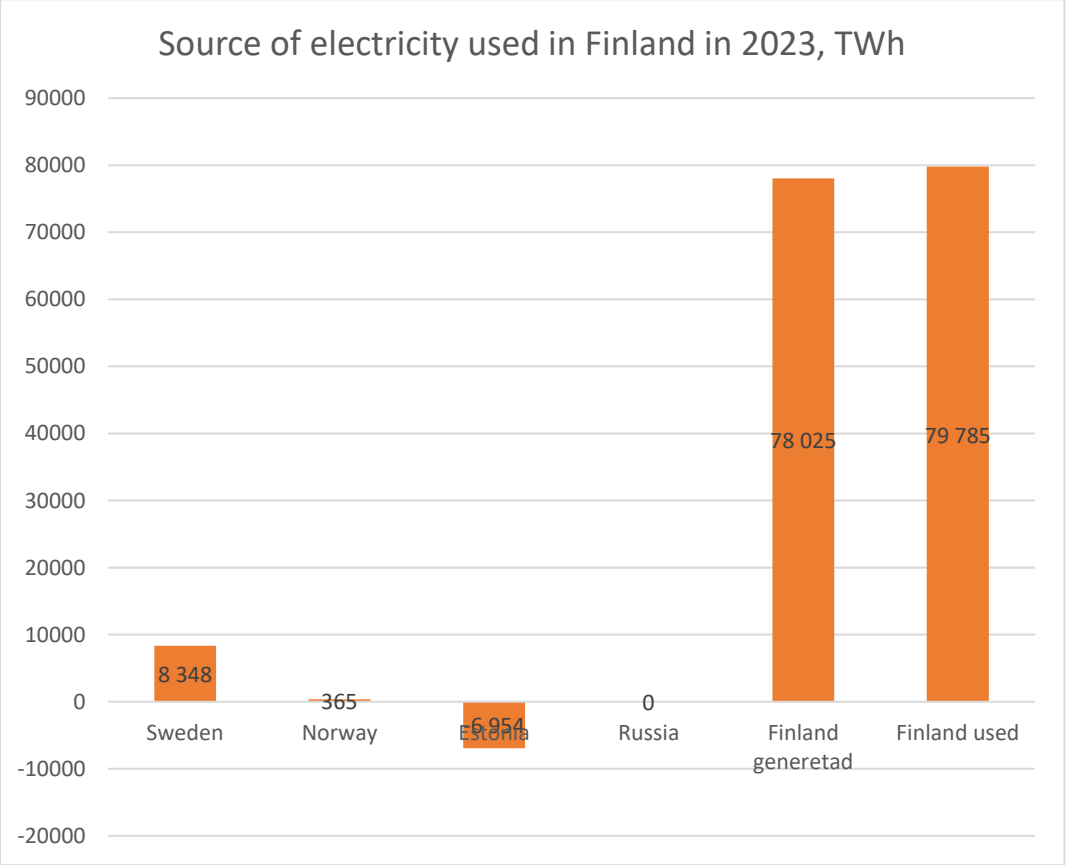

Electricity generation in Finland 2013–2023, gCO2e/kWh
gCO2e/kWh
400
350
300
250
200
150
100
50
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Finnish Energy
Combustion CO2 (CHP energy method)
Well-to-electricity CO2e (CHP energy method)
Well-to-electricity CO2e (CHP benefit sharing method)
Well-to-electricity CO2e incl. green CO2 (CHP benefit sharing method)
Well-to-electricity CO2e (CHP exergy method)
Well-to-electricity CO2e (CHP price method)
Well-to-electricity CO2e (CHP no sharing method)

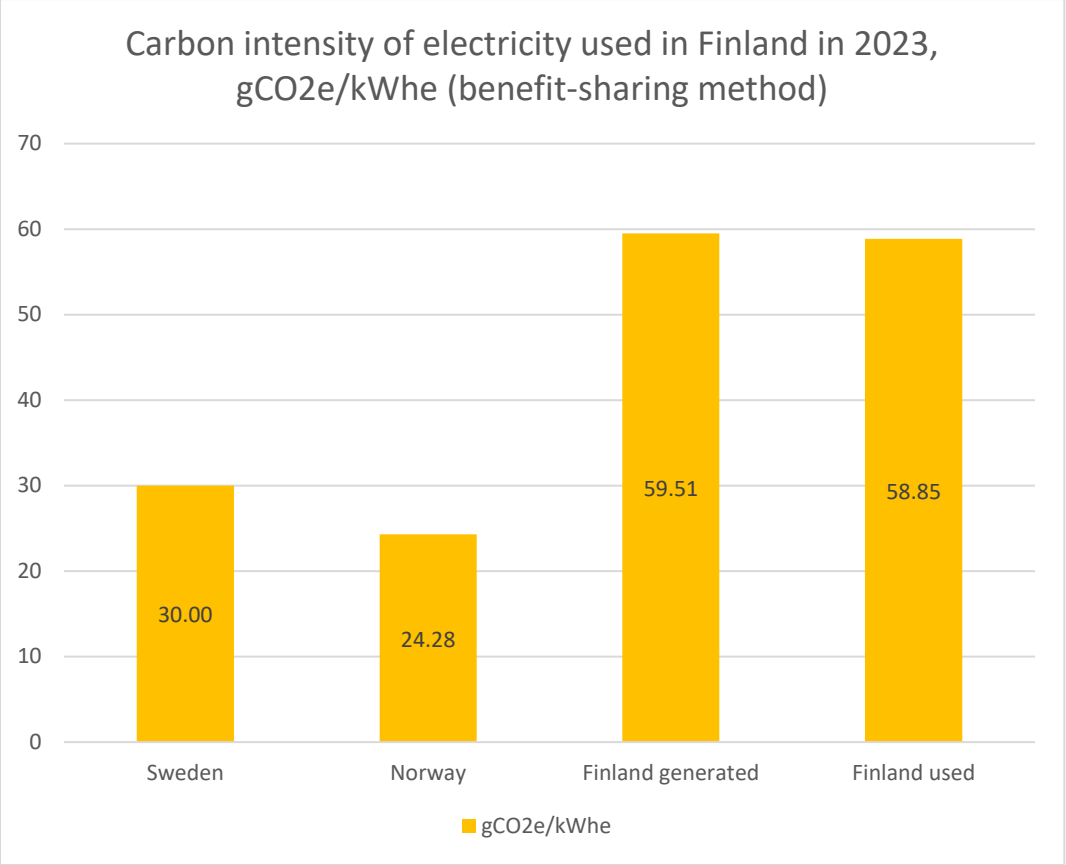

Electricity generation in Finland 2013–2023, gCO2e/kWh
gCO2e/kWh
400
350
300
250
200
150
100
50
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Finnish Energy
Combustion CO2 (CHP energy method)
Well-to-electricity CO2e (CHP energy method)
Well-to-electricity CO2e (CHP benefit sharing method)
Well-to-electricity CO2e incl. green CO2 (CHP benefit sharing method)
Well-to-electricity CO2e (CHP exergy method)
Well-to-electricity CO2e (CHP price method)
Well-to-electricity CO2e (CHP no sharing method)

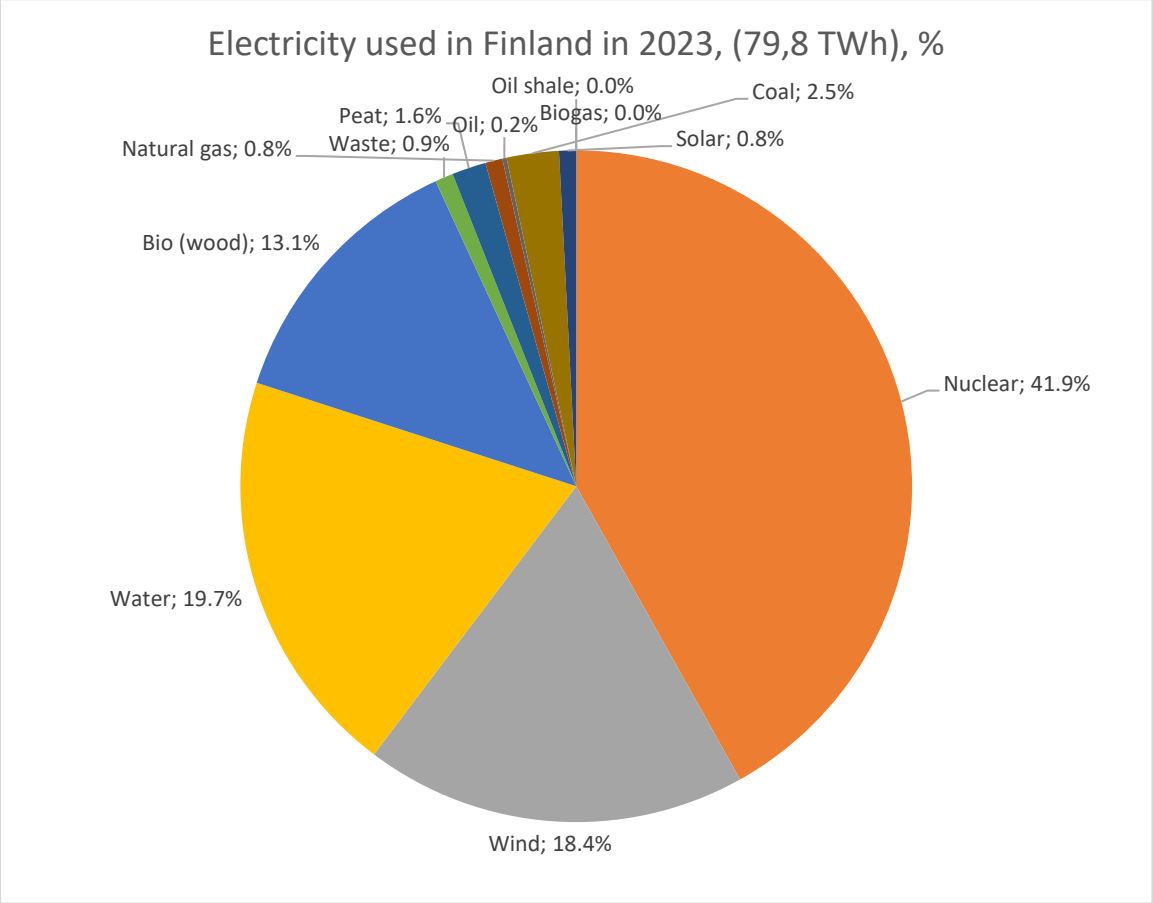

Electricity generation in Finland 2013–2023, MtCO2e
Mt CO2e
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Finnish Energy
Combustion CO2 (CHP energy method)
Well-to-electricity CO2e (CHP energy method)
Well-to-electricity CO2e (CHP benefit sharing method)
Well-to-electricity CO2e incl. green CO2 (CHP benefit sharing method)
Well-to-electricity CO2e (CHP exergy method)
Well-to-electricity CO2e (CHP price method)
Well-to-electricity CO2e (CHP no sharing method)

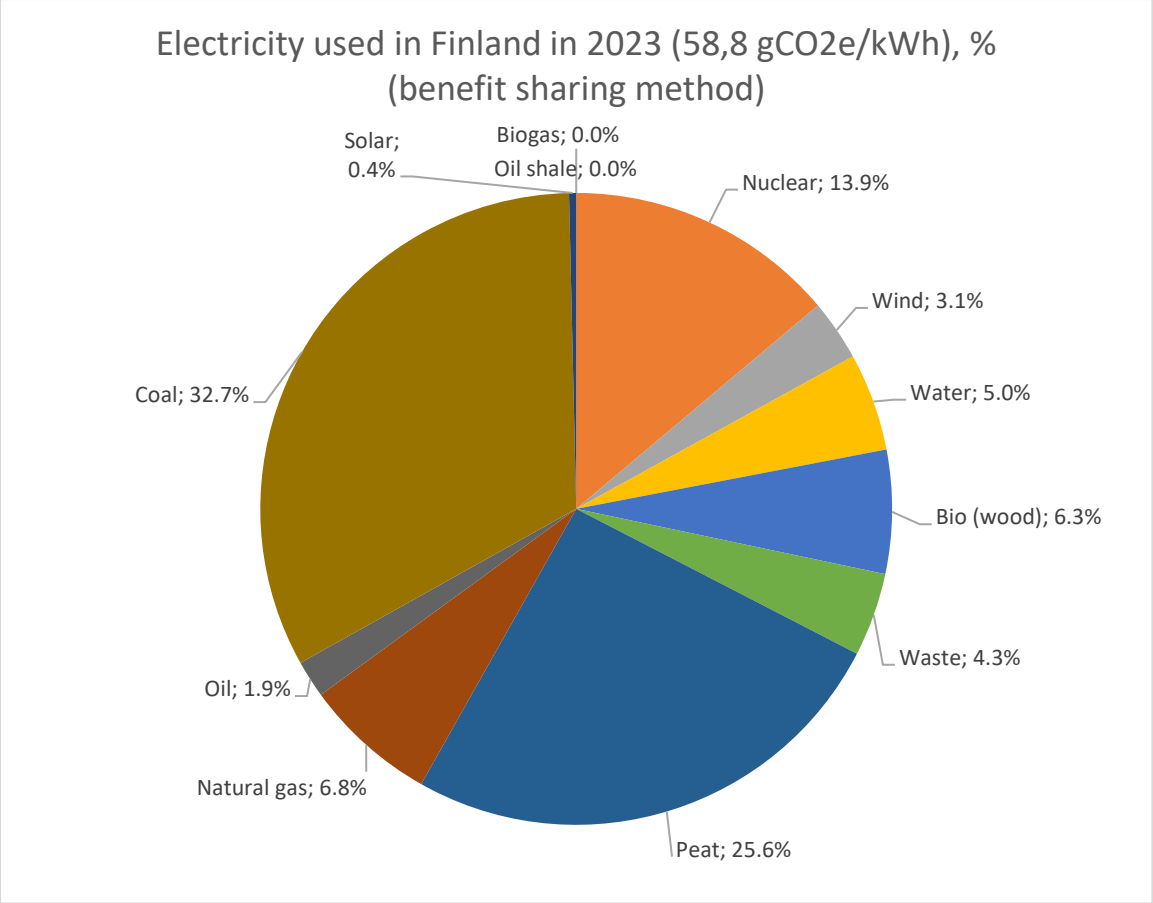

Electricity generation in Finland in 2023, gCO2e/kWhe
70
60
50
40
30
20
10
0
1.08
2.69
44.47
1.49
3.29
54.64
Energy method (CHP)
Benefit-sharing method (CHP)
gCO2e(CO2)/kWhe
gCO2e(CH4)/kWhe
gCO2e(N2O)/kWhe
gCO2e(other gases)/kWhe


Electricity generation in Finland in 2023, gCO2e/kWhe
70
60
50
40
30
20
10
0
20.30
28.03
22.78
36.74
Energy method (CHP)
Benefit-sharing method (CHP)
gCO2e/kWhe, fuel-to-electricity
gCO2e/kWhe, well-to-fuel


Source of electricity used in Finland in 2023, TWh
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
-10000
-20000
8 348
365
-6 954
0
78 025
79 785
Sweden
Norway
Estonia
Russia
Finland generetad
Finland used


Carbon intensity of electricity used in Finland in 2023, gCO2e/kWhe (benefit-sharing method)
70
60
50
40
30
20
10
0
30.00
24.28
59.51
58.85
Sweden
Norway
Finland generated
Finland used
gCO2e/kWhe


Electricity used in Finland in 2023, (79,8 TWh), %
Oil shale; 0.0%
Coal; 2.5%
Peat; 1.6%
Biogas; 0.0%
Oil; 0.2%
Natural gas; 0.8%
Waste; 0.9%
Solar; 0.8%
Bio (wood); 13.1%
Nuclear; 41.9%
Water; 19.7%
Wind; 18.4%



Principles and parameters

In combined heat and power (CHP) generation, the energy inputs and emissions are allocated between heat and power outputs. The principles of the allocation methods are explained by Soimakallio and Manninen[1]:

- ***Energy method: primary energy is allocated to heat and power on the basis of the energy (enthalpy) content of those products.*** Burning 100 MJ fuel in a CHP plant generates 36 MJe usable electricity and 51 MJ heat. These values are used in this analysis. In power generation, the power station losses are taken into account.
- ***Exergy method: primary energy is allocated to power and heat on the basis of the exergy content of those products.*** The exergy of power is higher than the exergy of heat and thus e.g. the CO_2e emissions per kWh for power are higher than in energy method. The exergy factors used for power and heat are 1 and 0.24, respectively. These values were used by Soimakallio and Manninen.
- ***Price method: primary energy is allocated to power and heat on the basis of the difference between the prices of those products.*** The price of power is higher than the price of heat and thus e.g. the CO_2e emissions per kWh for power are higher than in energy method. The

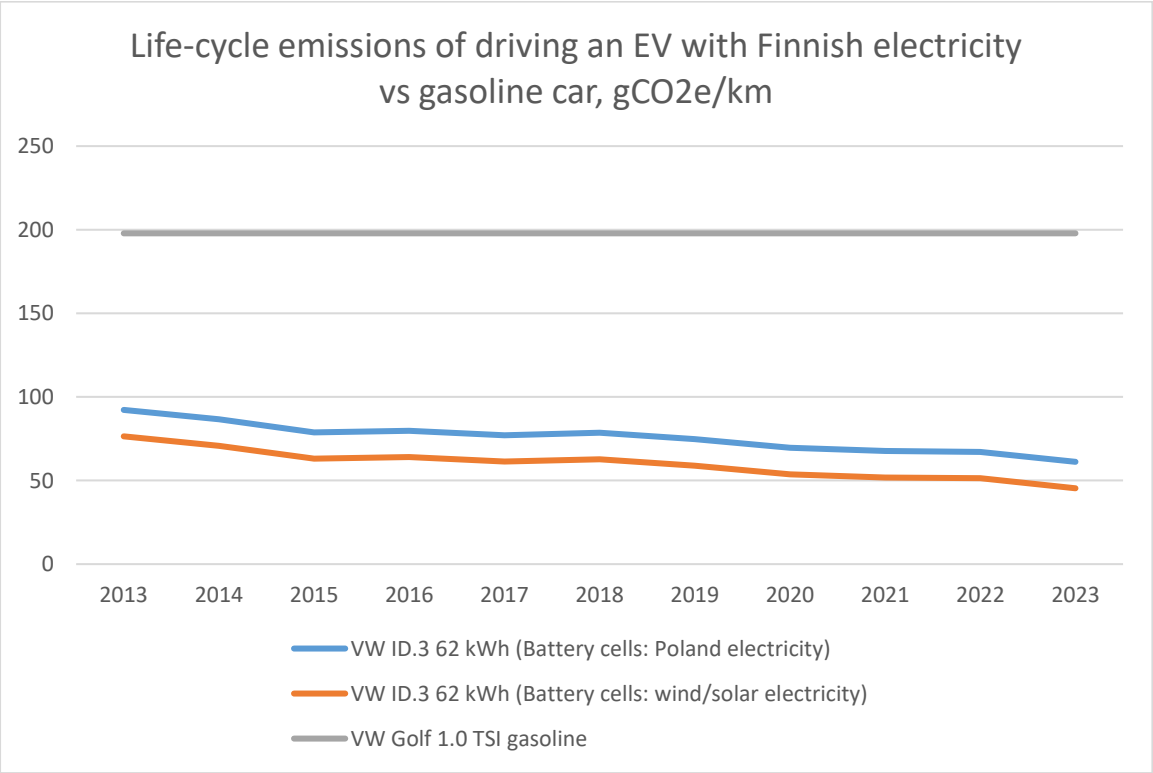
[1] Soimakallio Sampo, Manninen Jussi, Chapter 2: Energy efficiency and the Finnish energy system, in Energy Use – Visions and Technology Opportunities in Finland, VTT, Edita, 2007.

average household prices for electricity and district heat were calculated from 2015 to 2017 and were found to be 16.99 cent/kWh and 7.80 cent/kWh, respectively[2].

- ***Benefit sharing method: primary energy is allocated to heat and power on the basis of the fuel consumption of the forms of heat and power production replaced by CHP.*** The benefit for power is higher than the benefit for heat and thus e.g. the CO_2e emissions per kWh for power are higher than in energy method. The efficiencies of the replaced heat and power production plants used here equal to 89 % and 36 %, respectively. In power generation, the power station losses are taken into account.
- ***Partial benefit sharing method: primary energy is allocated to heat on the basis of the fuel consumption of alternative heat production, and the remaining share is allocated to power.*** Not calculated in this analysis.
- ***No sharing method: primary energy is allocated without sharing, i.e. allocated to one product only.*** If all primary energy is allocated to electricity, e.g. all CO_2e emissions are allocated to power.

Electric car vs gasoline car

The life-cycle emissions (gCO2e/km) including car manufacturing, materials, operation (electricity, fuel), maintenance and end-of-life were calculated for Volkswagen ID.3 and Volkswagen Golf gasoline cars for a time period of 2013–2023, if the electricity is Finland's generated electricity (benefit sharing method). Volkswagen ID.3 battery cells are manufactured in Poland, and thus Poland's electricity mix was used in calculations. The calculations were carried out also for the case where renewable electricity is used in battery cell manufacturing (e.g. Northvolt batteries). Life-cycle distance driven is 298000 km.



[2] Statistics Finland's PX-Web databases, Price of district heating by type of consumer, Price of electricity by type of consumer.

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