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Climate Indicators for Germany, 2°C and 1.5°C Targets Until 2050, Situation in 2030

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Abstract: In the following report, Germany's detailed efforts to achieve the climate targets are formulated. Necessary reduction of CO_2 emissions and the graph of the indicators for the 2°C and the 1.5°C target are determined for 2030 and 2050 according to worldwide requirements to achieve climate protection goals. The necessary associated changes in the structure of energy production and consumption are shown graphically for 2030; in particular the share of energy sources to cover the energy demand, the corresponding energy flow from primary energy to the end energies and the related detailed CO_2 emissions. Achieving climate goals poses major challenges to the international community. Between 1870 and 2017, around 390 Gt of carbon were released into the atmosphere through the combustion of fossil fuels. In order to limit the temperature rise from the pre-industrial period to 2°C, the carbon content of the atmosphere must not exceed 800 Gt in total by 2100, and to meet the 1.5°C target only 550 Gt C. Not only the main emitters of CO_2 such as the USA and China, but all countries must make an appropriate contribution. How the load distribution for the 2°C or 1.5°C climate target should look for Germany has been analyzed in detail taking into account the economic development with the help of IMF statistics. The given development of the indicators and thus compliance with the 1.5 degree target seems to be possible for Germany.

Keywords: Climate Protection, CO_2 Emissions, 2°C Target, 1.5°C Target, Energy Flow, Share of Energy Sources, Targets Until 2030 and 2050

1. Introduction

In order to limit the temperature rise from the pre-industrial period to 2°C, the carbon content of the atmosphere must not exceed 800 Gt in total by 2100, and to meet the 1.5°C target only 550 Gt C [8-10]. How the load distribution for the 2°C or 1.5°C climate target should look for all continents has been analyzed in detail in [1, 2, 6, 13, 16].

1.1. CO_2 Emissions

What is the result for Germany in particular? Figure 1 shows the history [3] and the necessary future of CO_2 emissions up to 2050 to achieve the stated climate targets. Note that these are just the effective emissions in this country. Contributions made through necessary and economically viable emissions trading in other countries are not to be included in this. This is to be understood as the help of the strong industrialized countries for the establishment of a sustainable energy structure in the developing countries. Also as help for those countries whose economies are largely financed by the depletion of their own fossil-fuel reserves and which are therefore struggling to find the way to a post-fossil energy economy. National and international politics must support this and ensure it as far as possible.

1.2. Indicators

It makes sense to assess the emissions reduction relative to the economic power. This is done, for example, by the GDP PPP (gross domestic product at purchasing power parity) determined by the IMF (International Monetary Fund) expressed in international $ of 2010 [4].

The corresponding sustainability index can be expressed in g CO_2/$. The 2019 figure for Germany is 174 g CO_2/$. This indicator is the product of energy intensity of the economy in kWh/$ and the CO_2 intensity of the energy in g CO_2/kWh. Figure 2 shows the history of these indicators for Germany The energy intensity must continue to diminish from 0.86

kWh/$ in 2019 to about 0.69 in 2030 and to scarcely more than 0.5 kWh/$ in 2050. But it should be noted that the final energy electricity, will hardly decrease, due to the electrification of transport and the increased use of heat pumps. Therefore the CO_2 energy intensity must be reduced all the more, particularly for the 1.5° target, from 203 g CO_2/kWh in 2019 to 140 g CO_2/kWh in 2030 and 33 g CO2/kWh in 2050.

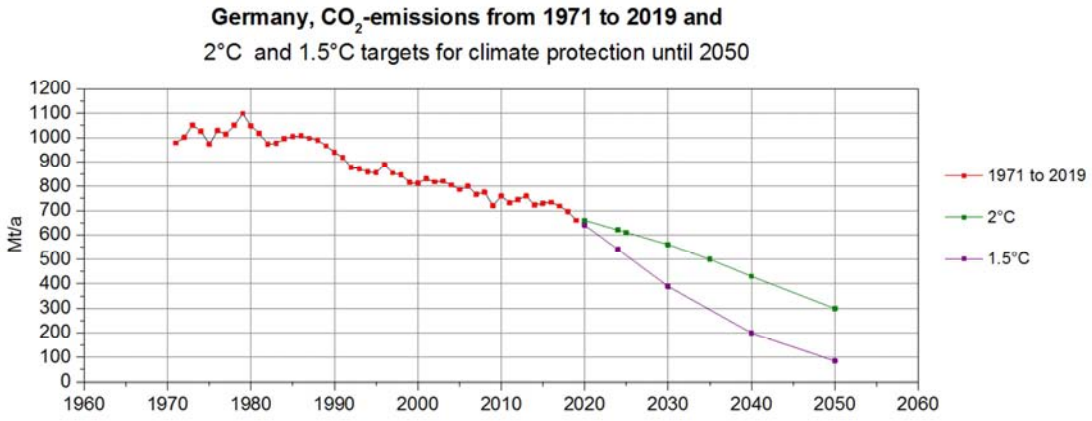

Figure 1. *CO_2-emissions from fossil fuels, 1971 to 2019 und until 2050 to meet 2°C and 1.5°C goals.*

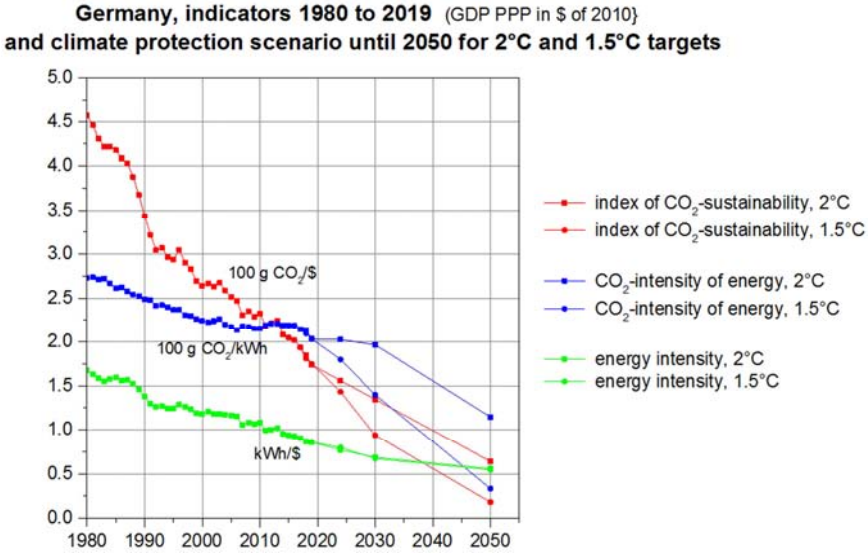

Figure 2. *Indicators from 1980 to 2019 and climate protection targets until 2050.*

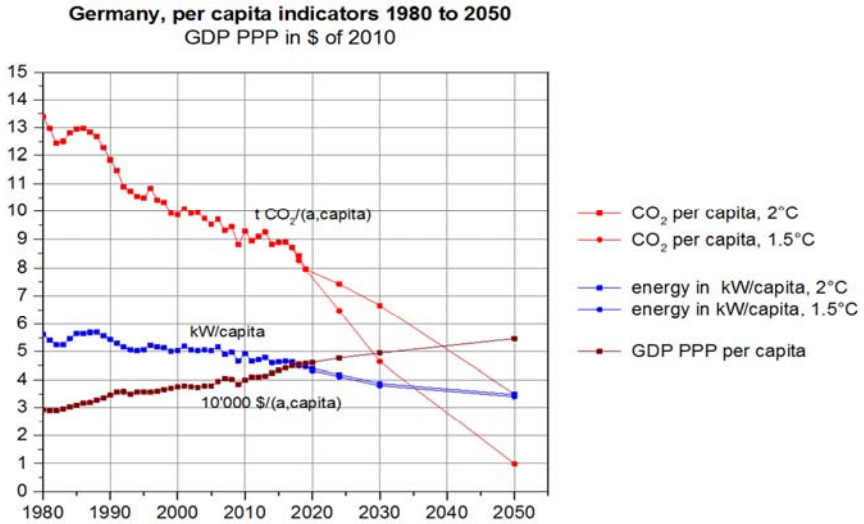

Figure 3. *Per capita indicators 1980 to 2050 and climate protection targets 2°C and 1.5°C.*

Figure 3 shows the per capita values for GDP, gross energy and CO_2 emissions compatible with the above indicators. The assumed development of GDP (PPP) corresponds, until 2024, to the IMF predictions [4]. The per capita emissions should be reduced from about 8 t CO_2/capita in 2019, to 3.5 t CO_2/capita by 2050 for the 2°C target and even further down to 1 t CO_2/capita for the 1.5° target.

2. Situation in 2018

2.1. Share of Energy Sources and Corresponding Emissions

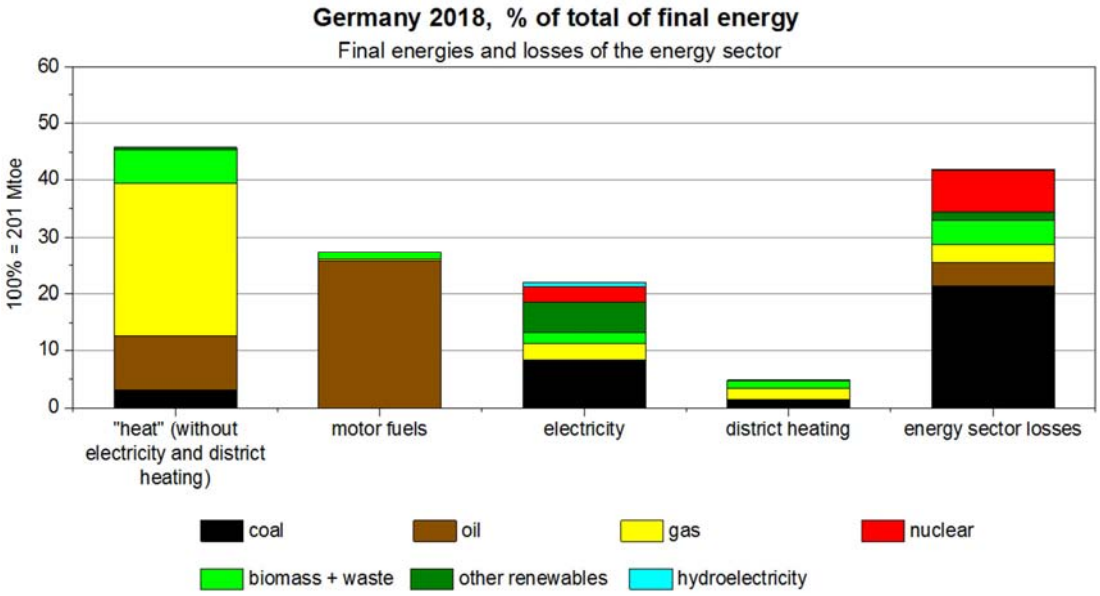

Figure 4. *Share of energy sources to cover the gross energy demand in 2018.*

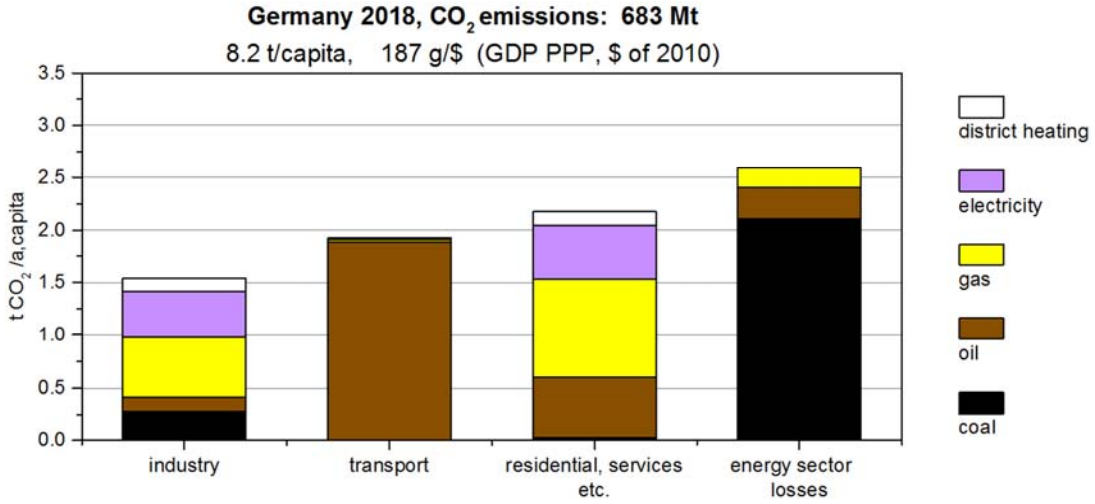

Figure 5. *Emissions per capita of end user and of the energy sector in 2018.*

For a better understanding of where action is necessary, Figure 4 shows details of the different energy sources in the gross energy requirement of Germany in 2018. The latter consists of the 4 final energies (heat from heating fuels, transport fuels, electricity and district heating) and the losses in the energy sector. The gross energy requirement is 142% of the final energy requirement Figure 5 shows the corresponding CO_2 emissions of end users and of losses arising in the energy sector. It is clear that, for Germany, transport and building heating are important for climate protection, but more decisive are the coal-intensive losses in the energy sector caused by electricity generation.

2.2. Energy Flows in 2018

Finally, Figures 6 and 7 show the detailed energy flow in the energy sector and to the end users and the corresponding CO_2 emissions, corresponding to the statistics of the International Energy Agency (IEA) [3].

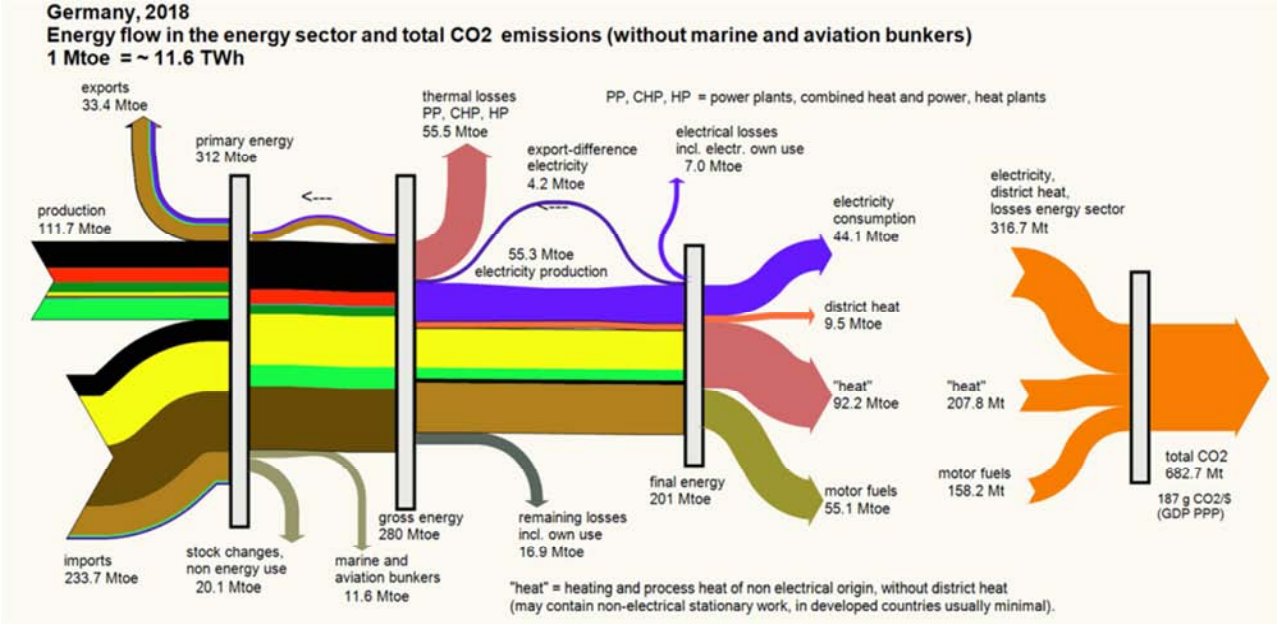

Figure 6. *Energy flow in the energy sector from primary energy via gross energy to the 4 final energies, and corresponding CO_2 emissions. Gross energy = final energy + losses in the energy sector.*

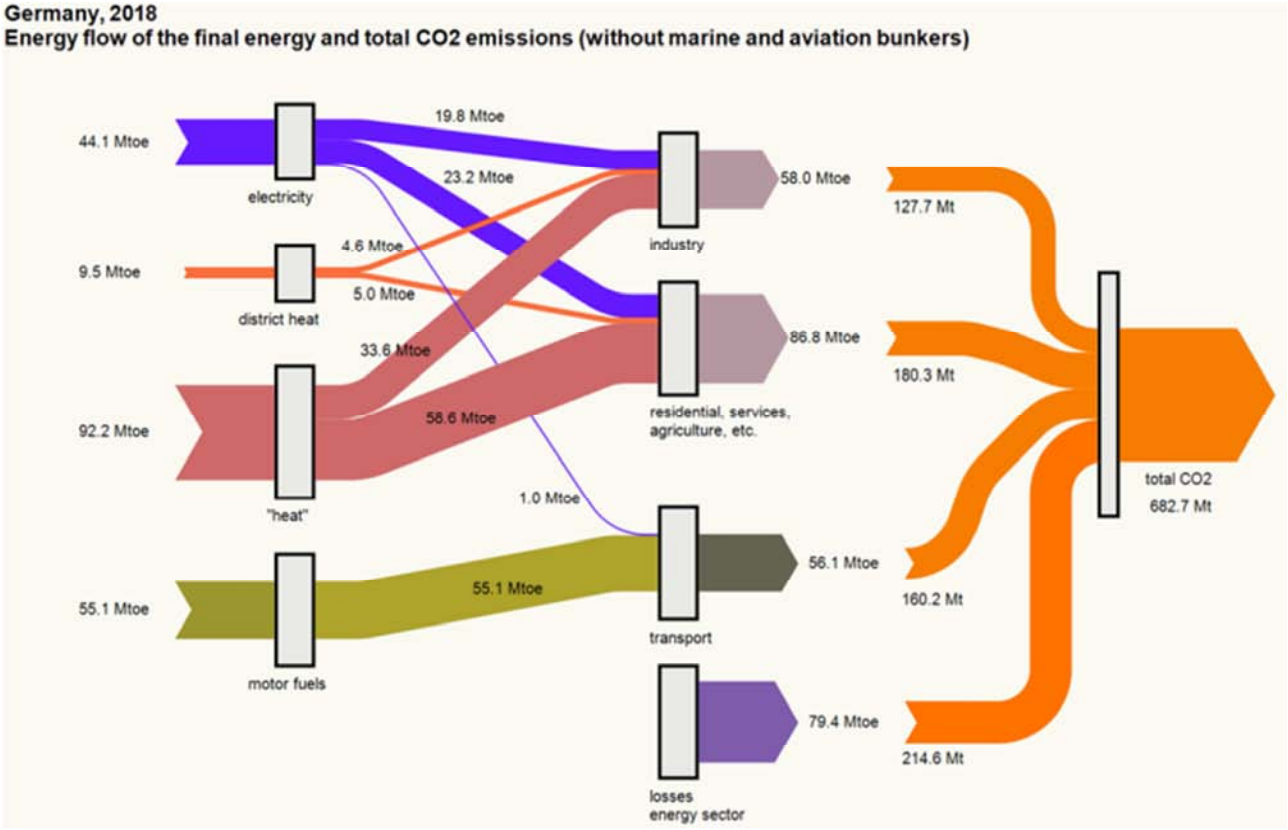

Figure 7. *Energy flow of the 4 final energies to the end user and corresponding CO_2 emissions.*

3. Required Measures Until 2050

Above all for the 1.5°C target [1, 8, 11, 14] the following measures are necessary:

In transport: extensive electrification of short-distance traffic; hydrogen and other CO_2-neutral synthetic fuels for long-distance goods transport, air and sea travel.

For buildings: new buildings and building refurbishment with widespread use of heat pumps and photovoltaics.

For this, the policy must implement a higher CO_2 price, for all fossil fuels and combustibles. The proceeds should be

partly recompensed by appropriate support measures to those heavily affected.

Central to this is also adequate and CO_2-free electricity generation. Nuclear energy must not be replaced by gas-fired power stations and imported energy from fossil fuels. Large-scale use of photovoltaics and wind power [7],[12] with storage facilities to compensate their variability, and the corresponding decentralising of the feed-ins places large demands on the safety and stability of high, medium and low-voltage grids. However, the problem is soluble with suitable capacity expansion and digital monitoring and control [5, 15].

The above requirements can be only partly fulfilled by 2030. Possible scenarios for 2030 for the 2°C and 1.5°C targets are shown in the following.

3.1. 2°C Climate Target: Situation in 2030

To meet the 2-degree climate target, Germany must reduce CO_2 emissions to 560 Mt as shown in Figure 2. The corresponding indicators are then 0.69 kWh/$, 196 g CO_2/kWh and 135 g CO_2/$. A scenario for energy carrier shares and energy flows that more or less meet this target is shown in Figures 8 & 9. As is shown, for example in Figure 8 (compare with Figure 4), efforts in the area of electricity are most notably necessary: Replacement of nuclear energy and partial replacement of coal by renewable energies (wind power and photovoltaics) as well as in transport from better efficiency, electric and hybrid mobility. The reduction achieved in emissions per capita of end users can be seen in Figure 9 (compare with Figure 5).

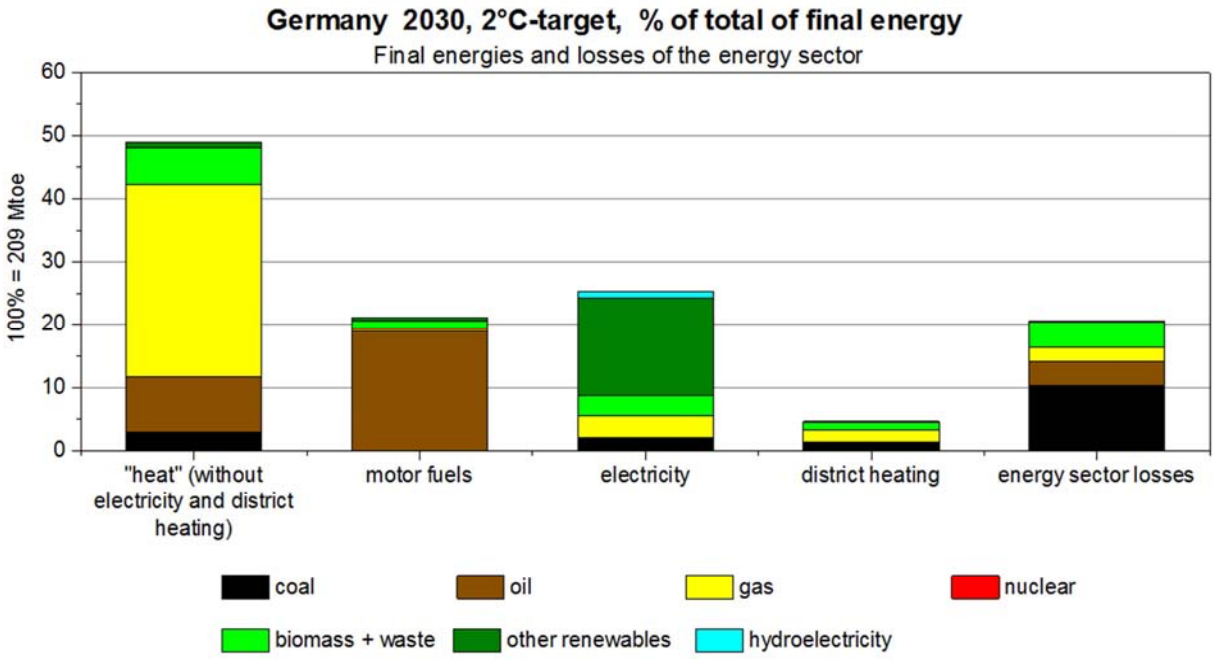

Figure 8. *Share of energy sources to cover the gross energy demand in 2030, 2°C -target.*

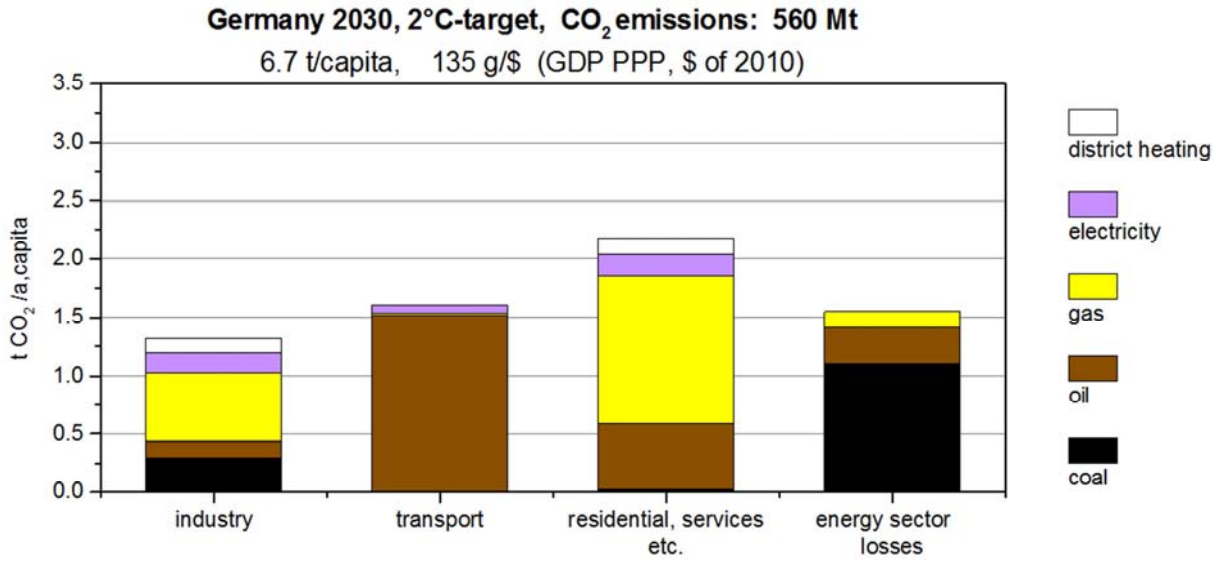

Figure 9. *Emissions per capita of end user and of the energy sector in 2030, 2°C -target.*

3.2. 1.5° Climate Target: Situation in 2030

Achieving the 1.5°C climate target makes more stringent demands. According to Figure 2, CO_2 emissions need to fall to 390 Mt. The corresponding indicators are 0.67 kWh/$ and 140 g CO_2/kWh and 94 g CO_2/$. A scenario for energy carrier shares (final energies and energy sector losses) that more or less meets this target is shown in Figure 10. The corresponding per capita emissions of the end users are shown in Figure 11 (see also Figure 3) Compared to the 2-degree target, the 1.5-degree target makes the elimination of coal crucial; in addition greater efforts in the matter of space heating in buildings are necessary, by reducing the use of oil and gas and making use of geothermal energy (heat pumps).

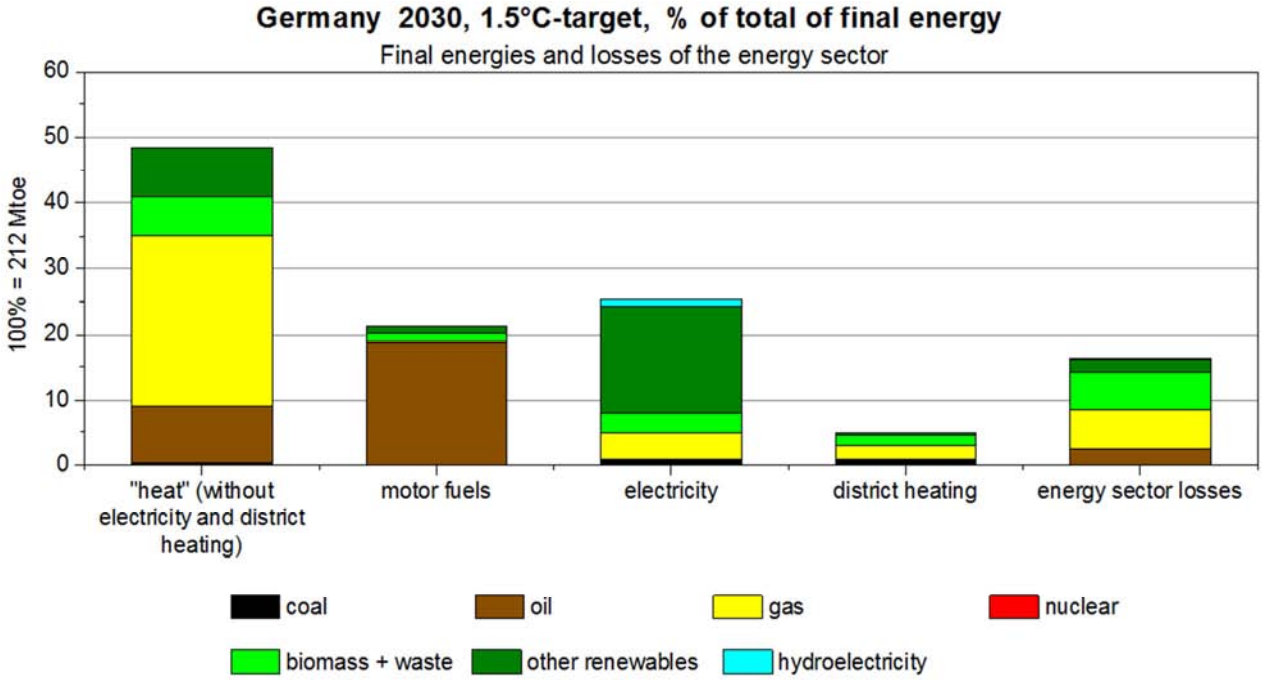

Figure 10. *Share of energy sources to cover the gross energy demand in 2030, 1.5°C -target.*

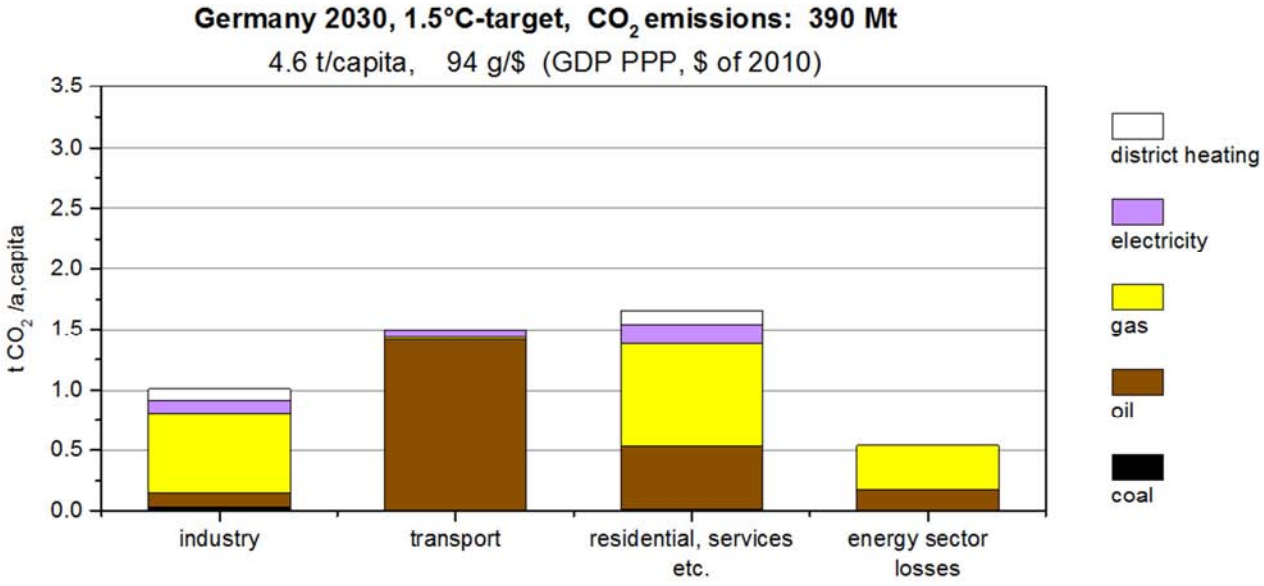

Figure 11. *Emissions per capita of end user and of the energy sector in 2030, 1.5°C -target.*

3.3. Energy Flows in 2030

To complete the presentation, Figures 12 & 13 show the energy flows to final energies in the energy sector with the corresponding shares of emissions for 2030 and for both climate targets, 2°C and 1.5°C. The changes are particularly clear in the energy sector: for the 1.5°C target the nearly complete elimination of coal and increased use of renewable energies, particularly geothermal in heat production.

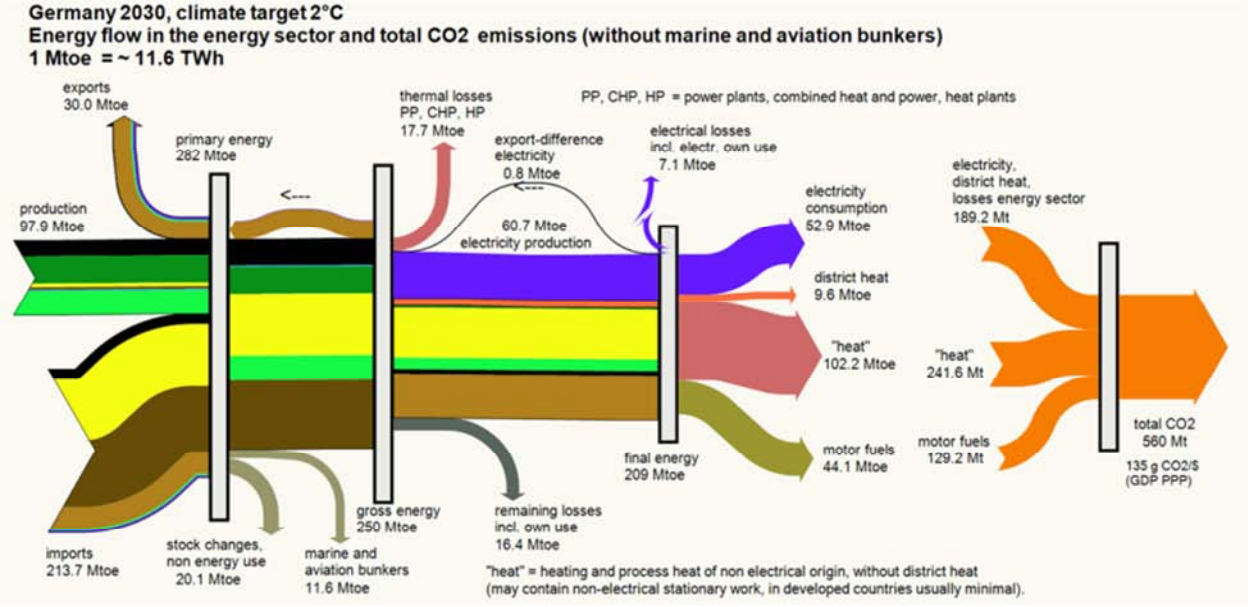

Figure 12. *2°C -target: energy flow in the energy sector, from primary energy via gross energy to the 4 final energies, and corresponding CO_2 emissions. Gross energy = final energy + losses in the energy sector.*

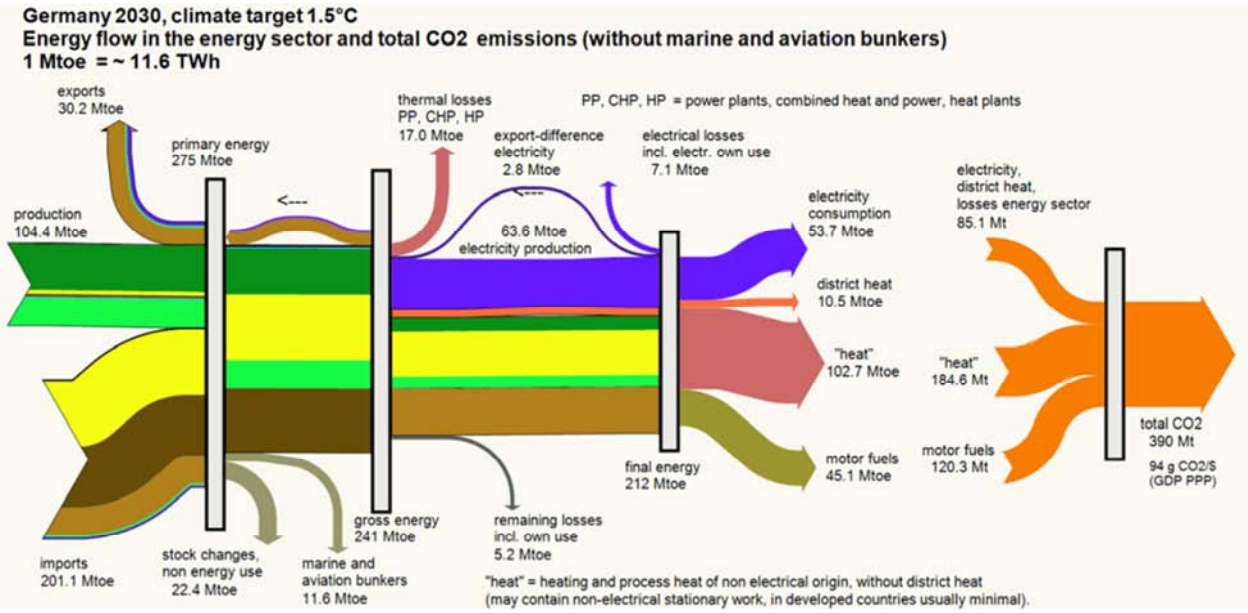

Figure 13. *1.5°C -target: energy flow in the energy sector, from primary energy via gross energy to the 4 final energies, and corresponding CO_2 emissions. Gross energy = final energy + losses in the energy sector.*

4. Conclusions

Achieving the 1.5° target, in line with global challenges, is possible for Germany. The prerequisite is a CO_2-free electricity production by 2030. Although this is made more difficult by the shutdown of the nuclear power plants, it is possible due to the progressive use of wind energy and photovoltaics as well as the strengthening of the network and storage options. From 2030 to 2050, the electrification of transport must also progress strongly and the use of CO_2-free fuels for long-haul, sea and air transport. The modernization of the building with regard to energy consumption by means of better insulation, photovoltaics and heat pump heating is also necessary in order to achieve the goal of an almost CO_2-free energy consumption by 2050.

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