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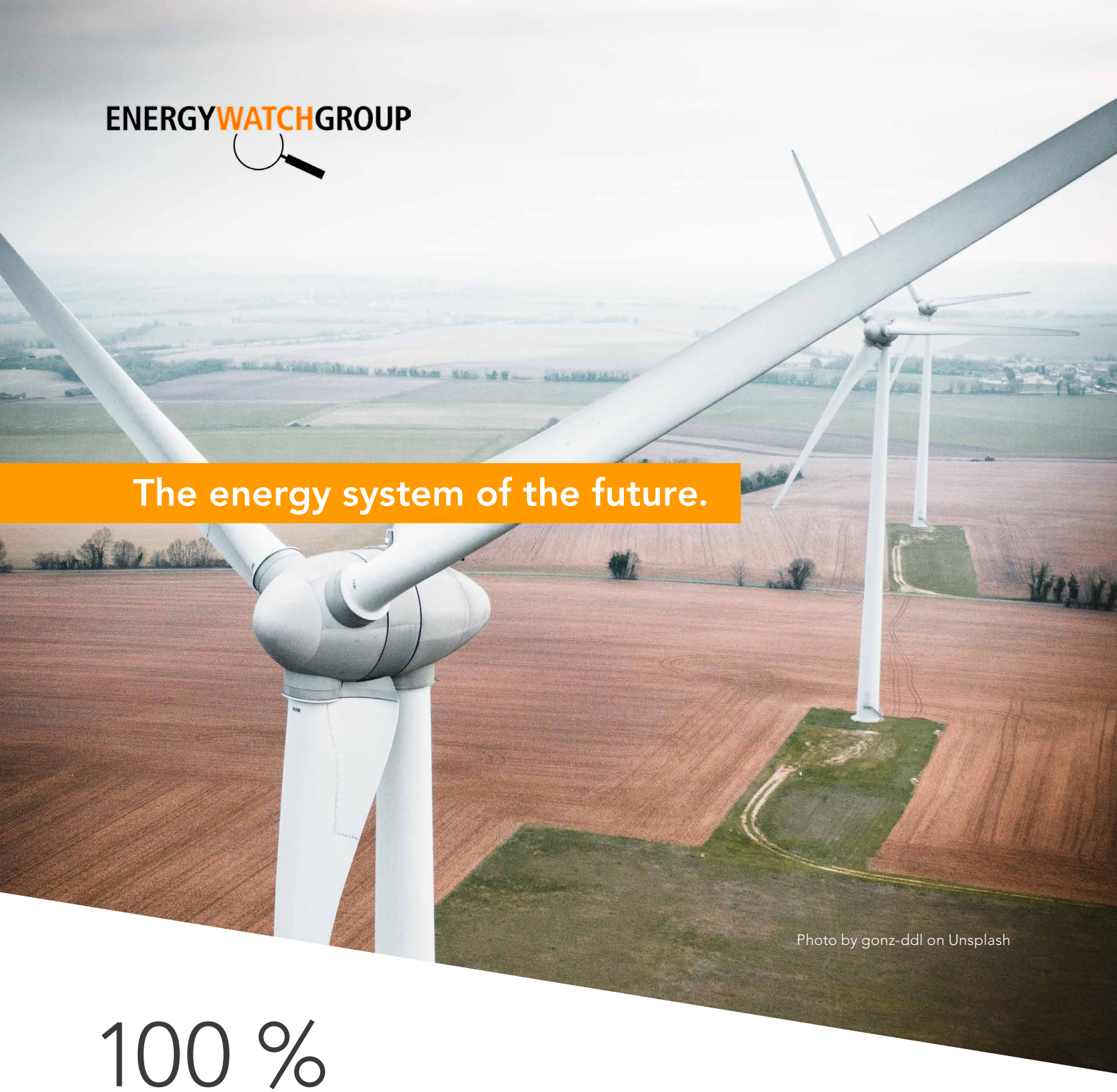

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100 %

renewable energies for Germany by 2030

Climate protection – Security of supply – Economic efficiency

Executive Summary

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Executive Summary

The Federal Republic of Germany signed the Paris Climate Agreement, which is binding under international law. An emission reduction schedule by the German Federal Government that is incompatible with the Paris Climate Agreement is criticised by the German Federal Constitutional Court's ruling of April 2021 on the inadmissibility of the Climate Protection Act of 2019. This meant the ruling also indirectly underlined the need to develop a faster and more ambitious climate policy. According to the currently permissible emission levels, Germany's residual budget for CO2 emissions, as identified by the German Advisory Council on the Environment (SRU), would be largely used up by 2030.

Compliance with the 1.5 °C target consequently calls for the elimination of all greenhouse gas emissions by around 2030. The core of this necessary task of the century involves transitioning to 100 % renewable energies across all sectors. Most current cost calculations clearly reveal that developing conventional fossil fuel is not only inefficient in terms of energy, but also too expensive and too slow to make a sufficient contribution to climate protection.

We are not aware of any previous studies for Germany, whether in the energy sector or across all emission-relevant sectors, that show a scenario based on 100 % renewable energies by 2030. EWG is thus presenting the first comprehensive energy scenario that ensures the use of 100 % renewable energies on an hourly basis across all sectors by 2030 – in a technically and economically feasible manner and including complete coverage of demand even during dark periods in the winter.

The result of the calculations is the presentation of a cost-effective energy system that enables Germany to meet its portion of the climate target of 1.5 °C agreed in binding international law by means of an energy supply with 100 % renewable energies. A core theme of our study is to quantify the expansion of generation, conversion and north-south transmission capacities required for a complete transition in the next ten years.

This study demonstrates which target system of generation, sector coupling and storage technologies could be used to achieve the transition to 100 % renewable energies in all energy sectors (electricity, heat, mobility, industrial energy consumption with demand being met at all hours) in a climate protection-efficient and timely manner by 2030.

For this purpose, in the context of (1) the regionally differing policies for renewable energies expansion and (2) the discussions regarding electricity grid expansion, we created three scenarios for a cost-minimised, zero-emission energy economy with complete electrification based 100% on renewable energy sources:

Scenario 1: Complete halt to further wind power expansion in the south*

Scenario 2: 50 % (24 GW) utilisation of the potential for wind power expansion in the south

EWG scenario 3: 100 % (37 GW) utilisation of the potential for wind power expansion in the south

Grids
EWG scenario 3 yields a comparatively modest need for transmission grid expansion from north to south. The study estimates the current north-south transmission capacities at 8.9 GW. Scenario 3 will require a further expansion of 7.6 GW to 16.5 GW, which is roughly equivalent to the north-south transmission lines now being planned and built. Without the further expansion of wind energy in the south of Germany, the transmission lines would have to be considerably expanded to 21.3 GW.

Renewable energies
Regarding the expansion of onshore wind energy, the necessary annual expansion varies between 3 GW (scenario 1) and 5 GW (EWG scenario 3). The expansion of solar energy in scenario 3 is 85 GW per year. The expansion volumes for all other renewable and sector coupling technologies remain in the same order of magnitude, regardless of the respective scenario. The required annual average by 2030 is 3 GW of offshore wind expansion, 4 GW of bioenergy expansion, 15 GW of heat pump expansion and 3 GW of electric heating expansion.

Renewable energies – solar
Partially refraining from wind power expansion in southern Germany (scenarios 1 and 2) requires PV facilities to expand with 120 GW and 100 GW per year, respectively, compared to the already challenging average annual expansion requirement of 85 GW in scenario 3. In comparison, the current expansion of wind power in the south is only slightly higher than in scenario 1.

These volumes, especially when it comes to PV, cannot be added in the coming year. Expansion would thus resemble an S-curve rather than a straight line, with new facilities expanding rapidly at first until existing installation capacities are used fully. An even faster expansion would be possible in the second half of this decade if several gigafactories of additional PV manufacturing capacity (including domestic capacity) were built up.

Storage systems
Alongside renewable energies, storage capacity must also be considerably expanded by 2030. As the temporal applications of storage technologies differ, two variables are relevant in this case. Firstly, the total storage capacity to be installed in scenario 3 is around 20 TWh – evenly distributed between northern and southern Germany to ensure a temporal balance between energy consumption and renewable energy availability. The more wind energy is missing in the south, the greater the need for seasonal storage capacity, especially in the south. This would mean an increase of 50 % to about 30 TWh for scenario 1. Secondly, while seasonal storage capacities are covered by hydrogen, a greater role in the final energy supply is played by heat storage systems, battery storage units and pumped storage, accounting for a total of about 60 %. This is because batteries and heat storage systems are charged and discharged in an almost daily cycle, meaning that the energy supplied by stored heat and battery storage units is comparable to that supplied by hydrogen. Battery storage units and heat storage systems thus play a similar role to seasonal storage using hydrogen in the energy system of all three scenarios. Refraining from the expansion of wind energy in the south of Germany also results in a significantly increased storage demand (+79 %) with regard to the final energy supply.

Efficiency
In addition to the expansion of renewable energies and storage capacities, transitioning to 100 % renewable energies and zero emissions requires a considerable increase in energy sector efficiency. The increase in the annual building renovation rate from the current 1% to 6% by 2030 and an annual increase in process heat efficiency of 1% are key factors in increasing the potential end use efficiency – compared to 2018 – in the heating sector and especially in the building sector by a total of 217 TWh. Other sectors also have room for efficiency improvements, such as in the distribution and transmission network or the transport sector, where comprehensive traffic avoidance and redesign measures (regional freight transport, public transport, bicycle and pedestrian) can and should be taken to reduce energy consumption.

Costs

Energy production costs of €76 per MWh on average in the most favourable scenario 3 are at similar levels as in 2018; total annual energy costs are between €155 billion (scenario 3) and €191 billion (scenario 1) compared to €189 billion in 2018.

Electrification

Electrification of the transport and heating sectors in particular yields significant efficiency improvements compared to the system still largely based on fossil fuels in 2018, especially in scenario 3. They result in a significantly reduced final energy demand of 2069 TWh compared to 2500 TWh in 2018, which had caused a total primary energy demand of 3500 TWh. To achieve the objective of a 100 % renewable energy system a mix of many different renewable energy technologies will be needed, with wind and solar power (PV) accounting for about 80 % across scenarios and battery power, geothermal and hydropower contributing a further 12 % across Germany. Ongoing electrification also ensures that electricity will account for by far the largest portion of the total energy system (approximately 80 to 95 % of total energy demand).

The study examined only applications of renewable energies that already account for a substantial portion of electricity generation. Sustainably grown biofuels, biogas and solid biomass as well as solar thermal or geothermal energy that does not generate electricity will nevertheless also have to play an important role if a 100 % renewable energy supply is to be achieved. To map all the sources of greenhouse gas, other sectors such as cement production, metal production and the chemicals industry (that can allow for flexibility and limit the need for storage) must also be taken into account in the near future in addition to the energy sectors considered in this study. In addition to the necessary abatement of greenhouse gas by the energy and industrial sectors, the agriculture and forestry sectors must not only support the electricity system by supplying bioenergy, but also make an important contribution to climate protection by storing carbon in the soil. This must be taken into account in more comprehensive future studies.

Comprehensive expansion of all renewable technologies required

The study shows that the necessary transformation of all energy sectors based on a systematic expansion of renewable energies can be implemented cost-effectively by 2030. Therefore, a policy approach, which disregards the potential of wind energy in Southern Germany turns out to be very expensive, especially due to the almost non-existent expansion of wind power in southern Germany. Refraining from wind power expansion in the south will result in a high additional need for grid expansion and storage construction. Current grid planning is difficult to justify economically and is coming up against the limits of the rapid implementation that would be needed to meet the 1.5 °C target.