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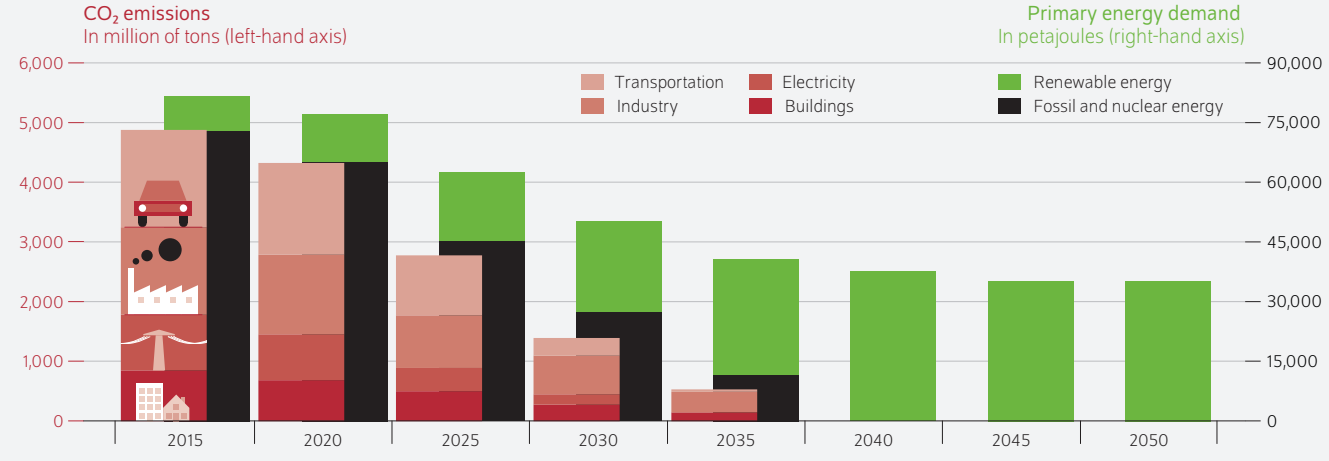
AT A GLANCE

European Green Deal: Using Ambitious Climate Targets and Renewable Energy to Climb Out of the Economic Crisis

By Karlo Hainsch, Leonard Göke, Claudia Kemfert, Pao-Yu Oei, and Christian von Hirschhausen

- To achieve climate neutrality and the targets set by the European Green Deal and the Paris Agreement, emissions must be reduced by 65 percent instead of 40 percent compared to 1990 levels by 2030
- Achieving this requires a switch to 100 percent renewable energy: no more nuclear power, coal, natural gas, or crude oil
- Model calculations show large investments are needed in renewables and energy efficiency as well as the potential for significant savings by avoiding fossil fuel imports
- Money from EU funds and economic stimulus programs should be connected to measures related to climate neutrality and renewable energy
- German EU Council Presidency has the task of combining climate change mitigation with economic recovery

With an ambitious climate change scenario: Net-zero emissions and 100 percent renewable energy in the EU by 2040



Quellen: Authors' own calculations.

FROM THE AUTHORS

"The German EU Council Presidency could kill two birds with one stone: economic recovery and climate change mitigation. To that end, they must ensure that the expansive economic packages that were implemented in response to the coronavirus pandemic are used for investments in renewable energy and energy efficiency in the context of the European Green Deal." — ***Christian von Hirschhausen*** —

MEDIA

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European Green Deal: Using Ambitious Climate Targets and Renewable Energy to Climb Out of the Economic Crisis

By Karlo Hainsch, Leonard Göke, Claudia Kemfert, Pao-Yu Oei, and Christian von Hirschhausen

ABSTRACT

The European Green Deal, initiated by the EU Commission, is a package of measures aimed at decarbonization and sustainable economic development with the goal of making the European Union climate neutral by 2050. To achieve this goal, the emission reductions target must be increased from 40 percent to 65 percent compared to 1990 levels, as the model calculations in this Weekly Report show. Fossil and nuclear power plants must be completely substituted with 100 percent renewable energy sources. Compared to the current course, over 60 billion tons of CO_2 could be saved as a result. Expansive investments must be made to build a solid basis for the current national and EU-level economic stimulus packages. Investments in renewable energy require around 3,000 billion euros; however, they are accompanied by savings of almost 2,000 billion euros from not importing fossil fuels. The German EU Council Presidency (its term lasting from July to December 2020) faces the challenge of persuading the Member States to adopt a common strategy for implementing the European Green Deal as part of their respective economic stimulus packages.

In December 2019, the European Commission presented its first draft of the European Green Deal, which will gradually be developed further over the course of 2020. This package of measures aims to develop a sustainable, climate-neutral, and circular economy in Europe by 2050.[1] Fairly distributing profits and sharing burdens is an important aspect of the Deal, as it requires solidarity between both Member States and between more and less burdened regions. It focuses on measures that strengthen the importance of environmental protection and climate change mitigation for the innovative and economic power of the EU and its Member States as the switch to renewable energy is made. The Deal is divided into sections such as "sustainable transport," "clean, reliable, and affordable energy," and a sustainable agricultural policy ("from farm to fork"). Economic packages adopted as a reaction to the coronavirus pandemic offer the opportunity to combine the investment measures planned with sustainability targets under the European Green Deal.

The following report[2] presents selected policy areas of the European Green Deal that make decisive contributions on the path towards climate neutrality, especially the energy sector, which currently produces around 55 percent of greenhouse gas emissions; the transport sector (around 25 percent); and industry (around 10 percent). This covers almost 90 percent of CO_2 emissions.[3]

This report is based on analyses using two energy system models, GENeSYS-MOD and anyMOD (Box), and investigates if the sectoral measures in the European Green Deal are sufficient enough to achieve decarbonization. The extent to which investment potential, savings in raw material imports,

1 Communication from the Commission, *The European Green Deal* (Brussels: 2019) (available online; accessed on June 17, 2020. This applies to all other online sources in this report unless stated otherwise).

2 This Weekly Report is based on a study by Karlo Hainsch et al., "Make the European Green Deal Real – Combining Climate Neutrality and Economic Recovery," *DIW Politikberatung kompakt* 153 (2020) (available online). In addition, it combines research results from two ongoing European H2020 projects ("OpenEntrance" and "OSMOSE") as well as two projects from the Federal Ministry of Education and Research ("CoalExit" and "Future of Fossil Fuels – FFF").

3 The agricultural sector, as a large sector, is also an important part of the European Green Deal and must reduce its emissions over the next years. However, it is not depicted in the energy model and is thus not discussed here.

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Box

Model coupling to quantify the effects of climate scenarios

As a part of a study on the European Green Deal, DIW Berlin and partner organizations carried out a detailed, model-based analysis of the climate change scenarios as well as macroeconomic implications related to the Green Deal.[1] Two different energy system models were used to calculate a cost-effective pathway for developing the energy system until 2050. Energy, transport, heating, and industry, so all sectors excluding agriculture, are covered by the energy system model GENeSYS-MOD. This way, interactions between sectors induced by the transformation of the energy system, such as an increased use of renewable electricity in the transport or heating sector, are illustrated.

Building off of these results, the electricity sector, which will play a more prominent role as electrification rates increase, is analyzed more closely. For this purpose, a model generated with anyMOD is used, which guarantees hourly coverage of the electricity and power-based fuel demand. For this purpose, the investments necessary in facilities for generating, storing, and transporting electricity are once again calculated separately. Both calculations are performed country-by-country for the European Union (with the exception of Malta, and Cyprus as well as Turkey, Norway, Switzerland, Great Britain, and, combined as one region, the non-EU states in the Balkans).

GENeSYS-MOD is a well-established analysis model in science and policy advice and is used in a number of European and other projects.[2] The anyMOD framework was developed to combine approaches of energy system and power sector modeling.[3] Unlike existing approaches, anyMOD uses a graph-based approach, which allows for two special features. First, the degree of temporal and spatial detail can be varied depending on the energy source and in this way, the size of the model can be reduced noticeably while still illustrating certain flexibilities inherent to the energy system. Second, the substitutability of energy sources, depending on the context, can be demonstrated. In this way, the complex interactions of different technologies and energy sources that are conceivable in an integrated energy system can be illustrated more precisely.

1 Cf. Karlo Hainsch et al., "Make the European Green Deal Real – Combining Climate Neutrality and Economic Recovery," *DIW Politikberatung kompakt* 153 (2020) (available online).

2 Cf. Thorsten Burandt et al., "GENeSYS-MOD v2.0 – Enhancing the Global Energy System Model," *DIW Data Documentation* 94 (available online); Pao-Yu Oei et al., "Lessons from Modeling 100 Renewable Scenarios Using GENeSYS-MOD," *Economics of Energy & Environmental Policy* 9, no. 1 (2020) (available online).

3 Cf. Leonard Göke, "anyMOD – A graph-based framework for energy system modeling with high levels of renewables and sector integration," Working Paper (2020) (available online). As an open source tool, anyMOD is available online. The development of anyMOD is supported by, among others, the European Union's Horizon 2020 Program, under grant number 773406 ("OSMOSE").

and significantly reduced environmental and climate costs are reflected in the overall economy are also calculated.

Climate neutrality by 2050 requires more ambitious targets for 2030 and onward

Currently, EU bodies are discussing increasing climate targets for 2030. These increases must consider both the EU's commitment to climate neutrality by 2050 as well as the Paris Agreement. In addition, increasing climate targets is also a part of the 2050 long-term strategy. The EU is involved in this global process as part of the United Nations Framework Convention on Climate Change (UNFCCC). Originally slated to take place in November 2020, it has been postponed to November 2021 in Glasgow.

The EU Commission, Parliament, and Council have reached a consensus that the current target of 40 percent reduction compared to 1990 levels must be significantly increased. However, by how much it should be increased and the distribution among Member States (what is referred to as "effort sharing") are disputed. The impact assessment launched by the Commission is currently aiming for an increase to 50 to 55 percent. In contrast, suggestions from different factions in the EU Parliament aim as high as 65 percent.[4] The Climate Change Bill, which will be passed in fall 2020, will include this increase. Germany began its six-month term holding the presidency of the Council of the European Union in July 2020. It now has the particular challenge of persuading the EU Member States to adopt a common strategy to implement the European Green Deal as part of their economic stimulus packages.

Scenarios and calculations: majority of emission reductions must occur by 2040

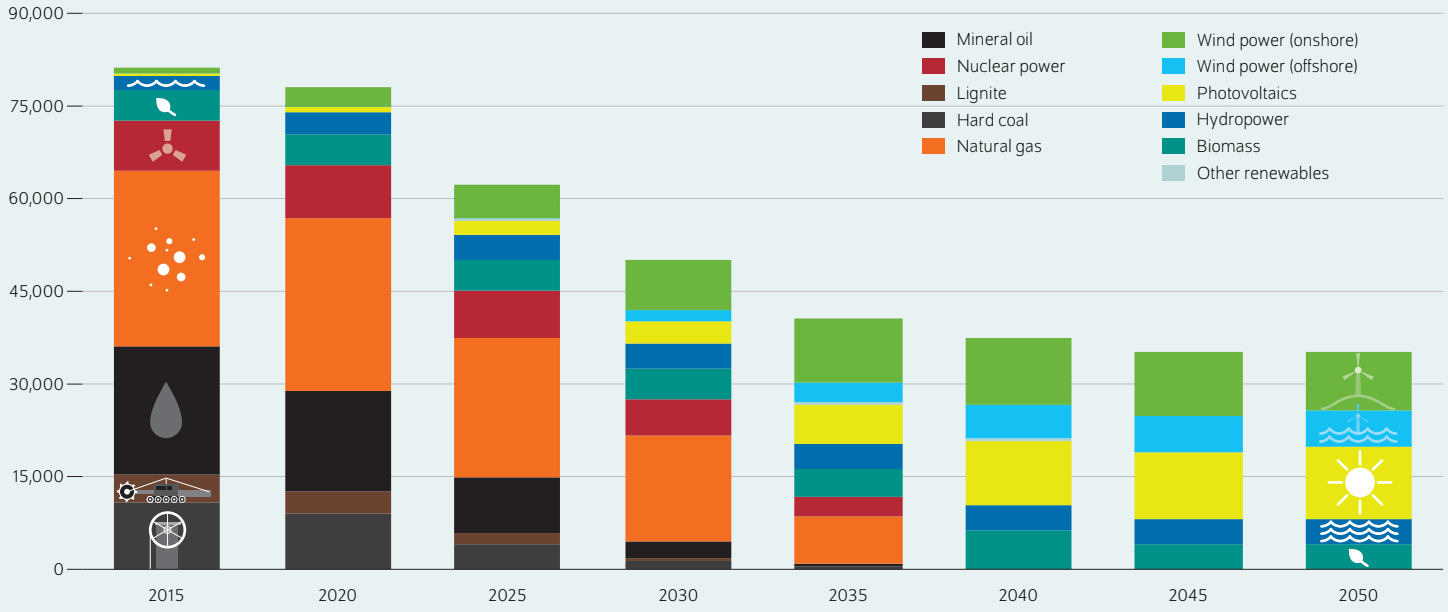
The following section investigates how the climate targets can be achieved. In a model analysis, the climate targets in the Paris Agreement are translated into an energy mix compatible with said targets (the Paris scenario).[5] This ambi-

4 Cf. Aleksander Zaklan et al., "EU ETS Cap Must and Can be Reduced More Quickly," *DIW Weekly Report*, no. 27/28 (2020) (available online; accessed on July 1), in which particular importance is given to the contribution of the European Emission Trading System (EU ETS) as well as Pao-Yu Oei et al., "Neues Klima für Europa: Klimaschutzziele für 2030 sollten angehoben werden," *DIW Wochenbericht*, no. 41 (2019) (in German; available online).

5 The Paris scenario is based on the societal commitment scenario, which was developed in the ongoing "Open-Entrance" project within the European Union's Horizon 2020. The results in this paper do not reflect any "Open Entrance" project output.

Figure 1

Primary energy demand in the Paris scenario
In petajoules



Source: Authors' own calculations.

In the climate change scenario, fossil energy sources and nuclear power will be gradually replaced by renewable energy.

tious climate scenario is compared with a baseline scenario in which current climate policy continues unchanged (BAU scenario, business as usual).

According to the baseline scenario, greenhouse gas emissions will be reduced by 40 percent in 2030 and by 80 percent in 2050. In contrast, in the Paris scenario, significant increases in energy efficiency and electrification as well as certain behavioral changes are assumed, which could lead to a reduction in primary energy demand (Figure 1). Due to the high investment costs involved, nuclear power plants are no longer being built in Germany. Similarly, the development of CO_2 capture, transport, and storage (CCTS) in power plants is proving to be unprofitable. As a result, both coal and fossil natural gas disappear from the energy mix. Thus, in the 2040s, the energy system will completely switch to renewable energy, which will become the most cost-effective solution.[6]

The model results suggest that to reach the Paris climate targets, emission reductions by 2030 must be increased to 60 to 65 percent, with net-zero emissions for the 2040s (Figure 2). Overall, in the observation period of 2015 to 2050, only half as many CO_2 emissions are emitted compared to the BAU scenario. This difference, around 60 billion tons of CO_2, equates to savings in environmental and climate costs of many thousands of billions of euros.[7]

The results are similar to the scenarios and recommendations of other organizations that are involved with the development of future European climate policy. One such example is the PAC Project (Paris-Agreement-Compatible Scenarios for Energy Infrastructure), where, together with a large number of stakeholders, pathways were developed to build a foundation for future European infrastructure planning, oriented towards 100 percent renewable energy.[8] The POLES-Enerdata model used in the German Environment Agency's "EU-ETS" study also highlights an energy mix with emissions compatible with the Paris target, although it still uses considerable amounts of nuclear power.[9] Various studies unanimously recommend to increase efforts to improve energy efficiency and to considerably expand renewable energy.[10]

6 In sectors which make material use of fossil fuels, such as the cement industry, this analysis assumes the development of alternative technologies so that CO_2 capture can be avoided in these sectors as well.

7 This involves calculating the global environmental, climate, and health costs of 180 euros per ton of CO_2 caused by carbon dioxide emissions. Cf. Umweltbundesamt, *Methodenkonvention 3.0 zur Ermittlung von Umweltkosten – Kostensätze Stand 02.2019* (Dessau-Rosslau: 2019) (in German; available online).

8 Cf. CAN Europe and EEB, *Paris Agreement Compatible (PAC) – Scenarios for Energy Infrastructure* (2020) (available online)

9 Cf. Zaklan et al., "EU ETS Cap Can and Must Be Reduced More Quickly."

10 Cf. Climact, *Increasing the EU's 2030 emissions reduction target* (2020) (available online); acatech, *Energiewende 2030: Europas Weg zur Klimaneutralität* (in German; available online); Solar Power Europe, and LUT University, "100 % Renewable Europe – How to Make Europe's Energy System Climate-Neutral Before 2050," Brussels, Belgium (2020) (available online).

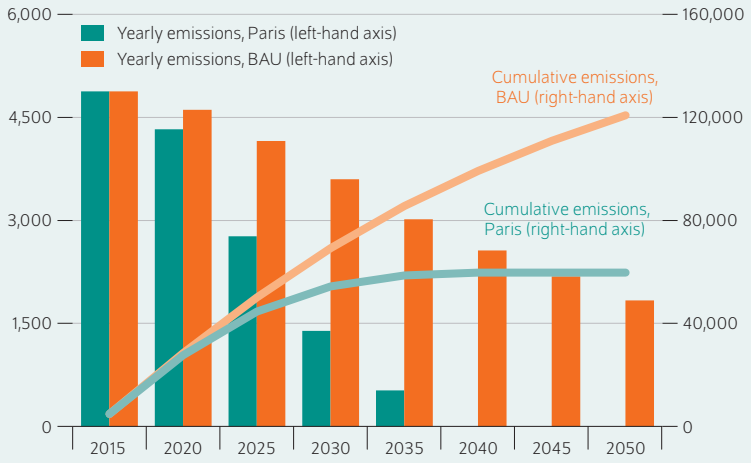
Sustainable investments and savings on fossil imports can provide an economic boost

The model results indicate that significant investments in renewable energy are necessary to implement the Paris scenario. The investment programs currently planned can function as a boost. Renewable energies require around 3,300 billion euros in investments, not including investments needed for network infrastructure and load management. There is also a need for further investment in energy efficiency and sector coupling. However, potential savings of just under 2,000 billion euros by eliminating oil and gas imports largely offset the described investments.

Concrete measures for transforming the energy system include incentives for the private sector to refurbish buildings to be more energy efficient, increasing national expansion targets for renewable energies, a solar bonus for private households, and promoting bicycle infrastructure, rail transport, and local public transport (ÖPNV).[11]

Figure 2

Emissions in the Paris scenario compared to the BAU scenario
In million tons of CO_2



Source: Authors' own calculations.

Climate neutrality and the Paris targets can only be achieved by 2050 with ambitious CO_2 emission reduction targets of 60 to 65 percent by 2030.

Energy sources: climate neutrality requires rapid coal and fossil fuel phase-outs

The model results show that climate neutrality in 2050 can only be achieved if the energy supply is 100 percent substituted by renewable energies. Phasing out energy sources from fossil fuels (oil, gas, and coal) must begin as soon as possible to adhere to the emissions budget. The Member States' plans for fossil fuel phase-outs should be sped up accordingly, with Germany as an example.[12] Fossil fuels will no longer be required with electrified transport and the end of the era of internal combustion in Europe. In addition to electric vehicles, the share of electric rail traffic is also growing strongly.

Moreover, a rapid natural gas phase-out is necessary to protect the climate and is possible from an energy management perspective. Biochemical studies from the 2000s and 2010s show that the global warming potential (GWP) from fossil natural gas (methane, CH4) is significantly higher than previously assumed. The climate impact can be estimated with the factor of 86 to 105, which means that natural gas is around one hundred times more harmful to the climate than CO_2; in contrast, the UN's Intergovernmental Panel on Climate Change (IPCC) and other organizations are calculating with a significantly lower GWP value of 25.[13] A breakthrough of CCTS in the power sector is so far neither technically nor economically foreseeable, even though the industry has been counting on it for more than ten years.[14]

In the energy system models used, the use of natural gas in the EU in 2030 drops by almost half compared to 2015 levels, and in the 2040s, no more natural gas will be needed. According to the model, a maximum of ten percent of the former infrastructure capacity is required for natural gas transport.[15] In this context, subsidizing fossil gas infrastructure, which is currently planned in trans-European projects, is counterproductive.[16]

Taking all costs into account, nuclear power is the most expensive energy generation technology and is therefore not part of the solution in the cost-minimizing model calculations.

11 Cf. with concrete measures suggested in current DIW Berlin publications, such as Stefan Bach et al., "Sozial-ökologisch ausgerichtete Konjunkturpolitik in und nach der Corona-Krise," *DIW Politikberatung kompakt*, no. 152 (2020) (in German; available online); Heike Belitz et al., "Mit Investitionen und Innovationen aus der Corona-Krise" *DIW Wochenbericht*, no. 24 (2020): 446–447 (in German; available online).

12 Cf. Martin Kittel et al., "Scenarios for Coal-Exit in Germany – A Model-Based Analysis and Implications in the European Context," *Energies* 13, no. 8 (2020): 2041 (available online); Pao-Yu Oei et al., "Klimaschutz statt Kohleschmutz: Woran es beim Kohleausstieg hakt und was zu tun ist," *DIW Politikberatung kompakt*, no. 148 (2020) (in German; available online).

13 Cf. Drew T. Shindell et al., "Improved Attribution of Climate Forcing to Emissions," *Science* 325, no. 5953 (2009): 716–718 (available online); Robert W. Howarth, "Methane Emissions and Climatic Warming Risk from Hydraulic Fracturing and Shale Gas Development: Implications for Policy," *Energy and Emission Control Technologies* 3 (2015): 45–54 (available online); as well as Robert W. Howarth, "Ideas and Perspectives: Is Shale Gas a Major Driver of Recent Increase in Global Atmospheric Methane?" *Biogeosciences* 16, no. 15 (2019): 3033–3046 (available online).

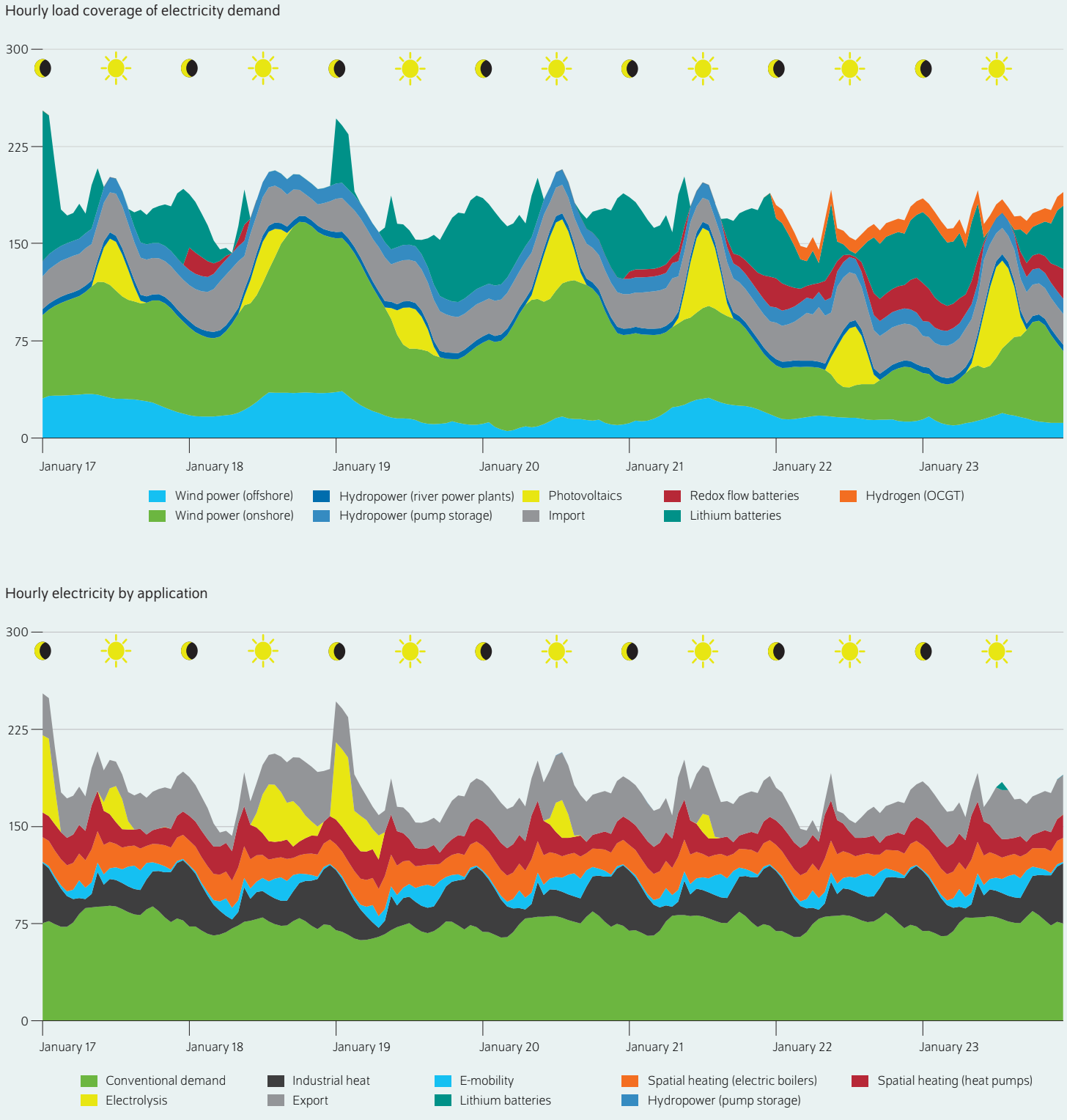
14 Cf. Christian von Hirschhausen, Johannes Herold, and Pao-Yu Oei, "How a 'Low Carbon' Innovation Can Fail – Tales from a 'Lost Decade' for Carbon Capture, Transport, and Sequestration (CCTS)," *Economics of Energy & Environmental Policy* 1, no. 2 (2012): 2160–5890 (available online); Christian von Hirschhausen and Fabian Präger, "Fossil Natural Gas Exit – A New Narrative for the European Energy Transformation towards Decarbonization," *DIW Discussion Paper* (2020) (forthcoming).

15 Cf. Hainsch et al., "Make the European Green Deal Real."

16 Cf. European Commission, *Commission Delegated Regulation C(2019)7772 final* (available online) inclusive *amending Regulation (EU) No 347/2013 of the European Parliament and of the Council as regards the Union list of projects of common interest* SWD (2019) final (available online).

Figure 3

Hourly load coverage of electricity demand and hourly electricity by application in France in a winter week in 2040
In Gigawatts



Source: Authors' own calculations.

Sector coupling and electrification are increasing electricity demand. Renewable energy and energy storage devices can guarantee electricity supply at all times.

Even lifetime extensions are not economically feasible.[17] In the energy system optimization shown here, nuclear power will therefore fall to half of its current capacity by 2030 and be completely off the grid in the 2040s. However, dismantling a large number of decommissioned nuclear power plants and searching for national repository sites for radioactive waste will generate high costs.

Complete substitution with renewable energy

The model results show that switching to 100 percent renewable energy is the most cost-effective alternative, if only because of the environmental and climate costs avoided. However, despite declining final energy consumption, the associated trend towards electrification will increase electricity demand: According to calculations, it will double from around 4,500 in 2020 to around 9,000 terawatt hours (TWh) per year by 2050 in the EU. The declining shares of fossil and nuclear power generation will be replaced primarily by onshore wind and solar photovoltaics. Assuming widespread availability and that costs continue to fall sharply, photovoltaics will grow strongly throughout Europe, especially from 2030 onward. In addition to Southern Europe, even northern countries such as Germany and Poland can produce cost-efficient solar power. Onshore wind energy is also a cost-efficient option and contributes a third of electricity generation in the Paris scenario in 2050. Offshore wind energy plays a certain role, especially in the North Sea countries, but its contribution is more sensitive with respect to assumptions about future cost developments.

In the ambitious climate scenario, intense sector coupling must occur to achieve decarbonization in a cost-effective manner throughout the system. Among other things, this leads to a switch from fossil combustion technologies to electric motors in the transport sector, especially in passenger transport. In addition, biofuels and hydrogen also play a certain role. The heating sector can also switch to renewable energy between 2020 and 2050: In the low-temperature range (such as spatial heating), electric heat pumps are becoming widespread. In the high temperature range (primarily industry), a certain share of bioenergy and synthetic fuels are still needed.

100 percent renewable energy will be able to meet energy demands

According to the results of the hourly calculations based on anyMOD (Box), concerns that a complete switch to renewable energies would be unable to meet the electricity or energy demands are unfounded. However, investments into direct energy storage devices, such as batteries, as well as indirect storage via hydrogen through electrolysis and corresponding turbines are required.

The hourly analysis of the energy system was performed simultaneously for all European countries. As an example, electricity demand coverage in France during a representative winter week in 2040 will be discussed here (Figure 3 top). In addition to renewable energy sources, imports and energy storage devices play a significant role. Batteries are mainly for short-term storage and are used when solar-reliant systems are producing less energy. Since producing and converting hydrogen into electricity is technically much more complex than directly using existing energy sources, these options are only used when renewable energy production is particularly low, such as towards the end of the period presented here. Fears that the switch to renewable energy would fail due to a lack of electrical storage technologies are unfounded.[18]

Power trading within the European transmission system also plays an important role in balancing local fluctuations. In line with sector coupling, the peak load increases strongly (Figure 3 bottom). Overall, the analyses show that even in countries that used to rely heavily on fossil fuels and nuclear energy, such as France and Poland, the energy system can be safely run with 100 percent renewable energy sources in the 2040s.[19]

Financing the structural change with EU funds

The third component, following climate neutrality and clean energy, is the financing of the European Green Deal, as many EU Member States have different requirements. Ursula von der Leyen, President of the EU Commission, emphasized that solidarity is an integral part of the European Green Deal; no one will be left behind. This solidarity must now be applied at national and sub-national level.

On a national level, increasing the EU climate targets will have different effects on the individual Member States. While the coal phase-out is already almost completely finished in some places, such as the United Kingdom, and actively underway in others, such as Germany, countries such as Poland, Romania, and Bulgaria are still in the midst of this massive structural change. These countries should immediately develop a coal phase-out pathway in the interest of planning security and avoiding stranded assets. They can thereby meet the climate protection targets, which would open up new prospects for the regions. Similar changes are imminent not only for the coal industry but also for other emission-intensive industries and must therefore begin now.

The EU has set up a fund to support structural change: The "Just Transition Fund" (JTF) is endowed with 7.5 billion euros and, together with the regional fund and the social

17 Cf. Claudia Kemfert et al., "Atomkraft für Klimaschutz unnötig – Kostengünstigere Alternativen sind verfügbar," *DIW Wochenbericht* no. 47 (2017): 1049–1058 (in German; available online).

18 Cf. with earlier DIW Berlin publications, such as Alexander Zerrahn, Wolf-Peter Schill, and Claudia Kemfert, "On the Economics of Electrical Storage for Variable Renewable Energy Sources," *European Economic Review* 108 (2018): 259–279 (available online) as well as Wolf-Peter Schill et al., "Die Energiewende wird nicht an Stromspeichern scheitern," *DIW aktuell* no. 11 (in German; available online).

19 For an analysis of Poland, cf. Hainsch et al., "Make the European Green Deal Real," 22.

cohesion fund, aims to mobilize considerable public and private resources to promote structural change.[20] Particular care must be taken to ensure that the funds are channeled into sustainable climate-neutral projects and are not used to support fossil development pathways, for example by funding CO_2 capture technologies in large power plants. In addition, there are ongoing attempts to use the money from the fund to finance nuclear power, which would go against the objective of sustainable development.[21]

Conclusion: German EU Council Presidency should promote climate change mitigation, a switch to 100 percent renewable energies

The European Green Deal offers a variety of starting points for overcoming the economic crisis caused by the 2020 coronavirus pandemic. Model calculations show a climate-neutral economy is possible by 2050 at the latest and the EU can adhere to the Paris Agreement in a cost-effective manner by making a 100 percent switch to renewable energy.

In addition to the coal phase-out in the 2030s, this also requires a rapid phase-out of crude oil and fossil natural gas. Nuclear power and CO_2 capture technology are disproportionately expensive, hinder sustainable decarbonization, and are not necessary from an energy perspective. This fossil infrastructure, which is no longer needed in the renewable energy system, should be gradually dismantled instead of subsidizing the expansion of natural gas pipelines and liquefied natural gas (LNG) terminals.

The climate change target for 2030 must be increased from 40 percent compared to 1990 levels to 65 percent. The investment requirement for renewable energy in particular is around 3,000 billion euros; further investments in energy efficiency and sector coupling are needed too. This is offset by almost 2,000 billion euros saved by avoiding fossil fuel imports. Even with a switch to renewable energies, energy supply remains secure. Countries which still use large amounts of coal or nuclear power, like France and Poland, can still completely switch to renewable energies in the 2040s.

The fund set up by the EU to finance this structural change, the "Just Transition Fund," should be used to manage and support local and national initiatives working on structural change. In contrast, the traditional system should not be subsidized so that the European Green Deal can open up real prospects for economic recovery and sustainability.

The German Federal Government has a special responsibility during its EU Council Presidency term: on the one hand, it must bring various climate policies in line with the economic stimulus packages and ensure that the funds are used in a forward-looking manner. On the other hand, in this context, unresolved issues concerning the switch to renewable energy must be solved in Germany, such as the fossil fuel phase-out, increasing the construction of renewable energies, and rapidly increasing energy efficiency.

20 Cf. Bruegel, *A Just Transition Fund – How the EU budget can best assist in the necessary transition from fossil fuels to sustainable energy* (2020) (available online).

21 Cf. FORATOM's statement from March 24, 2020 (available online).

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