NEW TARGETS USING OLD PATHWAYS?

Strategies for a greenhouse gas-neutral energy supply by 2045

This study looks at how to achieve the goal of greenhouse gas neutrality by 2045.

With the new Federal Climate Change Act (KSG), Germany has committed itself to greenhouse gas neutrality (net-zero emissions) by 2045. To this end, the team of scientists at Forschungszentrum Jülich's IEK-3 has developed computer models that enable a well-founded scientific analysis of cost-efficient strategies and measures to achieve the new greenhouse gas reduction targets. The models can be used to depict the German energy supply with its production pathways and all its important interactions.

Furthermore, the models are characterized by their great depth of temporal and spatial detail. For example, they can be used to analyze the expansion of wind power and photovoltaics right down to a regional level. Moreover, future international energy import and export networks (e.g. hydrogen) can be simulated and the role of possible imports and exports estimated.

The models also enable an integrated infrastructure analysis that accounts for all relevant energy carriers (electricity, gas, hydrogen, heat).

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The analyses show that...

1. the pathway to greenhouse gas neutrality can be **depicted from both a technical and an economic perspective**.
2. the tightening of greenhouse gas reduction targets while simultaneously shortening the remaining time frame for action to 2045 requires **a dynamic change in all sectors** that is fundamentally different from the developments in previous years and represents a major challenge.
3. **hydrogen is a central aspect of a reduction strategy** to achieve greenhouse gas neutrality.
4. residual emissions in 2045 must be compensated for by measures that remove carbon from the natural carbon cycle. The **geological storage of CO_2** is required for this.

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FORSCHUNGSZENTRUM JÜLICH (IEK-3)

The new objectives of the Climate Change Act represent a break from the previous reduction targets and require measures to be taken immediately in all sectors.

1216 TWh electricity consumption

The replacement of fossil energy carriers is leading to the increasing electrification of the German energy supply in all sectors and will result in a much higher level of electricity consumption in future. The transformation of the German energy system to CO_2-free renewable electricity production is therefore an essential prerequisite for achieving greenhouse gas neutrality. The scale of the required installation as well as the shortening of the remaining time frame for action necessitate a massive development of renewable energy.

285 GW wind power capacity required

Based on the assumptions made, the current level of onshore wind power capacity will have to increase fourfold. This will require an annual installation rate of roughly 6.3 GW for the entire period under consideration. The installation of offshore wind power stations will also be hugely important due to their long period of utilization.

456 GW photovoltaic capacity required

The success of the transformation process is also largely dependent on whether photovoltaic systems can be built on a large scale. To achieve CO_2-free electricity production, an annual installation rate of approx. 15.8 GW on average will be required for the entire period. This means that current installation rates will have to increase many times over.

12 million tonnes of hydrogen required; 47 % of which imported

While in some sectors the use of hydrogen is one option among many, in other areas of industry there is no alternative and it is therefore essential to achieving greenhouse gas neutrality. This particularly applies to the production of steel but also notably to the chemical industry. Against this backdrop, the use of hydrogen must be classified as a no-regret measure in both of these sectors. The two sectors currently account for more than 40 % of industrial CO2 emissions. Industry will be responsible for roughly two thirds of total hydrogen consumption in 2045.

30 % reduction in energy consumption required across all sectors

Energy-efficient measures across all sectors are the cornerstone of a greenhouse gas-neutral energy supply. The current level of final energy consumption can be reduced in a cost-efficient manner by roughly 30 % by 2045 under the constraints of greenhouse gas neutrality. In particular, the increasing electrification of all sectors means that energy-efficient measures will also help to reduce the consumption of electricity and in turn decrease the energy production capacities required.

20 % of primary energy consumption covered by bioenergy

Around one fifth of primary energy consumption will be covered by bioenergy in 2045. This makes it an important pillar of the future energy supply. Bioenergy can be used flexibly for many different applications (electricity, heat). To ensure that sufficient biomass is available, the current area of land used for biomass cultivation needs to be considerably expanded. However, the additional use of land to cultivate energy crops must not compete with the use of land for food production.

50 to 90 million tonnes of CO_2 storage required

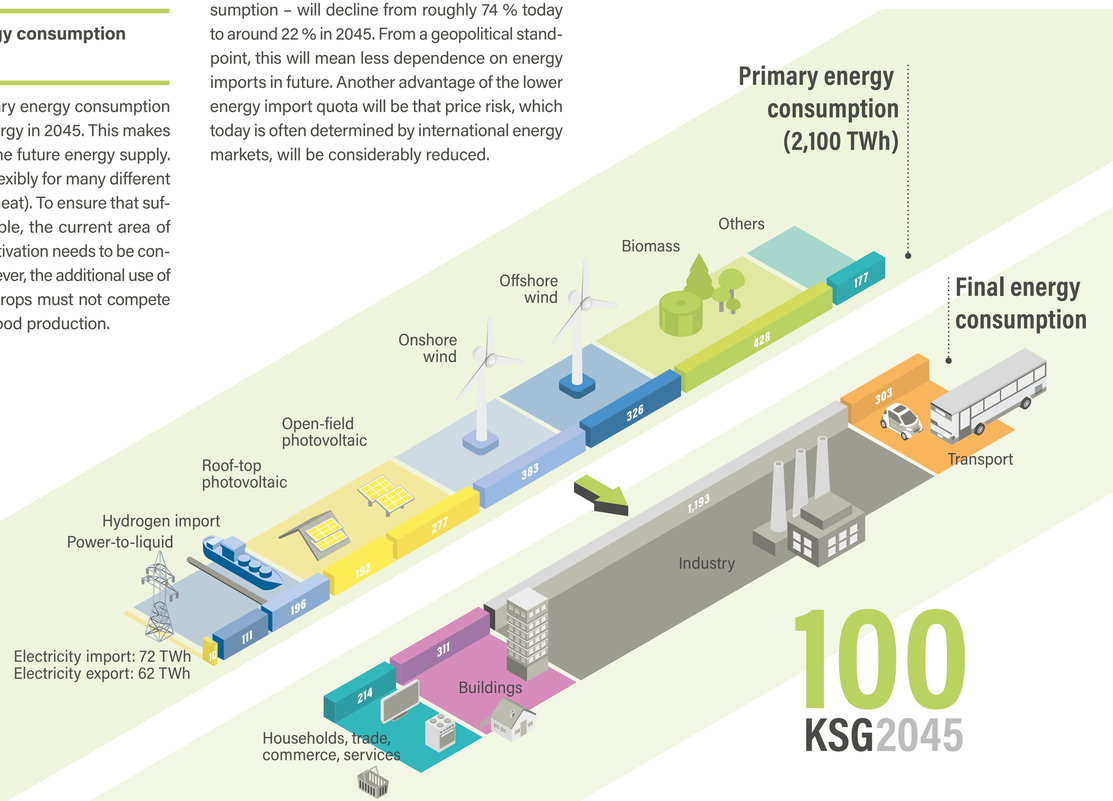
The remaining greenhouse gas emissions in 2045 will largely consist of the residual emissions of industry and agriculture. It will not be possible to avoid greenhouse gas emissions in the agricultural sector without a fundamental change in behavior. To achieve greenhouse gas neutrality, the residual emissions will have to be compensated for by the removal – and subsequent storage – of carbon from the atmosphere. The annual CO_2 storage requirements will be in the range of 50 to 90 million tonnes.

22 % energy import quota

The transformation of the energy supply will lead to a much lower energy import quota, which – coupled with 40 % lower primary energy consumption – will decline from roughly 74 % today to around 22 % in 2045. From a geopolitical standpoint, this will mean less dependence on energy imports in future. Another advantage of the lower energy import quota will be that price risk, which today is often determined by international energy markets, will be considerably reduced.

Approx. € 139 billion in additional annual costs in 2045

The annual costs involved in achieving greenhouse gas neutrality will increase significantly until 2045 and highlight the challenges associated with the transformation of the energy system. This applies in particular to the end of the period of transformation. The additional annual costs will amount to roughly € 139 billion in 2045. If the additional annual costs are added together for the entire transformation period and assessed in relation to gross domestic product (GDP), they represent a share of roughly 1.2 % in GDP.



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