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On the Brink of Disaster

Transforming the energy sector is necessary but not sufficient to prevent a climate catastrophe.

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The concentration of carbon dioxide in the atmosphere is rising rapidly. It has already reached 415 ppm (parts per million), up by 48% compared with the pre-industrial era (280 ppm). Such a high level has not been recorded for at least the last 800,000 years (we know this from the air bubbles trapped inside Antarctic ice) and, based on indirect data, probably for the last 10 million years. Carbon dioxide traps the heat that is returning to space after being delivered by the Sun, so an increase in its concentration causes the Earth's temperature to rise. It is good that some carbon dioxide is present in the atmosphere, because without it the whole of the Earth would be covered by ice. From the perspective of humanity, however, its current concentration is clearly too high. The average temperature on Earth is rising, glaciers are melting, sea levels are rising, hurricanes and floods are becoming increasingly violent, forest fires are increasing, and the precipitation zones are shifting. We are on the brink of disaster, and if we do nothing, our planet faces a very difficult time ahead. According to a report by the Intergovernmental Panel on Climate Change (IPCC), we must do everything we can to stop the temperature from rising by more than 1.5°C compared with the pre-industrial period to prevent a catastrophe and by more than 2°C to prevent a great catastrophe. We have little time left – if we cross the tipping point, there will be no turning back, because we know of no way we might be able to reverse the direction of the changes.

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There is no longer any doubt that humans have caused the amount of carbon dioxide in the atmosphere to rise by burning fossil fuels and additionally by cutting down forests. The emissions of carbon dioxide caused by human activity are unbelievably high, reaching 38 billion metric tons a year – two orders of magnitude more than the average amount released by volcanoes. If the carbon contained in this amount of gas (12.2 billion tons) were to be loaded onto the wagons of a train, this train would encircle the equator 47 times. And this is just the level of annual emissions in 2019. An important role is also played by other greenhouse gases, especially methane and nitrogen oxides. Although their emissions are small, the greenhouse effect of each unit of volume is many times larger than that of carbon dioxide. Their final impact is therefore significant, but not as significant as that of carbon dioxide. For this reason, we can only stop the temperature from rising by radically reducing carbon dioxide emissions.

Greenhouse gas emissions

One concept that is important in thinking about climate change is the amount of primary energy contained in coal or lignite, petroleum, and natural gas, the combustion of which leads to the emission of greenhouse gases. Overall, the emissions from these sources, which are used to produce electricity and heat as well as in combustion engines, account for 73.2% of total emissions (https://ourworldindata.org/ghg-emissions-by-sector). The remaining emissions are caused by agriculture, deforestation, and waste, as well as the carbon dioxide released in chemical reactions, for example in cement plants. This 73.2% is broken down as follows: industry

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– 24.2%, transport – 16.2%, and buildings – 17.5%. About half of the remaining 15.3% consists of unallocated fuel combustion (not classified as falling within the previous groups), while the rest consists of losses of various types. Of course, some but not all of the energy associated with these emissions is electric power.

Zero-emission energy generation

By various estimates, the power generation sector accounts for 27–40% of total carbon dioxide emissions. Let's assume that this share currently stands at one-third. This fact alone is a major argument in favor of the need to transform the power generation sector towards zero emissions, but there are also other important reasons. Transportation is responsible for approximately 16% of emissions, mainly from the direct combustion of petroleum products, so rapid growth in electromobility will drive up demand for electricity. If hydrogen starts to play a major role in transportation (and this appears likely at least in the case of heavy vehicles), it will ultimately come from electrolysis (green hydrogen), which will consume a lot of electricity. Thus, transportation's 16% share of emissions would eventually shift over to the power generation sector, assuming that it still relies on the burning of fossil fuels. Similarly, buildings are currently responsible for more than 17% of all emissions, largely in connection with heating and cooling, and the growing popularity of heat pumps, which use electricity, will shift some of that 17% over to the energy sector. We can already observe a rapid change of this type in the case of a small source of household emissions, namely cooking. Moreover, as the Earth's temperature goes up, people will use air conditioning more, thereby requiring more and more electricity. On the road to zero emissions, the use of fossil fuels in industry will drop, whereas the use of green hydrogen will rise, which will likewise require additional electric power. To save the climate, we will most likely need to capture and store some of the carbon dioxide contained in the atmosphere. This, too, will also require significant amounts of electricity. For all these reasons, the power generation sector needs not only to rapidly develop zero-emissions technologies, which will initially reduce and ultimately eliminate fossil fuels, but also to greatly increase power generation capacity.

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Tesla cars parked at the Tesla Supercharger electric vehicle charging station in the Westminster Mall parking lot, California, United States, 22 January 2020

Energy storage

There can be no doubt that the power generation transition has to bear the brunt of the efforts to achieve zero emissions – or strictly speaking, we should better say "climate neutrality," because it is impossible to reach zero emissions in full, and some emissions will have to be absorbed or neutralized by the natural environment. Fortunately, the technologies needed to achieve this goal are mature, but we should and we will continue working hard to improve them and bring down their cost. The most serious challenge is posed by the development of energy storage, because the new power generation sector will be largely reliant on wind and solar energy and therefore dependent on weather conditions. In all likelihood, chemical storage in the form of hydrogen will be the most important form of energy storage. The production, storage, and use of hydrogen still require certain improvements. Another challenge consists in adapting the transmission networks to the growing share of distributed energy sources. All countries of the world are lagging behind in this respect, and this is especially true for Poland.

What a year it was!

There is every indication that this is what we will be saying about the year 2020 in the future. Of course, the main reason for this will be the pandemic, which is the pessimistic aspect. Fortunately, there is also an optimistic one – in 2020, most of the economically developed countries pledged to achieve climate neutrality: Norway in 2030, the EU in 2050 (Sweden and Finland in 2045), Japan and Korea in 2050, and China in 2060. Many countries are readying themselves to make similar declarations. The United States withdrew from the Paris Agreement under Donald Trump, but Joe Biden, elected in 2020 on the

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The first hydrogen-powered train in the Netherlands was shown to the public at the main train station in Groningen on 7 March 2020

back of green policy promises (among other pledges), brought the country back into the Paris deal and signed the document at the beginning of his term. This act was an important symbol. For that matter, it appears that public awareness is changing so rapidly that it will be impossible in a growing number of countries to win elections without pledging an active commitment to the energy transition or, more broadly, action aimed at achieving climate neutrality. Exxon Corporation, which may be one of the strongest bastions of the old order in the energy sector, announced the development of carbon dioxide air capture technologies rather late, namely in January 2021. But Exxon's executive board has not yet managed to bring itself to announce a program for shifting away from fossil fuels, as other oil corporations have (such as BP, Shell, and even Poland's Orlen).

Fair transition

For the time being, these are just declarations. Let us hope that there will be enough determination to put them into effect. However, such declarations of will do seem to be a crucial step for changes beneficial to climate protection to actually come into effect. The energy transition – or, more generally speaking, the transition towards climate neutrality – should be fair. The most affluent countries are currently the biggest emitters of greenhouse gases, and the amount of the greenhouse gases they emit *per capita* is many times larger than that in poorer countries, which want to develop economically and therefore have greater demand for energy. Unless the wealthier countries, which are now transitioning towards lower emissions, help the poorer ones to prevent their development from following a similar path of high emissions, we will not be able to save the world. In addition, the countries that have pledged climate neutrality should not succumb to the temptation of exporting emissions to other countries by simply relocating emission-intensive industries elsewhere. Climate neutrality achieved in this way may be a propaganda success, but it will not help avert the climate catastrophe, which is a global threat, not a local one.

The last 20%

Transforming the energy sector will not, on its own, be sufficient to save the climate. Why not? Firstly, changes will also be needed in other sectors, above all in industry. Here, technologies are often immature or, still worse, at the stage of laboratory research or prototypes. Implementing low-emission technologies will take a lot of effort. Moreover, there is still the problem of the last 20% or so of emissions, because they cannot be eliminated in full. Does this mean that we will have to store underground large amounts of carbon dioxide captured from the air? Or maybe we will succeed in transforming the previously degraded natural resources in a way that will re-enable them to capture such small emissions? It is certain that the natural environment will not be able to absorb them at their current level, but it may prove capable of capturing the last 20%. This is an important question, and science should be looking to answer it right now – as it will become a crucial issue, hopefully in just a few decades' time. ■