How is the energy transition possible in Europe?

Interview with Professor Georg Brasseur of the Graz University of Technology by Bert Beyers

Bert Beyers: How is the energy transition possible in Europe? We want to talk about this with Professor Georg Brasseur from the Graz University of Technology. Sometimes the idea circulates that Europe could become energy self-sufficient in the green sense. Let's play this out technically. Is there enough electricity from photovoltaics or wind in Europe to supply the continent?

Professor Georg Brasseur
Graz University of Technology

Georg Brasseur: In my opinion, that is a pious wish, a completely unrealistic dream. Man is a rather sluggish creature. In 2019, Europe imported 58 per cent of its energy. This is unlikely to change any time soon. And 85 percent of global energy is fossil energy. That's all still gas, oil and coal. If you wanted to convert the fossil energy needed by Europe in 2019 (17,100 terawatt hours) to green energy and generate it with wind power, you would have to increase the number of wind turbines in Europe from about 82,000 thirty-sixfold, a factor of 36. We would then have about 3 million wind turbines in Europe. Just imagine that, and anyone who wants something like that on their doorstep can get in touch right now. If we wanted to generate these 17,100 terawatt hours with photovoltaics, we would have to increase the area covered by photovoltaics in Europe - currently more than 2,000 square kilometres - more than a hundredfold, exactly by a factor of 111. That would be roughly the area of Romania.

If Europe were to import these 17,100 terawatt hours as electricity, what would that look like?

If Europe were to import the fossil energy in the form of electricity, 488 high-voltage lines would have to be available. And not the usual 380 kV high-voltage lines, but much more powerful DC overhead lines of 4 gigawatts each. And then a gigantic amount of power will fall out in the end, which we cannot distribute because we have no grids for it, and at the same time a power that no one can use either. A power plant today has perhaps 200 megawatts (such as run-of-river power plants on the Danube) or 1 gigawatt capacity (e.g. large coal-fired or nuclear power plants). And now, suddenly, 2000 gigawatts are coming over the line.

Because green electricity is very fluctuating. For that we would have to not only double the grids, but increase them tenfold and more. That is completely unrealistic.

What exactly does that mean for the grids and for storage?

We can't store electricity on an industrial scale. There are a few pumped storage plants, but we're talking about a few terawatt hours. But, as I said, we are talking about 17,100 terawatt hours. That seems ridiculous. With the pumped-storage plants, we can shift the daily cycle, for example when we need a lot of electricity in the morning. Or in the afternoon, then we can store the electrical energy temporarily and distribute it in the grids as needed. But that's just about electricity. And that is only 17 percent of the total primary energy globally and also in the OECD countries. The rest, the fossil energy that we consume in Europe, is burned in some form.

Could you illustrate that?

Let's take industry as an example. It needs an incredible amount of primary energy. In a steel mill, for example, you need coal to turn iron oxide into iron. Or the chemical industry, which needs a lot of hydrogen. Unfortunately, fossil methane is currently used to produce hydrogen. More than 95 percent of today's hydrogen is produced from this fossil methane. And the remaining fossil carbon is used sensibly in very few cases. It is burned, and thus we increase the fossil carbon in the form of CO_2 in the atmosphere. For CO_2-neutral production, the industry would need an incredible amount of hydrogen. And that is why it will be very difficult to provide enough electricity for households, especially if they use heat pumps instead of fossil energy for heating. This would actually be a good idea because you can save a lot of primary energy. But you need additional electricity for that. And you take that from a "reservoir" that currently accounts for only 17 percent of global energy demand. In addition, there are areas that only function with electricity, such as information and communication technology. So there is a great danger of a blackout due to too many consumers. And we cannot afford that in the highly developed countries.

In our thought experiments we asked whether it would be technically possible for Europe to supply itself with green electricity. We also considered whether we could import this green electricity. They say: neither can work. But even if it did work, would it be affordable?

Talking about money is certainly important. But first you need a vision of how to do it. It's a fact that we can't transport the amounts of energy we need in Europe exclusively by electricity, with several pipelines and ships, as we have today, it would be possible. If a pipeline were a cable, it would have about 60 gigawatts of connected load and, unlike electricity, it would also bring a storable energy source to Europe. Electricity does not have energy, electricity can only transmit energy from the source to the consumer. And if the power transmitted with electricity is very high, there are grid problems as a result of the high power to be transmitted. Electricity storage within Europe for the required amount of energy (17,100 TWh) and power (1952 GW = 17,100 TWh/year divided by 8760 annual hours) does not exist.

What kind of pipeline would that be?

Of course, it depends on the dimension and whether it transports oil or natural gas. But that is not important. There's this funny saying about engineering: When the engineer can't think of anything else, he becomes precise. In this case, that means we only need to worry about the numbers before the coma. We need to look at the big picture. The fact is, Europe imports 58 percent of its energy. And we cannot import or transport these quantities by means of electricity. We have already dealt with that.

So our thought experiment has failed.

Yes, the "electricity" option to obtain the required 17,100 TWh does not work.

So what is the alternative?

We have already learned something. That's the beauty of technology. When you have a problem, you make a list and record what doesn't work - in the hope that in the end something will remain that we hope will work. We already know that we in Europe are not energy-autonomous and cannot become so. Electricity alone won't do it either. Electricity is an important tool, but it cannot be done with electricity alone. That means Europe has to introduce some other form of energy. Not only to Europe, every continent has to ask this question, because you can't lay intercontinental pipelines. We have now seen how long it took to complete Nord Stream 2. With today's technologies, it is unthinkable to want to lay pipelines between the USA and Europe. So we need transportable forms of energy. And nature has already shown us that.

What is your suggestion?

To imitate nature. And nature tells us that the ideal energy carriers are glucose - produced via photosynthesis - or if it needs even more condensed forms, then nature has invented vegetable oil or fat for this purpose. In other words, if we need energy carriers that we can walk between continents, then we have to take note of the optimum found by nature over a good three billion years, and that is hydrocarbons. Humans have far too little time to find a better energy source. Whether that is methane or petrol or diesel, methanol, alcohol or ammonia, it doesn't really matter. But it has to be an energy carrier that is easy to transport and store under our environmental conditions. And that is not hydrogen. We can learn that from nature, too. Hydrogen does have a high gravimetric energy density, namely 33 kilowatt hours per kilogram, but a very low volumetric energy density. Because the gas hydrogen is so incredibly light.

So we can't transport hydrogen very well.

Almost not at all. You can try to transport hydrogen under high pressure. You might be able to do that at 700 bar in the small tanks for cars. If you put methane (CH_4) into a bottle at 200 bar, you would still have a factor of 1.5 more energy inside than in a comparable bottle of pure hydrogen at 700 bar. The reason for the strange behaviour that adding one carbon atom to every four hydrogen atoms significantly increases the volumetric energy density is atomic bonding. Nature teaches us how to make hydrogen a highly energetic, easily transportable and storable energy carrier via atomic bonding to e.g. carbon. Another way would be to bond hydrogen to nitrogen. Then we would have a nitrogen cycle with ammonia. This is toxic to us and it is water-soluble. But nature has found that the metabolism of a creature with a carbon cycle works much more efficiently than that of a creature with a nitrogen cycle. That's why we see predominantly carbon-based metabolism in the world today.

You are not talking about decarbonisation, but about defossilisation.

The carbon must remain with us, but it must be a biological carbon. Plants can do that, and that is still, thanks to photosynthesis, the cheapest way to capture carbon from the air and store it in the plant mass. Nature does this with low efficiency, as there is much more solar energy than is needed, but with high resilience, i.e. biodiversity, in order to preserve life on earth in the event of dramatic environmental changes. This will to survive has been anchored in every plant and animal since time immemorial. For today's mankind, instead of biodiversity, the efficiency of a process is important for cost reasons. As already explained, nature shows us that carbon is the most important element for turning hydrogen into a good transportable and storable energy carrier via atomic bonding. This can be methanol, for example. But if I have oxygen in my energy carrier, that's not a good idea, because then the energy density drops. Why? Because oxygen as an oxidant is available for free in the environment.

Europe represents about ten percent of global energy demand. Let's stay with the example. What is your concrete proposal for the European energy transition?

Quite simple in itself. We use exactly the energy sources we have today and copy them. Even the best engineers won't come up with anything better. Nature has had millions of years to experiment with finding the best possible energy source for our environmental conditions. In practical terms, this means we use so-called drop-in fuels, i.e. fuels with which we can dilute the fossil ones. Because the upcoming conversion processes will take decades. (Unfortunately, we don't have a "Charmed Jeannie" who just blinks her eyes once and everything works). Now we can discuss at length whether the energy carrier is methane or alcohol or diesel fuel or paraffin or petroleum or methanol. All of these lead to energy densities of 5000 to 10,000 watt-hours per litre. Nature has shown us that. And we have to imitate it. Plurality is important and the markets must show which solutions will last in the longer term.

At the beginning there is solar energy. It can be harvested through wind turbines and solar power plants. Where does it go from there?

Photovoltaics and wind turbines basically convert the volatile energy into electrical energy. That is the first step in the conversion process. The next step is to produce the energy carrier hydrogen in an electrolyser by splitting fresh water caused by the flow of electricity. So far, however, there are no plants that are anywhere near the size we will ultimately need. We have to build them. Basically, we know how to do it. We need huge amounts of hydrogen. But we can't transport it well, and certainly not intercontinental. That means we have to produce and consume this hydrogen locally, if possible. If, for example, wind farms are operated in Europe - and we will need many of them - then the electrical energy is fed to a large consumer, where it is converted into hydrogen with fresh water in an electrolyser and, if possible, stored temporarily in underground caverns. The large-scale consumer thus has sufficient hydrogen for its production throughout the year, decoupled from the availability of volatile energy, if the size of the wind farm or photovoltaic farm was sufficiently dimensioned. And this hydrogen is then used, for example, by a steelworks, or the ceramics industry, the cement industry, the lime industry and the chemical industry. And this hydrogen must be produced as locally as possible, in the respective continent, in the USA, in Europe, in Australia, because it cannot be transported intercontinental.

Is there a green energy storage facility that you prefer?

For decades, in addition to hydroelectric power plants, gas power plants powered by natural gas (fossil methane) have ensured that the balance between electricity demand and electricity supply is quickly achieved (in about 15 minutes), i.e. that the grid is stabilised, and have the lowest CO_2 emissions in terms of calorific value compared to oil and coal power plants. Synthetic methane would therefore be the most important green energy storage to stabilise the grids in the future under human control. For this we need caloric gas-fired power plants, even many years from now. Power plants that have already been in operation for decades and that are powered by natural gas, but that in the future will hopefully operate with synthetic methane and thus without fossil CO_2 emissions, because volatile energy, as the name already says, is not always available when we need it, but when nature gives it to us.

We are talking about wind and solar energy.

At the moment, these account for only 3.3 percent of primary energy globally. We have to make 100 per cent of that, so to speak. Hydropower and nuclear power are already quite developed. Even if we double these, it still doesn't add up to much. Pumped storage plants cannot be expanded indefinitely either. In Austria there are currently many with a total storage capacity of about 3 terawatt hours, and we can't suddenly make 50 of them. That is another reason why we need energy sources that can be stored and transported. And methane is incredibly important because it can be mixed with natural gas for decades. More and more synthetic methane can be injected into the gas grids. You can also increase the proportion of hydrogen in the gas grid within certain limits. You don't have to invent anything new. You can even use the existing infrastructure. And I doubt that any country can afford to build a completely new energy distribution infrastructure that can't actually do more than what we already have. We are looking at an optimum that nature has figured out in countless experiments. We cannot be smarter than nature because we do not have hundreds of millions of years to find a better solution to the energy source problem.

And finally, we need liquid fuels.

There are many applications where liquid fuels are better suited. And here we are with mobility, i.e. aircraft, ships, trucks or cars. Whenever you need an extremely high energy density, you turn to liquid fuels - at a reasonable pressure. If you take propane gas, for example, depending on the temperature and pressure in the bottle, the energy density is about 6,000 watt-hours per litre; with petrol and diesel it is about 10,000 watt-hours per litre.

And now it comes down to the "harvesting" of the energy.

In Europe, the utilisation of wind turbines is about 24 percent onshore and 40 percent offshore. If, for example, one installs a wind turbine with 5 megawatts (MW) and could operate it with 5 MW over the entire year, then that is 8760 hours times 5 MW. This should yield 43.8 gigawatt hours (GWh). In fact, however, only 10.5 GWh were obtained. This means that the utilisation of the wind turbine was "only" 24 percent. As you can see, 24 percent is not much, because you can get 40 or 50 percent for the same money in areas where there is more wind. And with solar energy, the situation is even more dramatic: the utilisation rate is 12 percent in Europe and only 11 percent in Germany. This means that you have to install a lot of power in order to get the same amount of energy per year as from a calorific power plant, which can operate for a good 8,000 hours per year.

This also means that domestic green electricity is in short supply.

An example. Currently, one and a half percent of vehicles in Germany are electric or hybrid. That works. But it won't work if it becomes 20 or even 100 percent. We don't have the electricity for that. The electricity has long been sold: for ICT, for heat pumps to reduce CO_2 emissions or for hydrogen, without which industry cannot exist to produce "clean". Moreover, it is not possible to distribute the charging power for the electric vehicles via the existing grid, let alone in a fully developed network. So the problem does not arise at all. We won't even get that far. Because we need the electricity for other applications much more urgently.

You said that wind and solar power plants have a relatively low output in Europe. Where should they be built?

Around the equator plus minus about 35 degrees of latitude the solar radiation is much better than in Europe. Of course, there have to be areas where it is rather dry so that cloud formation is rather low. There you can easily get a factor of two or three more "harvest" for the same investment. Coastlines are ideal for wind turbines. This is all beautifully documented. You only have to search the internet. There are atlases that list exactly how much energy can be generated where. Then you need fresh water for electrolysis. You can't use salt water because, as far as we know today, the salt, sodium chloride, destroys the electrodes in the electrolysis devices. But providing fresh water is not a big problem. For example, optimal locations for wind or solar farms have been found and high-voltage power lines are being built where fresh water for electrolysis is available and a port for shipping the transportable energy sources produced. One could also use seawater desalination plants to obtain the fresh water needed. However, this makes the production of the energy carrier more expensive and puts us at a competitive disadvantage on the market. Hydrogen is obtained through electrolysis. In the next step, this hydrogen is converted into liquid or gaseous fuels on site and partly loaded onto ships for transport, e.g. to Europe. "Partly", because regions for the construction of the synthesis plants, wind and solar parks will also be selected according to the viewpoint of making the remaining part of synthetic fuel available to the local population. These poor growing nations, which together are responsible for about 30 per cent of global CO_2 emissions, will thus be given the chance to obtain low-CO_2 drop-in fuels. Just like us Europeans, these countries also have the right to more prosperity.

What does that mean?

It means that if you want to achieve the climate goals, you have to give the people in the Growing Nations the chance to get green energy, i.e. build synthesis plants on site. Because a growth in prosperity is always fundamentally linked to an increase in energy consumption and thus in fossil CO_2 emissions. Thus, the production of synthetic fuels in poor countries not only serves to satisfy the energy hunger of the wealthy industrial nations, but in particular to secure peace. Jobs are created in the construction and operation of the plants. This also reduces the desire to emigrate, as the homeland offers an attractive future. If no growth in prosperity is possible, riot among the population arises and possibly war. In warlike conflicts, no one thinks about saving CO_2, but tries to somehow keep the family alive and protect themselves. This means that the industrial nations should conclude contracts with the Growing Nations and provide them with the facilities to produce synthetic fuels. This is how a worldwide free market can eventually develop. But that will take decades. We must not forget, fossil energy has a very high energy density and at the same time it is very cheap. This means that this transformation will not happen by itself. It has to be forced by the countries through regulations and incentives. The release of fossil carbon must be taxed in some form and the use of non-fossil (biological) carbon must be encouraged. It will not work otherwise.

Slowly the picture is rounding out. We started this discussion with a thought experiment, namely European green energy self-sufficiency. That quickly turned out to be unfeasible. So we need green, storable energy sources in some way. And finally, you drew the global picture, the cooperation between North and South. Do you see yourself represented anywhere in the current political landscape with this vision?

There are already many activities. The IPPC is concerned with climate change, I am currently more concerned with one of the causes of global warming, i.e. "energy". But there are other causes of the climate problem, such as agriculture. Sociological and political aspects also need to be taken into account.

And the economy should also be taken into account. After all, it all has to be paid for.

Well, we are still in the Corona pandemic now. "Whatever the cost", the Austrian Chancellor said. Because human life is not worth money. Hopefully, we won't have a pandemic in the coming energy transition, but we will have to spend similar money. We're talking about 1 or 2 percent of GDP that would have to be invested over a certain period of time. For comparison: Europe imports fossil fuels year after year for about 320 billion euros. They are simply burned and gone. And it's not much different in other countries and continents. This sum could just as well be invested in plants for the production of green energy. Afterwards, of course, you have operating costs. But they are manageable, because the primary energy wind, sun and water for electrolysis are free. And if you amortise the investment over 30 years, then you arrive at orders of magnitude similar to the 320 billion euros per year mentioned.

Do you have the feeling that these ideas are already mainstream?

No, it will take time. We are still doing far too well. Recently, we have seen many natural events that are obviously the result of climate change. And the Mediterranean is unfortunately a hotspot. The effects there are particularly rapid and intense. Just like in the Arctic, where the temperature is rising much faster than in the rest of the world.

How do you get your vision onto the rails politically?

The knowledge exists. Not only in my head, it exists in many heads. It's about using this knowledge to achieve understanding in the listener. Someone who really understands how it works and how everything is connected has a basis for decision-making and will choose the right thing because they have children or are thinking about their grandchildren and great-grandchildren. There are tipping points with the climate. If the energy transition does not happen in the next 10 or 20 years, it will be too late. Then there will be too much CO_2 in the atmosphere. This means that the Earth's "fur coat" is so thick that far too little heat is radiated into the universe - compared to what we permanently receive from the sun. And that is why it is getting warmer. Nature doesn't care, it knows the solutions. Then the earth changes and with it the species that thrive on earth. There will be a global and large-scale extinction of species, but this offers the chance for species that can adapt to the new world climate. Humans may be one of the species that are doomed as a result of climate change.

Again, what can be done to be heard?

Explain the interconnections of global energy flows and their impact on CO_2 emissions and human coexistence to the public and politicians at every appropriate and inappropriate opportunity. And do so scientifically, through verifiable facts and not through ideologies and political opinions. Write articles in media that are also read by the population. In a form that is also understandable, with as many examples and parables as possible that are tangible. No one can imagine 488 high-voltage power lines or 17,100 terawatt hours. But what one can imagine: In Austria we have 3 terawatt hours of pumped storage to store electricity. If you wanted to replace these 3 terawatt hours with batteries, it would cost about 300 billion euros. So the batteries as we have them today will not save the world. We have to spread these facts, not ideologies, not political opinions, but scientifically sound facts. And when politicians say that we're now going to do everything with green electricity, then they get a page-long list from science of what positive and what negative effects these political guidelines have on the energy transition. Ultimately, however, it is the politicians who have to decide, knowing the scientifically based advantages and disadvantages of each decision. The population will foot the bill for wrong decisions at the next election. Therefore, it is important that the population is well informed about the scientifically sound facts of the energy transition. To the Video.

Further Infos under:

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