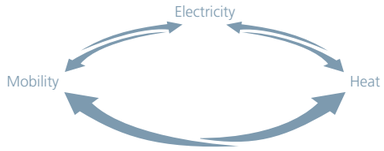
**Carsten Agert**

is Director of the DLR Institute of Networked Energy Systems. A physicist, he has been a professor of energy technology at the University of Oldenburg since 2008. At the same time, he took over the running of the newly founded EWE Research Centre NEXT ENERGY, which was transferred to DLR in 2017 and became the Institute of Networked Energy Systems. Among other roles, Agert was vice president of the Association of European Renewable Energy Research Centres (EUREC) from 2009 to 2011, a member of the Energy Transition Round Table of Lower Saxony's state government from 2015 to 2016, and has been spokesman for the Executive Board of the Lower Saxony Energy Research Centre since 2017.

# SYSTEM SWITCH DURING OPERATION




**The energy transition has two clear winners so far among renewable energy sources – photovoltaics and wind. In total, renewables now generate approximately 40 percent of Germany's electricity supply. But how can they be developed nationwide to provide heating and facilitate mobility for both people and goods? How can they replace fossil fuels, which are soon to be abandoned? Carsten Agert, Director of the DLR Institute of Networked Energy Systems, believes the answer lies in sector integration, also known as sector coupling.**

At DLR's Grid Lab in Oldenburg, it is possible to depict residential areas realistically, with all of their energy flows. For example, the researchers are investigating new network structures and the integration of electromobility into the energy system using a real-time simulation system.

## An interview with Carsten Agert on sector integration in the field of energy supply

**The average share of renewable forms of energy within our power supply system exceeded 40 percent this year. This demonstrates the success of the energy transition, right?**

**:** It is a gratifying snapshot – but we have to look at things in their overall context. Industrialised countries have set themselves the target of reducing emissions of carbon dioxide equivalents by 80 to 95 percent by 2050 compared with the base year of 1990. If we look at what has to be achieved by 2050, we can see a fundamental, far-reaching change ahead – which can probably only be compared to 19th-century industrialisation in terms of its sheer scale.

**So, have we been addressing the energy transition too slowly?**

**:** As I see it, we have been too one-sided. For about the last 20 years, since the Renewable Energy Sources Act came into force in 1998, we have done the obvious – installing wind turbines and solar power plants. So we have harvested the 'low-hanging fruit'. By contrast, the transport sector has largely been overlooked, which is why we are seeing stagnation in this sector, with the share of renewable energy in fuel at about six percent. The heating sector is looking very similar. So our interim conclusion is this – yes, the energy transition is under way, but we are still at the beginning. Now is when it actually starts to become difficult.

**… but are you confident that DLR's energy research will be able to develop robust concepts for a stable, safe and economically attractive energy supply system?**

**:** Absolutely. It is true that the expansion of solar and wind power within the electricity sector has reached a level that makes further expansion structurally and technically more difficult. However, if we include the heating and mobility sectors, which are also structurally complex, we will be able to develop attractive cross-sectoral solutions. As researchers, our task is to look for areas of flexibility within the energy system that may help us to cope better with the reality that patterns of production and consumption do not always match. The massive storage and flexibility potential that we need to match supply and demand can only be achieved through sector integration. Although it is a term usually associated with e-mobility, we understand sector integration to mean 'combining power, heat and transport in such a way that these three sectors can grow together to form a large, integrated energy system.

**Why are the interfaces between the different energy sectors so important to the success of the energy transition?**

**:** Sector integration represents the point of entry from a mere electricity transformation to the true energy transition. At present, for example, the heating sector is still primarily based on natural gas, and, in some cases, also on oil. But if we look at the 2050 climate goals, one thing is abundantly clear: we cannot continue to produce heat simply by using fossil-derived methane or oil. Mobility is facing a similarly profound change. Cutting around 80 to 95 percent of Germany's carbon dioxide emissions by 2050 means that cars can no longer be allowed to emit fossil-derived carbon dioxide molecules. The average lifespan of a car is 15 years, so the last new car that still burns fossil fuel should be produced no later than 2035 for the German market. The European Union recently held discussions about whether we can call for a 30, 35 or 40 percent reduction in emissions for new cars by 2030. We would actually have to demand 100 percent five years later. In other words, if we are to have a chance of achieving our climate goals, we must very quickly switch the heating and transport sectors completely to renewable energy. Making such changes will give us the opportunity to harness the immense potential for greater flexibility offered by sector integration. We need that flexibility if we want to design a stable energy system around the fluctuating supply of renewable energy. What is more, sector integration gives us access to major storage potential.

**How exactly does sector integration work? From a technical point of view, why is it important to make the energy system more flexible? How can we offset fluctuations in the power grid with heating and mobility?**

**:** If too much energy from renewable sources is fed into the grid – perhaps because there are strong winds – we can reduce the output of the generating plants, or we could use or store the excess energy. In this case, we have to bear in mind that it is much cheaper to store heat than electricity. So if I have an electrically powered heating system that is coupled with a thermal storage system, it makes sense to generate heat when there is a surplus of electricity, not just whenever I need heat. Thermal storage systems therefore give our energy systems greater flexibility.

But sector integration also works in the other direction. Take mobility, for example – we can make hydrogen during the periods when there is more than enough electricity. In this case, the energy is stored as a

The DLR Institute of Networked Energy Systems in Oldenburg, Lower Saxony, currently has approximately 150 employees. It develops technologies and concepts for future energy supply systems based on renewable energy sources.

chemical source. This hydrogen can be converted back into electricity at any point if the demand exceeds the available renewable energy in the grid. Our goal is to couple the transport sector with the electricity sector at both ends – we turn electricity into hydrogen but leave ourselves the option of using transport infrastructure to turn the hydrogen back into electricity. DLR's energy and transport institutes are already working closely together in this area.

**Your examples are based on hydrogen. Do you believe that this chemical source will shape the future energy system alongside electricity?**

**:** We would do well to agree on a common chemical energy source for the future, within the context of sector integration. I do not imagine, for instance, that we will be using hydrogen for transport, synthetic gas for heating, and perhaps another molecule for a third application, as we would need specialised logistics and infrastructure for each one. However, the question of which energy source that will be remains to be answered. Personally, I believe it will be hydrogen.

**Let us imagine a future in which one chemical energy source has been selected, and there are sufficient facilities supplying renewable energy. Does that mean that energy researchers will have done their job?**

**:** The work really begins once the individual technologies are running and established. The way in which these future networked energy systems operate will be fundamentally different from how they work today. Decentralisation, fluctuating generation and digitalisation are the key areas that will provide us with challenges at the system level of the energy transition for many decades to come. In order to address these challenges, we at the DLR Institute of Networked Energy Systems are developing technologies that can transport energy across sector boundaries. We want to be sure that such technologies do the right thing at the right time, work reliably and are user-friendly. In addition, we incorporate them into the systems analysis as part of our overarching strategy, which takes into consideration technical, sociological, environmental and economic aspects. When designing future energy systems, we also need individual technologies such as solar power plants, storage systems and gas turbines, which are being researched at other DLR institutes. But the further course of the energy transition will largely depend on whether we manage to fundamentally reshape our energy system using very good individual technologies, including the system level.

**Your researchers are looking at the desired transformation of the energy system from many different perspectives – from energy management to system services, through to highly specific recommendations for action by industry and government. Why does converting the existing system to renewable energy present such big problems?**

**:** The technical requirements of the future power system are very complex. Let us take one example – even on days when there should not be any storage problems, as the amount of energy available from the solar and wind generators approximately matches demand, we still need an array of new solutions in order to ensure a stable energy system based on renewable sources. Among other things, this is due to the fact that we are still deriving a lot of benefits from the inertia of large, traditional generators. These help us manage the stabilisation of our electricity system. Turning to solar and wind, we are essentially dealing with power electronics that do not have this inherent inertia. This has a number of implications, especially for the short-term regulation of energy systems. In addition, the energy system will be highly decentralised. It will no longer be a matter of controlling a handful of large power plants, but rather countless small power plants.

**Let us look at a current hot topic – the expansion of the major power lines from windy northern Germany to the south of the country. To what extent can the energy system be stabilised by interregional or even European networking?**

**:** Better interregional networking is a fundamental prerequisite for ensuring the security of supply that we are used to today while using renewable energies in the future. In the decentralised, regional parts of the energy system, we will never find the degree of affordable flexibility that would allow us to manage energy autonomously on a small-scale, at the local level. That is why we need large-scale, high-performance networking for security of supply. Otherwise, we will not be able to create an energy system that is reliable, stable and affordable.

**Given all these enormous challenges, do you sometimes wish that you had someone like Greta Thunberg at the Cabinet Table? In future, should the government create stricter framework conditions for the success of climate protection and the energy transition?**

**:** The spirit of the 'Fridays For Future' movement would be good for climate policy, there is no question about it. In the electricity sector, the energy transition is faltering, and the expansion of renewable energy sources has not yet delivered the desired degree of effectiveness in terms of reducing emissions. But the bottom line is that it is still making progress. In the transport, aviation and heating sectors, however, the energy transition has hardly begun. I would argue that the decisions on phasing out fossil fuels should be seen as an opportunity to finally install a nationwide – and cross-sectoral – system for minimum pricing or taxation of carbon dioxide. This would stimulate resourcefulness within our national economy much more effectively than fragmented, hotly contested attempts at regulation. The younger generation is reminding us on a weekly basis that we need to act now.

The interview was conducted by Heinke Meinen of Communications at the DLR Institute of Networked Energy Systems.

The 'eye2sky' monitoring network, which is currently being set up by DLR in northwestern Germany, measures the formation and movement of clouds in the sky across the entire country. This allows the yield of solar power plants to be predicted minute by minute. Such exact predictions are not possible using satellite imagery, because the shadows of clouds – rather than their position – are the decisive factor for the yield of solar power plants.

"Storing heat is much cheaper than storing electricity," stresses Carsten Agert. Against this backdrop, DLR is conducting research into electricity-based heating systems combined with thermal storage at its Combined Heat and Power (CHP) Laboratory. If the heat is generated at a time when there is a surplus of electricity, this makes the energy system more flexible.

The DLR researchers in Oldenburg are also investigating how electromobility can be integrated into future power systems. For example, this could make it possible to use the batteries of electric cars to compensate for power grid fluctuations.