Powering toward a zero-carbon energy system

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AI expert Dr. Stefan Klaiber (left) and ZO.RRO project staff member Juliane Sauerbrey (right) want to advance the cause of a CO2-neutral society. Credit: Fraunhofer IOSB-AST/ Martin Käßler

Can tomorrow's energy supply be freed of CO_2 Fraunhofer researchers want to answer that question with a consortium of partners in ZO.RRO,

a joint project underway in the German state of Thuringia. They are developing a complex IT ecosystem to facilitate the systemic exit from fossil fuels—a package of IT solutions designed to slash greenhouse gas emissions. This research venture centers on system services, which account for up to 20 percent of CO_2 emissins.

Germany is off to a good start on its journey to renewable power generation. As the nation's exit from fossil fuels enters the second phase, the focus is shifting toward reducing energy consumption and carbon emissions. This is what ZO.RRO is all about. Short for Zero Carbon Cross Energy System, the joint ZO.RRO project aims to deliver carbon-free energy to the Free State of Thuringia. The partners in this project are looking at the bigger picture of interconnected electricity, heat and gas grids—which experts call sector coupling. Unlike earlier projects that focused largely on supplying power, this venture is also addressing the impact of system services. Studies have found that they account for 20 percent of carbon emissions. System services are essential to keeping energy grids up, running and stable, and to restoring safe operations after outages.

The perfect energy mix for Thuringia

Researchers at the Advanced System Technology (AST) branch of the Fraunhofer Institute of Optronics, IOSB aim to make the most of heat, gas and electricity sector coupling to eradicate system services' carbon footprint. To this end, they are developing a complex IT ecosystem comprising hardware and software solutions. Their first step is to model the optimum mix of technologies for Thuringia. They are considering two scenarios: renewable energy systems and storage and hydrogen technologies figure prominently in the more innovative option. The conservative alternative factors power-to-gas and gas-fired power plants into the energy equation. "Our goal is to make Thuringia's energy supply CO_2-neutral by 2050 and to find the most cost-effective way of doing

this. CO_2 emissions are determined when the calculated cross-sector technology mix is sufficient for stable grid operations. If stable operations are not possible, this feedback flows to the energy system planning entity," says Steffi Naumann, a researcher and project manager at the Fraunhofer IOSB-AST.

The optimization model shows which technologies are best suited for installation in a future technology park in Thuringia, the prerequisite for inclusion being minimal greenhouse gas emissions.

An IT ecosystem for zero emissions

The research team at the Fraunhofer IOSB-AST designs IT systems for monitoring current CO_2 emissions and managing flexibility options. "If we want to minimize global greenhouse gas emissions, we will need IT systems to control the complex dynamic interactions of energy supply systems based primarily on renewable energies and to ensure safe and reliable operations at all times. They can also be used for other purposes, for example, to visualize forecasts for CO_2 emissions based on the supply system's energy usage plans and the companies that consume this energy," says Juliane Sauerbrey, Steffi Naumann's colleague in the ZO.RRO project. This researcher and her team are putting together a hardware and software package to create a complex IT ecosystem. It includes the ZO.RRO Box, a sensor system that furnishes data on electricity and gas consumption. Converted into a CO_2 equivalent, this data provides an indication of current CO_2 emissions. Other components include a database and a CO_2 monitoring tool that conveys the current CO_2 footprint to a supervisory system for optimization potential to be spotted that much faster during operations. The primary sources of CO_2 emissions are easily detected with this tool's live monitoring capabilities. Companies enjoy a monetary benefit by minimizing their CO_2 emissions: they are spared the expense of buying CO_2 certificates. "What sets our tool apart—alongside the live monitoring—is that it takes sector

coupling into account," says Sauerbrey.

An app for managing flexibility options puts the finishing touch on this package of solutions. With this tool, the operator can take advantage of existing flexibilities to shift gas, heat and electricity loads to minimize the CO_2 footprint and offer CO_2-free system services. These hardware and software solutions can be installed at companies, municipal utilities, government ministries, in neighborhoods and the like. "Of course, private households also benefit from the new energy concept." A three-person household consumes around 2,600 to 3,900 KWh per year. Given an emission factor of 500 grams per kWh for the German electricity mix, this amounts to up to 1.95 metric tons of CO_2 per year and—depending on how the CO_2 price develops—between 80 and 350 euros a year in CO_2 costs for electricity alone. We want to drastically reduce the carbon footprint and significantly lower costs for households with our approach," says the researcher.

Research approaches that work for all federal states

Researchers are developing this model for a cost-effective and climate-neutral energy supply system in Thuringia, but the ZO.RRO project's methods are portable. They could be transferred to every federal state and would work throughout Germany. The German Federal Ministry for Economic Affairs and Energy (BMWi) and the Free State of Thuringia are funding this project, which will wrap up in December 2021. It will be followed by a demonstrator phase involving companies and partners who will test the IT systems.

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