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Modeling and optimization for climate neutrality

Sonja Wogrin

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In Europe, we have embarked on the journey towards net-zero power systems. We want to reach full decarbonization by 2050 (European Commission "A clean planet for all") to comply with the Paris Climate Agreement goal of keeping global warming well below 2 °C compared to pre-industrial levels. As an intermediate step for 2030, the EU proposed the Fit-for-55 package in July 2021, which aims to reduce greenhouse gas emissions by at least 55% while increasing the share of renewable energy sources in the overall energy mix to at least 40%.

Austria wants to reach carbon neutrality in the power system already by 2030 (Erneuerbaren-Ausbau-Gesetz (EAG)) and the decarbonization of the entire energy system by 2040—an unprecedented challenge for the energy sector. In order to achieve this goal, the EAG defines that +27 TWh of electricity from renewable electricity sources (RES-E) (+11 TWh photovoltaic (PV), +10 TWh wind, +5 TWh hydro, and +1 TWh biomass) have to be added between 2020 and 2030. This fundamental change in Austria's electricity system necessitates considerable investments made in a timely and efficient way.

Complex systems, such as the electric power system, are governed by physical laws and technical limitations that often lead to non-convex, mixed-integer, large-scale optimization models. Moreover, electric energy is traded in liberalized electricity markets—competitive environments that can be assessed via game theory as equilibrium problems. The Institute of Electricity Economics and Energy Innovation (IEE) that I am heading here at the Graz University of Technology has contributed to both research and teaching in this field for more than 20 years. With this special issue, we want to shed more light on the significant contributions mathematical modeling, optimization, econometrics, and even machine learning can make as decision support tools to achieve such ambitious climate neutrality goals by tackling relevant challenges in energy economics.

Best,
Sonja Wogrin

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Sonja Wogrin, obtained a Dipl.-Ing. in Technical Mathematics at the Graz University of Technology and a Master of Science in Computation for Design and Optimization at the Massachusetts Institute of Technology in 2008. She obtained her Ph.D. in 2013 at Comillas Pontifical University, where she also worked as a researcher and Associate Professor in the Industrial Organization Department. Since August 2021, she has been the head of the Institute of Electricity Economics and Energy Innovation at Graz University of Technology. Her research interests lie within the area of techno-economic decision support modeling in the energy sector, optimization, and, in particular, the generation capacity expansion problem.

S. Wogrin is an OVE member.

S. Wogrin (✉)
Institute of Electricity Economics and Energy Innovation, Graz University of Technology, Inffeldgasse 18, 8010 Graz, Austria
wogrin@tugraz.at