RWTH Aachen University – Energy Hub Design Optimization

Case Study

Discover how a web-based tool – developed by a research group at RWTH Aachen University and powered by the Gurobi Optimizer – enables users to optimally configure and design complex energy supply systems.

The Challenge: Planning Complex, Cross-Sectoral Energy Supply Systems

Energy supply is one of the key considerations for planners who are designing and developing new buildings or districts. These planners must ensure that the energy supply systems they put in place are reliable, sustainable, and capable of handling energy demand – today and in the future.

Indeed, planning these cross-sectoral energy supply systems (which are also called multi-energy systems as they supply various energy forms including heating, cooling, and electricity) is a complex and challenging task. When designing these multi-energy systems, complicated decisions must be made on:

- Technology selection, taking into account many different generation and storage technologies including renewable energies, battery and thermal storage as well as natural gas, biomass, or hydrogen technologies.
- Component sizing.

Conventional, manual planning tools like Excel are not capable of handling the complexity involved in designing these multi-energy supply systems and determining the optimal configuration of technologies and storage options. These conventional, manual planning tools – which typically rely on heuristics – can only consider static design points for a very limited number of hours of the year.

To enable users to design the optimal energy system configuration – taking into account the behavior of the energy system over an entire year for a large number of design points with an hourly resolution – an automated tool powered by mathematical optimization is required.

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The Solution: An Automated, Web-Based Design Tool Powered by Mathematical Optimization

A team of researchers at RWTH Aachen University's Institute for Energy Efficient Buildings and Indoor Climate set out to build a user-friendly, automated, web-based mathematical optimization tool that could be used by energy industry professionals as well as students to rapidly generate the optimal configuration of multi-energy systems.

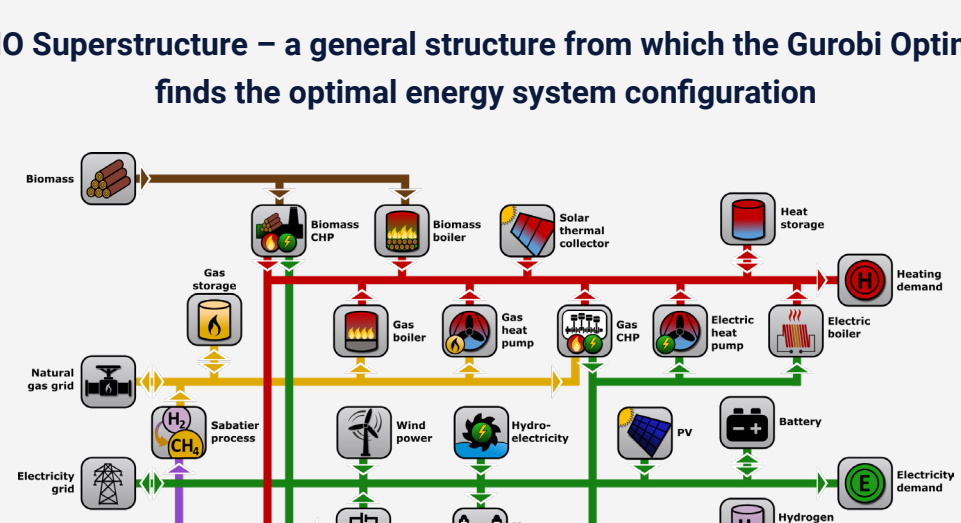
This Energy Hub Design Optimization (EHDO) tool, which was launched in early 2020, gives users the capability to plan and design optimal energy system configurations, taking into account a variety of factors including technology selection, component sizing, and numerous design points across a year-long time horizon with an hourly resolution.

"EHDO is a free, online, open-source tool that enables users – without any prior training in mathematical optimization techniques or technologies – to design efficient multi-energy systems in a matter of minutes by inputting some basic information and clicking the 'Run Optimization' button – it's as easy as that," said Marco Wirtz, a researcher at RWTH Aachen University who was involved in developing the EHDO tool.

The EHDO tool – which has the world's fastest solver, the Gurobi Optimizer, embedded in it – is built on a mathematical model that comprises:

- An economic objective function (total annualized costs) as well as an ecological objective function (CO2 emissions).
- Constraints such as energy balances, which ensure that the user-defined energy demands (heat, cold, electricity and hydrogen) are met on an hourly basis throughout the year.

EDHO Superstructure – a general structure from which the Gurobi Optimizer finds the optimal energy system configuration



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- Technical equations that describe the behavior of the generation and storage technologies, such as heat pumps, fuel cells, or heat storage units.

Users can define the parameters of their energy system in the EHDO tool by making selections from pre-defined fields to indicate the system's demand requirements, location, preferred generation and storage technologies, electricity and gas prices, and CO2 emissions and taxes.

After defining these parameters, users simply have to click a button to automatically produce the optimal configuration of their multi-energy supply system including:

- Optimal generation and storage capacities.
- An overview of heating, cooling, electricity, and hydrogen demand required by the system as well as the renewable energy resources used by the system.
- An overview of the estimated costs of the system including annual investments and energy supply costs.
- The ecological impact of the system including the annual CO2 emissions.

Users can also compare how the efficiency and profitability of their system stacks up against other energy systems.

With EHDO, users can rapidly, automatically design optimal energy system configurations, and then use these configurations to make critical decisions about technology selection and component sizing.

Why Gurobi?

Gurobi strongly supports the use of mathematical optimization within academic institutions. For this reason, the team of researchers at RWTH Aachen University was granted a free license to use the Gurobi Optimizer in the EHDO tool.

With Gurobi's state-of-the-art mathematical optimization solver at its core, the EHDO tool is able to deliver an optimal energy system design in one to two minutes.

"The Gurobi Optimizer is the mathematical optimization engine that makes the EHDO tool run," remarked Wirtz, "We chose the Gurobi Optimizer because – after conducting numerous tests against other commercial and open-source solvers – we determined that Gurobi had superior speed and also had a very easy-to-use Python syntax."

"We would like to thank Gurobi for supporting our work and partnering with us on this EHDO project," Wirtz added.

Click here for more information on the EHDO tool.