



## Saving energy in commercial and industrial parks

Planning tool helps establish economical integrated power networks



*Industrial parks are typically home to a diverse mix of cross-industry businesses. The requirements of these businesses vary when it comes to energy supply depending on the nature of their production. For businesses in the metal processing industry for instance, thermal energy requirements in the range of many hundreds of degrees Celsius are typical, while in the food industry, heat requirements are rarely above a hundred degrees Celsius. Businesses operating in the direct vicinity can make good use of waste heat from such processes.*

On an industrial park it is possible to network numerous energy supply systems and consumers of closely neighbouring companies and to interconnect processes. Great efficiency gains can be achieved through the effects of compromise and synergy between different companies than would otherwise be feasible through the separate optimisation of stand-alone systems. Industrial parks consequently are often supplied with power by a central site operator.

A newly developed software package is intended to assist planners and operators in tapping such efficiency potential. The software, developed jointly by researchers and practitioners in the scope of "Structurally optimising energy supplies for industrial parks – sOptimo" project, focuses on electricity, low and high-temperature thermal energy as principle energy sources. Further components can be included in future, such as compressed air supply, through programme extensions.

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The new software can be used to restructure or expand existing industrial sites and plan integrated energy supply infrastructures for new industrial parks. The objective in this regard is to fashion an optimal structure for highly complex industrial sites too with a vast range of supply variant combinations and topologies. The software makes it possible to optimise the energy efficiency of all systems and to intelligently interconnect mass and energy flows, e.g. through the use of waste heat, at an early stage in planning and with minimal investment costs. The software incorporates various energy sources, such as electrical power and low and high-temperature thermal energy at different temperature levels. The software maps different generator variants, such as boilers, combined heat and power plants (CHP) and chillers. The costs associated with the installation of line routes for new system construction are also factored in.

### Programme for tapping savings potential

Most businesses have steep targets when it comes to recuperating money spent on efficiency and savings measures. This is why some potential improvement measures with slightly longer payback periods or requiring reorganisation of proven production processes tend to be ignored.

The new software package provides suggestions for designing components, elements and systems. The software furthermore generates criteria for the assessment of different variants, e.g. based on investment and operating costs, capital value and CO<sub>2</sub> emissions. Computations factor in, among other considerations, the load profiles of the different consumers, the energy system structure, the topography and a technology database of integrable components.

Users predetermine the energy requirements of the components and specify a potential superstructure that establishes the maximum number and type of supply components theoretically feasible at the site. The programme uses this information to propose a cost or CO<sub>2</sub> optimal solution depending on the issue. The proposed optimal solution may also include technologies that – with a limited number of variants computable without an “optimiser” – would potentially have been ruled out from the outset.

### Optimisation with sOptimo

Pre-optimisation is implemented in a simplified method of calculation with constant efficiency factors and variable efficiency factors are used for subsequent re-adjustment. For a shorter computation time, the researchers use generator models with constant efficiency factors. This simplification drastically reduces the solution duration. The option to use variable partial load efficiency factors for greater accuracy results in a higher computing time for optimisation, in particular for complex systems. This can be counteracted through optimisation using an “optimality gap”, which specifies how far the final target function value may deviate from the theoretically possible, optimal target function value in per cent. A time limit can also be set that defines the latest possible point at which optimisation can be aborted. The two alternatives usually produce a capital value that is close to the optimum. The generator structure barely changes when the result of the calculation using an “optimality gap” is compared against the mathematically optimal solution. Where the solution duration is comparatively short, near-

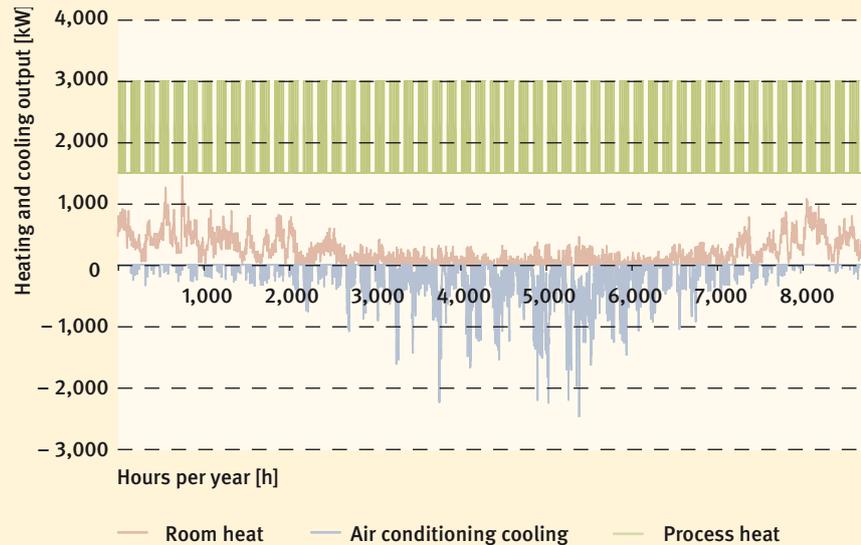


Fig. 1 Simulated load profiles of a laboratory building for air-conditioning cooling, room and process heat.

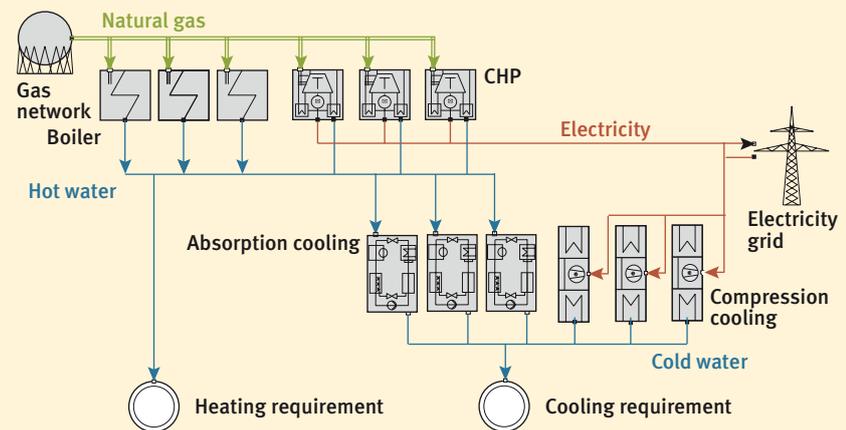


Fig. 2 Depiction of the superstructure of an energy supply system. The blue network represents the hot/cold water system, the red network represents the electricity supply.

optimal solutions are consequently delivered. Several different supply structures with almost identical capital values emerged in testing.

The new tool has been tested on a real life example with the support of the developers. The testing revealed the tool to be capable of mapping real life structures too in their full complexity and evidenced the capability of the optimisation processes to identify improvement potential. Several additional practical issues, however, might be better handled if the programme were to include additional functions. One of the objectives in this regard is to be able to identify several alternative proposals with the best possible solution properties. A further challenge lies in factoring in several conflicting target functions, e.g. costs and primary energy use.

### Simulation improves planning

To test the programme, the experts drew up an industrial site plan for a globally operating pharmaceuticals company and determined the optimal supply structure based on capital value. For anonymity, the experts transferred the industrial park's buildings and roadways to the site plan of RWTH Aachen. The experts were able to utilise existing data on maximum cooling loads in the calculations. The researchers calculated the maximum heat



## Waste heat from refineries destined for district heating

Karlsruhe provides an intriguing example of how waste heat potential can be utilised by networking generators and consumers and large quantities of energy can be saved. The Oberrhein mineral oil refinery (MiRO) is the largest refinery in Germany. The facility is unable to make further economic use of waste process heat registering below 130 °C. This temperature, however, is sufficient for district heating supply. Since autumn 2010, Karlsruhe municipal utilities have been using waste heat sourced from a section of the MiRO plant for district heating supply. The waste process heat is taken from the refinery's plants via compact plate heat exchangers and fed into the district heating network. The use of waste heat has increased the energy efficiency of the refinery by five per cent.

The municipal utilities sourced around 300,000 megawatt-hours in 2013. This equates to the heat demand of approx. 25,000 households and saves 65,000 tonnes of CO<sub>2</sub> annually.

Waste heat to be sourced from a second section of the plant from October 2015 is expected to supply a further 220,000 megawatt-hours.

The German Federal Ministry for the Environment funded this pilot project as part of the climate protection initiative, spending five million euros. It was distinguished with the Energy Award in 2013.

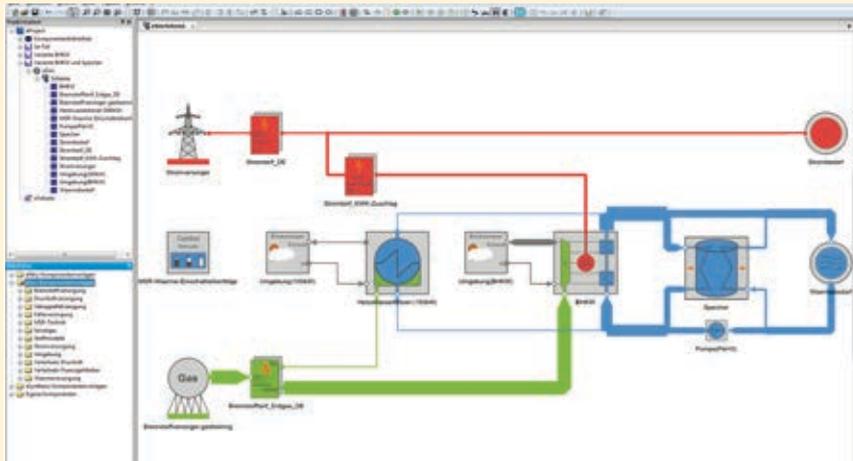


Fig. 3 Schematic illustration of a supply network in the TOP-Energy programme.



Fig. 4 Supply lines on Knapsack chemical park

loads and the load profiles for the required air-conditioning cooling and room heating with a thermal building simulation (Fig. 1). The estimated process heating and power requirements were illustrated as load profiles. Load profiles were generated for 21 buildings (production, research, office, warehouse, canteen and data centre). The real life energy supply system with electricity, heating and cooling consumers and suppliers – boilers, CHP, absorption chillers and vapour-compression chillers – is mapped by a superstructure in the Top-Energy programme (Fig. 2). All possible variants for supply of the energy required are coded in the superstructure. A subset is then selected from these variants in the optimisation.

Compared to the real life system structure, the optimal system with two integrated CHPs saves 40 % of the costs of procurement and investment over a ten-year period.

The researchers achieved this by optimising the supply structure: Compression and absorption chillers, CHPs and boilers, connected to the public power and gas network.

How long the computation takes depending on the complexity of the superstructure and the number of examined time steps was also looked at. Based on two generators with variable efficiency factors, it was possible to calculate models within a minute.

### Translation into operational practice

InfraServ GmbH & Co. Knapsack KG is involved in the project in a supporting role as a practice partner in the industrial parks sector. Two industrial parks operated by the company near Cologne are being used as application examples. For these industrial parks, the software automatically drafts variants of the existing power system and analyses these. In the process, both the structure and the topography of the power system are optimised. Criteria used in particular are the costs and air-conditioning efficiency of the system. The optimisation software not only compares variants already considered by planners, it also develops and analyses entirely new ones.

The objective of ongoing efforts is to make the methodologically verified model utilisable for a wider circle of users. The aim is to extend the tool's use to planners without proficiency in mathematical optimisation. This necessitates additional requirements with respect to the implementation of the method in TOP-Energy.

The project has been funded by the German Federal Ministry for Economic Affairs and Energy. The developers hope to launch a follow-on project to develop the software further. It is hoped future functionality will allow complex real life systems to be depicted with monthly metering time periods or even daily averages. In addition to integrating multi-criteria optimisation, the hope is that the programme will be able to address problems defined by industry partners too.



## Industry 4.0 and Smart City save energy

Industry in future will be a far cry from what we know and recognise today when it comes to production and energy management. Rather than an accumulation of businesses operating in relative isolation, goods will be produced in energy and raw material optimised processes in a networked, highly efficient and flexible system with intelligent energy management. This future approach to production is being developed by researchers and companies in a joint endeavour under the „Industry 4.0“ banner.

In intelligent energy efficiency networks, cooperating companies support one another to boost the energy efficiency of their production processes.

Yet, the holistic optimisation of energy flows does not stop there. The various generators and consumers are intimately connected at a regional level. In two EnEff:Stadt projects, models are being developed by researchers for an energy network.

In the Welheimer Mark quarter in Bottrop, Germany, they demonstrate how a mixed area containing industrial, commercial and residential infrastructures can be optimised with regard to energy utilisation and in terms of economic and ecological considerations. Software is being developed in this respect for the simulation, analysis and optimisation of urban districts, with the scope of application to be extended to other towns and cities too. The focal point in this regard is on modelling the individual system components and on creating simulation models for estimating the energy consumption of buildings. The Heatloop project investigates how waste heat in commercial areas with different industries and business sizes can be utilised via small-scale heating networks, using the example of two commercial zones in Bochum, Germany. The objective is to establish a reliable heating network that is economical to operate on a sustained basis and transferable to other districts.

Other concepts comprise entire cities. Such Smart-City strategies allow significant modernisation potential to be tapped with networked technologies in terms of energy utilisation, water economy, mobility, logistics and buildings. For Stuttgart, the “City with energy efficiency” research project has produced a long-term energy concept. It considers all energy consumers and includes households, transportation, industry, the commercial, trade and service sectors and municipal real estate. The objective for 2020 is to consume 20 % less energy than 1990 figures.

## Project participants

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## Links and literature

- » [http://www.ltt.rwth-aachen.de/en/research/energy\\_systems\\_engineering/energy\\_system\\_technique/project/Structural\\_optimization\\_of\\_distr/](http://www.ltt.rwth-aachen.de/en/research/energy_systems_engineering/energy_system_technique/project/Structural_optimization_of_distr/)
- » <http://www.eneff-stadt.info/en/design-tools/projects/details/soptimo-structurally-optimising-energy-supplies-for-industrial-parks/>
- » Stadt mit Energieeffizienz Stuttgart (SEE), [www.isv.uni-stuttgart.de/vuv/projekte/SEE/](http://www.isv.uni-stuttgart.de/vuv/projekte/SEE/)
- » Lernende Energienetze, [www.3opilot-netzwerke.de](http://www.3opilot-netzwerke.de), <http://leen.de/en/>
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