Optimising the operation of micro-CHP systems

EnEff:Wärme

Micro-CHP systems are highly efficient plants that can supply buildings with electricity and heat. Optimising the method of operation can improve the economic efficiency. Current micro-CHP systems are generally heat-led. The electrical energy generated parallel to the heat is fed into the electricity grid if there is surplus power. With electrically led operation, the generation could be adjusted to the electricity requirement of the building being supplied, thus improving the economic efficiency. A key element in this regard is the thermal storage system that enables the heating requirement to be decoupled from the electricity generation. In future this will enable micro-CHP systems to be operated as active components in smart grids.

Micro-CHP system on the test rig
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Settlement summary

Project status	Concept
Location	TU München
Project themes	Decentralised solutions, Heating and cooling, Heat and cold storage, Cogeneration, Centralised + decentralised energy supply

Project description

By 2020, it is planned to double the proportion of electricity generated from CHP plants to 25%. With an overall reduction in the heating demand, this proportion will only be achieved if, in addition to large central district heating systems, small, decentralised plants are also deployed. Mini-CHP plants with electrical capacities between around 5 and 10 kW and thermal capacities between 10 and 25 kW have been available on the market for several years. Micro-CHP plants with electrical capacities of around 1 kW and thermal capacities between 1 and 5 kW are currently being introduced to the market.
Both the heating and electrical needs of buildings and their users are subject to considerable fluctuations across time. These are only partly correlated, which means that when using CHP systems it is desirable to decouple the electricity generation from the heating requirement of the building being supplied. The key component in this regard is the thermal energy storage system. An innovative thermal storage management system was therefore developed as part of a completed project. This enables the condition of the heat storage system to be determined with little effort. This makes it easier to plan the plant operation.

Project

In addition to economically designing the overall system, a particular focus of this project is on optimising the operation of the CHP module and the management of the thermal storage system. An independent, electricity-led operation is limited by the size of the thermal storage system and the limited heating requirement of the building being supplied. The project aims to demonstrate the potential for optimising and increasing the efficiency of micro-CHP systems and to assess the energy usage in economic terms.
As part of the test rig investigations and field measurements, numerous measurement data have been acquired that enable the operating behaviour and efficiency of micro-CHP systems to be analysed and evaluated. Based on this, a simulation model will be produced and parameterised that contains all relevant components and which enables the operational conditions occurring in practice to be depicted realistically. The aim is to optimise the plant operation in a manner that enables the heat and electricity to be provided in accordance with needs. It is intended that the CHP module should supply, if possible, the building’s entire heating requirements, with an additional boiler only being used when there are thermal peak loads. The current subsidy situation means that it is more economic to use the electricity generated within the building itself, whereby only surplus electricity is fed into the grid. Should micro-CHP systems actively take part in the smart grid in future, external factors will also be decisive for the plant operation. These could include, for example, price signals that reflect the degree to which electricity is available from renewable energies. To enable micro-CHP plants to take part in the electricity markets, they are being linked for information purposes and combined to form so-called virtual power plants.
In addition to efficiently providing thermal and electrical energy, the use of micro-CHP plants for supplying electrical balancing energy at short notice is also desirable. In a supply system with a high proportion of electricity generated from fluctuating renewables that can only be planned to a limited degree, balancing energy

from virtual power plants can help secure the grid stability and thus the supply security.
Corresponding control algorithms are being developed and analysed in the simulation. The intention is to deploy robust control mechanisms that also provide good results when there are deviations from forecasts, for example as a result of changes in user behaviour.
Based on the simulation, their ability to be implemented will be investigated using test rig experiments. Using a building simulation, realistic and reproducible conditions will be created on the consumption side. All relevant parameters from the CHP plant, peak load boiler and thermal storage system will be measured with a high temporal resolution. Various control schemes can also be implemented.
In conclusion, the practical implementation of the optimised control system is planned as part of a field test. Micro-CHP systems with their standard controls have already been measured in advance during actual use. The data gained will be evaluated and used for simulations and test rig investigations. The optimised control for operating CHP plants and managing thermal storage systems will be implemented in the plants and new measurements series made. It is intended to determine the extent to which CHP systems can be electrically led in terms of their operation and whether the economic feasibility of the overall system has improved.
If in future micro-CHP systems are used on a large scale in Germany, this will have an impact on the energy industry. This impact is being analysed using scenario calculations. For this purpose the university department has an energy system model that can determine the economically most favourable development of the power plant infrastructure and its use for generating electricity under specified framework conditions such as the load characteristics for the electricity demand, the extent of development of renewables and cost parameters. This will be used to determine the economic potential for deploying micro-CHP systems.
This EnEff:Wärme research project is also being conducted as part of Annex 54, "Analysis of Micro-Generation &Related Energy Technologies in Buildings", which forms part of the IEA’s ECBCS programme.
Duration of the project: November 2011 until March 2015.