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Prospective Integration of Renewable Energies with High Capacities Using Combined Heat and Power Plants (CHP) with Thermal Storages

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Abstract

The increasing use of fluctuating generation plants like wind turbines and solar power systems makes new demands on the existing power grid. Aiming at the expand of renewable energies in our electrical power supply system and their implementation as a basic grid component will lead to an increasing demand of operating reserve and balancing energy due to the stochastic feed in character. At the same time also a strong increase of efficient CHP systems in the current supply structure will be aspired. Regarding this context decentralized plants like combined heat and power (CHP) can be used in our present power supply system in such a way, that a future electricity supply with high fraction of fluctuating renewable energies as wind power and photovoltaics could be possible. In connection with enlarged thermal storages, their specific application can add a substantial contribution in combination with an aimed electricity supply of 80 % renewable energy. According to the heat demand also this form of generation indicates a stochastic feed in or consumption behavior. The integration of thermal energy storages can decouple the production of electricity and heat from time to time. Seeing that on one side the fraction of CHP systems can be developed clearly and on the other side this kind of plant configuration makes a contribution to a functioning future power supply. The paper will describe the integration of such cogeneration systems on basis of the German supply system. To combine heat and power operated solutions the operation schedule of the system and his participants is calculated by a linear optimization tool. Based on a high fraction of those combined systems, a functioning future power supply is possible basically also without intense use of battery storages.

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1. Introduction

In the course of the German "Energiewende" there should be a power supply with 80 % of renewable energy in 2050 [1] [2]. A power supply with such a high fraction of renewable energy has considerable fluctuations between electrical production and electrical demand. At the same time the removal of the present residential building stock up to passive house standard will be implemented and the local heat demand will decrease significantly.

The current analysis deals with a power supply based on 100 % of renewable energy and aims on the detection of useful compensation strategies for this application case (Fig. 1). The investigation shows on one side, that our actual heat supply can be increasingly moved by the conventional heat production to a supply with CHP systems and otherwise that a partly separation of heat and power production is possible for the provision of balancing energy (see also [3], [4], [5]).

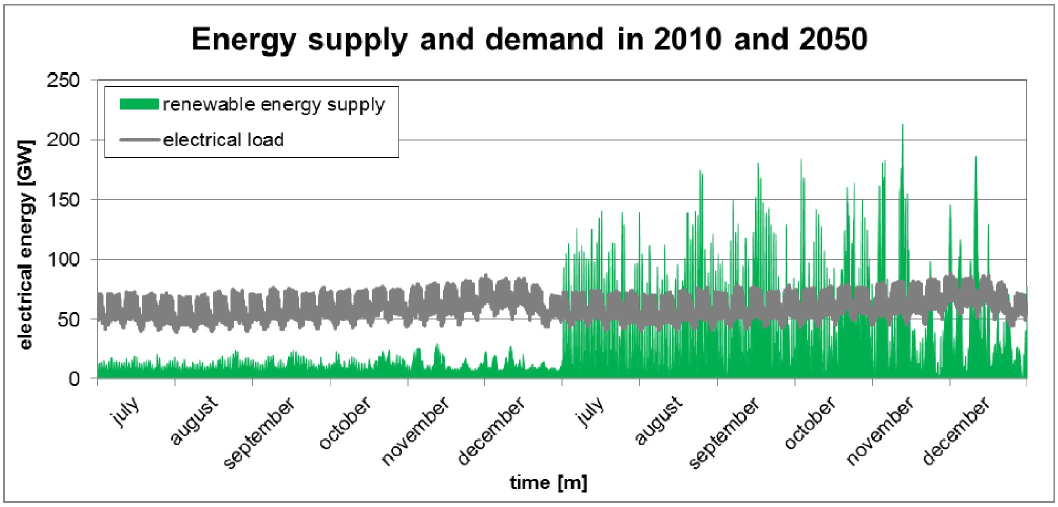

Fig. 1. Half year comparison between 2010 and a 100 % renewable supply in 2050

The efficiency of conventional centralized power systems is generally low in comparison with combined heat and power (CHP) technologies which produce electricity or mechanical power and recover waste heat for process use (cogeneration). CHP systems can deliver energy with efficiencies exceeding 90%, while significantly reducing the emissions of greenhouse gases and other pollutants. Generally residential CHP systems or cogeneration power plants connected to a district heating network are heat operated. That means the operation control of the CHP system mainly follows the heat demand of the consumer. In order to integrate residential CHP systems into energy management a mixed control strategy is needed combining both heat and power operated solutions. Based on a forecast of the power and heat demand the operation schedule of the distributed system will be calculated by an energy management optimizer (presented in [6] and [7]). In the next sections a procedure is described to find a functional configuration of the CHP units and enlarged thermal storages within a virtual plant structure. Such a virtual plant can be used for the substitution of missing wind and solar energy. Thereby the demand of heat and electricity of the buildings can be covered and guaranteed.