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A New DH Control Algorithm for a Combined Supply and Feed-In Substation and Testing Through Hardware-In-The-Loop

Toni Rosemann, Jan Löser, Karin Rühling *

Technische Universität Dresden, Professorship of Building Energy Systems and Heat Supply, Helmholtzstr. 14, 01062 Dresden, Germany

Abstract

The integration of decentralized feed-in of solar heat into district heating networks results in a high volatility regarding daily and seasonal pressure and temperature characteristics. Therefore new control and automation devices and algorithms are required to handle the complexity of the system. Furthermore the presented combined supply and feed-in substation – a so-called prosumer substation – needs a state machine (automation of switching between the several operation modes) in order to optimise the distribution of solar heat gains: feed-in into the district heating network and/or partly to local consumption. This paper presents results regarding the developed controller system, the test rig for emulation of the solar thermal system and a building as well as measurement data of a complex part of chosen daily load curves. The latter is the synthesis of the emulation test rig, the functional model of the combined supply and feed-in substation and the control system. The presented results are gained as parts of the R&D projects "Dezentrale Einspeisung in Nah- und Fernwärmesysteme unter besonderer Berücksichtigung der Solarthermie" and "Kostenreduktionspotential beim Ausbau der Solarisierung von Fernwärmenetzen durch Standardisierung" (see [1] and [2],[3]).

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Keywords: Feed-in substation; Prosumer; Solar thermal; Control; hardware-in-the-loop

* Corresponding author. Tel.: +49 351 463-34709; fax: +49 351 463-37076.
E-mail address: toni.rosemann@tu-dresden.de

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NOMENCLATURE

Symbols

A	area	m²
c	collector parameter	-
$\dot{G}$	radiation	W/m²
Q	heat	kWh
$\dot{Q}$	heat flow	kW
$\dot{V}$	volume flow	m³/h
w	setpoint	-
η_0	optical degree of efficiency	-
ϑ	Celsius temperature	°C
τ	time	s

Abbreviations/Indices

AP	aperture
coll	in collector plane
COMBINED SUBSTATION	combined supply and feed-in substation
CON	consumer
Dev	Deviation
DH	District heating
FEED-IN	operation mode (like a feed-in substation)
G	global
HX	heat exchanger
In	entrance heat exchanger
Out	outlet heat exchanger
Pu	pump
PRI	primary
RL	return line
SEC	secondary
SL	supply line
STS	solar thermal system
SUPPLY	operation mode (like a district heating substation)
Tol	tolerance
Va	valve

1. INTRODUCTION

1.1. Substation concepts

The classic district heating network consists of one or more centralized heat generators and multiple consumers. The consumer is connected to the network via a supply substation, which is used for control, heat transfer and often hydraulic separation (see Figure 1). Decentralized heat generators need a feed-in substation in order to transfer small fractions of the design heat load of the network into it. Their position within the network is more arbitrary than the placement of centralized heat generators and one main task is to deal with the dynamic pressure difference of the network while transferring the maximum heat at the given temperature setpoint. A new plant concept of a combined supply and feed-in substation hereinafter referred to as COMBINED SUBSTATION is presented in this paper.