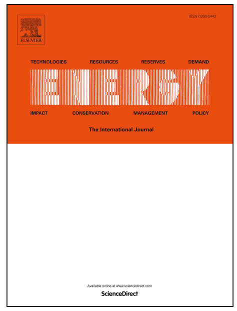
Accepted Manuscript



Optimal design of decentralized energy conversion systems for smart microgrids using decomposition methods

Thomas Schütz, Xiaolin Hu, Marcus Fuchs, Dirk Müller

PII: S0360-5442(18)30870-3

DOI: 10.1016/j.energy.2018.05.050

Reference: EGY 12883

To appear in: *Energy*

Received Date: 9 November 2017

Revised Date: 8 April 2018

Accepted Date: 8 May 2018

Please cite this article as: Schütz T, Hu X, Fuchs M, Müller D, Optimal design of decentralized energy conversion systems for smart microgrids using decomposition methods, *Energy* (2018), doi: 10.1016/j.energy.2018.05.050.

Optimal design of decentralized energy conversion systems for smart microgrids using decomposition methods

Thomas Schütz[a], Xiaolin Hu[a], Marcus Fuchs[a] and Dirk Müller[a]

[a] RWTH Aachen University, E.ON Energy Research Center, Institute for Energy Efficient Buildings and Indoor Climate, Aachen, Germany, tschuetz@eonerc.rwth-aachen.de

Abstract:

The design of decentralized energy conversion systems in smart residential microgrids is a challenging optimization problem due to the variety of available generation and storage devices. Common measures to reduce the problem's size and complexity are to reduce modeling accuracy, aggregate multiple loads or change the temporal resolution. However, since these attempts alter the optimization problem and consequently lead to different solutions as intended, this paper presents and analyses a decomposition method for solving the original problem iteratively.

The decomposed method is verified by comparison with the original compact model formulation, proving that both models deviate by less than 1.8%. Both approaches furthermore lead to similar energy systems that are operated similarly, as well. The findings also show that the compact model formulation is only applicable to small- and medium-scale microgrids due to current limitations of computing resources and optimization algorithms, whereas the distributed approach is suitable for even large-scale microgrids. We apply the decomposed method to a large-scale microgrid in order to evaluate economic and ecological benefits of interconnected buildings inside the grid. The results show that with local electricity exchange, costs can be reduced by 4.0% and emissions by even 23.7% for the investigated scenario.

Keywords:

Decomposition, Mixed Integer Linear Programming, Optimization, Smart Residential Microgrids, Urban Energy Systems.

1. Introduction

The transition towards a more energy efficient and environmentally friendly economy is a recognized objective of the European Union [1]. In Germany, this concept is known as "Energiewende" and aims at reducing greenhouse gas emissions, increasing electricity generation from Renewable Energy Sources (RES) and achieving higher energy efficiency in general [2]. In the context of buildings, which account for approx. 40% of total energy consumption in the European Union [1], emission reductions and energy savings can for example be achieved by installing more efficient heating devices and by improving their control strategy.

In recent years, many different heat and electricity generation as well as storage technologies evolved for application in buildings. Small-scale Combined Heat and Power (CHP) units offer a highly efficient method for generating heat and electricity simultaneously from fossil fuels. Potential benefits can further be leveraged by introduction of Thermal Energy Storage (TES) devices. In addition, Heat Pump (HP) systems present a technology to efficiently use electricity for heating purposes. RES, especially solar systems, can also be used on building level, for example Solar Thermal Collectors (STCs) or Photovoltaic (PV) modules. Storage devices such as TES units and batteries (BATs) can further enhance the integration of fluctuating solar generators.

When considering neighborhoods instead of individual buildings, economic and ecologic benefits can be obtained [3], for example through better integration of efficient, small-scale technologies within local microgrids [4]. According to Marnay et al. [4], microgrids are electricity distribution systems that comprise generation and storage units as well as loads. Additionally, microgrids have to be controllable and can be operated either with connection to a main power network or in an is-