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Economic and environmental cost of self-sufficiency - analysis of an urban micro grid

Alexander Wanitschke[a,*], Norman Pieniak[a], Florian Schaller[a]

[a]*Reiner Lemoine Institut (RLI), Rudower Chaussee 12, 12489 Berlin, Germany*

Abstract

In this paper we analyze the economic feasibility as well as the environmental ramifications of operating a renewable energy based micro grid for achieving ultimate self-sufficiency. Results show that in the present case ultimate self-sufficiency is neither economically feasible nor environmentally viable due to large overcapacity in storage and generation. Based on the results we propose that economic viability as well as ecological effectiveness of a local micro grid can only be achieved by an optimized combination of storing, curtailing and feeding-in of excess renewable power, all of which should be considered in a new reform of the German Renewable Energy Act (EEG).

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Keywords: micro grid; self-sufficiency; EEG; multi-objective optimization

1. Introduction

The latest reform of the German Renewable Energies Act (EEG 2017) took effect in 2017. The reform remains to disadvantage partial self-sufficiency of local energy systems by applying EEG levy for small systems and entirely eliminating the option of self-sufficiency for larger energy systems looking to receive a market premium. According to §61a of the EEG 2017 storage operators are exempted from EEG levy as long as the energy is completely fed into the grid in terms of intermediate storage. As soon as energy is used for self-sufficiency the levy has to be paid for the amount of energy that is drawn from the storage system according to §60(1) and §61(1) EEG 2017. This also applies for energy that is produced and stored by renewable energy power plants exceeding 10 kW nominal power which belong to the storage operator (§61(2) 4 EEG 2017). Thus, in consideration of §60 (2) 2 EEG 2017, one of the alternative concepts appears to be that of complete self-sufficiency in which operators are exempted from EEG levy entirely if they are not directly or indirectly connected to the grid. In this paper, we analyze the economic feasibility as well as the environmental ramifications of installing and operating a renewable based local energy system for achieving ultimate self-sufficiency, using the example of the urban micro grid located at EUREF Campus in Berlin. Within the framework of the *Micro Smart Grid EUREF* project as one of the 30 *International Showcase*

* Corresponding author. Tel.: +49-30-1208-43481; fax: +49-30-1208-43499.
E-mail address: alexander.wanitschke@rl-institut.de

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Electromobility Berlin Brandenburg core projects the mentioned urban micro grid has been significantly extended. The main objective of this project was the installation and operation of a micro grid consisting of various types of renewable energy generators and storage systems to provide local consumers with locally produced renewable energy. Besides providing energy to the buildings the project focuses on the supply of the growing demand of energy for electric mobility. It is seen as a motivator to install micro grids using storage systems to cover high peaks in the energy demand. One of the project's objectives was to research on the feasibility of a micro grid which is completely disconnected from the utility grid and achieves ultimate self-sufficiency. These circumstances enable the following analysis and discussion of the economic feasibility and ecological effectiveness of micro grids under the regulatory conditions of the new German Renewable Energy Act.

Nomenclature

An	annuity
Cap	capacity
CapEx	capital expenditure
CHP	combined heat and power
DHR	darrieus helix rotor
Em	green house gas emissions
E	energy demand
η	electric efficiency
fix	fixed, associated with production, installation and recycling
ICE	internal combustion engine
IH	immersion heater
l	lower limit
LCE	life cycle green house gas emissions
LCOE	levelized cost of electricity
Li	lithium ion battery
MSG	micro grid constellation
MSI	mono-crystalline silicon
OpEx	operational expenditure
OV	optimization version
P	power
Pb	lead acid battery
PtH	power to heat
PV	photovoltaic
SC	supercapacitor
SOC	state of charge
Sto	storage
SWT	small wind turbine
t	time step
TA	time-based autarky
u	upper limit
var	variable, associated with operation
WACC	weighted average cost of capital