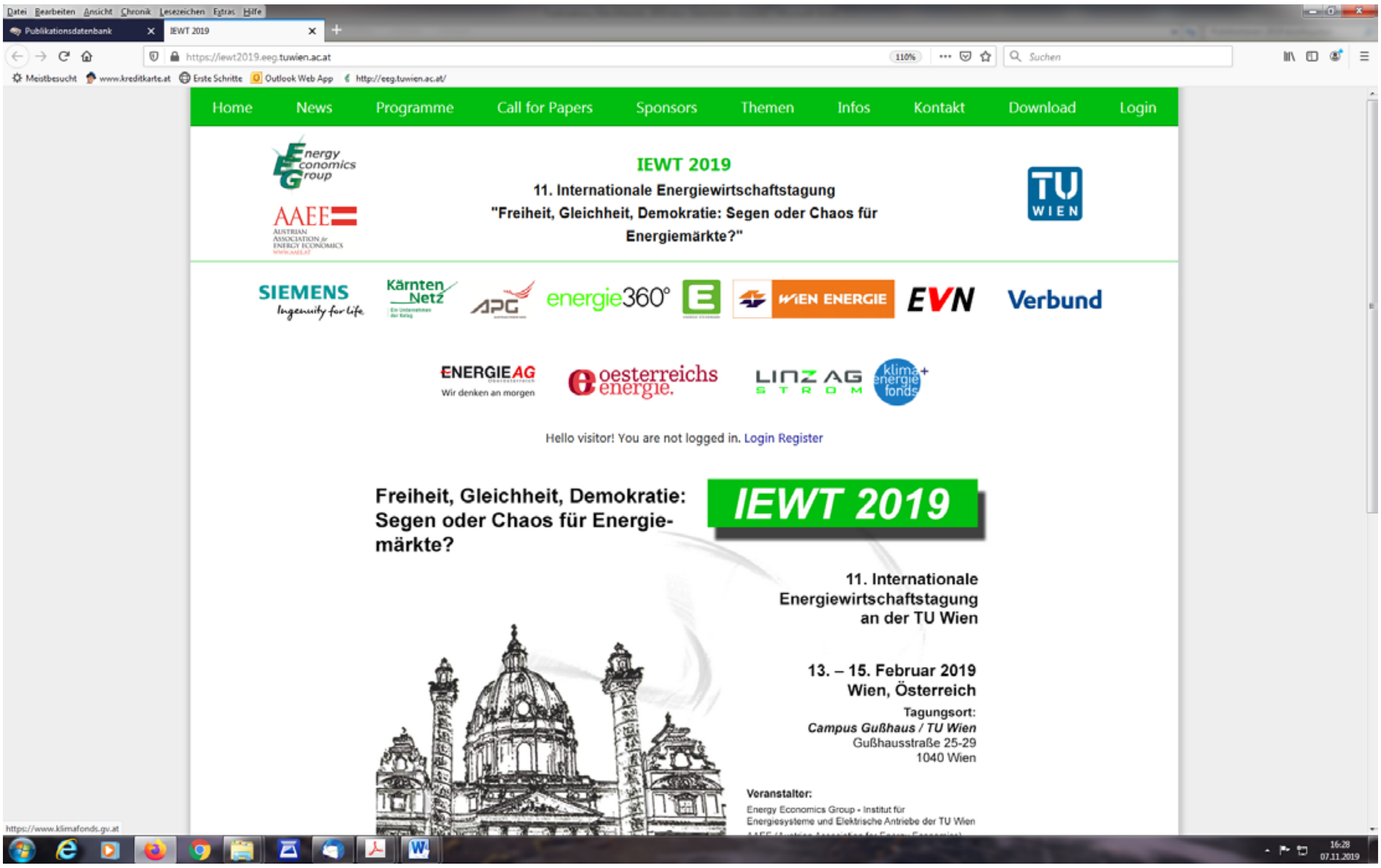
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Operation strategies of battery energy storage systems considering flexible loads

Themenbereich 2

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Introduction

High penetration of PV systems can lead to difficult grid situations (Bayer, 2018), especially in rural residential areas with high PV penetration and low consumption during the day. In the project LEAFS[1] we evaluate ways to reduce this impact by applying different operation strategies, using storage systems or activating flexible loads.

This paper examines how incentives and penalties affect PV generation, as well as the operation of battery energy storage systems (BESS) and flexible loads. In addition to classic self-consumption optimization, the operation strategies include flexible electricity tariffs, feed-in limits, power fees and time-dependent bonuses. Depending on the various incentives, the benefits for the prosumers are determined.

Methodology

Based on real measurements of the field-testing areas Eberstalzell and Köstendorf, flexible and inflexible loads were generated (Zeilinger, 2017) for each household as part of the research project LEAFS. The measured data of 103 PV systems is used in 5 minutes resolution for realistic simulation.

In the baseline scenario, we consider the entire load as inflexible and without any storage systems. Whereas for the improved scenario we include flexibilities. We model for every PV prosumer a BESS, corresponding to the PV size given in Table 1. In addition, all flexibilities have the shifting potentials given in Table 2.

Table 1: Assumptions of PV to BESS size

PV system [kWp]					rated capacity [kWh]
		PV	≤	3,6	4,5
3,6	<	PV	≤	4,8	6
4,8	<	PV	≤	5	5
5	<	PV	≤	6	7,5
6	<	PV	≤	7,2	9
7,2	<	PV	≤	8,4	10,5
8,4	<	PV			12

Table 2 Load shifting potential of flexible loads (de Bruyn et al., 2014)

Flexible load	Shifting potential (h)
Refrigerator	1
Freezer	4
Hot water boiler	12
Electric radiator	1
Heat pump	1

Beside the classical operation strategy of maximizing self-consumption, we analyze the effect of flexible tariffs for the prosumers. The operation strategy “minimize PV curtailment” curtails the feed-in power at 70%. In other scenarios the effect on power prizes of 40 €/kW feed-in and procurement are observed. The strategy “sunshine bonus” gives incentives of 10 cent/kWh for consuming energy times of high local PV generation.

Results and conclusions

Without optimization of flexible loads and BESS, the share of self-consumption (PV direct use in Figure 1) of PV production is at 40%. By including flexibilities, the self-consumption increases by 20% (PV stored in Figure 1). The flexible loads (Figure 2) increase the share of self-consumption by another 10 percentage points.

[1] This contribution is based on the project "LEAFS - Integration of Loads and Electric Storage Systems into advanced Flexibility Schemes for LV Networks". The project LEAFS is financed by the „Klima- und Energiefonds“, and operates within the program „Energieforschungsprogramms 2014“.

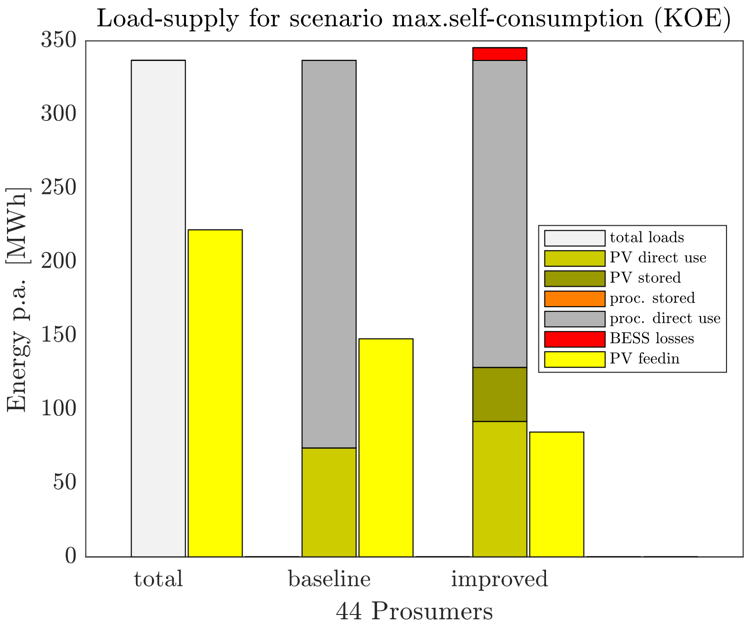

Figure 1: Total loads and total PV-production compared to PV-consumption and PV-feed in

The implementation of a real-time pricing tariff (RTP) (EPEX 2016) leads to reduction of PV use of the storage to 60%, whereas 40% of full-load cycles are used for arbitrage.

By applying a 70% feed-in limitation of PV generation, 0.8% of the annual generation is limited (without optimization or BESS measures). In comparison, a feed-in power-price price of 40 €/kWp p.a. leads to curtailment of 10 % for the total PV production. No curtailment occurs if we implement BESS.

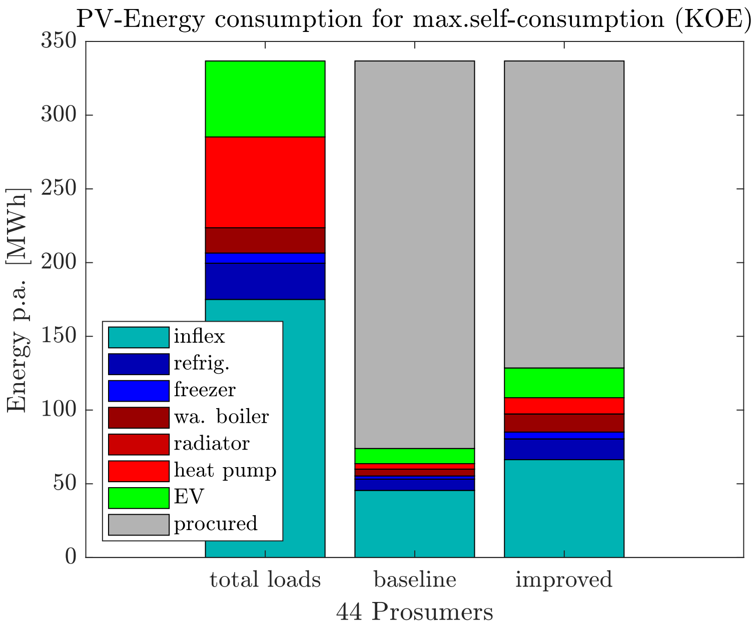

Figure 1: Total loads in comparison to PV-Energy consumption by loads

Without considering costs of BESS, storages reduce in every operation strategy the feed-in power and increase self-consumption. Flexible loads support self-consumption by 10 percentage points. When applying RTP, the storage is used 40 % for arbitrage. Curtailment of 70% PV-curtailment without BESS means almost no PV-losses, whereas power prices increase the curtailment to 10% in average.

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