Local Sustainable Communities: Consumer involvement for sustainable development in energy transition

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Motivation

Decentralisation and consumer involvement are becoming increasingly important in the energy transition. Through the introduction of energy communities, consumers have increased opportunities to use energy sustainably. However, according to the United Nations Sustainable development goals, resource sustainability is an important aspect that must be addressed. Therefore, the European Union taxonomy for sustainable activities considers water sustainability and circular economy operations as key performance indicators for classifying sustainable activities. Sustainable communities applying such actions on the community level are predominantly based on the voluntary nature of limiting energy and resource consumption. As many consumers may not be willing to reduce consumption without further benefits, incentives for sustainable behaviour must be created. Therefore, local sustainable communities (LSC) are introduced as an extension of conventional renewable energy communities beyond the sector electricity, gas and heat. These combine the financial incentives for local energy use in energy communities with sustainability aspects of communities. Moreover, technology involvement to enable efficient sector coupling within the LSC is a critical aspect. In LSCs, business models are extended to be applicable to resource utilisation. Resource reduction is to be promoted through financial rewards for sustainable behaviour. Furthermore, disposal of resources without recovery of energy or material contradicts sustainable development goals. To use the full potential of LSCs, additional stakeholders such as wastewater treatment operators or waste management companies must be part of the LSC. In summary, the combination of business models, technology operation and industry involvement are the fundamental pillars of an LSC. This work examines the contribution of LSC operations to sustainability.

Methods

An existing sustainable community in Waidhofen/Ybbs (Lower Austria) is extended to an LSC to investigate the impact on sustainable resource utilisatoin and circle economy. Previously mentioned business models, technology operation and industry involvement are applied to the community to assess their impact. The LSC operator acts as a coordinator for the processes within the LSC. An optimisation model for sector coupling in energy communities is developed for the investigation.

Business models that are already applied in energy communities are adopted for the LSC. Additionally to electricity trading/exchange, trading/exchange of heating and cooling is implemented. To address resource utilisation, the business models are extended to water sharing and waste treatment. Water consumption prices are regulated within the LSC. Water consumption beyond a predefined threshold causes additional costs for consumers. Furthermore, consumers can gain financial benefits by reducing their total water consumption and provide water consumption rights to other LSC consumers.

Technology operation is considered in the form of joint generation and conversion technologies. The LSC operator owns the technologies and consumers can purchase electricity, heating and cooling from the LSC at a predefined price. Waste treatment sustainability is considered by implementing industry partners in the LSC. Recovered energy from incineration is assigned to the LSC. However, the LSC must cover the costs for treatment and labour. Similar approaches are investigated for sewage sludge energy recovery by sewage treatment operator involvement in the LSC. The impact on energy system operation and resource sustainability is investigated by the application of the optimisation model. Cost minimisation is performed in the process to assess the flows between LSC members and sectors. However, technology parameters can emerge as limiting factors. Thus they must be considered as constraints in the model.

Results

The results reflect the total optimum of the LSC operation in terms of operational costs in all sectors. Due to the consideration of multiple sectors in the LSC, a large variety of options to purchase energy and resources arises for consumers. Energy procurement from the LSC has a higher significance for consumers without their own generation and conversion technologies like PV or heat pumps. Consumers without own conversion technologies benefit from other consumers, as investments in technologies can be saved while still contributing to a sustainable energy transition.

Furthermore, revenues can be generated by trading energy. Additional revenue streams result from rewarding consumers' resource savings. Consumers with a higher (stochastically predefined) willingness for resource reduction can generate higher revenues.
All tradings are performed via the LSC operator. Sector input flows arise from consumer trading and recovered energy of resource treatment like waste and sludge incineration. Trading is mainly performed in the electricity sector. In the considered setup, the most efficient heat generation option is the joint LSC heat pump. Therefore, electricity procurement from consumers for heat pump operation is more efficient than direct heat procurement from consumer heat pumps. However, by providing technology services to the LSC members, the LSC operator can generate revenues that are required for technology investment.
Costs for each consumer vary dependent on the willingness for resource reduction and on the consumers' generation and conversion technologies. Consumers having both can achieve the least costs. These aspects lead to the main conclusion that for an efficient operation of an LSC, an efficient technology use from the consumers' and LSC operator's perspective is required. Furthermore, a sustainable mindset and willingness to sustainable resource utilisation are vital aspects for consumers to benefit from the LSC in the best possible way.

Acknowledgement

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Provided Figures

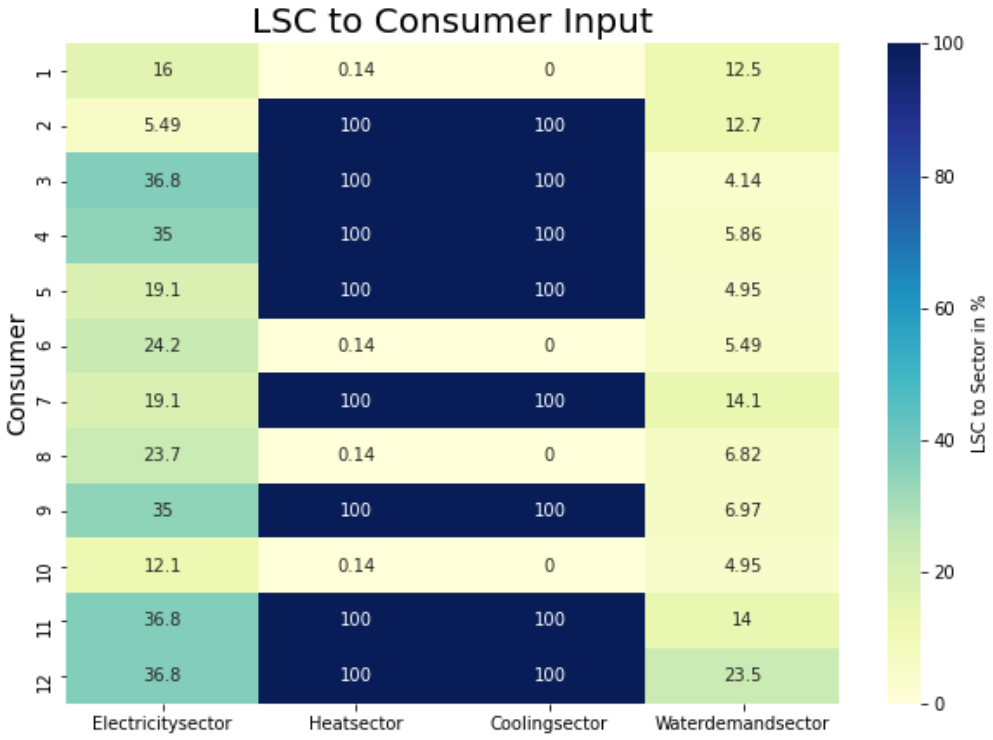

figure 1 Heatmap LSC procurement

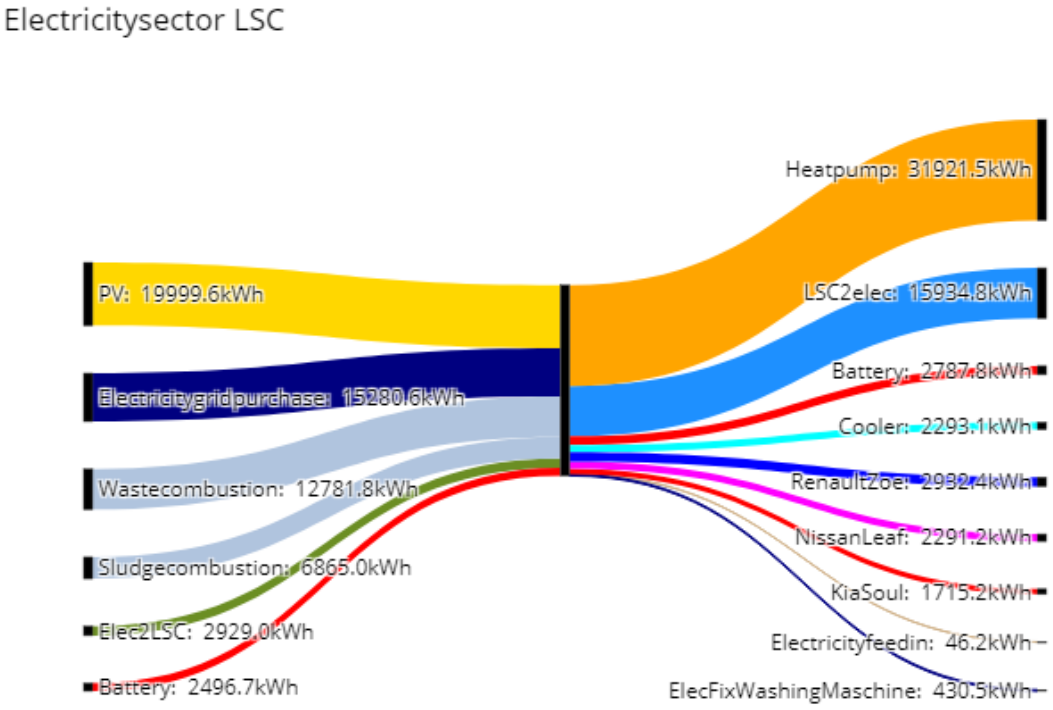

figure 2 LSC flows electricitysector

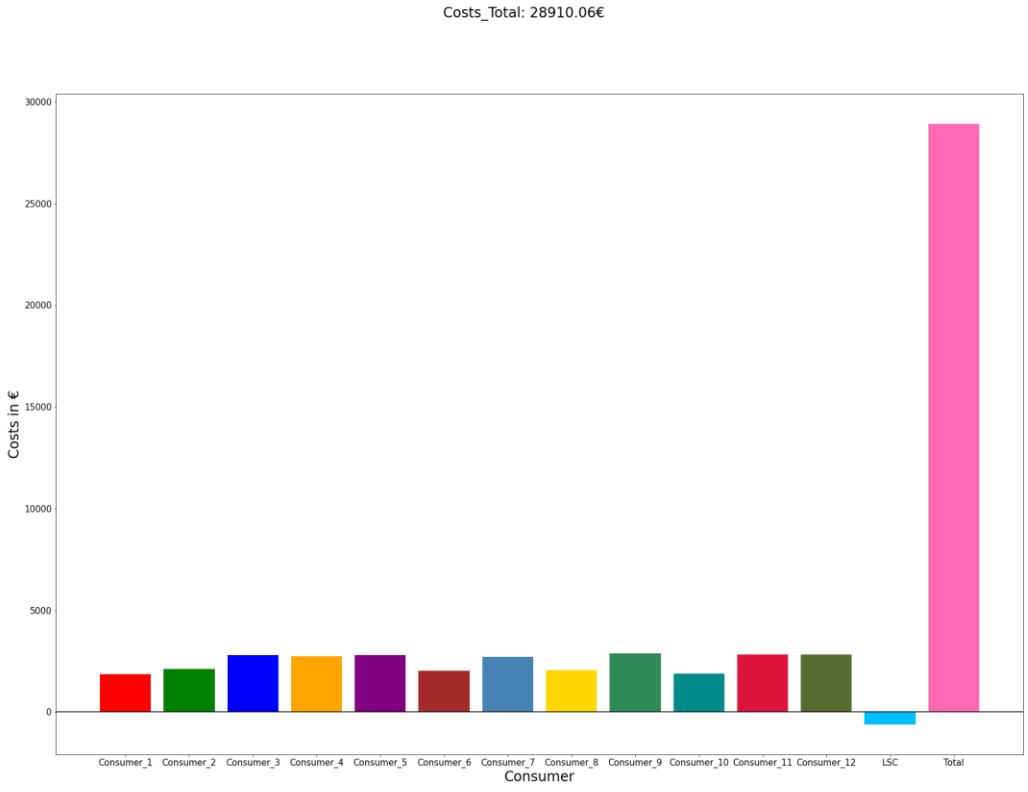

figure 3 Total costs