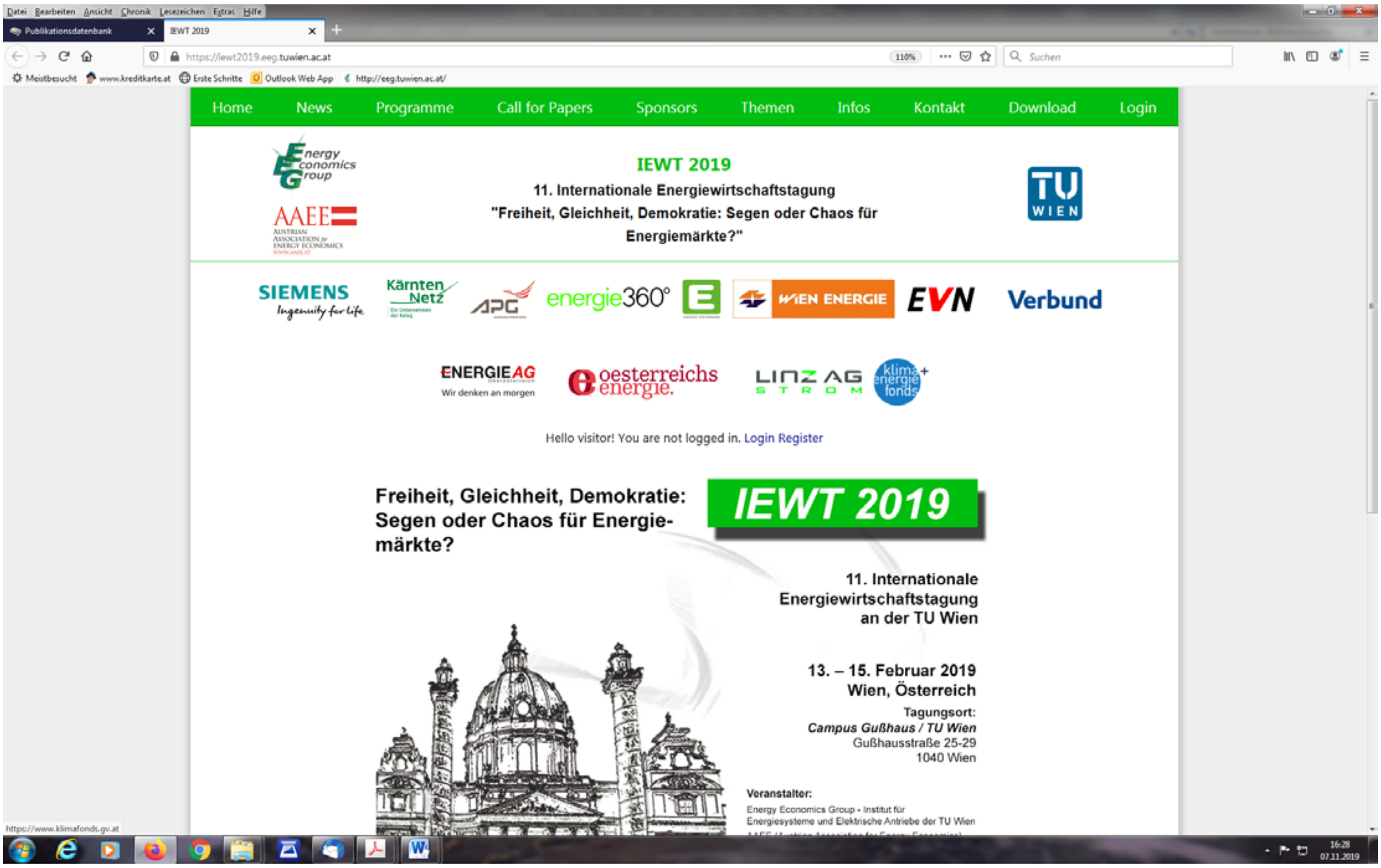
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ENERGY SHARING CONCEPTS IN ENERGY COMMUNITIES

Themenbereich (4) Aktive Endkunden-/Prosumerpartizipation

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Introduction

Solar generation is one of the critical technologies in decarbonizing and decentralizing the energy system. Hence, to address the energy-climate challenge, innovative solutions have to be developed to make better use of distributed energy resources (DERs) and Photovoltaic (PV) in particular. The project PV-Prosumers4Grid[1] aims at a better power system integration of PV with a focus on market integration.

In the past years, the term energy communities (EC) has been established to promote a better market integration of DERs and implement energy efficiency measures (European Commission, 2016). In our work, the purpose of the EC I is to invest in joint generation and storages for electricity and heat provision. In this case, the members of the EC form a coalition to share the benefits, e.g., economic benefits by the increase of self-consumption and economies-of-scale (EoS). We assume that there is a set of households, consumer (C with $C_j, j \subset I$), who consider joining an EC. On the other hand, there may be an owner (O) of the rooftop, who is not consuming energy within the EC. However, he is also interested in joining the coalition, by renting out the rooftop.

Methodology

The following Fig. shows the methodological setup of this paper based on (Wang and Huang, 2017). In a first step (I), we define the setup of the game and clarify the members of the EC by the set I, as well as potential rent costs C_{PV}^{Rent}. Furthermore, we differentiate, if the O plays a cooperative or non-cooperative game. In the second stage (II), we use a joint investment and operation problem (JIOP) to compute the payoffs of different games, e.g., the prosumers forming a coalition without the owner and aggregators. Thirdly (III), we solve the payoff sharing problem (PSP) by the Shapley value (Shapley and Shubik, 1973) and the Nash Bargaining (Compte and Jehiel, 2010) to allocate the payoff among the players. The idea of this methods is to determine the side payments between the players, necessary to ensure a coalition stable.

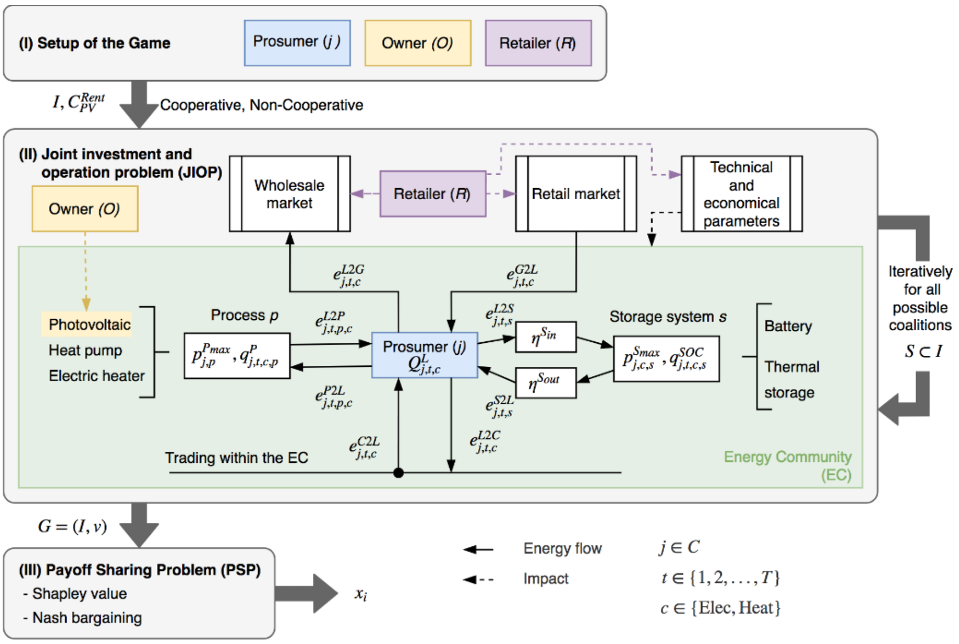

Figure 1: Graphical representation of the methodology of this paper, consisting of three blocks.

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[1] Disclaimer: The project PV-Prosumers4Grid has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 764786.

Use Case

To illustrate a potential application of the proposed models, we apply the framework to a use case in Austria. We consider a potential energy community consisting of four consumers: one grocery store (shop), one kindergarten and two residential consumers (see Figure 2). We use data from the year 2017. Without any investment, the load of the Cs is satisfied via the electricity and heat grid. As shown in Figure 1 and 2, we assume that the EC can invest into processes (PV, HP, EH) and storages (BESS and TESS). As a result of limited rooftop area, PV investments are restricted by a rooftop area of 150 m² (22.8 kWp).

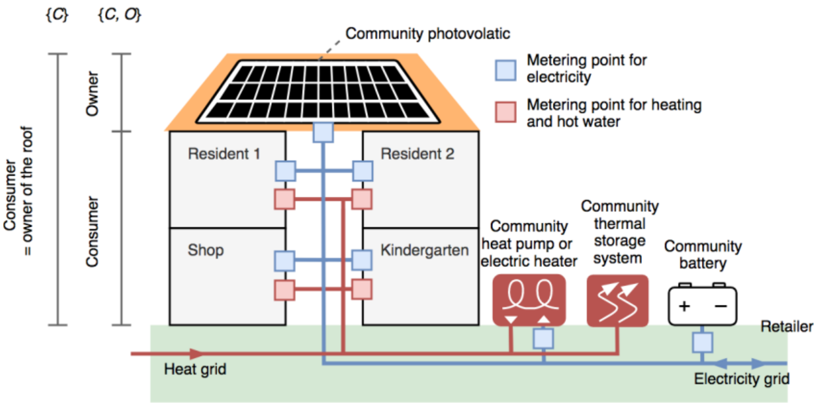

Figure 2: Use case of the energy community in Austria.

Results and conclusions

The results in Figure 3 show the individual allocation of all players. The payoff of the grand coalition (all players participate the EC) is 14 109 EUR in total, while the allocation changes drastically between the different games and setups (e.g. cooperative or non-cooperative). With the assumptions of our paper, the O has the highest benefit, if he joins in a cooperative way.

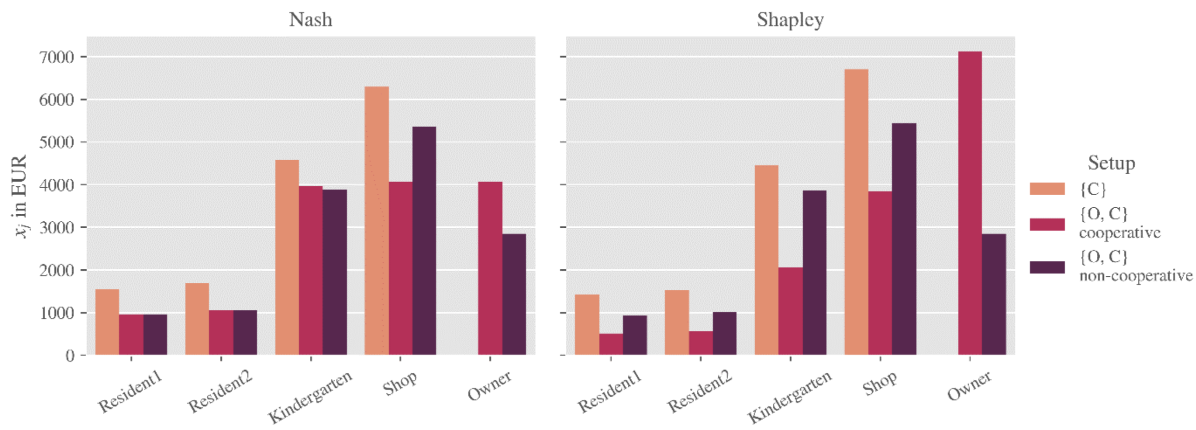

Figure 3: Results of the individual allocation for cooperative and non-cooperative games.

The cooperative game formulated in our work provide high benefits for EC, as the (a) encourages cooperation between the members, (b) provide a mechanism for stabilizing the EC, (c) allows joint investments under the aspect of win-win situations.

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