ESTIMATING THE LARGE-SCALE ECONOMIC PV POTENTIAL ON THE BASIS OF ENERGY COMMUNITY OPTIMISATION : EVIDENCE FROM AUSTRIA

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Overview

Within the last years, PV systems have evolved from a technology reserved for wealthy single-family homeowners to a cost-efficient solution for people in different living situations. The legislative background allows for PV sharing concepts in energy communities (ECs) to be realised among residents in multi-apartment buildings in most countries. In some countries, ECs can already be realised between multiple buildings. However, whether PV system implementation in general or PV sharing concepts in ECs will evolve to be state of the art in residential buildings depends not only on the regulatory background, but especially on the profitability. Thus, it is highly important to investigate the economic viability of such concepts, because – generally speaking – most people only invest if a break-even can be expected. Recent studies provide strong evidence for the profitability of PV sharing concepts in individual multi-apartment buildings [1,2] and ECs [3] between buildings on a neighbourhood level. The next step and thus the motivation of this work is to assess the economic potential of PV systems on a large-scale, based on ECs formed on a neighbourhood level. A use case is provided for Austria.

Methods

To achieve the goal of a realistic economic PV potential estimation, a mixed-integer linear optimisation model, with the objective of maximising the net present value of any EC over a time horizon of 20 years, is developed in a first step. This optimisation model determines the profitability of PV systems in ECs along with the according cost-optimal PV system capacities. Second, four different settlement patterns (city area, town area, rural area and mixed area) are identified which are considered characteristic for Europe and other regions in the world. Based on these settlement patterns, four model ECs (one for each settlement pattern) with a specified number of characteristic buildings and real-measured load profiles are set-up. The default setting in this study is to consider 10 buildings per model EC. The cost-optimal PV system sizes are determined for these four model ECs by using the introduced optimisation model. The third step concerns the large-scale area, for which the economic PV potential is assessed: An algorithm is developed to assign buildings of different types per political district (or any other geographical granularity of the area of investigation) to the four predefined settlement patterns and, based on that, the number of ECs that are formed per political district within the different settlement patterns are determined. Knowing the number of ECs per settlement pattern and thus for whole Austria as well as the cost-optimal PV system sizes for the four model ECs, the large-scale economic PV potential can be estimated by upscaling. In a fourth step, the geographical PV potential is estimated for comparison.

Results

The results show that community PV system installation is profitable for the individual model ECs in all four settlement patterns. In the model EC of the city area, the largest PV system capacities are installed and the highest cost savings are achieved due to the great load profile diversity. In the rural model EC, the optimal installed PV system capacity is much lower because single-family households have small electricity load profiles compared to multi-apartment buildings; however, the added value of forming an EC is highest in rural areas.

An upscaling of the results for the four model ECs to the level of Austria as described in the Method-section leads to results that show that the least significant amount of PV is installed in city areas while rural areas have the most PV system capacities installed. The reason for this is that Austria is in general a country with many rural areas: The share of single-family houses on the total building stock is largest. On the contrary, densly built areas such as cities with multi-apartment buildings are rare in comparison. The estimated economic potential in Austria for city areas is around 1.2 GW, for rural areas it is more than 4 GW, for town areas it is approximately 3 GW and for mixed areas it is 1.5 GW. Comparing these results with the estimated geographical potential it becomes obvious that there is a massive geographical over-potential in rural areas. This means that there is a lot more roof space available than is actually used for cost-optimal PV system installation. In city or town areas on the contrary, the roof space is limited, which means that most rooftop areas would be saturated with PV. Thus, forming ECs between city/town and rural areas can be recommended due to the following reasons: (i) On the one hand, city residents would profit from a lot of additional roof space for optimal PV system installation (in Austria, PV sytems facing South receive the best solar irradiation and are therefore most profitable.) and (ii) on the other hand, residents from rural areas would profit from increased synergy effects (the more different load profiles, the more synergy effects, the higher the profitability of PV).

In the default setting of this study, ten buildings were considered per model EC. As a sensitivity analysis, the number of buildings per model EC is reduced to five. Results show that the more buildings per EC, the more efficiently the available roof space and PV electricity can be used wherefore less PV capacity needs to be installed for achieving cost-optimal results. Moreover, the retail electricity price (in eurocent/kWh) as well as the specific PV system costs (in €/kW_p) have a significant impact on the economic PV potential. Dropping retail prices (22 eurocent/kWh to 18 eurocent/kWh) lead to a reduction of the economic potential. The cheaper the electricity from the grid, the smaller the cost saving potential by installing PV. However, when considering a drop of retail electricity prices (22 eurocent/kWh to 18 eurocent/kWh) along with a 20% reduction of specific PV system costs (1050 €/kW_p to 840 €/kW_p), the large-scale economic potential of PV is even higher than in the default setting (retail electricity price of 22 eurocent/kWh and 1050 €/kW PV system price). Thus, PV system prices seem to have the highest influence on the economic potential of PV.

Conclusions

In general, the results indicate that in the future, ECs should be installed beyond the borders of individual settlement patterns to optimally utilize synergy effects between different load profiles and available rooftop areas. However, right now, forming ECs between a limited number of buildings on the neighbourhood-level, as indicated in this study by the model ECs, is reasonable. People are often suspicious towards novel concepts like PV sharing and, to gain trust, small-scale ECs are a good point to start. In this respect, this work provides a solid basis for policy decision makers concerned with the development of ECs on a neighbourhood scale and the thereon derived large-scale economic potential of PV.

References

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