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Scaling energy communities for a more optimal energy market design

Guest Contributor • Dec 21, 2023

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Dr Ana Trbovich, cofounder of Grid Singularity and the Energy Web Foundation, reports on a new study on the financing of energy communities.

External financial support is generally only required for energy communities until two regulatory-related conditions are met.

One is that the red tape surrounding the establishment and operation of energy communities is reduced to the level of accepting terms for a digital app, with local service providers offering turnkey solutions for renewable energy installations and asset management.

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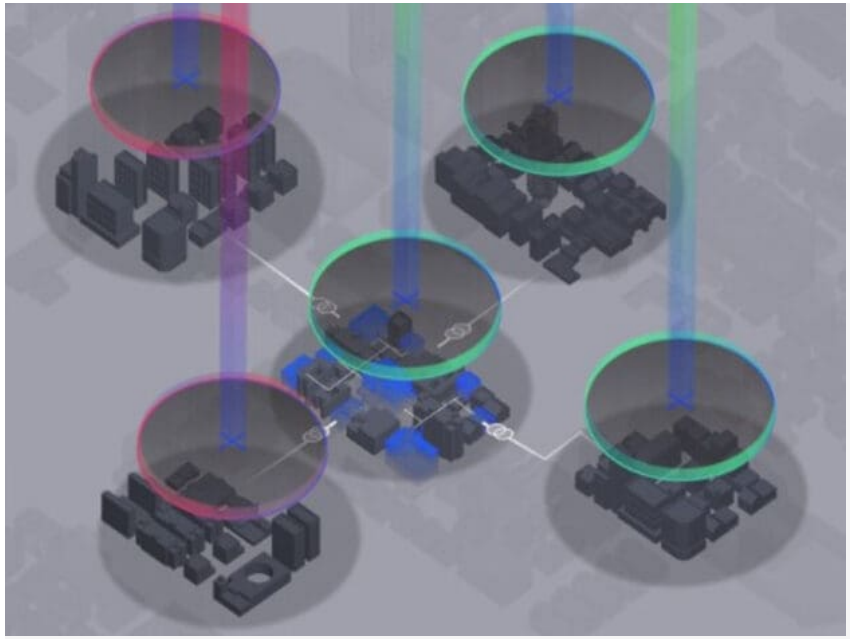

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The second is that the scope of energy community trading is extended to peer-to-peer trading within and among communities, which is permitted by the related EU directives but not yet by the member state implementation of these.

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The new study, which was conducted by Grid Singularity in collaboration with the Fraunhofer Institute of Applied Information Technology (FIT) and published by the German Energy Agency dena, confirms this perspective.

The study, titled 'The decentralised energy system in 2030. A systemic bottom-up approach to market integration of decentralised consumption and generation assets' ('Das dezentralisierte Energiesystem im Jahr 2030 – Ein systemischer Bottom-up-Ansatz zur Marktintegration dezentraler Verbrauchs- und Erzeugungseinheiten'), received support from the German Federal Ministry for Economic Affairs and Climate Action (BMWK).

Bottom-up approach to market integration

In the study a bottom-up, agent-based model of the German energy market was simulated, with 967 agents representing distributed energy assets (PV, electric vehicles, heat pumps, battery storage, consumption load profiles, wind power plants) and their owners' trading preferences in a possible German electricity system in 2030, with our open source Grid Singularity Exchange software tool for simulating and operating local, regional or national energy markets.

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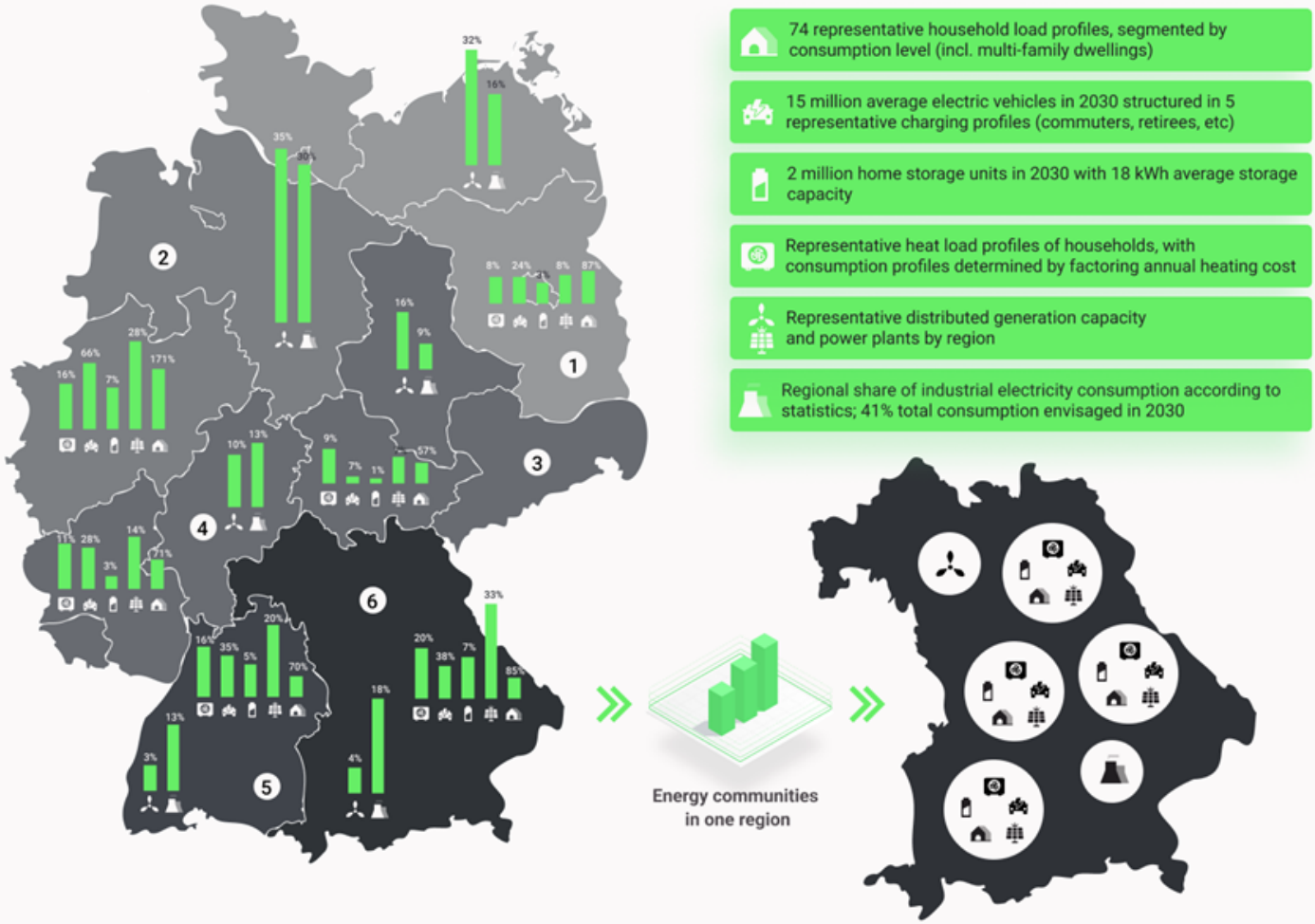
The number and the regional distribution of the respective agents were determined by our research partner, FIT, which based its calculations on the German Market Master Data Register and the German government's forecasts for distributed energy resources (DER) expansion for 2030 (Bundesministerium für Wirtschaft und Klimaschutz, 2022 and 2023, Bundesnetzagentur, 2022).



The study envisaged the German electricity market in 2030 as one that is composed of connected local electricity markets in the form of local energy communities (LECs) fully engaging in peer-to-peer trading.

Features and Analysis >

The applied simulation model has three market levels and the trading is bottom-up peer-to-peer electricity trading (P2P), i.e. asset-based, moving up the market hierarchy, as follows: i) trading within the LEC, ii) trading within and among LECs in one region, and iii) trading within and among LECs across the entire country.

The market design follows the pay-as-bid spot market type, where bids and offers are matched hourly in a P2P exchange. Prices for matched trades are determined by market conditions, considering feed-in tariff rates and utility rates, accounting for grid costs and ensuring that any matching gap is supplemented by the utility.

The study investigated six simulation scenarios in addition to the base case scenario, researching the implementation of P2P trading at different market levels, with additional analysis of the impact of the time-variable grid fee and time-variable electricity price models.

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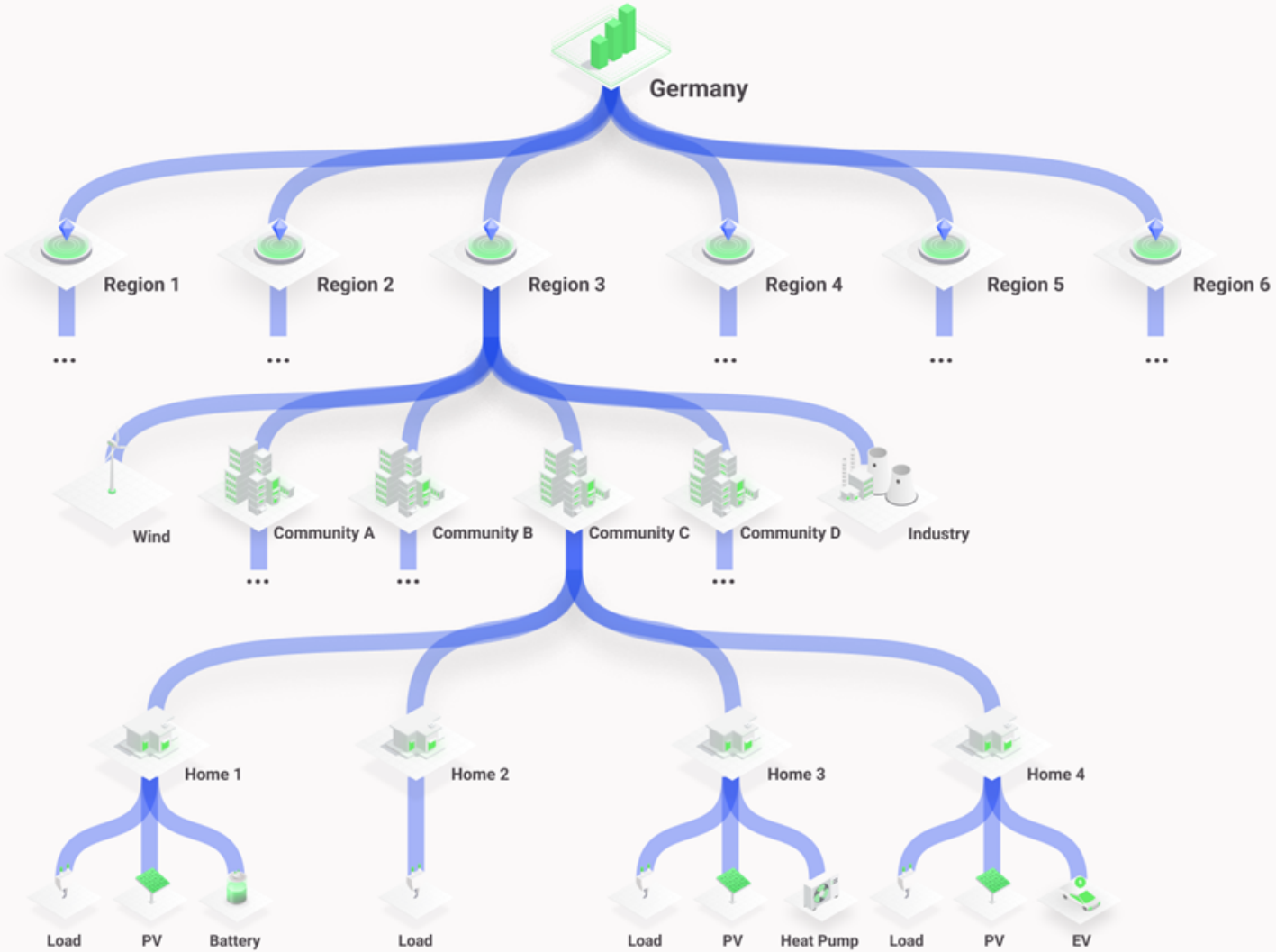

In the study, we applied actual asset-to-asset (peer-to-peer) electricity trading among market participants which is in general compliance with the EU directives on energy communities, but still more advanced than the trading mechanisms currently applied in the EU, in particular in Austria and Spain, which are among the most progressive compared to other EU members.

These EU countries still allow only indirect intra-community trading with a single, predefined energy price and more correctly described as peer-to-market energy trading mechanisms. To this day, none of the EU members allow trading between communities and the study finds this to be a significant opportunity.

Key findings of Germany 2030 bottom-up market simulation

The analysis shows that the implementation of P2P electricity trading markets leads to an important reduction in electricity cost for the participating households and the industry. For households, the electricity bills would be reduced by 4% in the case of local, intra-community P2P implementation without inter-community trading and up to 20% if P2P trading is enabled across all communities and regions in Germany.

Participants in P2P electricity trading were able to purchase electricity from their peers at a lower price than from the utility, resulting in improved matching of electricity generation and consumption at the local, regional and national levels. Electricity cost savings progressively increased with the expansion of P2P electricity trading scope, from community alone to between communities in a region, finally resulting in a fully-fledged bottom-up energy market for the entire country.

Furthermore, the P2P trading scope expansion also brings about a momentous increase in the degree of autonomy, also termed self-sufficiency, which reflects the ratio of total demand satisfied by generation at the analysed market level (or differently put, the share of self-consumption in the total consumption).

The average self-sufficiency rate for the community rises from 6% in the base case scenario where self-consumption is limited to owners of renewable assets, to 31% with the activation of local P2P trading when these assets are effectively shared with other local energy community participants.

When P2P trading is scaled to inter-community trading at a regional level and then at national level, the average self-sufficiency rate for the region increases to a very high 70% and 73% respectively, effectively including wind generation and industry consumption in P2P market trading.

In conclusion, the study indicates that over two-thirds of the electricity demand of households and industry in Germany can be met with the country's PV and wind generation by implementing a bottom-up P2P market design.

This outcome implies a significant relief of the transmission grid use but can also lead to a higher utilisation of the lower grid levels, and the implications for grid network planning and operation can be a subject of further research.

At the same time, the results show no significant impact on electricity costs, emissions or self-sufficiency when time-variable electricity prices and grid charges are introduced, which may be due to limitations of the modelled asset configuration and/or selected time of use grid fee model.

Notably, in the simulated model of the German energy market in 2030, battery storage is the only modelled energy asset that offers flexibility and responds to the corresponding price signals, providing benefits exclusively to owners of these assets and increasing electricity costs for inflexible consumers when time-variable electricity prices are introduced.

In order to take advantage of dynamic grid fee models, the flexibility in the system must be increased, rewarding those that invest in renewable and especially flexible resources while providing a reasonable level of protection for inflexible consumers.

Recommendations for policymakers

The study concludes with the following recommendations for German and other European policymakers:

■ The EU directive on the regulation of energy communities should be advanced and implemented nationally, strongly considering enabling inter-community trading in addition to intra-community trading to unleash more benefits for citizens and the grid.
■ In line with the EU Digital Energy Action Plan, a framework for testing P2P electricity trading in demonstration projects should be created to demonstrate the benefits of energy communities and to define clear criteria for implementation in Germany.
■ Market platform models should be researched and developed to ensure holistic operation of P2P electricity markets, enabling the operational and regulatory framework to control, protect and settle financial transactions (effectively enlarging the current, more limited scope of community coefficient-based exchange).
■ The rollout of smart metering systems, enabling remote access to high resolution (at least 15 minute) submeter

data for energy asset generation and consumption, is a prerequisite for P2P electricity trading as well as other flexibility and energy optimisation services and should be implemented quickly and worldwide.

■ To connect and integrate a broader level of market participants, additional digital technologies such as digital identities and corresponding, decentralised registers for machine identities of energy assets – ideally linked at EU level – are recommended. With the help of digital identities and data exchange concepts such as data spaces, granular time-based proof of electricity origin and distribution can be leveraged to issue and trade fully verifiable guarantees of origin and to enable a rapid transition of market roles (e.g. from self-consumption to ancillary services to trading markets and back to self-consumption). End-to-end digitalisation is an accelerator for implementing and enabling an efficient and secure operation of energy communities.

■ The penetration of flexibly deployable home energy storage systems envisaged for the future is not sufficient for time-variable tariffs to induce a global cost-reducing influence on the electricity price. To effectively reduce electricity prices, flexible operation of heat pumps and EVs is necessary across the board. Further studies could investigate which market share of flexible consumption units, such as heat pumps, should be achieved or how high the degree of flexibility of loads should be for variable electricity tariffs to contribute to a global reduction in electricity costs.

For more information, see the study (in German) and the longer article (in English) by Grid Singularity.

On November 29, ENLIT 2023 featured a panel on "Financing energy communities" inquiring about the fate of these novel energy markets post-public support. Ana Trbovich, cofounder of Grid Singularity and the Energy Web Foundation – both working on leveraging new technologies to accelerate energy transition, participated in the panel, together with Venizelos Efthymiou from the University of Cyprus FOSS Research Centre, Chris Vrettos from RESCoop European Federation of Energy Communities, Stoyan Danov from CIMNE Research Centre and Zia Lennard from R2M Solutions, with moderation by Arjan Haring of Seldon Digital.

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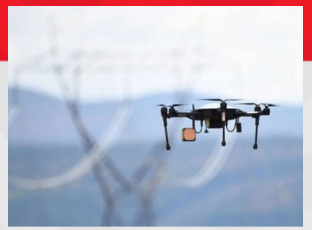

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