***Introducing pEER-TO-PEER IN eLECTRICITY MARKETS: dIFFERENT GOVERNANCE MODELS TO ALIGN supporting PILLARS***

Jean-Michel Glachant, Florence School of Regulation, +39 0554685872, jean-michel.glachant@eui.eu

Nicolò Rossetto, Florence School of Regulation, +39 3405350747, nicolo.rossetto@eui.eu

Golnoush Soroush, Florence School of Regulation, +39 3920481684, golnoush.Soroush@eui.eu

## Overview

Exchanging electricity peer-to-peer (P2P) represents a radical novelty in the electricity industry. Although a consensus definition of P2P electricity is still in the making, that expression broadly refers to exchanges, typically but not necessarily with a monetary compensation, where the provider and the receiver of electricity are peers, that is economic actors similar to each other, although not necessarily identical.[[1]](#footnote-1) More specifically, peers are of a small size and a non-professional nature (Einav et al., 2016; Glachant, 2020). They can be residential electricity consumers and prosumers. They can also be non-energy small and medium-sized enterprises or other types of organizations. In any case, peers generate, store and consume electricity only in the kWh or MWh range.

These characteristics of peers, combined with the technical features of electricity, make P2P electricity difficult to perform. However, the massive deployment of distributed energy resources (DERs) and the advances in the digitalisation of electricity over the last decade create the conditions for the emergence of P2P electricity. Pilot projects led by universities and start-ups, often with the support of local electric utilities and communies, can be found currently in Europe, Australia, the US and in emerging economies like Thailand and Colombia. In some countries, companies already offer commercial solutions consistent with existing regulation, which allow their customers to enter P2P electricity schemes, where they can choose the peer from which they want to buy electricity. In other cases, P2P electricity trials go one step further and foresees the possibility for peers to optimize the use of their DERs in order to perform demand response and provide flexibility to the network (Sousa et al., 2019; Küfeoğlu et al., 2019; IREANA, 2020; Tushar et al., 2021). Academic research has grown significantly in the past few years. Sousa et al. (2019), Tushar et al. (2020), Tushar et al. (2021) and de Almeida et al. (2021) provide extensive summaries of the research conducted so far and highlight some of the current knowledge gaps. From them, it is apparent that a robust conceptualisation of P2P electricity is still under development. Moreover, the analysis of the conditions that enable the introduction and uptake of P2P electricity in existing electricity markets is rudimentary. Many contributions look at aspects like market mechanisms and ICT requirements but do not address thoroughly how P2P electricity can be introduced in electricity markets that have evolved and are organized based on the assumption that transactions are only between energy companies (B2B) or between an energy company and an energy customer (B2C).

The aim of this paper is to develop a conceptual framework that allows to organize the current discussion about P2P electricity, recognizing the heterogeneity of this phenomenon and the fundamental pillars that are necessary to support its implementation in the real world.

## Methods

This paper investigates P2P electricity and tries to fill the above mentioned gaps in the existing knowledge by adopting the traditional *modus operandi* of institutional economics. It recognises that the possibility to exchange or trade a certain good or service depends on a series of factors, including the characteristics of the economic actors involved, the characteristics of the good or service exchanged, the technologies available to perform that exchange, and the institutions that define the framework within which that exchange take places. The paper then reflect on the specific case of P2P electricity, where the parties involved are small and non-professional, the product exchanged is technically complex, delivered in a highly regulated environment and represents only a rather small expense for the exchanging parties. Three pillars supporting the implementation of P2P electricity are identified as a result. Deductive reasoning about the conditions necessary to implement P2P transactions in the case of electricity is integrated with early insights from some of the concrete cases of P2P electricity that have been recently implemented around the world. Primary documentation about these cases and interviews with project developers are used to produce an overview of a sample of concrete cases of P2P, containing information about the characteristics of the actors involved, the product exchanged between the peers, the technologies used and the institutional and regulatory framework within which the exchanges take place. A few governance models or ideal-types of P2P electricity that enable an alignment between the different pillars necessary to support P2P electricity are identified and their main characteristics discussed, with particular attention to the regulatory issues that they rise.

## Results

Exchanging electricity peer-to-peer is particularly demanding because the actors involved are small and non-professional, which means that they have limited skills and dedicated resources. Moreover, the limited amount of the electricity they exchange and the specific characteristics of electricity imply that transaction costs are particularly high. However, although an important problem for the implementation of P2P electricity, transaction costs are not the whole story. Peers must have the right incentives to invest in DERs and operate them in a way that mutually beneficial exchanges are possible. On top of that, the realisation of any significant electricity exchange requires for the time being the use of an electricity grid which is often not under the control of the peers, but costitutes a regulated infrastructure. Hence, the paper identifies three supporting pillars that must be aligned in order to make P2P electricity possible. They are: a) the transaction loop required to lower transaction costs; b) the pricing mechanism required to provide peers with adequate incentives for investing and exchanging electricity; and c) the delivery loop required to ensure the physical supply of the product to the receiver.

The paper also shows that different forms of governance are possible to ensure the alignment of those three pillars. They are: aa) intermediated prosumer-to-peer; bb) collective peer-to-peer; cc) franchised collective peer-to-peer; dd) business intenternalising peer-to-peer; ee) peer-to-grid. These forms can be considered as alternative ideal-types of P2P electricity, presenting different characteristics and a different degree of fitness for governing the exchange of different products (e.g., surplus electricity from prosumers, electricity with specific attributes, flexibility for the electricity grid). Moreover, the different forms of governance have alternative implications for the regulatory and legal framework of existing electricity markets. Some of them can be more easily integrated in the current architecture of electricity markets, while others require a more extensive adjustment of regulation.

## Conclusions

P2P electricity is not an homogeneous phenomenon, but can assume different forms depending on the identity of the peers involved, the precise product that is exchanged and the alternative forms of governance that are adopted to ensure that all the supporting pillars are aligned. The identification of alternative forms of governance provides clarity in the current discussion on the regulatory adjustments and policy decisions needed to enable its uptake within electricity markets that were designed without considering the possibility for small and non-professional actors to exchange electricity.

## References

De Almeida, L., V. Cappelli, N. Klausmann and H. van Soest (2021), ‘Peer-to-Peer Trading and Energy Community in the Electricity Market - Analysing the Literature on Law and Regulation and Looking Ahead to Future Challenges’, *EUI RSCAS Working Papers*, no. 2021/35, March.

Einav, L., C. Farronato and J. Levin (2016) ‘Peer-to-Peer Markets’, *Annual Review of Economic*, **8**, 615-635.

Glachant, J.-M. (2020), ‘Peer-2-Peer in the Electricity Sector: an Academic Compass in the Making’, *EUI RSCAS Policy Brief*, issue 2020/36, October.

IRENA (2020), *Innovation landscape brief: Peer-to-peer electricity trading*, International Renewable Energy Agency, Abu Dhabi.

Küfeoğlu, S., G. Liu, K. Anaya and M. G. Pollitt (2019), ‘Digitalisation and New Business Models in the Energy Sector’, *EPRG Working Paper*, no. 1920, June.

Shipworth, D., C. Burger, J. Weinmann and F. Sioshansi (2019), ‘Peer-to-Peer Trading and Blockchains: Enabling Regional Energy Markets and Platforms for Energy Transactions’, in F. Sioshansi (ed.), *Consumer, Prosumer, Prosumager. How Service Innovations Will Disrupt the Utility Business Model*, Academic Press/Elsevier.

Sousa, T., T. Soares, P. Pinson, F. Moret, T. Baroche and E. Sorin (2019) ‘Peer-to-peer and community based markets: A comprehensive review’, *Renewable and Sustainalbe Energy Reviews*, **104**, 367-378.

Tushar, W., T. K. Saha, C. Yuen, D. Smith and H. V. Poor (2020) ‘Peer-to-Peer Trading in Electricity Networks: An Overview’, *IEEE Transactions on Smart Grids*, **11** (4), 3185-3200.

Tushar, W., C. Yuen, T. K. Saha, T. Morstyn, A. C. Chapman, M. J. E. Alam, S. Hanif and V. H. Poor (2021) ‘Peer-to-peer energy systems for connected communities: A review of recent advances and emerging challenges’, *Applied Energy*, **282**, 116131.

1. The concept of transactive energy, more common in the US debate, presents overlaps with that of P2P electricity (Shipworth et al., 2019). [↑](#footnote-ref-1)