

Peer-to-Peer Energy Trading and the Sharing Economy: Social, Markets and Regulatory Perspectives

Alexandra Schneiders*, Michael J. Fell^a and Colin Nolden^{b,c}

^a *Energy Institute, University College London, London, United Kingdom; 0000-0002-6605-3434 (Alexandra Schneiders); 0000-0003-2764-7464 (Michael J. Fell)* ^b *School of Law, University of Bristol, Bristol, United Kingdom* ^c *Environmental Change Institute, University of Oxford, Oxford, United Kingdom; 0000-0001-7058-445X (Colin Nolden)*

* a.schneiders@ucl.ac.uk; + 44 (0)20 3108 6872; 14 Upper Woburn Place, London WC1H 0NN, United Kingdom

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Peer-to-peer (P2P) energy trading is a new data-driven business model currently being trialed within the energy sector. Introducing P2P transactions to an essential service such as energy could have far-reaching implications for individuals and the grid. This paper raises considerations and questions from social, economic/markets and regulatory points of view, that should be understood and addressed by societies and policymakers. It does this by considering under what circumstances it is reasonable to conceptualize P2P energy trading as part of the sharing economy, and drawing parallels to the sharing economy experience in other sectors. In order to reap the full societal benefits, while avoiding considerable risks to infrastructure and individuals, a policy approach promoting dialogue and innovation is necessary. We suggest the regulatory sandbox is the most appropriate tool to achieve this and would help avoid the breakdown of trust between policymakers and platform companies observed in other sectors.

Keywords: peer-to-peer energy trading; P2P; sharing economy; collaborative economy

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I. Introduction

Peer-to-peer (P2P) energy trading, which enables energy consumers to buy and sell energy directly between each other, is a new business model being trialed within the energy sector (Zhang, Long, and Cheng 2017). It is an outcome of the data-enabled economic transformation process, sometimes referred to as Industry 4.0, and is often conceptually linked with the emergence of the ‘sharing economy’ exemplified by services such as Airbnb (Langley and Leyshon 2017).

Due to its experimental nature, however, it is often unclear what P2P energy exactly implies, what it entails and why it might be important. This is particularly problematic for policymakers, who have to assess the practical implications of this new

model when deciding how and whether to regulate it. They will be grappling with some of the same questions as those being tackled by policymakers looking at the wider sharing economy phenomenon. However, as the energy sector is very different in some important respects from transport and accommodation, where the most successful and contentious P2P models have emerged (Uber and Airbnb respectively), it will be faced with a unique set of challenges.

This paper, which takes the form of a conceptual piece, aims to explore these challenges by looking at P2P energy trading in relation to the wider sharing economy phenomenon from a multidisciplinary perspective. We discuss a number of key questions which we believe societies and policymakers will need to understand and answer in order to move forward with sharing approaches in energy in a fully informed way- from social, economic/market and regulatory perspectives.

We first introduce the main drivers and risks associated with P2P energy trading, before considering how it can be placed within the wider concept of the ‘sharing economy’ and the social benefits that could result from this model. This is followed by an analysis of the economic and market implications of P2P energy trading, particularly focusing on the important role played by data in such models. Finally, we evaluate how peer-to-peer energy is regulated and, drawing parallels with the regulation of the wider sharing economy, provide recommendations on how to approach the regulation of P2P energy trading.

This paper recognizes that P2P energy trading can have multiple social benefits, potentially even more far-reaching than those observed so far in other sharing economy sectors. It acknowledges the crucial role played by data in such sharing models, and the risks thereof to energy consumers in particular. Mostly using the UK as an example, but also looking at other countries, our general approach to regulation is precautionary; while

we support innovations which can potentially support more decarbonized and democratic approaches to energy service provision, we believe it is important to anticipate the range of possible outcomes so that negative ones can be more easily recognized and protected against (Stirling 2007).

Before we delve into the main questions that this paper focuses on, some background on P2P energy trading is provided in the next section.

II. Background

The energy sector is undergoing a transition driven by decarbonization, decentralization, digitalization and democratization (the ‘four Ds’) (Institute for Public Policy Research 2018; Burger et al. 2020). Consistent with this is a rise in energy consumers producing their own energy (‘prosumers’), thanks to the accessibility of cheaper renewable energy technologies (Zahedi 2011). In many countries, uptake has been supported by subsidies such as feed-in tariffs, but these are being ramped down and suspended (Nolden, Barnes, and Nicholls 2020). Other, more market-oriented approaches are being explored to allow prosumers to benefit from their renewable energy generation (Brown, Hall and Davis 2019, 2020).

Prominent among these is the concept of P2P energy trading, where prosumers/consumers buy and sell electricity directly from and to each other (Brown, Hall and Davis 2019, 2020; Zhang, Long, and Cheng 2017). Using a smart meter, connected to an internet device such as a smart phone or computer, they can trade energy with other consumers at local, regional and national level (Zhang et al. 2018). Distributed ledger technologies (DLTs) such as blockchain are sometimes used to enable direct trading between consumers. This is facilitated by smart meters (collecting data on produced and consumed energy) being connected to a blockchain-running device. Consumers set their terms for the sale and purchase of energy on the device, which are

recorded on the blockchain. Once the blockchain finds matching terms, a (financial) transaction automatically takes place between ‘peers’ on the network (Exergy 2018).

P2P energy trading could permit prosumers to exploit the gap between selling electricity at wholesale prices and buying electricity from the grid, by enabling them to make profits by setting prices below grid supply (Brown, Hall and Davis 2019, 2020). Consumers would also see bill savings when participating in P2P transactions by reducing financial ‘leakage’ to intermediaries such as energy utilities and electricity network operators (Hall and Roelich 2016). These ‘sharing’ approaches are also often portrayed as having wider benefits, such as improved community cohesion and generally a more personal approach (UCL Energy Institute 2019). P2P energy trading is also perceived by some policymakers as a way to decarbonize the energy sector and increase the share of renewables on the grid (Butenko and Cseres 2015).

There are also potential risks. By enabling direct transactions between peers, depending on the regulatory regime and specific context (such as in private wire arrangements), P2P may allow participants to circumvent certain costs associated with use of the electricity network (Brown, Hall and Davis 2019, 2020). While these participants may still be substantially reliant on network infrastructure for reliable power, they could end up making relatively little contribution to maintaining it – the costs of which instead weigh more heavily on those who are not part of P2P arrangements (Solar Trade Association 2019). Reviews are underway, in the UK for example, to ensure that those who “take action which benefits the electricity system and consumers as a whole pay less” (Ofgem 2018, 5). There are also important questions to consider around who actually gets to participate in P2P trading – whether by virtue of ownership or access to particular technologies, or simply the existence (or not) of local schemes, and other reasons (Brown, Hall and Davis 2019, 2020; Solar Trade Association 2019).

The energy sector is not alone in seeing rising interest in approaches involving P2P transactions, which are broadly termed the ‘sharing’ or ‘collaborative’ economy. The sharing economy is a new economic model enabled by digital technology and the free flow of data (Langley and Leyshon 2017; Richter and Slowinski 2019), facilitating the exchange of ‘underutilized assets’ for monetary gain by private individuals (‘peers’). As part of the sharing economy, platform companies including Airbnb in accommodation and Uber in transport, allow participants to easily economize assets such as rooms or vehicles by making them available to others (for monetary gain) through online platforms (Böcker and Meelen 2017; Langley and Leyshon 2017).

We see the introduction of sharing or P2P models in the energy sector as substantively different from other sectors for two reasons. Firstly, provision of energy is usually considered to be an essential service, the loss of which could present a “threat to the life, personal safety or health of the whole or part of the population” according to the International Labour Organisation (2006, 119). Similarly, the United Nations considers:

“Energy [...] crucial for achieving almost all of the Sustainable Development Goals, from its role in the eradication of poverty through advancements in health, education, water supply and industrialization, to combating climate change.” (United Nations 2020)

To our knowledge, the introduction of P2P trading to the electricity sector stands out alongside shelter (e.g. Airbnb) as the first substantial incursions of a sharing economy model into an essential service sector. This is significant because Airbnb has been linked to rising rents in cities such as Berlin and Barcelona. Rather than economizing assets,

Airbnb increases demand, which leads to increases in prices and reduces the availability of affordable shelter for city dwellers (Oltermann 2018).

Secondly, electricity networks are uniquely interdependent forms of infrastructure. In order to operate properly, supply and use of electricity must be kept in balance at all times (Mileva et al. 2016). Above a certain magnitude, the actions of any actor on the system have physical implications for the operation of all other actors. There is therefore an acute need for effective common resource governance to avoid harm to unrepresented vulnerable parties (Gollwitzer et al. 2018).

This is where the difference between shelter and energy becomes apparent. While Airbnb may have very localized effects on shelter availability, P2P energy, and electricity in particular, has potentially systemic effects on the entire energy system. While shelter as well as transport certainly display levels of interdependence (e.g. tourism economies and traffic congestion), we believe that no other areas where sharing economy models have been introduced so far have such high interdependence as electricity.

There is currently substantial interest in how the energy sector should be regulated to permit beneficial innovation while minimizing harm (for examples in the UK see [Kuzemko et al. 2016] [Ofgem 2018b] [Sandys, Hardy, and Green 2017] [Willis et al. 2019]). For the reasons described above, we think that special consideration needs to be given to the introduction of sharing and P2P market models in this sector. The next sections will aim to bring some important considerations to the forefront by analyzing the main questions to be asked around P2P energy trading from social, economic/market and regulatory perspectives. This will be done through comparison with other sharing economy sectors (e.g. accommodation, transport).

III. Social perspective: Can you share electricity?

Before discussing the relevance of the sharing economy experience in other sectors, it is first necessary to consider what constitutes ‘sharing’, and whether (and in what circumstances) it can be said to apply in the context of electricity. Belk (2007, 127) describes sharing as “the act and process of distributing what is ours to others for their use as well as the act and process of receiving something from others for our use”. The point of sharing here is that the actual ownership is not transferred, but that access is granted for others to some resource - indeed, Chasin et al. explicitly state that sharing and collaborative consumption models “do not involve ownership transfer” (2018, 297). Other authors, however, take a more liberal view of what may be considered sharing - or at least sufficiently so to form part of the sharing economy. For example, Codagnone, Biagi, and Abadie (2016), among others, admit P2P selling platforms such as eBay and Etsy within their conception of the sharing economy.

Does P2P electricity trading involve transfer of ownership? This must depend on how you interpret (or how an organizer frames) what is bought and sold in such a P2P scheme. Mention in these contexts is sometimes made of selling electrons - for example, Belinda Kinkead, one of the directors of LO3 Energy (the company which operates the Brooklyn Microgrid), speaks of people being “willing to pay more for those locally generated green electrons” in that scheme (DNV GL 2020).

Putting aside the question of whether the electrons bought are indeed green or local, the ‘electrons’ model of P2P trading contains an implicit suggestion that electrons are in some way owned by the supplier, up to a certain point at which they are sold to (and consumed by) the buyer - ownership is transferred. In a recent article considering the concept of sharing in the energy sector more generally, Plewnia treats P2P energy trading as an example of exchange of goods, saying “it can be considered a very tangible

good” and categorizes the energy which is exchanged as a “material” (2019, 7). Authors such as Belk and Chasin would, presumably, therefore exclude this model from their conception of sharing.

Is it right, however, to think of a P2P trading scheme being based around sale and purchase of electrons? Plewnia (2019), while treating electricity as a good, also goes on to say that in P2P trading “it is rather the PV or wind production facility that is shared economically instead of the energy itself”. Ownership of the generation asset is certainly not transferred. Rather, use of its output is virtually assigned to the owner and/or any purchasers of that output. Since total electricity used by assignees must equal total output, any output not assigned to the owner could therefore be viewed as practically unavailable to them while being available to others and therefore, in effect, shared.

There are existing models of P2P energy trading that are more consistent with this alternative view. The CommUNITY Project in Brixton, South London (UK), for example, allocates each participant a share of a communal PV array and battery, which entitles them to cheaper electricity (EDF Energy 2020). They are then able to buy or sell this ‘option’ of cheaper electricity between each other depending on their needs at the time. In this case the PV and battery are already shared resources, but there is no reason why a similar approach could not be taken to sharing of privately-owned generation and storage facilities. In this case, what would be shared would be the right to use (for example) a certain amount of output from a PV panel over a certain time – the ownership of the panel itself, and therefore the future flow of electricity – remaining unchanged. Similarly, the solar gardens concept from Australia allows households to purchase or subscribe to a share of a communal PV array (Institute for Sustainable Futures 2018).

While both these examples of sharing are more consistent with Plewnia’s (2019, 7) (“it is rather the PV or wind production facility that is shared economically instead of

the energy itself”), we go further to maintain that it would also be legitimate to claim that people can meaningfully share in an output of electricity in a way that goes beyond just ‘virtual’ or ‘balance sheet’ representations. Due to the extreme interconnectedness of the electricity system, every generating asset plays a role in setting up the instantaneous state of the overall network. The ability of system users to derive energy services from it is determined in part by this state. What is shared is the option to benefit from this state which, as just suggested, can be attributed proportionally to all generators – if a generator owner/controller is sharing its contribution to a useful state of network, they cannot benefit from it themselves (i.e. by self-consuming it). It is a ‘service’-based, rather than a ‘good’-based, conceptualization of P2P trading. Such a discussion is of more than simply theoretical interest, but to explore this further it is useful to briefly consider another frequently cited tenet of sharing – that of underutilization of assets.

Sharing and (social) optimization

A commonly cited argument in support of sharing models is that they make better use of an underutilized resource (e.g. Cusumano 2015; Parente, Geleilate and Rong 2018). In the context of energy, we must therefore ask whether energy assets such as PV panels or batteries can be considered underutilized. Let us first consider the example of a PV panel. On the face of it, so long as the panel is grid-connected, any generation that is not used onsite is automatically exported and used elsewhere. Utilization may therefore be considered to be 100% - which is hardly a case of underutilization.

However, viewed another way, arguments can be made for underutilization, or at least sub-optimization, of PV panels. Firstly, there are grid management challenges associated with unmanaged exports from assets such as PV panels on distribution networks. In areas with higher prevalence of PV, substations can become overloaded and there may be other power management issues (Luthander, Lingfors, and Widén 2017).

So, while it can be said that the output of the panel is indeed used in full, it also causes negative externalities that amount to sub-optimal utilization. However, this sub-optimality has the potential to be managed through (for example) location-specific direct load control, time-varying tariffs or more flexible use of shared batteries that are not explicitly based around the idea of sharing or direct P2P trading. So why introduce these ideas of sharing at all?

Consider that electricity systems are socio-technical in nature. The technical components exist to service social needs and desires, are created and operated by people, and operate more or less effectively depending on factors related to the beliefs, activities, and practices performed by people. In such a context, might we consider a PV panel that is exporting indiscriminately to the grid, even in a context where there is local load management, as being used optimally in service of the social benefits that the electricity system aims to provide?

Advocates of sharing might argue that creating direct links between specific prosumers/consumers, or at least within societies, has benefits and meanings (e.g. energy saving and community cohesion) that could not be realized through simple exporting. That these benefits are not realized represents an underutilization of the social potential of the PV panel. It could be said that a kind of ‘social exergy’ – the level of social-energy benefits that are available to be used – is higher in this configuration than without such direct relationships. It could be in this way that P2P sharing of PV output can be most usefully conceptualized as reducing underutilization.

Put simply, P2P trading or sharing have the potential to open the door to more compelling narratives that could be more effective in helping realize good societal outcomes than other more purely technical approaches. For example, could the knowledge that you are using electricity from your local school, or your neighbor, or your

parents, result in you using electricity differently? The power of narrative and storytelling in energy has been demonstrated (Moezzi, Janda, and Rotmann 2017), but further research on its role in this context would be required to test this hypothesis.

In light of the arguments above, it can be said that P2P energy trading does not have to be treated as the sale of electrons between peers. It can be conceptualized as the sharing of a useful state of the electricity network set up by the combination of all electricity generation or storage installations. The provision of access to (a share of) this flow by individuals can then be viewed as a service-based transaction. Crucially, through the sharing of energy generated by assets such as solar panels, P2P energy trading could fulfil important social functions such as strengthening community cohesion and fulfilling a common (policy) goal such as increasing energy self-sufficiency- although such benefits are largely still to be empirically demonstrated. It could be argued that these are more far-reaching social implications than those extolled by other P2P sectors. What impact will P2P energy trading have beyond consumers? The implications to the wider electricity system of P2P will be assessed in the next section.

IV. Markets perspective: New data actors

This section analyses the market implications of P2P energy trading within the context of socio-technical change towards sustainability and how societal and individual value are captured. It is an element of change which is putting into question the role of all market stakeholders, including energy suppliers and the State itself.

The decentralization trend towards P2P trading is part of a series of overall transitions in energy system governance. The first transition, associated with economic liberalization policies of the 1980s, saw governance and responsibility shift from the public sector towards highly regulated, competitive markets (Mitchell 2008). Some argue that we are now witnessing a second transition which is shifting governance and

responsibility towards civil networks, households and individuals (Heldeweg 2017). An increasing range of grid-edge innovations is fueling this transformation, with sharing economy models promising scalable market platforms capable of redeveloping the energy grid from the bottom up (Burger et al. 2020).

How do these transformative forces shape and reshape the energy system and where does market governance responsibility lie? P2P trading resembles a retreat of the State and its governance capacity. This raises questions about where value associated with decarbonization, energy security and the provision of energy as an essential service materializes. Energy governance is thus confronted with the need to simultaneously ‘keep the lights on’, while shifting from a prescriptively regulated fit-for-purpose system based on fossil fuel supply towards a facilitatory system where responsibilities are diffuse yet risk-taking needs to be encouraged. A new fit-for-purpose system consequently needs to maintain security of supply while facilitating necessary socio-technical and socio-ecological innovations (Sandys, Hardy, and Green 2017; Willis et al. 2019).

If reintermediation through P2P energy trading platforms follows similar patterns to accommodation and transport services, it is in danger of producing platform capitalism in the energy sector (Langley and Leyshon 2017; Srnicek 2016). Under such a scenario, platform providers seek to extract monopoly rents by concentrating market governance through reintermediation. As a result of Airbnb and Uber coordinating two-sided markets connecting accommodation and transport customers with car owners and landlords, traditional incumbents in both markets are made redundant. P2P transactive energy business models that seek to create value through network effects might therefore emerge as platform providers in the energy sector. With increasing network and scale effects, two-sided (P2P) business models can grow into multi-sided markets where platform

providers are best placed to provide energy grid services and client offers thanks to their amassed data (Park and Yong 2017; Zhang, Long, and Cheng 2017).

Individual consumers might benefit from the replacement of traditional intermediaries and market structures through discounted and often vastly increased supply. The consequences for society, on the other hand, include an increasing concentration of transactive, consumption and behavioral data among platform providers. Regulating their multi-sided markets to the benefit of society as a whole will prove difficult using current regulatory instruments. These will need to evolve to accommodate change, while protecting social value from monopoly rent accumulation (Langley and Leyshon 2017; Willis et al. 2019).

The data underpinning the decentralization trend that has made P2P possible in the first place entails a focus on devices, individuals and households. Transformative change towards a more transactive system facilitating their incorporation, while guaranteeing their protection, requires changes to every aspect of the energy system, ranging from governance and infrastructure, to markets and behaviors.

Where is value created, accumulated and ‘shared’ in such market governance arrangements? If socio-economic grid services such as flexibility are enhanced and peers include those without the financial capabilities to invest in capital-intensive generation technology, P2P could play a central role in reducing both overall grid enhancement costs and inequality. Providing socio-economic grid services may create value by enabling electricity generated locally to be traded and balanced locally (as envisaged by e.g. Energy Web Foundation 2020).

Such value lies in reducing demand for peaking load, which reduces the need for fossil-fuel peaking power plants, and the provision of grid services, such as demand reduction, flexibility and demand response (Burger et al. 2020). This might involve

energy balancing at a substation level through P2P trading and battery storage in microgrids and a reduction in load, for example by remotely switching off cooling devices for short periods of time, in response to real-time flexibility market signals.

Data governance implications

Such P2P energy scenarios are dependent on data infrastructures overlaying electricity infrastructures, which provide ‘visibility’ through big data capturing and analytics. Smart meters create such visibility at increasingly short intervals, in some cases approximating ‘real time data’ (International Energy Agency 2017). The capturing of data at household peer level is accompanied by increasingly sophisticated measuring, metering and accounting technologies ranging from sensors through to satellites. These act as enablers for new business models and market arrangements by providing the foundation for innovative approaches to managing energy and value production (Burger et al. 2020; Kragh-Furbo and Walker 2018).

To date, gathering and analyzing energy data has been limited to energy system businesses such as District Network Operators (DNOs) and related public sector organizations. With the increasing penetration of such smart meters, sensors and the Internet of Things (IoT), energy data is also captured at increasingly granular levels down to individual energy demanding devices. Machine learning and Artificial Intelligence (AI) facilitate big data analytics and the assetization of energy data (Kragh-Furbo and Walker 2018; Nolden 2019). Distributed ledger innovations allow ownership of energy production, consumption and demand-side response derived from smart meters to be transparently authenticated and tracked, which provides the basis for value and accounting chains (Andoni et al. 2019).

Fundamentally, therefore, P2P energy is underpinned by energy data (Zhang et al. 2018). P2P energy seeks to produce value from energy distribution and management

through spatiotemporally granular electricity data capturing and assetization. Rather than a central entity supervising transactions, P2P energy platforms use this data to facilitate decentralized virtual bidding and financial transactions (Sousa et al. 2019).

While conventional electricity meters measure monodirectional flow of electricity from the distribution network across the property-boundary, these updated metering and data infrastructures promise new value creation from measuring bidirectional flow of electricity using smart meters. Solar home systems may lead to an ‘uncontrollable’ outflow of electricity, while their combination with storage and smart meters allows outflow to be minimized or targeted at particular times. P2P energy adds the dimension of provenance beyond the property-boundary (International Energy Agency 2017; Kragh-Furbo and Walker 2018).

This implies that owners of solar home systems supply the electricity market where previously, without a solar home system, they only demanded and were supplied with electricity. Under a P2P energy trading scenario, they also take some control over where the electricity flows to by creating provenance regarding where it originates using their meter data (Zhang et al. 2018). Ultimately, however, it is the responsibility of the P2P energy trading platform provider to ensure that supply and demand are matched, irrespective of individual trading preferences. In the absence of private wire connection between homes, the question of where becomes abstracted in virtual flows encapsulated by data pairing and offsetting on the P2P energy trading platform (Kragh-Furbo and Walker 2018).

Given that this space has traditionally been the remit of DNOs, P2P energy assumes significant changes to the way responsibility for electricity distribution is regulated. Yet P2P energy is not only a factor of regulatory change and technological progression. It is also part of a wider trend towards digitally networked exchange

relations, proponents of which promise disintermediated, collaborative and democratizing approaches to sharing the use of existing assets (Langley and Leyshon 2017; Srnicek 2016).

For P2P energy to work, it requires multi-sided electricity distribution markets that overcome some of the restrictions currently determining electricity distribution system management and regulation. Keeping the system in balance requires some form of trading platform that ensures that individual trades do not create constraints. Electricity is in principle intangible, invisible and undifferentiated. Only the timestamping of generation and outflow metering create visibility for subsequent trading/sharing and associated value creation. Differentiation according to individual peers on a network can only be created through trading platforms that create digital provenance.

In sum, P2P energy trading could play a key role in smoothening the transition towards a sustainable renewables-based energy grid, by providing an efficient transaction mechanism for the matching of supply (i.e. microgeneration of energy by prosumers) and demand. However, this relies on the availability of energy data and the entrance of new profit-making data companies to the sector. This carries risks, as seen in other sectors undergoing decentralization, such as data monopolies.

Policymakers should ensure that the social benefits set out in the previous section, accruing from the services provided and value gained by energy-producing peers to the P2P community, are maximized by these new data entities by operating trading platforms through progressive energy system governance. How the regulator approaches such companies will define whether and how the social benefits of P2P energy trading will be maximized, as suggested by the next section on regulation.

V. Regulatory perspective: How to manage risk while innovating?

Peer-to-peer energy trading is currently at an experimental and pre-competitive phase. The regulatory approaches adopted by countries around this model will define its future success. They will also shape the social and market repercussions set out in the previous sections. This section assesses existing regulatory approaches to P2P energy trading and makes a case for looking closely at the lessons learned from other sharing economy sectors.

The European Union's recently revised Renewable Energy Directive defines peer-to-peer energy trading as "the sale of renewable energy between market participants by means of a contract with pre-determined conditions governing the automated execution and settlement of the transaction, either directly between market participants or indirectly through a certified third-party market participant" (Art. 2(18)). This is supported by other provisions in the Directive stipulating the conditions under which P2P energy trading may take place. For instance, consumers participating in trading will continue to be protected, provided such an activity does not constitute their "primary commercial or professional activity" (Arts. 2(14), 22) (European Commission 2018).

The European Union's approach of setting conditions in legislation around P2P energy trading is comparable to that taken by individual European countries such as France and Spain, where laws have been formulated (mostly before the EU finished revising its Directive) to enable the collective self-consumption of energy at small scale, subject to strict conditions. For instance, the original French law requires individuals to be part of one legal entity and connected to the same low-voltage substation (Art. L. 315-2) (Legifrance 2018). The latter condition is similar to that imposed by the original Spanish law, which recognizes "self-consumption by one or several consumers" of electricity originating from production installations that are "connected to the internal

network of associated consumers”, either through direct links or the same low-voltage substation (Art. 9) (Jefatura del Estado 2013).

Despite such legislation making small-scale P2P pilots possible, limits such as the geographic proximity between residents have proven to be stifling for those running pilots in France, who in addition to this are not able to become fully operational without government subsidies (UCL Energy Institute 2018). It should be noted that, likely due to these concerns, the French law has been changed in November 2019 to widen the perimeter within which collective self-consumption can take place to 2 km (Legifrance 2019). The same can be observed in Spain, where the law was broadened in April 2019, making it possible to share energy at residential scale (Molina 2019).

On the other hand, an increasing number of countries such as the United Kingdom and the Netherlands are opting for the ‘regulatory sandbox’ approach. This enables organizations to trial innovative ideas which are not foreseen in regulation, in a real-world environment with a small number of domestic customers during a limited amount of time, without some of the usual rules applying. The aim is for the learnings and results of pilots to be taken on board by the government and regulators when revising the applicable rules and legislation, potentially enabling pilots to operate at a wider scale post-sandbox. P2P energy trading trials (mostly using blockchain technology) are currently taking place under the UK and Dutch sandboxes.

Ofgem, the UK energy regulator, has stated that its sandbox (‘Innovation Link’) is crucial at a time when regulation must evolve to facilitate the “deep and wide-ranging transformation” the energy system is undergoing. Its view is that a “flexible approach that relies... on learning over time” is necessary in a situation of “regulating for uncertainty”. The protection of consumers’ interests is crucial in this transition. The sandbox, launched

in 2017, allows pilots to run for up to two years. Trial participants must partner up with a licensed supplier/distributor (Ofgem 2020).

The Dutch sandbox ('Experimenteerregeling') was launched in 2015. Its declared intention is to assess whether current legislation presents a barrier to enhanced renewable energy generation at a local level, as well as the efficient use of available energy infrastructure. These aims are part of the government's programme to meet its renewable energy targets. Trials have a duration of up to 10 years and they can deviate from a wider regulatory framework as compared to the UK sandbox (RVO 2018).

What can previous attempts at regulating the sharing economy teach us?

It is clear so far that there are two regulatory approaches when it comes to P2P energy trading: legislation and sandboxes. As the European Union formally recognizes P2P energy trading in its legislation, EU Member States will need to align their national legislation while being careful not to stifle innovation. Recent attempts to regulate other sharing economy sectors can provide valuable lessons for the regulation of P2P energy trading.

The sharing economy model does not fit within any existing legal framework. It is not only a disruptive innovation, but also a 'regulatory disruption' (Cortez 2014, 175-177). This is due to the new types of horizontal transactional relationships it creates between individuals, and the role played by new Internet platform companies facilitating these exchanges (Hausemer et al. 2017). These platforms are being relied on to enforce rules drafted by policymakers, since they have direct access to users and their data (Scassa 2017). So far it has proven difficult for local authorities to hold platforms accountable for a lack of enforcement. For instance, in London Uber's license was suspended in 2017 and 2019 due to its unwillingness to respect conditions set by local authorities (Browne 2019).

Several academics argue that the legislation imposed on such companies is too restrictive (Durkin 2018).

Another example is the upcoming market of P2P lending, which has become increasingly popular due to its ability to fund start-ups, and in the UK is regulated in a way that is criticized as being too burdensome and not innovation-friendly enough (Arnold 2018). Some academics argue that for the sake of providing legal certainty to stakeholders, some form of regulation is necessary around such models. This must strike a balance between not being too prescriptive and avoid being too vague. No or not enough regulation would cause legal uncertainty and enable unfair competitive behavior, thereby hurting platform users. On the other hand, imposing the current (prescriptive) regulatory framework to sharing economy companies would stifle the benefits brought about to consumers by this market model, since the framework is not designed for the sharing economy (Stemler 2016).

Due to facilitating consumer-to-consumer (C2C) transactions, platform companies hosting P2P energy trading markets will be responsible for ensuring that rules such as those in consumer protection legislation are met (Schneiders and Shipworth 2018). This is particularly important, since it is difficult to imagine how trust-creating (and safety-enhancing) systems found in P2P platforms such as Uber/Airbnb, for instance user and provider ratings, can work in a P2P energy trading context (i.e. it would be impractical due to a large volume of small trades)¹. Platform companies will also have additional responsibilities, such as making sure that energy demand and supply are constantly balanced within the P2P network (i.e. there are enough peers producing energy).

¹ A model where a person is given an overall rating by the community could be a feasible option.

P2P platforms operating in the energy sector are therefore likely to be monitored more heavily than those in non-utility sectors. This is also because energy is an essential service (as stated in the introduction) and the infrastructure used (i.e. energy grid) is of critical national importance, which is why the sector is already heavily regulated. However, as the energy sector is becoming more decentralized and innovative, the lesson from the other sectors on the stifling of innovation due to restrictive rules and a consequent breakdown of trust between platforms and policymakers should be borne in mind.

There may be other ways, aside from drafting rules and regulation, for government authorities to ensure that P2P energy participants are protected. Examples of alternatives are standards and principles (Ofgem 2018b; Sandys et al. 2018). These could be the result of dialogue and negotiation between policymakers and platforms, so that they are designed to be innovation-friendly and a breakdown of trust (as witnessed in sharing economy sectors) is avoided.

A regulatory sandbox would be an ideal forum to start such a dialogue, enabling both regulators and innovators to learn from one another and exchange insights on trials. This is a more flexible option than regulation, the drafting of which moves at a slower speed than technological innovation. It should however be noted that sandboxes and regulation are not mutually exclusive. Provided rules are not drafted in a too prescriptive manner, they could provide space for further experimentation within a regulatory sandbox environment. France is an example of a country keeping both options open (Commission de régulation de l'énergie 2020).

In the current pre-competitive stage at which P2P energy trading is, sandboxes are a preferable approach to regulation, as they allow for the testing of new ideas and subsequent drafting of flexible innovation-friendly rules and regulations. However, since

they are a relatively new phenomenon, their future regulatory impact is unknown. Due to their limited scope (e.g. in the UK only certain rules can be deviated from) and timeframes, it is not certain to what extent sandboxes can warn policymakers about wider market impacts such as network effects and the existence of (data) monopolies. They should be designed so that they can represent, as accurately as possible, the impacts of such new business models on consumers and the role that will be played by existing and new market actors when rolling these out.

As evidenced by the other sharing economy sectors, a lot is at stake when it comes to consumer wellbeing (increase in prices, monopolies etc.). Downsides would be particularly acute in the energy sector, as it is an essential service. Policymakers should therefore retain a cautious approach to regulating P2P energy trading. However, they should do this by maintaining an open stance, bearing in mind that P2P energy trading can also have many benefits for consumers and the wider market. One of the main lessons from the wider sharing economy is to find a way for continuous dialogue with innovators, to learn from one another and ultimately regulate in a way that benefits consumers. Currently the best option to achieve these goals is a regulatory sandbox.

VI. Discussion and conclusions

Peer-to-peer energy trading, currently at an experimental stage, could become an important part of the future energy system. Proponents argue that it is a promising way of meeting renewable energy and climate targets, and a means to help balance supply and demand in an increasingly decentralized energy grid.

More cautionary voices point towards the concentration of value accruing through sharing economy approaches, primarily among sharing platform providers through value monopolization, and secondly among platform users through cost socialization. This is a consequence of P2P energy trading being enabled by digital technology and increasing

data generation and capture abilities, as with other sharing economy sectors. If energy trading can be regulated appropriately, it may represent one of the building blocks that make up the decarbonized energy systems we require.

In this paper, we raise important questions- from a social, economic/market and regulatory point of view- that we think should be considered and answered by policymakers and societies before they move forward with the wider rollout of this new business model.

From a social perspective, we first consider whether it is reasonable to conceptualize P2P energy trading as a form of sharing economy activity, and under what circumstances. We conclude that this is more legitimate if electricity is treated as a service rather than a good. Similarly to other sharing economy sectors, consumers would be able to sell energy services through online P2P platforms.

We further argue that a sharing conceptualization of P2P energy highlights its higher societal potential than alternative approaches which have similar grid management goals (such as direct load control and time-varying tariffs), but which do not have a sharing element. This is because energy trading could allow more compelling stories to be told around ideas of community, neighborhood, family, etc. – although research would be needed to test this. The potential for P2P energy trading to benefit the wider community also highlights its more far-reaching societal impact as compared to other sharing economy sectors.

We then explore P2P energy from a markets/economic perspective. Given the different conceptualizations of P2P, its emergence poses questions regarding market governance. Historically, the evolution of energy systems, distribution networks and security responsibilities has created one-sided value creation and cost recovery structures. Platform capitalist energy models threaten to undermine these structures through the

concentration of transactive, consumption and behavioral data. If P2P energy evolves along similar lines, the platforms providing multi-sided markets hold the power over energy trades through gatekeeping data infrastructures overlaying electricity infrastructures.

Energy governance thus increasingly incorporates data governance to maximize the benefits of such data overlays while minimizing the risks. P2P energy is one particular business model which is rapidly evolving into multi-sided markets as a result of such data overlays. It facilitates virtual bidding and financial transactions by creating digital provenance. To establish a social license for the operation of P2P energy trading, governance needs to ensure that social P2P benefits result in public value, rather than the socialization of costs.

Regulators currently evaluating the strengths and weaknesses alongside drivers and barriers to P2P energy trading should bear in mind the results of present P2P platforms in accommodation and transport, creating monopolistic entities benefiting consumers while making society in general worse off in some cases.

Policymakers' attempts at regulating these consequences in other sectors have proven unsuccessful so far. These are likely to take place in a more far-reaching manner in the energy sector, presenting risks to (vulnerable) consumers and the energy grid infrastructure. Energy policymakers should ensure that the regulatory frameworks they establish mitigate against harm, while facilitating innovation. The latter will enable consumers and wider society to reap the full benefits of innovative business models such as P2P energy trading.

Such a balance can only be achieved by choosing the right regulatory tools. Following a review of existing regulatory approaches, this paper concludes that regulatory sandboxes (providing regulatory exemptions) are an appropriate tool to assess

and eventually modify regulation to maximize benefits for all stakeholders involved. This is because they provide a platform for constructive dialogue between industry, consumers and the regulator.

However, policymakers should ensure that an energy regulatory sandbox is properly designed, in order to provide a complete picture of the impacts of P2P energy trading on all stakeholders involved. This is particularly necessary to gauge consumer appetite, as ultimately consumer desirability will be more crucial to the success of this model than technical and economic viability.

Regulatory exemptions and the increasing datafication of energy will provide a diverse range of opportunities for increasing energy governance experimentation and value creation at the peer and community level. In that case, the data aspect of energy trading might become a more important market determinant than the actual energy traded. The value of data is already leading to the entrance of many non-State actors with expertise in data management and profit-making motivations. Further research on the role played by non-traditional data actors in the energy sector, and how they can help protect consumers taking an active role on the grid, will be necessary.

In the absence of a more fundamental change to energy system governance, and while P2P energy trading is at a pre-competitive stage, this paper therefore suggests that policymakers and regulators should err on the side of caution, especially in relation to issues that are becoming increasingly apparent in sharing and platform economies. This is particularly crucial in relation to energy due to its essential services we all depend on. The regulatory sandbox is currently the best option to assess potential risks, while supporting innovation which can bring benefits to consumers and the sector.

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VIII. Declaration of interest statement

The authors declare that no financial interest or benefit has arisen from the direct applications of their research.

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