Designing a Just P2P Energy Trading System

Translation of energy justice value into justice norms for P2P energy trading

Darmawan, A. 4737687

***Abstract*—The rapid development of renewable technologies has opened the opportunity for households to produce their own energy, and to either self-consume or sell it. In the Netherlands, it is projected that not less than 7 GW of solar PV capacity will be installed in 2020. Therefore, the Netherlands is expected to experience abundant energy supply from solar generation in the near future. Energy sharing can be a reliable method to manage a great number of solar PV production. This direct sharing might reduce the strain and improve the stability of the main grid because it lessens the power to be transported and balanced across the main grid. Such an energy sharing method is also known as *peer-to-peer (P2P) energy trading.* Despite its potential benefits, the pre-established requirements to perform such trading can be perceived unjust for some communities. As an illustration, P2P energy trading by design requires people to own solar PV to generate distributed power, in which not everybody could afford it economically. This study is then aimed at specifying a set of norms for a just P2P energy trading system by operationalising the framework of *value-hierarchy.* Accordingly, the abstract level of energy justice as a value will be translated into a more concrete set of norms. This set of justice norms for P2P energy trading is expected can guide the system a step closer to be a just energy innovation.**

Keywords—Design for Values; Energy justice; Norms; Peer-to-peer energy trading; Value-hierarchy.

I. INTRODUCTION

The rapid development of renewable technologies has opened the opportunity for households to produce their own energy and to either self-consume or sell it. Among currently existing renewable technologies, solar PV is the fastest growing and the most promising renewable technology to be installed on households level (Group, n.d.). In the Netherlands, it is projected that not less than 7 GW of solar PV capacity will be installed in 2020 (Versteeg, 2018). Therefore, the Netherlands is expected to experience abundant energy supply from solar generation in the near future.

Energy sharing can be a reliable method to manage a great number of solar PV production, which also promotes local market solutions (Long, Wu, Zhou, & Jenkins, 2018). It involves multiple parties where not only the consumers could responsively adjust their consumption according to the changing electricity prices, but they could also distribute their excess production directly to their neighbours. Additionally, this direct sharing will reduce the strain and improve the stability of the main grid because it lessens the power to be transported and balanced across the main grid (Zhu et al., 2013). More precisely, when there is a connection between the main grid and the microgrid, the direct sharing provides another option to spread the excess power across the distribution grids (microgrid) instead of feeding it back immediately to the main grid. Such an energy sharing method is also known as **peer-to-peer (P2P) energy trading** (Lakshminarayana, Quek, & Poor, 2014; Long et al., 2018; Tushar et al., 2018).

Despite its potential benefits, the implementation of P2P energy trading in society is rather problematic. The pre-established requirements to perform P2P energy trading, especially with regards to the technologies that are used, can be perceived unjust for some communities. As an illustration, P2P energy trading by design requires people to own certain resources to generate distributed power, such as solar PV, in which not everybody could afford it economically. Therefore, a set of actions to address such "unjust pre-established requirements" has to be formulated to approach a juster P2P energy trading system where poor communities can also participate and be benefited herewith.

As opposed to the technical functionalities of which the designers strive for clarity, the roles of values are frequently made implicit in engineering design. Accordingly, the value of justice can be considered somewhat missing within the concept of P2P energy trading. Nevertheless, the increased demand towards more user-centred products where users become the main focus of products has stimulated the idea of design for values. The idea expects the designers to put more efforts at collecting needs, concerns, and values of users, and then incorporate them explicitly into the products.

Addressing the issue of the value of energy justice is still implicit or somewhat missing in the design of P2P energy trading, **this research is aimed at specifying a set of norms for P2P energy trading system that can guide the system a step closer to be a just energy innovation.**

The rest of this paper is organised as follows: Section II provides literature review of important key-concepts of this research; Section III explains the methodology that was applied to approach the objective of this research; Section IV characterises the P2P energy trading system from a socio-technical perspective; Section V elaborates the translation of energy justice value into justice norms for P2P energy trading; Lastly, section VI presents the discussion and conclusion of this research and recommendation for future research is given in section VII.

II. LITERATURE REVIEW

2.1 Value-hierarchy

Van de Poel (2013) introduces value-hierarchy as a framework to translate a rather abstract value into a set of concrete design requirements. As shown in Figure 1 Hierarchical relationship between values, norms, design requirements, the framework suggests that values and design requirements may have a hierarchical relationship with norms as an intermediary between them. Although hierarchical, the relationship between values, norms, and design requirements is not immediately deductive.

Elements in the lower level are more concrete than the upper, and they inhibit specific context. Therefore, the context has to be known to be able to understand how the lower-level elements are derived from the higher-level elements. Furthermore, the relation between two different layers can be either *"for the sake of"* or *"specification"*. The latter, in particular, refers to top-down relationship that the higher-level elements are translated to lower-level elements.

Before going into the specification, value conceptualisation has to be done first as the preliminary step. Value conceptualisation is by large a philosophical activity where the meaning of values is clarified, and their applicability, as well as the concern in which they are most interested in, are analysed. A value might be interpreted in different ways. Accordingly, the most proper definition where the value can be justified valuable needs to be selected before proceeding to the next step of translation.

After selecting the most proper definition of value, it is further specified by inserting content. The content itself is domain-specific. Consequently, having sufficient domain-specific knowledge is mandatory to be able to specify values into a set of norms. Translating values into norms also means moving from evaluative domain into prescriptive domain. While the values are used to evaluate whether certain objects or actions are worthwhile or acceptable, the norms are used to prescribe some actions. Furthermore, it is important to ensure that each norm that has been developed can be regarded as an appropriate response to the value, and collectively, they are sufficient to respond to the value (van de Poel, 2013). Put differently, they should be correct and complete.

Having ensured that a set of norms is correct and complete, it can be further specified into specific design requirements. The norms, which describe actions or means to be undertaken, by or to whom these actions are to be done, or goals to be achieved, are added with more information. Accordingly, design requirements are more specific than norms in terms of scope of applicability, ends that are pursued, and means to achieve respective ends.

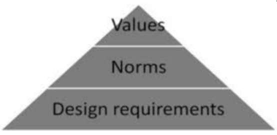

Figure 1 Hierarchical relationship between values, norms, design requirements (van de Poel, 2013)

2.2 *Energy justice*

The concept of energy justice was derived from another domain of justice which priorly appeared as a modern concern, namely environmental justice (Pesch, Correljé, Cuppen, & Taebi, 2017). Although both may be argued to share similar philosophical ideology, environmental justice focuses more on environmental degradation and its resolution from social justice perspective whilst energy justice leans its focus toward energy system and energy policy (Pesch et al., 2017). Furthermore, McCauley et al. (2013) argue that the work of energy justice aims to realise affordable and sustainable energy for every individual across all regions. Meanwhile, Sovacool & Dworkin (2015) posit that the pursuit of energy justice should, in the end, establish a global energy system where it distributes both costs and benefits fairly and allows impartial decision making for all individuals.

Jenkins, McCauley, Heffron, Stephan, & Rehner (2016) develop the framework of energy justice as a way to help operationalise the value of energy justice. Their framework distinguishes three sub-values of energy justice which commonly known as *triumvirate* or *tripartite* model of energy justice. These sub-values are *distributive justice*, *procedural justice*, and *justice as recognition*.

2.2.1 *Distributive justice*

Distributive justice is mainly concerned with a fair allocation of benefits and ills, as well as their associated responsibilities (Jenkins et al., 2016). Sovacool & Dworkin (2015) suggest the structure of which distributive justice should be operationalised. It should comprise three main aspects of distribution, which are:

1. The goods or objects to be distributed (what should be distributed?);
2. The entities of which the goods or objects are going to be distributed (who are the recipients/donors?);
3. The underlying principle which governs the distribution of the goods or objects, such as based on the capacity of an individual, on need, on merit, or something else (how is the pattern of distribution?);

Related to point 3 above, Bianchin & Heylighen (2018) promote Rawls' principle of social justice as the principle to govern the distribution of items when designing an artefact or system. The principles address two main points, which are:

1. <u>First principle:</u>
   "Each person is to have an equal right to the most extensive total system of equal basic liberties compatible with a similar system of liberty for all"

2. <u>Second principle:</u>
"Social and economic inequalities are to be arranged so that they are both: (a) to the greatest benefit of the least advantaged, consistent with the just savings principle, and (b) attached to offices and positions open to all under conditions of fair equality of opportunity"

2.2.2 *Procedural justice*

Procedural justice is mainly concerned with inclusion of stakeholders during the decision-making process of energy projects under non-discriminatory principle (McCauley et al., 2013). With respect to local community development projects, Bianchin & Heylighen (2018), Nieusma & Riley (2010), Pols & Spahn (2015) promote non-discriminatory principles to govern such a decision-making process. Their principles can be grouped within three different dimensions, as shown in Table 1 below.

Table 1 Main principle for fair decision-making

Dimension	**The main principle for fair decision-making process in community development projects**
Position	The decision-making process is fair if the position of the worse-off is maximised when deciding for a solution while individual freedom and fair equality of opportunity are protected.
	The decision-making process is fair if the power imbalances between stakeholders are minimised.
Involvement	The decision-making process is fair if there is a proportional composition of representatives from all affected stakeholders in the organisation.
	The decision-making process is fair if there is substantial and central involvement of the communities.
Resource	The decision-making process is fair if stakeholders are endowed with equitable information which enables them to make rational decisions
	The decision-making process is fair if it allocates time for public trust development through public consultation, workshop, deliberation, etc.

2.2.3 *Justice as recognition*

The third tenet of energy justice, justice as recognition, is mainly concerned with equal appreciation of the people who are affected by energy projects (Milchram, Hillerbrand, van de Kaa, Doorn, & Künneke, 2018). McCauley et al. (2013) further distinguish participation of the people from recognition. They define recognition as *"manifestation of process of disrespect, insult, and degradation that devalue some people and some places identities in comparison to others"*. Additionally, Jenkins et al. (2016) posit that justice as recognition should address diversities in society that are originated from social, cultural, and belief differences. They bring forward the issue of misrecognition of society as the result of not taking attributes of diversity in society seriously.

In related work, Pesch et al. (2017) identify justice as recognition as one driver of local opposition towards energy projects. When the locals feel that their concerns are not heard by the authority or that the energy projects could harm their position or whatever they collectively consider as important, overflowing or social conflicts may occur (Cuppen, 2018; Pesch et al., 2017). Therefore, acknowledgement towards local's identity becomes a prerequisite for a smooth realisation of energy projects.

III. METHODOLOGY

The work to approach the objective of this study was grounded in the framework of *value-hierarchy*. In general, two steps were taken to operationalise the respective framework. The first step was investigating what information about socio-technical characteristics of P2P energy trading that could be relevant to the domain of energy justice. Afterwards, an attempt was made to specify the justice norms for P2P energy trading which contain that information/items. Those steps are illustrated in Figure 2 below.

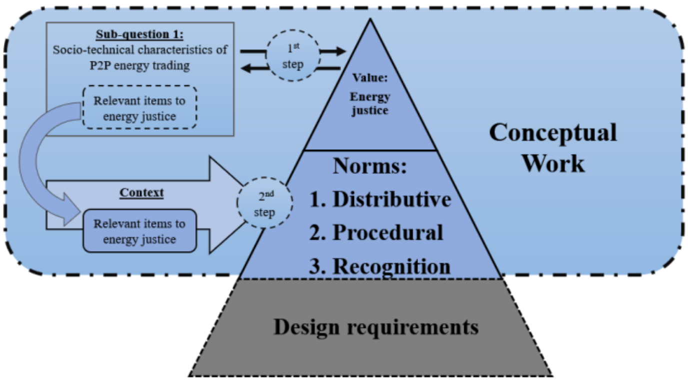

Figure 2 Two general steps of value-hierarchy operationalisation

3.1 *Step 1*

The first step entailed two activities, which were identifying the socio-technical characteristics of P2P energy trading and connecting the characteristics to the energy justice domain. For the first activity, the technology-focused approach and the framework of multi-layered energy system proposed by Zhang, Wu, Zhou, Cheng, & Long (2018) were jointly applied. Accordingly, an attempt was made to distinguish the main technology drivers that are used in P2P energy trading. One technology was deliberately assigned to each layer of P2P energy trading system. As suggested by Figure 3, **solar PV system** is responsible for the physical layer, **smart metering system** is responsible for the cyber layer, and **P2P platform** is responsible for the business layer. Upon the selection of the main technology drivers, an attempt was made to characterise them under several topics/themes.

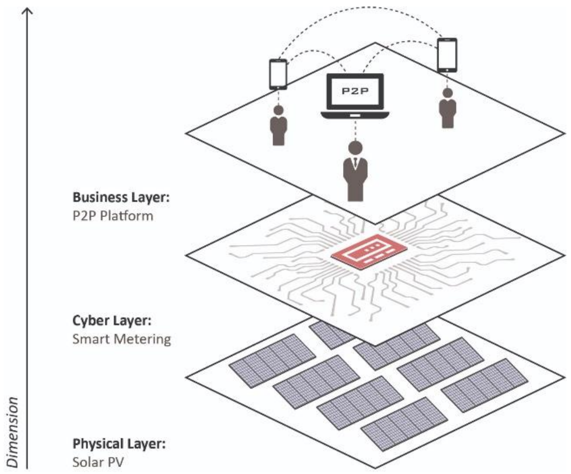

Figure 3 Multi-layered framework of P2P energy trading including the main technology drivers per-layer

For the second activity, a set of criterion was formulated to connect the socio-technical characteristics of P2P energy trading system to the energy justice domain. More precisely, they were used as the guidance to distinguish information/items available in P2P energy trading that can be relevant to the energy justice domain. The criteria themselves were derived from the interpretation of each tenet of energy justice, as indicated in Table 2 below.

Table 2 Guiding criteria used to distinguish relevant items in the characteristics of P2P energy trading to the energy justice domain

Tenet of energy justice	Derived criteria
Distributive	Attribues/goods/events that can be distributed/allocated/divided
Procedural	Attributes/goods/events that can be organised/deliberated together with communities or that are needed to conduct such deliberation
Recognition	Attributes/goods/events where their organisation can be influenced by the characteristics/identity of the communities

3.2 *Step 2*

A set of steps and rules was applied to specify a set of justice norms, taking into account the relevant items in the P2P energy trading system as the context. Those steps and rules were:

- Determine the goal for the formulation of each group of norms (distributive norms, procedural norms, and recognition norms), which is what each group should address, or what to be achieved through the formulation of each group of norms;
- Find the principles that have been developed by other authors as the starting point to govern the identified items in each group of norms. Those principles must be somewhat related and, with some adaptions, applicable or relevant to govern the organisation of respective items;
- Only select and adapt the principles that are introduced within the context of design of products/systems.

Confronted with the arrangement above, desk research was conducted in the Scopus database to explore and select the initial principles. Upon the review, the final set of literature which contains the initial principles that satisfy the rules above, as well as the keywords to find it, are given in Table 3. In addition, during the review, the references that are cited in the paper that was being reviewed were visited, and it was repeated in the subsequent paper. That was how the final set of literature listed in Table 3 could be collected.

After selecting and adapting the principles to properly govern the organisation of the items in the previous step, an attempt was made to structure the complete norms. Accordingly, a set of norms was formulated by using the grammatical rule of institutions: **ADIC**. It stands for **A**ttributes (to whom does a rule apply), **D**eontic (permission, obligation, or prohibition), a**I**m (actions or expected outcomes), and **C**ondition (when or where are the actions or outcomes permitted).

Table 3 Keywords to find the final set of literature which contains the desired initial principles, and the results

Group of norms	Keywords	The final set of literature taken as the reference upon iterative review
Distributive	(TITLE-ABS-KEY ("distributive justice")) AND (("design")) AND ("system")	Bianchin, M., & Heylighen, A. (2018). Just design. *Design Studies*, *54*, 1–22.
	(TITLE-ABS-KEY ("distributive justice")) AND ((("design")) AND ("system")) AND (cost)	Sovacool, B. K., & Dworkin, M. H. (2015). Energy justice: Conceptual insights and practical applications. *Applied Energy*, *142*, 435–444.
	(TITLE-ABS-KEY ("distributive justice")) AND ((("design")) AND ("system")) AND (benefit)	Ostrom, E. (2010). Beyond Markets and States: Polycentric Governance of Complex Economic Systems. *American Economic Review*, *100*(3), 641–672.
	(TITLE-ABS-KEY ("distributive justice")) AND ((("design")) AND ("system")) AND (access)	Fahlquist, J. N., Doorn, N., & Poel, I. van de. (2017). Design for the Value of Responsibility, 1–15.
	(TITLE-ABS-KEY ("distributive justice")) AND ((("design")) AND ("system")) AND (responsibility)	
Procedural	(TITLE-ABS-KEY ("procedural justice")) AND (("design")) AND ("system")	Bianchin, M., & Heylighen, A. (2018). Just design. *Design Studies*, *54*, 1–22.
	(TITLE-ABS-KEY ("procedural justice")) AND ((("design")) AND ("system")) AND ("involvement")	Nieusma, D., & Riley, D. (2010). Designs on development: Engineering, globalization, and social justice. Engineering Studies (Vol. 2).
	(TITLE-ABS-KEY ("procedural justice")) AND ((("design")) AND ("system")) AND ("position")	Pols, A., & Spahn, A. (2015). Handbook of Ethics, Values, and Technological Design. *Handbook of Ethics, Values, and Technological Design*, 1–24.
	(TITLE-ABS-KEY ("procedural justice")) AND ((("design")) AND ("system")) AND ("information")	
Recognition	(TITLE-ABS-KEY ("recognition justice")) AND (("design")) AND ("system")	Jenkins, K., McCauley, D., Heffron, R., Stephan, H., & Rehner, R. (2016). Energy justice: A conceptual review. *Energy Research and Social Science*, *11*, 174–182. McCauley, D., Heffron, R. J., Stephan, H., Jenkins, K., Gillard, R., Snell, C., & Bevan, M. (2013). Advancing energy justice: the triumvirate of tenets and systems thinking. *International Energy Law Review*, *32*(3), 107–110.

IV. Identification of P2P Energy Trading System from a Socio-Technical Perspective

4.1 P2P energy trading system demarcation: one microgrid connected to wholesale markets

Stedin & Energy21 (2018) developed a concept of electricity trading under the name of *layered energy system* (*LES*). The concept adopts the interconnected P2P structure with also taking into account the socio-technical characteristics of the Dutch electrical system. The most striking feature being proposed in their concept is that it allows people within a microgrid or local market to purchase the electricity from the wholesale markets instead of direct trading between microgrids. However, they claim that the way households make the transaction in their model fits better to the idea of peer-to-market rather than peer-to-peer.

To ensure compatibility and consistency, P2P energy trading in this research will still be defined according to Stedin's concept, considering their concept is developed within the setting of the Dutch electrical system. More precisely, the physical structure of electricity trading drawn in Stedin's concept will be followed. The demarcation of the P2P energy trading in this research is illustrated in Figure 4 below. The respective boundary rules out the complex interaction between multiple interconnected microgrids or local markets.

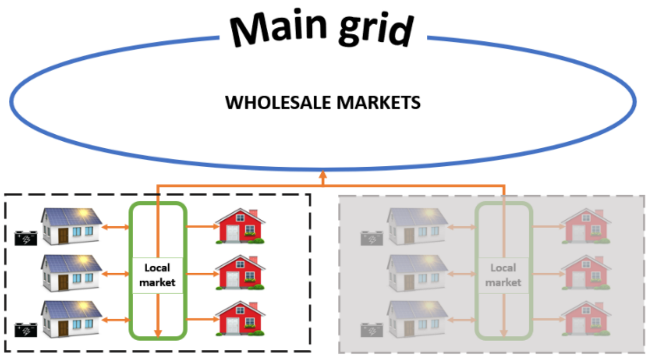

Figure 4 Definition of P2P focusing on one microgrid/local market connected to the main grid/wholesale markets (adapted from (Stedin & Energy21, 2018))

4.2 Characteristics of solar PV system as an instrument in P2P energy trading to generate electricity

Typical on-grid solar PV system for households consists of PV panels or modules and supporting components, also known as Balance of System (BoS). This BoS comprises inverter, DC-DC converter, mounting structure, and cables. A simple representation of on-grid solar PV system is given in Figure 5 below.

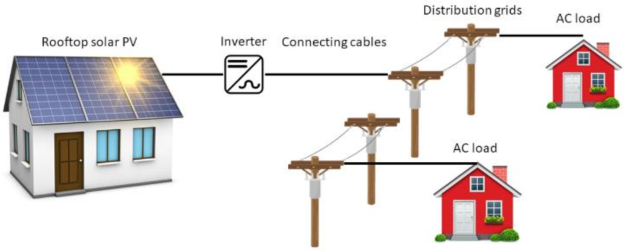

Figure 5 On-grid solar PV system (Smets, Jager, Isabella, Swaaij, & Zeman, 2010)

4.1.1 Investment and ownership

Costs are an important parameter for people or investors who are making a decision for which solar PV technologies to be invested. They need to invest in a set of on-grid PV technologies that, in the end, can bring benefits for them. This partly means that the investment has to be recoverable throughout technologies' lifetime. Therefore, the total costs from PV panels and BoS components that are installed for electricity trading should not then exceed the potential revenue which people could earn from supplying the electricity.

Investing in solar PV can be problematic not only because of the up-front costs that may become very expensive, considering there are several components that must be set together but also because of the difficulty to own solar PV. By default, the solar PV system can be privately owned and installed in a private roof. However, limited availability of private roofs in certain neighbourhoods can be a significant barrier for this type of ownership. The Dutch postal code area regulation, known as *postcoderoosregeling*, provides an alternative of ownership to address the respective issue. With *postcoderoosregeling*, it becomes possible to own solar PV that is installed in other people's properties or roofs within the same postal code (Proka, Hisschemöller, & Loorbach, 2018).

Although *postcoderoosregeling* may promote local cooperation, the prescribed spatial restriction can be harmful at the same time. When a postal code constitutes a very small area, the electricity trading may become very exclusive if it is only allowed to be performed within that postal code. Consequently, only a small number of people could be benefiting from electricity trading. Moreover, it could contrast the social disparity within a narrower scale if one postal code happens to have residents who together able to provide both property and solar PV whilst its adjacent postal code areas cannot. As the pre-defined P2P energy trading in this research also requires a clear defined boundary, the size of a postal code area to support the respective type of ownership must then be planned carefully.

Postcoderoosregeling also suggests that communities need to be flexible in adding or removing members from the system or market of P2P energy trading. There is a possibility that old residents leave and new residents enter the neighbourhood. This mobility may result in overwhelming administrative issue to allow new residents to access others' property while at the same time prohibiting the former residents.

4.1.2 Profitability

The concern about profit and investment is closely related. As implicitly indicated in sub-section 4.1.1, a feasible solar PV investment is by large determined by whether the resulting profits could recover the investment costs. Accordingly, incorporating economic analyses within the investment plan becomes imperative. These analyses should reflect the real condition of where and for whom the system is planned to be installed. One of the most important economics analyses, especially for households, to make a recoverable investment is regarding compensation schemes (Smets et al., 2010). There are two compensation schemes for small PV instalment in the Netherlands, namely *Net Metering* and *Feed-in tariffs* (RES Legal, 2016).

With regards to Feed-in tariffs, the Netherlands has its own programme called SDE+ (*Stimulering Duurzame Energieproductie*) scheme. Under this scheme, the households will be subsidised by the Dutch government when the market price of electricity drops below the cost price (Frontier Economics, 2015). High Feed-in tariffs, however, may discourage people from doing peer trading. It allows them to simply receive a high amount of money without having to deal with the hassle of community or market interactions. Therefore, it is necessary to adjust the Feed-in tariff scheme, if not suspend it, to the level that can motivate people to make peer trading.

Further, both Net Metering and Feed-in tariffs scheme are perceived to be partially responsible for transforming the distribution grids into compensating buffer. Without time consideration for the reward, people are being incentivised to overfeed the grids with the power during the day although the peak consumption is in fact in the evening. Consequently, the grids become more vulnerable to the voltage fluctuation where the voltage rises during the day as they receive additional power from solar PV and suddenly drops in the evening (Karimi, Mokhlis, Naidu, Uddin, & Bakar, 2016).

P2P energy trading scheme may become an alternative that can provide better incentive to maintain the grid balance in comparison to both Net Metering and Feed-in tariffs. Within P2P energy trading, the reward from excess production can be obtained only when there is demand for electricity from other households. Put differently, the rewards are arranged in occasional or timely manner. Therefore, people will not be incentivised to oversupply the grids during the day if there is no actual consumption which provides the rewards at the time.

4.1.3 *Local flexibility and grid balance*

It has been demonstrated in sub-section 4.1.2 that people may earn profits from solar PV system through compensation schemes and P2P energy trading. Relative to the discussed compensation schemes, P2P energy trading might also provide a better incentive with respect to the grid balance. Even so, it is still important to control the amount of power to be traded via distribution grids. That is because the grids still have certain capacity limitation and very intense electricity trading in large volume could accelerate grid defection instead. Consequently, DSOs may need to reinforce the grids at the cost of higher connection tariffs, causing the wholesale electricity prices in general to increase (Koirala, Koliou, Friege, Hakvoort, & Herder, 2016).

As mitigation, energy storage can be applied for flexibility to relieve the tension in the grids from electricity trading (Bouffard & Kirschen, 2008). Such energy storage provides households with more opportunity to control their electricity distribution and give them a wider space to manoeuvre their trading. Furthermore, energy storage may induce a new form of coordination between households and DSOs. For instance, DSOs may indicate the households that the grids are overloaded at the moment. Energy storage then allows households to respond to the signal by postponing the trading instead of having it terminated. DSOs may also coordinate with the locals to procure flexibility from the local energy storage and then pay them with the price higher than the normal energy price in the market (Stedin & Energy21, 2018).

Regardless of all the potential benefits, adding the storage into the system may also incur several uncertainties ultimately to the realisation of P2P energy trading. First off, the profitability and the return of the PV system in general shrink when it is complemented with a large size battery. This is because every addition of kilowatt-hour in battery capacity will raise the total cost of the PV system quite significantly (Bruch & Müller, 2014). Secondly, provided with more flexibility to control electricity distribution, people might be tempted to exert harmful strategic behaviour. Purely driven by profitability, people may be incentivised to hold their production and refuse to make a trade when they do not find the market prices very attractive. Accordingly, the agreement between households for the goals to be achieved and correct incentives from the regulator might become necessary to prevent such strategic behaviours.

The presence of energy storage in the on-grid PV system for flexibility might be essential for the DSOs to balance the grids that are disrupted by P2P energy trading. However, Stedin & Energy21 (2018) demonstrate that the role of *Balance Responsible Parties* (*BRP*) is also equally important to support the grid balance when the practice of electricity trading happen. They will need to harmonise the P2P energy trading plan with the wholesale market process and communicate it to the system operator for grid balance management (Koirala et al., 2016). Furthermore, they need to ensure that the actual electricity traded between households follow the plans that are registered.

To support the novelty of P2P energy trading concept, communities are expected to be *balance responsible*, and the role of *BRPs* should be then taken over by them (Koirala et al., 2016; Stedin & Energy21, 2018). Otherwise, it will never be a pure P2P energy trading as some external parties still have partial control over the trading. However, this proposal requires the communities to comprehend all responsibilities and market processes set for BRPs, which might be difficult for such regular communities.

4.3 *Characteristics of smart metering system as an instrument in P2P energy trading to manage data flow*

As illustrated in Figure 6, smart metering, which implies two-way energy metering, requires three main components, namely smart meter, communication network, and database. The smart meter functions as the interface device that is installed at houses. Meanwhile, the communication network operates as the conduit for information, and the connector between multiple stakeholders as depicted in Figure 7. On the other hand, the database is used to store and process information.

4.3.1 *Data utilisation in communication network*

The typical communication network of the smart metering system specifies that at least three actors in the electrical system are connected at both ends of the network to share data. These actors are DSOs,

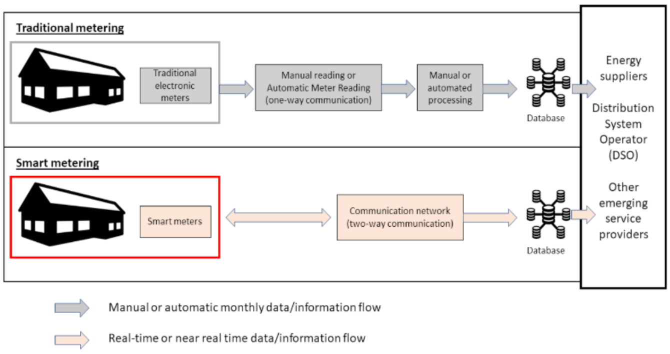

Figure 6 Components in smart metering system in comparison to the traditional metering (Ekanayake, Jenkins, Liyanage, Wu, & Yokoyama, 2012)

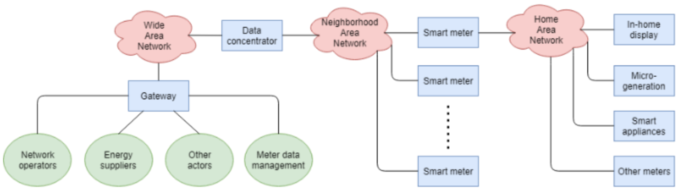

Figure 7 Typical communication network of smart metering system (Ekanayake et al., 2012)

energy suppliers, and households. To allow electricity trading to happen, DSOs must provide households access to their grids. However, it may become a concern for them to do so because P2P energy trading may impair the stability of the distribution grids at a certain point. For that, the DSOs might need the data of electricity trading to anticipate and balance the grid from the resulting disturbances and accordingly determine the service fee to be imposed to the households.

The pre-defined P2P energy trading in this research still allows traditional energy suppliers to provide energy to communities through the wholesale market. Therefore, they may need to have or receive data from electricity trading for various purposes. Zhang et al., (2018a) suggest that energy suppliers, together with the DSOs, may use the data to determine whether it is feasible to proceed certain electricity trading, taking into account the physical limitation of the grids and their own production. Alternatively, they may use the data from electricity trading to adjust their production accordingly such that the maximum capacity of the grids will not be exceeded.

On the other hand, the dual position of households as both consumers and producers suggest modification of data utilisation with respect to billing purposes. Acting solely as consumers, households only need to know the data regarding their energy usage to see how much money they must pay to their energy supplier accordingly. For P2P energy trading, however, they may also need to have the data which can allow them to bill their neighbours.

Although several existing actors in the electrical system who may have a stake in the P2P energy trading system and get connected through the communication network can be distinguished already, the new actors could still emerge and engage in the system. Koirala et al. (2016) submit the role of *aggregators* as an emerging actor in P2P energy trading system to aggregate production, as well as flexibility of the households. As suggested in sub-section 4.1.3, the households might as well take over the role of *BRPs*.

With regard to the emerging actors, it is more difficult to predict how they should be connected in the communication network and which data should be provided to them. That is because their operations or services are still new, and perhaps still changing, so that there is not much reference for those. Additionally, in great numbers, the involvement of emerging actors in data sharing could aggravate the data traffic in the network, especially when the trading has gotten more intense. Consequently, the performance of the network might get depleted and cause the entire communication services to be slow (Boycom, n.d.; Sytek, n.d.).

4.3.2 Reliability of automatic smart meters

In the Netherlands, DSOs are the only legal body who has the authority to distribute smart meters (Milchram et al., 2018). In comparison to the smart meters distributed in the United Kingdom, smart meters in the Netherlands are not featured with in-home display and are expected to be fully automatic. The decision to make smart meters fully automatic may erode the barrier of data literacy as the users do not need to understand and process the resulting data by themselves. Everything related to the data is projected to be algorithmically computerised. However, the side effects of being fully automatic are that households will need to trust the operation of smart meters entirely and they will have little means to inspect the algorithm or whether the meters operate accurately or not. For that, the reliability of smart meters in the Netherlands may need to be contested, especially when there is only one entity who is allowed to distribute the meters.

Zhang et al. (2018a) demonstrate that within P2P energy trading, smart meters may indicate a different amount of electricity that is received by a household from what has been agreed with her supplier neighbours. With that kind of possibility, it becomes more important to contest the reliability of smart meters. Communities need to be reassured that the smart meters do not make a false recording when there is such discrepancy. Otherwise, it will create distrust to the entire system when the discrepancy happens.

Additionally, the automatic smart meters are perceived as more reliable when they can be integrated with multiple other smart appliances or meters. The data that are recorded and can be processed by the meters will be richer and more meaningful when they can be connected to many devices. For instance, smart meters that can be connected to Electrical Vehicles are then able to record the electricity used by the vehicles for charging. Similarly, the meters are then able to record the electricity supply from vehicles when they discharge the electricity that is stored within their battery. Accordingly, it can help households to trade electricity with their neighbours better as they know more about their actual energy flow.

4.4 *Characteristics of platform as an instrument in P2P energy trading to facilitate the transaction*

P2P energy trading platform is the technology which could facilitate a secure and efficient marketplace for local people to buy or sell energy (Pouttu et al., 2017). Morstyn, Farrell, Darby, & McCulloch (2018) submit three novel values offered by P2P energy trading platform, namely energy-matching, reduction of uncertainty, and preference satisfaction. As a marketplace, several basic operations are embedded within the platform, including *user authentication, account verification, transaction summarising,* and *settlement* (Pouttu et al., 2017).

Several energy companies or local energy communities in the Netherlands have initiated P2P energy trading pilot project, such as **Engie NL**, **Vandebron**, and **GridFlex Heeten**. They also developed their own P2P platform for the members to make transaction. Interestingly, their platform demonstrates different business model one to another. Engie NL seems to adopt a more Top-Down model, whereas GridFlex Heeten adopts a more Bottom-UP model, while Vandebron is rather somewhere in between. Additionally, both Engie NL and Vandebron have already established their P2P business as for now, while GridFlex Heeten is still a running pilot project. The key differences between their P2P energy trading platform are presented in Table 4 below.

The transaction between households to exchange energy could be facilitated by a specific platform. This platform subsequently operates as a local P2P market. The important characteristic of P2P platform is that the way transaction happens within the platform might differ from one to another, and it is highly dependent on how the platform owners conceptualise it. Therefore, it might be confusing for some users as a side-effect. The currently known and established P2P platform in the Netherlands, hence omitting GridFlex Heeten from the list, only offer an implicit peer trading, preserving the role of retailers. A real P2P energy trading platform should have dismissed the role of intermediaries to set the prices and revoked the exclusive right to sell electricity.

Table 4 Comparison between Engie NL's, Vandebron's, and GridFlex Heeten's P2P energy trading platform

Key parameter	Engie NL (established project)	Vandebron (established project)	GridFlex Heeten (running pilot project)
Main concept	Collaboration with local producers while maintaining its position as retailer (Top-Down)	Community-oriented connecting local producers to local electricity demand	Full community P2P energy trading where households manage and organise their electricity production and consumption by themselves (Bottom-Up)
Role of supplier	Both Engie NL and households act as supplier	Only farmers behave as supplier	All households may behave as suppliers
Peers	Households + Engie NL – Households	Farmers – (Vandebron) – Households	Households-Households
Supply mechanism	Primary supply comes from households' production, the shortage will be filled by Engie NL's renewable generation	Households are fully responsible to supply the demand. In case of shortage, they need to purchase the remaining needed electricity from other suppliers	Households are fully responsible for electricity supply in community. Energy storage is featured to improve self-reliance from main grid
Transaction settlement	Contract-based	Contract-based	Flexible-pricing mechanism
Benefits for members	Management obligations are mostly taken care by Engie NL, primarily during shortage	Vandebron sets up a competitive electricity pricing for the members	Communities/members take full control of the organisation

V. Translation of Energy Justice Value into Justice Norms for P2P Energy Trading

5.1 *Distributive norms for P2P energy trading*

There are several items in the P2P energy trading system that can be relevant to the tenet of distributive justice. As shown in Table 5, those items can be grouped into four types of goods, namely costs, benefits, access to public goods/services, as well as responsibilities.

The ultimate goal for the formulation of the distributive norms is to define the pattern of principles to fairly distribute those types of goods listed in Table 5.

Table 5 Attributes/goods/events in the P2P energy trading system that can be distributed/allocated/divided

COSTS	ACCESS
• Investment costs to procure solar technologies and BoS • Investment costs to procure batteries • Cost for distribution grids reinforcement • Cost for communication network expansion	• Access to other people's properties/roofs • Access to the communication network and DSO's grids • Access to data from electricity trading • Access to important features of P2P platform (i.e. purchasing and selling electricity)
BENEFITS	**RESPONSIBILITIES**
• Financial profit from compensation scheme/subsidy (e.g. Feed-in tariffs) • Financial profit from supplying electricity/selling excess production • Financial profit from local flexibility services via batteries • Benefit from new position/job opportunities (e.g. aggregators)	• Responsibility for the balance of electricity production and consumption • Responsibility for managing/organising local database • Responsibility for setting the electricity prices in the platform independently • Responsibility for the new emerging actors

5.1.1 *Distribution of costs*

Table 5 suggests that households or other entities must finance the procurement of solar PV together with its supporting components and energy storage. The costs to procure those technologies, especially for the batteries, may become very high that such costs may close the opportunities of some people to become part of the system. Consequently, those who do not have adequate financial means will be allocated zero opportunity as they simply do not have the means to own the pre-requisite technologies to begin with.

Financial means should not be the attribute to segregate the opportunity among people to be part of P2P energy trading. Rather, the opportunity should be distributed equally to people regardless of their financial capacity. Sidortsov & Sovacool (2015) argue that energy is a required substance for many basic goods of which people are entitled. Accordingly, electricity trading is a means to provide sufficient energy to other households so that they could satisfy those basic goods. It is then practically unacceptable if the worse-off people do not have any opportunity to participate in electricity trading just because no one in the neighbourhood owns solar PV or there is not enough solar PV in there. This makes them have unequal chance to attain their basic goods due to potential energy shortage (that could have been subdued by electricity trading) (Rawls, 1971).

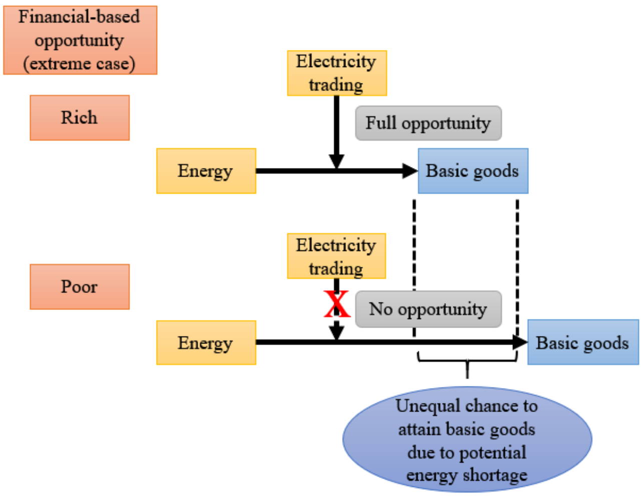

Figure 8 Illustration of inequality to attain basic goods between the rich and the poor in association with their financial capacity to perform electricity trading referring to Rawls (1971)'s principles

Aside from the cost to own technologies, Table 5 also suggests the existence of externality costs that will be burdened to those who do not engage in electricity trading. There are costs for distribution grids reinforcement and communication network expansion to be exact. As national or public infrastructure, the resultant costs from their reinforcement or expansion are likely to be socialised irrespective of the financial capacity of the people. Socialising the costs without careful consideration for this particular case can be very harmful to those financially disabled. Not only they do not engage in the system, but they will also pay for something which perhaps they do not volunteer for or beyond their capacity.

Nevertheless, those costs provided in Table 5 may be inevitable and must be covered to realise P2P energy trading. The main issues regarding those costs, in the context of energy justice, are they have high potential to become a barrier for some people to join the P2P energy trading system and might even be harmful to some. In order to resolve the barrier and to protect people from harmful externality costs, a norm for P2P energy trading can be structured as follows:

> ***"Households must be able to afford all the costs that are incurred to perform or support the practice of electricity trading"***

The norm prescribes the distribution of costs among households to be not excessively burdening that the households can afford those. There has to be an effort to reduce the costs of technologies to make those sufficiently low for various people so that the costs will no longer become a prominent barrier, and the opportunity for all people to engage in the system can increase. The norm also addresses the possibility of households paying to support electricity trading practice regardless of their participation stance. Those people who choose to seclude themselves from the system need not feel burdened with the socialised costs such as with network reinforcement costs. Therefore, when they can afford the externality costs, they might be less likely to feel burdened, and the costs are no longer harmful to them.

5.1.2 *Distribution of benefits*

Table 5 suggests that people who can supply electricity for the trading may increase their financial wealth. The amount of financial wealth that people could earn from electricity trading is likely to be proportional to their capacity to supply the electricity (which is also the case with Feed-in tariffs, only the rewards come from the authority, and not directly from the communities). Put differently, the more the electricity they could offer to their neighbours, the more financial wealth they could gain. However, when we are being sceptical with the difference in energy use, and assume everybody uses electricity at the same level, rich people are the most likely to attain the most financial wealth. This is because they are already at a better position to finance a larger capacity of solar PV, which enables them to offer more surpluses, something that poor people simply cannot afford.

The financial wealth does not solely come from supplying electricity for the trading. Table 5 also indicates the possibility of a new service emerges, which is local flexibility services via batteries, of which people could exploit to gain more profit. However, irrespective of the sources, they rather face a similar situation where the rich are already at a better position to gain more financial wealth to begin with. To be exact, the rich are likely the one who could provide that flexibility service and then gain the profit accordingly, considering the expensive cost of batteries which the poor simply cannot afford.

As indicated above, the poor may have little to even zero means to afford a large capacity of solar PV (including its supporting components) or batteries because of their limited income. This implies that the fair equality of opportunity between the rich and poor for the position of same level supplier is absence. Judging from the second principle of Rawls' justice theory, the resulting economic inequality from having the rich attaining more wealth from electricity trading or local flexibility service is therefore unacceptable in this case. In fact, such economic equality may promote the infamous phenomenon of *the rich getting richer*.

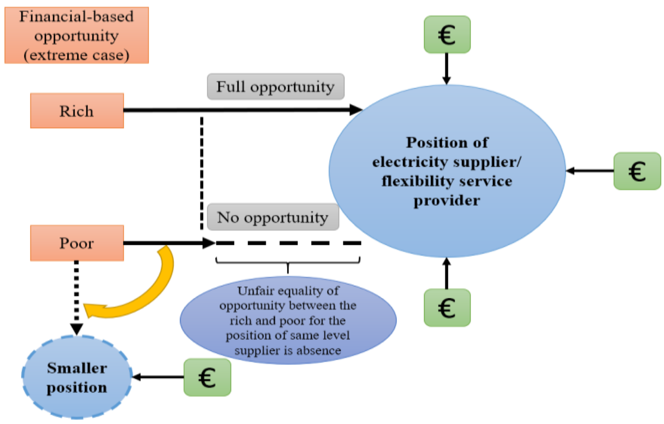

Figure 9 Illustration of unfair equality of opportunity between the rich and the poor for the position of the same level supplier which makes the resulting economic inequality unacceptable according to Rawls (1971)' principles

Apart from financial wealth, Table 5 shows that P2P energy trading may offer more job opportunities as the benefits since there will be new actors or positions emerge, such as with the *aggregators*. However, there is also potential that this type of benefits would also rather favour those who are already better-off. It may be the case that the poor also could not afford enough education to allow them to fill those new positions. Hence, finding the proper underlying principle to govern the distribution of benefits under a circumstance where the rich are already at a beneficial position becomes the main challenge to structure the respective norm.

The principle needs not to disregard the fact that economic inequalities as both driver and outcome are as good as inevitable. The attainable rewards or benefits would or should differ from one another. Referring to Bianchin & Heylighen (2018)'s interpretation of Rawls' justice theory, the social and economic inequalities are only allowed if they are arranged to the greatest benefit of the least advantaged members of society. Therefore, contrary to the principle for the costs that everybody should be able to afford the costs regardless of their financial or social condition, the principle to govern the distribution of benefits should rather consider them. Aligned with Rawls' proposal, a norm to distribute the benefits listed in Table 5 can be structured as follows:

"Households must receive the benefits from the electricity trading practice where the excess benefits are generally allocated to the advantage of the worse-off"

The proposed norm addresses the issue of some people might receive the benefits differently, that some might receive more wealth than others, for instance. Accordingly, the norm suggests that the worse-off should receive more from the respective difference. It then supports the idea of re-allocation of benefits from the most advantaged to the least advantaged people.

5.1.3 Distribution of access to public goods or services

Apart from the utilisation of technologies that could be owned privately, such as solar PV, Table 5 also suggests the use of public goods or services in P2P energy trading, which are distribution grids and communication network. These public goods or services do not always have to be provided by regulated parties such as DSOs or government. Communities could also provide a similar type of goods or services. As indicated in Table 5, households could offer their properties/roofs to be installed by solar PV of others as a common service under *postcoderoosregeling* scheme.

For public or common goods/services, access right is an important property to be thought about besides the costs (Ostrom, 2010). With private solar PV or batteries, owners have full access right to the items, and they could exclude anybody else with no problem. However, the same condition does not apply to common goods/services. Rather, access right oftentimes becomes fuzzy since many people may claim for the right.

Ostrom (2010) further elucidates that the right of access to common goods or services must be accompanied by another property right, namely exclusion. It is the right to decide who will have access to those goods/services. However, Ostrom does not specify in more detail regarding the principle to govern such a decision. This, however, leaves plenty of room for context adjustment, considering the proper principle might be different from one goods or case to another.

Finding proper principle to regulate access right also becomes the challenge in P2P energy trading as there are various common goods or services involved. It is also worth to remember that not all goods in P2P energy trading are tangible. Furthermore, not every goods can be easily classified as either private or public goods, and they could even shift class.

The data from electricity trading is intangible and could be argued as a private goods belongs to those who make the trading. However, there is a possibility that multiple other stakeholders demand this data in order to operate or deliver services to support P2P energy trading. For instance, the DSOs may need the data to balance the grids or traditional energy suppliers may need the data to adjust their investment or production. Subsequently, when the data loses its property of excludability because multiple stakeholders can access it, and then it becomes hard for the original or the true owners to distinguish who access which data, the data becomes no longer a private goods (Doorn, 2019).
Reflecting on access to distribution grids, the DSOs are mandated to provide the access equally and non-discriminatory to all households. This is due to distribution grids hold critical function for electricity supply-chain. Without the access right, the chance for people to receive sufficient energy is minuscule. Put differently, access to distribution grids is simply imperative for households to obtain and consume electricity. Analogous to this, a norm for public and common goods/services in P2P energy trading can be structured as follows:

"Households and other stakeholders in electrical system must be able to access public goods or services that are necessary to perform or support electricity trading"

The proposed norm specifies that access to particular public goods or service must be granted if they hold important function to enable or support electricity trading. Access to distribution grids and communication network are essential for electricity trading despite the technical challenges. Access to others' properties/roofs would also be essential for those who do not have space to mount their solar PV in order to perform electricity trading. The norm also addresses the goods that is intangible, hard to classify, or could shift the class of goods, which is the data from electricity trading. The data must be accessible if it is for enabling or supporting electricity trading. Similarly, households must be given access to the features in the P2P platform that allow them to both sell and purchase the electricity. Without the access right to both features, it becomes less likely for them to perform electricity trading since they would not have the medium to facilitate the transaction.

5.1.4 *Distribution of responsibilities*

As a system that will be embedded in the electrical system, several stakeholders who may be affected by or involved in the P2P energy trading, besides the households, can be identified already. Table 5 indicates that the role of DSOs is still essential to support the electricity trading as they are the one who is in charge to provide access to the distribution grids. They may also need to cooperate with traditional energy suppliers to balance the electricity production and consumption when there are shortages in local generation.

Table 5 also shows that the practice of electricity trading is still open to the possibility that new stakeholders emerge and get involved. Whether they are already known or emerging, however, those stakeholders must carry their own responsibilities to ensure electricity trading can function as desired. Failure of one stakeholder in undertaking its responsibilities might harm the entire system because there is a high dependency between stakeholders for the operation of electricity trading, as illustrated with the cooperation between the DSOs and traditional energy suppliers. Therefore, (re-)assigning proper (new) responsibilities is crucial under this circumstance.

As there is a possibility that new actors emerge in P2P energy trading system, a proper principle to fairly assign or allocate responsibilities for these actors need to be defined. Besides the new actors, the possibility of new responsibilities being added to the existing actors in the electrical system also needs to be anticipated. This should be obvious given the fact that households must carry a new responsibility to supply the electricity to begin with. Table 5 also shows the possibility that households may take the responsibility to manage or organise their own data from electricity trading, as well as setting the electricity price in the platform, which are new for them.

Fahlquist, Doorn, & Poel (2017) provide a comprehensive analysis of design principles to distribute responsibility. They argue that the design of a system should allocate responsibilities in a fair way across individuals. However, they are also aware that people intuition towards fairness could differ between one to another. Therefore, it is important to reflect on the context and accordingly structure the norm which could represent a fair way of distributing responsibilities.

With regards to responsibility, a technocratic approach can be applied, in which the P2P energy trading system is considered more as a technical system. For a technical system, functionality becomes one important aspect to be safeguarded. A responsible actor must be qualified to execute certain tasks to maintain the functionality of the system and keep it running. Fahlquist et al. (2017) further substantiate that individuals' capacity should be examined to allocate responsibilities. They have to be able to reflect on their actions and behave responsibly on their own. Additionally, Hooft (2006) defines a responsible person as one who is willing to make sacrifices for something they signed up for. This condition is likely to be satisfied when the responsibility addresses his/her interest. Based on this consideration, a norm for the distribution of responsibilities in P2P energy trading can be structured as follows:

"Households and other stakeholders in electrical system must carry responsibilities to support the operation of electricity trading that are aligned with their capacity and interest"

The proposed norm entails the judgment towards the capacity of actors for certain responsibilities. It prescribes the avoidance of giving too much burden or tasks to certain actors which could risk the operation of electricity trading when they fail to undertake those tasks. It also values the interest of actors towards a specific part of electricity trading where they want to be responsible for.

5.2 *Procedural norms for P2P energy trading*

P2P energy trading system that is defined for this research has an emphasis on the role or participation of the communities or locals, although it still allows the wholesale market (traditional energy suppliers) to supply the energy. As such, it can be considered as a community development project. The principles of procedure presented in Table 1 can then be relevant to the context of this research. Therefore, the norms for P2P energy trading derived from procedural justice sub-value can be formulated to address the dimension of involvement and position of stakeholders, as well as the resource with respect to the required information.

The goal for the formulation of procedural norms, in all three dimensions collectively, is to define a just procedure for the design process of the P2P energy trading system. In this context, the design process refers to the meeting where people deliberate how things can or should be organised. There are several items in the P2P energy trading system that can be deliberated/organised together with the communities, as shown in Table 6. The table also shows important information worth known by the communities to organise respective items.

Table 6 Attributes/goods/events in the P2P energy trading system that can be deliberated/organised with the communities and important information worth known by the communities to organise respective items

ITEMS FOR DELIBERATION	IMPORTANT INFORMATION
• Size of postal code • Feed-in tariff level/compensation scheme/subsidy • Grid connection tariffs • Data sharing/data access • Concept of P2P platform (features to be embedded or associated for the users)	• Information regarding investment for the technologies/infrastructure • Information regarding ownership administration (to support mobility/changing ownership in *postcoderoosregeling* scheme) • Information regarding the reliability of the smart meters • Information regarding the functions of each feature in the P2P platform and the instruction to operate the features

5.2.1 *Procedure for involvement and position*

Bianchin & Heylighen (2018) bring forward two general considerations for a just design, namely *design for all* and *design with all*. They argue that totally designing for all is nearly unrealistic (although it still could be approached through the optimal application of distributive justice norms). They further indicate that the second consideration is rather more important when striving for a just design. The concept of a just system is more attainable if the focus is shifted into enabling the people to deliberate how the system should operate instead of forcing the system to be operable for everyone. If after the deliberation they found out that the system indeed cannot function for all and some sacrifices are required, the equal opportunity for the position of decision-makers is at least can be honoured (Rawls, 1971).

Since P2P energy trading system in this research emphasises the role of communities, and given the specific goods/items to be organised in Table 6, the involvement of communities in the design process becomes even more crucial to avoid arriving at unjust P2P energy trading system. The involvement of communities in arranging the size of postal code for *postcoderoosregeling* scheme may help overcome the issue of a postal code ended up being filled by only poor residents. Their involvement can give the authorities real illustration of the composition of the residents, and the authorities can directly observe types of people who reside in a particular postcode, and see or hear whether it already has a mix composition for a juster *postcoderoosregeling* scheme or not.

Similarly, the involvement of communities in arranging Feed-in tariffs, subsidy, and grid connection tariffs may help prevent the authorities trapped in their own assumption at the expense of the communities. The authorities can immediately hear whether the level of tariffs or rewards being proposed is perceived just or reasonable by the communities. Even further, they can co-formulate those tariffs or rewards to approximate a level that is perceived just by or for the communities.

The involvement of communities in arranging data sharing is equally important to make the P2P energy trading system just. The authorities can hear directly from the communities whether they want to share or have a problem in sharing their data from electricity trading to particular parties. Accordingly, they can respond to it by adjusting the related policy or even issuing a new one to address or protect communities' interests.

It is important to involve the communities during the creation of P2P platform. It can reduce the potential of missing some features to be used by the communities that can lead to an unjust P2P platform business model since the communities can directly share what they want to do or have within the platform. In addition, the authorities can evaluate the concept or business model in the P2P platform through the help of the communities later on. The authorities can hear from the communities, whether the platform owners or developers already provided features that allow them to sell and purchase the electricity equally.

Although the normative principles which give direction in distributing prevailing goods in P2P energy trading have been promoted in section 5.1, the detail technical arrangements to distribute or organise specific goods/items in still require deliberations with the communities. As an illustration, the authorities can grant a subsidy to help the people to afford solar PV and batteries. Table 5 distinguishes this subsidy as a benefit, which therefore should be allocated more to the poor according to the norm in sub-section 5.1.2. However, in what form, to what extent, and from whom this subsidy originate, still need to be deliberated together with the communities to achieve a juster system.

Furthermore, it is unlikely that all the communities could be gathered in a single room to have deliberation at a time and the main challenge in designing with all is indeed determining who should be invited for the deliberation. Alternatively, Pols & Spahn (2015) suggest a more democratic way of deliberation by rather inviting a sufficient number of representatives. Adhering to their suggestion can make the design process in this context more feasible as there are fewer people to be gathered and the essence of locals' involvement through their representatives can still be safeguarded through their representatives.

The selection of these representatives might differ across communities and is very context-dependent. It can be up to the communities on how they will choose their representatives. However, in general, the representatives must be the member of the communities, and they must know what communities expect from P2P energy trading, and willing to defend the interest of their communities to have fair treatment in P2P energy trading.

Addressing the issue of designing with all within the context of P2P energy trading that deals with the organisation of specific goods/items listed in Table 6, a procedural norm can be structured as follows:

"Representatives of communities must be involved to decide for technical arrangement to distribute specific goods in P2P energy trading"

The proposed norm specifies the involvement of communities during the design process of P2P energy trading which needs to be secured. Although the principles for the distribution of goods that can be used as guidance to approach a just system have been proposed, communities still need to deliberate how things must be organised on a more practical or technical level. The norm also addresses the democratic way of deliberation, which at the same time increases the feasibility of deliberation that involves the communities.

Pols & Spahn (2015) further substantiate frequent issue in a democratic deliberation where all representatives from different stakeholders cannot reach consensus. This issue may also happen during the design process of P2P energy trading that communities have a conflicting say against DSOs or traditional energy suppliers. For instance, the DSOs and communities may have a debate regarding to what level new grid connection tariffs should be set as a result of grid reinforcement and who should bear the additional costs to make the new tariffs affordable for all. That is a distribution issue on a more practical or technical level where conflicts between stakeholders may jeopardise the consensus. Nevertheless, a deliberation must still result in an agreement. Therefore, such a negotiation with compromise-oriented model has to take place.

Oftentimes, some parties have to give up or sacrifice something during this negotiation, depending on how they can bring themselves during the discussion. Parties with better resources are likely able to defend their argument better so that they can push forward their interest. However, this will, at the same time, press the worse-off parties in an unfavourable position, whereas according to Rawls' theory of justice and the principle in Table 1, the least advantaged party should be given priority or favoured position. Accordingly, a norm to address the position of the worse-off in P2P energy trading can be structured as follows:

"Representatives of communities and other stakeholders in electrical system must maximise the position of the worse-off during negotiation for technical arrangement to distribute specific goods in P2P energy trading"

The norm proposed above specifies that the design process of P2P energy trading should be arranged to the greatest benefit of the worse-off.

5.2.2 *Procedure for resource*

With regards to a just procedure, Bianchin & Heylighen (2018) underline the importance of stakeholders' ability to make a rational decision. A just procedure is not only about providing equal opportunity for all stakeholders to partake in deliberation, but it also concerns the process during the deliberation and how the outcomes are eventually decided. Put differently, it is not enough to allow all the stakeholders to engage in the deliberation alone. They also need to be able to argue for their interest, make instrumental reasoning, and finally decide for what they think the best for them after the deliberation. Such premises will make their participation more meaningful (Jenkins et al., 2016).

Adhering to Bianchin & Heylighen (2018)'s idea, the technical arrangement to distribute specific goods in P2P energy trading must then be proposed by rational stakeholders. However, such rationality should not be used as the main criteria to distinguish which stakeholders can be involved in the design process through their representatives and which cannot. Rather, rationality should be something that is fostered to all stakeholders.

Jenkins et al. (2016) claim that disclosing greater information is an effective means to foster the rationality within stakeholders. With more information, people can examine things more comprehensively. Therefore, they can make better judgment towards whether or not the decision and the whole process behind it are just or acceptable. Additionally, more information also allows people to reason and defend their interest better. In short, more information, although not always, can develop people to be more rational.

Addressing the issue pertaining to information, Sovacool & Dworkin (2015) and Jenkins et al. (2016) suggest that only high-quality information should be disseminated. They argue that the information should be able to make participation of each stakeholder in the deliberation process more meaningful. As indicated in Table 6, there are some types of information which could make the participation of the stakeholders in the electrical system, particularly the households, in the design process of P2P energy trading more meaningful.

The households may need to know what kind of investment (and to what extent) the DSOs must make as a response to the increased volume of the electricity being traded so that the households can better judge whether the formulation of new grid connection tariffs is just. The households may also need to know from whom the DSOs will finance and recover their respective investments so that they can decide on the form of subsidy and the right party to earn it. It is also important for the households to know what exactly the solar PV ownership via *postcoderoosregeling* is and what the following administrative issues are before being invited to participate in the scheme. Having that information beforehand can make their contribution in arranging the size of postal code more significant.

Table 6 also suggests that the information regarding the reliability of the smart meter is meaningful for the households. The households could trust the organisation of data sharing better by knowing the respective information. Consequently, they might be more willing to discuss how the data should be distributed in practice and to assess whether it is already just. In addition, distrust to the system from the beginning can rather nullify all the potential of communities' involvement.

The information regarding the functions of each feature in the P2P platform is also meaningful for the households so that they can evaluate whether the whole concept of P2P platform drawn by the developers is already just. It is also important for the households to be able to follow the instructions to operate the features in P2P platform so that they can actually experience the features. It can improve the contribution of the households in the design process as they can better propose the alternatives features or new features to be added coming from their own experience.

Having understood that there is some meaningful information that can increase the possibility and the quality of households/communities' participation in the design process of P2P energy trading, a procedural norm which addresses the dimension of resource can be formulated as follows:

"Households and other stakeholders in electrical system must receive meaningful information that is necessary for them to make rational decision for the technical arrangement to distribute specific goods in P2P energy trading"

The proposed norm specifies the need for every stakeholder to receive adequate information to make a fine decision.

5.3 Recognition norms for P2P energy trading

P2P energy trading that is defined for this research emphasises the involvement of the communities and locates them at the centre of the system. Therefore, the norms for P2P energy trading system that are derived from the tenet of recognition might as well be formulated to recognise the existence of those (local) communities. Subsequently, two categories can be distinguished to recognise the local communities, namely by *acknowledging local's diversity with respect to their socio-cultural identities*, and *respecting local's opinion.*

The goal for the formulation of recognition norms, in all two categories collectively, is to incorporate socio-cultural aspects into the design process of P2P energy trading system. Recalling the design process in this context refers to the meeting where people deliberate how things are or should be organised. For such a purpose, the same list of specific goods/items in Table 6 will be considered. As will be substantiated shortly, those items can also be relevant to be organised in association with socio-cultural aspects (the characteristics/identity of the communities).

5.3.1 Recognition of diversity

One of the categories for recognising the local communities in the P2P energy trading project is acknowledging the diversity with respect to their socio-cultural identities. This category is induced by Jenkins et al. (2016) who draw the phenomenon of injustice with respect to *misrecognition* to the communities in the energy projects. They argue that energy projects oftentimes, if not always, fail to capture specific needs or motivations of various groups of people. Therefore, capturing or acknowledging the diversity in the communities can be a form to recognise them which, in contrast, draw the phenomenon of justice.

Jenkins et al. (2016) further substantiate that energy projects within a community tend to make assumption or generalisation from similar works without actually consulting to the residents of where the project is established. They provide an example of how energy poverty in a community is typically associated with knowledge deficiency. This generalisation or stereotyping has many times, resulted in little effort to find the real motives of why certain communities experience energy issues. Eventually, it leads to misrecognition to certain communities as their issues, together with the motives, are not properly recognised.

The phenomenon of misrecognition to the community gives a lesson that different communities should not be immediately identified as the same when they experience similar issues. Rather, Jenkins et al. (2016) imply that each community may own distinctive socio-cultural identities where they motivate and play a significant role in energy-related issues. It may be true for some "energy poor" communities that they happen to have a social issue with respect to knowledge deficiency. However, it is not always the main motive for other communities to be "energy poor", and hence should not be used as universal identification.

A traditional community, in spite of knowing the potential rewards, may intentionally choose to be "energy poor" because the energy technologies that are introduced to them could modify their cultural landscape or are against their custom. The campaign of NIMBY (not-in-my-backyard) where farmers refuse to have more energy supply from wind generation provides a solid illustration to this matter. For them, alteration or destruction to their pristine landscape is unacceptable and cannot be exchanged with more energy supply (Smith & Klick, 2008).

Similarly, the (re)-organisation of the size of postal code for *postcoderoosregeling* scheme may potentially modify the existing landscape of the communities. An organisation of a postcode which strives for mix composition between the rich and the poor may indeed prosper the number of installed solar panels. However, the increased number of solar panels on the roofs may induce the feeling of discomfort for some communities. They may feel that "blue roofs" are unfamiliar and that it will change the way their surroundings have always looked from the start. They may, therefore, against the entire idea of *postcoderoosregeling* scheme and revoke themselves from the design process of the postal code.

Apart from the landscape, the possibility of the P2P energy trading system modifies the existing organisation or the custom of the local communities, to which they may find it culturally undesirable, needs to be anticipated. The way the local communities normally communicate or interact may get affected by the designation of transaction via P2P platform. Regardless of the efficiency that a platform could offer, traditional communities may oppose the idea of transacting or communicating via digital platform because they are accustomed to interacting verbally and directly with their neighbours. Similarly, sharing data to the outsiders may not be a common practice for traditional communities as they are quite isolated, or choose to be one. Subsequently, they may feel discomfort to the "new" idea of data sharing in P2P energy trading and refuse to take part in the respective design process.

With consideration towards misrecognition in mind, the deliberative team, or more precisely representatives of stakeholders in the electrical system must be able to capture and address those possible reactions that are rooted from socio-cultural identities of the communities in the design process of P2P energy trading. Forcing a system to be implemented in the communities without actually consulting how they are built, or what they perceive as important is then not recommended for the sake of justice as recognition. In fact, it can be harmful to the realisation of the P2P energy trading system itself. As what have been discussed, the communities may be culturally driven to refrain from the design process and resist the P2P energy trading system accordingly.

Adapting Jenkins et al. (2016) principle, the socio-cultural identities of communities must be covered and taken into full consideration when deliberating how specific goods in P2P energy trading above should be distributed. Therefore, a norm that recognises the diversity in communities can be structured as follows:

"Representatives of stakeholders in electrical system must acknowledge socio-cultural identities of communities throughout the deliberation process for the distribution of specific goods in P2P energy trading"

The proposed norm addresses the diversity in the communities that is originated from their socio-cultural identities, which could be their (traditional) landscape, custom, or common practices. The norm also specifies that this diversity, which may trigger "unforeseen reactions", must be explored and captured within the design process of the P2P energy trading system.

5.3.2 *Recognition of opinion*

Another category for recognising the local communities in the P2P energy trading project is respecting the opinion of the locals. This category is based upon the act of disrespecting communities' opinion to disregard their existence of which Jenkins et al. (2016) refer to as the phenomenon of injustice. Therefore, listening and respecting the opinion of the communities can be a form to recognise their existence that, in contrast, draw the phenomenon of justice.

As indicated in section 5.2.2, the local communities must have a stake to submit their genuine opinion to make their participation in the design process more meaningful. In return, other deliberative team members must capture and take their opinion seriously for the sake of recognition justice. Accordingly, other stakeholders in the electrical system must listen carefully to the communities and capture how they want specific goods in P2P energy trading system to be distributed.

McCauley et al. (2013) promote a principle to ensure that genuine opinion of communities can be impartially captured and respected. It suggests that people are entitled to their own opinion and for that, they must be free from physical threat. However, the physical threat may not be the only relevant threats in P2P energy trading system. Rather, the communities must also be free from emotional and distorted financial threats.

There is a possibility that some of the rich state their objection to the technical arrangement of subsidy if it enforces the collection entirely from the rich. They might also object the technical arrangement of grid connection tariffs if it enforces the rich to bear all the additional costs from the reinforcement. Regardless of the final technical arrangement chosen for both specific goods, those people must not receive negative framing, such as being selfish or stingy, because of their opinion or objection that they brought forward during the deliberation. Similarly, traditional communities who state their uncomfortable feeling in any kind of data sharing must not be framed as uncivilised. This potential negative framing or labelling to their opinion can be seen as an emotional threat that must be avoided.

Communities must not also be deceived to pay a great amount of money when they disagree to a certain technical arrangement of specific goods. Traditional energy suppliers must not threaten the communities who disagree to share them the data from electricity trading with an exaggeratedly higher electricity bill. If there is indeed a consequence of higher electricity bill as a result of traditional energy suppliers do not have sufficient data to perform optimal energy-saving measures, they must tell it as it is without exaggeration. This exaggeration towards the bill to influence people's opinion can be seen as a financial threat that must be avoided as well.

Adapting McCauley et al. (2013)'s principles, a norm to capture and respect the genuine opinion of the communities in the design process of P2P energy trading can be formulated as follows:

"Communities must be free from any physical, emotional, and distorted financial threat when they propose or reject technical arrangement to distribute specific goods in P2P energy trading"

The norm above specifies that all stakeholders must be entitled to what they perceive as a correct or just technical arrangement to distribute specific goods in P2P energy trading. For that alone, they must be free from any form of threats, including physical, emotional, and financial.

VI. Discussion and Conclusion

This study aims to specify a set of norms for P2P energy trading system that can guide the system a step closer to be a just energy innovation. The journey in approaching the objective was started with the identification of P2P energy trading system. An attempt was made to define the system from a socio-technical perspective by using the framework of multi-layered energy system proposed by Zhang et al. (2018a). The framework was then operationalised by assigning one technology driver to each available layer. However, the framework is lacking the information about how the technologies in each layer should be examined to arrive at comprehensive socio-technical characteristics of energy systems. For such a purpose, this study has proposed that those technologies could be discussed under several relevant topics/themes. The topics could be based on several designated criteria depending on what the researchers prioritise or strive for.

After acquiring the specific knowledge related to the socio-technical characteristics of the system, an attempt was made to connect those characteristics and energy justice value. Several relevant items were distinguished and grouped. As suggested by the framework of value-hierarchy, those items were subsequently used as the context to specify the value of energy justice into a set of norms. Although the framework does an excellent job in distinguishing between the values and the norms, and how both can be connected, it does not provide the systematic steps to construct a norm from a value. Accordingly, this study has proposed an alternative, as well as a critical step to operationalise the framework, which is by adapting the principles that have been promoted by other authors who made somewhat related research to the items that are discussed or aimed to be organised. However, such an adaption technique requires extensive interpretation of the researchers, which may vary from one to another.

From connecting the items available in the P2P energy trading system to the energy justice domain, interpreting and adapting the principles of other authors to organise those items, a set of justice norms for P2P energy trading can be distinguished as follows.

Distributive norms	Procedural norms	Recognition norms
1. Households must be able to afford all the costs that are incurred to perform or support the practice of electricity trading;	1. Representatives of communities must be involved to decide for technical arrangement to distribute specific goods in P2P energy trading;	1. Representatives of stakeholders in electrical system must acknowledge socio-cultural identities of communities throughout the deliberation process for the distribution of specific goods in P2P energy trading;
2. Households must receive the benefits from the electricity trading practice where the excess benefits are generally allocated to the advantage of the worse-off;	2. Representatives of communities and other stakeholders in electrical system must maximise the position of the worse-off during negotiation for technical arrangement to distribute specific goods in P2P energy trading;	2. Communities must be free from any physical, emotional, and distorted financial threat when they propose or reject technical arrangement to distribute specific goods in P2P energy trading.
3. Households and other stakeholders in electrical system must be able to access public goods or services that are necessary to perform or support electricity trading;	3. Households and other stakeholders in electrical system must receive meaningful information that is necessary for them to make rational decision for the technical arrangement to distribute specific goods in P2P energy trading.	
4. Households and other stakeholders in electrical system must carry responsibilities to support the operation of electricity trading that are aligned with their capacity and interest.		

VII. RECOMMENDATION FOR FUTURE RESEARCH

1. As suggested by the framework of value-hierarchy, the developed norms can be further specified into more specific and concrete design requirements;
2. The relevancy of the developed norms can be assessed and evaluated against the specific setting of particular communities as empirical research;
3. The implementation of the developed norms in particular communities can be investigated, whether they can evoke conflicts with other values or attributes or not.

REFERENCES

Bianchin, M., & Heylighen, A. (2018). Just design. *Design Studies*, *54*, 1–22. https://doi.org/10.1016/j.destud.2017.10.001

Bouffard, F., & Kirschen, D. S. (2008). Centralised and distributed electricity systems. *Energy Policy*, *36*(12), 4504–4508. https://doi.org/10.1016/j.enpol.2008.09.060

Boycom. (n.d.). What Affects Speed? Retrieved from http://www.boycom.com/pdfs/What Affects Speed.pdf

Bruch, M., & Müller, M. (2014). Calculation of the cost-effectiveness of a PV battery system. *Energy Procedia*, *46*, 262–270. https://doi.org/10.1016/j.egypro.2014.01.181

Cuppen, E. (2018). The value of social conflicts. Critiquing invited participation in energy projects. *Energy Research and Social Science*, *38*(January), 28–32. https://doi.org/10.1016/j.erss.2018.01.016

Doorn, N. (2019). *Water Ethics: An Introduction Minors Electives*. Rowman & Littlefield.

Ekanayake, J. B., Jenkins, N., Liyanage, K., Wu, J., & Yokoyama, A. (2012). *Smart Grid: Technology and Applications*. John Wiley & Sons.

Fahlquist, J. N., Doorn, N., & Poel, I. van de. (2017). Design for the Value of Responsibility, 1–15. https://doi.org/10.1007/978-94-007-6994-6

Finley-Brook, M., & Holloman, E. L. (2016). Empowering energy justice. *International Journal of Environmental Research and Public Health*, *13*(9). https://doi.org/10.3390/ijerph13090926

Frontier Economiccs. (2015). Scenarios for the Dutch electricity supply system, (September), 1–169. Retrieved from http://www.frontier-economics.com/documents/2016/09/scenarios-dutch-electricity-supply-system.pdf

Group, T. G. M. (n.d.). Time to shine: Solar power is fastest-growing source of new energy | Environment | The Guardian. Retrieved February 21, 2019, from https://www.theguardian.com/environment/2017/oct/04/solar-power-renewables-international-energy-agency

Heffron, R. J., & McCauley, D. (2017). The concept of energy justice across the disciplines. *Energy Policy*, *105*(March), 658–667. https://doi.org/10.1016/j.enpol.2017.03.018

Hooft, S. van. (2006). *Understanding Virtue Ethics*. Acumen Publishing.

Jenkins, K., McCauley, D., Heffron, R., Stephan, H., & Rehner, R. (2016). Energy justice: A conceptual review. *Energy Research and Social Science*, *11*, 174–182. https://doi.org/10.1016/j.erss.2015.10.004

John Rawls. (1971). *A theory of justice*. Cambridge: Mass: Belknap Press of Harvard University Press.

Karimi, M., Mokhlis, H., Naidu, K., Uddin, S., & Bakar, A. H. A. (2016). Photovoltaic penetration issues and impacts in distribution network - A review. *Renewable and Sustainable Energy Reviews*, *53*, 594–605. https://doi.org/10.1016/j.rser.2015.08.042

Koirala, B. P., Koliou, E., Friege, J., Hakvoort, R. A., & Herder, P. M. (2016). Energetic communities for community energy: A review of key issues and trends shaping integrated community energy systems. *Renewable and Sustainable Energy Reviews*, *56*, 722–744. https://doi.org/10.1016/j.rser.2015.11.080

Lakshminarayana, S., Quek, T. Q. S., & Poor, H. V. (2014). Cooperation and storage tradeoffs in power grids with renewable energy resources. *IEEE Journal on Selected Areas in Communications*, *32*(7), 1386–1397. https://doi.org/10.1109/JSAC.2014.2332093

Long, C., Wu, J., Zhou, Y., & Jenkins, N. (2018). Peer-to-peer energy sharing through a two-stage aggregated battery control in a community Microgrid. *Applied Energy*, *226*, 261–276. https://doi.org/10.1016/j.apenergy.2018.05.097

McCauley, D., Heffron, R. J., Stephan, H., Jenkins, K., Gillard, R., Snell, C., & Bevan, M. (2013). Advancing energy justice: the triumvirate of tenets and systems thinking. *International Energy Law Review*, *32*(3), 107–110. https://doi.org/10.1016/j.erss.2017.05.012

Milchram, C., Hillerbrand, R., van de Kaa, G., Doorn, N., & Künneke, R. (2018). Energy Justice and Smart Grid Systems: Evidence from the Netherlands and the United Kingdom. *Applied Energy*, *229*(September 2017), 1244–1259. https://doi.org/10.1016/j.apenergy.2018.08.053

Morstyn, T., Farrell, N., Darby, S. J., & McCulloch, M. D. (2018). Using peer-to-peer energy-trading platforms to incentivize prosumers to form federated power plants. *Nature Energy*, *3*(2), 94–101. https://doi.org/10.1038/s41560-017-0075-y

Nieusma, D., & Riley, D. (2010). *Designs on development:Engineering, globalization, and social justice*. *Engineering Studies* (Vol. 2). https://doi.org/10.1080/19378621003604748

Ostrom, E. (2010). Beyond Markets and States: Polycentric Governance of Complex Economic Systems. *American Economic Review*, *100*(3), 641–672. https://doi.org/10.1257/aer.100.3.641

Pesch, U., Correljé, A., Cuppen, E., & Taebi, B. (2017). Energy justice and controversies: Formal and informal assessment in energy projects. *Energy Policy*, *109*(November 2016), 825–834. https://doi.org/10.1016/j.enpol.2017.06.040

Pols, A., & Spahn, A. (2015). Handbook of Ethics, Values, and Technological Design. *Handbook of Ethics, Values, and Technological Design*, 1–24. https://doi.org/10.1007/978-94-007-6994-6

Pouttu, A., Haapola, J., Ahokangas, P., Xu, Y., Kopsakangas-Savolainen, M., Porras, E., … Casado, S. (2017). P2P model for distributed energy trading, grid control and ICT for local smart grids. *EuCNC 2017 - European Conference on Networks and Communications*. https://doi.org/10.1109/EuCNC.2017.7980652

Proka, A., Hisschemöller, M., & Loorbach, D. (2018). Transition without conflict? Renewable energy initiatives in the dutch energy transition. *Sustainability (Switzerland)*, *10*(6). https://doi.org/10.3390/su10061721

R A N Smith, E., & Klick, H. (2008). Explaining NIMBY opposition to wind power.

RES Legal. (2016). Legal Sources on renewable Energy - Lithuania Summary. Retrieved April 10, 2019, from http://www.res-legal.eu/search-by-country/netherlands/

Sidortsov, R., & Sovacool, B. (2015). Left out in the cold: energy justice and Arctic energy research. *Journal of Environmental Studies and Sciences*, *5*(3), 302–307. https://doi.org/10.1007/s13412-015-0241-0

Smets, A., Jager, K., Isabella, O., Swaaij, R. van, & Zeman, M. (2010). *Solar energy*. *Delft University of Technology*. https://doi.org/10.1201/b10163

Sovacool, B. K., & Dworkin, M. H. (2015). Energy justice: Conceptual insights and practical applications. *Applied Energy*, *142*, 435–444. https://doi.org/10.1016/j.apenergy.2015.01.002

Stedin, & Energy21. (2018). Whitepaper: Layered Energy System - Inclusive enablement of local power, (November), 1–20.

Sytek. (n.d.). Why Does My Internet Connection Appear to be Slow? Retrieved May 5, 2019, from https://www.sytekcom.com/pdf/sytek-video-script.pdf

Tushar, W., Saha, T. K., Yuen, C., Liddell, P., Bean, R., & Poor, H. V. (2018). Peer-to-Peer Energy Trading with Sustainable User Participation: A Game Theoretic Approach. *IEEE Access*, *6*, 62932–62943. https://doi.org/10.1109/ACCESS.2018.2875405

van de Poel, I. (2013). Translating Values into Design Requirements. In D. P. Michelfelder, N. McCarthy, & D. E. Goldberg (Eds.), *Philosophy and Engineering: Reflections on Practice, Principles and Process* (pp. 253–266). Dordrecht: Springer Netherlands. https://doi.org/10.1007/978-94-007-7762-0_20

Versteeg, K. (2018). Dutch Solar PV - Market Growth & Trends — The Solar Future NL '19. Retrieved February 14, 2019, from https://thesolarfuture.nl/nieuws-source/2018/2/28/dutch-solar-pv-market-growth-trends

Zhang, C., Wu, J., Zhou, Y., Cheng, M., & Long, C. (2018a). Peer-to-Peer energy trading in a Microgrid. *Applied Energy*, *220*(February), 1–12. https://doi.org/10.1016/j.apenergy.2018.03.010

Zhang, C., Wu, J., Zhou, Y., Cheng, M., & Long, C. (2018b). Peer-to-Peer energy trading in a Microgrid. *Applied Energy*, *220*(February), 1–12. https://doi.org/10.1016/j.apenergy.2018.03.010

Zhu, T., Huang, Z., Sharma, A., Su, J., Irwin, D., & Mishra, A. (2013). Sharing Renewable Energy in Smart Microgrids.