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Opinion paper

Prosumers in the post subsidy era: an exploration of new prosumer business models in the UK

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ABSTRACT

This paper explores the evolving renewable energy 'prosumer' phenomenon in the United Kingdom (UK). It identifies and evaluates how prosumer business models can exist beyond direct subsidy and the range of prosumer business model archetypes currently in operation. Through a series of in-depth interviews and document analysis, the paper identifies the key opportunities and challenges for these innovative energy business models. The analysis shows that recent developments in technology such as the diffusion of smart meters, li-ion batteries, peer-to-peer trading platforms and electric vehicles are opening up a range of new value propositions, which in turn are beginning to be exploited by a range of new business models. In many cases the regulatory, financing and institutional governance landscape of the UK lags behind, however, inhibiting these emerging business models. Moreover, these business models rely on managing a complex set of values for consumers that reach deeper into their lives than traditional tariffs. Thus, successful business models must manage this complexity if they are to be adopted by the disengaged majority. Energy policy and energy practitioners can leverage these emerging trends in service of a low carbon energy transition by adopting 'ten principles' of prosumerism; and six UK policy recommendations.

1. Introduction

Energy systems are undergoing significant change. Traditional centralised, fossil-based systems - are giving way to an increasingly renewable, decentralised, but unpredictable system. Whilst these changes aim to reduce greenhouse gas emissions (CCC, 2018), these decentralised energy systems (DES) are increasingly seen as economically competitive with centralised fossil fuel models - especially with appropriate carbon pricing (Lazard, 2018; Wegner et al., 2017). Similarly, there is an expected explosion in electric vehicles (EVs), with 750 million expected globally by 2030 and nearly 3 billion by 2050 – a twenty-fold increase from current levels (IEA, 2017). Alongside power and transport, meeting the 2°c target as outlined in the 2015 Paris climate agreement will require a massive increase in low carbon heating and cooling. It is expected this will involve significant electrification of heat (22% in G20 and 28% in the rest of the world) largely through heat pumps, as well as increased uptake of air conditioning (IEA, 2017). Taken together, the diffusion of intermittent renewable energy sources and the electrification of heat, transport and cooling is likely to add significant new demand, system volatility/intermittency, a changing load profile - bringing new complexity to the management of electricity networks.

This system transition brings a range of new challenges. The diffusion of intermittent renewable electricity resources such as wind and solar is already creating volatility in electricity spot markets, with periods of extremely high but also negative prices (Brijs et al., 2015). In networks with a high proportion DES, there are already issues of 'voltage deviations, line losses, system balance and reserve issues, robustness and power quality' (Bray et al., 2018). These issues can lead to curtailment of inflexible renewable generation, greater risk of imbalance for suppliers, increased use of system (UoS) charges and subsequently higher bills for consumers - potentially aggravated by large new load sources such as EVs and electrified heat and cooling (Bray et al., 2018).

Alongside these challenges a range of opportunities are emerging. The diffusion of smart metering, internet of things (IoT) enabled appliances, flexible loads such as heat pumps and storage technologies, including EVs and stand-alone Li-ion batteries, presents new opportunities for flexibility in both production and consumption of electricity (Shomali and Pinkse, 2016; Wegner et al., 2017). The potential to shift supply and demand to more favourable periods and provide a range of ancillary services and storage, may overcome these challenges and

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enable the wider diffusion of DES (OVO Energy and Imperial College, 2018). While previous waves of system decarbonisation have left the utility business model relatively intact (Richter, 2013a), this decentralised system is multiplying the possibilities for citizen and small-scale participation in the energy transition - compounding the above challenges but also presenting new ways of overcoming them.

The growth of DES, is in part due to the 'prosumer' phenomenon – characterised by actors who both produce and consume energy (Parag and Sovacool, 2016). It is argued that prosumers - who both produce renewable energy and also actively modulate their demand - may be the key players in a distributed and increasingly democratised energy future (Hiteva and Sovacool, 2017). Through self-consumption, localised trading of renewable energy, and active participation in system balancing, prosumers may help to overcome many of the challenges associated with this new system (Parag and Sovacool, 2016). Existing regulatory frameworks and energy markets in most industrialised countries are weakly aligned with this agenda, however, having co-evolved with the incumbent model, dominated by large suppliers (Hannon et al., 2013). Recent work has highlighted the potential of innovative business models in overcoming incumbency and promoting sustainable energy systems (Bolton and Hannon, 2016; Brown, 2018; Hall and Roelich, 2016). The prosumer differs in important ways to other energy system actors. As energy production is not prosumers' primary function, this new relationship with the energy system should be beneficial to other areas of their life or business (Toffler, 1980). To date prosumers have relied on simple subsidy regimes to take part in the energy market, but across the developed world subsidies are being removed and reduced (IEA, 2018).

The United Kingdom (UK) has seen amongst the most rapid decarbonisation of electricity supply in the developed world (Staffell et al., 2018), alongside the unbundling of its electricity generation and supply systems, this has triggered new market entrants and business models (Hall and Roelich, 2016). This decarbonisation has been achieved through: a shift to gas; large-scale renewable energy installations such as offshore wind; decentralised capacity such as onshore wind and utility scale solar (CCC, 2018); a large rollout of rooftop and small-scale photovoltaic generation; and other prosumer level generation such as biogas, combined heat and power systems or community scale wind (BEIS, 2018).

This paper will explore how a range of emerging business models may help to promote the prosumer phenomenon beyond subsidies: reflecting on the value of prosumers to the whole energy system. As feed-in-tariffs (FITs) reduce, the prosumer business model needs to evolve if small-scale generation and demand response is to play a productive role alongside heat and transport electrification. This paper identifies the current state-of-the-art in 'prosumer business models' in the UK. We further unpack how the current UK energy market design and regulatory framework hinders these business models, before providing some recommendations to policymakers on how to promote renewable prosumption whilst delivering system value.

2. Prosumers, business models and the energy system

Prosumption is being advocated at the European Union (EU) level, with several high-level initiatives seeking to promote the phenomenon across member states (EC, 2017). In this paper, we adopt the definition of 'renewable self-consumer' as outlined in the European Union's Renewable Energy Directive II:

> "'renewable self-consumer' means a final customer operating within its premises located within confined boundaries or where allowed by Member States, on other premises, who generates renewable electricity for its own consumption, and may store and sell self-generated renewable electricity, provided that, for non-household renewable self-consumers, those activities do not constitute their primary commercial or professional activity" (European Commission, 2018)

Thus, we consider prosumers to include household, commercial and industrial actors who produce, self-consume and modulate their consumption of renewable energy.

Through active participation in electricity networks, prosumers are presented as key actors in overcoming the intermittency challenges of renewable electricity systems (Karnouskos, 2011). By modulating their consumption through demand response or storing energy - either in the form of stationary batteries or through other vectors including heat or EVs - prosumers can help to overcome the issues of variability inherent in wind and solar power (Parag and Sovacool, 2016). Prosumers may also earn additional revenue through ancillary services to system operators in the form of frequency response, reserve services and grid balancing – all increasingly necessary as renewables proliferate (Jacobs, 2017). In addition, by utilising electricity generated on site, 'behind the meter', close to the point of generation, or at the distribution network level, prosumers can help to avoid the utilisation of electricity transmission and distribution network infrastructure and the need for expensive grid reinforcement (Bray et al., 2018).

Despite this potential, many of these sources of value face significant challenges before they can be realised. Although larger-scale industrial and commercial actors have been engaged with these more sophisticated forms of prosumption for some time, smaller-scale commercial and residential actors face a range of challenges and barriers to accessing these emerging markets and providing system services (Ruggiero et al., 2015). Current metering and settlement arrangements provide little or no data on real-time consumption and do not incentivise small-scale consumers/prosumers to shift their consumption to periods of lower pricing or to reduce network stress (Römer et al., 2012). The majority of small energy consuming devices are 'dumb' and cannot respond to price signals or interface with smart metering technology (Foxon et al., 2015). In addition, current regulatory frameworks including: UoS pricing methodologies; codes surrounding supplier and generation licences; access to wholesale, balancing and ancillary services markets - were all designed with the centralised large-scale actors in mind (Bray et al., 2018). In addition to these technical and regulatory challenges, others have highlighted non-technical barriers to increasing prosumption, including a lack of knowledge, trust and reticence to change (Albala et al., 2018; Shove and Walker, 2014). In overcoming these barriers, scholars and practitioners have emphasised the role of new business models (Parag and Sovacool, 2016; Regen, 2018). The following section reviews the contemporary energy business model literature, highlighting the need for empirically grounded research on prosumers.

2.1. Prosumer business models

2.1.1. Business models: conceptual foundations

The term 'business model' has become prevalent since the wave of new businesses that accompanied the rise of online commerce in the late 1990s and early 2000s (Zott et al., 2011). The concept is increasingly used to differentiate organisations' business models and to understand how they influence competitiveness and the nature and direction of technological change (Teece, 2010). Business models thus describe:

> *"the nature of value delivered to customers, how organisations and networks create that value and the means of capturing revenues from these activities"*(Brown, 2018).

Following Brown (2018) and Boons and Lüdeke-Freund (2013), we synthesise the key business model perspectives of Osterwalder and Pigneur (2010) and Zott and Amit (2010) into a conceptual framework shown in Table 1. These components of the business model structure our discussion of prosumer business models in Section 5.

Table 1
Business model conceptual framework (Brown et al., 2018a).

Component	Definition
Value proposition	The value proposition refers to the value or utility from goods and services that an organization or network provides to the customer (Boons and Lüdeke-Freund, 2013; Engelken et al., 2016).
Supply chain	The supply chain describes the upstream relationships between an organization and its suppliers (Boons and Lüdeke-Freund, 2013), comprising the logistical and technical elements that enable delivery of the value proposition (Osterwalder, 2004).
Customer interface	The customer interface covers all downstream, customer-related interactions (Boons and Lüdeke-Freund, 2013) including the relationship the customer has with the supplier organisations in terms of marketing, sales and distribution channels and the ongoing relationship with the product or service (Osterwalder and Pigneur, 2010).
Financial model	The financial model constitutes the combination of an organisation's capital and operational expenditures with its means of revenue generation (Osterwalder et al., 2005). This is linked to the value proposition, in terms of what products and services customers pay for and how revenues are collected and distributed.
Governance	Business model governance involves both the co-ordination and management of the other components and the organisational form of the business model (Amit and Zott, 2001; Zott and Amit, 2010). As such, business models may involve a single organisation or a network of interdependent firms that interact to provide a service or product (Hellström et al., 2015). This may involve range of legal forms, with varying levels of public, private and civil society governance (Smith, 2007).

2.1.2. Business models, energy systems, and prosumers

New business models are instrumental in driving the adoption of radical and disruptive innovations, such as those which characterise 'sustainability transitions' (Baden-Fuller and Haefliger, 2013; Bohnsack et al., 2014). The traditional business model for the provision of energy services involves the extraction, distribution and combustion of non-renewable fossil and fissile materials by large centralised energy suppliers (Shomali and Pinkse, 2016). This business model relies on increasing throughput consumption of energy to generate profits and has tended to a create monopoly position for a number of large multinational companies able to capture increasing economies of scale (Steinberger et al., 2009). The existential threat posed by climate change, alongside the proliferation and rapid cost reduction of smart DES is presenting a direct challenge to this business model (Shomali and Pinkse, 2016).

A recent body of literature identifies a range of new business models that could radically overhaul how energy is produced, delivered and consumed (Brown, 2018; Hall and Roelich, 2016; Richter, 2012). Richter (2013a, 2013b, 2012) emphasises that whilst the current business model of the large utilities has incorporated large-scale renewable electricity resources such as large wind and hydro, the diffusion of smart, distributed energy technologies such as rooftop solar, EVs and small-scale storage requires a more fundamental change to the incumbent business model.

Various scholars highlight how a sustainable energy system must abandon business models predicated on the increasing throughput of energy commodities, towards models based on delivering useful energy services (Hannon et al., 2013; Roelich et al., 2015). Studies have highlighted the potential of energy service companies (ESCOs) to deliver useful services such as light, heat and useful work through long-term energy performance contracts (Hannon and Bolton, 2015; Sorrell, 2007; Steinberger et al., 2009). Other studies emphasise how the diffusion of smart meters, IoT-enabled devices and blockchain technology may enable peer-to-peer (P2P) business models to become increasingly viable – potentially negating the need for traditional energy suppliers altogether (Davis and Cartwright, 2019; Verbong et al., 2013). Others explore how new business models based on electric mobility services may increasingly replace vehicle ownership (Budde Christensen et al., 2012; Sarasini and Linder, 2018) with others discussing how EVs can provide network services in vehicle to grid (V2G) models (Engelken et al., 2016; Kempton and Tomić, 2005). Yet further studies emphasise the trend towards local energy business models (Hall and Roelich, 2016), where electricity is used close to its point of generation - promoting local value retention, energy democracy and justice (Hall et al., 2018). Such outcomes are synonymous with resurgent forms of community (Seyfang et al., 2014) and municipal (Roelich et al., 2018) energy governance, with increasing community and municipal ownership of renewable energy systems in countries such as the UK, Germany and the Netherlands (EC, 2017).

Fewer studies have emphasised the specific role of prosumer centred business models. Parag and Sovacool (2016) highlight three hypothetical areas where prosumers may play important roles: prosumer grid integration; P2P models; and prosumer community groups, but provide little detail on the nature of these business models. Goncalves Da Silva et al. (2014) note the importance of demand and generation forecasting for local prosumer models, whilst Hwang et al. (2017) describe the potential for P2P models based on blockchain technology – although both studies are largely based on hypothetical examples. The same lack of empirical evidence characterises Rodríguez-Molina et al.'s., (2014) study, which describes prosumer business models based on: ESCOs; virtual power plants; aggregators/retailers and models that earn revenues through contracts with distribution system operators (DSOs). Hall and Roelich (2016) provide some real world archetypes of novel local energy business models, which involve both production and self-consumption of renewable energy – although again the more innovative archetypes remain hypothetical.

In this paper we seek to address this gap in the literature by identifying the range of prosumer business model 'archetypes' currently being trailed in an advanced market – the UK. Following Brown (2018) and Hall and Roelich (2016) in this paper we define an 'archetype' as an ideal type or generic form of particular business model. Recent developments in the UK electricity market have seen a range of these business models move off the drawing board and into practice (Regen, 2018). Combined with the EU's drive to promote the prosumer phenomenon (EC, 2017), this presents a prescient moment for an empirically-grounded study of these emerging business models, the problems they solve and the challenges they face. By involving both production and consumption, prosumerism should deliver value to the prosumer and the wider energy system. Thus, we characterise the 'bi-directional' value propositions these business model archetypes present. We explicate the full range of revenue streams being accessed by these business models, before reflecting on the value of the prosumer concept and these business models in the light of our findings.

3. Methods

Using a qualitative mixed methods approach, involving a baseline documentary analysis and in-depth semi-structured interviews, we map the extant prosumer business model landscape in the UK to form a cross-sectional research design (De Vaus, 2002). Interview data was supplemented with a review of academic literature alongside and technical publications surrounding distributed energy, new business models, and the prosumer phenomenon in the UK (Accenture, 2015; Barton et al., 2015; Braunholtz-Speight et al., 2018; Bray et al., 2018; Green Alliance, 2019; Hall and Roelich, 2015; Ofgem, 2016a; Open Utility, 2018, 2016; Pace et al., 2016; Regen, 2018). This led to the development of seven UK prosumer business model archetypes as the basis of this cross-sectional investigation, explored in the following section.

Subsequently, nine semi-structured interviews were carried out during the winter of 2018–19. Interviews were sought from each of the key archetypes identified. Interviewees were typically practitioners involved in delivering these models in the UK, usually senior individuals with an overview of the organisation and wider supply chain. Interview questions were designed to elicit how different models approach the key components of the business model, namely: the *value proposition; supply chain; customer interface; financial model* and mode of *governance*. Questions also probed the organisation's key motivations in entering the market – whether commercial, environmental or otherwise. We also focused on the range of revenues that the business model could access, including drivers and barriers to adoption, whether technical, regulatory or cultural. A list of interviewees is provided in Appendix A.

Interviews were coded using the NVivo 12™ qualitative analysis software to elucidate key themes and findings using the conceptual framework. This qualitative methodology was appropriate given the need to develop new conceptual insights (Yin, 1994) as to the range of business models adopted, their key features, their potential along with the barriers they face. The grey literature review provided triangulation of these findings, overcoming some of the potential selection bias inherent in interviewee selection.

4. Results

4.1. Business model archetypes

We first introduce the basic, subsidy-dependent business model that has been the mainstay of prosumption to date. We subsequently explore a range of new business models that are beginning to emerge in a post-subsidy and increasingly smart, distributed energy landscape.

4.1.1. Basic prosumer

The basic prosumer business model in the UK (Fig. 1), typically involves distributed renewable electricity generation – usually wind or PV – installed behind the meter. Prosumers are able to benefit from the free electricity, provided they can self-consume at the moment of generation. Since the introduction of Feed-in-Tariffs (FITs) in 2010, UK prosumers have received an export tariff of £0.0372–0.0524/kWh (Ofgem, 2019), for any energy they do not self-consume – set much lower than the price of grid electricity to promote self-consumption. Without real-time metering, this is considered negative load by energy suppliers, and an arbitrary assumption of 50% export 50% self-consumption is applied. Historically this model has instead relied on a generous FIT paid to prosumers (and amortised across all electricity bill payers) whether they are exporting to the grid or not (Ofgem, 2019). This produced an explosion of installations of rooftop solar in the UK in the years following the FIT's introduction, with 937,000 + PV installations by 2018 (Open Utility, 2018), and large returns available over the 25-year lifetime of the scheme for those with the capital to invest.

Fig. 1 shows how the wider electricity system (upstream of licenced supplier) does not interact with this business model, with UoS charges, system operator functions such as the balancing mechanism and energy trading occurring without prosumer involvement.

However, with the close out of the FIT and emerging disruptive technologies, this subsidy dependent business model has limited future potential in the UK. When introduced in April 2010, the FIT scheme offered a generous £0.46/kWh for small rooftop solar installations. This has reduced through a process of 'degression', to a level of £0.0379 before the scheme's closure on 31st March 2019, with the export tariff also coming to an end (Ofgem, 2019). Despite significant cost reductions of PV panels, prosumers are increasingly unable to create economically-viable projects, in this post-subsidy landscape: "The main challenge is finding a post-subsidy business model." (Community Energy Company, 2018). Thus, new business models that improve export prices, promote increased self-consumption and access additional sources of revenue are increasingly seen as essential if the prosumer phenomenon is to have a future in the UK.

4.1.2. Private wire/micro-grid

Private wire arrangements, often termed 'micro-grids', have long been a solution to electricity provision in remote areas, where the cost of grid connection is prohibitively expensive. Early examples such as the island of Eigg off the west coast of Scotland, originally used diesel generators, although have recently converted to small-scale hydro, wind and PV. In these models, a local private network operator owns the low-voltage distribution network rather than the statutory Distribution Network Operator (DNO). These entities may also form a virtual energy company (VEC), responsible for billing customers for the energy they consume within the private network. These models are now also being trialled in grid connected areas, with the aim of creating a viable business model for prosumers (Regen, 2018).

As shown in Fig. 2 these models promote consumption 'behind the meter', by shifting the Meter Point Administration Number (MPAN) to the perimeter of the site. The aim is to share any distributed generation between prosumers in the private network area. The VEC can offer an improved export tariff and a lower import tariff, based on a privately-owned metering infrastructure. The VEC can also incentivise optimal consumption behaviour through time-of-use (TOU) tariffs during high generation periods. In the UK, provided the VEC is managing a system of < 2.5MW it qualifies as a licence exempt supplier and does not have to abide by the balancing and settlement codes (Ofgem, 2016a). The VEC may then negotiate an improved supply tariff with a licenced supply who takes on the responsibility for balancing and settlement. Under current market arrangements, the VEC can also reduce UoS costs as the private wire network is making reduced use of the transmission and distribution network.

> "any generation that you have on site or any energy flows can actually be accounted for internally, where everybody can benefit from those flows and those financial arrangements with the community supplier [VEC]." (Private Wire Developer, 2018)

The underlying logic is that the sum total of these costs, including the construction and maintenance of the private network "is hopefully providing everything at a cheaper price than if they all individually went with an energy supplier" (Private Wire Developer, 2018). Therefore, *private wires* are typically being trialled on small island grids or new developments where the private network and its ownership can be designed into the project. Such models are likely to be more problematic for existing locations where the network between meter points is owned by a DNO.

4.1.3. Local energy company

Local tariffs or local energy companies aim to retain energy generated within a local area, although unlike private wire networks they utilise the DNO owned distribution network 'in front of the meter', in what is sometimes called a virtual private network (Fig. 3). These models link local generation with demand and provide prosumers/customers with improved export and import prices. These models typically involve either a licenced exempt local energy company (LEC) offering a local tariff, with balancing and settlement occurring through a fully licenced supplier. In more sophisticated variants, the LEC offers consumers a TOU based on dynamic price signals derived from demand data from smart meters as well as generation data. During periods of high demand/low generation, prices will be higher and *vice versa.* Examples such as the Energy Local trial in North Wales also incentivise lower UoS charges by entering customers into half-hourly (HH) settlement– shifting demand away from the daily Red, Amber and Green

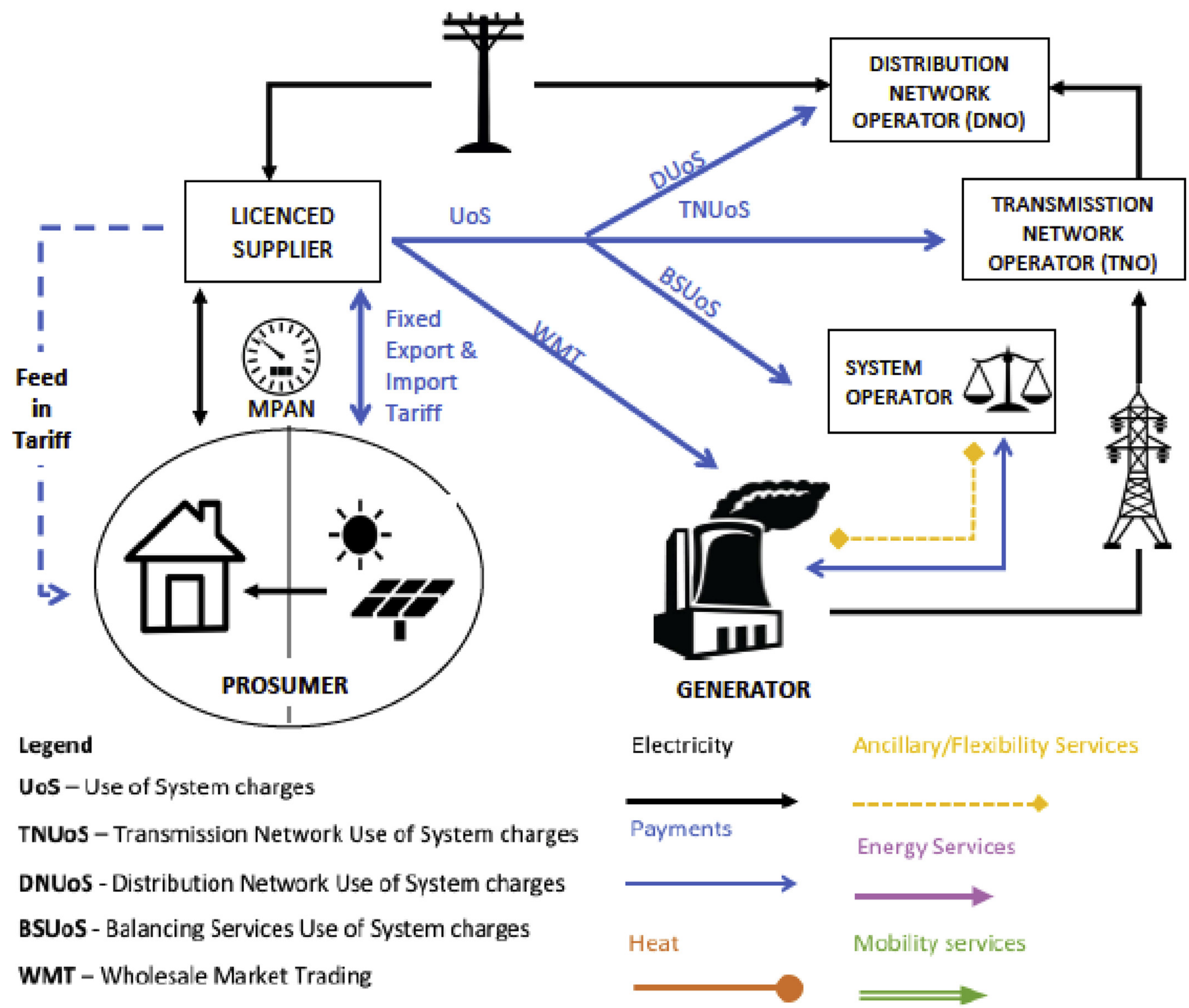

Fig. 1. Basic prosumer business model archetype.

Distribution Use of System charging periods (DUoS) and the three annual TRIAD periods of peak Transmission Network Use of System charges (TNUoS).[1]

Examples such as Smart Fintry provide a link from larger local grid connected renewables with local consumers, although these cases perhaps stretch the prosumer concept:

> "there were … people saying, 'We'll just run a cable from the wind farm down to the village and be 100% renewable.' Of course, that didn't happen. Obviously, there was a bit of naivety … back then." (Local Energy Company, 2018)

Further, these 'in front of the meter' models are subject to the UK energy market regulation allowing customers to switch their energy supplier within 28 days (Ofgem, 2016b). Unlike the long-term price security of the FIT, or a microgrid, this creates risks for a local energy company and those looking to build distributed energy assets, as the business case and export prices could collapse should customers switch away from the scheme (Hall and Roelich, 2015).

[1] Conversely, larger prosumers/distributed generators receive a series of embedded benefits for generating during these periods (Pace et al., 2016).

4.1.4. Peer-to-peer

P2P business models are predicated on removing the energy supplier as an intermediary in the trading of distributed electricity generation, shown in Fig. 4. These models are theoretically based on the use of a third-party platform where prosumers can trade energy with each other with minimal involvement from suppliers (Open Utility, 2016). In principle, prices can be negotiated directly with other prosumers, allowing them to select the provenance of their electricity. The promise of these models is that they allow prosumers to negotiate fairer prices for their generation rather than being forced to accept whatever price a supplier is prepared to offer. Moreover, models adopting dynamic TOU pricing incentivise prosumers to produce and consume energy at times when generation is being generated locally by their peers:

> "The optimisation process that we developed … enabled … a multi-buyer, multi-seller optimisation or merit order process where you can have any number of people who want to purchase something from any number of people who are selling it.…[which] is approaching Pareto efficient" (Trading Platform Provider, 2019)

However, the current UK market design necessitates a contract with

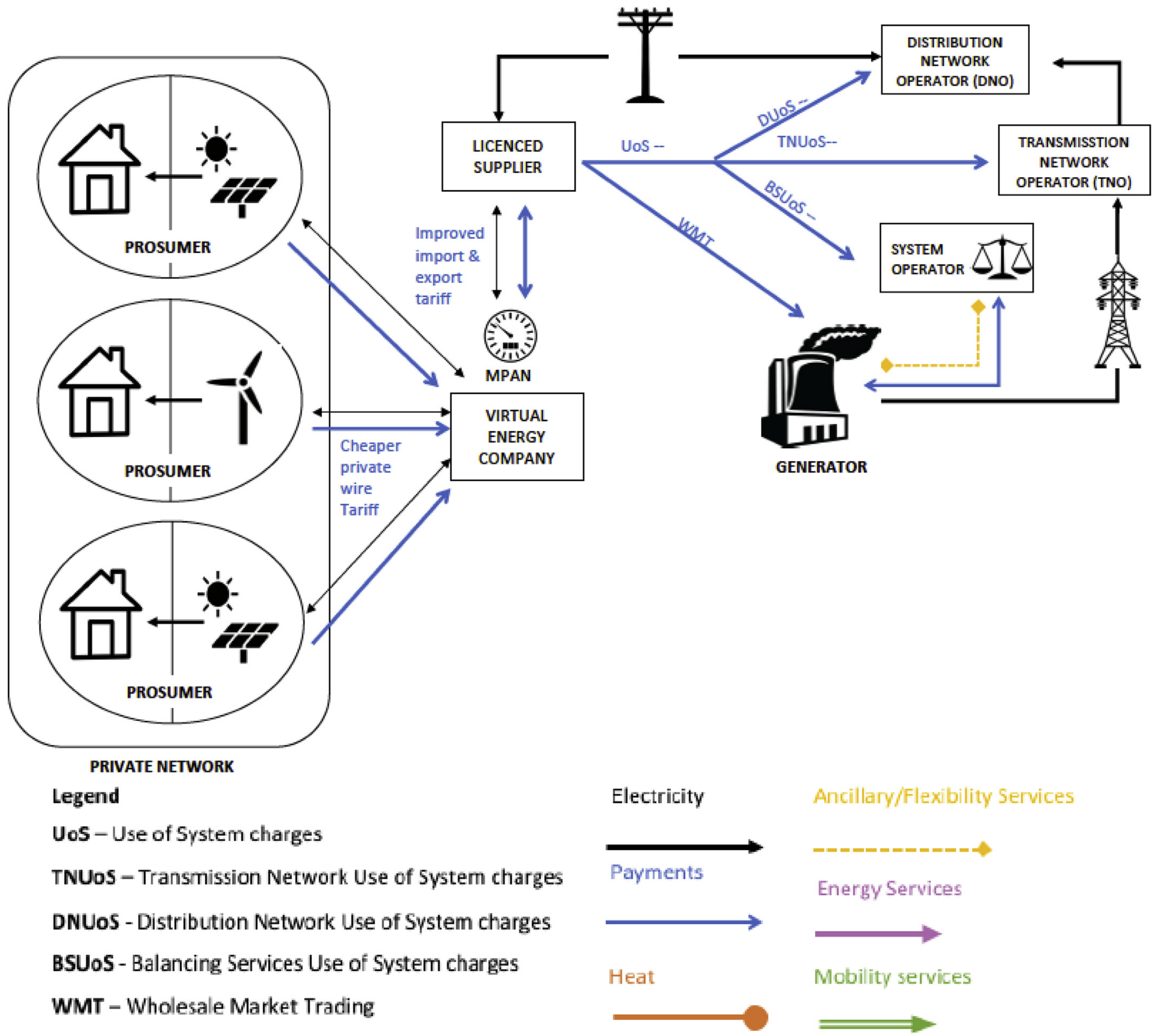

Fig. 2. Private wire/microgrid archetype.

a licenced supplier who balances the system and the use of the public network currently means that prosumers pay the full UoS costs for any power generated and traded over the public network:

> "you still need that central coordination point to make sure that physical balance of the grid is maintained and … that's why it becomes very difficult to try to create this perfect distributor system, where every single actor is like acting on its own" (Peer-to-peer Consultant, 2019)

The only UK trial of P2P models to date has involved a licenced supplier, Good Energy, in partnership with the P2P platform provider Open Utility (now Piclo), which offered 37 non-domestic prosumers the option to choose their distributed energy supplier in Cornwall (Open Utility, 2016). However, current DSUoS regime, lack of half hourly settlement, and the requirement for partnering with a licenced supplier is currently prohibiting further commercial trials of P2P models in the UK (Bray et al., 2018).

4.1.5. Flexibility service provider

Flexibility service providers have traditionally been large transmission network connected generators such as coal and gas fired power stations. In addition, a number of very large consumers have also been involved in demand side response programs. Historically, National Grid – the UK's system operator – has contracted for these services through the half-hourly balancing mechanism and a range of ancillary service markets. These markets sit alongside wholesale trading and are designed to optimise voltage and match supply and demand in real time. In addition, a number of large pumped hydro storage sites have been involved in energy 'arbitrage' purchasing power when cheap and reselling at peak periods.

Various business models are emerging that enable prosumers to exploit these value pools, through flexible distributed energy assets (Fig. 5). Small-scale electric batteries, CHP units, heat pumps and other demand side assets have inherent flexibility that can be paired with more intermitted DES, to offer a range of grid services as well as arbitrage between periods of low and high market price. It is expected that with the further diffusion of intermittent DES these value pools will

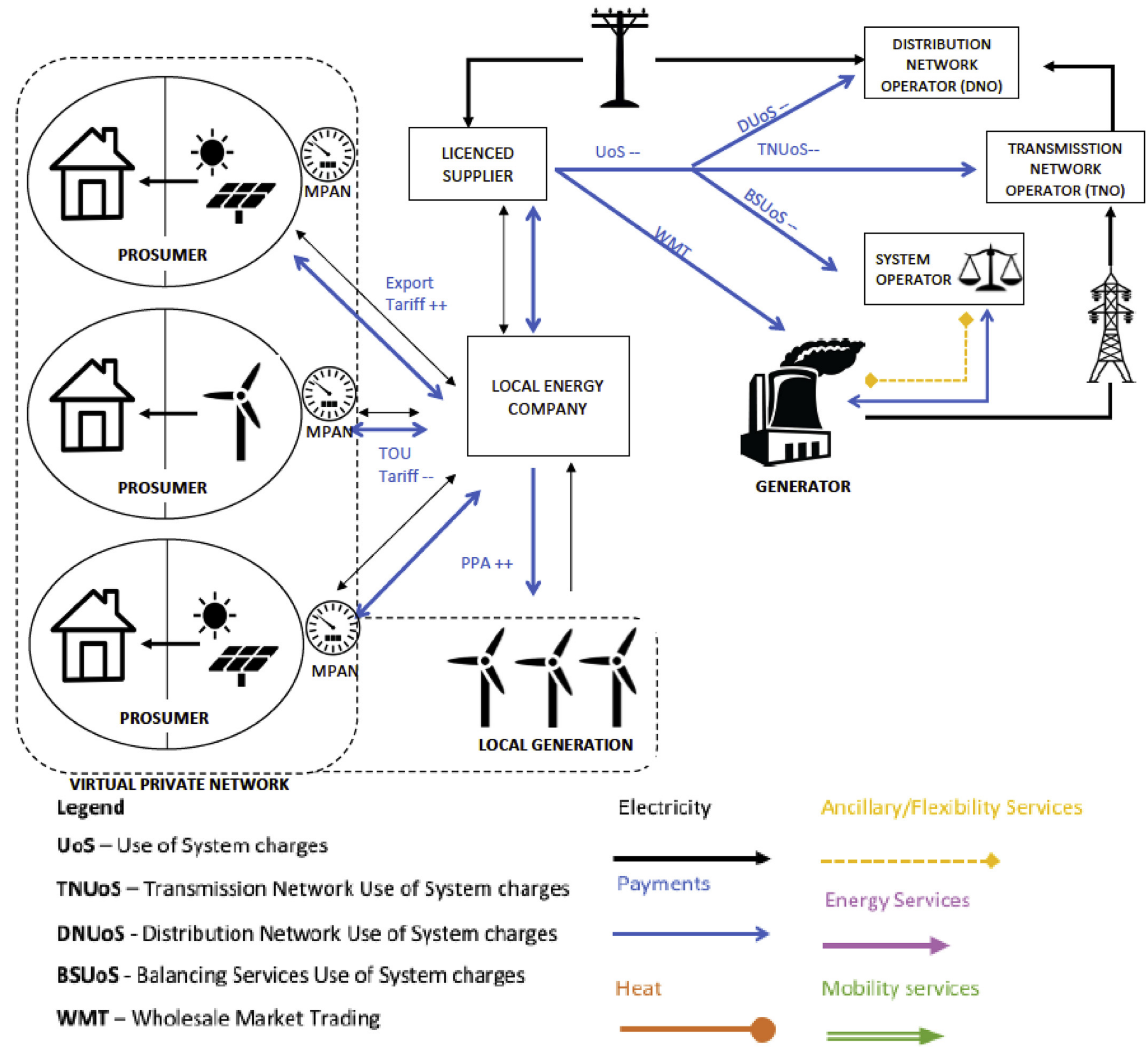

Fig. 3. Local energy company archetype.

increase in the coming years: "we expect to see balance mechanism values I think double [by] the end of 2030" (Flexibilty Service Provider, 2019). In addition, DNOs are soon set to procure flexibility services at the distribution level, opening up new value pools as DSOs: "The model we spotted as an opportunity was … the DNO side and helping facilitate them purchasing flexibility to manage their grid constraints." (Trading Platform Provider, 2019).

These models differ from those based on TOU tariffs in that they are typically reliant on direct load control – with aggregators turning up or turn down demand/generation – rather than price incentives alone:

> "[if] the customer is optimising their energy assets then … we've got it wrong …. Because they won't have the information and the tools to do that [in] the best way" (Flexibilty Service Provider, 2019)

These models are largely reliant on the aggregation of small-scale flexibility to produce meaningful volumes for system operators or in wholesale markets. Aggregators such as Kiwi power and Open Energy have participated in these markets for several years, although mostly have focussed on larger commercial/industrial consumers/prosumers. Recently, OVO energy and their flexibility arm Kaluza have been involved in trials in the Orkney Islands where excess generation from onshore wind farms is diverted into domestic heat storage rather than being curtailed. OVO/Kaluza and other providers such as Smartklub hope these trails will provide a test bed for a more comprehensive domestic flexibility platform where assets such as PV, heat pumps, battery and heat storage and EVs are controlled remotely as a 'virtual power plant' with minimal involvement from prosumers:

> "there's self-consumption of the PV, …the timing of when you run the heat pumps … because you've got a heat store as well as a battery. So, you can arbitrage between the energy vectors, between time of use and providing ancillary services to the grid. So, [its] the best of both worlds in terms of the default position being self-consumption but actually there might be … higher revenues particularly at peak times available elsewhere." (ESCO, 2019)

These models may present new routes to market for distributed

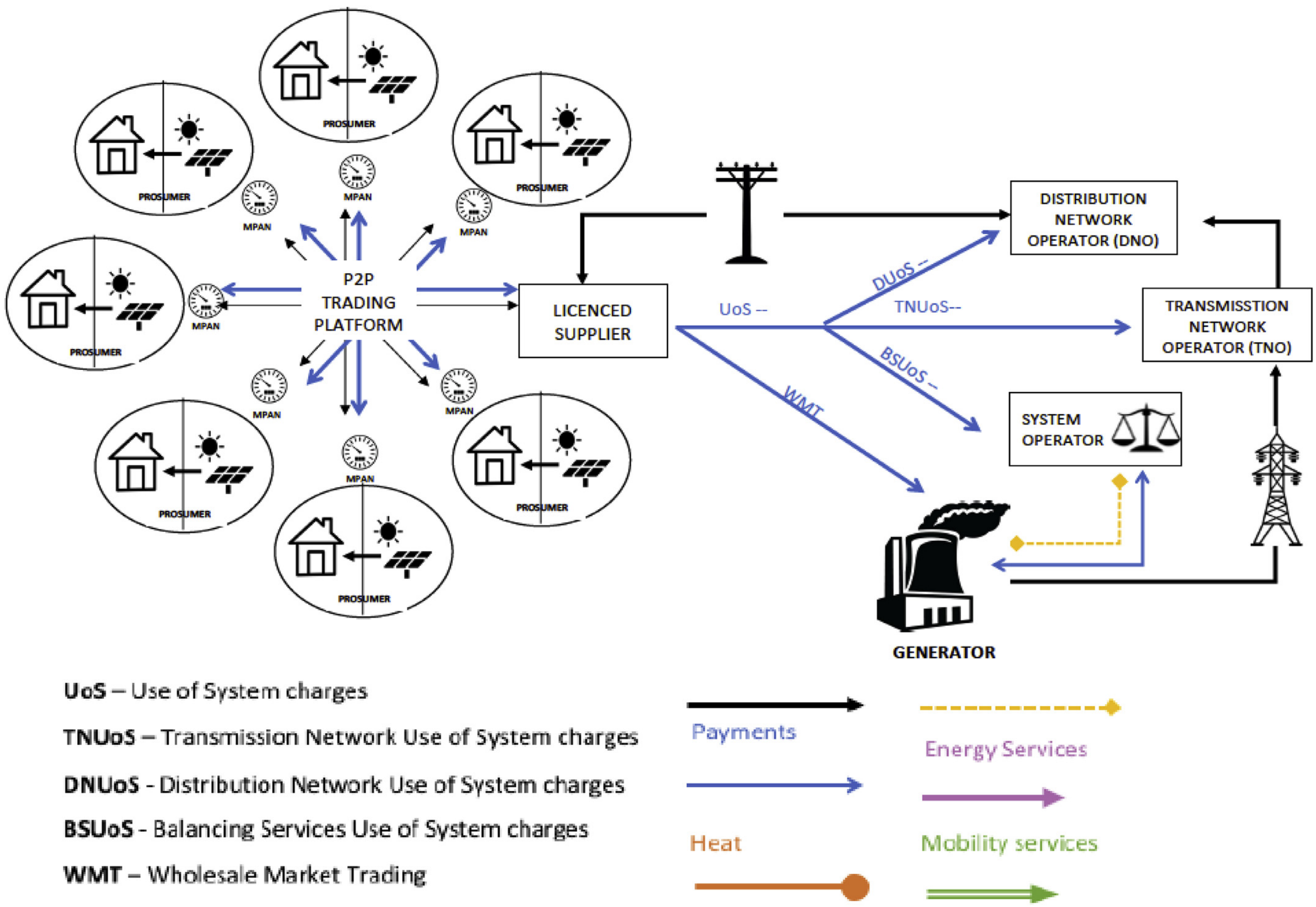

Fig. 4. P2P archetype.

generation co-located with flexible demand and storage assets, stacking revenues from generation and flexibility markets.

4.1.6. Energy service company

Energy service business models (Fig. 6) provide consumers/prosumers with useful end service (e.g. reliable electricity, hot water, room temperature) rather than the technology or energy commodities themselves (e.g. PV panels & intermittent electricity, natural gas, insulation). These models shift the responsibility for the quality and reliability of these services into long-term contracts with ESCOs, who may also own the energy conversion and distribution infrastructure (Nolden and Sorrell, 2016). Solar-as-a-service models allow customers to become prosumers through a solar tariff, with an ESCO owning the PV panels and taking responsibility for financing, installation, maintenance, upstream supply, balancing and settlement (Overholm, 2015). Other common models offer heat-as-a-service and are often a feature of district heat and CHP projects, again with ESCOs owning the infrastructure (Hannon and Bolton, 2015). These models may even offer energy performance contracts for specified comfort, such levels or internal temperature, further incentivising efficiency in building fabric, lighting and appliances (Sorrell, 2007).

Although basic service models for district heat provision are common for large public sector or commercial sites, more comprehensive ‘multi-vector’ service contracts for distributed renewable electricity provision, and thermal comfort are emerging in the UK. The Energiesprong initiative is a deep retrofit programme originating in the Netherlands with trials now underway in the UK. In an Energiesprong retrofit, homes are given a comprehensive makeover involving a new insulated envelope, low energy heating and ventilation systems and rooftop PV panels. These measures are designed to ensure net-zero energy consumption over the calendar year, based on a long-term energy performance contract. The 30-year contract guarantees: internal comfort and temperature of 21°c, volumes of hot water as well as a fixed electricity volume – all for a fixed price which is equivalent to their previous energy bill:

> “it is the ‘mobile phone bundle’ [for] energy … so it's an easy to understand product within … assured comfort and costs “(ESCo Intermediary, 2018)

SmartKlub are trailing a similar model in the Trent Basin new-build housing project. The project features a large PV array, 2.1 MW battery, rooftop solar and ground source heat pump connected to a district heat network. Smartklub have created an ESCO which is designed to manage the system and ensure optimal delivery of energy services with limited involvement from the prosumers/residents. Residents receive a reliable power and heat supply with the ESCO optimising the system to secure the best revenues and balance between import and export. Unlike Energiesprong, Smartklub do not offer comfort guarantees. However, using their large battery they are contracting into flexibility markets through an aggregator for additional revenues. Profits from the ESCO are recycled into a community fund, whilst the ESCO itself passes into community ownership at the end of the trial phase:

> “money or capital that's paid back under that regime … can be … a revolving fund and … invest in the next scheme … So, it's a … less scary way for communities to start owning their own energy infrastructure and having control” (ESCO, 2019)

Such models must currently allow prosumers to switch electricity

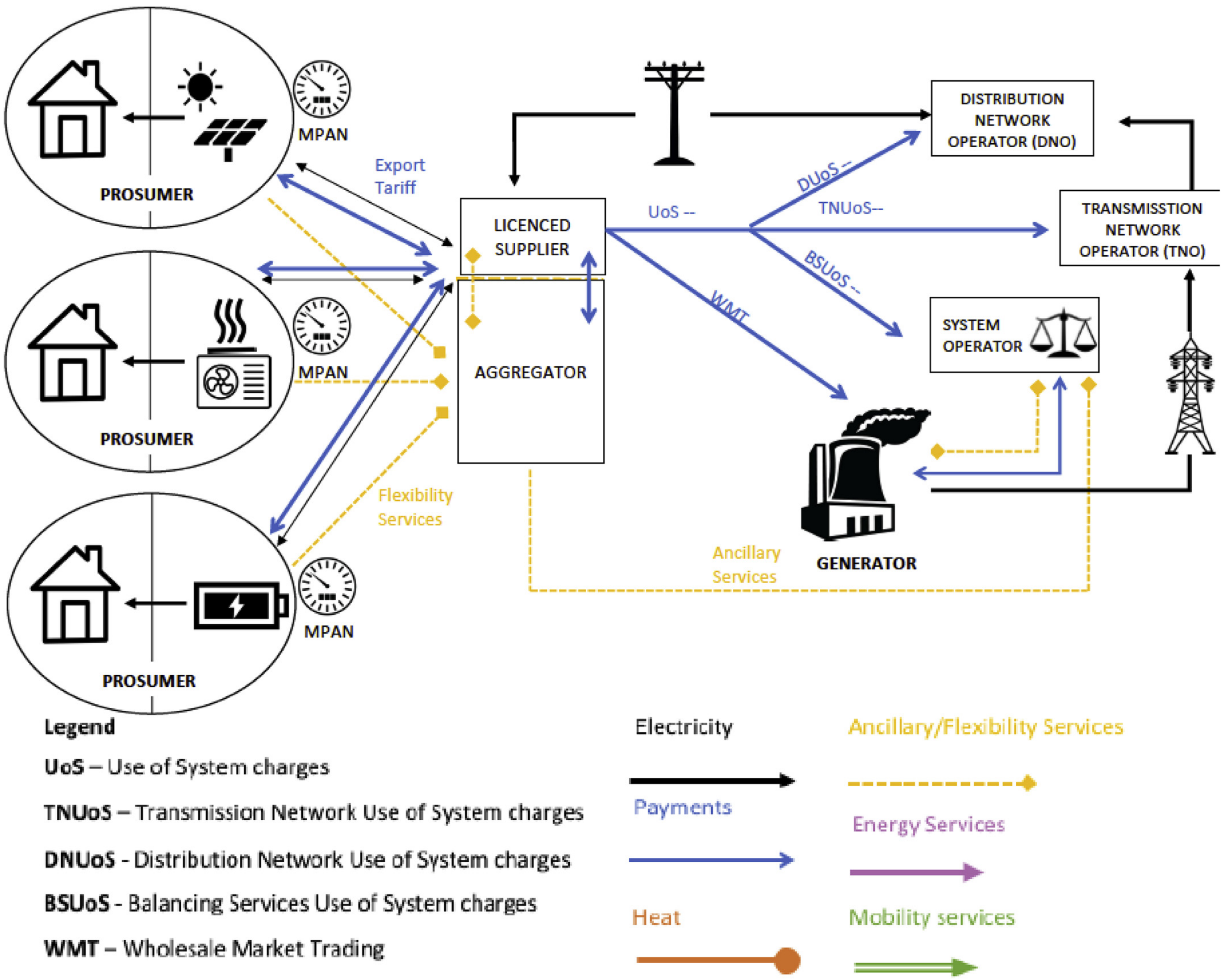

Fig. 5. Flexibility service provider/virtual power plant.

supply contracts[2] due to the 28-day switching requirement, although are designed to disincentivise supplier switching though the lower costs of the ESCo tariff.

> "So … it would be economically irrational for a tenant to not accept the … comfort plan tariff but, you know, they could switch away from that. I think we'll fix it for two years or five years … then …, after that, they shouldn't want to switch but … some people just sign up for the wrong thing and get a bit confused." (ESCo Intermediary, 2018)

4.1.7. Mobility service provider

Transport prosumption models are emerging in tandem with the diffusion of EVs. In their simplest form, these models allow prosumers to charge EVs using locally-generated electricity. In more sophisticated variants, aggregators may use EVs' batteries to provide flexibility services to the grid and system operators – accessing the same revenues as the flexibility service business models – under vehicle-to-grid models (V2G). Indeed, it is expected that EVs may present the most significant source of distributed flexibility in the future: "this wave of flexibility, like momentum given to the markets on the EV roll out is pretty significant (Flexibilty Service Provider, 2019). Such models may also be incorporated into mobility-as-a-service models, where prosumers share the use of EVs, which are owned or operated by third party providers (Sarasini and Linder, 2018). A variant of mobility-as-a-service models use EVs and V2G platforms in public transport provision through electric busses as illustrated in Fig. 7.

In the UK, early adopters of EVs are using their existing solar panels to charge their EVs based on a 'dumb' assessment of when their panels are producing. A number of companies including OVO/Kaluza are introducing 'smart chargers' that can automate this process, purchasing from the grid when prices are low and renewable generation is high. A number of V2G trials are also underway including a bus-to-grid trial with Transport for London. Big Lemon is a community-owned Brighton bus company that owns a large PV array and a small fleet of electric busses, which are partly powered by the panels. These models may provide opportunities to secure a long-term customer/user for the power they would otherwise export for a low price.

5. Discussion

The goal of this paper was to understand how different business models can help to move beyond the FIT-based, subsidy-dependent model of prosumerism in a way that delivers wider system values. These business models are summarised in Table 2. Having used

[2] These issues do not apply to heat or comfort contracts.

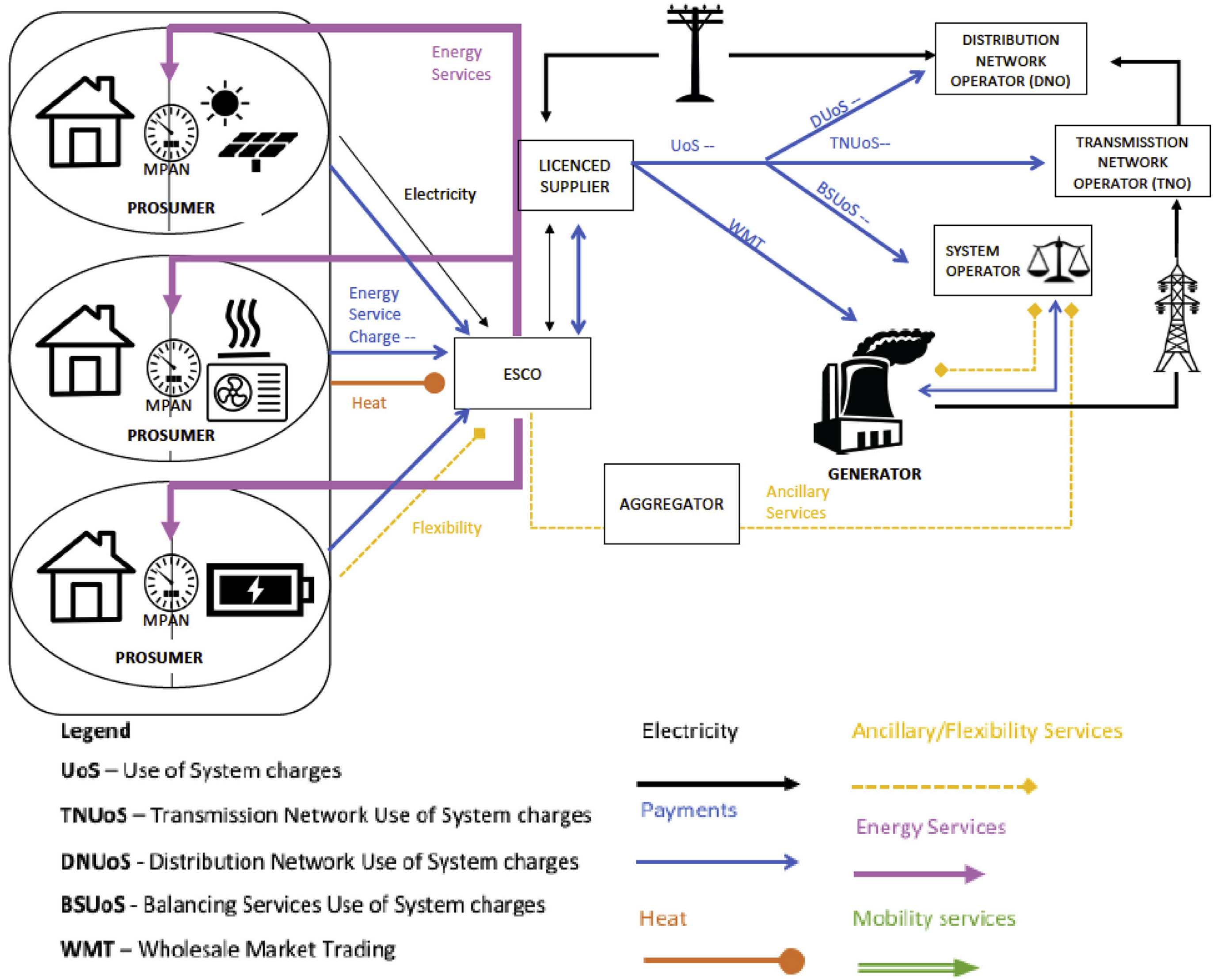

Fig. 6. Energy services company archetype.

contemporary examples from the UK to characterise latent or emerging business models, we now explore these ideas through the components of the business model in the context of the literature.

5.1. Value proposition

Our findings suggest that prosumer business models are most likely to succeed when delivering value for both prosumers *and* the wider energy system. Thus, they should offer bi-directional value propositions where benefits to the energy system are synergistic to prosumer benefits. There are obvious synergies between models that promote local consumption (*microgrids, local tariffs and P2P*) in real time through TOU tariffs, and the desire to reduce the need for expensive network upgrades and peak period charging. These models may also deliver community benefits and retention of local value (Seyfang, 2010). However, previous studies on behaviour change under TOU tariffs have shown mixed results (Filippini, 2011); with consumers often unable, too busy or unwilling to respond to price signals (Friis and Haunstrup Christensen, 2016). Indeed, it was felt by several of our interviewees that the focus on energy provenance and emphasis on the active selection of generators in *P2P* models, belies the current lack of engagement with the energy system and supplier switching (Yang, 2014).

Consequently, apathetic consumers may only become prosumers if system optimising actions are taken with little or no involvement from them (Fell et al., 2015). Models based on *flexibility services, virtual power plants and energy services* may optimise distributed energy systems through direct control and management in a manner that requires minimal input from prosumers themselves. Consistent with Siano (2014), we suggest that these models may be more effective at aggregating and optimising these actions than those based on voluntary price signals - delivering greater system value than islanded microgrids due to greater network effects (Hirsch et al., 2018). Whilst local energy models can produce meaningful impacts in specific locations of the LV distribution network, more dispersed models based on national aggregation will require a 'critical mass' before these network effects become meaningful.

As we have shown, service-based models can deliver 'multi-vector' energy services to prosumers, potentially at no up-front cost (Tunzi et al., 2017). These models can facilitate not only the uptake of low carbon electricity, but also heat and electrified transport – considered greater challenges for climate change mitigation (IEA, 2018). These models can deliver comfort and mobility services for prosumers whilst increasing capacity for price arbitrage, ancillary services and reduced imbalance risk for suppliers.

A common observation in our interviews was that the complexity of smart and flexible DES requires the involvement of sophisticated actors

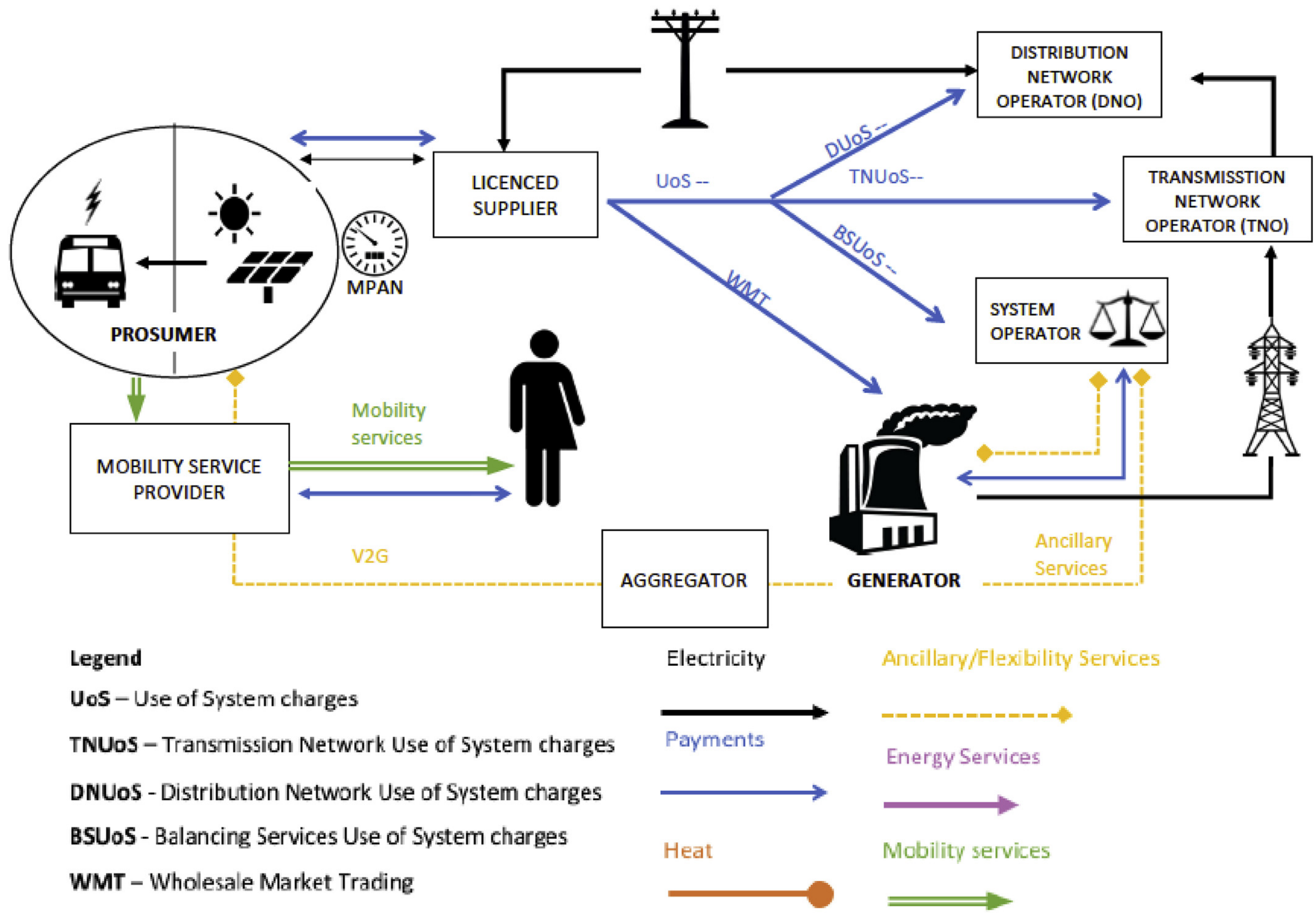

Fig. 7. Transport prosumption, vehicle to grid and mobility as a service.

who may take control of these resources in one form or another. This narrative is driven by opportunities in automation and system optimisation, which may be at odds with the original normative goals of the prosumer movement, including energy autarky, off-grid models and citizen autonomy (Müller et al., 2011; Seyfang et al., 2013). Understanding the different values behind these competing narratives is an important area for future research.

5.2. Supply chain

Importantly, all of the prosumer models identified in this study require the wider energy value chain to remain largely intact (Hall and Roelich, 2016; Richter, 2013a). There remains the need for some transmission level generation, a DNO and TNO to maintain the distribution and transmission networks, a system operator to balance demand and supply and licenced suppliers to retail energy and pass on the cost of the system to consumers/prosumers.

Although these new business models present a challenge to the hegemony of incumbent energy suppliers (Richter, 2013b), some are adapting to capture the values that a distributed energy future may bring, whilst new entrants such as OVO and Good Energy may mainstream these offers. Although, islanded models such as microgrids and P2P models are potentially more disruptive, they still rely upon the traditional energy value chain for network, balancing and settlement services.

Our study did find an emerging ecosystem of new players, including: community groups, energy platform providers, and technology companies all keen to access new pools of value presented by these business models. This aggregation and manipulation of load at smaller-scales, often geographically-defined, also suggests prosumers may be able to offer services to the emerging DNO/DSO market by mitigating network stresses on low voltage networks (Ruggiero et al., 2015; UKPN, 2018). Ultimately, our findings suggest a prosumer-led energy future may see an evolution of the current market structure, rather than some of the more radical visions presented in some scenarios (Parag and Sovacool, 2016; Seyfang et al., 2013).

5.3. Customer interface

Many of the prosumer business models in our study adopt novel methods for customer acquisition and retention. Here, community-led models often show a clear advantage – trading on a local, ethical brand through familiar channels and individuals – building trust with customers/prosumers (Van Der Schoor and Scholtens, 2015). Many are also reliant on new metering, monitoring and control technologies, to promote behavioural changes and inform prosumers about their production and consumption (Gottwalt et al., 2011). Our findings suggest that above all prosumers may value simplicity over greater control over their electricity system. Although our examples are drawn largely from early-stage innovation trials, generally understanding of how these systems operated is low (Fell et al., 2015). Although prosumers are concerned that the system is reliable and sustainable, they may delegate the management and optimisation to a third party or their energy supplier (also Fell et al., 2015). This questions the extent to which the majority will engage with P2P models that emphasise energy provenance, perhaps preferring these models to cost optimise behind the scenes.

Table 2
Prosumer business model archetypes in the UK.

Business model	Value proposition	Customer interface	Supply chain	Financial model	Governance
Basic prosumer	Intermittent renewable electricity behind the meter. Traditionally guaranteed revenue stream through FITs but this is eroding.	*Channels* Sales through small-scale installers. *Relationships* Limited aftercare or monitoring. *Segments* Home/business owners (requires site location of RES).	*Partners* Small-scale SMEs. *Activities* Installing RES behind the meter at consumption site. *Resources* Model may require battery and increased self-consumption to remain viable.	*Cost structure* Typically, self-funded although some financing available in the market. *Revenue streams* Business model viable due to substantial subsidy, some self-consumption.	*Organisational form* Market logic, *Legal form* For profit Ltd SMEs and private households/businesses. Community ownership also common.
Private wire/ micro-grid	Emphasis on self-consumption of RES by aggregating generation assets and consumption activities 'behind the meter'. Prosumers pay lower than market price when consuming locally through virtual energy company (VEC), who may also procure cheaper import price.	*Channels* Users are engaged by VEC/developer as part of the housing sales/rental process. *Relationships* Developer- i.e. community land trust (CLT), housing association (HA) or business park developer has long term relationship through VEC. *Segments* Typically undertaken as part of a new building project only.	*Partners, Activities & Resources* Often the VEC/developer designs and builds the system and develops the platforms necessary for the billing and settlement. The VEC then contracts with a licenced provider upstream with a single meter for the site.	*Cost structure* RES financed by the project developer and re-funded through billing and fixed charges on residents. *Revenue streams* Less need for subsidy. Returns from VEC bills & revenues shared amongst community. Curtailment/export can also be reduced. Embedded benefits. TRIAD avoidance.	*Organisational form* Integrated VEC and tenancy/freehold offering requires third party skill sets in RES installation and commissioning, monitoring and billing platform *Legal form* Community owned/LA and not for profit models common.
Local energy company/ TOU tariff	RES presumption behind and in front of the meter. Offering local consumers ability to self-consume power locally. Based on utilising power generated in distribution network area. Dynamic time of use tariffs (TOU). Potentially lower prices for consumers and better revenues for local generators.	*Channels* Local energy company markets through highly localised channels i.e. other community organisations. *Relationships* Ongoing relationship through smart metering, billing and in-home displays and other forms of monitoring and signalling through TOU.	*Activities* Linking local generation with supply via smart metering and digital platform. *Resources* Requires geographically specific assets and service provision. *Partners* Often partnering with licenced supply for balancing and settlement.	*Cost structure* Range of options but can include mix of self-funded, community owned and commercially owned generation. *Revenue streams* Improving export revenues for generators by purchasing power locally based on a local tariff. Curtailment/export can also be reduced. Embedded benefits. TRIAD avoidance.	*Organisational form* Local nested networks, local ownership, local supply chain. Model may involve partnering with licenced supplier *Legal form* Community/private hybrid forms currently common.
Flexibility service provider	Aggregator models allow prosumers to provide a range of services to the energy market and network operators which are aggregated to produce meaningful changes in supply and demand at specific periods. This often involves a mix of demand side response and dispatchable generation and storage which can receive a range of incentives to improve the networks operation and efficiency.	*Channels* Similarly, to local tariffs and P2P models these approaches rely on digital platforms.These models may be based on certain tariff structures or direct offer of DSR services (common in B2B examples) *Relationships* Price signals to incentivise the desired response, although in most cases these interventions are automated.	*Partners, Activities & Resources* Requires short term metering and settlement with the host as well as the ability to power up or power down certain systems remotely. Contracts with TSO and DSO. Therefore, flexible demand, storage or generation usually required.	*Cost structure* Controls and platform often offered for free based on platform operator taking share of revenues. *Revenue streams* Payments for DSR and other flexibility services cover the capital cost of installing the control equipment: ● Frequency response ● Fast reserve ● STOR ● Balancing mechanism	*Organisational form* Range of options although aggregator typically separated from RES solutions provider. *Legal form* Largely private sector led currently.
Peer-to-peer	RES presumption in front of the meter. Similar to local RES tariff but without geographical or local focus.	*Channels*Digital P2P platform*Relationships*Models such as Good Energy's Selectricity are based on a P2P tarriff where customers choose their generation mix through a user-friendly platform.	*Resources* Non-geographically constrained assets. *Partners* Large information technology requirement possibly through the use of third-party platform & Blockchain technology. *Activities* May require separate balancing and settlement – thus effectively a shadow market.	*Cost structure* Can also involve P2P financing although these are not necessarily deployed together. *Revenue streams* Peer to peer trading with instantaneous payment for power generation. Curtailment/export can also be reduced. Embedded benefits.	*Organisational form* Market based governance with multiple generation and consumption sites with transactions governed by price signals. *Legal form* Largely private sector led currently.
Energy service company	Integrated energy service offering based on downstream energy services. Electricity, heat/comfort services are provided usually for a fixed cost based on a consumption quota. Service provider/ESCO optimises system performance upstream of customer.	*Channels* Interface based on long term service contract with ESCO. *Relationships* Ongoing relationship through O&M agreement as well as performance monitoring.	*Activities* Integrated offering of electricity and heat services. *Resources* Renewables, heat, controls and storage may be offered as a package. *Partners* Electrical supply contract may be bundled upstream.	*Cost structure* Energy performance contract based on service payments and upstream financing of hardware. *Revenue streams* Single service payment bundled with rental/service agreementReduced O&M costs on buildings.	*Organisational form* Incentivises supply chain integration to form ESCOs. *Legal form* Partnering between LAs, Housing provider and private sector solutions providers.
Mobility service provider	Prosumer self-consumes RES by supplying electric vehicles (EVs). In V2G models EV owners supply the	*Channels* May be sold with EV package, or as part of mobility service models. *Relationships*Ongoing relationship could be either through vehicle provider or a V2G tariff and utility intermediary.	*Resources* Requirement for both electricity and EV charging infrastructure. *Partners* V2G models require aggregator platforms.	*Cost structure* Majority of costs lie in vehicle hardware and charging facilities. *Revenue streams* Revenue model Based on avoided cost of purchase of power for EV	*Organisational form* Range of options including integrated solution through vehicle provider or V2G and charging services from separate provider. *Legal*

(*continued on next page*)

Table 2 (*continued*)

Business model	Value proposition	Customer interface	Supply chain	Financial model	Governance
	grid with a range of services and balancing.			V2G models may access similar markets to aggregator models.	*form* Largely private although public transport solutions may be public or community owned.

5.4. Financial model

Our study confirms that in a post-subsidy environment the basic prosumer business model will struggle to be financially viable in the majority of cases, unless there is sufficient onsite demand to ensure self-consumption, and retail prices remain high or climb further. Cost reductions in static batteries could change this picture, however (Reid and Wynn, 2015).

We suggest that new prosumer business models can improve revenues in four main ways: (1) increase self-consumption behind the meter; (2) achieve improved prices for exported power; (3) access balancing and ancillary service markets; and (4) shift energy vectors. Fig. 8 provides an overview of the revenue streams that are accessed by these models, highlighting how revenues can be stacked to produce a viable business model. Green revenues represent those that are accessible under current market arrangements; Amber those that are somewhat accessible; and Red represents potential streams not accessible under current market arrangements.

5.4.1. Increase self-consumption behind the meter

Prosumers are incentivised to utilise electricity they generate behind-the-meter, as this electricity is essential free at the point of use. Private wire business models extend this logic by increasing the size and heterogeneity of the loads that are behind the meter – pooling the demand of multiple homes, commercial or industrial units (Hirsch et al., 2018). VECs can incentivise self-consumption though price signals from TOU tariffs that are internal to the private wire – a largely unregulated space. Transport prosumption, and energy service business models, can also increase behind-the-meter consumption providing a shift to alternative energy vectors, explored more in section 5.4.4.

Historically, consumption behind the meter has also benefitted from reduced UoS charges, charged in the UK on a volumetric basis. As shown above, all of the models in our study still rely on this system to be available at all times. As behind-the-meter consumption effectively avoids these volumes, this has presented a significant benefit to these models. Increasing behind-the-meter prosumption in the UK, however, is leading to non-prosumers paying a greater share of the burden for the distribution (DUoS), transmission (TNUoS), and balancing (BSUoS) system costs (Ofgem, 2018). Concerns over this 'death spiral' effect (Bray et al., 2018) is leading the UK's regulator Ofgem to propose that demand users should pay 'fixed charges' allowing system and network operators to recover these costs more 'fairly' (Ofgem, 2018) – eroding this business case.

5.4.2. Achieve improved prices for exported power

A second principle for new prosumer business models is to ensure that the best possible prices are achieved for any power that is exported. Historically, smaller prosumers have achieved a low price for power exported under the export tariff, whilst larger prosumers have negotiated PPAs with suppliers – again often struggling to achieve a good price (Barton et al., 2015). With the abolition of the FITs and export tariff (Ofgem, 2019), Ofgem and BEIS are hoping a more market-based pricing will emerge, even for small prosumers (Ofgem, 2018).

Consistent, with previous studies we find that prosumer business models such as the Local/TOU and P2P that match supply and demand in real-time are likely to be key to improving this picture (Hall and Roelich, 2016; Ofgem, 2016a). Through price signals and TOU tariffs these models can incentivise consumption when power is being generated by actors in the local network – ensuring the best price for generators and consumers. These models are currently reliant on a licenced supplier to provided balancing and settlement where a < 2.5 MW licence exempt, LEC provides metering and billing of prosumers. Although P2P models present the most efficient means of matching generation and demand locally, these models currently require partnering with a licenced supplier (Open Utility, 2016; Zhang et al., 2017).

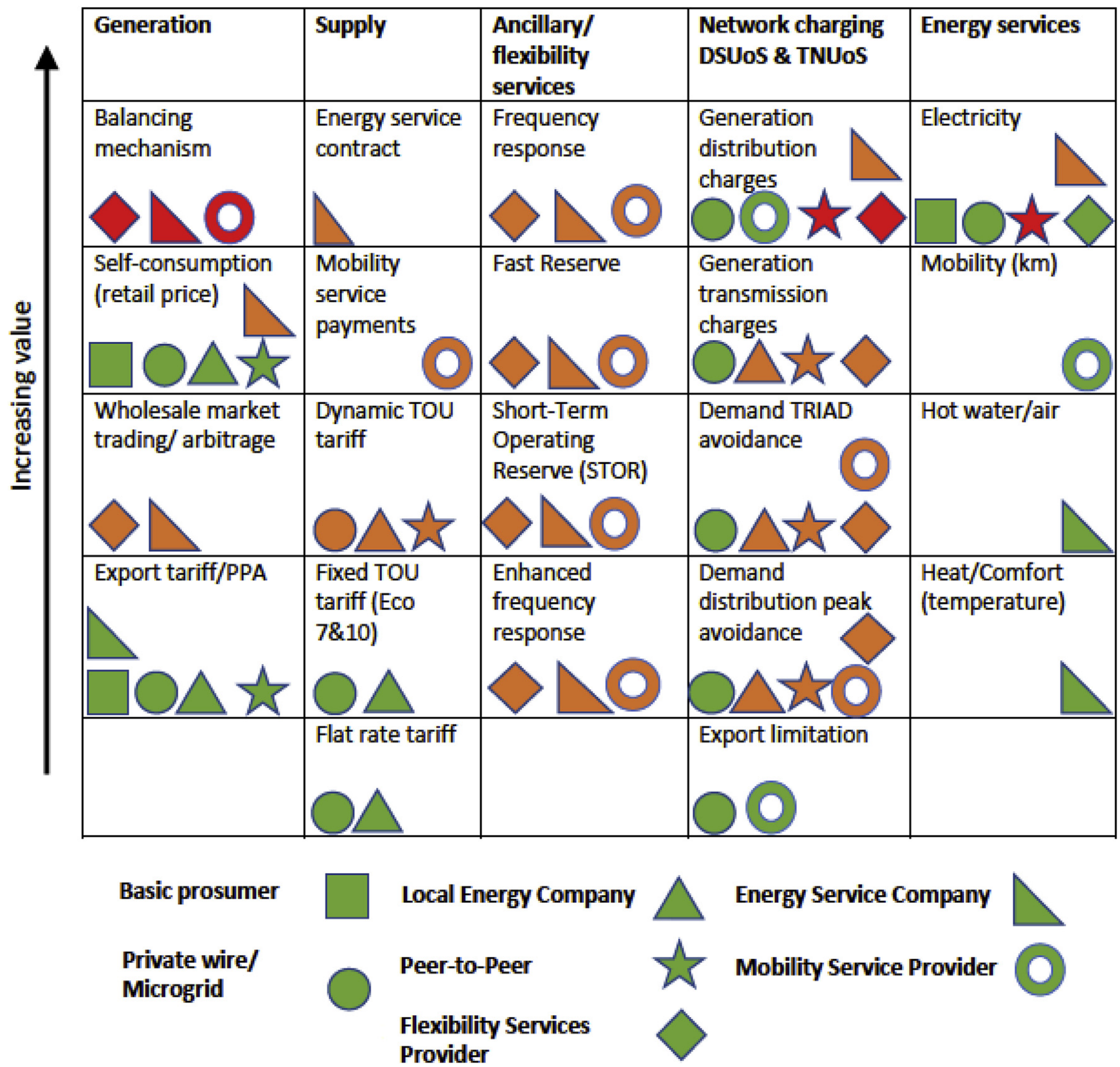

Fig. 8. Revenue stacks for prosumer business models.

A further benefit of these models is the reduced load they place on networks. Historically, distributed generation has received embedded benefits – incentives to generate power at the distribution level, especially during high-use of the transmission system periods, i.e. TRIADS. These benefits are to be slashed from £47.30 per kW of capacity to less than £2 per kW, in a move to make the benefits of DES more cost-reflective (Bray et al., 2018). Proponents of Local/TOU and P2P have thus echoed calls for the benefits of local matching to be better reflected in DSUoS charges for generators where supply and demand can be matched locally at the lowest voltage level (Open Utility, 2018). As shown in Fig. 8, currently only Private Wire models can access these reduced DSUoS costs, with a recent review into new DSUoS charging methods inconclusive (Open Utility, 2018). This undermines a fair marketplace for Local/TOU and P2P models in the UK:

> "*local matching is being hindered by legacy network charging mechanisms that offers no financial incentives to either generators or end-users*" (Open Utility, 2018)

5.4.3. *Access flexibility, balancing and ancillary service markets*

Business models that involve flexibility services may present important new revenue streams for prosumers with flexible DES (Fig. 8). Batteries, EVs, CHP systems as well as flexible loads including heat pumps and IoT-enabled appliances may be able to offer a range of services to the grid at different periods (Siano, 2014). These models involve some form of direct load control, whether involving an aggregator, ESCo or V2G platform provider, and eventually operate alongside supply-focussed models, as in the Smartklub Trent Basin case. With HH settlement, consumers can also reduce their TNUoS and DNUoS on imported power peak time charging and TRIADs avoidance by shifting their demand profiles.

As argued by Bray et al. (2018), the transition from DNOs to DSOs will open up new flexibility markets for prosumers building on the revenue stacks in Fig. 8. Although aggregators without a supply licence cannot currently access the balancing mechanism (Bray et al., 2018), this may present a large new value pool for prosumer flexibility. However this involves prosumers ceding control. In the UK, the shift to DSOs is being facilitated by the Open Networks project, whilst Ofgem are currently consulting on access to the balancing mechanism (Bray et al. (2018).

5.4.4. *Shift energy vectors*

Prosumer business models will also play an important role in the decarbonisation of other energy vectors beyond electricity (Tunzi et al., 2017). Models based around flexibility, heat/cooling and mobility services can ensure low carbon electricity is used locally for a fair price, and drive the adoption of low carbon heat and transport systems – accessing these large value pools (Wegner et al., 2017). By providing these services, prosumers can establish a broader business case and help to deliver this agenda. Models based on services can help to overcome the high capital cost of distributed energy systems, although will require complementary financing mechanisms that remain underdeveloped in the UK (Brown et al., 2019). Moreover, models such as energy service contracts face a range of regulatory and cultural challenges, with the requirement for 28-day switching a potential barrier to long-term service or performance contracts (Hall and Roelich, 2016).

5.5. Governance

In our study, we identify three competing governance narratives within prosumerism. In countries with liberalised energy markets, a centralised market logic has dominated the structure and governance of the electricity system (Kuzemko et al., 2016). Proponents of community energy see prosumerism as a challenge to this model, with ownership and management of distributed energy assets increasingly in the hands of citizens (Seyfang et al., 2013). It is argued this new paradigm represents an opportunity to increase energy democracy, and better share the proceeds of the transition (Hiteva and Sovacool, 2017). A competing narrative sees a renewed role for municipalities in distributed energy governance (Bale et al., 2012; Roelich et al., 2018). Proponents argue that the municipal actors can better ensure distributional equity in distributed energy transitions as well as having the fiscal, planning and political tools to facilitate significant change (Webb et al., 2016). A third narrative is an evolution of the centralised market logic that puts individuals and behavioural changes at its centre (Rodríguez-Molina et al., 2014). This model sees new market entrants and start-ups driving the adoption of innovative technologies, products and services towards a 'distributed market logic', emphasising cost-efficiency and consumer choice (OVO Energy and Imperial College, 2018).

Our findings suggest that all of these logics are present in different forms in prosumer business models. Many have involved community decision-making and fundraising through co-operative-type legal structures – showing that future community energy projects could find viable business models in the majority of archetypes. This will involve the handover of the control and management of elements of these systems to third party suppliers, aggregators or ESCos. The viability of these models, especially those contingent on multi-vector and scalar changes to energy systems, also see an increasing role for municipalities, with several entering these markets with their own prosumer offerings. This presents a case for future research into how these hybrid forms and competing narratives affect the direction that prosumerism may take.

We subsequently introduce a series of key principles for prosumer business models, shown in Table 3.

6. Conclusion and policy implications

In this paper, we outline how the basic prosumer business model – largely reliant on subsidies – is unlikely to be economically viable, now FITs in the UK have come to an end. This is especially the case where there are limited options for self-consumption, combined with low or zero export payments. New business models are able to overcome these issues by offering new sources of value to prosumers and the grid - in turn generating new sources of revenue from these activities. These models often involve relinquishing various forms of control over prosumer energy systems, however, which may be perceived to contradict the normative objectives of 'prosumerism'.

Given the current policy and regulatory environment of the UK, we propose a series of policy recommendations that will help to overcome barriers to prosumer business models and the wider prosumer phenomenon in the UK and beyond:

- Government should assist in removing barriers to new value propositions, such as those that involve multiple energy vectors and long-term service-based models;
- Current legislation that requires mandatory 28-day switching should be reviewed in light of the multiple benefits that long-term energy service contracts can provide;
- The regulator should expedite cost-reflective distribution network tariffs: developing prices that better reflect the actual costs of network services, without unfairly charging wider energy customers;
- The system operator should create a new route for independent aggregators to access the balancing mechanism, making it simpler for small-scale flexibility providers to access ancillary service markets;
- Customers cannot trade electricity between themselves without a third-party licenced supplier. This should be reviewed in the light of the potential for P2P models, requiring alternative models than the 'supplier hub' approach;
- The smart meter rollout should ensure that meters have sufficient interoperability with these emerging models, systems and markets.

Our findings suggest a more complex but potentially bright future for the prosumer phenomenon in a post-subsidy landscape. New business models delivering new sources of value can generate new and/or improved revenues and savings for prosumers, as well as deliver wider, non-financial forms of value. The above regulatory barriers, alongside a range of technical and cultural challenges, will still need to be overcome before this value can be effectively created and captured. Further research should seek to provide a comparison of how different policy measures are most effective for supporting these new prosumer business

Table 3
Key principles for prosumer business models.

Value proposition	1. Prosumer business models should deliver bi-directional value propositions that are synergistic to both prosumers and the energy system; 2. Greater value can be created and captured through models that deliver services across multiple energy vectors; 3. Prosumer business models create non-financial value that is important but difficult to measure;
Customer interface	4. Prospective prosumers are likely to value simplicity over control of their energy systems. Prosumer business models should emphasise the customer journey in their design;
Supply Chain	5. Despite delivering greater decentralisation, prosumer business models still rely on the existing energy value chain and therefore must contribute to its upkeep;
Financial model	6. New prosumer business models can improve their revenue streams in four key ways: • Increase self-consumption behind the meter • Achieve improved prices for exported power • Flexibility, balancing and ancillary service markets • Shift energy vectors 7. Prosumer business models need to be effectively remunerated through reduced UoS charges, if they create value for distribution and transmission network infrastructure; 8. Business models solely based on avoiding network charges are likely to be unsustainable long term – as they violate 1 and 5; 9. Business models that involve the provision of flexibility services need access to these markets and should be remunerated through payments or reduced charges;
Governance	10. Community, municipal and market logics are all a feature of the prosumer phenomenon – based on a range of competing 'normativities' and visions of the future, these governance logics should be made explicit.

models, and the ways in which they reduce the prosumer's project risk while increasing returns.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.enpol.2019.110984.

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