PROSEU

Prosumers for the Energy Union: mainstreaming active participation of citizens in the energy transition

Business Models for Prosumers in Europe

Deliverable 4.1 of the Horizon 2020 PROSEU project (H2020-LCE-2017)

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Authors	Stephen Hall, Donal Brown, Mark Davis (University of Leeds), Moritz Ehrtmann, Lars Holstenkamp (Leuphana University of Lüneburg)
Reviewers	Kristian Petrick (Eco-Union); Inês Campos (FC.ID)

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Summary of PROSEU

PROSEU aims to mainstream the renewable energy Prosumer phenomenon in the European Energy Union. Prosumers are active energy users who both consume and produce energy from renewable sources (RES). The growth of RES Prosumerism all over Europe challenges current energy market structures and institutions. PROSEU's research focuses on collectives of RES Prosumers and will investigate new business models, market regulations, infrastructural integration, technology scenarios and energy policies across Europe. The team will collaborate with RES Prosumer Initiatives (Living Labs), policymakers and other stakeholders from nine countries, following a quasi-experimental approach to learn how RES Prosumer communities, start-ups and businesses are dealing with their own challenges, and to determine what incentive structures will enable the mainstreaming of RES Prosumerism, while safeguarding citizen participation, inclusiveness and transparency. Moving beyond a case by case and fragmented body of research on RES Prosumers, PROSEU will build an integrated knowledge framework for a socio-political, socioeconomic, business and financial, technological, socio-technical and socio-cultural understanding of RES Prosumerism and coalesce in a comprehensive identification and assessment of incentive structures to enable the process of mainstreaming RES Prosumers in the context of the energy transition.

Summary of PROSEU's Objectives

Eight key objectives at the foundation of the project's vision and work plan:

- **Objective 1:** Document and analyse the current state of the art with respect to (150-200) RES Prosumer initiatives in Europe.
- **Objective 2:** Identify and analyse the regulatory frameworks and policy instruments relevant for RES Prosumer initiatives in nine participating Member States.
- **Objective 3:** Identify innovative financing schemes throughout the nine participating Member States and the barriers and opportunities for RES Prosumer business models.
- **Objective 4:** Develop scenarios for 2030 and 2050 based on in-depth analysis of technological solutions for RES Prosumers under different geographical, climatic and socio-political conditions.
- **Objective 5:** Discuss the research findings with 30 relevant stakeholders in a Participatory Integrated Assessment and produce a roadmap (until 2030 and 2050) for mainstreaming RE Prosumerism.
- **Objective 6:** Synthesise the lessons learned through experimentation and co-learning within and across Living Labs.
- **Objective 7:** Develop new methodological tools and draw lessons on how the PROSEU methodology, aimed at co-creation and learning, can itself serve as an experiment with institutional innovation.
- **Objective 8:** Create an RES Prosumer Community of Interest.

PROSEU Consortium Partners

Logo	Organisation	Type	Country
	FCIENCIAS.ID	Private non-profit association	Portugal
	UPORTO	University	Portugal
	ICLEI EURO	Small and medium-sized enterprise	Germany
	CLIENTEARTH	Non-governmental organisation	United Kingdom
	UNIVLEEDS	University	United Kingdom
	DRIFT	University	the Netherlands
	UNIZAG FSB	University	Croatia
	LEUPHANA	University	Germany
	ECO-UNION	Non-governmental organisation	Spain
	IÖW	Private non-profit limited company	Germany
	CE Delft	Small and medium-sized enterprise	the Netherlands

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Glossary

CEC	Citizen Energy Community
CO_2e	Carbon Dioxide Equivalents
DSO	Distribution System Operator
EE	Energy Efficiency
EMD	Electricity Market Directive
EU	European Union
FiT	Feed-in-Tariff
GWh	Gigawatt hours
kW	Kilowatt
LCOE	Levelised Costs of Electricity
LTS	Long Term Strategy
MW	Megawatt
NECP	National Energy and Climate Plan
PV	Photovoltaic
RE	Renewable Energy
REC	Renewable Energy Community
RES	Renewable Energy Sources
RED II	Renewable Energy Directive (Recast) from 2018
TSO	Transport System Operator

Executive Summary

Introduction

This report explores the different business models being adopted to enable renewable energy generation and self-consumption in the European Union. Individuals, businesses and energy communities that install renewable energy generation and self-consume some of that generation are called 'prosumers'. Prosumers may be householders, businesses or communities whose primary business is not energy generation.

The price of installing on site renewables is falling, which means homes and businesses can increasingly afford the up-front cost of installing a system. At the same time, governments are removing the subsidies formerly paid to prosumers for feeding renewable energy into the grid. In parallel, energy systems are getting smarter, so it is becoming easier to account for smaller and smaller amounts of energy and to trade them between smaller players in the energy market; even down to household to household trades.

The recent Clean Energy Package (CEP) for All Europeans enshrines the rights of European citizens to become individual and/or collective prosumers. Collective prosumers are defined in the Clean Energy Package by two new types of organisation; Renewable Energy Communities and Citizen Energy Communities who are empowered to generate, use and to sell energy *collectively*, between themselves. How these Renewable Energy Communities (RECs) and Citizen Energy Communities (CECs) are established in each Member State (MS) is a matter for each MS's energy policy and regulation.

This report explores why these RECs and CECs are necessary, what kinds of value they might be trying to capture in the energy transition, and how they can be empowered through MS' energy policy and regulation. To do this we investigated the business models being adopted by individual and collective prosumers.

Research

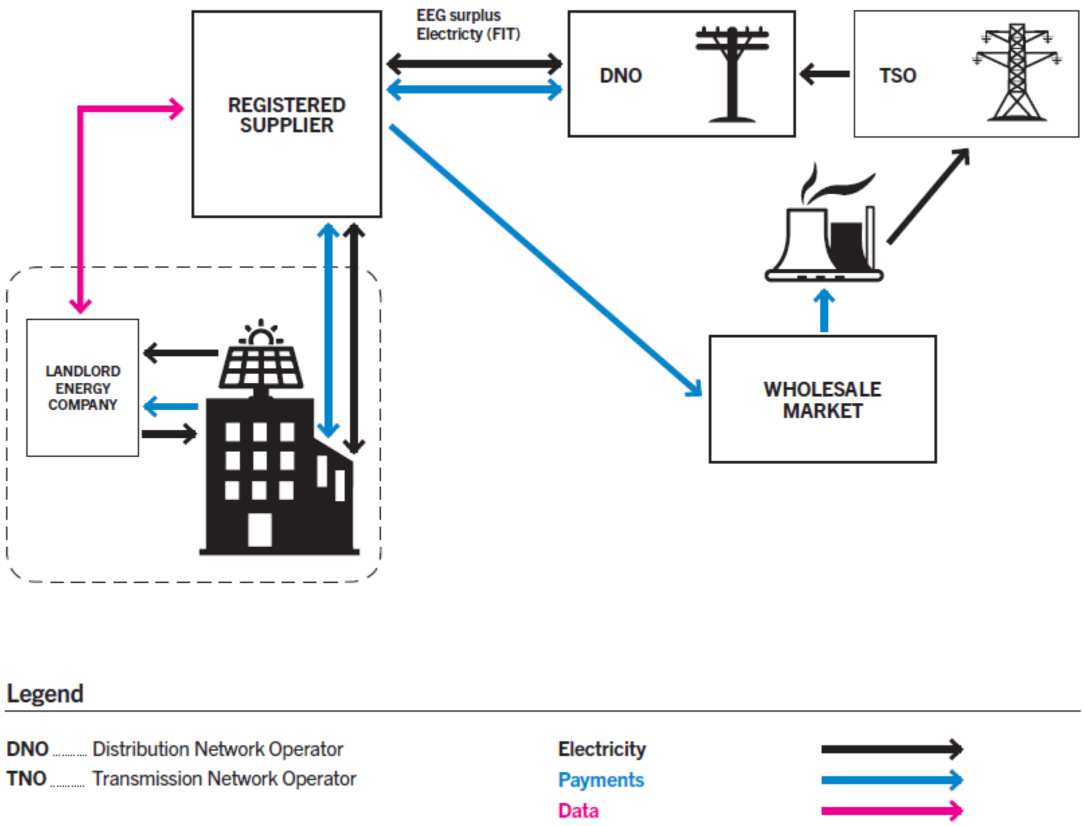
The research team undertook research effort in seven countries, engaging 84 stakeholders from across the energy value chain: citizens, businesses, utilities, regulators, researchers, innovators and financiers. We used business model collaboration workshops, expert semi-structured interviews, and desk research to investigate the business models being adopted by individual and collective prosumers. This research produced 25 business model 'archetype' diagrams; representations of how energy, energy services, payments, data, and 'balancing' services flow around the system.

We subsequently focussed on 15 of these business models that were either in the market, in a trial phase, or in the development phase. We used these business model archetypes diagrams to question how each model solves problems for prosumers and other stakeholders. In each case we identified what values are being captured and by whom. We then used 10 'key principles of prosumerism' to explore how each model pays for energy networks, if they avoid or pay energy taxes, and whether they can generate new revenues by offering system flexibility or decarbonising other energy vectors.

Results

We found that collective prosumer business models in the market, or close to market, were extending the definition of self-consumption in diverse ways. In Germany, a Landlord-to-Tennant energy model allows for a form of self-consumption from solar PV on multi-occupancy buildings. In the UK, private wire networks are allowing prosumers to experiment with different energy technologies that both maximize self-consumption and offer services to grid operators. In the Netherlands, co-operatives can ‘collectively’ self-consume renewable energy from adjacent post codes. And in Spain, a new Royal Decree allows residents in multi-occupancy buildings and local communities to establish ‘collective auto-consumption’ models that the local grid operator enables by close management of prosumers meter data. Figure 1 shows the simplified German Mieterstrom model.

Figure 1: Simplified Landlord Tennant Electricity model, ‘Mieterstrom’.



By presenting 15 prosumer business models in this way, we can explore how each model benefits from avoiding different elements of the retail price of energy, or from earning new revenues either from flexibility of from decarbonising other energy vectors.

We found several models seek to 'aggregate' prosumers' flexibility and use the flexibility of many small energy systems to service bigger needs of electricity system operators. The Clean Energy Package also empowers these business models by directing MS governments to open up flexibility markets to these smaller scale aggregators.

We found collective prosumer business models that derive value from energy efficiency retrofit or decarbonisation of other energy vectors such as heat and transport. Each of these business models is assessed for its compatibility with the 10 'key principles of prosumerism' set out in the report.

Analysis

By comparing each business model, we found that there are multiple ways of extending the definition of 'self-consumption' and for prosumers to earn new revenues in the energy market. We also found that individual business models do not necessarily travel well between MS. The differences in extant system regulation, the retail price of energy, and the underlying renewable resources of wind and sun in each nation, along with the different stages or energy market development, make each prosumer business model an almost bespoke solution to each MS.

To tackle this, we have explored exactly where each MS has made regulatory space for these prosumer business models. In the Netherlands, specific tax breaks for co-operative prosumers have been secured. In the United Kingdom, a derogation from the need for an energy supply license is made for supply under 2.5MW. In Spain, the collation of meter data by the distribution operator is the enabling factor.

In each case prosumer business models are finding new ways of breaking out of a 'niche' and trying to enter the mainstream or 'regime' of the energy market. We use a set of theories based in evolutionary economics and socio-technical systems thinking to show how some prosumer business models may exist alongside the existing energy regime, while some may pose a challenge to it. We make clear that while each of the business models explored is trying to build a business case, the reason for their existence in the energy market is often non-profit driven.

We conclude by asking how MS policymakers and regulators tasked with transposing the Clean Energy Package into law can empower RECs and CECs. We ask whether MS regulators only exist to remove barriers to participation in utility dominated energy markets, or whether they can do more to protect and empower the 'collective prosumer niche', given its wider social, economic and environmental value. The challenge is to establish what it is that Renewable Energy Communities and Citizens Energy Communities can do, that a private for-profit company in the energy system *cannot* do.

We split these policy options between (1) 'fit and conform' options, which would bring RECs and CECs into direct competition with commercial actors in the energy market by reducing barriers to entry; and (2) 'stretch and transform' policy options, which empower collective prosumer business models by allowing the niche to grow through tax, subsidy and regulatory advantages that RECs and CECs can access but commercial actors cannot. See Table 1 below.

Table 1: Two streams of policy options for empowering the prosumer niche

'Fit and Conform' policy options for empowerment of the prosumer niche	'Stretch and Transform' policy options for the prosumer niche
Opening up balancing, ancillary services and capacity markets to smaller scale demand side response.	Opening up balancing, ancillary services and capacity markets to smaller scale demand side response and reserve a portion of each auction for REC and CEC participation.
Create an export guarantee that obliges retail suppliers to offer a price above zero for energy exported to the grid.	Create an export guarantee that obliges retail suppliers to offer a price above zero for energy exported to the grid.
Experiment with derogations from supplier licensing under certain power ratings for all stakeholders.	Experiment with derogations from supplier licensing under certain power ratings only for RECs and CECs
Allow peer-to-peer platforms to operate without supplier license requirements when partnered with a licensed utility.	Allow peer-to-peer platforms and Local Energy Companies to operate without supplier license requirements when partnered with a licensed utility.
Expose prosumers to full costs of network utilisation	Maintain limited protection from full costs of network utilisation
Create a specific scheme for shared self-consumption in multi-occupancy buildings or in very local geographies that benefits from tax incentives or explicitly justifies avoidance of network charges or supplier costs.	Create a specific scheme for shared self-consumption in multi-occupancy buildings or in very local geographies that benefits from tax incentives or explicitly justifies avoidance of network charges or supplier costs. Where only REC and CEC organisational forms can operate the scheme
	Re-establish explicit subsidies for prosumers where the prosumer business model used includes other, hard to decarbonise energy vectors such as heat or transport.

These policy options are developed as the main report progresses; future work by the PROSEU consortium will engage MS regulators and policy makers in how these two sets of options for empowering the prosumer niche can be transposed into energy policy and market regulation.

Introduction

1.1 Objectives of this report

This report describes the business models being created by citizens to accelerate the energy transition. EU citizens and communities are moving away from being passive 'consumers' of energy. They are creating new ways to generate, use and trade renewable energy - this is 'prosumerism'. This report explores how reduced or eliminated energy subsidies mean new business models are needed to make prosumerism work. We show how common challenges across European Union MS are being met by a diverse set of prosumer business models. The objective of the report is therefore to understand what new business models are needed to mainstream prosumerism and how well they integrate into different energy markets[i].

We used to think of prosumers as individual households with solar panels or other small renewable technologies, but recently the term has been extended to prosumer "communities". These are citizen led renewable energy projects, they might include homes, businesses, neighbourhoods or commercial sites. These 'communities' generate, use and trade renewable energy. It is true that prosumer communities have existed for some time; what is new however, is that the rights of these communities to enter the energy market are now enshrined in EU law under the Clean Energy Package[1] in the second Renewable Energy Directive (REDII)[2] and the Electricity Markets Directive[3].

This is new because in *most* MS, the rights of citizens to act together in the energy market have been ambiguous[4]. It has been unclear whether electricity generated on site can be traded between households or in a multi-occupancy block. It has been (and still is in many Member States) unclear how to sell a co-operative's electricity directly to its own members. It has been unclear how to account for small scale, distributed renewable energy that 'spills' onto the grid when its owners are not using it 'behind the meter'. In short it has been unclear how this generation can be accounted for *in the market.* This matters because it is difficult to match when renewables are generating with when a householder or business is using electricity. What to do with the excess, and how it is accounted for, can make the difference between sustainable and unsustainable business models.

Energy systems across the European Union are becoming smarter - where smaller units of energy can be measured and used more accurately and cheaply. This means it becomes more realistic to account for and *exchange* smaller units of energy even down to the household scale. Barriers to entry are reduced because the cost of smarter renewable technologies are decreasing at the same time as a legal framework evolves to use them in new collective[ii] ways.

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[i] It is a substantive contribution to PROSEU Objective 3: Identify innovative financing schemes throughout the nine participating Member States and the barriers and opportunities for RES Prosumer business models.

[ii] By collective we mean as part of renewable energy communities or citizen energy communities which are both legally defined in the new EU Directives.

We investigated how these trends lead to new prosumer business models in 7 MS. We ran business model co-production workshops, documentary analysis and research interviews in the United Kingdom, Germany, The Netherlands, Portugal, Spain, Belgium and Croatia. We present the results of this research effort by defining common problems for consumers, system operators, and MS governments, then mapping these problems onto each business model to understand how different subsidies, revenues and savings can be captured by prosumers. We conclude with recommendations for European energy policy and regulation on how the prosumer 'niche' can be better empowered.

In order to discuss business models, prosumer 'niches' and different values in the energy system, we first need a common set of terms and understandings which we take from three fields of academic theory.

1.2 Three academic approaches to understand the 'mainstreaming' of collective prosumers.

We use three fields of academic analysis to address our research objective. These are Transitions Management, a Multi Actor Perspective and Business Model Co-evolution. These are critical foundations for later analysis as they explain why and how prosumer business models may or may not be able to mainstream in the EU energy system. This moves us beyond simple identification of individual legislative 'barriers', which even if removed may still be insufficient to mainstream or empower collective prosumerism.

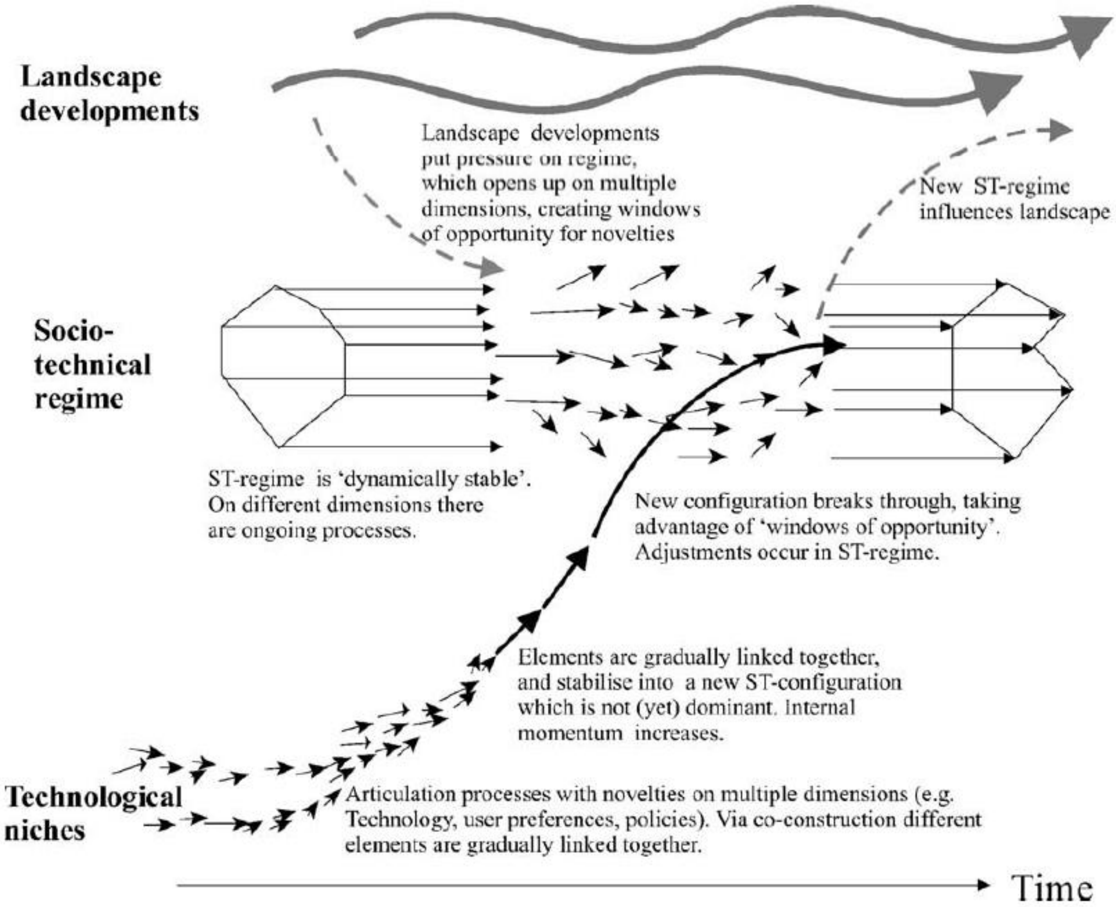
1.2.1 Sustainability Transitions and Transition Management

The Transitions Management school explores how large socio-technical systems like energy, transport and water change over time[5]. This body of research shows how large socio-technical systems are made up of technological artefacts such as power stations, solar panels, electricity grids etc, alongside the social systems needed to reproduce them such as engineer training, administrative institutions, legal frameworks etc. A Multi-Level Perspective on sustainability transitions, shows how reproducing socio-technical system leads to 'regime' formation[6], or dominant ways of making and doing that rely on a stable set of laws, companies and technologies.

In the EU energy system, the dominant regime is large corporate utilities operating within a market framework set by successive directives, largely focussed upon privatisation and unbundling of hitherto state operated electricity systems. Thus the 'regime' includes the existing technologies of the system but also the individuals, skill sets, corporate actors, policymakers and daily practices tasked with reproducing the system.

Regimes, however, are subject to constant pressures from small scale innovator 'niches' and broad social, economic and ecological or 'landscape' pressures. Over time these pressures can alter the regime in either unmanaged or managed ways (Fig. 1).

Figure 1: How Landscapes and Niches affect socio-technical Regimes, from Geels (2004) p.915[7]



If a sustainability transition is 'managed'[8], niches can be protected or empowered by governments and regulators so that they disrupt the regime for policy goals such as decarbonisation or delivering social welfare[9]. One such pressure coming from niche and landscape level is the need to decarbonise energy systems to avert ecological collapse. This has led regime actors to create policies to manage the niche of renewable energy technologies. This includes making legislative space for renewables to MS energy markets, creating subsidies or incentives to allow renewable energy developers to make profit, and levying taxes on conventional generation so renewables can compete more effectively on wholesale markets. The protection of the technological niche of large-scale renewable energy has been successful to the extent that renewables can now be considered part of the technological and institutional 'regime' of the EU electricity system.

Growing prosumer scale renewables means growing two specific institutional niches: 'Renewable Energy Communities' (RECs) and 'Citizens Energy Communities' (CECs). These are two types of citizen-led participation in renewable energy generation. To be classed as mainstream, they would have to disrupt the regime to a level where they become a larger part of a 'new normal'. They are 'niche' actors in part because they are only just becoming technologically and economically viable.

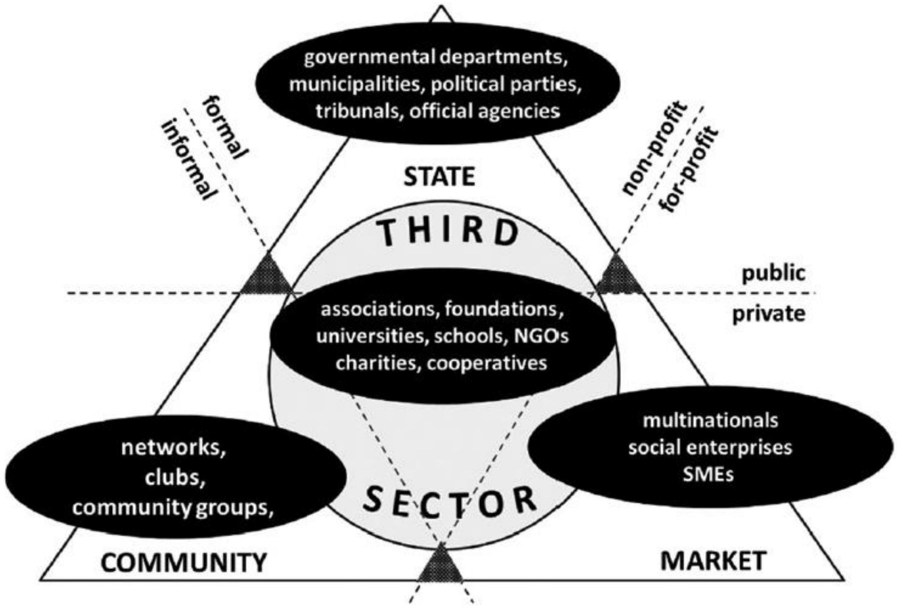
Another reason they are a niche, is that these types of organisation do not adopt the same institutional values as the existing regime. The legal definition in the Clean Energy Package for RECs and CECs states they must be effectively controlled by shareholders or members, natural persons, SMEs or local authorities, including municipalities; and their primary purpose must be to provide environmental, *economic or social community benefits for its shareholders or members or for the local areas where they operate, rather than financial profits*[2,3]. This is critical. The Clean Energy Package defines an institutional niche and explicitly states it must operate by a different set of governing principles and be based on a different set of values than other actors in the energy market. This brings us to the second academic approach we need to fully understand the findings of this report, a 'multi actor perspective'.

1.2.2 A Multi Actor Perspective

Energy systems involve numerous stakeholders across multiple levels. These actors hold and exercise different forms of power, with incumbent actors in centralised and fossil dominated systems still predominant. However, the relationship between different groups of actors and the power they exercise is often under conceptualised in discussions of energy transitions – including those which are prosumer led. Avelino and Wittmayer[10] unpack and structure these issues of power and agency by developing a 'Multi-Actor-Perspective' (MaP) (Figure 2). Building on the Welfare Mix Model[11], the MaP identifies four overlapping sectors in society: (1) the state (2) the market (3) third sector which mixes state market and community logics, and (4) the community. The state, market, and community sectors are divided by three axes in terms of their public/private character, the non-profit/profit dimension and the formal/informal nature of their organisation; whilst the 'third sector' is seen to straddle these boundaries. The MaP further outlines how the very notion of 'actors' in energy transitions often conflates those operating at different levels. Avelino and Wittmayer argue that power dynamics operate both within sectors and between them, Thus, established regime: niche dynamics operate across *and* within public, private and community spheres.

These different sectors and actors operate with very different values, norms and beliefs. These 'value logics'[12], correspond to respective understandings of the relationship between individuals, organisations and society[13]. While the 'market logic' may emphasise competition and treat individuals as 'consumers', a 'state logic' emphasises public policymaking and views individuals as voters.

Figure 2: A multi-actor-perspective on 'logics' of collective action[10]



A 'community logic' might instead emphasise localism and involve individuals directly as stakeholders[14]. Published research from the PROSEU consortium shows the top four drivers for establishing prosumer business models are ecological and social, with "decentralising production" and "creating a sense of community" as strong motivations for establishing prosumer initiatives[15]. At the bottom of the motivations for establishing prosumer communities were market-based values like "Improve revenues for your community/organisation" and "take advantage of subsidy schemes" (op. cit). Clearly prosumer communities are having to find business models that can survive in a market setting while being motivated by different value logics.

Each of these logics may represent alternative approaches to governing an energy transition in which prosumers are to play a significant role. The Clean Energy Package enshrines a strong market logic by placing consumer choice and rights at the centre of its rationale. This package puts faith in the notion that active individual consumers and suppliers in wholesale and retail markets will lead to efficient system outcomes[32]. It goes on to enshrine institutional principles and directives that reflect this logic.

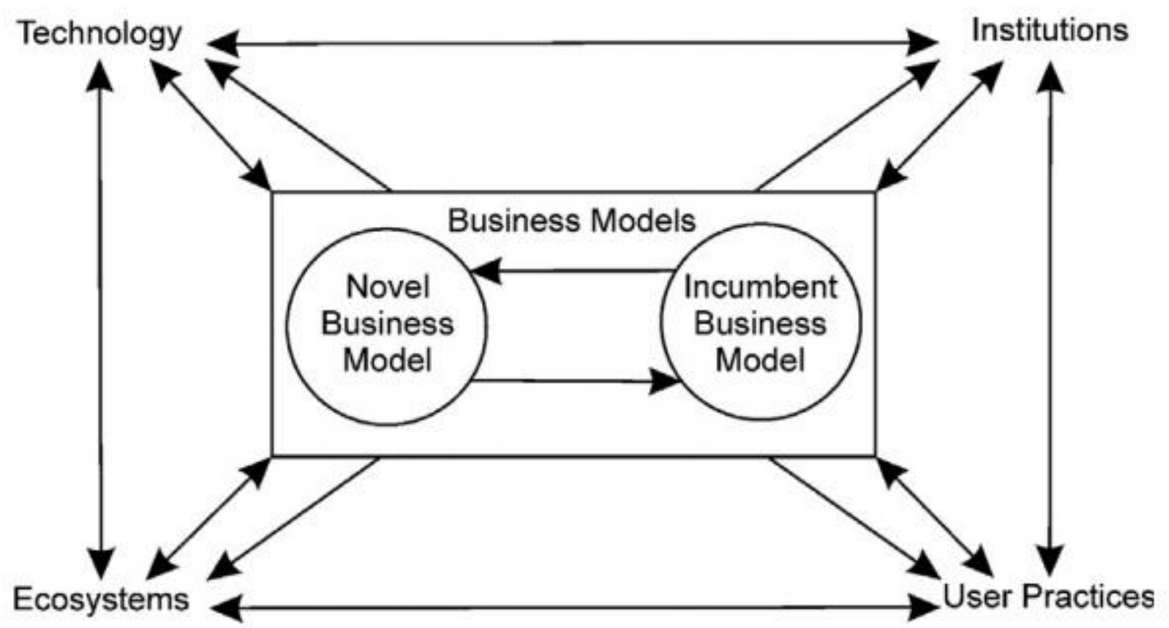
Throughout the Clean Energy Package there is an acceptance that RECs and CECs are not operating on purely market logics; they have governance structures that may lead them to ignore or side-line otherwise available revenues. The text of the package recognises this, but the tension between the community and market logic is not resolved. The question of *how* to empower the niche of prosumer business models, is left to MS regulators. How this empowerment happens depends to a large degree on what business models' prosumers are adopting to act in the energy market.

1.2.3 Business models and co-evolution

Whilst the term 'business model' has become common in the business community, business models are increasingly analysed in academia – they provide a lens to understand organisations' role in economic and social change. Business models 'describe of the nature of value delivered to customers, how organisations and networks create value and the means of capturing revenues from that value'[16]. A business model is not a profit formula or financial prediction. It is a blueprint for understanding value creation and value capture. There is an increasing body of research which explores how business models may co-evolve alongside other elements of socio-technical systems like technologies, institutions, user practices and ecosystems[17], to deliver social, economic and ecological change.

Business model co-evolution originates in evolutionary economics and argues that business models co-evolve in response to changes to their surrounding 'ecosystems'[18] (Figure 3). For energy systems, these changes may be economic, such as cheaper solar panels, or institutional, like the Clean Energy Package – creating new selection environments where new business models can be explored. Recent work on business model co-evolution has explored how energy efficiency retrofit[19], energy as a service business models[20], and local electricity trading[21], are all fertile grounds for social, institutional and technological innovation. Therefore, as shown by Figure 3, business models do not sit in isolation, but shape, and are in turn shaped by, the wider ecosystem within which they are situated. Although we situate the business model at the centre of our analysis, we recognise that the wider selection environment promotes or inhibits certain business models.

Figure 3: The business model at the centre of a co-evolving energy transition[22]



To understand how new business models might enable social and economic change - such as mainstreaming prosumerism - we must also unpack the different elements of a business model. Adopting a simple 'business model canvas', as developed by Osterwalder and Pigneur[23], allows us to map the different elements and explore which elements are changing both at the corporate utility and collective prosumer level (Table 2). As shown in Table 2, the central concept is the 'value proposition', which describes the mix of products and services that are delivered to the customer and crucially the value that is derived from them. In the energy sector, value propositions are a complex mix of electricity system needs and the social and environmental goals of prosumer collectives. New prosumer business models are likely to involve different value propositions, but may also involve different supply chains, new customer interfaces or financial models and new approaches to governance, such as cooperative control.

Table 2 The elements of a business model

Element	Definition
Value proposition	Value or utility from goods and services
Supply chain	Upstream relationships between an organization and its suppliers
Customer interface	Downstream, customer-related interactions: marketing, sales, aftercare
Financial model	Combination of an organisation's capital and operational expenditures with its means of revenue generation
Governance	Co-ordination and management and the organisational form: varying levels of public, private and civil society governance

In summary, to understand the dynamics of mainstreaming prosumersm, we must both understand the types of actors involved and their power relationships, alongside the values and ends that different groups ascribe to prosumerism. Then can we understand the motivations and outcomes that new business models are seeking to serve, and subsequently evaluate their ability to meet these ends. In this context 'mainstreaming', the current 'niche' of collective prosumer business models would need to become dominant and thus enter the 'regime'.

To enter the regime, RECs and CECs will need to find business models that both withstand market forces while retaining their core values of community and citizen participation. Finally, the business model co-evolution literature shows how a close examination of the flows of energy, payments and services that different business models propose, allows us to compare the 'value propositions' being brought to market by RECs and CECs. Together these approaches afford an understanding of what it really means to 'mainstream' prosumer communities in the European energy market.

Our next task is to synthesize some of the ongoing developments within the existing energy regime and ask: *what are the common forces affecting all European prosumers?*

1.3 Five forces shaping European prosumerism

There are five broad forces in European energy systems that directly affect the ability of citizens to become individual or collective prosumers of renewable energy.

1. Renewable electricity is now cheaper than it has ever been. Subsidy schemes for small scale renewables have driven down the cost of renewable energy technology[24,25,26]. Alongside these subsidy schemes for small scale generation, European MS have implemented parallel price support for utility scale (i.e. >5MW) projects which, combined with taxing emissions from coal and gas generation, has brought large scale renewables close to cost parity with traditional fossil power plants[27,28]. This means that consumers wanting green energy are seeing the carbon content of grid electricity reduce in most MS[29]. This reduces the need to generate one's own zero carbon electricity. At the same time the capital needed for would-be prosumers to generate their own electricity is reducing as installations get cheaper, lowering barriers to entry.

2. The subsidies, incentives and guaranteed buyers for prosumers are reducing. While some utility scale renewables (ground solar, onshore and offshore wind, some biomass) are beginning to be economically competitive in wholesale power markets, the cost case for onsite generation is less clear. While technology costs have reduced, so have subsidies[30]. This means that prosumer business models that used price guaranteed feed in tariffs (FiT) to make prosumerism work financially, have disappeared in many MS[31]. In other MS the falling costs of renewable power make it unclear whether the creation or maintenance of new subsidy schemes is the best way to facilitate the growth of the sector. In summary, governments are asking whether price support is still necessary, and if not, whether changing market regulation would be a more efficient way of growing distributed generation?

3. Business models which seek to 'island' prosumers off from the grid are being regulated away. Some of the business models being adopted to deal with falling subsidies were based on avoiding paying for the maintenance of electricity grids. In the early days of small-scale renewables there was a good argument for prosumers to pay less for the grid because they used it less. However the more we understand about how electricity infrastructures earn revenue, and the investments they need to accommodate smarter energy systems, the more we recognise that a prosumer business models based on completely avoiding grid charges is unsustainable[31,32]. However, business models which allow power to be consumed close to its point of generation do help reduce stress on network infrastructure. This is creating problems for regulators looking to incentivise local markets, whilst not penalising ordinary consumers.

4. Small scale players are becoming smarter and flexibility can be rewarded. There are ways of pooling prosumers together so their flexibility can significantly benefit the system. The smart meter rollout across the European Union is making real progress. This means that the consumption behaviour of domestic and small commercial consumers that used to be 'visible' only as a large 'block' can now be accounted for individually. Homes and commercial sites with battery storage, electric heating and cooling, vehicle charging, refrigeration, and any number of electric loads that can be flexible, are able to capture some value from that flexibility. At the same time, allowing these flexible consumers to enter the market is a complex technological and regulatory task. It is yet to be seen whether there is enough value in flexibility markets to be worth building new business models at the consumer level[33]

5. It is becoming increasingly illogical to separate electricity generation from heat generation, vehicles and building energy efficiency. We are used to analysing these elements of the energy system in isolation, and assuming these discrete elements need discrete policy. While experts focus on single areas of domestic and commercial energy policy, citizens see a set of energy using practices like making rooms warm and cleaning clothes[34]. This means the next generation of prosumers may buy into new, whole system forms of engagement with the energy transition which will need new policy and market regulation. Whole house retrofit, 'energy as a service' and 'mobility as a service' business models bundle energy efficiency, generation, mobility and flexibility. The PROSEU project has shown prosumer collectives are already developing projects across energy vectors[35]. If these integrated models grow, it will become harder to set policy and regulation only for electricity without considering the heat, home appliance, vehicle, and construction sectors.

Returning to our analytical framework, prosumer business models will co-evolve with these 'five forces' shaping the energy system. These forces disrupt existing utility business models and regulatory structures. They force new business models to emerge and empower new stakeholders in the energy transition. They create problems for established ways of working and new opportunities for collective prosumers. How these pressures empower the niches of prosumer business models, Renewable Energy Communities, and Citizens Energy Communities, will depend on the value propositions they can bring to their members and the wider energy systems, what problems they solve, and for whom.

1.4 What problems are new prosumer business models trying to solve?

1.4.1 Member State Governments

Problem 1: The need to decarbonise energy systems in line with Paris Agreement

In the Paris Agreement signed in 2016 governments committed themselves to limit global temperature increase to well below 2 °C below compared with the preindustrial levels and undertake efforts to limit the increase to 1.5 °C[36]. The IPCC outlines that CO_2e emissions must reach net zero by 2050 to reduce the increase of global warming to 1.5 °C[37]. The European Commission has set the EU-wide long-term objective to reduce greenhouse emissions to net zero by 2050 in order to limit temperature increase to 1.5 °C[38]. To meet these greenhouse gas reduction targets a complete decarbonisation of the energy system will be crucial[39,40]. The transformation process forces extensive structural changes from centralized fossil-based energy sources to centralised and/or decentralised renewables[41,42,43]. Several studies show that a rapid expansion of decentralised renewable energies, such as onshore wind and PV systems, as well as the decarbonisation of the transport and heating sector is necessary to fulfil the Paris Agreement[44,45,46,47]. In order to mobilise all climate mitigation potentials, prosumers could play an important role in the energy transition process.

Problem 2: Balancing market creation with social pressures

It is estimated that more than 50 million people in the European Union are affected by energy poverty with a disproportionate impact on women[48,49,50]. Energy poor households are not able to access energy services to an extent necessary to guarantee a decent standard of living and health integrity at affordable costs[51,52]. The reasons for energy poverty range from inefficient buildings, to high energy costs and low household incomes. Individuals and households with low income are particularly affected[53,54]. Forms of individual and collective self-consumption can target this issue: Insulation programmes combined with prosumer models could help mitigate energy poverty[55,56]. Landlord to tenant electricity models, on the other hand, could support lower-income households to gain access to green and cheap electricity[57]. In addition, these approaches link energy poverty alleviation with climate change mitigation[58,59].

Problem 3: Building domestic innovation capacity

The transition to a decentralized renewable energy system means an extensive change in the way energy is generated, distributed and consumed[60,61]. This requires far-reaching transformations of the electricity, heat and transport sector and the need to foster technological as well as social innovations[62,63,64]. The extent to which each socio-technical innovation prevails has a decisive influence over the pathway each energy system takes in decarbonisation[65]. Energy communities and prosumers can have a key impact in enabling innovations to leave the niche, creating pressure on sociotechnical regimes[66,67,68,69]. With a significant share of prosumers and the resulting greater diversity of actors in the energy system, the capacity for innovation is also likely to increase[70]. By developing decentralized renewable resources, creating participatory energy networks or bringing other sociotechnical grassroots innovations on its way, energy communities and prosumers challenge the former fossil-based centralized system[71,72,73]. From this, innovative business models evolve which can contribute to the transition of the energy system[74,75].

1.4.2 System Operators

Problem 4: Keeping the grid stable

In liberalised electricity markets, wholesale trading meets the majority of supply and demand up until 'gate closure', when all trades must be settled. Subsequently, System Operators (SO) procure a range of 'flexibility services' to ensure an equilibrium is achieved and operating frequency is maintained. With increasing penetration of intermittent renewables (including prosumers), the market for these services is likely to increase[76,77]. These markets are divided into the balancing function/mechanism – addressing the imbalance between wholesale position at gate closure and final demand – and ancillary service markets designed to maintain system frequency and provide reserve in the event of power station outages[78]. Historically, these services were provided by large thermal power stations and industrial demand management. However, prosumers may increasingly provide aggregated flexibility from EVs, batteries, heat pumps and other forms of dispatchable distributed generation[79,80]. This is leading to electricity suppliers and aggregators developing sophisticated prosumer flexibility business models - enabled by smart and demand responsive technologies and appliances[81,82,83]. However, reliance on these markets is always more expensive than optimised wholesale trading[84,85]. Therefore, supplier and aggregators may in future use prosumer systems in wholesale trading, often without prosumers involvement[86]. Across MS, these developments present new challenges for regulators and SOs to ensure these markets are accessible to prosumers and aggregators[87,88].

Problem 5: Maintaining the grids

The profusion of prosumers and decentralised energy systems also presents emerging challenges for electricity network operators[89,90]. Large centralised systems of generation and transmission are increasingly complicated by lower voltage distributed generation which grids were not originally designed to accommodate[91]. This potentially leads to increased stress on network infrastructure, either in periods of high generation, or during high demand - exacerbated by increasing electrification of heat and transport[92]. To resolve these issues a range of solutions are emerging that will increasingly involve prosumers[93,94]. Examples such as Piclo, a software provider and platform operator are working with UK Power Networks to aggregate small scale 'turn up' and 'turn down' signals to reduce network stress, exemplifying DNOs move towards DSOs[95,96]. Other 'behind the meter' models are seeking to minimise their use of the public networks altogether, combining multiple sites of generation and demand on privately owned networks[97,98]. These models are introducing new challenges for suppliers and in turn regulators recoup network charges in a way that is fair to both prosumers and non-prosumers alike[99,100].

Problem 6: Planning for the near future

Advocates of prosumerism envisage a future where prosumer energy systems and other forms of decentralised generation become the dominant means of power production[101]. However, future energy system modelling often depicts these scenarios alongside futures which retain much of the centralised character of the current system; involving large amounts of offshore wind, CCS and nuclear for example[102]. Predicting which energy future will become dominant is complicated by a multitude of factors including technology development and costs, public policies and the geo-political and socio-economic dimensions of an uncertain future[103,104]. Prosumerism represents a future where individual and citizen led action plays a significant role in the energy transition[105]. Emerging trends suggest that this may exploited by existing utilities and large technology companies, although community energy groups seek to ensure greater citizen and civic control[106,107,108]. Equally, there are signs that the prevailing 'market logic' of the last 30 years may be increasingly challenged by greater municipal and state involvement[109,110]. This uncertainty presents a problem for policymakers, regulators, system and network operators alike, as they attempt to accommodate the needs of these divergent interests and visions of the future.

Summary

Each of these problems are important to understand when evaluating current and future prosumer business models. Successful prosumer business models are likely to address some of these problems for other system stakeholders. Prosumer business models that exacerbate some of these problems will meet more barriers and enjoy less longevity. As we explore if and how prosumer business models can be mainstreamed, we must keep these problems in mind and highlight how each business model develops shared value.

1.5 Electricity markets and prosumers: retail prices, subsidies and system charges

While it is beyond our scope to compare local conditions, there are five elements that remain common across EU MS, these are the retail price of electricity, the level of direct subsidy, whether there is an export price paid for excess generation, if net metering is used, and whether prosumers avoid 'system' charges. These are shown in Table 3 for the MS studied.

Table 3: An overview of retail prices and support schemes for prosumers in case study Member States in 2019

Subsidy/ fiscal incentive	Belgium	Croatia	Germany	Netherlands	Portugal	Spain	United Kingdom
Residential Market Price Average[iii]	**0.293 EUR/kWh**	**0.132 EUR/kWh**	**0.300 EUR/kWh**	**0.170 EUR/kWh**	**0.229 EUR/kWh**	**0.247 EUR/kWh**	**0.202 EUR/kWh**
Feed in Tariff (FIT)	None.	PV FIT ran from 2012-16 1.91 -1.1 **HRK/kWh** in 2018 the FIT model has reached its end.	Yes, fixed for small installation (EEG), auctions for large wind and PV	Yes, allocation process twice a year (large installations)	No, bidding process for price discounts on a reference tariff of € 95/MWh	None	None. PV FIT Ran from 2010-2019 ~0.50 -> 0.04€/kWh, closed in 2019
Export Tariff[iv]	None.	2016, tenders introduced guaranteed prices up to 500 kW	None	None	None after current FiT ends.	Yes: Limited to 100% of the user's consumption.	Yes: Smart Export Guarantee price guarantee >£0/kWh
Net metering	Brussels-Capital – Yes Flanders – Yes, RES ≤10 Kw Wallonia - Yes	Yes, up to 500kW installed capacity	No	Yes	Yes	Yes	No

[iii] Eurostat (2018), *Electricity prices for household consumers (2 500 kWh < annual consumption < 5 000 kWh, taxes included), second semester 2018* https://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_price_statistics

[iv] In some MS the FiT and export tariff were the same thing, although in the UK you were paid twice, once just for generating (even if self-consuming) and again when exporting, although the export tariff was very low.

Tax incentives	Tax deductions of up to 10.5% of investment cost. Grants totalling 20.5% - 25.5% of cost.	none	Yes, tax exemptions on self-consumed electricity	Tax exemptions / tax reductions for (collective) self-consumption	No	No: But 'Sun Tax' removed 2019	Equipment No: 15% VAT on PV and other hardware – removed in 2019. Electricity: Yes, volumetric tax avoided through self-consumption.
Grant Schemes	Flanders – Provincial governments grants for PV and/or SHW[v] Brussels - 40% financial assistance for commercial buildings Wallonia EUR 800-1500 and cannot	The Environmental Protection and Energy Efficiency Fund awards interest-free loans.	Yes, grants for certain technologies; credit subsidy programs	Yes, investment subsidy scheme	No	No	No

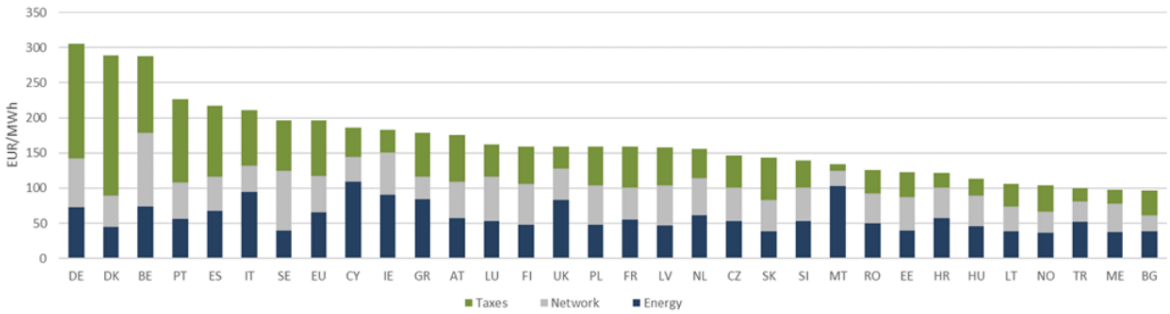
[v]IEA (2019) https://www.iea.org/policiesandmeasures/pams/belgium/name-24375-en.php?s=dHlwZT1yZSZzdGF0dXM9T2s,&return=PG5hdiBpZD0iYnJlYWRjcnVtYiI-PGEgaHJlZj0iLyI-SG9tZTwvYT4gJnJhcXVvOyA8YSBocmVmPSIvcG9saWNpZXNhbmRtZWFzdXJlcy8iPlBvbGljaWVzIGFuZCBNZWFzdXJlczwvYT4gJnJhcXVvOyA8YSBocmVmPSIvcG9saWNpZXNhbmRtZWFzdXJlcy9yZW5ld2FibGVlbmVyZ3kvIj5SZW5ld2FibGUgRW5lcmd5PC9hPjwvbmF2Pg,,

	exceed 70-75% of the costs. Households/ SMEs 20% of cost to EUR 3500.						
Other	Brussels- Low interest Loan Scheme: Homes are eligible for a 0-1%APR green	Renewable energy loans are issued by the Croatian Bank for Reconstruction and Development (HBOR).	Advantages for energy communities in the auctioning process		New laws allow for increased size of prosumer installations and established prosumer communities in law		
Financial support trajectory	Stable -> marketisation	Failing (limited capacity being delivered)	Falling	Constant?	Improving	Improving	Falling

The Retail Price: This is the average price consumers pay per unit of electricity. If a consumer, e.g. a medium sized office building, installs renewable generation ‘behind’ their meter, that meter will only record the difference between what is being generated and what is being taken from the “public” grid. The consumer is then only charged the retail price for the electricity from the public grid. So, if an office is using 30 kW constantly for one hour on a sunny day at midday, they will have used 30kWh. If they have a solar array of 30kWp and assuming no conversion losses they will generate 30kWh during that period and the meter will record nothing, they have paid 0.00 Euros for that hour’s electricity. In Germany they would have saved 0.3 Euros, 30 Eurocents, in Portugal 0.229 Euros. In summary, the higher the retail price of energy the better financial case for the prosumer.

This is where the similarity ends however, as depending on the country involved and the tariff selected, a commercial company or household could be paying a standing charge for electricity which is levied every day no matter their consumption. The retail price is a mix of whatever the retailer paid to the wholesale market for the power, the costs of running the physical electricity grid called ‘network charges', the administration and profits of the retailer, and taxes or policy costs levied by governments. As shown in Figure 4, the proportion of these charges varies substantially across MS:

Figure 4: Composition of household energy prices in 2017 Source [111 pp.3]



The same mix of network charges, taxes and energy costs that make up the household retail price also make up retail prices for commercial and industrial consumers. Broadly speaking, consumers pay many of these charges volumetrically, i.e. per unit of energy used. This means the less you use the less you pay. To an electricity meter and to the system as a whole, on site generation that is consumed on site, looks the same as if that consumer had made efficiency savings.

Increasingly, the highest value electricity to a consumer is that which they consume themselves, as subsidies have reduced, it makes more financial sense to self-consume; indeed, in MS with high insolation[vi] and high retail prices, such as Italy and southern Germany, subsidies become obsolete between 25-50% self-consumption[112]. Much of the business model analysis that follows can be understood as attempts to treat as much energy as possible as 'self-consumption' even if the definition of 'self' goes beyond a given house or business and includes a group of properties, individuals, and multiple meter points.

It is however unlikely that intermittent renewables like wind and solar, will always generate electricity when it is needed in the property. We often use our electricity at night when our solar is not generating or be away from home during the sunniest of days. A wind turbine on an office car park may generate the most energy on a windy weekend when the site is empty. When prosumers use more than they generate they pay the retail price for energy, but when they generate more than they use, they should be paid for the excess, as some other consumer will use it. *How* they are paid for the excess, drives the payback period and financial performance of the investment. There are three elements to this, whether net metering is available, whether there is an export tariff, and how any subsidy is paid.

[vi] "Sunnier" countries

Net metering: where MS allow net-metering, prosumers get compensation for energy generated over a long period of time, ranging from one month to several years. With net-metering, customers can offset their electricity consumption with small-scale RES over an entire billing period, using it at a time other than when it is produced, they effectively "store"[vii] their energy in the utility's grid[113] and use it when convenient. Pure net metering would mean a consumer who used most of their electricity at night but owned a rooftop solar array could behave as though they were consuming their own generation and be billed as such. In this case if the prosumer used 100 units a month during the night and generated 100 units a month during the day, their bill would be zero.

In practice many net metering schemes have a cap on how much the prosumer can 'net' off and/or allow the netted supply to be charged back to them at some ratio. This allows utilities to recover some of the network charges and taxes that comprise the retail price. This means prosumers who make use of the physical grid, pay something for its upkeep. Calculating the fairness of this payment and determining whether prosumers are paying the true costs of their network use is a critical issue. It is critical because network charges are socialised across all consumers, and any of those charges that prosumers avoid, are subsidised by non-prosumers4.

Feed in tariffs: renewable energy subsidies are diverse and the detail of each is unique to each MS. In general, they amount to a payment received by the prosumer which is above what they could earn selling power on a wholesale market[viii]. One model that has become popular is the FiT approach, were prosumers are paid a fixed price for energy they actually or notionally 'export' or feed into the wider public grid[114]. We will not dwell on FiTs here because they are reducing across most MS. MS who wish to grow a small-scale renewables sector may find FiTs and other subsidies a critical tool on the path to establishing domestic capabilities in distributed renewable generation[115]. However, we observed a general downward trend and a desire to phase out such subsidy.

Renewable energy subsidies do exist and are growing, but the trend is for them to exist on a 'level playing field' on which large utility scale renewables developers participate in subsidy auctions, competing to be the developer who can build the most renewable capacity for the least subsidy[116]. Economies of scale matter, and the simple administrative burden of participating in these auctions makes any prosumers winning an auction unlikely.

Export prices: Export prices are different to FiTs when they reflect the actual value of the exported power to a licensed utility. A utility will have a power purchase agreement (PPA) with the prosumer which will usually be a fixed price per unit. Until recently these PPAs between utilities and prosumers

[vii] They do not 'store' electricity, but because of the way the administration works it appears as if they had.

[viii] Prosumers are unable to participate directly in wholesale markets and usually rely on their retail supplier to purchase excess generation. Whether this generation has any real value to a retail utility, or whether it only complicates the trading strategy of the utility depends on the sophistication of that utilities systems and how many prosumers they are contracted with.

were more common where the prosumer was a larger commercial site. This is because larger commercial sites had sophisticated metering and sufficient export of energy, to make it worthwhile for the utility to include these generators in their wider wholesale trading market. For household prosumers the amount of excess power produced was often too small to account for, often ‘spilled’ onto the grid, often more of a hindrance than a help to those managing the wholesale markets. However as smart meters are rolled out across the EU, and electricity billing is digitalized, it becomes more realistic to account for these small units of power in real time. This means utilities can offer prosumers a ‘market price’ for the excess they produce.

In the United Kingdom the Smart Export Guarantee[117] ensures prosumers are paid a price above zero for their excess capacity. As the UK does not have net metering, and FiTs have been removed for prosumers, this is the only price small scale generators will receive for exported power. In a perfectly competitive market prosumers would switch tariffs until they found a tariff with the optimal deal for them; the price the utility offered them would reflect the “real” value of prosumer ‘spill’. This approach only allows the ‘market value’ of power to be remunerated to the prosumer, it does nothing to value the ecological, social or wider economic development benefits of these local prosumer investments, nor recognise the weaker negotiating power of prosumers vs utilities.

Network charges: Electricity consumers pay for and maintain the network of power lines, sub stations and other infrastructures that make up the physical ‘electricity grid’ through their energy bill. These ‘network’ costs go to the companies with responsibility for these assets. Because all EU citizens have the right to choose their energy retailer, the network companies and the retailers are different companies. This means the retailer (the company that sends the final bill) needs to redistribute part of that payment directly to network companies. In some situations, like our ‘pure’ net metering example, prosumers avoid paying for networks. If we want to understand whether or not different prosumer business models *should* be mainstreamed, network charges are a critical factor.

In the Netherlands for example, net metering customers pay a grid charge[ix] and in Spain only part of the retail bill is eligible for net metering and other fixed costs remain. In the Netherlands as in other MS, and as with FiTs, the tendency is for diminishing or time limited net metering provisions, the aim being to maximize self-consumption and minimize direct subsidy from other user charges or general taxation. It is not always the case that net metering substantially undermines fair network charging[118], but at the levels of penetration we would class as ‘mainstreaming’ network charge avoidance would lead to ordinary consumers subsidizing the network use of prosumers.

The ‘hidden’ subsidies of network charge avoidance arise when prosumers self-consume electricity and reduce their overall demand for ‘grid’ electricity. If the network costs are recovered on a volumetric basis, i.e. by how many kWh the meter records, prosumers naturally pay fewer network

[ix] http://www.res-legal.eu/search-by-country/netherlands/single/s/res-e/t/promotion/aid/net-metering-1/lastp/171/

charges as their self-consumption is not recorded. Yet prosumers still require the same services of grid infrastructure, even if they use it less intensively. The value of the grid for prosumers is that it is there when they need it. The argument is that prosumers should pay for that opportunity to use the grid, not for how much of it they use. In countries where prosumerism and distributed generation are becoming more prevalent, such as the UK, regulators are moving away from a network cost recovery model based on how much metered electricity consumers/prosumers use, to a fixed charge based on the average cost of the network to all users in particular voltage bands. Prosumers will pay more in electricity bills if system regulators across MS choose to eliminate the 'hidden' subsidy of volume charging prosumers for grid services[119,120].

Taxes and freedom from 'undue' charges: The final consideration for the prosumer models is whether or prosumers avoid energy taxes in the retail price of energy. Perhaps one of the most impactful additions of the Recast RED is article 21 is that households who self-consume renewable electricity sources without feeding that electricity into the public grid are exempt from disproportionate procedures or grid charges that are not cost-reflective2. The case of Spain's "Sun Tax"[121] shows how charges for self-consumed electricity can still be made, they were justified by paying for the 'hidden' subsidy of network charge avoidance. The challenge will be striking a balance between a cost reflective and non-cost reflective charging structure for self-consumed energy [122].

In some nations such as Germany, taxes on the energy bill translate to a large proportion of the retail price of energy. Where energy is self-consumed, these taxes can be avoided if they are levied volumetrically. However, where electricity uses the public grid, i.e. beyond the meter, it will be for states to decide whether different business models seeking to extend self-consumption are made liable for these taxes or not.

Value for other system stakeholders: The value prosumers bring to the system in the early part of a renewables transition is not just in terms of low carbon energy. Building a prosumer base helps to build local and national skills and capacity in renewable energy installation and maintenance. MS Governments may favour high initial FiTs to increase learning rates and reduce costs for eventual utility scale deployment. Whether this pathway is necessary for all nations now utility scale renewables are replicable and well understood is questionable. Therefore, individual prosumers are unlikely to be the cheapest way of developing a future renewable and decarbonized electricity in many of host nations.

Summary: In summary the ability to generate one's own electricity in the absence of a FiT still exists. The Energy Market and Renewable Energy Directives in the Clean Energy Package ensure the rights of prosumers are clearly defined. However FiT type subsidies are reducing across Europe at the same time that more attention is being paid to the ways in which prosumers avoid other socialized costs. Prosumers self-consumed electricity often avoids paying network costs and energy taxes. It is up to MS whether these subsidies on self-consumed electricity should continue, if they do not, like in the UK with the move to fixed network pricing, the reduction in subsidies for prosumers could be even sharper than the simple removal of FiTs.

At the same time, the way exported power is treated is also changing. The roll out of smart meters enables prosumers to get a 'fair' market rate for the value of their exported energy. In wholesale markets however, that fair price is likely to be anywhere between 0.01 Euros and 0.05 Euros and nowhere near the same value as self-consumption. If we want to see prosumer business models enter the mainstream, the easiest option is to find some 'convergence' of business models across Europe where a single 'winner' emerges. Far from converging however, the prosumer business case becomes more diverse as individuals must negotiate the landscape of taxes avoided, network charges paid or not paid, the export price one can secure, and the volume and value of retail priced electricity avoided. This means we have to pay attention to the diversity of business models emerging. One element of that diversity is where the definition of self-consumption ends.

1.6 Research Question

Our objective is to understand how new business models can mainstream prosumerism, moving RECs and CECs out of the 'niche' and more or less establishing them within the 'regime'. We need to understand how prosumer business models solve the problems of multiple actors and create value propositions in doing so. We need to understand if those value propositions can be monetized. We need to understand these business models at a granular level, which leads to our research question:

What prosumer business models are emerging across Europe, how do they work and what problems do they solve for multiple actors i.e. prosumers, governments and the energy system?

2. Methodology

To explore this research question, we sampled the seven Member States (MS) that host the PROSEU consortium; The United Kingdom, Germany, The Netherlands, Belgium, Portugal, Spain, and Croatia. Where other Proseu work also includes France and Italy the resource intensiveness of the business model co-creation method used led us to limit our sample to nations where project partners are based. Each MS has different electricity prices, subsidy schemes, renewables sectors and energy policies. Each MS has different levels of market and state involvement and different actors involved in the energy system. Each MS has interpreted and transposed EU Directives differently into system regulation. This means the business models being adopted by prosumers will be different in each MS.

2.1 Methods

To explore these different business models, we used a business model co-creation method[123]. This method captures the flows of energy, payments, flexibility services, and system balancing by creating single component diagrams showing how each business model works. By creating multiple business model component diagrams, we see different business model 'archetypes' emerge. We can then compare how each archetype addresses different problems faced by the energy system.

The methods used to create these component diagrams varied (Table 4). In the UK, we used eleven semi-structured interviews to explore emerging business models with their founders or with regulators. In Germany and Croatia, we used desk research alongside a small industry sample of interviews. In Spain, Portugal, the Netherlands and Belgium/Flanders, we ran a one-day business model innovation workshop where participants were drawn from industry, academia and NGOs and prosumer groups.

Table 4: Methods and Sample

Country and dates	Sample and method	Archetype component diagrams
UK: Q4 2018 / Q1 2019	Baseline documentary analysis and 9 in-depth semi-structured interviews with representatives of each business model or regulators.	7 x archetype diagrams developed by project researcher
Germany: Q1 2019	Baseline documentary analysis and expert opinion from PROSEU researchers.	5 x archetype diagrams developed by project researcher
Spain: Q2 2019	Business model co-production stakeholder workshop. 19 participants connected with the Spanish energy transition participated. This included distribution utilities, renewable energy companies, and environmental NGO's.	4 x archetype diagrams developed by workshop participant groups.
Portugal: Q2 2019	13 participants connected with the Portuguese energy transition participated. This included academics and postgraduate researchers from the Faculty of Sciences at the University of Lisbon and representatives from Portuguese distribution network operators and prosumer innovators.	3 x archetype diagrams developed by workshop participant groups.
Croatia: Q3 2019	4 x semi structured interviews Croatian Energy Regulatory agency, Ministry of Environmental Protection and Energy, University of Zagreb – Implementation of Advanced Concept for	The creation report developed insights of drivers of collective prosumerism and is appended to this report.

	Electricity Trading (IMPACT) project, Renewable Energy/ Crowdfunding Platform Developer.	
Netherlands: Q2 2019	19 participants connected with the Dutch energy transition participated. This included researchers, policy makers, energy cooperative members and local energy companies.	4 x archetype diagrams developed by workshop participant groups.
Belgium: Q3 2019	10 participants connected with the Belgium energy transition participated. This mostly included energy cooperative members, researchers and employees of local energy companies.	2 x archetype diagrams developed by workshop participant groups
Totals:	84 stakeholders engaged from across energy innovation, utilities, regulators, researchers, innovators and financiers in 7 MS.	25 x archetypes were identified or proposed across 7 EU Member States

Full empirical reports from each of these empirical activities in each MS are included on the PROSEU website with the raw diagrams and narrative on each system. In this report a sample of these archetypes are used, and the diagrams have been presented in a common format.

Pilot study: The UK research was undertaken towards the end of 2018 and in early 2019. The Authors aimed to explore a case that was likely to have multiple business models relevant to this research. The UK is an appropriate case study because the UK's market has been unbundled for longer than most EU nations and, as research by the Council of European Energy Regulators identified, several UK prosumer cases are already in trial phase[4]. We identified seven collective prosumer business model archetypes and analysed their relation to the problems faced in the UK energy system. These archetypes are presented in the main results section alongside those from other MS. However, this analysis also allowed the research team to define 10 'key principles for prosumerism'. These principles are grouped in the business model canvas categories identified in section 1.2.3[124], they mirror the concerns of the Council of European Energy Regulators[4] who also assert RECs and CECs should not pass costs to non-participating consumers, that customer data and protection is maintained, and competing market vs community and ecological values may distort pure market behaviours and dull responses to system price signals. Our 10 'key principles for prosumerism' are shown in Table 5:

Table 5 The 10 'key principles of prosumerism'

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.

We use these principles in Section 4 to explore whether the business models proposed in section 3, and developed by the international workshops, are likely to reinforce the European energy transition or undermine its sustainability. While the PROSEU project has defined broader guiding principles for prosumer policy options[125], here we are concerned only with using the 10 'key principles' above for the business model element of the system.

3. Results

Our results are organized throughout this section by the problems they solve for prosumers, as well as other system stakeholders such as MS governments, distribution grid operators, regulators and system operators covered in section 1,4. In section 3.1 we explore the elements that make up the financial incentives for individual and collective prosumers. We then use these categories to understand how different prosumer business models, capture revenues or avoid system costs to make themselves viable.

3.1 Prosumer business models and the problems they solve.

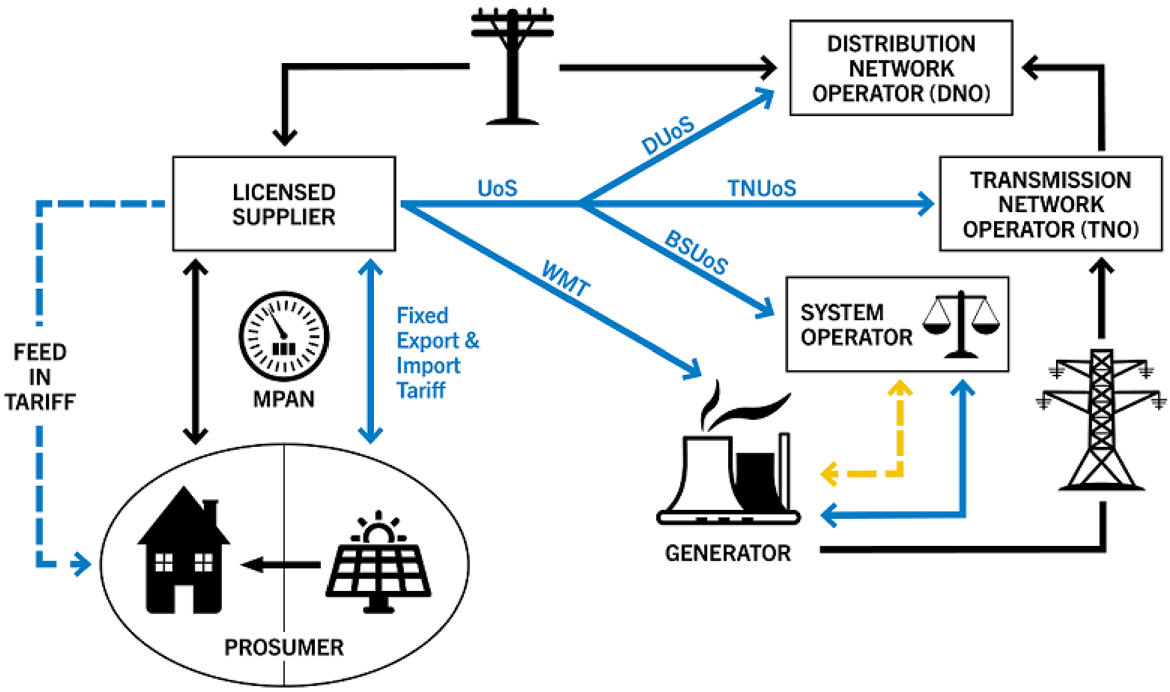
3.1.1 I just want to generate my own power but I've heard subsidies have gone?

Building an attractive economic case for the installation of on-site renewable generation depends on the cost of equipment, installation and maintenance, against the volume of retail price electricity saved, and the sum of any subsidy and/or the price paid for exporting excess electricity[126]. When generous subsidies in the form of FiTs exist, and/or various net metering schemes are set against high retail prices, the financial case for prosumers can be attractive. However, there is no perfect subsidy or financial model that makes prosumerism 'viable'.

Some households or businesses will be content with longer payback times because they value the contribution, they are making to an energy transition, whereas others will want shorter payback times. The decision to become an individual prosumer is driven by a mix of financial and non-financial value logics[15]. Business models #1 and #2 presented below show the basic flows of value around the system in the UK and Germany for FiT supported prosumers.

Business model #1 represents the basic prosumer model for the UK as it was *prior* to the removal of the FiT subsidy in 2019[127]. In this model the Prosumer received two payments one for export and one subsidy tariff. The prosumer also did not pay full network charges. The removal of both the FiT and the 'embedded benefits'[128] accrued from avoiding grid charges, has undermined the cost case for the basic prosumer model in the UK.

Business Model #1: Basic Prosumer UK [prior to FiT removal]

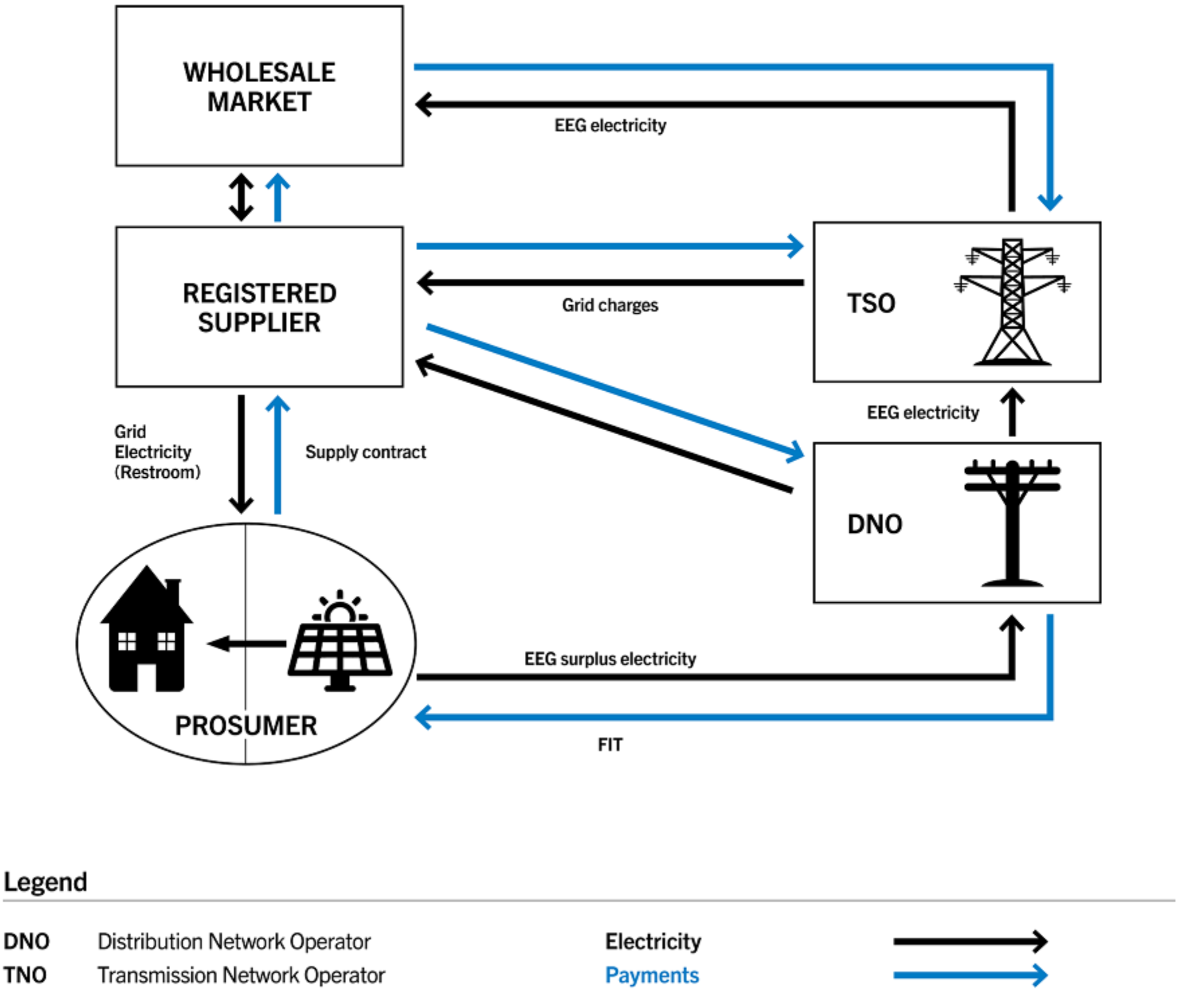


Legend

UoS	Use of System charges
TNUoS	Transmission Network Use of System charges
DNUoS	Distribution Network Use of System charges
BSUoS	Balancing Services Use of System charges
WMT	Wholesale Market Trading

- **Electricity** (black solid arrow)
- **Payments** (blue solid arrow)
- **Ancillary/Flexibility Service** (yellow dashed arrow)

Business Model #2: Basic Prosumer Germany



In Germany, according to the Renewable Energy Sources Act EEG 2017[129] (§ 3 No. 19) self-consumption legally exists, if three criteria are fulfilled: (1) plant operator and electric consumer are the same person, (2) immediate spatial proximity between generation and consumption, (3) no usage of the public grid. The regulatory framework for self-consumption favours small systems under 10 kWp. For that power range, self-consumption is exempt from most electricity price components and no EEG levy has to be paid. For larger systems, a reduced EEG levy of 40 percent on self-consumed electricity must be paid to the grid operator. FiT subsidy still exists in Germany, the retail price of electricity is one of the highest in the Eurozone, and some avoidance of grid charges is possible. This makes the cost case for the basic prosumer remain attractive, though with some tariff digression and potential residential market saturation the overall financial viability of UK prosumerism may be falling.

The financial part of the calculation for the two business models above, and across Europe, differs due to peculiarities of national energy systems and by local conditions such as the prices installers charge and the suitability of individual sites. Given the hidden subsidies of network revenue loss and tax avoidance from self-consumption, individual prosumption may create more problems than it solves for MS governments. Individual prosumers without smarter participation in energy services (discussed below) are also likely to have an exacerbating effect on uncertain wholesale markets and would not contribute to system balancing. Individual prosumers as constituted in business models #1 and #2 are therefore not the cheapest way to solve decarbonisation problem of states, the revenue needs of networks, or the energy needs of system operators.

Because retail price energy avoided (through self-consumption) is now the highest of value use of self-generated energy, one way for prosumers to increase the financial viability of their schemes is to extend the definition of 'self' consumption geographically, beyond an individual meter point. The next problem is then whether or not electricity generated *close* to a group of would be prosumers, can be treated as self-consumption even when it passes beyond the metering infrastructure of the generator in question.

3.1.2 Can we collectively self consume beyond more than one user?

If the definition of self-consumption can apply to more than one household or a collective of households and business, then they will each be able to avoid paying full retail price for electricity. Again, where retail prices are high and renewable resources such as wind or sun plentiful, prosumerism can make financial sense without subsidy at between 25-50% self-consumption**Error! Bookmark not defined.**. We found four distinct models of achieving this from our research.

Landlord tenant electricity Germany: The first business model we explore that aims to achieve an extension of the self-consumption definition is the German Mieterstrom Model. Landlord to tenant electricity is defined in the 2017[x] Renewable Energy Sources Act[129] and allows small PV-plants up to 100 kW to be placed on multi occupancy buildings and for the landlord (or service company operating the panels) to sell that energy to residents without paying network fees and other taxes and levies[xi].

In order to retail energy, the landlord, or delegated energy service company, must meter and bill residents separately for energy from the building's system and energy from the public grid. Landlords then get a subsidy in the form of the tenant electricity surcharge. This subsidy is only available if the electricity is supplied and consumed within the building, without using the public grid. This support is lower than the feed-in tariff, but by avoiding other costs like network charges and some taxes, the landlord can sell to residents cheaper than the market rate but retain a surplus[130]. The price tenants

[x] There was a similar model before the introduction of the landlord to tenant electricity provision in the 2017 version of the EEG. That model was based on a reduction of the EEG surcharge under specific conditions ("green electricity privilege"). In 2013, the coalition government decided to discard that privilege. It was also called "Mieterstrom" as it had the same target group.
[xi] though the consumer still pays for renewables subsidy on the wider German system

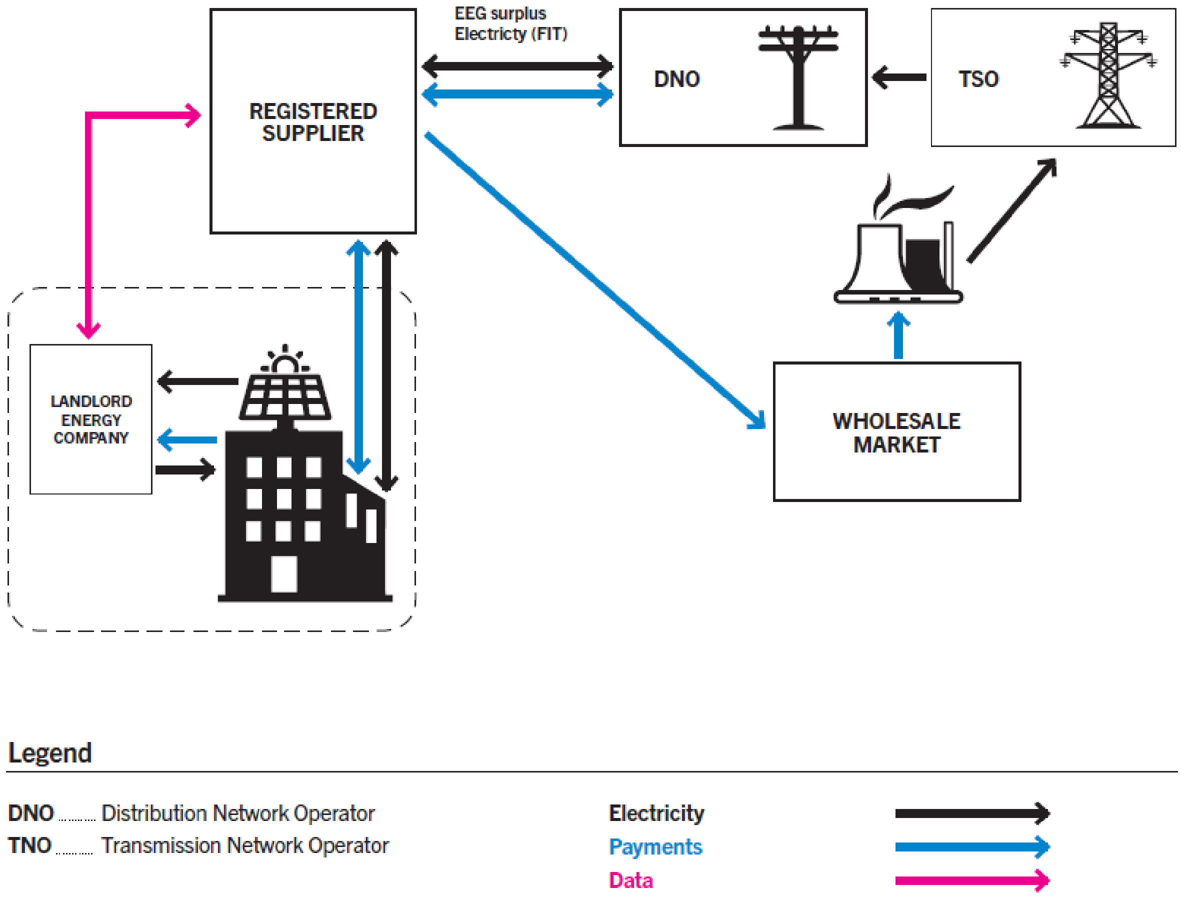
pay for electricity must be no more than 90% of a regional reference price. Tenants can still choose a retail supplier to meet the difference between what the building mounted scheme provides and their total demand. Tenants must also have a choice to participate – thus the contract for the electricity building supply must not be part of the rental agreement.[131]

In theory Renewable Energy or Citizens Energy Communities could operate these schemes as a co-operative of residents or similar. If the residents invest in and own the scheme it would be more analogous to 'collective self-consumption'. Conversely, if a commercial energy service company were to own and operate the scheme, residents get little benefit beyond being guaranteed the provenance of their renewable power. In the Mieterstrom example, whether this is 'collective prosumption' depends on ownership and control of the system, and the values and governing principles of those owners, as opposed to the technicality that it is energy generated on a single building 'beyond' the public grid.

There are two versions of how a tenant may become indirect owner of the solar PV installation, and thus a "true prosumer": First, a cooperative owns the system and works with a service company for electricity supply. The tenant customer becomes a member of the coop. Second, the tenant lives in a building owned by a housing cooperative, of which she is a member. Usually, the housing coop has to create a subsidiary that operates the system due to tax reasons.

Some issues with the Mieterstrom model include the relatively heavy administrative burden of establishing a landlord energy company and the marginal profitability of the scheme. Indeed, this model has not reached the levels envisaged even where commercial energy service utilities are undertaking the landlord's role[132].

Business model #3: Simplified 'Mieterstrom', or 'tenant electricity' Germany



Collective auto consumption Spain: The second Business model that extends self-consumption is the Spanish collective auto-consumption model. This model can be split into two possibilities, one where the self-consumption remains within a single multi occupancy building and one where prosumers within 500m of an installation or within one low voltage feed can participate. These models were made possible by the recent Royal Decree[133] on energy which also repealed the aforementioned 'Sun Tax'. For simplicity we have combined Business model #4 into a single diagram but two schemes are represented.

In the first model different parties within the same multi occupancy building (or plot) share collectively the power output of a RES installation. The installation is not behind the meter of any of the parties, but it is within the premises of the building. There are two types of subjects: the producer and the consumer; also, the owner of the plant. The difference between this business model and a private micro grid, is that there is no need for a virtual energy company which offers special tariffs, and there is no "behind-the-meter" consumption. Each consumer can continue to have another energy supplier.

The distribution company measures the hourly consumption of each consumer as well as the hourly production. This data is shared with the energy supply companies which issue the invoices by subtracting the on-building production (and any excess generation) from each consumer's consumption. The allocation of production is defined in a contract between the participants which is communicated to the distribution company[xii]. In this way network charges remain but wholesale energy costs, some taxes and company profits are avoided by the prosumers.

In the second model, different consumers are connected to the RE installation through the low voltage grid. They have to be either connected under the same transformer station, within 500m, or within the same cadastral reference ("instalación próxima a través de la red"). In these cases, the producer will have to register as a producer of renewable energies and sign a contract of representation on the market. Depending on the kW rating of the system, the installation could be exempted from certain administrative steps. Excess energy has to be sold to the market.

As with the first model each consumer keeps their own meter, there is no behind-the-meter measurement. Again, there is no need for a common supplier; each participant could still have their own energy supplier. The allocation of generation would be based on the data provided by the distribution company. Again, network costs are avoided, and the prosumer is able to access cheaper energy than they otherwise would through retail priced electricity. The system owner can benefit from higher prices than they can achieve through a wholesale PPA.

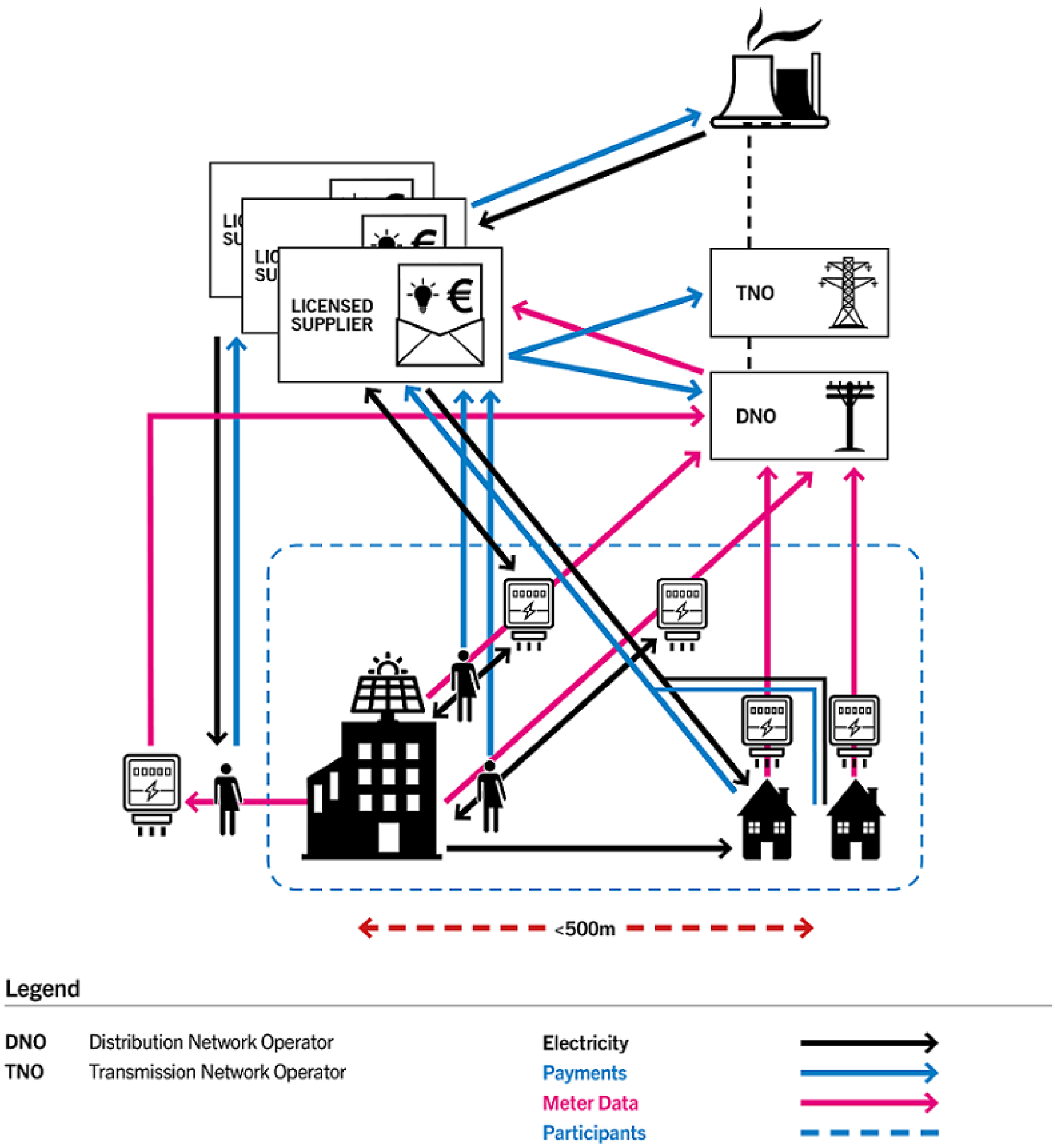
In both auto-consumption models the key intermediary is the distribution network operator, who in Spain retains all meter data and can communicate self-consumed volumes of each scheme participant to their utilities. The DNO can act as a single data manager ensuring self-consumed volumes are accurately distributed between scheme participants whether they be in one building or several. In the UK utility retailers are the primary holders of meter data and though this data is notionally available, it adds a further level of complexity for distribution operators to access it - raising transaction costs for small schemes. In contrast to the German Mieterstrom model, the Spanish model avoids the need for a landlord energy service company, reducing transaction costs, or at least loading them onto the DNO.

The data flows are represented as accurately as possible in the Business Model #4 diagram because they highlight the value of the distribution network operator being a single data manager. In this way the variable parts of the bill can be reduced for the self-consumer, excess electricity can still be sold to the market, and fixed network costs can be recovered. This reduces the financial incentive in comparison to a pure self-consumption approach where all charges are avoided for self-consumed energy. However, it offers a route for would be prosumers in rented, multi occupancy buildings, along

[xii] There are still on-going discussions if the allocation can only be done with a fixed coefficient or also with a dynamic coefficient which allocates according to the hourly consumption ratio.

with owners with unsuitable roof space, to participate in prosumers business models. In this way it satisfies more of the key principles renewable self-consumption than individual prosumer models.

Business Model #4: Collective auto consumption Spain



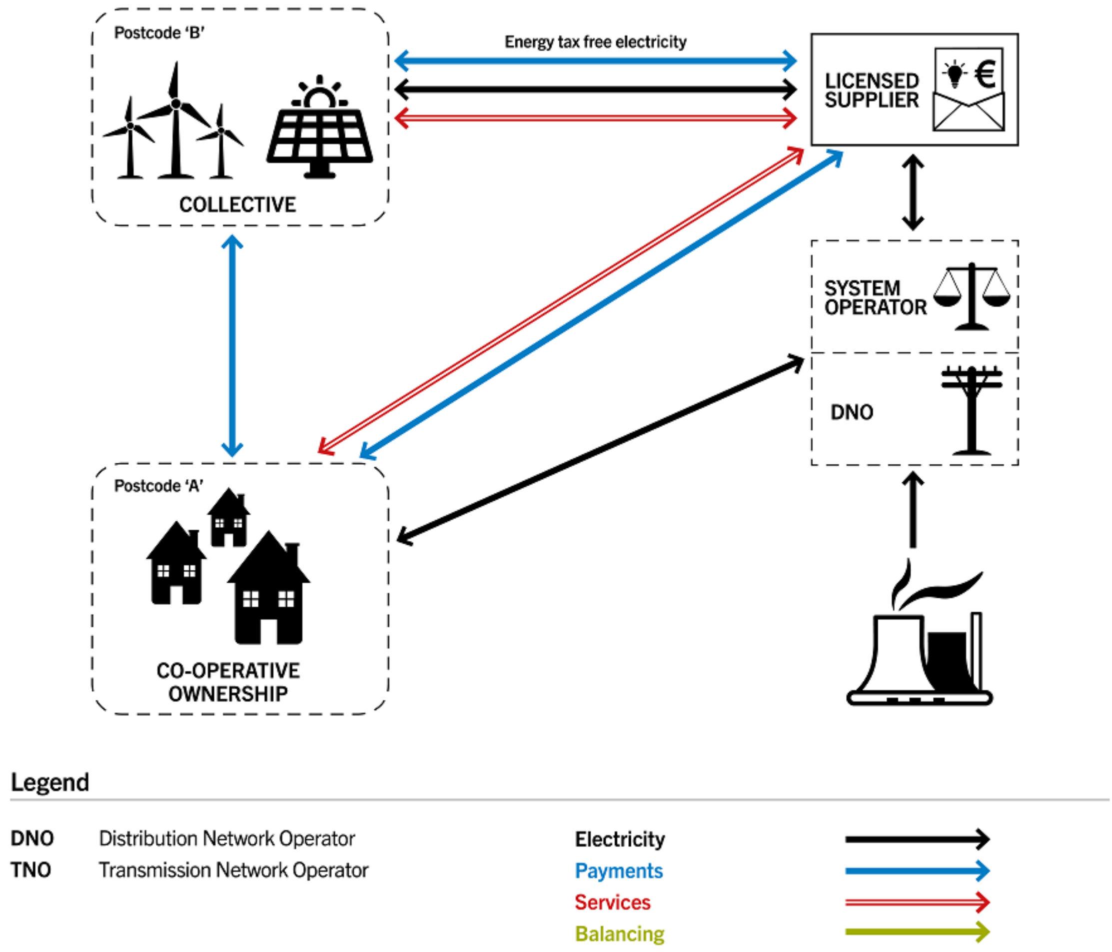
The postcode rose Netherlands: The third business model that extends some elements of self-consumption is the Netherland's Postcoderoos (post code rose) model. In the Netherlands, business models similar to tenant electricity are being trailed which allow for some degree of shared self-consumption in multi occupancy buildings, though they still require the establishment of another

meter owning utility and therefore come with more transaction and administrative costs than the Spanish collective auto consumption model[134]. For solar installations in a given geographic area the only current provision for collective self-consumption beyond this is the Postcoderoos model.
In this model anyone living in one post code can invest in a PV system in their own or a neighbouring post code[xiii]. They usually invest in a co-operative ownership model by buying parts of individual installations. An energy supplier then matches the consumption of the individual to their share of the renewable generation. This proportion of the individual's energy that is generated in the postcoderoos scheme is then eligible for a tax deduction of approximately € 0.11 / kWh + VAT (= € 0.133 / kWh) [135] up to 10,000 kWh/year for 15 years. In this way all network charges continue to be paid but the element of self-consumption enjoys a discount. Further, the co-operative can redistribute the revenues from energy sold to a licensed supplier. In practice there are several suppliers who now bundle the installation, maintenance and licensed supplier roles such as Energie VanOns[xiv].

Critically for this research, the post code rose tax discount is only available through co-operative membership. This means this form of collective self-consumption is only open to citizens who are part of a governance structure which is 'more than' a corporate utility, and that has self-governance and co-operative principles at its heart. It is unique in the business models presented so far in that it does something collectively with prosumerism that individuals and energy utilities alone cannot do.

[xiii] The central post code is where the generation is situated; neighbouring post codes form the rose "petals".
[xiv] https://energie.vanons.org/

Business Model #5: The 'Postcoderoos' or 'Post Code Rose' model, Netherlands



Private wire models [UK example][xv]: The final model that extends the definition of self-consumption is the private wire model. 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[xvi], 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 DNO. These entities may also form a virtual energy company (VEC), responsible for billing

[xv] Summarised from authors PROSEU project work reported in: Brown, D., Hall, S. and Davis, M.E., 2019. Prosumers in the post subsidy era: an exploration of new prosumer business models in the UK. *Energy Policy*, *135*, p.110984. https://doi.org/10.1016/j.enpol.2019.110984

[xvi] http://isleofeigg.org/eigg-electric/

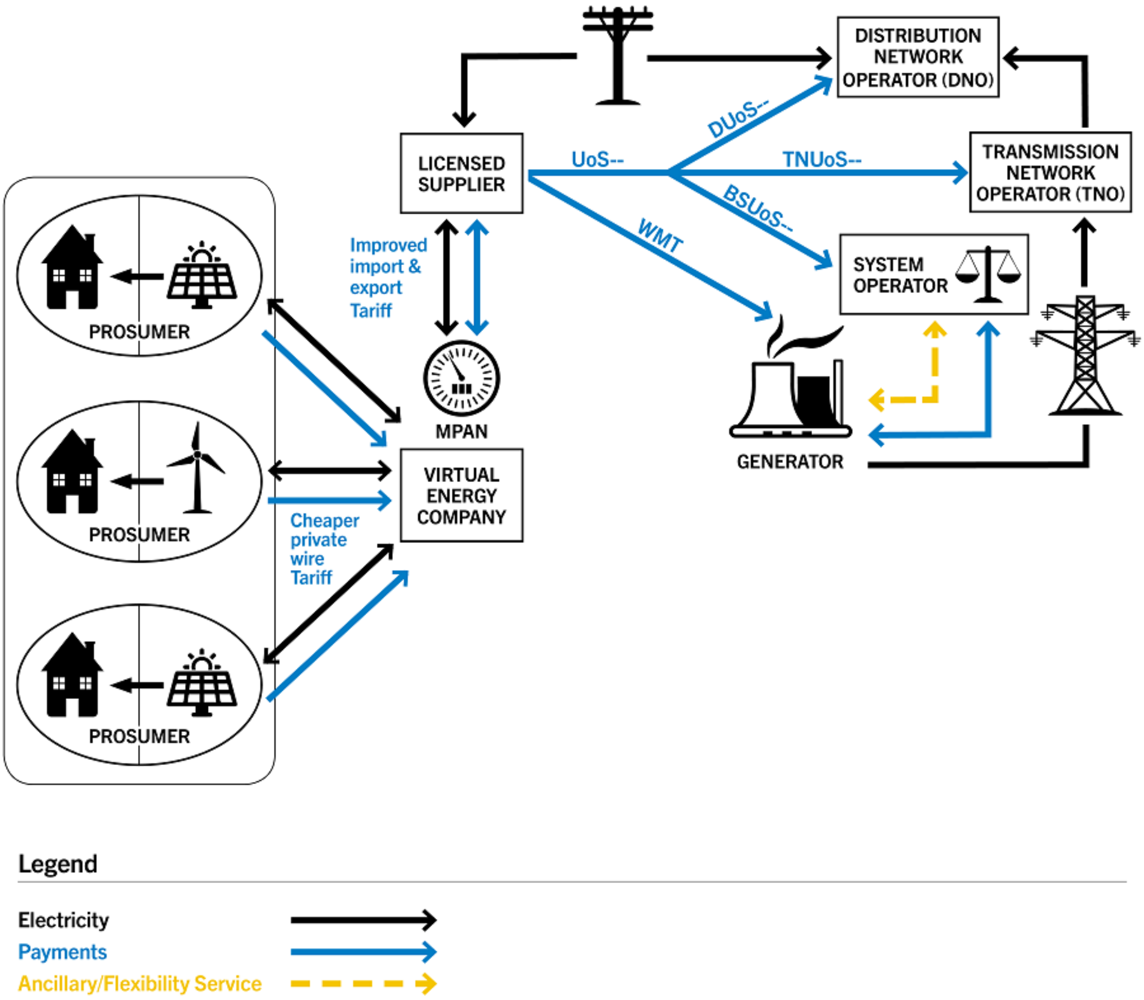
customers for the energy they consume within the private network. These models are now also being trialled in grid connected areas, with the aim of creating a viable business model for prosumers[136].

These prosumer facing 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 license exempt supplier and does not have to abide by the balancing and settlement codes[137]. The VEC may then negotiate an improved supply tariff with a licensed 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.

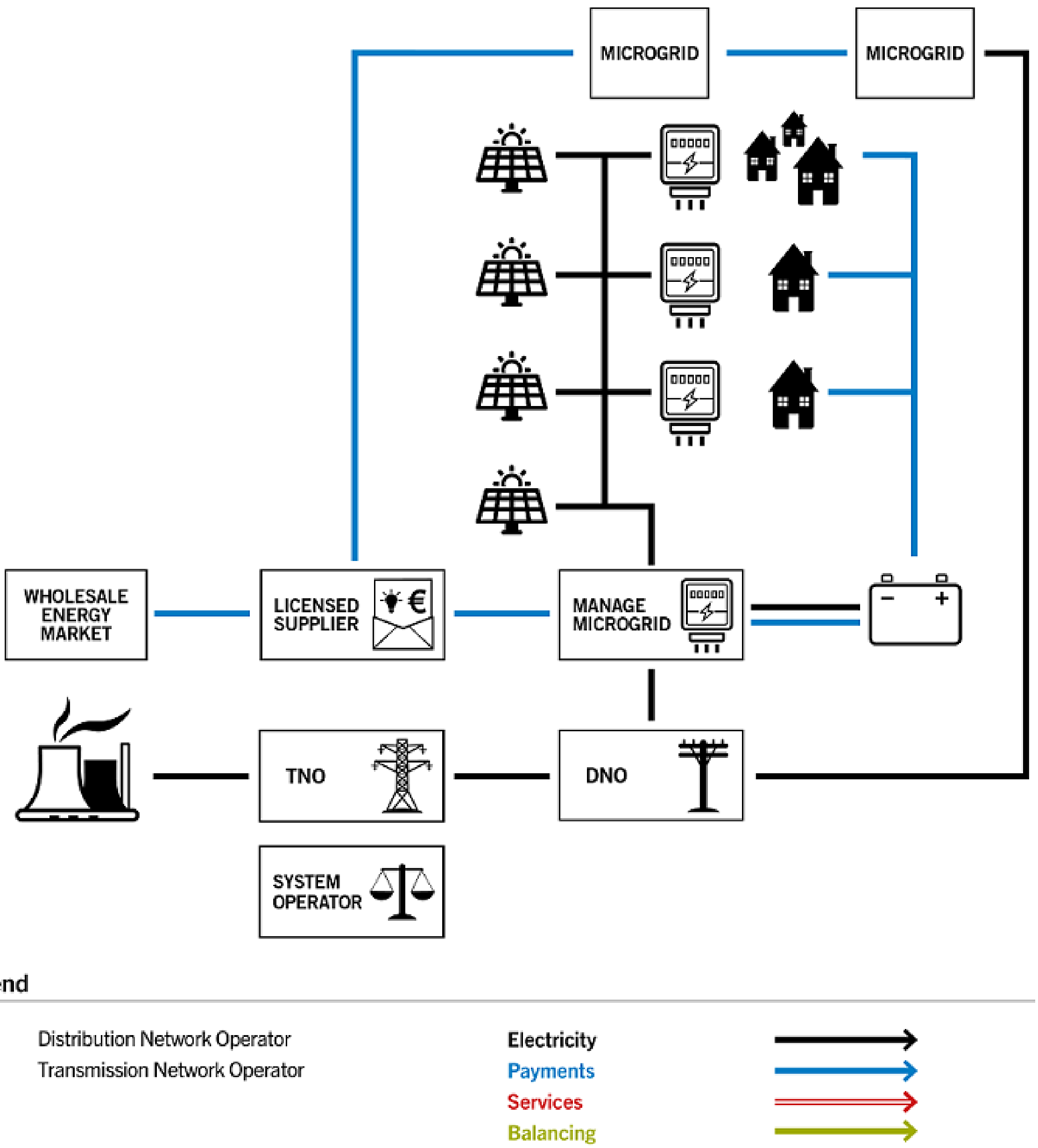
However, as new network charging arrangements are explored there is a risk that private wire networks will see these savings reduce over time. There is also a disconnect between how private wire networks pay for fixed network costs, and the balancing services private wire suppliers can access due to expanding flexibility markets. For example, in Gateshead, UK the municipal council has set up an energy company to run an energy centre providing heat to local commercial buildings and households. The electricity produced by the combined heat and power plant is used 'behind' the meter of a private wire network, with excess sold to a licensed supplier. At the same time the flexibility of the gas fired CHP units, means the licensed supplier 'Flextricity' can help the System Operator balance the system and get paid to do so[138]. Here one benefit to the system is increased by having more competition for ancillary services (lowering system balancing costs overall). However, the same model reduces the network cost recovery for the DNO.

In the Portuguese workshop, a microgrid solution was also proposed and explored using the archetype generation method. Fewer market connected microgrids currently exist in Portugal. Island systems are growing[139], but the workshop developed a model with similar goals to the Gateshead example, albeit with an anchor role for solar PV with battery storage as opposed to management of a heat led gas CHP. This shows how the potential for and market design of microgrid business models will be climatically driven as well as being influenced by the institutional conditions of MS energy markets. The UK and Portuguese micro grid business models are shown in business model diagrams #6 and #7 below.

Business Model #6: Private wire or 'microgrid', UK example



Business Model #7: PV and storage microgrid, Portugal[xvii]



Summary: The ways in which self-consumption are being extended beyond individual prosumers differ across the MS investigated.

[xvii] Due to time constraints this model was not fully developed by workshop participants, but it points to a clear appetite for experimentation with market connected microgrids even where institutional arrangements are still developing.

In Germany one way to extend 'self' consumption is by participating in a tenant electricity model that benefits from a small amount of tax relief, avoids network charges, and creates a new subsidy for the scheme owner. The scheme owner can be a landlord, or the landlord can delegate to a corporate utility. There is no specific 'protection' for the types of non-profit Renewable Energy Communities or Citizen Energy Communities that provide environmental, economic or social community benefits for their shareholders or members or for the local areas where they operate.

In Spain the collective auto-consumption model allows the definition of self-consumption to be extended beyond individual dwellings to multi occupancy buildings and/or to schemes within a 500m radius or on a given low voltage feeder. The orchestration of meter data held by the DNO and not by disparate retail suppliers is critical for efficient allocation of self-consumption between scheme participants. Participants still pay network charges but avoid wholesale elements of the retail price, some utility profits and volumetrically applied taxes are avoided by prosumers. There is no specific need for the operating legal entities to be non-profit led, however some collective governance arrangement is clearly required to establish each scheme and it remains to be seen which organisational form the majority of schemes take.

In the Netherlands the post code rose scheme gives a tax advantage to participants while still contributing to network costs. This model explicitly requires co-operative governance and is the only one of the four business models presented in this section to specifically operate on a community or 'non-market' governance logic.

The private wire model explored in reference to the United Kingdom is possible to different degrees in different nations but there the specific derogation for a supplier license under 2.5MW of supply has allowed diverse models to emerge. Some fixed network charges have been avoided in the past, it remains to be seen if capacity based as opposed to volume based charges will eliminate the business case for such micro grid developments and whether other 'stacked' revenues like flexibility can make up for this gap. While the Gateshead scheme cited is municipally led, there are no barriers to commercial utilities establishing such a model.

The answer to the question 'Can we collectively self-consume beyond more than one user' is a qualified 'yes' in the cases studied. While the Clean Energy Package defines, in the REDII Directive, the right of Renewable Energy Communities to 'share' the energy produced by the renewable assets they own, and for DNOs to facilitate these transfers. The realities of making sure residual supply is met, mean that a licensed utility is often needed to manage the allocation of self-consumption between parties so the revenues and costs can be apportioned fairly. In none of the examples investigated do any groups 'share' energy in the sense that excess electricity is given without exchange, or that the demand for energy is managed beyond a price incentive by any sort of commons-based management principles[140]. The architecture of all of the models above aim to apportion exactly the benefits of whichever part of the retail energy price is avoided by self-consumption.

In some cases, such as in the Spanish collective auto-consumption model, the apportionment of self-consumption is done by the DNO using best available meter data. In others it is the responsibility of the supplier. This adds transaction costs as institutions need building to administer and account for these flows. Recently the digitisation of metering infrastructure and the rise of peer to peer platforms in markets such as ride and accommodation "sharing" have called into question the traditional role of these intermediaries. Leading to the following question.

3.1.3 I want to trade energy locally, do I have to buy from a corporate utility?

Closely aligned with both the issues of extending the definition of self-consumption beyond an individual meter point, and trading prosumer energy between neighbours is the notion of maximizing the amount of local energy utilized before it either 'spills' onto the grid or is purchased by a utility by an export tariff. Local tariffs are created by local energy companies which are often small enough to operate under the 2.5MW derogations in the UK. They aim to retain energy generated within a local area; unlike private wire networks they utilise the DNO owned distribution network 'in front' of the meter. This is sometimes called a 'virtual' private wire network. Below, Business Models #8 and #9 show an existing trialled model in the UK and a similar proposed model for Portugal. These models link local generation with demand and provide prosumers/customers with improved export and import prices. These models typically involve either a license exempt local energy company (LEC) offering a local tariff, with balancing and settlement occurring through a fully licensed supplier.

In UK examples the LEC offers consumers a time of use tariff. This does not have to be set up to maximise local generation. The price signals in a time of use tariff can be based on more dynamic price signals derived from smart meter data and signals from both the wholesale market and network providers. Examples such as the Energy Local trial in North Wales[xviii] also incentivise lower use of system charges by entering customers into half-hourly (HH) settlement– shifting demand away from the daily Red, Amber and Green Distribution Use of System charging periods (DUoS) and the three annual TRIAD periods of peak Transmission Network Use of System charges (TNUoS).

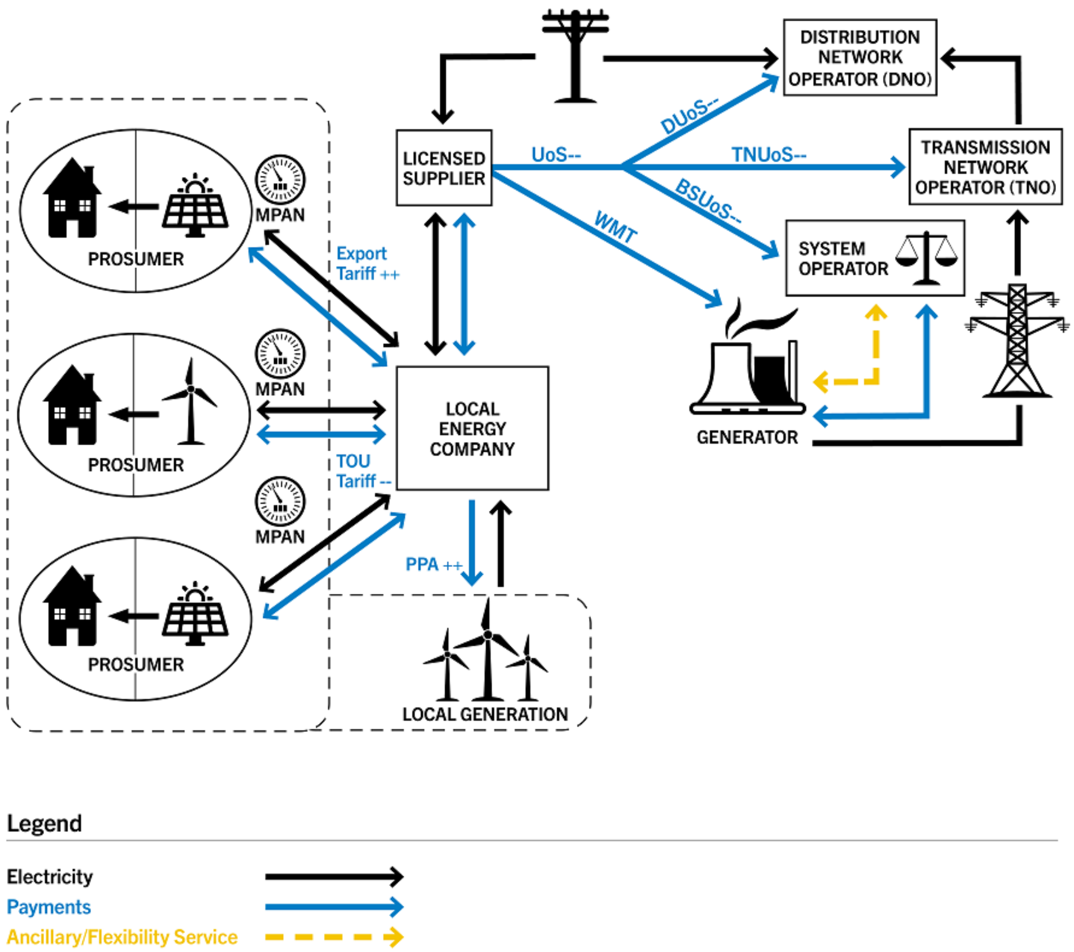
This has been achieved not only with price signalling but with close community engagement to explain how the system works. It is at one remove from a purely price-based system as it relies on collective participation and close member engagement. Speculatively, it may be these forms of closely engaged communities with a trusted intermediary that may wish to take advantage of the enhanced rights allowed as Citizens Energy Communities in the clean energy package as they already have a relevant understanding of network protection needs.

In the Portuguese example, Business Model #9, a similar business model is envisaged with two suppliers, one managing the local tariff and close consumer relations and another managing the

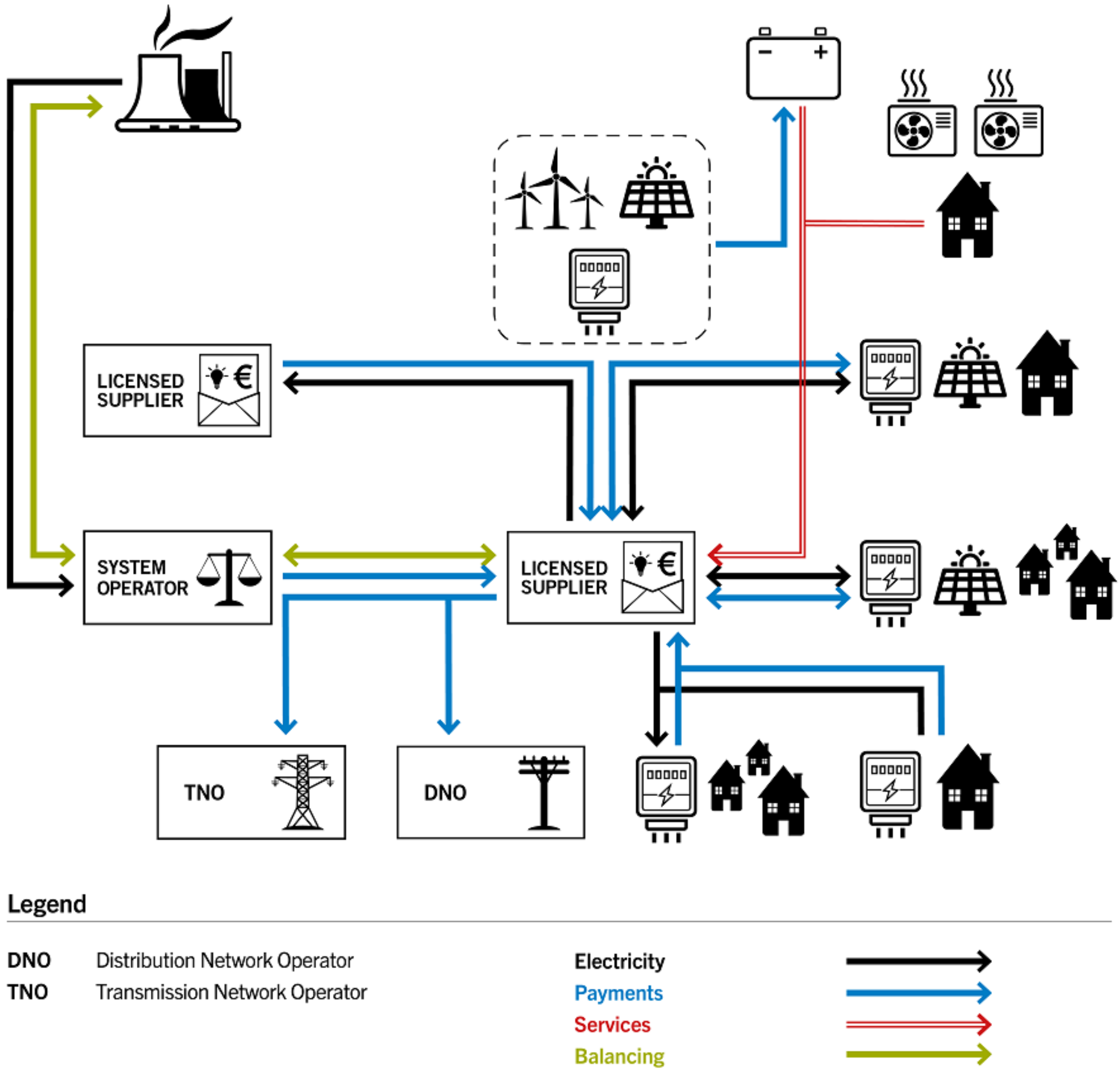
[xviii] http://www.energylocal.co.uk/cyd-ynni/

relation to the wholesale market for shortfalls in collective self-consumption. Similarly, the local energy company has the opportunity to enter into contracts for balancing with the System Operator. While it is a requirement of the Clean Energy Package that barriers to participation in these types of balancing market are removed as much as possible, recent work[141] has shown that only Great Britain, Ireland, France, and Belgium have built up markets for demand side flexibility, that is the opportunity earn revenue from demand flexing.

Business Model #8: Local Energy Company UK



Business Model #9: Local Energy Company Portugal



Peer to Peer trading[xix]**:** P2P business models are predicated on removing the licensed supplier as an intermediary in the trading of distributed electricity generation. These models are based on the use of third-party digital platforms where prosumers can securely trade energy with each other with minimal involvement from suppliers[142]. 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

[xix] Summarised from authors PROSEU project work reported in: Brown, D., Hall, S. and Davis, M.E., 2019. Prosumers in the post subsidy era: an exploration of new prosumer business models in the UK. *Energy Policy*, *135*, p.110984. https://doi.org/10.1016/j.enpol.2019.110984

whatever price a supplier is prepared to offer. Moreover, models adopting dynamic TOU pricing incentivise prosumers to produce and consume energy at times when local generation is high.

In the USA, the most high-profile example of this is the Brooklyn Microgrid trial[xx]. Here prosumers and collective prosumers (those without direct generation but who are signed up) can participate in an online marketplace for energy 'behind' a virtual meter. In this geographic footprint 'virtual' trades can take place. In this way prosumers and collective prosumers can trade energy. Price depending, they can maximize the local use of energy, using the platform to see when the best time to consume local energy will be.

Peer to Peer trials are emerging all over Europe. In Croatia the IMPACT project[xxi] is exploring P2P trading to optimize an island microgrid on the island of Krk[143]. As testing of the trading platform occurs in a lab setting more is being learned not only about how to make the microgrid and P2P platform work in an island setting, but also about how ready the remainder of the Croatian market is for this scale of actor (see empirical reports at proseu.eu).

In Germany, the company 'Enyway' is building utility scale solar, but instead of trading directly to wholesale markets, Enyway is seeking to use an 'off the shelf' distributed ledger technology developed by Ponton GmbH to divide individual solar modules from the large installation between individual customers transparently and securely. Enyway then acts as the retail supplier for any shortfall between the collective prosumer and the energy generated from their part of the wider array[144].

In the United Kingdom a partnership between the Community Benefit Society Repowering London, the licensed retail supplier British Gas, and the technology provider Verv, is using a P2P platform to trade the solar generation on the roof of a multi occupancy block. Prior to the trial the solar generation could only be used for communal areas and services, the remainder receiving an export price and FiT. Within the trial residents can buy the solar directly. Verv acts as an exempt supplier and British Gas will provide a bill split between energy self-consumed and that which was bought from the market. The regulatory exemptions for this are around voluntarily giving up the FiT for the trial period, ensuring customers are not exposed to risk and suspension of billing accuracy to account for new technology in the trial[145].

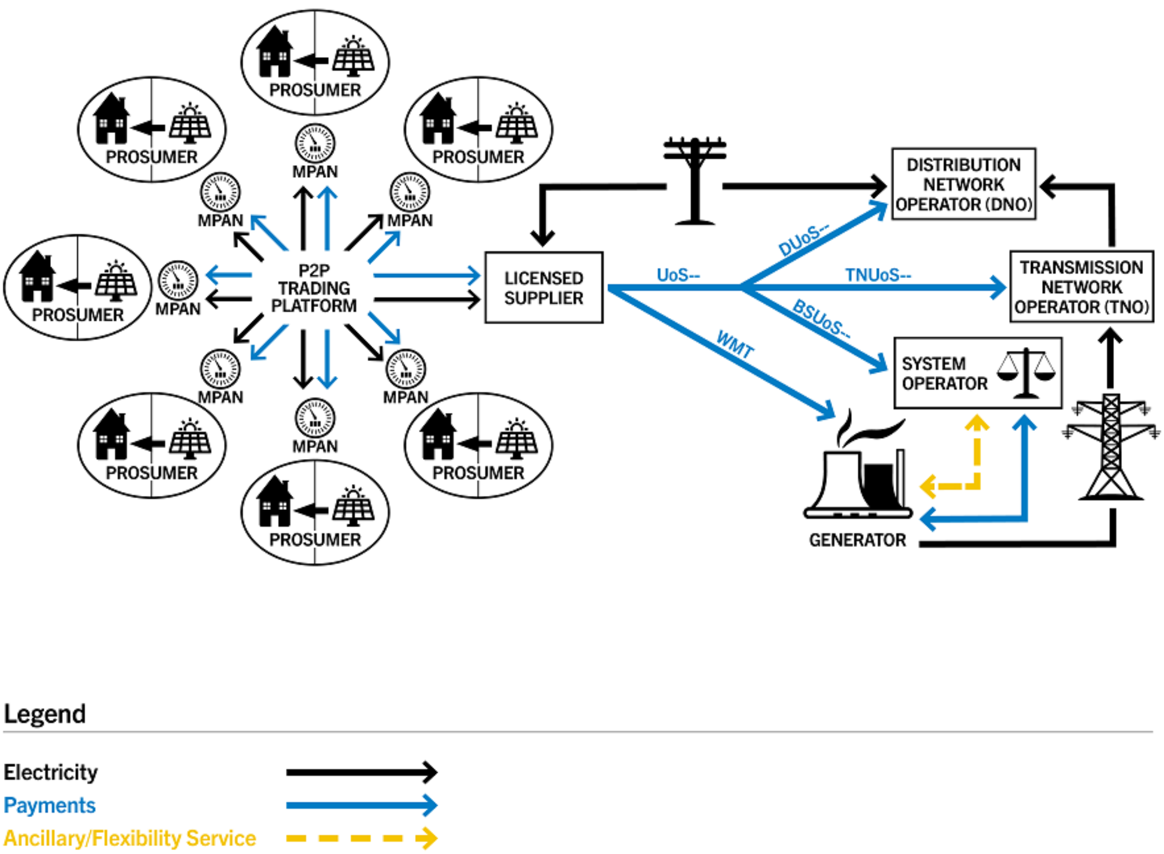
A recent review of P2P energy[146] found the majority of trials are focusing on the use of distributed ledgers to similarly link distributed renewable generation with would be prosumers without having to use market intermediaries like DNOs or licensed suppliers to handle data needs. P2P platforms may be able to reduce administrative costs and drive optimization of localized renewables by signalling when the best time is to increase or decrease one's own demand. They reduce but do not yet eliminate the need for a licensed supplier to act as a buffer between individual prosumers and wholesale markets.

[xx] https://www.brooklyn.energy/
[xxi] www.impact.fer.hr

It is also important to note P2P platforms are only platforms, they do note 'create' value in the system. The collective prosumer groups that might want to use them will use them to secure other values like increased self-consumption, reduced carbon content of electricity, reduced taxation, reduced network costs, reduced supplier costs etc. We use the UK as an example for a business model diagram where the P2P technology organises household prosumers around a decentralised trading platform. It would be equally possible to organise the diagram around a multi occupancy block or a distant utility scale renewable installation with individualized shared of that generation.

P2P technology can be used by corporate as well as community or state actors in the energy transition. Barriers to entry are not as high as might be thought for collective prosumers in Renewable Energy Communities or Citizens Energy Communities, as 'off the shelf' platforms can be purchased for 500 Euro per month. Any collective prosumers using the platform will still have to navigate the individual regulatory requirements in each MS to find the value proposition just as business models #1-#7 have done.

Business Model #10: Peer to peer, UK example



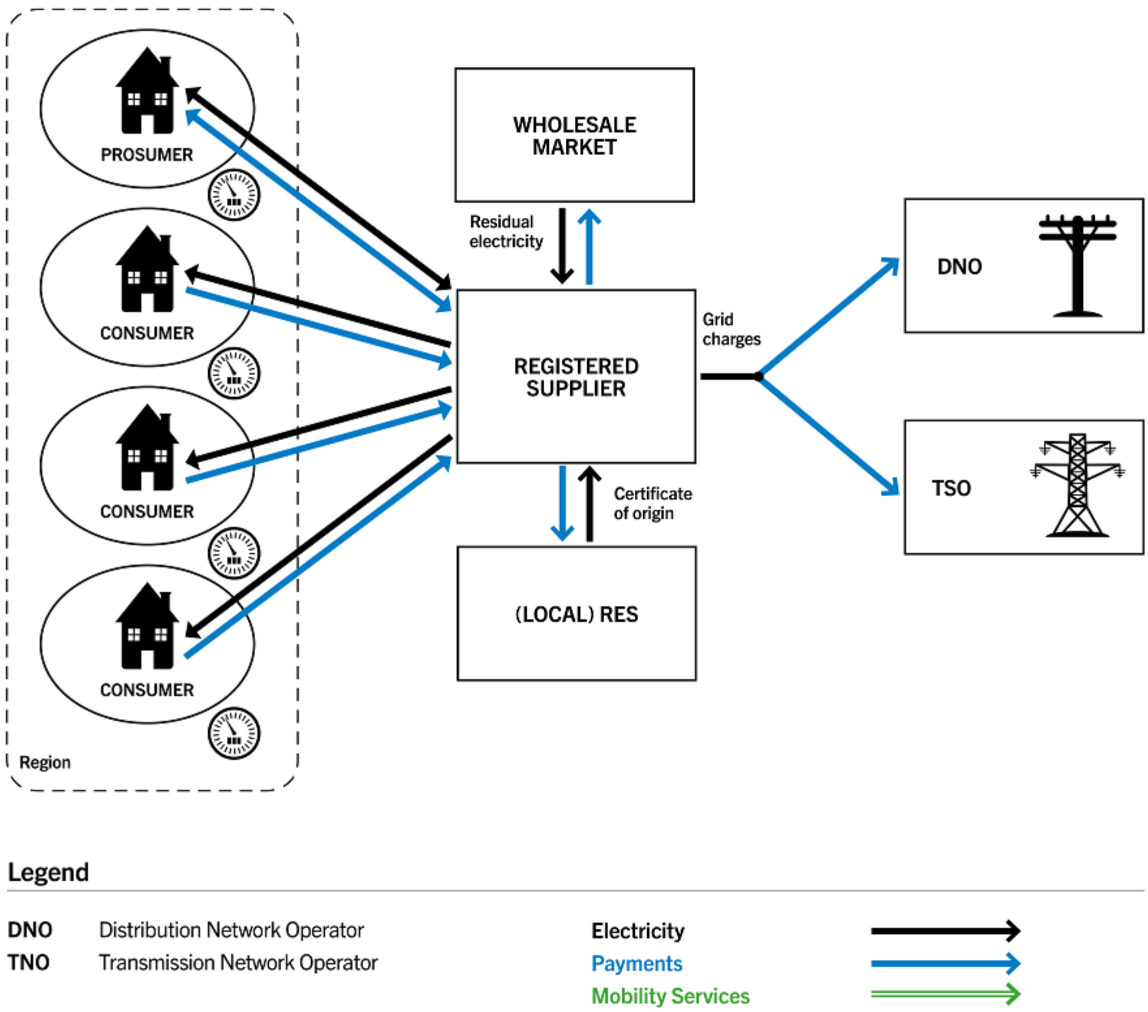
The question that faces peer to peer models is whether or not they are the most efficient way of prosumers fulfilling their needs. As we show below there are existing market models that do not require engagement with a software platform that can still be used to understand the source of ones electricity beyond the broad wholesale 'pool'.

3.1.4 Can we buy utility scale renewable generation as a group?

Even without P2P models and distributed ledger technologies there are opportunities for consumers to emulate prosumption by buying directly from individual generation sites. Where co-operatives or other local energy groups buy shares in medium scale renewable energy installations, i.e. larger than building mounted, they will often sell direct to market via a PPA with a utility. That utility can then allocate the certificates of origin that come with the generation to the consumption of the co-operative members on a dedicated tariff. In most Member States there are no regulatory barriers to this form of dedicated tariff. The prevalence of these tariffs will be determined by how active the co-operative or community energy sector is in that Member State.

These models however stretch the definition of a collective prosumer, since there is little that can be classed as 'self' consumption and the market remains largely unchanged. In some MS these models may avoid transmission charges if they are in a single low voltage distribution network but given our key principles above, and the direction of travel for network charging this saving may not persist. We have generalised the business model diagram accordingly to apply to most MS.

Business model #11: Regional electricity tariffs



The ability of Local Energy Companies to enter into demand side markets, which we have rolled into single component arrows entitled either ‘balancing’ or ‘ancillary/flexibility services’[xxii] is being trialled. It may be that close communication with participants in a community model is necessary to ensure more buy in than a price only incentive can achieve. The next set of collective prosumer business models are explicitly geared towards capturing flexibility revenues.

3.1.5 Can we use flexible assets to earn some money from the system?

The need to balance the electricity system from moment to moment, plan for a more intermittent future, and protect the physical networks, means that in most MS there is an opportunity for collective

[xxii] We would usually make a single term for these flexibility revenues or services but instead we used the terminology most recognisable to workshop participants who were gracious enough to the authors to undertake this work largely in English.

prosumers to solve problems for other stakeholders and get paid for doing so. This is the first time in the exploration of prosumer business models that the focus shifts from re-arranging elements of the retail price to earning new value that has hitherto been unavailable at the prosumer/consumer and of the energy value chain. For those unfamiliar with 'ancillary services' or 'flexibility markets' their operation can seem opaque. Essentially however the revenues that can be earned from them fall into five broad categories.

- The first is basic 'arbitrage' which means storing energy during cheap price periods then releasing it during higher price periods. This can be done with pumped storage hydroelectricity as well as with large grid connected batteries, multiple small batteries or electric vehicles in different places but managed as one asset.

- The second is trading flexibility, here before the trading market closes (gate closure) and the system operator takes over (usually around half an hour before the time energy is to be used), the utilities can fine tune their position, if they are 'long' and have bought more power than they think their consumers will need, they may ask flexible consumers to turn up demand. If they are 'short' and think the customers will use more power than they have bought in the market, they can ask flexible consumers to reduce demand.

  In this way they avoid the system operator having to manage trading mistakes for them and charge them heavily for doing so. They then pass some of these savings on to the prosumers and prosumer communities with flexible assets like batteries, electric vehicles or smart appliances. In Portugal, EDP's 'Activation and marketing of end user flexibility' project accomplishes this by dispatching customers flexible load and reducing imbalance charges from the system operator [147]. In MS where market design does not yet allow the participation of aggregators in of peer to peer energy other balancing mechanisms and ancillary services markets (below), these flexibility services that supplier use to fine tune their own position before gate closure can still be trailed. EDP Spain is trailing a similar aggregation of commercial office and agro-industrial consumers to reduce imbalance exposure (op. cit).

- The third set of services flexible consumers can offer are to 'balancing services'[148]. Typically, balancing services are traded by larger generators registered in the wholesale market. They offer services to the system operator after gate closure to 'balance' the difference between the sum of what retailers have bought from generators and what the actual demand on the system is, these power volumes can be quite large and usually need to be sustained for more than a minute.

- For smaller system fluctuations the ancillary services market fine tunes the system. Ancillary services such as frequency response are needed within seconds, this can be achieved through turning flexible demand up and down, either from a few large players or by many small players, which is where prosumers come in. The system operator pays the providers of these services.

- The fifth value that can be derived from flexibility is longer term in 'capacity markets' here, the system operator buys the option to use some capacity at a point in the future where there is a risk of an overall system short fall. These capacity mechanisms are emerging across Europe[149] and have different structures and payment methods. A common direction of travel is to allow demand side response to enter these markets[150]. Instead of contracting an ageing power station to stay open longer, large chunks of aggregated flexible demand can be used to reduce pressure on the system as long as the entity aggregating that demand can guarantee its availability during the contracted period.

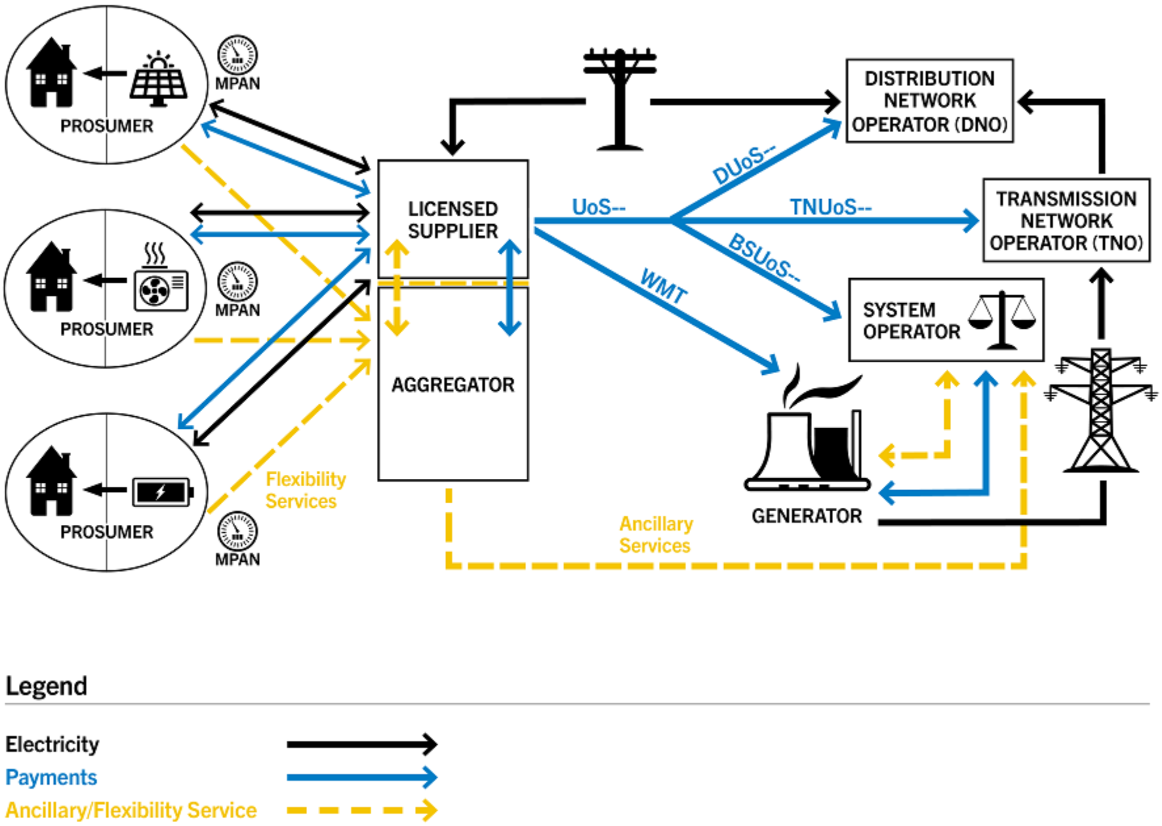
- The final value that can be derived from flexibility is for network management at the low voltage level. In the UK Piclo have explored how a market can be created to allow actors with flexible loads to solve constraint problems on local networks[xxiii]. These actors can then be paid a proportion of the savings the network operator makes by not having to invest in traditional network reinforcement.

The Clean Energy Package and particularly the Energy Markets Directive[3] clearly seek to drive demand side participation in these markets and envisage this will be done through dedicated electricity tariffs and/or by third party 'aggregators'. In the CEP both Renewable Energy Communities and Citizens Energy Communities have the right to participate in these flexibility markets through aggregators or in a non-discriminatory manner[2,3]. This, along with similar rights for individual consumers, means that regulators in MS need to find new ways of allowing 'demand side' activity to compete on a level playing field with traditional energy utilities.

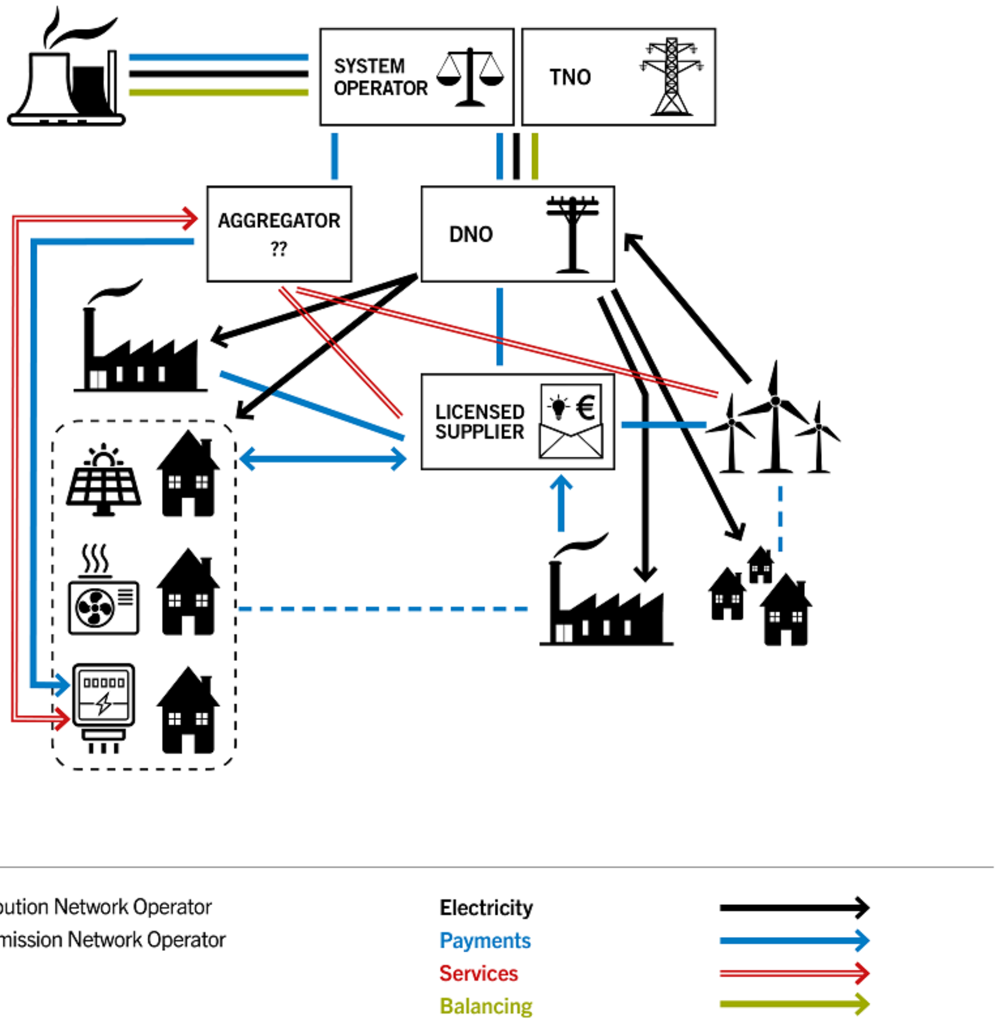
The 'aggregator' signs up multiple small loads into large enough bundles so they can participate in the markets for these different revenue streams. In the UK OVO energy and their flexibility arm Kaluza have been involved in trials in the Orkney Islands where excess generation from onshore wind farms is diverted into domestic heat storage rather than being curtailed[151]. OVO/Kaluza and other providers such as Smartklub**Error! Bookmark not defined.** hope these trails will provide a test bed for a more c omprehensive 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 behavioural involvement from prosumers.

[xxiii] https://picloflex.com/dashboard

Business Model #12: Prosumer Aggregator UK



Business Model #13: Prosumer Aggregator Spain



The ability of collective prosumers to earn revenues from flexibility provision is driven by the extent to which energy markets in host nations are accessible for aggregators**Error! Bookmark not defined.**. In S pain and Portugal both workshops focused on the potential of aggregators to establish these relationships in the future.

Business Model #13 is one example of this, but across the workshops the participants explored how aggregators could aid prosumer business models by bringing a new revenue into the financial calculus of collective prosumption. The activities of EPD in both Portugal and Spain show utilities are developing offers, however the market has not yet trailed this form of participation for collective prosumers. In Business Model #12 from the UK, the separation between aggregator and licensed supplier is small.

This reflects the Kaluza business model where retail tariffs of a parent utility can support and complement the activities of the aggregator. Here the benefits of flexibility to a utilities portfolio in the pre gate closure trading period can be optimized against revenues from the system operator, distribution network operator, and any future capacity markets. Trails are also ongoing in Cornwall, UK with aggregated demand response; where a mix of the revenues identified above are being bundled into a single platform that aggregators can bid into[152].

The implications of aggregators for Renewable Energy Communities and Citizen Energy Communities are yet to be seen. Aggregators react to strong commercial drivers which may override other values held by collective prosumers operating a different value logic as shown by Figure 2 in the 'multi-actor perspective'. One recent study showed aggregator profitability increased for managing a communities distributed generation when price only signals were followed, and greenhouse gas reduction targets were subordinated[153].

The complexity of operating aggregator business models and the size of market they access may preclude community decision making structures as a successful governance model. This means commercial companies are most likely to offer to partner with RECs and CECs to share the benefits of flexibility. Equally it may be the case that revenues from aggregation are sufficient to bypass REC and CEC business models completely and operate a more individualistic aggregator to household relationship.

Aggregation in and of itself does not ensure a viable prosumer business model nor does it ensure cost reflective network charges, or that system taxes etc are fairly paid. It does offer a way of solving some of the problems of other actors in the energy system; this is why it represents one of the few 'new' revenue streams to prosumers and prosumer communities can access that is not a direct or indirect subsidy.

A strong theme in the UK pilot study was that aggregation relies on some level of control being automated. Time of use tariffs cannot be relied on because consumers can choose not to react to price incentives. If a system is automated and the consumer knowingly signs that automation of flexibility to the aggregator, then both parties can enjoy more certainty. While some aggregators are experimenting with heating and cooling for demand sinks, the aggregator business model does not automatically address the decarbonisation of heating along with electricity. The next business model we explore does cross these energy vectors.

3.1.6 Can I bundle all my energy services into one package and pay back with savings?

Until now most of the prosumer business models explored are predominantly about electricity. However, across Northern Europe, heat demand is a greater problem for MS governments in their decarbonisation efforts. There is an urgent need to retrofit substantial energy efficiency measures to the Northern European housing stock[154]. There are multiple business models for housing energy efficiency retrofit[155] and those for retrofit only are useful for decarbonisation targets but do not help us here. Where domestic (and small commercial) retrofit does intersect with our research question, is when it is undertaken alongside the installation of microgeneration, heat pumps/heat networks, and smart meters/ smart appliances. The most prevalent model for this type of 'deep retrofit' is the Energy Service Company or ESCO business model.

Energy service business models guarantee consumers/prosumers receive the final energy service such as: reliable electricity, hot water, and stable room temperatures, rather than selling a specific technology or energy commodity (units of electricity, gas, oil etc). These models shift the responsibility for the performance of the building into long-term contracts between the ESCO and the household/business[156]. Solar-as-a-service models help people become prosumers without the upfront cost, as the ESCO owns the panels and takes responsibility for finance, installation and maintenance as well as a solar tariff and dealing with the export agreements[157]. Heat-as-a-service models sign consumers to a comfort agreement and can operate with district heat network with gas or biomass CHP or by installing heat pumps, again with ESCOs owning the infrastructure[158,159]. These models may even offer energy performance contracts for specified comfort, such as levels of internal temperature, further incentivising efficiency in building fabric, lighting and appliances.

Although basic energy service models for district heat provision are common for large public sector or commercial sites[160], more comprehensive 'deep retrofit' models are growing in the UK, France and Netherlands. The Energiesprong initiative is a deep retrofit program where homes are given a 'net zero' makeover which includes a new exterior shell, microgeneration, new heating and heating controls. Over a 30-year contract the ESCO guarantees the performance of the building, energy bills stay constant, but the householder has an improved exterior appearance and internal building health.

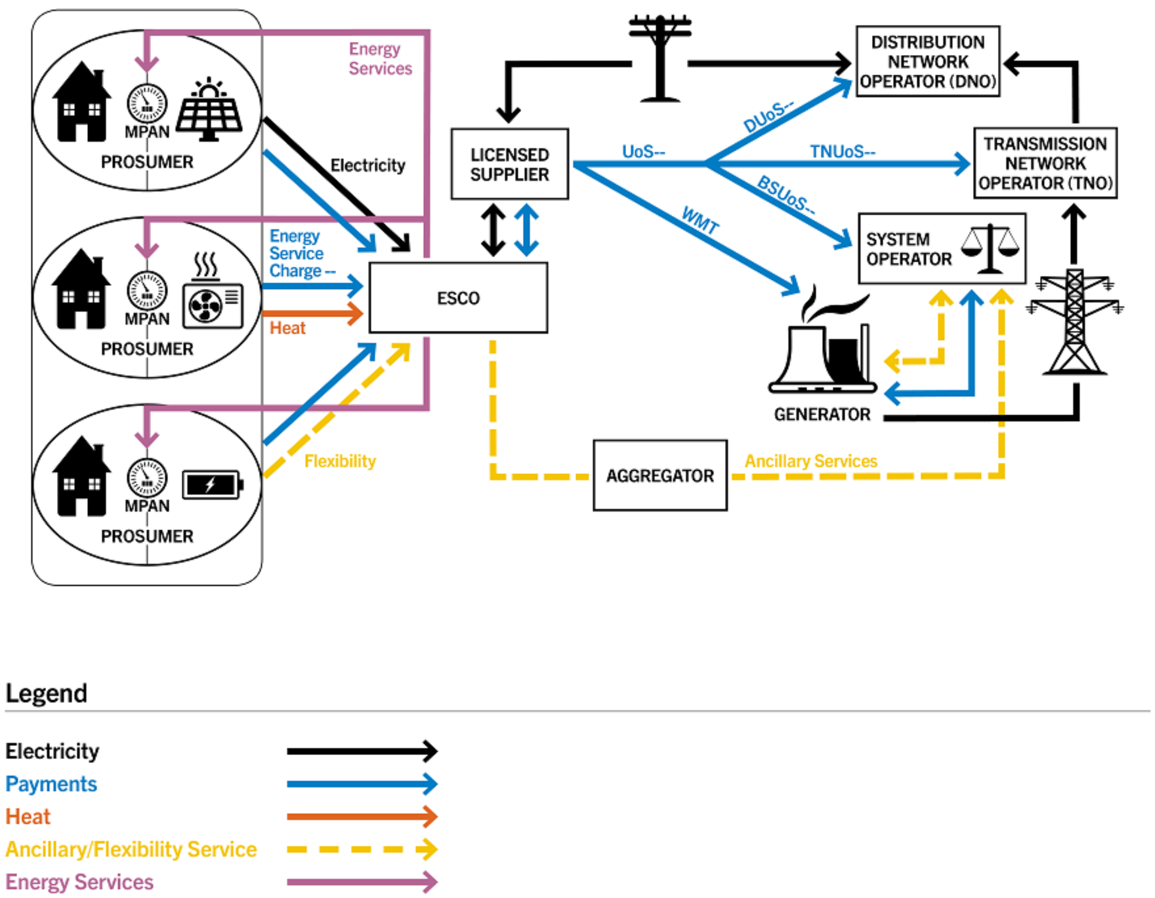
Savings on the energy bill pay back a large proportion of the investment over 30 years. This model has been successful in the Netherlands where costs per home have reduced by focusing on uniform social housing and working with local governments and other housing providers. The standout benefit from a prosumers perspective is the ESCO or a delegated licensed utility can play the role of optimizer or aggregator of heat sinks, batteries and microgeneration control, without the need to engage closely in the energy market or respond directly to price signals.

In the UK, SmartKlub**Error! Bookmark not defined.** are trailing a similar model in the Trent Basin new-build housing project. The project features a large PV array, 2.1MW 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[31]. 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 (op cit.)

The consumer's right to switch supplier is strengthened in the Clean Energy Package, and switching times are to reduce to as little as 24 hours. This means financing deep retrofit directly through 'on the bill' savings where the ESCO is also the retail supplier is difficult. Instead tenants can still switch supplier, it is only that they are switching with a much-reduced energy demand. The remainder can be paid on an energy service charge particularly when the householder is a tenant of a larger housing provider and the Heat Plan can be part of the wider service charges on the property.

Below we show the UK example because this was the most developed by the primary research undertaken. However, it should be noted that wherever retail energy prices are high, and there are cold, difficult to heat homes, an ESCO model could well be viable. The Energiesprong model is only one approach with a particularly 'deep' approach to retrofit and other models may become even more viable by focusing on cost optimal measures.

Business Model #14: Energy Service Company UK



Energy service models currently being trialled may also experiment with parts of the other business models explored here, for example, post retrofit a household could also benefit from a postcoderoos model, a collective auto consumption model, or a local energy company with time of use tariff. How the households or small businesses in a scheme interact with each other is not fixed, and as such they may find new ways of further optimising the locally generated energy. ESCOs enable cross vector decarbonisation of electricity and heat. The final vector of energy consumption which remains unexplored is transport.

3.1.7 Can I link transport into prosumerism?

In the REDII on common rules for the electricity market, Citizens Energy Communities may offer energy services such as charging electric vehicles. The addition of electric vehicle charging to any business model that also extends the definition of 'self-consumption' is important. It offers a new set of options for storage, particularly for those business models which practice collective self-consumption such as the Mieterstrom, Postcoderoos, and Collective Auto-consumption. Could multi occupancy buildings use electric charging stations as part of the 'self-consumed' electricity? Could car sharing and car clubs become involved in such activities? If so an EV charge station may substantially increase self-consumption by adding an intermittently available battery to the assets of a citizen's energy community.

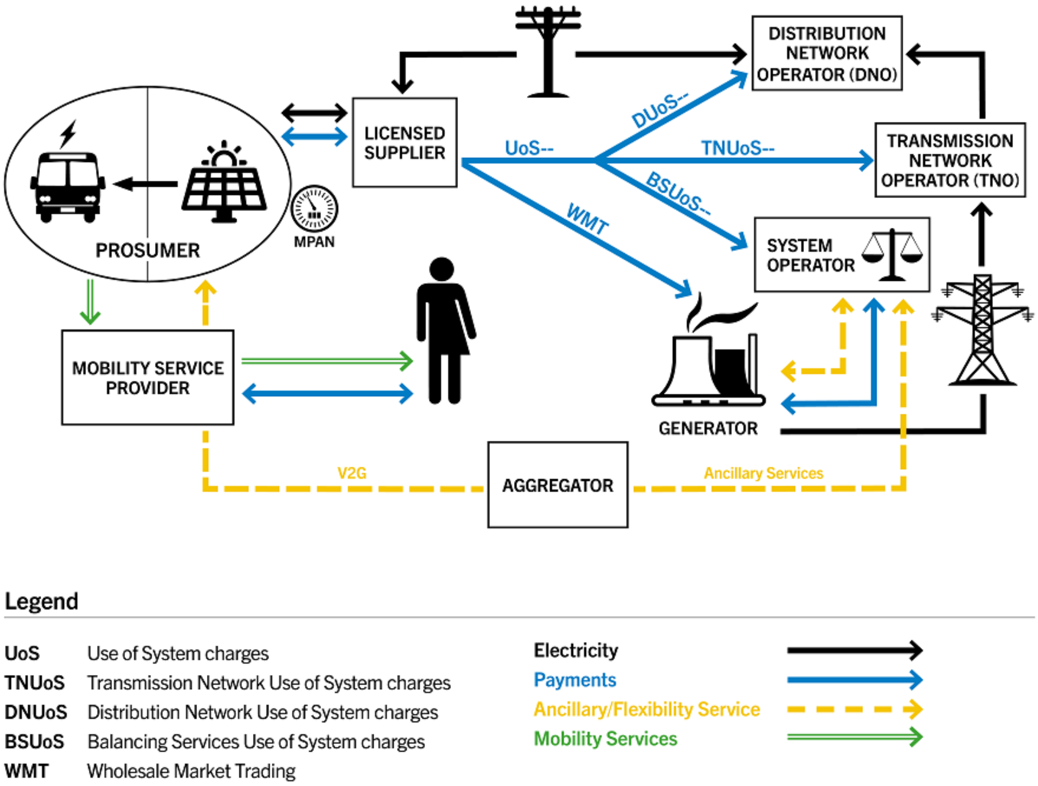
Recent work has explored how energy business models and smart charging can be linked with other urban infrastructures[161]. The needs of city governments, the auto industry and energy utilities align in that there are air quality benefits of electrification for cities, climate compatible modes of automobility for manufacturers to support, and a new energy vector for electricity utilities to service. The emergence of transport electrification across private cars, commercial fleets and public transport mean the opportunities to link local generation with diverse local storage are growing. The rise of ride sharing and mobility as a service offers - where owning a private vehicle is supplanted by mixed public transport and vehicle sharing[162] - mean that Citizen Energy Communities that offer charging services may have an expanded set of options in how to offer those services. Prosumer communities may be able to sell power directly to reliable loads like public transport providers, enrolling another actor and another energy vector in the collective prosumption model.

These business models are currently speculative however, outside some isolated examples such as Big Lemon Bus Company in Brighton UK, where part of the electricity demand of their e-bus fleet is met by solar PV installed on their own depot[xxiv]. Similarly, bus to grid services are being trialled in the UK in a project with London's bus fleet, where 'vehicle to grid' capable busses are being provided to Go Ahead London and an aggregation platform will be used to allow them to participate in flexibility markets. While collective prosumption business models #3-14 above are still emerging, it will remain

[xxiv] https://thebiglemon.com/

important to track the role and possibilities of transport electrification for supporting their growth. In Business Model #15 below we present the Big Lemon example as if it were V2G equipped.

Business Model #15: E-Mobility service provider



3.1.8 Summary

This section has presented 15 of the 25 the business model archetype diagrams developed by the researchers over a ten-month, mixed method, seven country research effort during 2018 and 2019. The business models presented are those which: A) most clearly developed by workshop participants and B) most closely addressed specific problems or questions facing prosumers and collective prosumers. In the supporting materials for this report on the PROSEU website https://proseu.eu/, we publish the in country empirical reports and all of the business model archetype diagrams.

Most of these business models are at some stage of market entry, be they in trial phase, or early market operation. Some are more speculative such as local energy companies in Portugal (Business Model #9) and prosumer aggregation in Spain (Business Model #13). Some business models are already, to a degree, mainstreamed; these are Business Models #1 & 2 Individual prosumers in the UK and Germany and Business Model #11 regional energy tariffs in Germany. However, the individual prosumer business model, and its financial attractiveness, is rather a hostage to fluctuating FiT subsidies that are reducing throughout Europe. Increasingly reverse auction subsidies for utility scale renewables suit nation states as the most cost-effective way of decarbonizing the overall carbon intensity of grid electricity. As subsidies reduce, self-consumption becomes the most valuable thing to do with on-site generated energy. Where the retail price is higher and the local resource plentiful, becoming a prosumer can have an attractive payback period without subsidy at 25-50% self-consumption.

Extending the definition of self-consumption beyond a single meter point is the focus of business models #3, #4, #5, #6, and #7. . They all achieve this in different ways, and they all allow prosumer communities to avoid different proportions and elements of the retail price. While they increase the overall level of 'self' consumption, they also become liable for some network charges, taxes etc. They do nothing to actively shift demand to periods of high local production using 'smart' tariffs or automation, however this will be incentivized naturally by the savings prosumers make on retail price avoidance.

Local Energy Companies, Business Models #8 and #9, seek to use dynamic price incentives to maximize local self-consumption and/or reduce grid charges. The members of the prosumer community can decide which preferences the tariffs should reflect. The model is available in the UK under the supplier derogation of 2.5MW of supply and is therefore viable for sets of up to 500 average homes, though trials are smaller. At present the Local Energy Company model is available only with a licensed retail supplier and prosumers cannot switch supplier and stay with the Local Energy Company.

In the P2P example, Business Model #10, individual prosumers can trade excess generation, storage etc with neighbours to maximize self-consumption and respond to internal market preferences. These may conflict with overall market signals, but the preferences of individuals in the prosumer community can be automated on a trading platform. The peer to peer platform's value is in reducing the transaction costs otherwise borne by suppliers or grid operators.

Aggregator Business Models #12 and #13 enable prosumer communities to secure a 'new' revenue stream by demand side participation in flexibility markets. This means some level of automation is needed by the aggregator and some form of flexible asset like batteries, heat sinks, or interruptible appliances are needed as opposed to microgeneration alone. Aggregators might find prosumer communities a good partner but may also contract directly with individual households.

Business Model #14, the ESCO model, bundles deep retrofit/ new build homes and small businesses to high energy efficiency standards with installation of microgeneration and smart heating/appliances. By paying an energy service charge and guaranteeing the comfort of residents, the ESCO or a nominated supplier can optimize the model for market performance and serve both prosumers and the energy system. The most effective models rely on uniform housing stock and uniform tenancies to bring down costs and build scale. Business Model #15, the mobility service provider, similarly focusses on cross vector energy services but begins to roll in transport electrification. The attractiveness of this model may be underplayed by this investigation simply because of the early market stages of other enabling business models for extending self-consumption beyond a single meter point.

These business models each have characteristics distinct to the market, resources, and regulations of each MS. However, they each address common issues of extending prosumerism beyond individual households and small businesses into different forms of collective self-consumption. Some of these models avoid taxes, wholesale costs, transaction and supplier costs and network charges, some earn new revenues, and some bundle in new energy vectors. They solve the problems of system stakeholders in diverse ways. In the following discussion we explore how well different models respond to the key principles of prosumerism that were established in our UK pilot study and presented in Brown et al (2019[31]).

4. How do prosumer business models align with the 10 key principles of prosumerism?

The 10 key principles of prosumerism set out in section 2.1 and developed by the authors in Brown et al (2019)[31]are designed for prosumer business models that hope to 'mainstream' with least disruption to the current regime. We question this more closely in Section 5 but here we assume the best way to mainstream prosumer business models into the current European energy 'regime' is to do so without fundamentally undermining how other parts of the system operate.

Principle 1. Prosumer business models should deliver bi-directional value propositions that are synergistic to both prosumers and the energy system.

We have organized our analysis around the problems prosumer business models solve *for* prosumers. However, throughout the report we have shown that prosumers can either exacerbate or reduce problems for other stakeholders in the energy system. When it comes to the problems that MS face, i.e. energy system decarbonisation, all of the models above solve this problem to a degree. The reason MS are reducing or eliminating subsidies for prosumer scale renewables, however, is that prosumers are some way off the most efficient use of public subsidy if grid decarbonisation is the only goal.

Larger utility scale renewables projects are able to attract more public subsidy because they produce more low carbon electricity per Euro than small scale distributed schemes. Only business models #14 and #15 have the potential, if subsidised, to drive deeper forms decarbonisation because they support decarbonisation of other, harder to reach energy vectors. If the only value proposition prosumer business models bring to MS is cleaner energy, they are unlikely to persuade policymakers to re-introduce feed in style support.

Principle 2. Greater value can be created and captured through models that deliver services across multiple energy vectors.

The only prosumer business models we found that explicitly cross into the heat and transport sectors were the ESCO and Mobility Service Provider models. Aggregator models #12 and #13 benefit greatly from heat sinks or vehicle batteries in which to place excess local or wholesale generation, however they are not premised on growing those sectors. The complexity of making small scale collective self-consumption work in business models #3-#11, suggests that even where a compelling business case may exist for cross vector business models, transaction costs and information barriers may restrain any possibility to mainstream.

Principle 3. Prosumer business models create non-financial value that is important but difficult to measure.

Our exploration of the different stakeholder logics at play in section 1.2.2 suggest that the market logic of the Clean Energy Package exposes a tension between the not for profit governance structures of the RECs and CECs, and the for-profit governance structures of corporate utilities and other actors. The not-for profit sector has to enter a market where all of the incentives are monetized, priced and exchanged. In this way prosumers can express their preferences for local low carbon power in the 'Peer to Peer' model #10, by setting higher price tolerances on their automated trading platforms for things they value, like the 'closet' or the 'greenest' power.

Other values are secured by prosumers however, they include solidarity economies, local economic development, ecological protection, self-governance, and building of social networks and associations[21]. In later PROSEU deliverables, we will explore these incentives, but here we focus on those value streams that can be monetized to support a business model. We do this because we are adopting the framing of the Clean Energy Package that establishes electricity as a simple commodity. Something which can and *"should"* be exchanged in free markets. This means that while these more complex non-financial values *are* more difficult to measure, they are also subordinated when they are exchanged in a market *because* they are non-market values[10]. By enclosing, pricing and exchanging values like 'ecological consciousness' and 'self-governance' in a peer to peer business model, something which animated prosumer communities in the first instance can be lost[163]. We pick this up in Section 5 when we explore prosumerism as a more consciously disruptive force to the current energy regime.

Principle 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.

The Mieterstrom, Postcoderoos, and Auto-consumption models each require some form of active opt-in from collective prosumers but much of the administration is dealt with beyond the individual by an energy company. The Peer to Peer model requires much closer engagement and sustained interest, particularly if it is to escape the trial phase and manage the risks of fatigue and declining interest common to time of use pricing trials. Managing consumer's exposure to risk, particularly in Aggregator business models, is a key factor of enabling business model innovation[164]. Finally, the depth of disruption experienced by consumers undertaking deep retrofit, as in the ESCO, model, means that consumer trust and realistic building performance guarantees will define the success of the model. While the Clean Energy Package ensures consumers rights are protected, the consumer journey and consumer information will need to become a key part of business model design for all forms of collective self-consumption.

Principle 5. Despite delivering greater decentralisation, prosumer business models still rely on the existing energy value chain and therefore must contribute to its upkeep.

In most of the collective prosumption business models outlined above there is some form of revenue or saving obtained by extending the definition of self-consumption beyond an individual household. This may come from lower taxation, some avoidance of network charges, or avoidance of utilities' costs and wholesale power prices. These elements together make up the retail price. Models that depend on the avoidance of network charges are unsustainable because they are unlikely to be avoiding costs 'dynamically' and are avoiding socialized payments for fixed elements of network costs.

By exploring each prosumer business model in turn, we can understand how each builds a revenue model based not only on the subsidies they attract, but on which parts of the energy value chain they contribute to. This allows us to identify what hidden subsidies or new revenues they can access. Only then can we have a policy discussion about which of these value streams can or should be protected by MS regulators[165].

Principle 6. New prosumer business models can improve their revenue streams in four keyways:

- ***Increase self-consumption behind the meter***

All prosumer business models #3-#15 seek to increase and/or optimize self-consumption 'behind' the meter. Business models #3-#7 did so by combining several meter points in collective prosumer models which extend the definition of self-consumption to the community or neighbourhood scale. Business models 3-7 are primarily based on increased 'self' consumption and do little to achieve better exported prices, deliver flexibility or shift energy vectors.

- ***Achieve improved prices for exported power***

The Peer to Peer Business Model #10 changes the prices individuals can attain for exported power by allowing other users to pay premiums for local generation. The Regional Electricity Tariffs, Business Model #11 are not strictly prosumer models, but do allow direct collective consumption of renewables by allowing members of an energy co-operative to buy energy from the installations they finance. The Local Energy Company business models #8 and #9 aim to optimize the local exchange of power and therefore do increase the export potential for individuals in the collective.

- ***Access flexibility, balancing and ancillary service markets***

Local Energy Company business models #8 and #9 can benefit somewhat from flexibility by giving prosumers dynamic price incentives to use networks and wholesale energy during low price periods. Local Energy models however are not immanently entering ancillary service markets. Aggregator Business Models #12 and #13 are fundamentally about accessing flexibility service markets using automated demand side management.

- ***Shift energy vectors***

While aggregator business models #12 and #13 benefit from electric vehicle battery storage or electrified heat as energy sinks for demand response, their primary goal is not shifting energy vectors. Recent work has shown that shifting energy vectors away from liquid fuels for transport, and gaseous fuels for heat, creates a substantial pool of new value which new business models can pursue[33]. Business Model #13 the Energy Service Company and Business Model #14 the Mobility Service Provider seek to exploit this new value while at the same time optimizing self-consumption. As yet the deep retrofit ESCO model has not been linked with any aggregator model to benefit from flexibility markets.

Principle 7. Prosumer business models need to be effectively remunerated through reduced UoS charges, if they create value for distribution and transmission network infrastructure

Any business model with either time of use pricing or dynamic response i.e. Business Models #8-#13 can theoretically solve problems of network congestion for distribution system operators (DSOs). However, with the market for distribution level flexibility in its infancy[98], it may be some time before collective prosumers can reliably calculate the value of this servie. It will also be location specific, in that it will depend on prosumers being able to solve problems where they exist geographically, which is uneven.

Principle 8. Business models solely based on avoiding network charges are likely to be unsustainable long term – as they violate 1 and 5

The Council of European Energy Regulators has made clear that in transposing the Clean Energy Package into National Regulation that regulators should be very cautious of allowing collective prosumer models to thrive that rely on network charge avoidance. This avoidance is unsustainable as it is likely to load costs onto lower income or less agile network customers[4]. Moves to more dynamic cost reflexive charging across EU MS are likely to undermine any such business case**Error! Bookmark not defined.**.

Principle 9. Business models that involve the provision of flexibility services need access to these markets and should be remunerated through payments or reduced charges.

The provisions in the Clean Energy Package ensure MS regulators open up the markets for flexibility to much more varied actors in the short to medium term[3]. Where prosumer communities are concerned, there is a potential to optimize collective assets and earn new revenue streams that were unavailable previously. At the same time there is no barrier to commercial firms signing up consumers with smart appliances and electric heating/vehicles onto aggregator tariffs. It remains to be seen whether incentives for self-consumption and requests for ancillary services will compete with each other, and whether the complexity of trying to make both work together will lead prosumer communities to choose *either* self-consumption led models *or* flexibility led models.

Principle 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.

All of the business models investigated here are presented with flows of information and transactions around the energy system. By representing business models in this way, we are showing only the element of the energy system that a market logic can 'see'. Flows of data, energy, payments, and services can be monetized, they are costs or revenues depending on where in the system one sits. What cannot be seen using the business model component diagrams are other motivations. By calling for 'explicit' recognition of the different value logics involved in creating prosumer communities, we seek to uncover tensions between these business models and the existing regime. This is the focus of the following section.

In summary, business models #1-#15 all interact with their host energy system in different ways and fulfil some but not all of the key principles of prosumersim. The business models most likely to thrive within the current regime are those which contribute to system upkeep and are unlikely to be regulated away or disappear when overt or hidden subsidies disappear. At the same time there are other motivations beyond 'growing a business' that apply to prosumerism that motivate the establishment of prosumer communities in the first place.

5. Mainstreaming 'collective' models in a competitive market

The three fields of academic theory we use to frame our analysis show us three things. First, the socio-technical transitions field allows us to see prosumers and prosumer communities as a 'niche' that is trying to grow into an energy regime, which is currently composed of much larger corporate utilities that are themselves in competition for market share. Secondly, our multi actor perspective allows us to 'see' how the Clean Energy Package adopts a predominantly market logic. It seeks to build a set of regulating institutions that can price and exchange all the 'values' associated with electricity, from basic payment per unit of energy, to dynamic and cost reflective rewards for smart flexibility. Third, we can use a business model generation approach to characterise the business models that are being generated and extrapolate from them how they might interact with the rest of the energy system using a co-evolutionary perspective. This means we can see the business models that are forming the 'niche' of collective prosumerism and explore how this niche might be empowered to enter the mainstream or regime.

Expanding collective prosumerism, however, exposes an unresolved tension within the Clean Energy Package, specifically the REDII[2] and Common Rules for the Internal Market for Electricity[3]. Both Directives define and make space for the establishment of Renewable Energy Communities (RECs) and Citizen Energy Communities (CECs) as legal entities. These entities are to have for their "primary purpose to provide environmental, economic or social community benefits to [their] members or shareholders or to the local areas where [they] operate rather than to generate financial profits"[3].

It is worth questioning why such entities might be necessary if one was really to trust that an open, free market for electricity would lead to all the societal efficiencies baked into the idea of a flexible cost reflective energy system for all citizens. One explanation might be that the politics of energy transitions are much more fraught than a dispassionate business model analysis might suggest[166,167,168].

To be explicit, some forms of collective prosumerism[169], community energy[170], co-operative energy[171], and civic energy[172] are fundamentally about organising *against* an unbundled free market approach to delivering energy systems and an energy transition. As such, exploring these business models as though their primary purpose was to support the existing regime and compete with it on a level playing field is naïve. In reality there are two forms of prosumer niche, one that seeks to construct a business model that can compete in a relatively unchanged energy market, and one that seeks to change the rules of that market to favour prosumer business models *over* the current regime dominated by large corporate utilities.

This has implications for our research question: *What prosumer business models are emerging across Europe, how do they work and what problems do they solve for multiple actors i.e. prosumers, governments and the energy system?*

We have answered the first part of our research question by detailing 15 business models for prosumerism across Europe. We have shown these business models have varying abilities to solve problems for prosumers; enabling them to generate, consume and sell renewable energy. They deal with problems of subsidy reductions by extending self-consumption, benefitting from flexibility, and decarbonizing other energy vectors. Some models also solve problems for other actors in the energy system, predominantly by making flexibility available to system operators.

These business models fulfil some or all of the ten principles we outline for prosumerism. They require what Smith and Raven (2012[163]) call 'fit and conform' niche empowerment. "Fit and conform empowerment makes the niche innovation competitive with mainstream socio-technical practices in otherwise unchanged [selection] environments" The drive in the Clean Energy Package is therefore to bring consumers, prosumers, and demand side response into the 'logic' of the single energy market[32]. The Clean Energy Package has created pressure on MS regulators to 'level the playing field' for RECs and CECs, so they may participate in energy exchange and demand response programmes. In this way the Clean Energy Package can be understood as 'fit and conform' niche empowerment.

However as Smith and Raven also note: "there is always pressure for sustainable innovations to become competitive on the more narrow economic, technological, organisational and other criteria of existing markets, compared to the broader sustainability values that might originally have motivated the innovative effort[163]". This concern should be reflected against earlier work by the PROSEU consortium which shows the motivations for establishing these initiatives are predominantly ecological and social, reliant on community empowerment and association logics as opposed to market logics and revenue optimization[15].

These broader sustainability values may be at the heart of the non-profit principles adopted by RECs and CECs. Consequently, fit and conform niche empowerment is likely to be insufficient to allow RECs and CECs to thrive. A different form of niche empowerment may be needed. Smith and Raven's second form of niche empowerment is 'stretch and transform'. If policymakers adopt a 'stretch and transform' approach they often do so as a result of political pressure from outside the regime[165]. Pressure external to the regime is necessary because empowering these more disruptive niches means undermining incumbent power structures and committing to reforms that transmit different value logics into current institutions[163]. Using our co-evolutionary understanding of energy systems change, this means MS regulators re-writing energy market regulation to specifically protect the niche of collective prosumer business models. This is a more active form of empowerment than simply allowing them to co-opt and replicate a miniaturized or digitalised energy market logics at the neighbourhood scale.

Of all of the business models explored[xxv] in the 'post subsidy' landscape, only the Postcoderoos model (Business Model #5) is an example of stretch and conform niche empowerment. This is because it is the only example where the co-operative or resident's association is the only legal form that can benefit from the tax incentive in the model. It is the only example of a concrete revenue advantage that a corporate or private company cannot access. In the Mieterstrom model, landlord energy

[xxv] Bearing in mind this research sampled only seven participating Member States

companies can be run by corporate utilities. In the Collective Auto Consumption Model, there is no requirement for a non-profit legal form (though individuals benefit together). In the UKs Local Energy Companies and Private wire networks, there is no barrier to for profit participation. Neither ESCO's nor Aggregators, nor Mobility Service Providers need be non-profit. All apart from the Postcoderoos model can operate on a market logic in the 'fit and conform' space for growing prosumer niches in national energy systems.

MS regulators who are tasked with transposing the Clean Energy Package into national system regulation therefore have critical questions to answer. Are the business models that collective prosumers adopt to be empowered by 'fit and conform' type regulation, where 'barriers to entry' are removed? Or are they to be empowered by 'stretch and conform' type regulation, where their wider "environmental, economic or social community benefits[3]" are recognised and supported? If collective prosumer business models are to thrive, we need, as in the Postcoderoos model, to establish what it is that Renewable Energy Communities (RECs) and Citizens Energy Communities (CECs) can do, that a private for profit company in the energy system *cannot* do.

6. Conclusion

Prosumers across the European Union are seeking new ways of extending prosumerism beyond individual households and businesses. They are using a series of national variations in energy law and regulation to extend the definition of self-consumption beyond single meter points. To do this they rely on either, avoiding some element of the retail price and sharing this benefit between participants, finding new revenues from flexibility, or decarbonising other energy vectors.

We have explored a diverse set of business models both to understand the flows of value within them and to establish how compatible they are with the 10 'key principles of prosumerism'. Business models based on extending the definition of self-consumption to neighbourhoods or multi occupancy buildings fulfil more of these key principles of prosumerism than individual subsidy dependent models. More contributions are made to system charges, and they enrol a more diverse set of actors into prosumerism and the energy transition.

As they seek broader revenues, however, they need to solve problems for other system stakeholders. The more a business model expands into capturing flexibility revenues and decarbonising other energy vectors, the more complex it tends to be. This complexity increases the need to invite other stakeholders into partnership, such as peer to peer platform providers, aggregators or larger energy service companies (ESCOs). Where this is the case there may be a tension between the community value logic of some RECs and CECs and the commercial logic of partners.

For MS regulators, managing this tension between pure market actors and RECs and CECs means drafting regulation that explicitly shows where simple 'barriers to entry' are being removed, and where RECs and CECs/collective prosumer are being specifically empowered to do something a commercial entity is unable to do. In the analysis above, the only explicit example of this is the Postcoderoos model whereby predominantly co-operatives and Residents Associations can access the tax incentive of collective self-consumption. In other models, the need for close local engagement and small-scale organisational forms may lead to mutual and not for profit governance structures being preferred. However, if MS regulators are to specifically empower RECs and CECs, they have two sets of options. These are shown in Table 4:

Table 4: Two streams of policy options for empowering the prosumer niche

'Fit and Conform' policy options for empowerment of the Market Prosumer Niche:	'Stretch and Transform' policy options for the Collective Prosumer Niche:
Focus on opening up balancing, ancillary services and capacity markets to smaller scale demand side response.	Focus on opening up balancing, ancillary services and capacity markets to smaller scale demand side response and reserve a portion of each auction for REC and CEC participation.
Create an export guarantee that obliges retail suppliers to offer a price above zero for energy exported to the grid.	Create an export guarantee that obliges retail suppliers to offer a price above zero for energy exported to the grid.
Experiment with derogations from supplier licensing under certain power ratings for all stakeholders.	Experiment with derogations from supplier licensing under certain power ratings only for RECs and CECs
Allow peer to peer platforms to operate without supplier license requirements when partnered with a licensed utility.	Allow peer to peer platforms and Local Energy Companies to operate without supplier license requirements when partnered with a licensed utility.
Expose prosumers to full costs of network utilisation	Maintain limited protection from full costs of network utilisation
Create a specific scheme for shared self-consumption in multi-occupancy buildings or in very local geographies that benefits from tax incentives or explicitly justifies avoidance of network charges or supplier costs.	Create a specific scheme for shared self-consumption in multi-occupancy buildings or in very local geographies that benefits from tax incentives or explicitly justifies avoidance of network charges or supplier costs. where only REC and CEC organisational forms can operate the scheme
	Re-establish explicit subsidies for prosumers where the prosumer business model used includes other, hard to decarbonise energy vectors such as heat or transport.

To grow the collective prosumer niche in the European Union, more explicit protection and empowerment beyond simply 'levelling the playing field' will be necessary. The policy options offered under 'stretch and transform' retain the spirit of market participation and cost reflectivity without placing RECs and CECs into direct competition with commercial utilities operating only a market logic. As such, the niche can be empowered beyond what an innovative commercial utility would achieve.

To be explicit: the only justification for this approach is if MS regulators are incentivised to go beyond the ideas that well-functioning, competitive markets are the best way to achieve societal and environmental outcomes. This would mean recognising that energy markets are sometimes unpredictable and have to manage difficult distributional outcomes that RECs and CECs may be well placed to adapt to and address. Issues such as fuel poverty, inactive consumers, and poorly insulated building stocks are as much a product of the current market framework as a smart and efficient market for flexibility services. Growing the REC/ CEC niche may mean sacrificing some level of price efficiency in the short term to better establish a substantive bottom up and citizen led portion of the energy regime, which is better suited to deliver both efficient energy services as well as other socio-economic and environmental outcomes.

The future of prosumerism as mainstreaming citizen participation in the energy transition may be largely dependent on the ability of system regulators to make space for a set of value logics which have been antithetical to market regulation practices to date.

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