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Multi-agent Simulation of Households' Behaviors Towards Hourly Electricity Price Scheme in Denmark

Ma, Zheng; Værbak, Magnus; Jørgensen, Bo Nørregaard

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Policy Challenges for the Development of Energy Flexibility Services

Abstract

European energy policies call for an increased share of renewable energy sources and a more active role of the energy consumer. This is facilitated by, amongst others, buildings becoming energy flexible hubs, supporting smart energy grids with demand response strategies. While there is abundant technical research in this field, the related business and policy development is less well documented.

This research scopes existing policy programmes and identifies opportunities and barriers to business development supporting energy flexible buildings. Using examples from seven European countries, this work reviews influencing niche management factors such as existing policy instruments, business development cases and identified stakeholder concerns, using literature research, narrative analysis and stakeholder research.

National policy pathways show many differences but confirm that European buildings might become active players in the energy market, by providing energy storage, demand response and/or shifts in the use of energy sources. Slow sustained business development for energy flexibility services was mainly identified in the retail industry, and for energy service companies and aggregators. The direct involvement of end users in energy flexible buildings is still difficult. Stakeholders call for policy improvement, especially concerning the development of flexible energy tariffs, supporting incentives, awareness raising and more stakeholder-targeted business development.

Keywords: energy policy; energy flexibility; smart grids; demand response; service development; stakeholder research; strategic niche management.

1. Introduction

Buildings account for approximately 40% of the annual energy use worldwide. In the European Union, the residential sector represented 25.38% of the final energy consumption in 2015 (Bertoldi et al., 2018). Compared to gas consumption, electricity consumption is steadily increasing within Europe. In the EU-28, comparing 2015 to the year 2000, shows that the final residential electricity consumption has grown by 10.7%, while the final residential gas consumption has dropped by 11% (Bertoldi et al., 2018).

Many factors influence the energy consumption in the residential sector, such as population size, economic development, weather conditions and occupant behaviour (Bertoldi et al., 2018; Guerra Santin, 2010). However, also policies for improving energy performance of buildings (Beerepoot, 2007; Murphy, 2016) and policies supporting innovation development (Mlecnik, 2013; Stutvoet, 2018) can have an effect on reducing energy needs and steering technical change. The International Energy Agency (IEA DSM Task 25, 2018; IEA, 2019) envisions that, next to building energy efficiency, demand side response strategies can reduce the impact of rising electricity demand on the power sector, but effective policies are needed to address the current market barriers and promote investment.

Meanwhile, energy production is increasingly relying on renewable energy systems (RES) with less predictable output than conventional power generation. A quarter of Europe's power already comes from RES, but this proportion is forecast to rise to 50 % by 2030 (De Groote and Rapf, 2015). For instance, the Danish government's 2030 target is reaching 50 percent renewable energy by 2030 and independent of fossil fuels by 2050 (State of Green, 2018)[1]. The Italian Energy Efficiency Action Plan[2] set for 2030 the rate of renewable energy sources in the Italian energy supply to the 30% of the total national energy consumption. In particular, this value is the average between three main sectors: electrical energy

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[1] State of Green (2018), New Danish energy agreement secured: 50 percent of Denmark's energy needs to be met by renewable energy in 2030, Copenhagen, Denmark https://stateofgreen.com/en/partners/state-of-green/news/new-danish-energy-agreement-a-green-focus-towards-2030/

[2] Italian Energy Efficiency Action Plan, 2017. Link: https://ec.europa.eu/energy/sites/ener/files/documents/it_neeap_2017_en.pdf

(target 55.4%), thermal energy (target 17.1%) and transport (target rate 22%). Future electricity grids and heat networks will have to operate in a reliable manner, producing relatively constant voltages and temperatures, despite the fluctuating input from RES. Grid flexibility, which can come from various sources, is required to facilitate high penetration of wind and solar energy (Denholm and Hand, 2011). Grid developers consider buildings to be a part of the energy systems as, theoretically, they could provide flexibility services to the energy systems when they manage their thermal and electrical loads in a flexible manner, which responds to the needs of the grid as well as the end-user.

In this complex energy environment, a more active role for the existing and future buildings' infrastructure within the energy market is still a key innovation to be unlocked, with a potentially large value to be captured (De Groote and Rapf, 2015). Although energy efficiency measures are still to play an important role, an optimal balance needs to be found between energy efficiency and other methods that can be used to meet global and national CO_2 reduction targets, such as control strategies and demand response (Pernetti et al., 2017). Most demand side management policies (funding, subsidies, rules and legislation, as well as other forms of support) have been developed to support the creation and uptake of single products and technologies, not services (IEA DSM Task 25, 2018).

Connected to the development of energy efficiency and demand response strategies, buildings have a potential to become micro energy hubs consuming, producing, storing and supplying energy in a flexible manner. The applicability of Energy Flexibility in Buildings and smart energy grids was investigated in many research projects, but mainly from the viewpoint of electrical power engineering of energy systems and energy storage (Giordani et al., 2013; IEA EBC Annex 67, 2019). Future strategies to ensure the security and reliability of energy supply will need to involve simultaneous coordination of distributed energy resources, energy storage and flexible, schedulable loads connected to distribution networks (Jensen et al., 2017; Ma et al., 2019).

While literature abundantly shows that technical research and development is happening, the required service and policy development is less well documented. Policy development is needed to support the integration of technologies and processes for 'energy smarter' buildings and communities. To facilitate such policy development, it is important to understand the perspectives of multiple stakeholders, the scope of existing policy programmes, and market development drivers and barriers, as for example those experienced by innovation champions, to identify and remove obstacles to market penetration of supporting technologies and processes.

2. Research goal and question

The goal of this research is to better understand the innovation challenges and opportunities for introducing energy flexible buildings as active demand side management instruments in future smart grids in seven European countries: Austria, Belgium, Denmark, Italy, The Netherlands, Spain and the UK. Particularly, this research aims to better understand the way existing policies relate to energy flexible buildings, and to identify stakeholders' perceived barriers and opportunities for the development of energy flexibility and how these experiences can help develop policies. The main research question is:

How can policy remove barriers for the development of commercial services for energy flexible buildings?

The work presented in this paper analyses this qualitative question with a triple-helix approach covering seven European countries and reviewing existing policy instruments, analysing business development of energy flexibility services and discussing stakeholder concerns. The research first identifies what current national policies stimulate the development of energy flexible buildings and further analyses what barriers and opportunities can be identified from market frontrunners. The results are then discussed from various stakeholder perspectives, finally resulting in energy and innovation policy recommendations.

3. Research method

As the advent of energy flexible buildings can be considered a strategic niche development, strategic niche management (SNM) is used as a theoretical framework for analysis. The SNM theoretical framework is well-established in the last decades (Van de Belt and Rip, 1984; Kemp, 1994; Kemp et al., 1998; Rotmans et al., 2000; Schot and Geels, 2008) and is well-suited for this analysis, as it covers aligning processes at multiple levels (policy, industry, technology, user preferences,..), aiming at principles to improve the chance of diffusion of innovations. SNM scholars analysed successes and failures of innovation trajectories involving, for example, energy systems (Raven, 2005; Hendry, Harborne and Brown, 2007; Woei, 2007; Verbong, Geels and Raven, 2008) and energy-efficient housing (Smith, 2007; Mlecnik, 2014). SNM literature regarding niche development for energy flexibility services is scarce. On a more holistic level, some authors advocate using decentralized models of ownership for distributed energy systems, developing services involving multiple agents or exploiting demand side or aggregator business models (for example: Meadowcroft, 2009; Behrangrad, 2015; Heleno et al., 2016; Koirala and Hakvoort, 2017; Ma et al., 2017).

The theory is used to detect factors from current policy pathways, innovation journeys and stakeholder concerns in the energy and building service sectors in the seven countries. The research does not focus on technology assessment and does not attempt to provide a conclusive answer to the question of what is the best strategy for market niche entry or policy development; rather it seeks to review and integrate experiences which may help to understand the barriers for the market development of services for energy flexible buildings, particularly regarding key SNM features, such as the formulation of expectations and visions, and requirements for learning, innovation and policy changes.

This paper is based on policy literature study and qualitative research using narrative analysis of presentations of institutes, businesses and policy makers on public workshops on Energy Flexible Buildings organised in the period 2015-2019 in Austria, Belgium, Denmark, Italy, the Netherlands, Spain and the UK, as well as interviews (the Netherlands) and focus group results (Belgium). These countries were chosen because, e.g. Denmark has a long tradition of setting ambitious national energy targets and is now widely recognised as a global leader in integrating variable renewable energy supported by a flexible domestic power system and a high level of interconnection (IEA, 2019)[3]. Italy can be seen as a late adopter, since, although the renewable energy sources penetration is almost in line with the EU targets, and the rollout of smart metering is completed, the market is still closed, and the Integrated National Plan for Energy and Climate[4] reports only pilot projects about energy flexibility and aggregation. Nevertheless, the plan registered a clear willingness to set-up new market strategies for fostering the investments to increase the storage capacity and generation potential that will also foster the implementation of energy flexibility and the inclusion in the regulatory framework. Narrative analysis is suited to analyse the question as it captures the stakeholders' views and memories of the moment, this means during the emergence of experiments and first market experiences for energy flexible buildings. A disadvantage of this method is that the narratives of businesses and policy actors might be influenced by their personal experience, wishes and beliefs. This is countered by reflecting their views on the narratives from scientists and researchers, which to a certain extent might be less biased.

As a reflection base, various sources are used resulting from the IEA EBC Annex 67 working group 'Energy Flexible Buildings', which mainly consist of researchers and scientists. The aim of IEA EBC Annex 67 was to increase the knowledge, identify critical aspects and possible solutions concerning the Energy Flexibility that buildings can provide and the means to exploit and control this flexibility (Jensen et al., 2017). These sources include Annex meeting minutes, newsletters, notes, scientific articles and Annex reports. Amongst others, 13 researchers summarized stakeholder experiences in a report covering 16 cases analysing viewpoints from educational, retail and office building stakeholders as well as households (Ma et al., 2019). Although the Annex work did not focus on studying policy recommendations per se, a policy discussion is produced from analysing the stakeholder data from the research question perspective.

In Section 4, an overview is presented of existing supporting policy instruments in the seven countries. In Section 5 experiences from market frontrunners are presented, focusing on perceived barriers and opportunities. In Section 6 the observations are discussed in terms of needs of stakeholders for developing policy related to energy flexible buildings. The concluding section frames all experiences in general policy recommendations.

4. European policies supporting the development of energy flexible buildings

To investigate where policy currently supports the development of energy flexible buildings, the evolution of policies applied in the EU and in a selection of countries in the period 2015-2019 is discussed.

European policies are already actively promoting energy flexible solutions. In its efforts to reduce carbon emissions, the European Commission has long advocated the need for energy security and energy savings in buildings, resulting in a legislative framework that includes, amongst others, the European Performance of Buildings Directive (published in 2002 and revised in 2010) and the Energy Efficiency and Renewable Energy Directives. The recently introduced Clean Energy

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[3] IEA (International Energy Agency), Global Engagement-Denmark, https://www.iea.org/countries/Denmark/

[4] Integrated National Plan for Energy and Climate (Italy). Link: https://www.mise.gov.it/images/stories/documenti/Proposta_di_Piano_Nazionale_Integrato_per_Energia_e_il_Clima_Italiano.pdf

For All Europeans Package (EC, 2016) updates all energy policies and adds new rules which were formally adopted in 2019 (EC, 2018) as part of delivering on the EU's Paris Agreement commitments. The new EU policy developments are to be implemented in Member States in the coming decades and aim to empower European consumers to become fully active players in the energy transition, providing them with more choice and better feed-in rights, to modernize the EU electricity market towards flexibility, and to establish an obligatory renewable energy target of at least 32 % and an energy efficiency target of at least 32.5 %, with a possible upward revision in 2023 (EC, 2018). An underlying motive is that consumers who benefit from appropriate energy price signals can drive the needed renewable energy investments.

The package is currently impacting revisions of the Energy Performance in Buildings Directive (EPBD, 2018), the Renewable Energy Directive (RED, 2018), the Energy Efficiency Directive (EED, 2018) and the EU Governance Regulation (GEU, 2018) with expected changes in 2019 for the Electricity Directive, Electricity Regulation, Risk-Preparedness Regulation, and Regulation for the Agency for the Cooperation of Energy Regulators (ACER). Another EU objective is to introduce a Smart Readiness Indicator for Buildings, for which options are being explored (VITO, 2018; Pernetti et al., 2017).

Besides EU initiatives, national policies have also evolved in the period 2015-2019 to support the energy transition, particularly in the building and energy sectors. The following paragraphs illustrate policies in selected countries that influence the development of energy flexible buildings.

In Austria, there are three relevant initiatives to develop innovations and the market for energy flexibility. The first is the Austrian Climate and Energy Strategy, called "mission2030" (BMNT/BMVIT, 2018), where the federal government states that the energy market design of the future should enable companies to market their flexibility; generally "flexibility" is addressed 24 times to introduce a future flexible energy system. The second is the Energy Research and Innovation Strategy for Austria (BMVIT, 2017), which launches a topical energy research area "Buildings and urban systems", envisioning new buildings to have greater energy flexibility, and being able to adapt their energy consumption to the sources available at any given time. The third is an industry and public initiative via the Technology Platform Smart Grids Austria (TP SGA, 2019). The aim of the platform is to pool joint forces for future intelligent electricity grids, also linked to smart grids projects and other industry initiatives in this field.

While Austria develops a comprehensive strategy towards flexible energy use, policy developments in many countries merely follow European Directives, although markets, and think-tanks, might already be more advanced. For example, in Belgium, the Flemish transition arena "New Energy Demand & Delivery 2025" specified the need to transform to a new energy system in Flanders within the EU context: captains of society and industry proposed a systemic approach to create a strong basis for adapted economic modelling and the development of new business models (VRWI, 2014). They expect that new energy systems will include interaction between energy demand, supply, storage and grids. A highest priority was given to develop storage systems (VRWI, 2014: 226), for example, via solar boilers, building integrated thermal storage, geothermal solutions, batteries and the development of related control systems. However, these are not yet at full market maturity (De Groote and Rapf, 2015) and energy flexibility services and networks still need to be developed. Recent urban planning in the Low Countries (Cabus et al., 2017) proposed a long-term vision for having abandoned the use of fossil fuels and nuclear energy in 2100, in favour of renewable energy sources and targeting a 50 % reduction in energy use due to energy efficiency measures.

While Denmark also follows EU goals, it also has some national climate goals (Danish Government, 2013) and facilitating policy for energy flexible buildings. For example, real-time energy pricing is possible in Denmark if the supplier offers this service. This gives customers an opportunity to participate in the Nordic spot market. Demand response is however still hard to implement. Electricity suppliers can become an aggregator or they can outsource this service. To be a third-party independent aggregator, the company needs to register as a Balance Responsible Party (BRP) or be in a contractual relationship with one. The Danish Public Service Obligation (PSO) tax (in the Electricity price) will be fully removed from the electricity price in 2022. Furthermore, the Danish government wants to reduce the electricity levy by almost one third. These incentives reduce the electricity price and create incentive for the electrification based on renewable energy. The stabilisation of the energy system against fluctuating imbalances requires the storage for wind, solar and other renewable energy. However, it is difficult to store energy without a significant loss. To improve the utilization of energy flexibility service in Denmark, the Danish government has agreed to spend 130 million kroner (17,50 million euro) on large-scale energy storage projects (Copenhagen Capacity, 2018)[5].

Energy flexbility strongly relies on digital solutions for real time data, function markets and available control systems. The Danish energy agreement of 2018 underlines the objective to increase the utilisation of data and digital solutions and create a smart energy system (Energi-, Forsynings- og Klimaministeriet, 2018)[6]. Meanwhile, smart meters will be rolled out to all consumers by 2020 in Denmark, and it will enable consumers to participate in the energy markets through aggregation.The current Italian regulation (National Decree n.28/2011: MED, 2018) requires that all new buildings and major interventions integrate renewable energy sources, to cover at least 50 % of the yearly energy consumption for heating, domestic hot water preparation and cooling. Coupled with the national Plan for uptake of nZEBs (National Decree 06/2017: MED, 2017), this fosters the diffusion of distributed energy production systems. Like in many countries, feed-in revenues are given to building users according to the amount of energy delivered and the installed power, without consideration of the daily energy production, seasonal variations or stress caused on the energy grid. The optimisation of the energy use through energy flexibility, which is potentially allowed by the law, is thus not fostered by the Net metering Scheme and not widely applied. Overall it can be remarked that most regulatory schemes based on the one-to-one consumption model (i.e. self-consumption) do not allow for the introduction of aggregation models for enabling energy communities and energy flexibility at cluster scale (Chiaroni et al., 2018). Future schemes might allow for a more open energy market, since the National Regulation Authority for Energy, Grid and Environment has recently launched a series of pilot cases for implementing different aggregation models, to test the effectiveness and the potential impact on the market (ARERA, 2018). The Observatory of Storage Systems[7] highlights that currently the installation of batteries occurs in the 2.6% of the installed photovoltaic system. This is fostered by the regional contributions allowing for a non-repayable funding of 50% of the installation costs (towards a maximum amount of 3000 €). At national level, there is the will to establish an incentive framework to reach the objective of reaching 6000 MW storage by 2030.

In The Netherlands, the knowledge and innovation agenda TKI Urban Energy (2015) defines a Dutch vision for 2016-2019 for developing innovations for solar energy supply, heat and cold, energy saving, integration and intelligent control of energy systems in the built environment. Amongst others, it suggests to abandon the classical energy supply and demand system in favour of central renewable energy production (wind, hydro, large solar and bio-energy), connected local renewable energy production, energy storage using heat, cold, and electricity (also in vehicles), data management and control, and smart grids that offer variable rates and tariffs. From 1st July 2018, the Dutch Government abandoned the obligation of a gas supply connection for (small) new buildings (WetVET, 2018). The government is currently submitting a national climate agreement which might lead to an increased need for electricity for electrical vehicles and for heating of buildings (instead of gas). It can thus be expected that the need for energy flexibility (policies) will grow.

In Spain, the Ministry for the Ecological Transition developed the National Integrated Plan for Energy and Climate 2021-2030 (PNIEC, 2019) which, besides describing various initiatives for supporting energy efficiency measures in buildings, also introduces obligations and economic incentives for reaching a net zero energy label for buildings (obligation for new public buildings since 12/2018; for all new buildings since 12/2020). Supporting research and innovation should focus on the flexibility and optimization of the different sources, including topics such as demand participation in the system operation, and the needed investment in national industry developing the enabler technologies. A second relevant initiative is the new regulation for self-consumption and energy communities, launched in 2019, which enables and promotes the installation and sharing of PV and storage solutions (IDAE, 2019). Self-consumption regulation allows the installation of electrical storage systems to decrease contracted maximum power and demand peaks by means of storing the local generated PV surplus and using it when needed, energy arbitrage is not directly regulated neither forbidden. Additionally, this regulation facilitates the energy communities creating an aggregator agent, as well as the changes needed in the electricity market for enabling demand response. A public consultation will be launched by the Iberian Market Operator.

In July 2017, the UK Government published the "Upgrading Our Energy Systems: Smart Systems and Flexibility Plan" with the plan itself aiming to: remove barriers to smart technologies, including energy storage systems; enable smart

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[5] Copenhagen Capacity (2018), Denmark ready to fund large-scale energy storage projects, Copenhagen, Denmark, https://www.copcap.com/newslist/2018/denmark-ready-to-fund-large-scale-energy-storage-projects

[6] Energi-, Forsynings- og Klimaministeriet (2018), Copenhagen, Denmark, Denmark's Draft Integrated National Energy and Climate Plan, https://ens.dk/sites/ens.dk/files/EnergiKlimapolitik/denmarks_draft_integrated_energy_and_climate_plan.pdf

[7] Observatory of storage systems (Italy) https://anie.it/osservatorio-sistemi-di-accumulo-dati-al-31-marzo-2019/?contesto-articolo=/sala-stampa/comunicati-stampa/#.XbaskH97mUk

homes and non-domestic buildings (referred to as 'businesses'); and to create markets that allow for and incentivise energy flexibility (HM Government, 2017). This plan aimed to provide access to fair financial returns for providers engaged in flexibility services such as storage or demand side response (DSR). This was followed up by a 2018 progress report entitled "Upgrading Our Energy Systems: Smart Systems and Flexibility Plan: Progress Update." (HM Government, 2018) Both reports included a range of cases studies that provided practical examples of initiatives and have led to initial market uptake of energy flexibility.

Amongst others, the installation of smart meters in buildings, which provide the basis for consumers to participate in a half-hourly market, has been relatively successful in the UK. Also, the Electricity System Operator (ESO) has committed to receiving 30-50 % of competitive tenders from demand side flexibility by 2020; in the first 12 months that this was active, a 50 % target was met every month, with some months exceeding this target. This has also been supplemented by commitments to provide access to the balancing mechanism, including the EU Trans European Replacement Reserves Exchange (TERRE) and simplifying metering requirements for the capacity market, which includes storage and demand response systems (HM Government, 2018). At a distribution network level, efforts have been made to open up existing markets. Distribution Network Operators (DNOs) have already issued tenders for flexibility focused network issues. This is part of a move towards DNOs becoming Distribution System Operators (DSOs) with more active control of their networks; this has been underpinned by with the Government restricting the operation of generation (including storage) by existing DNOs, to avoid any conflict of interest (HM Government, 2018). Aggregators will play a key role in the development of flexibility markets, especially at a domestic level, and their access to the market has been opened through changes made to the UK Balancing and Settlement Code (BSC) and the Grid Code, allowing Aggregators access to the Balancing Mechanism (HM Government, 2018). The Association of Decentralised Energy has developed a voluntary code of conduct for Aggregators, who are currently only operating in the large consumer market (Association of Decentralised Energy, 2018).

European buildings are thus becoming active players in the energy market due to policy changes, and are expected to play a key role in solving energy demand and supply issues, using solutions that provide better energy efficiency, energy storage, demand response or shift in energy source. European countries advance their energy and building policy, but mainly rely on the market to develop energy flexibility services. Besides the country differences for policy implementation and widespread adoption, the supply sector is also challenged to organize demonstrations and business models. The next section discusses barriers and opportunities as observed by market frontrunners.

5. Experiences from service development for energy flexible buildings

Workshops (see addendum), interviews and field notes regarding energy flexible buildings realized in the period 2015-2019 were analysed to better understand why and how energy demand stakeholders, and intermediaries between energy supply and demand, engage in providing energy flexibility services to grid operators and what they perceive as main policy-related problems. Most business development examples were found in the retail industry, and for energy service companies and aggregators. While research can provide a lot of examples of emerging strategies being tested in the market, the following describes what type of energy flexibility services were sustained after testing and monitoring.

Retail industry

It was found that some retailers are willing to participate in the implicit demand response by energy control of their buildings. For example, one Dutch (retail) store made a (temporary) contract with the local distribution net manager and now provides energy flexibility to the electricity network. The underlying motive for the energy network manager was that the existing grid management experienced difficulties to provide sufficient capacity on time in an urban area where new construction was already planned: to avoid investing in grid reinforcement the network manager wanted to introduce energy flexibility in collaboration with neighbouring companies. They found a retail store that, at an agreed cost, now provides energy flexibility by storing energy in batteries or temporarily lowering freezing temperatures. The collaborating stakeholders did not find a solution to enforce limitation of energy use, neither did they find a legal way to share risks in grid operation. Similar examples were found in other countries.

Overall, influencing factors for retailers to participate in the demand response are related to, for example, whether the demand response participation matches the company goals, influences business operation, and whether retail industry lacks related knowledge (Ma et al., 2019). By the comparison between Denmark and the Philippines, Ma et al. (2019) also found that there are cultural differences regarding the energy control preferences and concerns in retail industry, but there were no significant differences regarding the employees' and customers' engagement.

Energy service companies (ESCOs)

Some companies, for example in Austria, offer flexible or "floating" energy tariffs, which are hourly, daily or monthly adjusted. For a flexible hourly tariff, there are 24 new prices per day, based on a detailed weather forecast and determined the day before on the stock exchange. Other, innovative models, introduce a shared "energy community" for private PV system operators, in which they can self-consume PV power, but also store surplus energy to consume it later without additional costs, except for a "community charge." Often this requires the companies to establish joint ventures between local or regional utilities (electricity grid operators and producers) or to enlarge their services also to other branches, e.g. contracting of energy plants, energy saving contracting or energy auditing.

A few bigger companies offer all-in-one "energy contracting" for heating and cooling, including electricity supply using their own tariff models. In the last ten years, companies offering different smart grid services for both power and district heating, for example in Denmark, have evolved with services like forecast-based, user adaptive and self-learning control systems, using swarm control to forecast load and flexibility. A lot of these companies offer comfort automation systems along with their other service products.

In Spain, ESCOs devoted to public building management are participating in research projects to learn how to manage and implement measures that enable demand side participation in the energy systems, mainly based on existing PV installations with potential surplus (REFER, 2019). Some joint actions between ESCOs and Distribution System Operators have been presented to the public energy communities' call to test new services and business models under the energy market operator (OMIE) guidelines.

Aggregators

Related to policy, the market for aggregators develops at different speeds in different countries. In some countries aggregators already exist in the balancing market. European aggregators base their activity mainly on industry or tertiary buildings. In The Netherlands, an aggregator, a car company and a power electronic company have built up a system based on PV panels and second life EV batteries which will perform peak shaving during high demand events at a large event location and will offer frequency regulation services when not providing these functions.

Perceived barriers are different in different countries i.e. in the Austrian wholesale market no aggregators are seen yet, though demand response could access the EPEX day-ahead market in principal. The individual load in an aggregator pool must be prequalified separately for each consumer, which makes the process inconvenient. Furthermore, all consumers need to install an expensive phone line to participate in the balancing market. All this increases the cost for each consumer's participation, and the process leads to a reduction of the pool size. An independent third-party aggregator needs to be contracted with the BRP/supplier.

In the UK relatively more aggregators actively participate in the energy system. UK customer surveys show that the main motivation for participating in demand services through an aggregator is to generate incomes from existing assets such as backup generators, CHP or renewable generation, and the main stoppers for doing so are insufficient rewards and regulatory uncertainty.

Overall, the aggregators are confronted with numerous regulatory barriers. On the one hand, contract signature management can cause competition issues (when retailers or energy service companies are involved) or administrative complications (caused by the high number of contracts to be signed with different stakeholders). On the other hand, the energy systems and markets lack regulation on the share of unbalance costs, their market rules conflict with those for grid operators when activating balancing services, and the technical requirements for providing these services (historically defined for traditional generation plants) are preventing the development of the aggregator business model (Ma et al., 2019).

Schultz (2019) showed that the aggregators' roles and responsibilities must be clearly defined and standardized to create the business opportunities for energy flexible buildings. A single but potentially useful demand response service product cannot succeed unless the market is well-functioning across all parts of the value chain. Market conditions enabling explicit demand response in the electricity markets are needed; electrification and sector coupling is necessary to improve the economic benefit of demand response; the electricity prices should reflect the market price and grid conditions by introducing different tariff models, removing or lowering taxes. A challenge is to aggregate different flexibility providers (loads and/or Distributed Energy Resources (DER)), allowing aggregators to participate in different electricity markets (Behrangrad, 2015).

6. Discussion

Overall the number of cases found where energy flexibility was introduced in services for buildings was very low. Only a few buildings were detected where users kept energy flexibility in operation after simulation and testing. One can speculate if this might be due to energy savings not being realized, cost savings being too low or presented customer values being unattractive. A reoccurring issue is that most introduced business models are still experimental and that in countries where policy facilitates the introduction of energy flexible solutions, the market niche appears sooner.

So far the introduction of energy flexibility policy initiatives has led to commercial service development mainly in the retail sector, and for energy service companies and aggregators. New market players have appeared that offer energy contracting, balancing services or demand response services to building stakeholders such as retailers, as well as district stakeholders, such as energy communities. Energy service companies are well positioned to create an entry to control building devices and heating systems. The aggregator role can be undertaken by different stakeholders. For instance, in some demand response markets, the existing market players, as supplier and BRP, undertake the role as an aggregator, and independent aggregators are allowed in some countries (Schultz, 2019). Nowadays, few energy markets are open to demand aggregator participation but in the countries where it is allowed, different companies are starting their activity offering flexibility to the system operators.

As not many energy flexible buildings and related commercial service models have been realised to date, it is helpful at this stage to consider additional findings from social studies (Li et al., 2017; Ma et al., 2019), reflecting how different users perceive the need for energy flexible buildings. Researchers expect, for example, that a large part of the buildings' energy demand - related to the use of space heating or cooling, ventilation, hot water production and use of electrical appliances - can be shifted in time or stored temporarily or seasonally. Legally, a user should be allowed to use the full capacity of its energy grid connection.

In theory, besides retail and commercial buildings and districts, other stakeholders might become important in the framework of the EU vision on the energy consumer. This provides opportunities for developing new business models including non-industrial consumers such as building owners and occupants, building, facility, asset and energy managers, consultants and suppliers. A summary of relevant stakeholders' motivations and barriers for developing business models can be found in the report developed by Ma et al. (2019).

The direct involvement of end users in energy flexible buildings appears to be difficult. Users tend to place the responsibility for the distributed energy system transitions on the national government and large energy supply utilities, and households still seem to lack willingness to invest in new distributed energy infrastructures (Seidl et al., 2019). IEA EBC Annex 67 results also show that introducing energy flexibility can disrupt occupant lifestyles, building systems for thermal comfort and health, as well as potentially increase cost or energy consumption, and that stakeholders need to be adequately informed to support energy flexibility solutions and change behaviour (Ma et al., 2019). An important barrier for building stakeholders is that energy flexibility IT and control strategies and services are designed and installed related to building and urban characteristics, expected grid flexibility gains, the spot market and daily market, expected occupancy and changing climate conditions, which is a labour-intensive development process that requires input from multiple stakeholders. The process can be particularly discouraging for innovators when even basic facilities such as digital meters and building energy management systems are not yet installed in buildings or configured to communicate with network control systems or other buildings.

Most stakeholders still lack knowledge about how to make their buildings suitable for demand response services. Also, innovative (decentral) energy production at the level of communities or groups of buildings poses specific additional challenges to centralized energy provision (Seyfang and Haxeltine, 2012). Another important challenge is to develop knowledge exchange between stakeholders using a network of innovators and international know-how from demonstration projects (Mlecnik, 2016).

Overall, energy network managers see opportunities to collaborate with other stakeholders to realise energy flexible buildings because this can reduce their investment in the networks by load levelling and load shifting. When introducing more renewable energy sources, demand side management also becomes crucial to guarantee the reliability of the grid. However, their vision development and learning can be hindered by slow or non-existent policy development regarding the promotion of renewable energy sources and demand side management.

The participation of other stakeholders in demand response services can be stimulated by their sustainability motives, but is often limited by a lack of stakeholders' knowledge and legal framework. Furthermore, energy flexible solutions still often have to be designed per building, which can be demotivating due to high costs for planning and renovation. The prospect of financial savings can be the most motivating factor for engaging energy consumers with either smart tariffs or appliances, with younger people, people in higher social grades, and larger households most likely to engage in energy flexible behaviour (HM Government, 2016; HM Government, 2017). However, in most countries energy tariffs are still fixed, which doesn't allow energy cost reduction when shifting energy loads.

The research presented here analysed policy development and frontrunner business development for energy flexible buildings and gives a more holistic perspective of policy needs. The following Table 1 gives on overview of the main detected political, economic, social, technological, legal and environmental (PESTLE) factors that can influence future policy development for supporting the adoption of energy flexibility services.

[Table 1: PESTLE-factors for the market development of energy flexibility services.]

Summarizing, both the policy and the market structure need to be redesigned for aggregators and energy prosumers (individuals and communities) to take part effectively in the energy market. The requirements and regulations for providing energy flexibility to the grid are still too complicated and too focused on traditional energy providers. There is however a good indication that the policy measures introduced in frontrunner countries such as the UK, Austria and Spain are beginning to create opportunities across the markets for energy flexibility to become a viable business opportunity.

7. Conclusion and Policy Implications

This research analysed the current development of the market for energy flexible buildings and supporting policies in seven European countries, covering the policy landscape development and the already developed business opportunities for energy flexibility services identifying the niche development, and discussed the observed opportunities and barriers for stakeholders.

European policy development in the field of energy flexible buildings is slow and appears to be following market development and positive stakeholder confirmation. While some countries do not aim to go beyond European Directives, others are paving the way for experimentation and energy transition with more ambitious policy initiatives. As each country has a different view on the needed policy development, networking policy makers, and cross-comparing and combining policy results can be an interesting way forward to support further European development.

Compared to the technical and environmental opportunities, the market development of energy flexibility services is slow and in many countries this is because the policy does not sufficiently support the development of energy flexibility and demand side services yet. From analysing the frontrunner policies it can be expected that policy development related to increased renewable energy production, energy consumer and energy community empowerment, increased use of electrical equipment and cars, and legal frameworks for the development of virtual power plants and smart grids can push the energy flexibility market.

The niche development for energy flexibility services depends on a lot of stakeholders with different perceived needs and innovation trajectories show multiple technical, social, legal and market barriers where energy policy might play a role to facilitate the introduction of services for achieving energy flexible buildings and districts. It is unlikely that energy flexible buildings and districts can be widely introduced at this stage without revision of the policies for energy distribution networks to allow new market players to benefit from energy flexibility.

There are relatively few buildings that already operate using energy flexibility services and most of these buildings offer energy flexibility on a temporary basis. In most countries there is no clear road map yet for how the strategic niche for energy flexible buildings should be developed or proceeded. Stakeholders call for policy improvement, especially concerning the development of flexible energy tariffs, supporting incentives, awareness raising and more stakeholder-targeted business development. The research shows that there is a need for supporting continued vision formation, stakeholder collaboration and networking, testing new business models, and learning from innovators and demonstration projects.

At this moment, it is important that policy makers, businesses and users continue testing multidisciplinary innovation pathways. Particularly, there appears to be a need to support better business models for achieving long-term energy flexible buildings and districts beyond experimentation, and increased customer value to convince different types of stakeholders of its benefits. If building or community stakeholders are not interested in delivering energy flexibility to the surrounding energy grids, it is unlikely that in the long term buildings can be regarded as flexibility assets for the energy networks.

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Appendix: list of key workshops in seven countries

CLIMA 2016 workshop: Grid-Supportive Buildings - Opportunities and Challenges. Aalborg, Denmark, May 2016.

The evolution of buildings: from the NZEB target towards energy flexibility. EREC & Annex 67 Seminar, Bolzano, Italy, October 2016.

Energy Flexible Buildings - Potential and Performance. Vienna, Austria, September 2017.

Energy Flexibility in buildings: a key asset in the future energy system. Barcelona, Spain, March 2018.

Urban Energy Innovation. Delft, The Netherlands, May 2018.

European Sustainable Energy Week workshop. Brussels, Belgium, June 2018.

FlexForward. Den Bosch, The Netherlands, June 2018.

Urban Energy Platform event. Delft, The Netherlands, May 2019.

European Sustainable Energy Week workshop. Brussels, Belgium, June 2019.

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