IEA EBC Annex 67

Aggregation potential related to business models

A technical report from IEA EBC Annex 67 Energy Flexible Buildings

Aggregation potential related to business models

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Preface

The increasing global energy demand, the foreseen reduction of available fossil fuels and the increasing evidence of global warming during the last decades have generated a high interest in renewable energy sources. However, renewable energy sources, such as wind and solar power, have an intrinsic variability that can seriously affect the stability of the energy system if they account for a high percentage of the total generation.

The Energy Flexibility of buildings is commonly suggested as part of the solution to alleviate some of the upcoming challenges in the future demand-respond energy systems (electrical, district heating and gas grids). Buildings can supply flexibility services in different ways, e.g. utilization of thermal mass, adjustability of HVAC system use (e.g. heating/cooling/ventilation), charging of electric vehicles, and shifting of plug-loads. However, there is currently no overview or insight into how much Energy Flexibility different building may be able to offer to the future energy systems in the sense of avoiding excess energy production, increase the stability of the energy networks, minimize congestion problems, enhance the efficiency and cost-effectiveness of the future energy networks. Therefore, there is a need for a increasing knowledge on and demonstration of the Energy Flexibility buildings can provide to energy networks. At the same time, there is a need for identifying critical aspects and possible solutions to manage this Energy Flexibility, while maintaining the comfort of the occupants and minimizing the use of non-renewable energy.

In this context, IEA EBC Annex 67 Energy Flexible Buildings was started in 2015 with the aim of gaining increased knowledge on the benefits and services the utilization of the Energy Flexibility in buildings may provide to the future energy networks. The present report is one among several outputs from IEA EBC Annex 67. For further information, please visit http://www.iea-ebc.org/projects/ongoing-projects/ebc-annex-67/.

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Summary
Buildings as prosumers have an important role in the energy aggregation market due to their potential flexible energy consumption and distributed energy resource. However, energy flexibility provided by buildings can be very complex and depend on many factors. The immaturity of the current aggregation market with unclear incentives is still a challenge for buildings to participate in the aggregation market. However, little literature has investigated business models for buildings' participation in the aggregation market.

Therefore, this report develops four business models for buildings to participate in the energy aggregation market: 1) buildings participate in the implicit DR program via retailers, 2) buildings with small energy consumption participate in the explicit DR via aggregators, 3) buildings directly access the explicit DR program, 4) buildings access energy market via VPP aggregators by providing DERs.

This study also finds that it is essential to understand building owners' needs, comforts, and behaviors to develop feasible market access strategies for different types of buildings. Meanwhile, the incentive programs, national regulations, and energy market structures strongly influence buildings' participation in the aggregation market. Under the current Nordic market regulation, business model 1 is the most feasible one, and the business model 2 has more challenges due to the regulatory barriers and limited monetary incentives.

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1. Introduction

The aggregation potential is mainly dependent on the market framed by different business models. This report aims to investigate 'given *different business models* for trading energy flexibility, what is the *energy flexibility potential* for *energy service aggregators* and *its impact on market exploitation?*'

To answer the research question, three objectives are discussed in this report:

- The current electricity market with an example of the Nordic electricity market
- The existing business models (demand response (DR) and virtual power plants (VPPs)) are introduced with the discussion of the stakeholders and their values
- The business model development for buildings' participation in the aggregation market

Four business model canvases are developed to explore the aggregation potential for buildings with different values and in different scenarios:

- Buildings participating in the implicit DR via retailers
- Buildings (especially small energy consumers) participating in the explicit DR via aggregators
- Buildings (large energy consumers) directly access the explicit DR program
- Buildings access the energy market via VPP aggregators by providing DERs (distributed energy resources)

This report conduces suggestions to encourage buildings to participate in the aggregation market, based on the SWOT& TSOW analysis for these four business model canvases.

2. Existing electricity markets

This section introduces the existing electricity market with the example of the Nordic electrify market. The electricity market of the Nordic countries is comprised of a wholesale market and a retail market. All Nordic countries' wholesale market is an integral part of the free Nordic electricity market. EU authorities have supported liberalization in order to stimulate free competition in electricity production and trade. The wholesale market trades via the power exchange Nord Pool, which facilitates trade between producers and traders[1]. The structure of the wholesale market is shown in Figure 1.

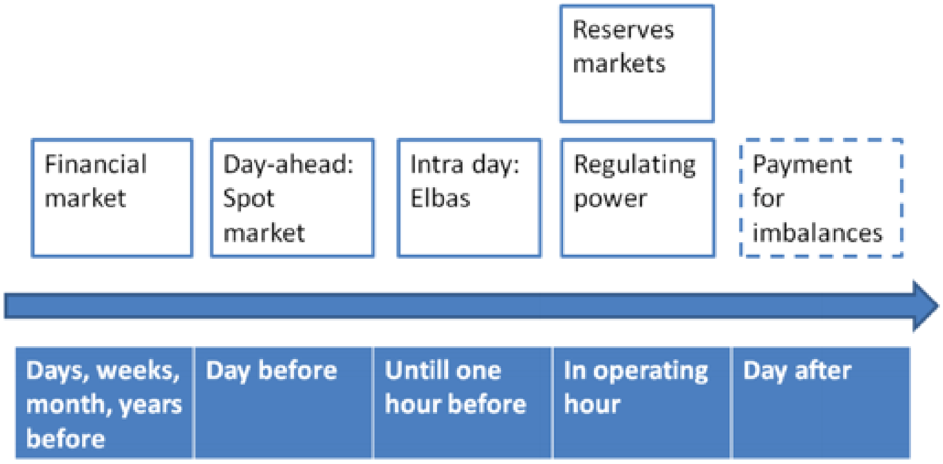

Figure 1. Nordic market structure [2]

The Nord Pool market is owned by the transmission system operators (TSOs) in the Nordic countries. There are two electricity marketplaces in the Nord Pool power exchange, namely Elspot (Day-ahead) and Elbas (Intra-day), and a regulating power market[3]. Nord Pool market uses the concept implicit auction where all trade between bidding areas must take place via Nord Pool[4].

2.1 Day-ahead markets (Elspot) [5]

The day-ahead market is an auction where power is traded for delivery during the next day. The players place their orders, hour by hour. Players can put their orders up to twelve days ahead, while the gate closure for the orders with the delivery next day is 12:00 CET. When all players have submitted their orders, the equilibrium between the aggregated supply and demand curves is established for all bidding areas. The system and area prices are calculated and published at 12:42 or later with a four-minute notice. Settlement of all orders in the day-ahead market is based on area prices.

- System price: Calculated based on the sale and purchase orders disregarding the available transmission capacity between the bidding areas in the Nordic market. The system price is the Nordic Reference price for trading and clearing of most financial contracts.
- Area price: The day-ahead market is divided into several bidding areas. The available transmission capacity may vary and congest the flow of electrical energy between the bidding areas, and thereby different area prices are established.

[1] http://www.energinet.dk/EN/El/Engrosmarked/Sider/default.aspx
[2] http://www.ea-energianalyse.dk/reports/1027_the_existing_nordic_regulating_power_market.pdf, page 10
[3] http://www.energinet.dk/EN/El/Engrosmarked/Sider/default.aspx
[4] Energinet.dk: Principles for the energy market, Regulation A, 2007. Rev. 1, page 6
[5] http://www.nordpoolspot.com/TAS/Day-ahead-market-Elspot/

Trading is based on three different types of orders: single hourly orders, block orders, and flexible hourly orders. The members can use any one or a combination of all three-order types to meet their requirements.

Trade via Elspot has the following time schedule[6]:

- Every day by 10:00, the Nordic transmission system operators make guaranteed transfer capacity between the bidding areas available to Elspot for the following day of operation.
- 12:00 noon is the players' bidding deadline for trade in electricity for the following day of operation (buying and selling bids).
- Subsequently, Nord Pool calculates the price. Initially, Nord Pool adds up all the buying and selling bids arriving at the price (system price) that strikes a balance between purchase and sale in the whole area. If sufficient transfer capacity between the areas is available, a common market price equal to the system price will become effective in all the areas. However, this is seldom the case.
- In situations of insufficient transfer capacity (congestion), the Nordic countries are divided into different price areas (market splitting). A price area may comprise one or more bidding areas. A bidding area's price is called the area price.
- At 13:00, Nord Pool announces the traded volumes and prices for the following day of operation.

2.2 Intraday markets (Elbas)[7]

Nord Pool offers an intraday market covering the Nordic, Baltic, UK, and German markets. The intraday market supplements the day-ahead market and helps secure the necessary balance between supply and demand in the power market for Northern Europe.

The majority of the volume handled by Nord Pool is traded on the day-ahead market. For the most part, the balance between supply and demand is secured here. However, incidents may take place between the closing of the day-ahead market at noon CET and delivery the next day. E.g., a nuclear power plant may stop operating in Sweden, or strong winds may cause higher power generation than planned at wind turbine plants in Germany. At the intraday market, buyers and sellers can trade volumes close to real-time (i.e., hour of delivery) to bring the market back in balance.
Trading close to real-time: At 14:00 CET, capacities available for Nord Pool’s intraday trading are published. This is a continuous market, and trading takes place every day around the clock until one hour before delivery. Prices are set based on a first-come, first-served principle, where best prices come first – highest buy price and lowest sale price.

Increasingly important: The intraday market is becoming increasingly important as more wind power enters the grid. Wind power is unpredictable by nature, and imbalances between day-ahead contracts and produced volume often need to be offset.

2.3 Reservation and Regulating Power Markets

The reservation market is a supplement to the regulating market. Resources can receive a payment for being present in the regulating power market. Electricity production and consumption always have to be in balance, and after the close of the Elbas market, 45 minutes before the operating hour, the task of balancing the two is left to Energinet.dk. It maintains this balance via the regulating power market and other markets for automatic reserves.

Reserve capacity is production capacity or consumption offered in advance by the balance responsible parties to Energinet.dk's disposal in return for an availability payment. Energinet.dk

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[6] Energinet.dk: Principles for the energy market, Regulation A, 2007. Rev. 1, page 6
[7] http://www.nordpoolspot.com/How-does-it-work/Intraday-market/

buys various types of reserve capacity, and these types of capacity differ with respect to response rate etc. The term "ancillary service" is a general term for the reserve capacity bought by Energinet.dk in order to ensure a reliable and efficient operation of the electricity system[8].

To anticipate the excessive use of automatic reserves and in order to re-establish their availability, regulating power is utilized. Regulating power is a manual reserve. It is defined as increased or decreased generation that can be fully activated within 15 minutes. Regulating power can also be the demand that is increased or decreased. Activation can start at any time and the duration can vary[9].

The Nordic regulation market differs from the markets at Nord Pool. The Nord Pool markets are organized as a common marketplace with common member agreements and bidding rules. The Nordic regulation market (or regulation list) on the other hand is a compilation of bids given to the national balancing marketplaces i.e. TSOs under rules and agreements set by the TSOs. This can make monitoring of the market more complex. The Nordic regulation market has some Nordic rules given in the Nordic system agreement, but the rules forbidding and payments are primarily given in the national balancing markets, and they may differ[10].

In the Nordic countries, there is a common regulating power market managed by the TSOs with a common merit order bidding list. The balance of responsible parties (for load or production) make bids consisting of the amount (MW) and price (DKK/MWh). All bids for delivering regulating power are collected in the common Nordic NOIS-list and are sorted in a list with increasing prices for up-regulation (above spot price), and decreasing prices for down-regulation (below spot price). These bids can be submitted, adjusted, or removed until 45 minutes before the operation hour. In Denmark the minimum bid size is 10MW, and the maximum is 50 MW. The Elspot price, meanwhile, represents the minimum price for up-regulating power bids and the maximum price for down-regulating power bids. Taking into consideration the potential congestions in the transmission system, the TSO manages the activation of the cheapest regulating power.

The Regulating power market is where production capacity or consumption is offered by the market players to Energinet.dk (TSO), during the actual day of operation. Through their respective BRPs, producers submit bids for increased production (upward regulation) or reduced production (downward regulation) to the common Nordic regulating power market (shown in Table 1). It is up to the individual players if and when they choose to be active on the regulating power market, given they have not concluded an agreement about reserve capacity with Energinet.dk.[11]

Table 1. Definition of up and down regulation

	Generation	**Demand**
Up-regulation	Increase	Reduce
Down-regulation	Reduce	Increase

The balance responsible forwards bids for upward and downward regulation, stating the volume offered in MW and the price of activating the power DKK/MWh. The regulation power market levels the imbalance (transfer capacity is allocated concurrently with electricity being traded) that might occur in the day-ahead and intraday markets.[12]

[8] http://www.energinet.dk/EN/El/Engrosmarked/Viden-om-engrosmarkedet/Sider/Reserver-og-regulerkraft.aspx
[9] http://www.ea-energianalyse.dk/reports/1027_the_existing_nordic_regulating_power_market.pdf
[10] http://www.nordicenergyregulators.org/wp-content/uploads/2013/02/monitoring-2007.pdf
[11] Energinet.dk: Principles for the energy market, Regulation A, 2007. Rev. 1, page 7
[12] http://www.energinet.dk/EN/El/Engrosmarked/Viden-om-engrosmarkedet/Sider/Reserver-og-regulerkraft.aspx

3. Existing business models for trading flexibility in energy generation and consumption

Today flexibility in generation and consumption is traded in the markets described in section 2. This section firstly describes the stakeholders participating in the building energy flexibility, and then the existing business models (demand response and virtual power plant) are introduced to understand the aggregation potential for buildings and the relationships across stakeholders in the energy aggregation market.

3.1 Stakeholders

This section lists and discusses the interest of different stakeholders (building facility manager, ESCO, DSO, Local authority, etc.) in accessing building energy flexibility (shown in Table below).

Table 2. Stakeholders participating in the energy flexibility in buildings

Stakeholder type	Description
Investors	The term refers to organizations or people who finance the construction process. Provide capital for the retail stores/supermarkets with the expectation of financial return. Investors participate in the energy efficiency incentive programs in collaboration with the government and other stakeholders [1].
Property / real estate owners	The terms refer to organizations or people who own property or real estate. For commercial and industrial buildings or some residential buildings, they collaborate with the design teams for the designing of the energy efficient and flexible buildings with related technologies [2].
Real estate developers	Real estate developers are companies or people who coordinate the renovation and re-lease of existing buildings to the purchase of raw land and the sale of developed land or parcels to others.
Construction clients	The term construction client refers to the organization or individual that is procuring the building development.
Construction client advisors	The term construction client advisor refers to the consultant firm or individual consultant that advises a construction client.
Architects	The term Architect refers to the firm or individual who plans, designs, and reviews the construction of buildings.
Consultants	The term consultant refers to an engineering company or an individual engineer who provides services as part of the building construction process.
Contractors / builders	A contractor/builder is a company or person that performs work on a contract basis.
Suppliers	The term refers to suppliers of building materials and technology
Building managers	The term refers to the function of overseeing employee and visitor safety, building maintenance, repair and upgrades, and comply with environmental, safety and health procedures. On the other hand, building managers [3] are responsible for energy management practices in buildings and manage the building operation [2].
Facility managers	The term refers to the business function concerned with the successful and profitable maintenance, operation, and monitoring of buildings or properties.
Tenants	The term refers to the organization or individual who rent a building.
Occupants	The term refers to a person or group that resides in or uses a physical space of a building.

Transmission system operator (TSO)	Owns and runs the transmission grid (>100 kV). The TSO is responsible for the security of supply of the electricity system, including the safeguarding of the physical balance, and for the drawing up of market rules that will ensure a well-functioning electricity market[13,14.] The only TSO in Denmark is Energinet.dk.
The Grid company/Distribution System Operator (DSO)	Owns and runs the distribution grids (<100 kV). Their primary task is to deliver electricity to customers. They must ensure valid measurements for settling production and consumption.[15]
Balance Responsible Party (BRP)	Buys and sells electricity in the wholesale market and settles with the "imbalance settlement responsible". The role as balance responsible party is a collective term for the balance responsibility found in the market: Production Responsible: Responsible for any imbalance between electricity sold and produced for all associated metering points. Trade Responsible: Buys and sells electricity. Must ensure balance before the notification and schedule phase ends. Consumption Responsible: Responsible for any imbalance between electricity bought and consumed for all associated metering points. [16] The BRPs operate freely on commercial terms in the power system and have a formal legal role and are responsible for supplying the expected and reported products in the electricity markets. [17]
Electricity Producer	Generates electricity and sells it prior to the delivery hour to the electricity suppliers/retailers or to Nord Pool. In the actual delivery hour, the producer sells electricity to/from the transmission system operator on the regulating power market, managed by the Energinet.dk[18]
Electricity Supplier/Retailer	Buys electricity from the producer, from Nord Pool or from another supplier/retailer, and resells it to the end customers. They are reconciliation accountable. [19]
Electricity Customer	Maybe private, commercial, or industrial electricity customers - with or without their own local production.[20]
Governments or regulators	Involve in planning and developing energy policies [2], regulate energy rules that shape the future energy systems (e.g. Department of Energy)[1]. For example, Danish Energy Regulatory Authority (DERA) monitors and publish energy prices to ensure transparency on energy market [4].
Local communities	Refer to group of people or individuals [5] in the society, and involve in different community programs (e.g. incentive energy efficiency program) [1].
Third-party private operators	Collaborate with the building owners in the renovation of building design, energy development, and energy production. Third-party private operators consist of remodeling specialists, energy development consultants, energy engineers and energy researchers. Remodeling specialists

[13] Energinet.dk: The Danish role model, Regulation F: EDI communication. Rev. 1, page 6
[14] Smart Grid in Denmark 2.0, page 12
[15] Smart Grid in Denmark 2.0, page 12
[16] Energinet.dk: The Danish role model, Regulation F: EDI communication. Rev. 1, page 4
[17] Energinet.dk: The Danish role model, Regulation F: EDI communication. Rev. , page 6
[18] Energinet.dk: Principles for the energy market, Regulation A, 2007. Rev. 1, page 4
[19] Smart Grid in Denmark 2.0, page 12, 14
[20] Smart Grid in Denmark 2.0, page 12

	[5] involve in the building renovation or redesign. The development consultants [5] are independent contractors who are hired by an organization to develop effective energy management plans. On the other hand, energy engineers [5] involve in the energy production and are also involved in energy equipment design and selection. Energy researchers [6] are usually approached by companies to conduct energy-related research.
Market operators	Manage the wholesale market operation (e.g. providing wholesale price signals [4] and bidding).

3.2 Existing Business models

This section presents the two aggregation models that provide flexibility in the electricity system: Demand Response (DR) and Virtual Power Plants (VVP).

3.2.1 Demand Response

DR is defined by the European Commission as "*voluntary changes by end-consumers of their usual electricity use patterns - in response to market signals*"[7]. It is a shift in electricity usage in response to price signals or certain request [8],[9],[10],[11],[12].

DR motivates consumers to participate in generation-load balance [13], [14]. DR reduces peak load, electricity cost and improves system reliability [15],[16],[17],[10]. Grid operators and energy suppliers can utilize DR to compensate for the uncertainty behavior of renewable resources [12], [17]. DR also reduces carbon emission and provides financial benefits to consumers [12].

Electricity consumers (commercial, industrial and residential) can participate in the energy-load balance through DR [18]. Controllable appliances in buildings that contribute to DR include HVAC and other home appliances (e.g. dishwashers, dyers, and freezers) [17],[9] and energy storage (e.g. batteries of electric vehicles, heat pumps and refrigeration)[11].

The engagement of demand response depends on consumer behavior. DR is well established in countries like the USA [19]. However, the level of the DR penetration in Europe is low because the majority of consumers are unaware of the DR benefits [19] and do not have access to the DR services [12]. In addition, inefficient ADR (automatic DR) and the lack of knowledge about consumers behavior [28] are the main barriers to the DR market [17]. Furthermore, privacy, user acceptance and security [20] are just a few challenges of utilizing ADR in buildings.

3.2.1.1. DR Programs

DR programs can influence the energy habits and preferences of consumers [10, 16, 21] and reduce energy consumption [12]. There is two types of DR programs: explicit and implicit demand response.

The explicit DR (is also called incentive-based DR program) is divided into traditional-based (e.g. direct load control, interruptible pricing) and market-based (e.g. emergency demand response programs, capacity market programs, demand bidding programs and the ancillary services market programs) [22],[12].

In the explicit DR, demand competes directly with supply in the wholesale, balancing and ancillary services markets through the services of aggregators or single large consumers. The load requirements (the size of the energy consumption) need to comply in order to participate in the DR program [12]. Therefore, small consumers can earn from their flexibility in electricity consumption by contracting with DR service providers. The latter can be either a third-party aggregator or the customer's retailer. This is achieved through the control of aggregated changes in load traded in electricity markets, providing a comparable resource to generation, and receiving comparable prices. Through the incentive-based program, consumers receive direct payments to change their electricity consumption upon request (e.g. consume more or less) [12].

Explicit Demand Response is more flexible in terms of helping the DR service providers acquire the DR resources [23]. Direct load control is a traditional incentive-based program that enables the DR service providers to control the appliances within a short notice [12]. Explicit Demand Response provides a valuable and reliable operational tool for system operators to adjust the load to resolve operational issues [24].

On the other hand, implicit DR (sometimes called price-based DR program) refers to the voluntary program in which consumers are exposed to time-varying electricity prices or time-varying network tariffs (such as a day/night tariff) (or both)[12]. Compared to the explicit DR with direct load control, the price-based program provides less flexibility from the perspective of energy providers [23]. The price-based program depends on the cost of electricity production at different times and consumers' own preferences and constraints [12]. In the Nordic countries, customers have the opportunity to participate in the priced-based programs (e.g. time-of-use (TOU), critical peak pricing and real-time pricing) [12]. For instance, in the real-time pricing, consumers reduce electricity usage at the peak period or shift their usage to the off-peak period [18]. These prices are always part of their supply contract [24].

The two types of DR programs are activated at different times and serve different purposes within the markets. The consumers can participate in both programs. Consumers typically receive a lower bill by participating in a dynamic pricing programme, and they receive a direct payment for participating in an explicit demand response program. However, the implicit Demand Response (dynamic pricing) does not allow a customer to participate in the balancing or ancillary services markets, or in most existing capacity markets [24].

3.2.1.2 Actors and their relationships in the demand response

The DR market can include the producers, grid operators (TSOs, DSOs), retailers, aggregators, BRPs, policymakers and consumers (building owners and occupants). There are new actors (e.g. aggregators) and new roles (e.g. retailers' aggregation service) appear in the DR market. This section describes the actors and roles in the DR market.

<u>Aggregator</u>

The DR activation should be separated from the customers' electricity price (supply contact). The separation requires a new role – the role of the aggregator. An aggregator is '*a service provider who operates – directly or indirectly – a set of demand facilities in order to sell pools of electric loads as single units in electricity markets*' [24].

The aggregator may or may not also be a retailer of electricity that depends on the market regulation. The aggregators' roles in the balancing and ancillary service markets vary across countries. For instance, there is no independent aggregator in Denmark. In the UK and Germany, aggregators can participate in the balancing market, while in Spain and Italy, aggregators can only participate in the contract schemes [7].

Aggregators act on the behalf of the consumers (e.g. homeowners) to negotiate with the energy operators [25]. Aggregators provide DR incentives to consumers [12, 25]. For instance, consumers (e.g. residential, industrial and commercial) receive monetary compensation from aggregators by shifting their energy consumption pattern and for controlling consumers' appliances [25]. Aggregators provide backup for individual loads as part of the pooling activity that can increase the overall reliability and reduce the risk for individual consumers [24].

Retailers

Retailers can play the role of aggregator by providing DR incentives and other DR benefits to consumers [12]. Some countries (e.g. Germany, the Nordics, the Netherlands) are in the process of enabling Demand Response through the retailers only. The customers receive the offer of their flexibility bundled with their electricity bill. It means customers need to reject or accept the entire package.

Regulators

Regulators can promote DR awareness to market players (e.g. consumers) [12]. On the other hand, regulations also limit various actors' DR participation. In a competitive market, the TSO and regulator have the responsibility to enable a range of resources to compete equally, not only selected forms of generation [24]. For instance, Article 15 *of* the Energy Efficiency Directive (2012/27/EU) requires that regulators, TSOs, and DSOs, adjust the technical modalities and requirements for market participants in line with participants' capabilities and the market needs.

BRPs

BRPs and aggregators may have a conflict of interest. The retailers' BRP is required to buy, or source, electricity in advance in order to maintain balance. When demand response activation takes place, they may lose this purchased energy, as the consumer will not consume as planned. This may not be significant in a balancing market but it will be in the wholesale markets [24]. For instance, France has decided that the aggregator should pay the BRP for this energy. Furthermore, TSOs can buy reserve power capacity for frequency control from BRP and aggregators [26].

Data exchange is needed in the DR between BRP, aggregator, and TSO to ensure all can fulfill their obligations, at the same time, not share commercially sensitive information [24].

DSOs provide incentives/reward to aggregators for providing DR service (e.g. peak shaving, DG optimization) [27].

The main relationships between actors in the DR market are shown in the Table below.

Table 3. Actors in the DR

Actors	Offers	To	References
Aggregator	Pay for BRPs' energy loss	BRP	[24]
	Market access DR incentives	Consumer	[25] [28]
	Ancillary service Tariff	TSO	[13]
	Network balancing services Tariff	DSO	[12]
Supplier/retailer	Incentives and contract package for the implicit DR program	Consumers	[15] [18]
Regulator	DR incentives DR regulations DR awareness	All actors	[12] [25]
Consumer	Demand profile Direct control	Aggregator Supplier/re-tailer	[9] [23]
	The large consumer can direct provide energy flexibility to the DR market	DR market	[12]

3.2.2 Virtual Power Plants

Virtual Power Plants (VPP) aggregate DER units [29],[26] and offer to energy market [30]. VPPs can be managed by third-party aggregators [31], BRPs or suppliers [29]. VVPs provide a variety of services to power plant operators, industries, public services, energy suppliers and grid operators [30], [31], [32]. VPPs create new business opportunities for aggregators and suppliers [29]. In Denmark, DONG Energy implements VPPs known as Power Hub [35] that integrates DR from large industrial companies and use it to balance the power system.

The aggregated DERs maintain the reliability of the renewable energy resources [33],[32] and address grid's congestion [28],[33]. In order to participate in the energy market, DERs sign contract with the VVP aggregators [12]. The contract specifies the penalties of each DG (distributed generation) [34]. VPPs are aggregated DERs forming a local virtual plant (LVPP). Then the aggregated LVPPs form a regional virtual plant (RVPP) [35]. LVPPs provide various opportunities to stakeholders [29] such as energy trade, network services, and balancing services [35].

Virtual Power Plants focus on the physical aspect of the resources and their impact on the electrical system [31]. Geographical location is considered in aggregating distributed energy resources (DERs) [29],[32]. However, VPP units at different locations [33] are coordinated using networking infrastructure [36].

3.2.2.1 Components of VPPs

A VPP is comprised of generation units [26], energy storage and ICT (information communication technology) [29]. Generation technology in the VVPs consists of DER portfolios (supply-side and Demand Response) [26]. Supply-side in the DER portfolios are DG units [26], such CHP combined heat and power), biomass and biogas, small power plants solar, and wind generation [29]. While the DR in the DER portfolios consists of the flexible loads and energy storage [26]. Flexible loads refer to loads or consumption patterns shifted in response to the price signals (e.g. heating, cooling and electrical Vehicles) [32]. VPPs require energy storage to store energy such as HPES (hydraulic pumped energy storage), CAES(compressed air energy storage), FES (flywheel energy storage), SMES (superconducting magnetic energy storage) and BESS (battery energy storage system) and electric vehicles [32]. VPPs connect to ICT that helps to reduce the transmission system losses, relieve congestions and provide the grid's stability [37]. Through ICT infrastructure (e.g. EMS, SCADA), VPPs can monitor the energy flows of the DERs, storage facilities and controllable loads [30], [10].

3.2.2.2 Virtual Power Plants for Trade

VPP system provides the Energy trade opportunity to the VPP owners. VVPs optimize and aggregate DERs' capacity (DG units and DR) and provide DERs with visibility and market access [32], [29]. VPP owners submit bids and optimize DERs' revenue in the wholesale market [38].

The DER owners can receive more benefits by collectively participating in the wholesale energy market collectively compared to participate individually. Moreover, the volume threshold for power producers may prevent small DER owners to trade their energy individually [35]. Practically, both DER owners and participants in demand-side response are represented by the RVPP operators as a single entity in the wholesale market [35].

3.2.2.3 Virtual Power Plants for Balancing

VPPs can participate in the energy 'balancing market' by employing the available DER units, storage devices and controllable loads [35]. The balancing market is the regulating market in the Nord Pool market structure. The BRP might be particularly interested in this VPP **operation**, due to the imbalance responsible.

The VPPs can contribute the short, medium and long-term balancing of the energy flow by the operations of virtual synchronous generator and demand-side management. The duration of the primary control is presented in seconds, and VPPs can contribute it with the fast power response obtained from rotating (synchronous) generators, supercapacitors and fast batteries [35]. The VPPs can contribute the secondary control by increasing the generation of reserve DER units (e.g. micro-CHP) for a period in minutes followed up decreasing the demand through the employment of controllable loads during few hours until the top-down power supply is recovered [35].

3.2.2.4 Virtual Power Plants for Network Services

Due to the increase of load or generation, the network operators need to either expand the capacity of the network or prevent the overload or congestion [35]. VPPs can provide grid services to TSO/DSO to support load and congestion management and improve the power quality [26]. VPPs also can provide services to DSO the local system management [29]. In addition, VPPs provide system services (e.g. black start, voltage control) to TSO[26].

3.2.2.5 The VVP stakeholders

The main actor in the VPP is the VPP aggregators. Third-party aggregators manage the VVPs [31], aggregate DERs, storages and adjustable loads [12] and offer to different market participants (e.g. TSOs, BRP) [27]. There are large and small (e.g. DERs, prosumers) energy producers. DERs are small energy generators located in the low-voltage grid expecting the high return on investment [35]. The energy consumers can provide adjustable loads, DERs, or storages to the VPP aggregators based on their energy flexibility resources. BRP can also play a role of an aggregator. For example, NEAS Energy, an independent BRP acts as an aggregator by aggregating various generation units (e.g. CHP, wind, hydro, solar) in Denmark [39]. The requirements for the stakeholders in the LVPP are shown in Table 4. The main relationship between actors in the VPP aggregation market is shown the Table 5.

Table 4. LVPP stakeholders and their requirements [35]

Local Virtual Power Plant (LVPP)		
Stakeholders	**Interests / requirements**	
RVPP	1 2	Data collection from LVPPs execute central commands
DER owners	3 4	facilitate power generation by DER return on investment
VPP operator	5 6 7	provision of value adding and 'smart' services increase of benefits for stakeholders return on investment
Network operator	8 9	reliable power supply to customers prevention of excessive expenditures to expand grid capacity
Regulator	10 11 12 13	compliance with codes compliance with privacy rules compliance with standards kWh prices and margins
Energy Supplier (Contractor)	14 15 16	delivery of contracted energy reliability of contracts charges of delivered energy
Balance responsible party	17 18 19	accurate forecasts of supply and demand specification of reserve resources participants in primary and secondary control
Suppliers of products	20 21 22	provision of smart hardware and software products to operators provision of smart services to operator increase of the volume of sales
Service providers (Communication)	23 24	provision of communication services increase of the volume of sales
Service provider (Metering)	25 26	provision of metering services increase of the volume of sales

Table 5. Actors in the VPPs

Actor	Offers	To	References
VPP aggregator	Market access	DERs owners	Aggregation of DER[30] [25]
	Ancillary services	TSO	EU Market Frameworks [40] Efficiency in Power Systems[41]
	Balancing services	BRP	
	Buy and sell electric-ity	Wholesale Market	Aggregator in DR markets[25]
	Network services	DSO	Aggregator in DR markets[25]
DER owner	Produce electricity	VPP aggregator	Aggregation of DER [30]
	Direct control	VPP aggregator	
BRP	Settle the imbalance [41]	Market	Efficiency in Power Systems [41]
	An accurate forecast of supply and demand	VPP aggregator	
	Bilateral contracts[41]	VPP aggregator	Efficiency in Power Systems[41]
Policymaker	Energy rules[12]	All actors[12]	DR Regulation [12]

4. Identification of aggregation potential for buildings

Buildings consume a large percentage of energy consumptions (e.g. about 45% energy consumption in Denmark is from buildings, shown in Figure below), and can provide the aggregation potential to the grid. Different types of buildings can participate in the aggregation potential market via different channels. Meanwhile, Energy activities and performance are varied among the residential, commercial and industrial buildings due to the building features. Therefore, this section firstly introduces three types of buildings (residential, commercial and industrial), their energy flexibility resources, and then applies the business model canvass to analyze business models for different types of buildings in DR and VPPs.

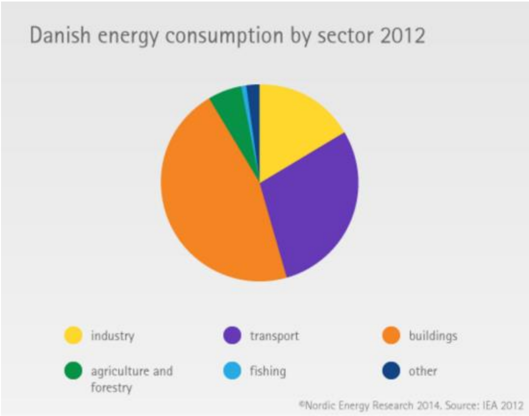

Figure 2. Danish energy consumption by sector 2012[21]

[21] http://www.nordicenergy.org/figure/energy-consumption-by-sector/danish-energy-used-mostly-in-buildings/

4.1 Three types of buildings

4.1.1 Residential buildings

Residential buildings are small electricity consumers with flexibility potentials [42] due to its numerosity. In Europe, residential buildings share 75% of the total number of buildings and 16% are high-rise buildings constructed in the period 1960-1980 [43]. Residential buildings purchase electricity from the retailers or produce their own electricity. There are different types of residential buildings (e.g. apartment, studio, summerhouse, villa, and dormitory). An example of the energy consumption by the appliances in the residential building is shown in Figure below.

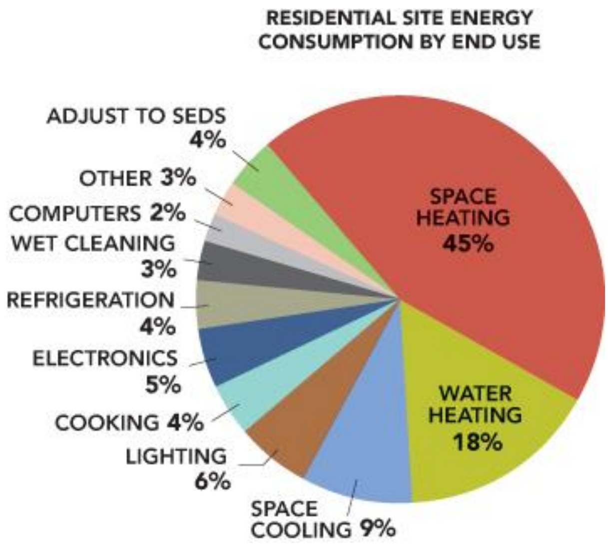

Figure 3. Energy consumption by the appliances in the residential buildings in the USA[22]

In Denmark, standard electrical technologies in buildings are heating, hot water, cooling, ventilation, and lighting [44]. White goods (e.g. dishwashers, washing machines, dryers) [27], heating and ventilation systems, freezers, and refrigerators are the most popular responsive appliances [17] in residential buildings. Large shares electricity usage during winter is accounted for heating and ventilation [17].

Table 6. Households and energy information

Types of buildings	Appliances			Occupants	Energy purchase method
	Common household appliances [45]	**Controllable loads/ appliances:**	**Standard building technologies**		
Villa, apartments, student dormitory, summer house	TV, freezers, washing machines, refrigerators, dishwashers, Dryers	heat pumps[19], dishwashers, clothes washers, clothes dryers, heating and ventilation systems, freezers, and refrigerators, heating, and ventilation[17]	Heating, hot water, cooling, ventilation, and lighting	Homeowners, tenants, building owners	supplier/retailer Own generation

[22] http://buildingsdatabook.eren.doe.gov/ChapterIntro2.aspx

4.1.2 Commercial buildings

Hotels, hospitals, stores, and offices are just a few examples of commercial buildings performing different types of businesses and accommodating different types of building occupants. On the other hand, heating, hot water, cooling, ventilation, and lighting are the standard technologies in commercial buildings. Commercial buildings buy electricity from retailers/ suppliers, wholesalers (large commercial buildings) and some commercial buildings generate their own electricity. An example of the energy consumption by the appliances in the commercial building is shown in Figure below.

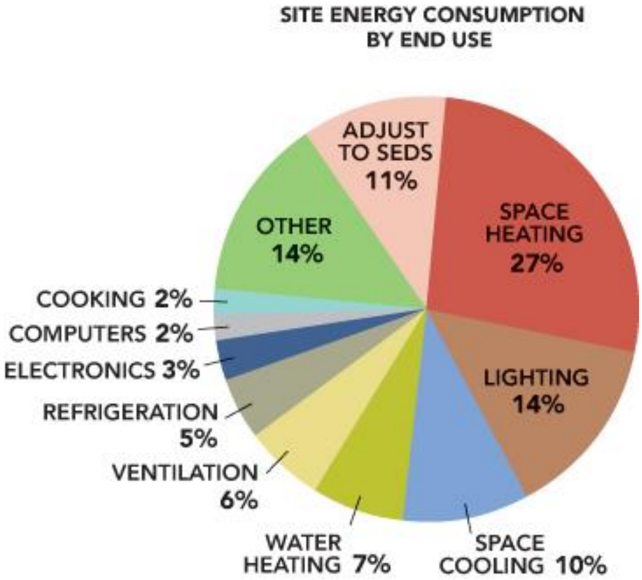

Figure 4. Energy consumption by the appliances in the commercial buildings in the USA[23]

Commercial buildings might be able to contribute to DR by reducing their electricity consumption upon a request of utilities [9]. For instance, shutting down machines or appliances when the energy supply is low. However, some large commercial customers are reluctant to shift their electricity pattern considering big profits [46].

Table 7. Commercial buildings and energy information

Types	Nature of business	Occupants	Standard Technologies	Purchase Method
Hotels	Room service, restaurant, parties/conference	Managers, owners, Service crews, office workers, guests	Heating, hot water, cooling, ventilation, and lighting	Supplier/retailer/ own generation
Hospitals	Medical treatment	Managers, owners, Medical team, office team, patients, maintenance		
Store	Retail/wholesale	Owners, managers, crews, customers		
Offices	Office works	Managers, clients		

[23] http://buildingsdatabook.eren.doe.gov/ChapterIntro3.aspx

4.1.3 Industrial buildings

There are different types of industries engaging in different processes [47] and technologies. DR can help to reduce the use of more expensive forms of flexibility (e.g. storage or backup plants) in industries [47]. DR potential differs from one industry to another. Thus, it is important to identify DR potential in different types of technologies in industries.

Industrial buildings can buy electricity from retailers/ suppliers, wholesalers and industries generate their own electricity. The industrial buildings concern the electric price due to their high power consumption [46]. Similar to some commercial buildings that have large energy consumption, the industrial buildings usually are reluctant to reschedule their usage of power considering their big profits [46].

Table 8. Industrial buildings and energy information

<table>
<tr><th>Types</th><th>Industry Processes</th><th>Standard Building technologies</th><th>Purchase Method</th></tr>
<tr><td>Food processing</td><td>Electric defrost, refrigerated warehouses, cooling production and distribution</td><td rowspan="5">Heating, hot water, cooling, ventilation, and lighting</td><td rowspan="5">Supplier/wholesaler/own generation</td></tr>
<tr><td>Manufacturing (e.g. aluminum)</td><td>Aluminum electrolysis, smelting</td></tr>
<tr><td>Steel industry</td><td>Steel mill, electric arc furnace, oxygen generation facilities, crushing</td></tr>
<tr><td>Textile</td><td>Wrapping, weaving</td></tr>
<tr><td>Wood industry</td><td>Mechanical refining</td></tr>
</table>

4.1.4 Flexibility resources provided by buildings

The nature of business affects the implementation of the DR and aggregation in buildings. For example, mills perform efficiently on the steady operation and shifting its machine operation that affects the operation output [47].

Majority of the buildings are consist of standard building technologies such as heating, hot water, cooling, ventilation, and lighting. However, residential building appliances' differ from one to another. The common controllable appliances in residential buildings are dishwashers, clothes washers, clothes dryers, freezers, and refrigerators, heat pumps, and electric vehicles. The residential buildings, such as apartments, can participate in the real-time pricing by reducing electricity usage at the peak period or shifting their usage to the off-peak period. Moreover, flexibility potential by home appliances vary. For instance, freezers and refrigerators provide less flexibility because more than 30 min interruption on freezer or refrigerator's operation may cause spoilage [17]. Compare to other appliances, heating and ventilation [17] provide more flexibility by shifting the temperature especially during the day when the households are empty [42].

Commercial buildings include hospitals, hotels, stores, and offices. Some commercial buildings are more reluctant to participate in DR (e.g. reschedule their usage of power) due to the effect on their business routines and their profits [46]. For instance, hotels and hospitals operate 24/7 and are reluctant to shift their usage of power due to the consideration of their profits or occupants' comforts. Small or medium-size commercial buildings (e.g. stores, offices) might participate in direct load control program. While hospitals, hotels and other large commercial buildings can participate in interruptible programs.

Industries are usually the large energy consumers. They can directly participate in the wholesale market or via the aggregators. There are different types of industries (e.g. Factories, steel, textile, food industries). The industrial operations can be influenced by the implementation of the DR program. Industries can participate in Demand bidding, time-of-use or interruptible Load Programs.

This report divides the three types of buildings into two categories: large and small energy consumers due to the requirement of the energy aggregation market (volume threshold). Majority of the residential buildings and some commercial buildings are the small energy consumers. Comparatively, the industrial buildings and some commercial buildings are the large energy consumers.

4.2. Business Model Canvas

There are four business model canvases described in this section (shown in Table below). Each business model is explained in detail in the sub-sections.

Table 9. Four developed business model canvases

	Types	Business Model Canvases	Direct participants	Indirect building participants
DR	Implicit DR (price based)	1- buildings participating in the implicit DR via retailers	Retailers	All buildings
	Explicit DR	2- buildings (small energy consumers) participating in the explicit DR via aggregators	Independent aggregator	Small energy consumers (residential buildings, or some commercial buildings)
		3- buildings (large energy consumers) directly access the explicit DR program	Large energy consumers (e.g. industrial buildings, or some commercial buildings)	
VPP	Trading, balancing, and network services	4- buildings access the energy market via VPP aggregators by providing DERs	VPP aggregators	DER owners (buildings which equip the DERs)

4.2.1. Business Model Canvass 1- buildings participating in the implicit DR via retailers

The DR offer to buildings is part of the supply contract provided by retailers. All buildings can participate in the implicit DR program.

Value proposition: buildings can receive a lower bill. For instance, buildings can reduce electricity usage at the peak period or shift their usage to the off-peak period.

Customer relations: retailers can provide different DR offers due to buildings' own preferences and constraints. Meanwhile, customers' satisfaction rate can be increased because of the lower bill.

Channels: retailers can send the price signal to buildings, or provide the DR offer as partly package of the supply contract.

Revenue stream and Cost Structure: retailers can improve consumers' satisfaction rate by providing the implicit DR offer. Retailers might get new customers via the competitive offers. On the other hand, retailers need to purchase DR software and provide consulting service to the customers. Retailers usually do not have the professional knowledge in the DR domain, and the DR service is a new business model for the retailers. Therefore, retailers need to hire experts and staffs for the DR business.

Partners: Price-based program depends on the cost of electricity production at different times. Therefore, the retailers need to receive the price information from the market. The alternatives of the pricing (e.g. time-of-use (TOU), critical peak pricing and real-time pricing) are defined by the regulators. Therefore, the main partners for retailers are regulators, billing companies, and market operators.

Table 10. Business Model Canvass 1- buildings participating in the implicit DR via retailers

<table>
<tr>
<td rowspan="2">Partners

Regulators

Market operators

Billing company

Datahub</td>
<td>Activities
Customer analysis to provide different DR offers;

Customer education to promote the offers

Customer consulting due to customer constraints

Billing system integration

Staffs/expert recruitment</td>
<td rowspan="2">Value Proposition

Receive a lower bill</td>
<td>Customer relation

Different DR offers due to buildings’ own preferences and constraints

Increase customers’ satisfaction rate due to the lower bill</td>
<td rowspan="2">Customers

All buildings</td>
</tr>
<tr>
<td>Resources
Price signal
Regulators’ support</td>
<td>Channels

Part of the supply contract</td>
</tr>
<tr>
<td colspan="3">Cost Structure
Integration of DR offers into supply contract (which might need DR experts and facility purchasing)
Price signal sending to customers (facilities and staffs)</td>
<td colspan="2">Revenue Streams
Customer loyalty
New customers due to a competitive offer</td>
</tr>
</table>

4.2.2. Business Model Canvass 2- buildings (especially for small energy consumers) participating in the explicit DR via aggregators

Value proposition: buildings, especially with small energy consumption, can get direct payment by participating in the explicit DR program via aggregators can optimize the energy pattern of consumers.

Customer relations: aggregators can maintain good relation with customers through 1) efficient and customer-friendly payment system and control system. 2) Training and consulting service, including the DR knowledge and market information sharing. Meanwhile, the customized DR contract should be based on customers’ energy constraints and preferences (e.g. what appliances should connect to the direct load control). Customers’ energy behaviors might need to be changed due to the participation of the DR market. 3) The participation of the DR market needs customers to install the direct load control system, which means the system can connect to the customers’ appliances and is controlled directly by the aggregators. Therefore, the aggregators can provide discount or free control system for the customers, and the maintenance service. 4) Aggregators provide backup for individual loads as part of the pooling activity that can increase the overall reliability and reduce the risk for individual consumers.

Channels: the small energy consumers (buildings) currently have an energy contract with energy suppliers (retailers). Therefore, the independent aggregators can access the small energy consumers via retailers. otherwise, due to the DR awareness and regulation, the independent aggregators also can contact the small energy consumers directly by providing the DR analysis and consultation.

Revenue stream: aggregators generate revenue by providing DR services to the market (e.g. wholesale market, balancing market, and ancillary service). Aggregators might also receive the incentives from regulators, TSOs, and DSOs, depends on the market regulation and structure.

Cost Structure: aggregators need to hire employees, procure DR control system (might for both the aggregator side and customer side). The aggregators need to pay fees to participate in the DR market (e.g. the fees to access the Nord pool wholesale market), and the tariffs to the DSOs and TSOs. Aggregators also need to cover the payment or incentives to the customers. For some DR market (e.g. France), aggregators need to pay BRPs' loss.

Partners: technology providers (load control system), retailers (have access to the customers), DSOs and TSOs (might provide DR incentives) can be the partners for aggregators. The aggregators need to have a contact with BRPs to participate the wholesale market because all players need to have an agreement on balance responsibility to participate the wholesale market (e.g. the Nord pool market). Strong participation of government/regulators on DR programs is an advantage.

Table 11. Business Model Canvass 2- buildings participating in the explicit DR via aggregators

<table>
<tr>
<td rowspan="2">Partners

Regulators
BRPs
DSOs
TSOs
Control system providers
Energy suppliers (retailers)</td>
<td>Activities
• Access customers via energy suppliers or other channels
• Provide consulting and analysis of customer demand pattern
• Participate in the DR market (wholesale, balancing or ancillary market)
• Control customers' appliances
• Payment to customers for energy flexibility</td>
<td rowspan="2">Value Proposition

Direct payment by participating in the explicit DR market via aggressors</td>
<td>Customer relation

• Payment system
• Incentives by regulation, TSOs, and DSOs
• Consulting service (e.g. training, building energy behavior analysis)
• Control system operations and maintenance
• Reduce risk and provide reliability</td>
<td rowspan="2">Customers
Buildings (who are small energy consumers)</td>
</tr>
<tr>
<td>Resources
• Local control system
• Customer data (demand pattern)
• Market information
• Customer access via energy suppliers</td>
<td>Channels
energy consulting directly by aggregators
access customers via energy suppliers (retailers)</td>
</tr>
<tr>
<td colspan="3">Cost Structure
DR control system (customer side and aggregator side)
Payment to customers
Tariffs to DSOs and TSOs
Payment/compensation to BRPs
Market access fees to the DR markets</td>
<td colspan="2">Revenue Streams
Payment from the DR market (including reserve capacity payment from TSO)
Incentive from TSO/DSO and regulators</td>
</tr>
</table>

4.2.3. Business Model Canvass 3- buildings (large energy consumers) directly access the explicit DR program

Customers: The large energy consumers (buildings) are the energy flexibility provider who directly participates the DR market (wholesale market, regulating the market or ancillary service). Therefore, the customers are the DR markets.

Value proposition: Large industrial buildings provide demand and compete directly with supply in the wholesale, balancing and ancillary services market.

Customer relations: to participate in the wholesale and balancing market, the large energy consumers need to comply with the market rules. Meanwhile, they need to allow the TSOs to directly control the resources of the building energy flexibility (e.g. building energy management system) in order to a participant in the reserve market as ancillary service.

Channels: the large energy consumers can directly participate in the wholesale and balancing market by providing demand. They also can send the biding to the reserve market as ancillary service (there are rules for biding and ancillary capacity, and control in the reserve market).

Revenue stream: direct payment by providing the demand via direct participating the explicit DR programs. The large energy consumers might get incentives from the regulators, DSOs, and TSOs

Cost Structure: the large energy consumers are usually the industrial and commercial buildings. The original business (e.g. production) might be influenced by participating in the DR programs. another potential cost for the large energy consumers to participate the explicit DR programs is a list in the Table below.

Partners: the buildings need to be equipped with the energy control system to provide the demand to the DR market and response the market signal. Therefore, the energy technology providers can be potential partners. Meanwhile, the building and business constraints need to be evaluated by either hiring experts or external consulting companies.

Table 12. Business Model Canvass 3- buildings directly access the explicit DR program

<table>
<tr>
<td rowspan="2">Partners

Technology providers
TSOs
BRPs
Energy consulting
DSOs
regulators</td>
<td>Activities
Install energy control system.
Analysis and integration of DR business into the existing building business.
Directly participate in the DR markets.</td>
<td rowspan="2">Value Proposition

Provide energy flexibility to the market</td>
<td>Customer relation

Allow direct load control by the TSOs in the reserve market as an ancillary service.

Comply the market rules in the wholesale and balancing markets</td>
<td rowspan="2">Customers

DR market (wholesale market, and ancillary service to TSOs)</td>
</tr>
<tr>
<td>Resources
Energy flexibility from appliances in the buildings.
Building energy control system</td>
<td>Channels
Direct participation in the wholesale and balancing market.
Biding in the reserve market (there are rules for biding and ancillary capacity, and control in the reserve market)</td>
</tr>
<tr>
<td colspan="3">Cost Structure
employee’s salary or expert consulting
control system installation/upgrade
market access fee (rules to participate the wholesale and balancing market)
fees to BRPs by contract
tariffs to the DSOs and TSOs
cost due to energy behavior changes (influence the production or occupants’ satisfaction in the building)</td>
<td colspan="2">Revenue Streams
Payment by providing demand in the wholesale and balancing markets
Reserve capacity payment from TSO
Incentive from TSO/DSO, and regulators</td>
</tr>
</table>

4.2.4. Business Model Canvass 4- buildings access the energy market via VPP aggregators by providing DERs

Value proposition: buildings (DERs) are able to get direct payment from VPP aggregators by providing energy flexibility. Meanwhile, the volume threshold for power producers may prevent small DER owners to trade their energy individually, and the VPP aggregators aggregate the DERs and flexible loads as a single entity in the wholesale market which can help the DER owners collectively participate the market with lower risk.

Customer relations: 1) different types of buildings can have different types of DERs. For instance, the residential buildings usually only have PVs. Therefore, the aggregation markets the DER owners can participate are different. Due to the response requirements of different markets (e.g. there are primary control and secondary control in the balancing market that require a response in second, minutes, or hours), the aggregation potential that the DER owners can provide mainly depends on different types of DERs. 2) The VPP aggregators can provide customized market access strategies for different types of DER owners. Meanwhile, the VPP aggregators should provide the accurate forecast information of supply and demand and user-friendly control system, because it influences the DER owners' daily business or energy usage patterns. 3) The main reason for DER owner to participate in the energy flexibility market is the monetary benefits. Therefore, the VPP aggregator needs to provide an efficient and fair payment system that also affect the DER owners' satisfaction and motivation.

Channels: The building information regarding DERs might be public access in some countries, e.g Denmark. Therefore, the VPP aggregators can directly connect to the DER owners. In addition, the DER technology/equipment providers who install the DERs for building owners obtain the customer information. The aggregators can connect with customers through the DER technology/equipment providers. It is unknown whether the energy retailers also have the information regarding their customers' DERs information. Otherwise, the aggregators also can reach the DER owners via the connected retailers.

Revenue stream: the VPP aggregators can participate different energy market with different types of business (trading, balancing, and network service) to different market players (TSOs, BRPs, and DSOs).

Cost structure: the cost structure is similar to the business model canvas 2 (Please see detail in section 4.2.2).

Partners: the DERs technology providers are potential partners for aggregators explained in the 'channel'. Strong participation of government/regulators is an advantage for the VPP aggregators. The rest of the partners is similar to the business model canvas 3 (Please see detail in section 4.2.3).

Table 13. Business Model Canvass 4- buildings access the energy market via VPP aggregators by providing DERs

<table>
<tr>
<td rowspan="2">Partners

Technology providers
TSOs
BRPs
Energy consulting
DSOs
regulators</td>
<td>Activities

Install control system
Customer service (analysis and package deal)
Directly participate in the aggregation markets.</td>
<td rowspan="2">Value Proposition

Market access with low risk
Direct payment</td>
<td>Customer relation
Customized market access strategy
Payment system
Forecast information
Direct control system</td>
<td rowspan="2">Customers

Building with DERs (e.g. PV, micro-CHP)</td>
</tr>
<tr>
<td>Resources
An accurate forecast of supply and demand
Storages
Adjustable loads
DERs</td>
<td>Channels
Direct contact;
Via the DER technology/equipment providers;</td>
</tr>
<tr>
<td colspan="3">Cost Structure
VPP control system,
Employee's salary (including expert payment)
market access fee (rules to participate the wholesale and balancing market)
fees to BRPs by contract
tariffs to the DSOs and TSOs</td>
<td colspan="2">Revenue Streams
Trading via the wholesale market
Balancing service offered to BRP
Reserve capacity payment from TSO
Network service offered to TSO</td>
</tr>
<tr>
<td colspan="5">Note:
1) This business model canvas only focuses on the 'independent VPP aggregator' that the scenario of the existing retailers/BRPs have a new role of 'VPP aggregator' is not considered.
2) The correlation between building types and installed DERs is not considered. However, it is important to be aware that different building types can equip different DERs due to the references and constraints of the buildings. For example, the majority of the residential buildings only equip the PV system, but the industrial buildings, such as greenhouses might equip with the CHP. The difference influence the market contribution by the DER owners</td>
</tr>
</table>

5. Impact of business models on the market exploitation of energy flexibility

This section discusses the aggregation market potential for the buildings based on the analysis of four business models. The SWOT and TSOW analysis is applied.

Opportunities: there is a market need for the buildings' energy flexibility, due to the market (e.g. imbalance payment) and grid (grid capacity) demand. Meanwhile, the technologies, including the control system, forecast software, DERs, are more advanced, cheaper and user-friendly compared to before. Therefore, the market players, such as aggregators, and buildings are much easier to participate in the aggregation market. In many countries, the regulators, TSOs or DSOs provide incentives for the participation in the aggregation market.

Threats: however, there are still regulation barriers for the market players to access the aggregation market. For instance, there is no DR market in Denmark, and in some countries, DR participation from small consumers is limited and only large consumers participate in the wholesale market. Meanwhile, the monetary benefit is not significant visible to encourage the buildings to participate in the aggregation market, especially with the compromise of comfort and investment.

Strengths: the majority of buildings have the possibility to provide the flexibility to the energy market, either by changing energy usage pattern or by giving the direct control of their appliances or DERs to the aggregators.

Weaknesses: The ROI is the main concern of the energy consumers, and for the small energy consumers, e.g. residential buildings, are still lack of the investment of the controllable appliances, control systems, and DERs. The energy consumers also might be conservative due to the effect on the daily business or energy usage patterns. Meanwhile, the limited capacity of the energy flexibility provided by the small energy consumers (e.g. residential buildings) might prevent the access to the aggregation market or have visible monetary benefits.

With the TSOW analysis, this study conducts the following suggestions to encourage buildings to participate in the aggregation market:

- Regulation needs to adjust to allow buildings to easily access the aggregation market;
- Incentives from regulators, TSOs/DSOs;
- Clear monetary benefits (e.g. payment) need to be defined;
- Financial support, e.g. loans, renting, cost reduction strategy and package, for the installation of the control system, DERs or controllable appliances;
- Easy and user-friendly control system with accurate forecast and analysis
- Customized service (e.g. payment and control solutions) for different types of buildings.
- Selective market access for buildings which can have visible benefit from the aggregation market (e.g. large energy consumers, or industrial buildings with a large capacity of DERs)

Table 14. SWOT/TOWS analysis for buildings to the aggregation market

	OPPORTUNITIES	**THREATS**
	• EU climate and energy goals • Technology readiness • Market demand • The constraint of grid capacity • Cost reduction • Incentives	• Regulation barriers • Limited monetary benefits • ROI
STRENGTHS • Flexible load • Installed DERs • Advanced appliances	**S-O STRATEGIES** • Cost reduction strategy and a package of the control system and DERs equipment; • The easy and user-friendly control system	**S-T STRATEGIES** • Regulation changed to allow buildings easy access to the aggregation market; • Clear monetary benefits& incentives; • Analysis and service (including training) regarding consumer behavior.
WEAKNESSES • No investment support • The constraint of daily business and energy usage pattern • Low capacity of the energy flexibility	**O-W STRATEGIES** • Aggregation of small consumers by DR and VPP programs; • Incentives from regulators, TSOs/DSOs; • Software support for forecast and analysis.	**W-T Strategies** • Financial support for the equipment control system (e.g. loans, renting); • Selective market access for buildings which can have visible benefit from the aggregation market (e.g. large energy consumers, or industrial buildings with a large capacity of DERs)

6. Conclusion

Aggregation plays an important role in providing flexibility in the power system. Retailers, BRPs, and independent aggregators have aggregation potentials. However, the energy aggregation market is regulation oriented. Besides the regulation barriers, there are also challenges for buildings to participate in the aggregation market.

This report discusses the existing business models for buildings (e.g. residential, industrial and commercial) to participate in the aggregation markets by providing flexible loads and DERs. Four business models are explicitly described for four aggregation potentials to the buildings. The results show that there are opportunities for the buildings to participate in the aggregation market. However, there are constraints for different types of buildings. The flexibility resources and potentials are different between different types of buildings, and the building owners have different needs and behaviors. Thus, it is essential to understand the building owners' needs, comforts and behaviors to develop the feasible market access strategies for different types of buildings.

Incentive programs can enhance buildings' participation. In addition, the involvement of the government and regulators in aggregation can provide incentives, and increase DR awareness and participation. However, the aggregation market is still immature, and regulations & policies of the aggregation market are variations across countries. Therefore, the business models of the aggregation potential for buildings need to be based on the national energy market structure.

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