User needs, motivation and barriers for application of Energy Flexibility in Buildings

A technical report from IEA EBC Annex 67 Energy Flexible Buildings

User needs, motivation and barriers for application of Energy Flexibility in Buildings

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Energy in Buildings and Communities Programme

Preface

The increasing global energy demand, the foreseen reduction of available fossil fuels and the increasing evidence off 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 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

Energy flexibility requires agreements and collaborations among different actors. However, the stakeholders' reaction to energy flexibility have not been fully investigated. Therefore, this report aims to investigate the stakeholder involvement in energy flexibility and their needs, motivation and barriers for application of Energy Flexibility in Buildings.

This report applies the business ecosystem concept (including actors, relationships, value alliances, and influential factors) for the discussion of the stakeholders' roles and their interrelation in delivering energy flexibility. The influential factors to the actual implementation of energy flexible operation of their buildings is also discussed.

This report chooses retail buildings for the discussion, because retail buildings have an important role for demand side energy flexibility due to their high energy consumption, variety of energy flexibility resources, and centralized control via building control systems. Based on a literature analysis, the results cover stakeholders' types and roles, perceptions (drivers, barriers, and benefits), energy management activities and technology adoptions, and the stakeholders' interaction for the energy flexibility in retail buildings.

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1. Introduction

Buildings are more than just stand-alone units using energy from the grid. They are becoming micro energy hubs consuming, producing, storing and supplying energy more flexible than before. Buildings can even help balance the grid with demand management and could play a leading role in transforming the EU energy market[1]. The energy flexibility in a building could be defined as *"the ability of demand side installations to respond to power systems requirements for ramping up or down using on-site storage capabilities, increasing or decreasing electricity consumption patterns whilst maintaining acceptable indoor comfort bandwidth during a specific time period*" (S. Mishra, 2016).

The energy consumers can be divided into the categories by Samad and Kiliccote: *residential, commercial (i.e., buildings and multi-building facilities),* and *industrial* (Samad and Kiliccote, 2012). Different types of consumers can provide different energy flexibilities (shown in Table 1). For instance, the refrigeration companies/ cold stores have especially high load shift potential with the duration of several hours, and there are several ways to make electricity from the refrigerator / freezer more flexible.

Table 1. Potential for load flexibility of different processes in agriculture and industry

Industry	**Electricity consumption, GWh /year (2001)**			**Flexibility potential, MW**		
	Eastern Denmark	Western Denmark	Total	East	West	Total
Agriculture	405	2.150	2.555	13	69	82
Food and beverage	518	1.738	2.526	13	43	56
Textile	14	194	208	0	4	4
Wood industry	123	281	404	2	6	8
Paper and printing industry	228	527	755	5	11	16
Chemical industry	1,116	1.079	2.195	17	16	33
Stone, clay and glass industry	211	719	930	4	15	20
Iron and steel mills	528	117	645	26	6	32
Foundries		196	196	0	10	10
Iron and metal	447	1.304	1.751	20	59	79
Trade & Service	1.507	2.206	3.173	54	79	134

Meanwhile, the consumers' energy flexibility not only contains the consumers' "flexibility activities", such as shifting electricity usage time, but also the "flexibility capacity", e.g. installed smart appliances, or PV.

The end-user acceptance and behaviour is very important when utilizing Energy Flexibility in buildings as this may mess directly with people's life/comfort/health. User acceptance and behaviour may be a barrier, which, however, may be reduced, if the people in the buildings are motivated in the right way.

[1] http://www.buildup.eu/sl/node/48888

Users can include different stakeholders: end-user (occupants of buildings), building owner, but also supply side actors such as facility manager, ESCOs, project developer, architect, contractor and product/system supplier. Users of flexibility are aggregators, DSOs (District System Operators) and TSOs (Transmission System Operators).

The stakeholders and stakeholders' interaction influence the energy flexibility activation and success, e.g. regulation, consumers' motivation, electricity suppliers' support, and also depends on the collaboration of all the smart grid actors (energinet.dk, 2011). The flexibility activation can require establishment of the agreements between the different actors. Following agreements may be negotiated between the aggregator and prosumer, such as: security of supply on time from prosumers' side, comfort requirements from prosumers' side, framework for billing, and aggregator's active marketing role to engage consumers in the delivery of flexibility products (to DSO / grid company, TSO etc.).

Therefore, this report aims to investigate the stakeholders' relationships and value alliances to understand users' needs, motivation and barriers for application of Energy Flexibility in Buildings. Furthermore, the building conditions and energy activities are explored to understand the building constraints and capacities for energy flexibility.

1.1. Project Case- retail stores

This project selects the retail stores and supermarkets as examples to discuss the role of the stakeholders and their interrelation in the energy flexibility with the influential factors to the implementation of energy flexibility in retail stores.

Retail stores are 'commercial-type buildings selling variety of products, owned or operated by the retailers'. Retail stores are the large commercial energy consumers, as it has round-the-clock business operations (Robert P. King, 2003). The energy consumption of the retail stores depend on the nature of business, store format, products, shopping activities of customers and store equipment (Kolokotroni et al., 2015). There are many ways of energy control in the retail stores. For instance, improving lighting system designs and incorporating daylighting reduce energy costs in buildings (Sheila J. Hayter, 2000). The retail store buildings can potentially provide various energy flexibilities, such as refrigeration. Meanwhile, there are many stakeholders involve, including the consumers of the consumers: buyers.

1.2. Methodology

The literature analysis methodology with Nvivo tool is applied in this report to extract relevant information systematically from the publications regarding the energy flexibility in the retail stores and supermarket for the survey preparation. The targeted databases to search the related literatures are: IEEE iexplore, EBSCO, Jstor, Scopus, Springer, Web of science, and Google scholar.

This report firstly defines the keywords and searches in the selected publication database, and includes the matched references into the Endnote (a reference management software). The keywords are:

(user OR stakeholder OR “building owner” OR “facility manager”) AND (flexibility OR need OR acceptance OR motivation OR barrier OR experience OR “thermal comfort” OR evaluation OR adoption) AND building AND energy

Based on the first-round results (more than 40 articles are included), to specifically investigate the energy flexibility in the retail stores, this study defines the second-round keywords to search from the results in Endnote. The keywords are:
There are fourteen articles matched the keyword searching and selected for the literature analysis. Based on the literature, this report conducts four assumptions.

(“energy flexibility” OR ‘demand response’) AND (“retail store” OR supermarket)

2. Users and Energy Flexibility

The users' acceptance of the energy flexibility in buildings are strongly influenced by the users' constraints (e.g. daily business for commercial buildings, or energy usage patterns for residential buildings), the flexibility resources (e.g. what appliances can provide flexibility or how much it can provide), and the energy management activities. There are two assumptions based on the literature analysis:

2.1 Energy Flexibility and Store Conditions

The energy flexibility activities in the retail stores varies according to the ownership group size, store format and regions (Robert P. King, 2003). Other factors, such as energy plans, responsible staffs, existing/new buildings and store activities, affect the energy adoption in retail stores:

Ownership group size: the adoption of the energy flexibility activities is affected by the ownership group size. For example, retail stores that operate under the umbrella of large organizations (e.g. malls) are more willing to adopt advanced energy technologies than single stores. Single stores are tend to be small and located outside the urban areas (Robert P. King, 2003). In additional, the knowledge of the energy management and new technologies can be more easily transferred from among stores under the same store chains (Mills, 1984). Large stores can hire energy management specialists for the development of energy management plans and energy efficient technology installations.

Locations: the energy price, consumption, climate and infrastructures vary according to regions or locations. Retail stores that locate in the high electricity rate areas are more eager to utilize energy efficient technologies or energy flexibility strategies.

Store formats: the store formats influence the types of the energy flexibility activities. For example, food supermarkets sell more perishable products, and they have more energy flexibility resources, such as refrigeration, than stores that sell dry goods (Robert P. King, 2003).

Energy plan and energy responsible staff: research shows, stores have structured energy plans and responsible staffs can utilize more energy management practices to reduce energy cost (Robert P. King, 2003) and response the regulations and incentives of the energy flexibility activities.

Existing/new buildings: the building conditions (new construction or existing buildings) can constrain the energy flexibility capacity due to the building material and technology embedded into the buildings, e.g. HVAC (heating, ventilation, and air conditioning). Therefore, it needs to be addressed in the retailers' incentive package of the energy flexibility (Carr, 2015).

Store activities: There are various business activities in the retail stores. Large-sized stores and stores with longer hour operation can potential provide more energy flexibility activities. Therefore, grocery, discount, and department stores are more active in the energy management and implementation activities compared to the drug and specialty stores (Mills, 1984).

2.2 Energy Flexibility and Energy Management Activities

- The energy management activities in the retail stores focus on various areas, and the technology readiness influences the energy flexibility activities in the retail stores

2.2.1 Energy management activities

The retail stores' energy management activities focus on various areas including indoor and outdoor lightings, heating, air-conditioning, building maintenance, planning/ operations, refrigeration and lobbying (Mills, 1984). Planning and operations involve the setup of the long-term goals, energy cost reduction planning, store remodeling and establishing internal company energy programs; and lobbying includes the participation in industry councils on energy management (Mills, 1984).

The indoor air quality (IAQ) is one of the important components in the energy development plan for the retail stores due to the building regulation and customers' satisfaction (Zaatari et al., 2016). Meanwhile, the energy development plan and activities in the retail stores need to consider the retail store image, cost, competition, regulations, internal concerns, and customer satisfaction. The retail store image is an essential element as it influences customers' shopping decisions. Research shows that flexible opening hours convey good image to the retail stores (Kasulis and Lusch).

An efficient energy management decision and plan for the retail stores depends on the availability and use of energy related information/advice. Retailers can acquire information from their direct contacts, such as trade publications, suppliers, utility companies, retail associations and Chamber of Commerce publications (Mills, 1984).

2.2.2 The energy flexibility technologies in the retail stores

The energy flexibility activities in the retail stores are influenced by the availability and readiness of the energy flexibility technologies. The technologies provide the resources of the energy flexibility in the retail stores. Lightings, refrigerators and ventilation are common technologies available in stores:

<u>Lighting</u> is the most important technology considered in buildings. Effective lighting can increase shoppers' satisfaction and encourage them to spend more time in the stores (Gerdeman, 2007). Meanwhile, Store lighting is a high energy expenditure in the retail stores. There is need of lighting for refrigerators, walk-in coolers, sales areas, and garage/parking. The energy consumption can be reduced by as much as 50% with simple application of energy efficiency technologies (Energia).

<u>Refrigeration</u> is used to store perishable products in the stores sharing up to 47% of energy consumption in retail store (Connell et al., 2014). There are several technologies that can improve the energy efficiency of the refrigeration in supermarkets, such as anti-sweat heater controls for refrigerated cases, strip curtains for walk-in coolers and freezers to help mitigate cold air spill.

<u>Ventilation</u> provides comfort to building occupants (e.g. staffs and customers) and increase stores' productivity (Zaatari et al., 2016). Ventilation rates are mandated by regulations and standards, such as indoor air quality, health requirements, and climate. The ventilation control technologies and strategies (e.g. HVAC control systems) not only can provide the energy saving but also the energy flexibility (Carr, 2015, Vítor Leal, 2000).

3. Stakeholders’ Motivation and Barriers

Majority of the consumers have been aware of the importance of the energy saving and energy efficiency. The literature indicates that there are different drivers, barriers and benefits to the retailers, shop-floor- staffs and building designers regarding the energy efficiency and flexibility. For instance, the barriers for energy flexibility implementation include financial, managerial and technological impacts.

3.1 stakeholders and awareness

- Stakeholders have been aware of the importance of the energy efficiency and flexibility, and the benefits of adopting the energy flexibility solutions. There are drivers, motivation, and barriers for different stakeholders to involve the energy flexibility in the retail stores/supermarkets.

3.1.1 Drivers to the retailers’ energy flexibility implementation

The legislation and the fiscal savings are the two main drivers of energy flexibility implementation in the retail stores:

- The increasing energy cost affects the product pricing in grocery stores and food supermarkets but not in the department stores (Mills, 1984, Ochieng et al., 2014). Therefore, the driver of fiscal savings influence differently to different types of retailers, and typically it drive the stores that consume large amount of electricity (e.g. grocery, food supermarket) to consider the energy flexibility.
- Retailers adopt energy related technologies and flexibility resources (e.g. PVs or energy storage) due to the energy legislation and building regulations. For instance, the food supermarkets apply the efficient energy technologies because of the rising energy cost and campaigns of Non-Governmental Organization (NGO) to reduce Greenhouse gas (GHG) emissions (Ochieng et al., 2014).

Financial incentives provided by the governments and utility companies also encourage the retailers to utilize efficient energy. Although the electricity cost is only 1% of the total supermarket operating cost, but supermarkets/retail stores are interested in any financial incentive that can generate profits (Connell et al., 2014).

Moreover, the demand response drives the energy flexibility and enhances the energy efficiency of the retail stores, utilities and grid operators. A research shows that demand response is considered as a secondary revenue stream for a supermarket chain as it lowers electricity cost (Connell et al., 2014) and lowers the wholesale energy market prices (Jianli et al., 2014). For instance, the demand response in the refrigeration system allows the adjustment of the demand of electricity (Connell et al., 2014).

Energy crisis is another driver of the energy flexibility implementation in retail stores. A research shows that that respondents of retail stores agree that there is an energy crisis in the US and has affected their store operation (Mills, 1984).

3.1.2 Benefits to the retailers:

- The adoption of the energy flexibility activities does not significant influence the customers' shopping behaviour. An experiment with a big British supermarket shows that the customers do not realize the changes of the indoor temperature during the experiment. Meanwhile, the energy control systems provide the energy flexibility potentials with customers' interaction(Ochieng et al., 2014).
- The retailers' involvement in the energy programs as part of the companies' Corporate Social responsibility (CSR) that can improve the company's reputation (Ochieng et al., 2014). Awareness of the presence of energy efficiency and flexibility in retail stores could develop trust and green image with the local communities.
- The retail stores' competence of energy flexibility to response to the grid's demand, e.g. instability or price signal not only can reduce the energy cost, receive the compensation from the grid, and also potentially can improve the collaboration with energy suppliers.

3.1.3 Barriers to retailers

- Not all supermarkets are convinced to adopt energy flexibility activities (Ochieng et al., 2014). Tassou et al. (Tassou et al., 2010) research shows that retailers receive pressure to practice energy management because of the energy legislation implemented by the government. Moreover, the benefits and potential of energy flexibility shows little ROI (Return of Investment) to the retail stores/supermarkets.
- There is lack of incentive of energy flexibility participation from the utilities or governments. Some utility incentives are not applicable to retail stores/supermarkets. Some incentives are classified on certain groups (e.g. motor replacement or one-for-one equipment change out incentives) (Carr, 2015).
- A research shows that department stores claim that the government demand and energy legislation is unfair and unrealistic (Mills, 1984) but food industry did not consider it as an issue. Therefore, the government themes or incentives of the energy flexibility should be adjusted based on different types of industries.

3.1.4 Drivers and Barriers to shop-floor staffs

There are multiple-goal conflicts affect shop-floor staffs' involvement in the energy flexibility in the stores (Christina et al., 2014). For instance, the working environment (e.g. indoor quality and lighting) influences employees' behaviour and performance. Research shows that financial incentives or energy flexibility included job responsibilities can drive the shop-floor staffs to actively involve the energy flexibility activities.

Barriers to building designers:

According to Cooke et al. (Cooke et al., 2007) the adaption of new approaches in the UK building construction is "poor", because there is little incentive for the building designers to concern the buildings energy flexibility. Therefore, it is necessary to create more awareness of the environmental and social impacts of energy flexibility to the building designs. However, the market and energy adoption barriers and challenges can overcome through political will, capital, and community support (Hutchinson, 2012).

3.2 The interrelated stakeholders' collaboration for the building energy flexibility

-Energy flexibility in the retail stores/ supermarkets requires interrelated stakeholders' collaboration, and there are different relationships among stakeholders

The literature shows the following stakeholders' relationship in the energy flexibility in the retail stores/supermarkets: retailers-customers/local communities, retailers and governments, retailers and utilities, retailers and shop-floor-staffs, retailers and third party operators:

3.2.1 Relationships between retailers and customers/local communities

Supermarkets are a highly competitive customer-driven market, and the first priority of supermarkets are developing effective strategies to attract different types of customers (e.g. new or existing customers, and green conscious consumers) (Ochieng et al., 2014). Research shows that the customers' behaviours and shopping decisions can be influenced by the retailers' reputation and strategies. The business strategies include factors of demands, beliefs and customer values.

Corporate Social Responsibility (CSR) is an effective strategy to create a sustainable competitive advantage and develop good company image, trust with the local communities and customers (Ochieng et al., 2014). A good CSR strategy can catch customers' attention, e.g. creating customers' awareness on the utilization of efficient energy technologies in retail stores and the benefits of environmental-friendly and health-related smart energy. Another example of good CSR practice is providing an environmental friendly condition to the users without high amount of energy (Kolokotroni et al., 2015). In general, good CSR practices are common strategies for the energy flexibility in the retail stores with the collaboration between retailers and customers/local communities.

3.2.2 Relationship between retailers and shop-floor staffs

Retailers set up energy goals in the stores and assign the shop-floor staffs to participate in the attainment of the goals. However, the energy flexibility goals in retail stores can sometimes create conflict to the stores' activities. Because it is hard for the shop-floor staffs to control the customers' shopping behaviour (Christina et al., 2014). Therefore, retailers should consider the customers' demands and behaviours when setting the energy goals, and make sure the goals are simple and clear to understand and follow up by the shop-floor staffs.

Some of the energy flexibility activities affect the shop-floor staffs rather than the customers. For instance, the customers might not be aware the indoor temperature changes in the supermarkets, but the temperature changes would significantly influence the shop-floor staffs due to the long working duration in the supermarkets. A survey shows that shop-floor staffs do not actively participate in the energy efficiency programs of the retail stores, unless the energy related programs are considered as a part of the job functions or with incentives (e.g. credit, or bonus) (Christina et al., 2014). Therefore, retailers should develop organisational policies involving the shop-floor-staffs in planning and implementing the energy flexibility programs in buildings.

3.2.3 Relationship between utility companies and retailers

The partnership between the retailers and utility companies brings energy flexibility products/solutions closer to the retailers. For example, in the US, utility companies and retailers work together and create the “build your own energy” incentive solution to respond to the government’s energy development program. This energy incentive program serves as a tool to utilize efficient energy technologies for new construction and existing retail store buildings (Carr, 2015). Moreover, the mutual trust between the utility companies and the retailers ease the energy project application processes (Carr, 2015).

In an unbundling energy market, customers can choose their utility companies. This is an opportunity for the utilities or distribution companies to collaborate with the retailers with funds and incentives to attract walk-in customers in the retail stores/supermarkets to switch their energy providers (utility companies). They retail stores/supermarkets also might provide the utility companies of their customers’ information (Hutchinson, 2012). In additional, retailers can also provide energy audits and energy upgrade assessments services on behalf of the utility companies to the walk-in customers in the retail stores/supermarket (Hutchinson, 2012). In this case, retailers act as intermediary between the utility companies and energy end-users.

3.2.4 Relationship between Governments and retailers

Governments need high involvement of retailers to secure the success of the energy development programs. A survey shows that store managers believe that there is potential of the government energy programs to solve the energy issues related to the store operations (Mills, 1984).

It is important to consider the retailers’ interests when implementing the energy programs, because the retailers would only adopt policies that are beneficial to their stores (Mills, 1984). Meanwhile, the retailers’ involvement in the energy management activities varies according to types of stores. For instance, grocery, discount, and department stores are more active in the energy management and activities compared to drug and specialty stores. Therefore, governments can influence the energy flexibility activities of some types of retail stores.

Retail stores comply the political directives when it is implemented through the retail organizations or association (Mills, 1984). The policy makers need to increase their effort in reaching out the retail industries by building strong communication channel and utilizing the energy information (Mills, 1984). For instance, in the US, the Department of Energy (DOE) provides a web-portal as an information tool to build strong collaboration with their energy partners (e.g. retail stores) (Carr, 2015).

3.2.5 Relationship between Governments and retailers

Retailers outsource some of stores’ tasks to the third party operators. For example, retailers usually have contracts with the development consultants and remodelling specialists for the advices of the green project opportunities regarding new buildings or retrofits (Hutchinson, 2012). Retailers also franchise software or energy systems (Hutchinson, 2012) from the third-party private operators.

Design teams also are part of the third-party operators in the building construction or remodelling. During the energy design process, design teams set up the energy goals at the beginning of the pre-design phase, and educate the building operators (Sheila J. Hayter, 2000).

4. Cultural impact on the building energy flexibility

Energy flexibility can happen across all sectors of the power system (generation, transmission, distribution and demand-side) (Kristiansen et al., 2016). Energy flexibility became a priority of many countries due to various national reasons like growing population size or climate change.

The reasons and solutions for the energy flexibility across countries vary due to the maturity of the energy system and the renewable energy resources potential. Other factors might also influence the national energy flexibility development, such as economic and climate situations.

Taking Denmark and Philippines as example, the reasons and motivation for the stakeholders to participate the building energy flexibility are different. Although both countries have high electricity price, Denmark has the highest electricity price in the Europe (shown in Figure 1), and so far there is little motivation for residential buildings in Denmark to provide the energy flexibility due to the high percentage of tax and grid tariffs in the electricity price (shown in Figure 2). Philippines has one of the most expensive electricity prices in Asia (Arangkada Pilipinas, 2016). Because the country is dependent on imported fuel and the government does not provide electricity subsidy. The private distribution utilities decide the electricity retail price according to locations and types of consumers. Although it is potential incentives for buildings to provide energy flexibility due to the high electricity price without high percentage of taxes, the electricity market structure doesn't provide the opportunity for the buildings to gain benefits by providing their energy flexibility.

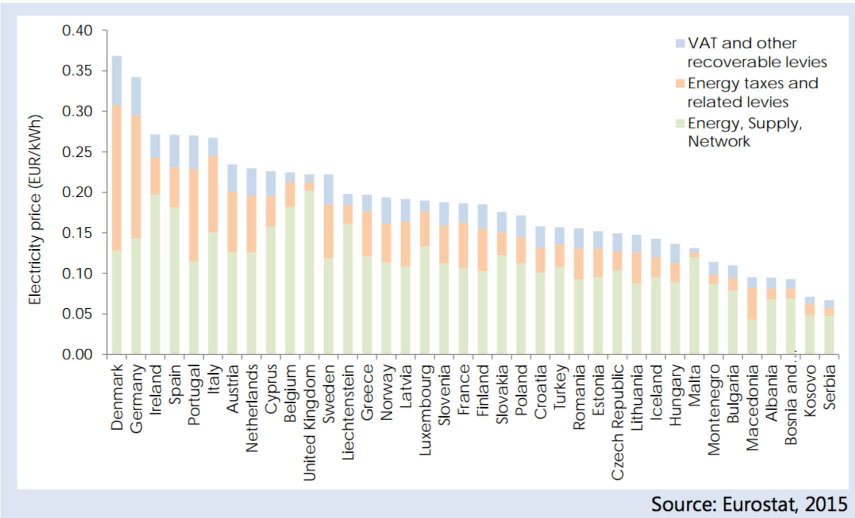

Figure 1. Residential electricity prices in European countries, first half of 2015[2]

[2] Eurostat, 2015. Electricity prices for domestic consumers - bi-annual data (from 2007 onwards), Download of data. Code: nrg_pc_204. http://ec.europa.eu/eurostat.

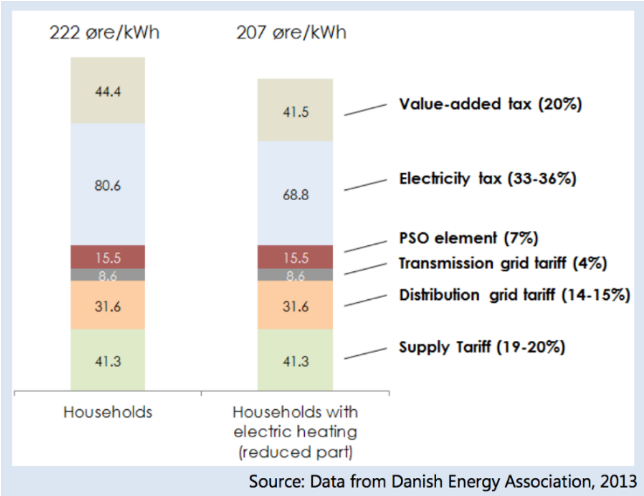

Figure 2. Composition of the residential electricity price simplified for a consumption of 4,000 kWh/y, average for 2012 3

The electricity market in Denmark can be divided into the wholesale market and retail market. The wholesale market is part of the Nord Pool wholesale market including the day-ahead and intra-day market, and the regulating market. The electricity market in Philippines is also divided into the wholesale Spot market (WESM) and retail market. WESM is a real-time energy market, wherein the generation schedules to meet customers' demand for each hour of the day. WESM timetable is divided into 2 periods: Dispatch period and settlement period (TRANSCO, 2003).WESM players include the Market Operator (MO), System Operator (SO), transmission provider, Distribution Utilities (DU's), directly connected customers, and suppliers. Comparatively, there is no BRPs or regulating market in Philippines. Therefore, the market of energy flexibility in the power system in Philippines does not exist.

Furthermore, the resources of energy flexibility provided by buildings in Denmark and Philippines are different. For instance, majority of the residential buildings don't equip the air conditioning in Denmark but the district heating. Comparatively, the air conditioning is compulsory in the buildings (if the building owners can afford) due to the climate, but no heating system needed in Philippines. In Philippines, the solar panels are commonly installed in buildings. However, the electricity produced from the solar panels is only for self-usage, and is not allowed to sell back to the grid. In Denmark, the buildings with solar panels are allowed to sell the electricity produced from the solar panels to sell back to the grid. Therefore, the incentives for buildings to provide energy flexibly between Denmark and Philippines are different.

Meanwhile, the buildings in Philippines have to provide the energy flexibility by the tolerance of the electricity blackout. With a population of more than 100 million people, there are 16 million who are not connected to the electricity grid in Philippines (Gonzales, 2013). The rapid population growth indicates an increase of electricity demand. There are 7% increase in the energy demand in Philippines (DOE, 2014). Due to the imbalance of supply and demand, series of power blackout experience in the Philippines between March and June in Luzon area in 2015 due to power shortage (Olchondra, 2015). Additionally, Philippines are prone to natural disasters as it is situated along a typhoon belt and the so-called ring of fire. The Philippines is

[3] Danish Energy Association, 2013. Gennemsnitlige månedlige el-forsyningspligtpriser for forbrugere og virksomheder i Danmark, Frederiksberg: Danish Energy Association (Dansk Energi).

experiencing frequent power outage especially during summer season wherein the temperature reaches up to 35 degrees affecting the operation of hydroelectric plants.

5. Discussions

The practice of energy flexibility varies according to size, location formats and activities. Both internal and external stakeholders contribute to the energy development of the stores. Stakeholders need to work actively together in order to achieve high level of the building energy flexibility.

The roles of stakeholders, relationships between stakeholders, and the factors influencing in the relationship between stakeholders are discussed with the example of retail stores in this report. However, there are some missing discussions in the current literature:

- In-detail information on the roles of stakeholders and systematic mapping of stakeholders and their involvement during the whole progress of the building energy flexibility.
- The factors that influence the relationship between stakeholders, within the organizations and external stakeholders, including the stakeholders' interaction and collaboration need to be further discussed.
- Drivers of external stakeholders to involve the energy flexibility. Further studies may include the factors that encourage the external stakeholders (e.g. governments) to implement the energy flexibility programs and the factors that influence customers to involve the building energy flexibility.
- The importance and involvement of the building design and construction is missing

This paper argues that the practice for consumers to participate the energy flexibility programs are not clear due to immature market and lack of regulation. From a process point of view, flexibility can be described in terms of: (1) flexibility speed, (2) flexibility duration, (3) flexibility of power (Wattjes et al., 2013). Therefore, the types and resources of energy flexibility provided by the buildings can be different due to the different needs and incentives from the grid.

This report also argues that the reasons and resources of energy flexibility in buildings can be different due to the types of buildings, legalisations, and control strategies, etc. Moreover, there are cross-national differences due to the variety of cultural, geographical, economic, technological, environmental factors.

6. Framework development

From the building lifecycle perspective, the energy flexibility in buildings should be considered at all of the stages of building design, construction, operations and maintenance. The whole process involves various collaborative stakeholders at each stage. Therefore, this report develops a preliminary framework (shown in Figure below) for the stakeholders' involvement in the building energy efficiency and flexibility with the integration of the building lifecycle (show in Figure below).

In the framework, different stakeholders participate diffferent stages, and the relationships between stakeholders and information sharing across stages influence the development of the energy efficient and flexbile buildings.

The relationships across the stakeholders are mainly bi-directional. For instance, the real estate developers provide the energy efficient and flexible buildings to the occupants. Meanwhile, occupants expect the green technologies and integrated building systems, because such systems are present in various commercial smart buildings (Johnson, 2007). Intelligent system, comfortable and efficient buildings are attractive for the occupants (Ehrlich, 2006). Therefore, it is important for the real estate builders to consider those qualities when developing a smart building to be more competitive in the market. Therefore, the framework can assist to understand the stakeholders' needs, motivation and barriers.

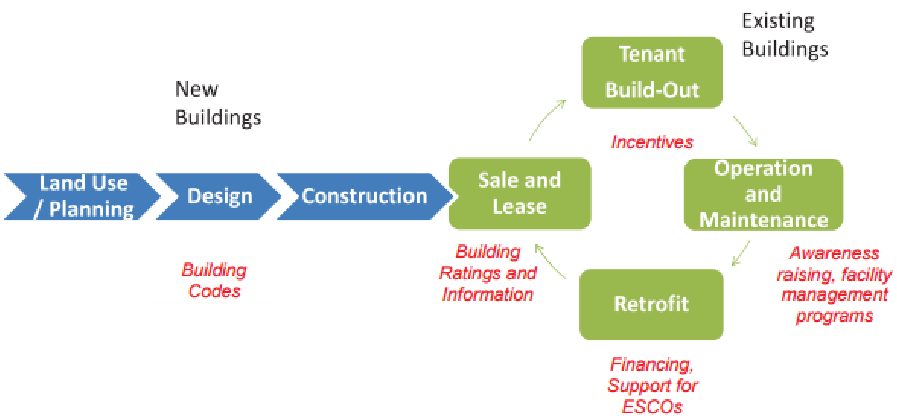

Figure 3. The Building Life Cycle and Selected Energy Efficiency Opportunities (SwitchAsia, 2016)

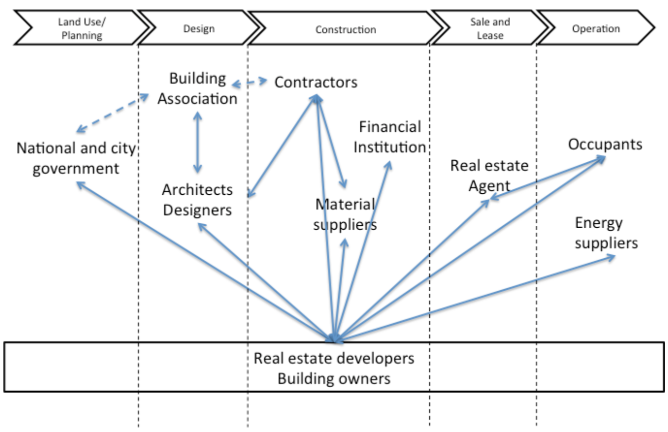

Figure 4. The stakeholders' participation in the development of the building energy efficiency and flexibility

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