Energy and Buildings 107 (2015) 254–263

Contents lists available at ScienceDirect

Energy and Buildings

journal homepage: www.elsevier.com/locate/enbuild

Buildings in the future energy system – Perspectives of the Swedish energy and buildings sectors on current energy challenges

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ARTICLE INFO

Article history:
Received 18 May 2015
Received in revised form 23 July 2015
Accepted 13 August 2015
Available online 15 August 2015

Keywords:
Buildings sector
Energy sector
Cooperation
Smart grids

ABSTRACT

Buildings are expected to play a key role in the development and operation of future smart energy systems through real-time energy trade, energy demand flexibility, self-generation of electricity, and energy storage capabilities. Shifting the role of buildings from passive consumers to active players in the energy networks, however, may require closer cooperation between the energy and buildings sectors than there is today. Based on 23 semi-structured interviews and a web survey answered by key stakeholders, this study presents the views of the energy and buildings sectors on the current energy challenges in a comparative approach. Despite conflicting viewpoints on some of the issues, the energy and buildings sectors have similar perspectives on many of the current energy challenges. Reducing CO_2 emissions is a shared concern between the energy and buildings sectors that can serve as a departure point for inter-sectoral cooperation for carbon-reducing developments, including the deployment of smart energy systems. The prominent energy challenges were identified to be related to low flexibilities in energy supply and use, which limit mutually beneficial cases, and hence cooperation, between the energy and buildings sectors today.

1. Introduction

Switching from fossil fuels to renewable resources for meeting the global energy demand is fundamental to combat climate change. Due to the intermittent nature of renewable energy resources, their integration with current power systems is, however, challenging. Current power systems remain largely unchanged since their introduction in the 19th century and cannot cope with the needs of the modern society as they offer limited flexibility, pose risks of blackouts, and operate with low efficiencies [1]. The "smart grid" is the evolved grid system that allows flexible and efficient operation of electricity networks through larger amounts of decentralised renewable energy, higher demand and supply flexibility, and self-healing capabilities [2,3]. In addition, complementing smart electricity grids with smart thermal networks in the future may contribute to the development of fully renewable energy systems [4,5].

As one of the major energy consumers, buildings can play an important role in the development and operation of smart energy systems through real-time energy trade, energy demand flexibility, local power and heat generation, and energy storage capabilities [5–8]. Smart energy systems are expected to shift the role of buildings in the energy system from passive consumers to active players that participate in the operation of networks [9,10]. This, however, may require closer interaction and cooperation between the energy and buildings sectors than there is today, both at the end-user level and at the inter-company level. Hashmi et al. [11] points out that "*realizing smart grids' potential will require a new level of cooperation between industry players, advocacy groups, the public and especially the regulatory bodies that have such immediate influence over the direction the process will take.*" A number of smart grid pilot projects in Sweden showcase examples of cooperation between various stakeholders, including those from the energy and buildings sectors, such as the Stockholm Royal Seaport and Hyllie urban development projects, and Framtidsgränd (Future alley) in Västerås [12–15]. It is crucial to shift the level of cooperation between the energy and buildings sectors from pilot projects to mutually beneficial initiatives that can lead to the wide-scale deployment of smart energy systems. This, however, would require better understanding or priorities and perspectives of the two sectors in regards to energy-related developments.

There are several studies in the literature that present the perspectives of the energy and buildings sectors on energy-related developments. To name a few, Richter [16] investigated the

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http://dx.doi.org/10.1016/j.enbuild.2015.08.027
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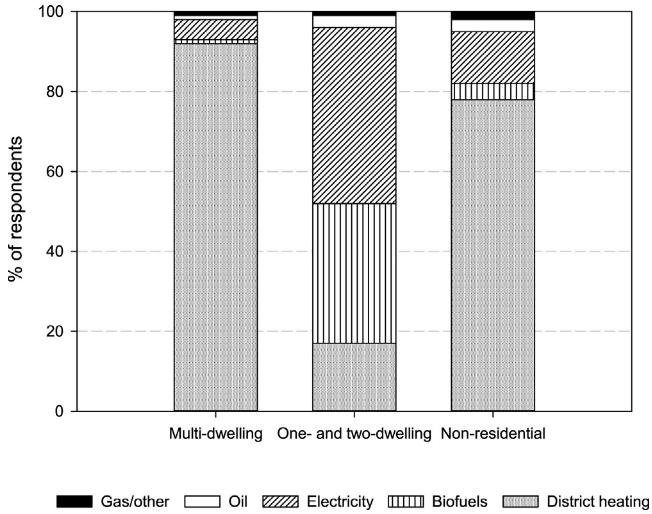

Fig. 1. Heating in Swedish buildings.
Data: Swedish Energy Agency [32].

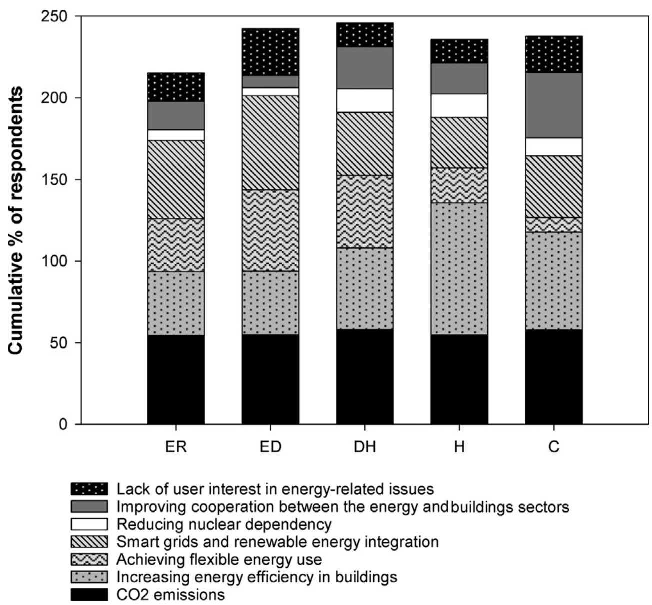

Fig. 2. Stacked bar chart of the answers to the question "What do you think are the current energy challenges in Sweden today?" presented as the cumulative shares of respondents by stakeholders groups.

perspectives of German utilities on the development of self-generation systems for local electricity production and accompanying business models, while Williams [17] measured the opinions of house-builders, local authorities, energy utilities and service companies on self-generation systems as part of the housing growth programme in the UK. Goldman [18] presented the views of utilities and commercial customers in the United States on energy efficiency and demand response. A survey by PWC [19] with utilities from around the world reported on the views of the power sector on important energy-related developments, including energy efficiency, smart grids, self-generation of electricity, and demand response. There is, however, a gap in the literature for a study that presents and compares the perspectives of the energy and buildings sectors on current energy challenges. This paper aims to fill this gap by presenting the results of interviews and a web survey that were answered by key stakeholders from the Swedish energy and buildings sectors. Several studies in energy research, such as Brandon and Lewis [20], Bürer and Wüstenhagen [21], Caird et al. [22], and Hondo and Baba [23], among others, combined surveys with interviews as data collection methods.

Table 1
Answers (in %) to the question "How do you think the following trends in the buildings sector would impact the energy sector? – 'Increased energy efficiency'".

	ER	ED	DH	H	C
Increased energy efficiency					
Very negative	0	0	0	0	2
Negative	0	3	5	3	8
Neither negative nor positive	32	21	32	15	24
Positive	32	47	43	38	24
Very positive	29	27	18	38	39
Don't know	7	2	2	6	3

2. Background

Sweden has taken progressive steps towards achieving a decarbonised and competitive energy market in the last decades. Despite a relatively high energy supply, the Swedish economy has the second-lowest carbon-intensity among OECD countries [24]. Sweden has announced the 2020 climate targets that involve cutting greenhouse gas emissions by 40% compared to the levels in 1990, increasing the share of renewables in the final energy use to 50%, and reducing energy use by 20% [25]. In addition, the country aims to become carbon-neutral by the year 2050 [26].

Sweden deregulated its electricity market in 1996 and joined Nordpool, the Nordic electricity market. The generation and retail of electricity are open to competition, although the distribution remains a monopoly. The Swedish power sector is fossil-free to a large extent, with significant shares of nuclear power and hydropower in the electricity generation mix [27]. Sweden has set the target to achieve 30 TWh of annual wind power production by the year 2020, which is primarily supported by the common electricity certificate scheme with Norway [28]. In addition, there are investment subsidies available for PV systems for self-generation of electricity and Swedish customers, as of 2015, are entitled to tax reductions on the surplus electricity that is fed back to the grid [29,30]. These developments are expected to boost the penetration of renewable energy into the electricity system, creating a further need for demand flexibility. In order to achieve a more flexible energy demand and encourage savings, Sweden followed a progressive smart grid roll-out policy and became one of the first Member States in the EU to reach universal coverage of smart electricity

Table 2
Arithmetic means of responses by stakeholder groups. Statistical significance (Tukey $p = 0.10$) is indicated by different letters (a, b).

	ER	ED	DH	H	C
Increased energy efficiency	3.97	3.99	3.75^a	4.22^b	3.93
Active and flexible consumers	3.81	3.71	3.8	3.86	3.63
Installation of self-generation systems	3.90^b	3.44	3.47	3.72	3.25^a
Participation in demand response	3.21	3.23	3.32	3.31	3.32
Increased fixed charges in the energy tariff	2.72^b	2.90^b	2.84^b	2.5	2.11^a
"There is very good cooperation between the energy and buildings sectors"	1.16^b	1.46	1.52	1.79	1.64^a