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Consumer perceptions of smart grid development: Results of a Hong Kong survey and policy implications

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HIGHLIGHTS

- Consumers have a major role in smart grid technologies.
- This paper reports findings of a Hong Kong survey on how consumers perceive and respond.
- Hong Kong consumers are interested in being informed and playing an active role in energy decision-making.
- Motivations and barriers are discussed.
- Policy recommendations for effective consumer engagement are suggested.

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ABSTRACT

Consumers have a major role to play in smart grid technologies which can be instrumental in addressing climate change and energy challenges. However, little is known about how consumers perceive, and how they might respond to the opportunities that smart grid technologies offer. This paper reports the results from a Hong Kong survey ($n=505$). It contributes to the literature by providing a better understanding of the perceptions and behaviour of electricity consumers about the possible deployment of smart grids.

Our results indicate that Hong Kong consumers generally welcomed smart grid technologies and had a preference for energy saving, energy efficiency and renewable energy while they showed a high level of opposition to nuclear power. They displayed an interest in playing a much more informed and active role in energy decision-making, but they were sensitive to tariff increases. Motivations and barriers for consumers to support smart grid developments are also discussed. We conclude with a discussion of policy implications for effective consumer engagement. More policy attention is needed on demand-side measures, introducing institutional and regulatory changes, and modifying relationships between consumers, the government and utilities.

1. Introduction

Impacts of climate change, gas price spikes and the renewed concerns about nuclear risks following the Fukushima accident have heightened the need to move away from current unsustainable energy systems. Smart grids, as a major innovative energy alternative, have received growing attention from policy makers and scholars. Smart grids are electricity networks that can integrate information technology into the grid (SGA, 2011; ETP, 2006). Smart grids can be instrumental in reducing carbon emissions, improving energy saving and efficiency, and integrating a broad range of generation and storage options including renewable energy. Such grids have therefore been regarded as a key to both demand-side and supply-side management of energy systems (Executive Office, 2011; IEA, 2011).

Electricity consumers have the potential to play an important role in addressing climate change problems through the development of smart grid technologies. On the demand-side, well-informed and price-responsive consumers are expected to play a more active role in managing electricity consumption rather than being passive users only. Consumers could contribute to energy saving, energy efficiency and peak load shifts through using real-time electricity information and smart meters that are linked with dynamic pricing systems (Executive Office, 2011; IEA, 2010a; Strbac, 2008). Consumers, for example, can connect smart appliances to the grid and respond to pricing signals and information, and alter their electricity consumption pattern by delaying

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consumption until off-peak periods when electricity is cheaper (Haney et al., 2009). On the supply-side, consumers could assume the role of electricity producers/suppliers, through decentralised generation technologies such as wind turbines and solar panels to generate electricity at the household and community levels (Nye et al., 2010).

The important role of consumers in sustainable energy management has been highlighted in a recent report published by the International Energy Agency (IEA) (IEA, 2009). In contrast to the overriding attention given to nuclear and other supply-side measures by the media and academics (IEA, 2010a), the IEA report argues that about half of our means for de-carbonising by 2030 would have to come from energy efficiency measures. Another quarter could be achieved through renewable and biofuels while nuclear and carbon capture and storage would contribute only 10%, respectively.

Worldwide, a number of countries and cities have made progress in smart grids using different approaches and with various outcomes. The recent publication of the smart grid policy framework in the US (Executive Office, 2011) and the Smart Grid Roadmap launched by the Korean government are examples of such initiatives (MKE and KSGI, 2010; Mah et al., 2011).

Consumer participation in smart grid development is emerging. Japan's large-scale demonstration projects and Korea's Jeju Testbed Demonstration Project are some of the examples of this emerging movement (Ogawa, 2010; KSGI, 2011). In Hong Kong, about 400 households have participated in a smart grid pilot in a private housing estate (Cheung, 2011).

The potential benefits of smart grids can be considerable in terms of energy savings and the creation of new global and domestic markets (IEA, 2009). However, current electricity systems are characterised by the dominance of fossil fuels, the presence of centralised grid systems, and linear supplier-end user relationships in which consumers play a passive role in energy decision-making. The real issue is how the potential contribution of consumers in smart grid technologies can be realised and contributes to the transition towards a more sustainable energy future.

Smart grids look different from the current electricity systems in important ways. They require a transition of current electricity systems that are characterised by centralised, fossil-fuel based facilities to one that can incorporate decentralised systems using more diverse energy sources as well as more price-sensitive and well-informed consumers (Nye et al., 2010). The transition would create electricity systems which enable consumers to make informed and empowered energy-related choices and make personal behavioural changes (DeWaters and Powers, 2011; ECME Consortium, 2010). Such systems also alter the provider–consumer relationships from the current one way to a two-way relationship in which consumers could assume the role of co-provider or "prosumer" in a more decentralised electricity system (Devine, 2007; Potter et al., 2009).

Such a transition therefore requires significant socio-institutional change, with implications for institutions and actors involved in market formation (Brown and Hendry, 2009). Beyond studies on the technical aspects of smart grids (see for example Depuru et al., 2011), an emerging body of studies has discussed and examined a broad range of policy and governance issues concerning consumers in the context of smart grid-related technologies. Such issues include consumer perceptions (Devine, 2007), motivations (Leenheer et al., 2011; Vasconcelos, 2008), concerns (Gan, 2009; Blumstein et al., 1980; Wiser, 2000), policy preferences (Curry et al., 2005), market impacts of different incentives schemes (Leenheer et al., 2011), and other governance issues such as empowering (Executive Office, 2011), power relationships, information sharing, loyalty, trust and accountability (Parag and Darby, 2009; Zio and Aven, 2011) and the attitude-behaviour gap (Litvine and Wüstenhagen, 2011; Parag and Darby, 2009).

Amidst the growing body of smart grid studies, public opinion surveys on smart grid-related issues have been increasing. These have focused on consumer awareness, knowledge levels, degree of concern (Business Wire, 2010; GE Energy, 2010; Wimberly, 2011), perceived motivations (OECD, 2011; Deloitte, 2011; Oracle, 2010), perceived barriers and risks (Oracle, 2010; Deloitte, 2011; Gan, 2009; Wiser, 2000) and willingness to pay (Deloitte, 2011; Oxfam, 2010). Some surveys focus on specific technologies or specific stakeholder groups. Surveys conducted by for example Leenheer et al. (2011) have examined consumer attitudes towards micro-generation while surveys conducted by for example Wimberly (2011) focus on households.

However, two major gaps in existing knowledge remain. First, the literature on the interactions between consumers and demand-side and supply-side-management has remained relatively limited, and this is particularly so in the context of smart grid technologies and Asia. Second, public opinion surveys on smart grid-related issues have been growing but few are able to draw instructive policy implications from survey data. To partly fill this knowledge gap, this paper draws on a survey of Hong Kong's electricity consumers and assesses their perception and behaviour, and how they would respond to the possible deployment of smart grids in the future.

Hong Kong merits study for a number of reasons. Hong Kong is an atypical city that differs from other cities in many important ways. Hong Kong has no indigenous fossil-fuel resources. It does not have strong energy policies and tends to emphasise a policy of laissez faire in relation to energy-related environmental issues. The disincentive created by the Scheme of Control Agreements, the regulatory framework for the electricity sector which links the rates of return with fixed asset investment, to energy efficiency has also set Hong Kong apart from other cities. However, Hong Kong may serve as a policy laboratory for future cities where high-rise buildings have substantial potential for energy efficiency. The focus on consumer perceptions of smart grids in this study has relevance beyond Hong Kong as the involvement of households in energy efficiency has become a growing trend in many western and Asian cities such as New York, Seoul and Singapore where green growth and green technology are underpinning new pathways of developments (Chua, 2012; City of New York, 2010; MKE and KSGI, 2010). Hong Kong's experience in smart grid development could therefore contribute to our understanding of how cities transit towards a more sustainable future.

Hong Kong also merits scholarly and policy attention in the broader Chinese context. Hong Kong and its neighbouring Pearl River Delta have been given an important role by the central government to pioneer and act as a role model for low-carbon development in the country (NDRC, 2008, 2010). China has occupied a central position in global climate change impacts and responses. The IEA has estimated that over 80% of the growth of world electricity demand will take place in China and other non-OECD countries by 2030 (IEA, 2009). China alone will be responsible for three-quarters of energy-related CO_2 emissions by 2030 (IEA, 2009). The experience gained in Hong Kong can be useful for deriving policy recommendations for China and the global community.

In the rest of this paper, we will first highlight global trends in the involvement of consumers in smart grids and the latest developments in Hong Kong. We will then discuss some key theoretical issues relating to consumers in the context of smart grid technologies. This is followed by a detailed discussion of our survey results. The final section discusses the policy implications of the findings.