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The citizens' role in energy smart city development

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Abstract

The purpose of the paper was to investigate citizens' experiences and feedback related to strategies and products targeting energy savings and emission reduction in Sweden. Survey results presented in this paper showed that consumers did not make use of the advantages of the smart meters and that tailored feedback is necessary to help them save electricity. Moreover, despite the high satisfaction levels among electric vehicles owners, additional improvements (e.g. reliable charging infrastructure) and information are needed to attract potential owners. Effective information dissemination is thus a crucial part of increasing urban sustainability.

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Keywords: sustainable urban development; end-users; smart cities; consumer feedback; electric vehicles.

1. Introduction

With a continuously increasing world population and with cities responsible for approximately two thirds of the global primary energy consumption with 86% of the energy demand being supplied by fossil fuels [1], most efforts are currently focusing on increasing urban sustainability and efficiency. Smart city initiatives around the world are aiming at fulfilling the citizens' needs and demands while reducing the impact on the environment. The energy used by the residential sector, especially in the developed countries, is becoming one of the most significant contributors to the countries' energy balances with forecasts showing that over 40% of the total yearly consumption will come from this sector [2]. Moreover,

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it is estimated that approximately 77% of the global transport oil demand in 2010 was on account of road transport, and it is expected that by 2050 the global energy demand will double or triple and oil and gas supplies are unlikely to meet the demand, making the transport sector an important issue to address [3,4].

The European Union (EU) has been strongly involved in providing support for the Member countries helping them increase their energy efficiency and reduce emissions. On the end-user side for instance, from 2015 new energy efficiency measures have been set to help consumers save up to 45€/year: energy labels for cooking appliances, automatic standby for coffee machines and network equipment, and energy labels for online sales [5]. Significant efforts have been put towards increasing the use of electric vehicles (EVs), due to their "tank-to-wheels" efficiency being a factor of about 3 higher than internal combustion engine vehicles, and also for being a more sustainable solution ensuring the security of energy supply and a broader use of emission-free energy source, thus helping the EU reach its CO_2 emission targets [6]. The EU provides additionally funding to carry out research, and for adoption of different practices and technologies in the related energy topics. As an example, the "Planning for Energy Efficient Cities" (PLEEC) project, where Sweden together with 17 partners from 13 cities combine their expertise to help 6 small-medium sized cities create and implement energy efficient action plans (including urban planning, citizens' behavior, and technology adoption), part of the results being presented in this paper. Within the EU, Sweden was in 2014 the country with the highest number of "Smart Cities", as indicated in the "Mapping Smart Cites in the EU" report [7], making the country of special interest for the analysis. This paper aims at answering the research question related to the smart meters benefits for the end-users and the experience of current EV owners – results that can be used for further improving the way new technologies and solutions are implemented by the cities. The paper presents survey results from the implementation of solutions and initiatives in Sweden targeting domestic energy consumption reduction, consumers' behavior and experience from private electric vehicle use.

2. Materials and methods

The results presented in this paper are based on strategies and initiatives carried out in Sweden related (but not limited) to the PLEEC project targeting energy savings and use of electric vehicles. A questionnaire and a web-based survey were used to collect information about the consumers experience, characteristics and preferences regarding use of electric vehicles and use of smart electricity meters. The obtained response rates were 64% for the EV survey and 56% for the smart meters users.

The online survey was distributed to customers of Mälarenergi, a city-owned power and district heating provider, located in the city of Västerås, Sweden. The link with the online survey was provided on the company's website as well as with the free magazine sent out to all their customers.

The questionnaire, on the other hand, was sent out to all EV private owners in Sweden; the addresses being provided by the Swedish Transport Administration.

3. Results and discussion

3.1. Household electricity consumption

Sweden counts with the second lowest carbon-intense economy among OECD countries despite a relatively high per-capita energy use [8]. According the Swedish 2020 climate goals, the country has to reach an overall reduction in greenhouse gas emissions by 40%, increase energy efficiency by 20% and reach 50% share of renewable energy in the final energy use [9]. Sweden became in 2009 the pioneer in

completing in 100% of the households the rollout of electricity smart meters and since 2012 providing consumers with the right to get hourly metering of electricity [10]. The possibility of using smart meter data to inform the users and reduce their consumption has in many cases, been proven as an effective tool [11, 12]. In Sweden, the introduction of smart meters has allowed customers to receive monthly electricity bills based on their actual consumption and not on estimated values, however, not many electricity providers count with additional tools/services that would allow their customers to follow-up their consumption. In a web-based survey carried out in 2014, 80% of the total 164 respondents stated to not use any device to follow-up their electricity consumption. In the same study, 69% of the participants answered to prefer information disaggregated into different appliances, while 62% considered energy saving tips based on their own consumption to help them achieve considerable savings. In a larger study, carried out in several cities in Sweden where different visualization tools were used to present energy consumption, saving of almost 18% were reached by consumers that visited a web-site which presented their historical consumption [13]. These findings however, are strongly dependent on the consumers' engagement, interest, income levels, and preference regarding visualization tools [14]. In Eskilstuna, part of the PLEEC project, different activities (e.g. personal visits by energy advisers) were carried out with the aim of increasing the citizens' knowledge on energy and water savings; some of the households reduced their consumption by 33%, reaching a total average saving of 1745 kWh/month for the period 2011-2013 [15]. Other activities included technical and building improvements: new kitchen equipment, improved ventilation systems, installation of solar panels on the school's roof (including special information and lessons to the students regarding renewable energy production), and improved bicycle paths. The example of Eskilstuna demonstrates that initiatives combining many aspects of the citizens' everyday activities (waste recycling, urban farming, cooking with organic products, energy and water savings, etc.) create a greater impact than if only targeting one aspect at the time. Moreover, the collaboration between the energy and building sector and the municipality facilitates the citizens' engagement, e.g. by participating in bicycle challenges, using frequently the public transportation after improving schedules and making the routes easier to understand.

3.2. Experiences from electric vehicles users in Sweden

Electricity generation in Sweden is largely fossil free with 48% hydropower, 38% nuclear power, 4% wind power and 10% combustion-based generation at combined heat and power plants [16]. A large share of EVs as an alternative to conventional combustion engine vehicles is thus considered a valuable solution to GHG emission mitigation.

In Sweden, regardless the lack of strong incentives, the number of EVs has been constantly increasing. March 2015, was the month with the highest number of EV registrations, with a total of 699 cars, surpassing the previous record number reached in June 2014, when the number of registered EVs was 579 [18]. Of the 247 EV drivers that responded the survey used for this study, 81% were male; between 40 and 45 years old; with income levels of approximately 11 000 EUR/month; and living in a 2 to 4-member families. The survey participants were asked to give their opinion regarding the options for Sweden to increase EV adoption, their responses indicating that "incentives" would be the best solution (31% of the respondents). Additionally, 17% opted for "free charging", while 1% responded that "free parking" would help increase the use of EVs in Sweden. 14% (N=250) of the participants stated that a combination of all the previously mentioned options would help increase EV adoption in Sweden. In the "free-text" option, the suggestions provided by the respondents included: better policy and regulation;

implementation of bonus system for CO^2 emissions, tax exemption of purchasing of EVs, and better business plans for building charging infrastructure for people living in apartments.

The majority of private owners of EVs suggested that Sweden should follow the incentive strategies introduced in Norway: use of bus lines, tax related benefits and free parking and charging. Some other suggestions and concerns also included: facilities for battery recycling; introduce queuing systems to avoid cars charging for too long periods at public chargers. Among the complains, the most common ones included charging infrastructure not working and taking too long to fix; lack of charging stations at hospitals, shopping centers and other public locations, and lack of regulation in cases where people have PV production at home during the day but are paying while charging at work as well as paying when charging at home at nights.

5% of the respondents also indicated that "more information is needed" in order to attract the attention of possible new users. In fact, a recent study carried out by the Swedish Energy Agency reached the same conclusion: the lack of knowledge was one of the major impediments to using EVs [18].

4. Conclusions

The use of digital technologies or information and communication technologies to improve urban services, increase sustainability without decreasing quality and performance, can transform current cities into "smart" ones, only if citizens are effectively and actively engaged. The results described in this paper present a clear example of how citizens' engagement and knowledge are essential for a successful implementation and use of new products and technologies: in this case, energy consumption information provided by smart metering technologies, and electric vehicles. In the case of smart electricity meters, despite of their capabilities and being available in all Swedish households since 2009, the end-users are not yet provided with frequent and detailed information regarding their consumption.

Specific policies and initiatives should be developed and implemented on local level especially in cases where the local authorities already count with a strong collaboration. Energy suppliers should be encouraged to provide their customers with the required information that will help end-users learn more about their appliances consumption and the impact of their everyday activities on the energy consumption, which would eventually increase their consumption flexibility.

On the transportation side, while continuing the work on installation and improvement of charging infrastructure and business models, national and local authorities should distribute the positive feedback of current EV owners and make complementary information available to potential users in order to supress existing misconceptions thus increasing the use of EVs. A possible solution to engaging potential EV owners is to increase the number of EVs in local car-pool/sharing initiatives (e.g. in combination with public transportation), or at car rental companies, which will allow drivers to test and learn more about EVs capabilities.

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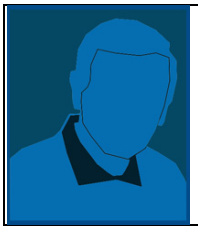

Biography

Dr. Iana Vassileva holds a PhD in Energy and Environmental Engineering, with focus on consumers' behavior change and awareness regarding energy efficiency and energy consumption. For the last several years she has been involved in several smart cities and sustainable urban development projects.