Cities 64 (2017) 54–65

Contents lists available at ScienceDirect

Cities

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

Smart energy city development: A story told by urban planners

Farnaz Mosannenzadeh [a,b,*], Adriano Bisello [c,b], Roberto Vaccaro [b], Valentina D'Alonzo [a,b], Garfield Wayne Hunter [d,b], Daniele Vettorato [b]

[a] Doctoral School in Civil, Environmental, and Mechanical Engineering, University of Trento, Via Mesiano 77, 38123 Trento, Italy
[b] Institute for Renewable Energy, European Academy of Bozen-Bolzano, Via G. Di Vittorio 16, I-39100 Bolzano, Italy
[c] Doctoral School in Management Engineering and Real Estate Economics, University of Padua, Via Venezia 1, 35131 Padova, Italy
[d] College of Architecture and Urban Planning, Tongji University, 1239 Siping Road, Shanghai, PR China

ARTICLE INFO

Article history:
Received 25 January 2016
Received in revised form 17 January 2017
Accepted 2 February 2017
Available online xxxx

Keywords:
Definition
Practical solution
Decision-making
Smart city
Sustainability

ABSTRACT

The smart energy city is an emerging concept in urban development, aiming to optimize urban energy systems and improve the quality of life for citizens. However, smart energy city development requires a well-defined and consistent conceptual core in order to ensure its accurate interpretation and successful implementation. This research aims to define smart energy city development not only in a theoretical context, but also in terms of practical solutions. We adopt the 5W + 1H (why, what, who, where, when, how) model integrated with literature review and expert knowledge elicitation, i.e., focus groups and interviews. This results in: (i) clarification of general interrelationship between smart energy city, smart city, and sustainable city; (ii) a holistic, multidisciplinary, and comprehensive conceptual framework of smart energy city, revealing its principles, objectives, domains of intervention, stakeholders, and time and spatial scales; and (iii) a set of smart energy practical solutions and technologies categorized in the eight domains of intervention: buildings and districts, transportation and mobility, energy and ICT (information and communication technology) infrastructures, collaborative planning, consumer behavior management, energy and data management, as well as two cross-cutting domains. We suggest that sustainable, rational, and integrated application of new technologies, collaboration of multiple stakeholders, and integration of multiple urban energy domains, mainstreamed in energy specific targets, enable distinguishing real from labeled smart energy city development. We suggest that smart energy solutions are mostly effective when combined with other sustainable solutions. This research is applicable for all smart energy city stakeholders, particularly decision makers and researchers, in order to enhance a common and comprehensive understanding of the smart energy city concept and its practical solutions to foster sustainable smart energy city development.

1. Introduction

Smart energy city (SEC) is an emerging urban development strategy in Europe. It is aimed at assisting cities to exploit recent opportunities in technology and economy in order to provide citizens with a better quality of life, while addressing urban energy challenges such as climate change, shortage of energy resources, and inadequate and deteriorating energy infrastructure (Coe, Paquet, & Roy, 2001; Washburn et al., 2009).

The appearance of multiple SEC initiatives in European cities lacks a well-defined conceptual basis (Hollands, 2008; Söderström, Paasche, & Klauser, 2014; Vanolo, 2014). This creates confusion in devising SEC strategies and plans, and allows distorted or simplistic interpretation and application of the concept (Vanolo, 2014). A simplistic approach arises when cities label themselves "smart" as they utilize some types of Information and Communication Technology (ICT) solutions (Hollands, 2008); while scholars emphasize that smartness is beyond solely the application of technology or ICT solutions (Coe et al., 2001; Hollands, 2008; Nam & Pardo, 2011). Therefore, a common and comprehensive concept for SEC development is necessary to ensure its correct and successful design and implementation.

Current academic literature on the SEC concept has approached the topic from three general perspectives. The first considers SEC as a "good thing" per se and seeks to actualize it through technological solutions for specific problems that affect the urban energy systems (e.g., Chai, Wen, & Nathwani, 2013; Krajačić et al., 2011). The literature on this perspective rarely makes an attempt to redefine already existing interpretations of the SEC concept. The second accepts the eligibility of SEC as well; however, it attempts to define and analyze SEC by considering its different components, aims, and characteristics (Belanger &

* Corresponding author.
E-mail addresses: farnaz.mosannenzadeh@alumni.unitn.it (F. Mosannenzadeh), adriano.bisello@eurac.edu (A. Bisello), roberto.vaccaro@eurac.edu (R. Vaccaro), valentina.dalonzo@eurac.edu (V. D'Alonzo), garfield.hunter@tongji.edu.cn (G.W. Hunter), daniele.vettorato@eurac.edu (D. Vettorato).

[1] Smart energy city.
[2] Information and communication technology.

http://dx.doi.org/10.1016/j.cities.2017.02.001
0264-2751/

Rowlands, 2014; Chai, Wen, Nathwani, & Rowlands, 2011; Chai et al., 2013; Nielsen, Ben Amer, & Halsnæs, 2013). There are a few studies from this perspective that focus specifically on the concept of the smart *energy* city, as compared to many attempts to define *smart city*. The existing definitions related to the smart energy city often do not address the urban perspective but are focused more on specific elements such as energy systems or energy networks. For example, Lund (2014) conceptualized smart energy *system*, and Chai et al. (2013, 2011) and Belanger and Rowlands (2014) defined the smart energy *network*. These definitions are very technical and lack a holistic overview of the concept. A more holistic SEC definition is provided by Nielsen et al. (2013, p. 3): "*The Smart Energy City is highly energy and resource efficient, and is increasingly powered by renewable energy sources; it relies on integrated and resilient resource systems, as well as insight-driven and innovative approaches to strategic planning. The application of information, communication and technology are commonly a means to meet these objectives. The Smart Energy City, as a core to the concept of the Smart City, provides its users with a liveable, affordable, climate-friendly and engaging environment that supports the needs and interests of its users and is based on a sustainable economy*." This definition, however, concentrates mostly on the objectives of SEC, and it is not clear on other important aspects of the concept such as stakeholders, domains of intervention, and temporal and spatial dimensions. Contrary to the two mentioned perspectives, the third criticizes the concept of smart city in general (which is extendable to SEC as well) and raises alarms about the risks and challenges implicit in blind acceptance of distorted smart city interpretations (Hollands, 2008; Söderström et al., 2014; Vanolo, 2014). Considering these three perspectives, subsequent fundamental gaps and concerns in SEC development arise.

The genealogy of the concept of smart city and its components (e.g., SEC) are not clear and validated (Kitchin, 2015). Söderström et al. (2014) doubt the concept, characterizing it as a story told by International Business Machines Corporation (IBM), which positions IBM and similar ICT companies as inevitable key actors in cracking urban problems. This highlights a need to define SEC from a coherent point of view, with a holistic and multi-disciplinary scope that puts public benefit as the first priority in the short-to-long term (Söderström et al., 2014). In addition, the boundaries between SEC, smart city, and sustainable city are nebulous (Hollands, 2008; Kitchin, 2015). SEC is presumed as a component of the smart city (Lazaroiu & Roscia, 2012; Mosannenzadeh & Vettorato, 2014; Nielsen et al., 2013); yet, to our knowledge, no scientific study has explicitly stated the detailed interrelationship between SEC and the smart city. In addition, it is not clear if SEC is a new label substituting for sustainable city, or if it is a distinct technological vision overlapping with it (see Tregua, D'Auria, & Bifulco, 2015).

The sustainability of the SEC development is the subject of concern as well. Social, economic, and environmental impacts of SEC development have received skepticism, due particularly to the specific emphasis on technology and ICT embodied in the concept (Viitanen & Kingston, 2014). Hollands (2008) asserts that smart cities (and therefore, SEC) will trigger marginalization of poorer residents and traditional communities with poorer access to schooling and technology. Viitanen and Kingston (2014) also purports the increase of e-waste due to adding infrastructure to cities in order to make them smart, considering the short shelf-life of technologies and the tendency of end users to upgrade.

SEC discourse raises further concerns, including the reduction of urban future to a single technology-centric vision that ignores other non-technological but creative and effective solutions to urban problems (Vanolo, 2014); underestimation of dissimilarities between cities by indicating prefabricated solutions that should work for all SEC developments; and a lack of dialogue and collaboration between stakeholders (Kitchin, 2015).

Finally, the connection between the general SEC theoretical definition and the specific and detailed practical solutions is not very clear (Kitchin, 2015). Consequently, urban decision makers and planners ask for a better understanding of how to locate SEC practical solutions within the wide SEC concept.

With respect to the mentioned concerns, we aim to develop a holistic, multi-disciplinary, and comprehensive concept of SEC development from the urban planners' perspective, following three objectives: first, concisely clarifying the general interrelationship between SEC, smart city, and sustainable city; second, developing a theoretical definition of SEC development that considers sustainability evaluation, reflects location specificity, and recognizes SEC key stakeholders and the dialogue between them; and third, understanding how SEC practical solutions and technologies with high levels of technology can fit within the SEC comprehensive and general theoretical context.

The present investigation retreats and develops the concept of smart energy city briefly presented within the Deliverable 2.1 "SWOT analysis report of the refined concept/baseline" of the FP7 SINFONIA project (Pezzutto et al., 2015). The paper is structured as follows: in Section 2, the research methodology is illustrated. In Sections 3, 4, and 5, the three research objectives are addressed sequentially. Section 6 concludes the paper by pointing out open discussions on the research results and suggestions for further investigations.

2. Methodology

Since SEC concept has not been totally explored and the development of its concept in two layers of theory and practice is yet required, we targeted and synthesized both literature and experts for knowledge elicitation (following Shadbolt & Smart, 2015). The detailed explanation of methodology to address each objective is presented as follows.

2.1. Clarifying interrelationship between smart energy city, smart city, and sustainable city

To address the first objective, we reviewed the scientific literature using four sets of search terms: ["smart city" AND (energy OR "smart energy" OR "smart energy city")], [("smart city" OR "smart energy city") AND (definition OR concept* OR defining)], ["sustainable city" AND (definition OR concept* OR defining)], [(smart AND sustainable) AND (city OR urban OR planning)]. Similar to Payne and Frow (2005), the literature review shaped the basis for conducting expert focus groups.

The expert focus group method is appropriate because it has a better performance than individual interviews in generating "original" responses and performs at least as well as individual interviews concerning "quality" and "acceptance" of responses (Massey & Wallace, 1991). Following Massey and Wallace (1991), a small and diverse group was selected—i.e., six experts with international academic and professional experience in urban and regional planning, environmental and energy planning, building engineering, energy economics, and transportation planning, from Iran, Jamaica, India, China, Austria, Germany, and Italy. Each focus group meeting averaged 2 h and was moderated by one of the experts (in urban and regional planning) on one specific topic, derived (by the moderator) from the literature review. The topic was discussed by the equal involvement of all focus group experts, taking advantage of interactive instruments such as shared documents, papers, projector, and pictures, among others. At the end of each meeting, the conclusions were written on a projected document and agreed upon by all the focus group experts. In case an agreement was not reached during the meeting, further exploration of the literature on the conflict topic and another session of discussion were done until final agreement among all experts. A regular series of expert focus group meetings (two to four meetings per month) was possible continuously and in the long-term (March to October 2015) because, during the research period, the experts were all involved at the Research Group of Urban and Regional Energy Systems in the Institute for Renewable Energy in European Academy of Bozen-Bolzano (EURAC Research). EURAC Research is a leading research institute in