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Japanese Experiences of Smart City Policies: User-Driven Innovation in Smart Community Projects

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Abstract
Since the term smart city was coined, theories and practices of smart cities have flourished. Regarding the theoretical aspect, user-driven innovation has been discussed in studies on the innovation ecosystems of smart cities. Smart cities have been built in various countries around the world in recent years, including in Japan, which has experienced the same global trends in smart cities since 2010. Four smart community projects run by the Agency for Natural Resources and Energy between 2010 and 2014 followed such trends. The present study addressed user-driven innovation using the quadruple helix model as an analytical framework for the four smart community projects, and the outcomes of the projects were evaluated. In conclusion, the smart community projects were evaluated as successful. However, it was revealed that these projects were not completely conducive to user-driven innovation.

Keywords
Smart city; Open innovation ecosystem; User-driven innovation; Smart community project; Energy management system; Environmental sustainability

1. INTRODUCTION

Since Gibson et al. (1992) coined the term smart city, theories and practices of smart cities have flourished. Regarding the theoretical aspect, definitions of a smart city have become more diverse as the number of smart city developments has flourished (Lazaroiu and Roscia, 2012; Albino et al., 2015). Among such diverse definitions, Caragliu et al. (2009) considered "a city to be smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance" (p. 50). According to this definition, participatory governance including citizens' participation is regarded as a part of the smart city concept.

Following the aforementioned definition, theories on user-driven innovation, which not only leads to sustainable economic growth and a high quality of life but is also a part of the smart city concept, have been developed within the framework of smart city innovation ecosystems. While defining a smart city as "environments of open and user-driven innovation for experimenting and validating" internet services, Schaffers et al. (2011a) emphasized that the establishment of such innovation ecosystems "requires sustainable partnerships and cooperation strategies among the main stakeholders" including users (p. 431). Following Schaffers et al. (2011a), Komninos et al. (2013) pointed out the importance of co-creation by both producers and users and characterized smart cities as

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having "a high level of citizen involvement in co-creating Internet-based applications in all sectors of the economy and society" (p. 120). Besides, Jorna and Veenstra (2015) specified the following three components of innovation ecosystems, which enable both top-down and bottom-up development of smart cities, namely a user-driven approach: an open infrastructure, needs-based value creation, and multi-party open governance. The most comprehensive framework regarding innovation ecosystems for smart cities may be the one presented by Zygiaris (2013), the smart city reference model. This model consists of six layers following the basic layer (Layer 0) community involvement, from the bottom (Layer 1) to the top (Layer 6): the green city, interconnection, instrumentation, open integration, application, and innovation layers. Urban planners might utilize this reference model to define smart city planning concepts and characterize smart city innovations.

Partly based on the aforementioned theories of smart city innovation ecosystems, case studies on user-driven innovation have been undertaken. These studies have mainly focused on the possibility of integrating open innovation platforms, namely living labs, with internet applications in various areas. Schaffers et al. (2011b) proposed an integrated system of living labs with internet access under three EU FP7-ICT projects, and, to a degree, verified the validity of this system, while Komninos (2011) showed that the combination of user-driven innovation and ITC made smart cities more efficient in city governance in the cases of Bletchley Park in the UK, Hong Kong, and Amsterdam in the Netherlands. The results of a case study undertaken in Vancouver, Canada by Lea et al. (2015), revealed that "community-driven ecosystems are more robust and self-sustaining," whereas, ordinary "innovation ecosystems are fragile and need nurturing" (p. 1542). However, it is possible to argue that, to date, the research on smart cities based on user-driven innovation has limitations. Besides, these empirical studies were chiefly conducted in European cities with only a few studies being undertaken in other parts of the world. This indicates that further smart city research is necessary, especially in a non-European context. The present study, therefore, examines user-driven innovation in smart city developments that took place in Japan.

Regarding the practical aspect of smart cities, various projects and programmes have been, and are currently being, implemented globally. A wide range of smart city programmes established by the Digital Agenda for Europe, commencing in the EU, in 2010, is an example of such smart city policies. Regarding smart city policies in Japan, it is clear that Japan has also experienced similar global trends in smart cities since 2010. The Japanese National Smart City Policy was introduced in 2010. At that time, the Agency for Natural Resources and Energy, under the Ministry of Economy, Trade, and Industry, initiated a national smart city policy entitled the Next Generation Energy and Social System Demonstration Project, also known as the smart community project. Four cities were selected to participate in this smart community project. Another national smart city policy implemented in 2011 was the Eco-Model and Future Cities Construction Project managed by the Cabinet Office on the basis of the Future City Initiative. In the future city project, 23 cities were designated as eco-model cities, and 11 cities were designated as future cities. Although both smart city national policies aimed for the construction of smart sustainable cities, the directions of the smart community and future cities projects were different. While the former was closely related to the term smart, namely ICT, the latter was oriented toward environmental sustainability.

Simultaneously, some Japanese companies have transferred their smart city-related technologies overseas since 2010. The Becamex Tokyu, a joint venture between Tokyu Corporation and Becamex IDC Corporation in Vietnam, launched the Tokyu Binh Duong Garden City Project in Binh Duong province, Vietnam, in 2012. In 2013, construction of a mass rapid transit (MRT) began in Jakarta, Indonesia, by a joint venture between Shimizu Corporation and some Indonesian companies. Since the end of these smart community projects in 2014, the experiences have resulted in some technologies being transferred to both domestic and international markets.

2. METHODOLOGY

The research subjects in this study were the four cities, Yokohama, Toyota, Keihanna, and Kitakyushu, selected for the aforementioned Smart Community Project run by the Agency for Natural Resources and Energy from 2010 to 2014. A smart community was defined as "a new form of social system that comprehensively manages the supply and demand of energy in the distributed energy systems, optimizes the use and application of energy, and incorporates lifestyle support services including monitoring services for the elderly, through the energy management system utilizing IT and storage energy technologies, while making use of distributed energy resources such as renewable energy and cogeneration" (Japan Smart Community

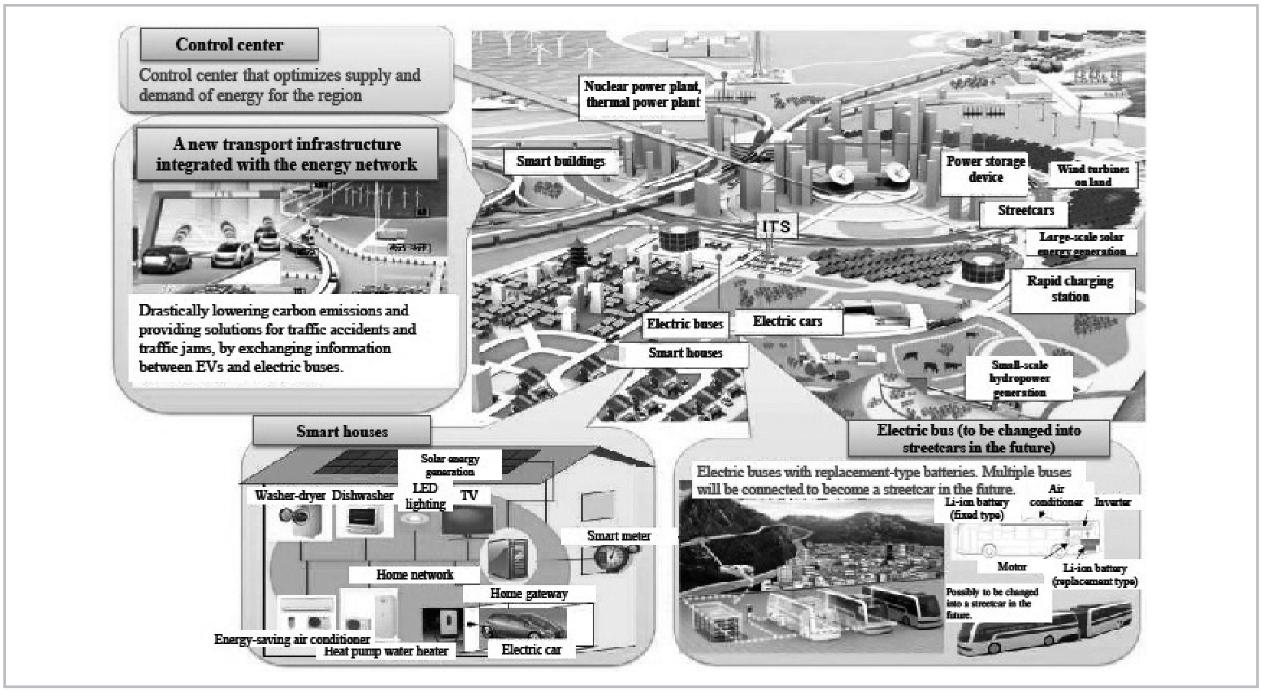

Fig. 1. The concept of a smart community

Source: Ministry of Economy, Trade, and Industry (2017)

Alliance, 2015, p. 2). A smart community was also regarded as a community where there was an "effort to change the social system of a defined area into a smarter state with technologies not only for electric power systems but also for a variety of public infrastructures including heat supply, water and sewerage, transportation, and communications" (Ibid). The concept of such a smart community is presented in Figure 1.

The reason for the smart community project was the intention of the Japanese government to change the energy supply system in Japan. Since the end of World War 2, ten electric companies have oligopolized the supply of electricity in ten large regional blocks. Furthermore, Japan is a country prone to natural disasters. After Japan experienced large-scale disasters, especially the 2011 Tohoku Earthquake and Tsunami, decentralizing the supply of power and introducing flexible power pricing at the local level has been emphasized in order to avoid large-scale electricity shortages, thereby bringing an end to the oligopolized electricity supply. Renewable energy resources have also become regionalized so that these resources may be incorporated into local energy supplies in smart communities using ICTs.

In the present study, the quadruple helix model was employed as the analytical framework for the user-driven innovation. The quadruple helix model, based on a collaboration between industry, government, academia, and society (Carayannis and Campbell, 2009), was regarded as the theoretical basis for the two aforementioned Japanese national smart city policies because these policies targeted open innovation (Bibri and Krogstie, 2017). Regarding applications of the quadruple helix model for smart city development, Martinez et al. (2016) discussed relationships between smart cities and the quadruple helix model in the context of health care. They pointed out the necessity of inclusive spaces, namely living labs, as a policy tool of the quadruple helix model. Such spaces comprising of health services and end-users such as citizens, patients, relatives, healthcare workers, and other professionals foster inclusive innovation, such as welfare technology, eHealth, telemedicine, and mobile health solutions. Mora et al. (2018), moreover, discussed the superiority of the triple or quadruple helix model regarding smart city development involving four European cities. However, smart city studies using the quadruple helix model are limited; therefore, further studies are also necessary. Thus, the present study intended to address such limitations.

Using the final reports of the four smart community proj-

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Table 1. The initial purposes and numerical targets proposed in the 2010 smart community projects

Name of City	Purposes and Numerical Targets
Yokohama	**Purpose:** To employ an energy management system in an existing large metropolitan area. **Numerical targets:** (1) Electricity supply by PV: 27MW, (2) Installation of home energy management systems (HEMSs): 4,000 households, (3) Introduction of electronic vehicles (EV): 2,000 vehicles.
Toyota	**Purpose:** To optimize energy usage and traffic demand and supply in the household sector in consideration of consumer behavior. **Numerical target:** Carbon dioxide reduction of 8,000 t-CO2/year in the project area, namely 67 households.
Keihanna	**Purpose:** To build a city with the lowest amount of carbon dioxide emissions per unit for all energy consumption in Japan without sacrificing quality of life (QOL) standards. **Numerical target:** The carbon dioxide emissions per capita per year should be 1.6 t-CO2/person/year in the project area.
Kitakyushu	**Purposes:** (1) To transform ordinary energy consumers, namely residents, business establishments and others, into production consumers (prosumers) via the installation of photovoltaic power generation panels, etc. (2) To realize "demand-side self-management" by enabling prosumers to manage their own energy usage. (3) To introduce a combined mechanism of dynamic pricing and incentive programmes. **Numerical targets:** (1) Carbon dioxide reduction: A 50% cut in the project area compared with regular city blocks. (2) Stable electricity supply: To maintain frequency and voltage fluctuation within a certain range (a voltage of 101±6V, a frequency at 60Hz) even when introducing a large amount of new energy.

Source: Ministry of Economy, Trade, and Industry (2011)

ects, the involvement of the four subjects in the quadruple helix model, namely the government, academia, industry, and society, were examined to identify user-driven innovation in smart cities. Along with examining innovation ecosystems, the present study evaluated the achievements of each smart community project. Table 1 summarizes the initial goals and numerical targets proposed in each project in 2010.

3. RESULTS

In this chapter, first, project outlines are described, and then the outcomes are evaluated. Finally, the validity of the quadruple helix model is examined.

3.1 Project Outlines

The results of each smart community project are summarized in Table 2:

3.1.1 Yokohama City

The Yokohama Smart City Project (YSCP) was implemented in an existing metropolitan area. Yokohama City has a population of approximately 4 million. In this project, around 4,000 households had photovoltaic (PV) panels and other smart equipment installed. This equipment was managed by home energy management systems (HEMSs) (see Table 3). Building energy management systems (BEMSs) were also established in 10 buildings. These HEMSs and BEMSs were connected to community energy management systems (CEMSs) to control peak cut and in turn conserve energy in order to reduce carbon dioxide emissions at the regional level.

3.1.2 Toyota City

Toyota City, which has a population of less than 420,000, is famous for being the location of Toyota Motor Corporation's headquarters. This company took a leading role in the Toyota City Low-Carbon Society Verification Project (Smart Merit). Unlike the Yokohama Smart City Project, the project in Toyota City was implemented in a small town named "Toyota Ecoful Town." This housing complex consisted of 67 newly built houses installed with HEMSs. Along with the energy management in houses, this smart community project also focused on the transportation sector. Privately-owned electric and fuel cell vehicles were provided with the aforementioned HEMSs as storages and generators.

Table 2. A summary of the results of the four smart community projects

Yokohama City (Wide-area metropolis)
- 4000 households and HEMSs.
- 10 large-scale buildings and BEMSs.
- Multiple storage batteries.
Toyota City (Separate housing)
- Local production for local consumption.
- 67 households equipped with solar panels, household fuel cells, and storage batteries.
- Advanced transportation system (EV, PHV).
Keihanna City (Housing complexes)
- 700 households and HEMSs.
- Consulting businesses regarding energy conservation.
Kitakyushu City (Designated supply area)
- Power is supplied by Nippon Steel & Sumitomo Metal Corporation.
- Dynamic pricing system for 180 households.

Source: Tobe (2015)

Table 3. Summary of the Yokohama Smart Community Project results

HEMS
- Solar power generation, fuel cells, solar heat, EV, etc. were introduced into existing housing complexes.
- Energy usage fell by approximately 40% through the utilization of renewable energy and distributed energy, interchange of electrical heat/integrated control, and the introduction of HEMSs.
- An 80% or higher rate of self-sufficiency in electrical power energy.
Integrated BEMS
- Two buildings were managed using an "integrated BEMS" and such BEMSs were also connected with each other.
- Approximately 10% more energy was saved compared to ordinary energy-saving buildings.
CEMS
- Large-scale demand responses were implemented.

Source: Komiyama (2012)

3.1.3 Keihanna City

The smart community project entitled the "Keihanna Eco City Next-Generation Energy and Social System" was run by a local government consortium under the auspices of an academia-industry-society collaboration (see Table 5). This is partly because Keihanna City consists of eight municipalities spanning three prefectures with a population of approximately 240,000. Among these local governments, Kyoto Prefecture and three municipalities under this prefecture participated in this smart community project. Likewise the Yokohama Smart City Project, the smart community project in Keihanna comprised approximately 700 HEMSs with around 100 EVs, 1 BEMS and 1 CEMS to manage demand response and peak cut.

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Table 4. Summary of the Toyota Smart Community Project results

Energy Management
- 67 homes equipped with solar panels, household fuel cells, Eco Cute, secondary cells, plug-in hybrid vehicles, electric vehicles, etc., were newly introduced in an urban district of Toyota City.
- From the perspectives of local prosumers and cutting back during peak hours, pseudo-dynamic pricing was implemented, and digital currency was awarded through smartphones, etc. HEMSs were also linked to an EDMS (energy data management system) to manage energy for the entire district.
- Plug-in hybrid vehicles (PHV) and electric vehicles (EV) were used as secondary cells.
Transportation System
- The driving conditions of PHVs and EVs were monitored using the EDMS. Using this system, optimal driving routes to destinations were presented for each vehicle in accordance with road conditions, and point-based incentives were offered as rewards to energy-efficient drivers.
- Power supplies for fuel cell buses and schools, among others, were demonstrated in the event of natural disasters.

Source: Komiyama (2012)

Table 5. Summary of the Keihanna City Smart Community Project results

HEMS (for 14 homes)
- HEMSs measured energy consumption by electrical apparatus.
- HEMSs were also utilized as energy and storage battery management systems.
BEMS (for the Keihanna Plaza)
- Reduction of CO2 emissions through fuel optimization and suppression.
- DR (demand response) measures were taken for not only approximately 70 building tenants and common spaces but also hotel rooms.
CEMS
- Identified the status of regional energy demand and supply, including energy and gas usage statistics for households, buildings, and EVs in the region, as well as PV energy generation.
- In order to draft an optimal energy usage plan, each EMS was developed and the effects of DR and balancing measures were verified.
Large-scale Demand Response (for approximately 700 homes)
- The energy demand suppression effect of price-induction was verified for approximately 700 households.
- Effects of energy-saving consultations based on energy-usage data were also verified.
EV Charging Management (for approximately 100 vehicles)
- This system collected and managed EV position, battery levels, and operation data.
- The effects of changing and energy suppression in harmony with the CEMS were also verified.

Source: Shigematsu (2015)

3.1.4 Kitakyushu City

This city, with a population of under 1 million, has been recognized as one of the world's most sustainable cities (OECD, 2013). The Kitakyushu Smart Community Project focused mainly on hydrogen (see Table 6). Houses in the project area were connected to a hydrogen factory using pipelines. These houses generated electricity using their own fuel cells, and sometimes electricity was stored as hydrogen. Using such innovations, this project also aimed to change electricity consumers to production-consumers known as "prosumers."

As a common characteristic of the four smart community projects, the EMS was the main pillar of these projects, though

Table 6. Summary of the Kitakyushu City Smart Community Project results

CEMS
- Using a steel company's distribution lines, flexible electricity pricing was implemented for approximately 230 households and 50 business establishments.
HEMSs and BEMSs
- For business establishments, real-time pricing based on two-hour notifications was implemented.
- In a hospital, a large proportion of demand for heat was covered by solar heat panels.
Use of Hydrogen and Fuel Cells
- By-product hydrogen generated in some factories was distributed to residential areas through pipelines and used by fuel cells at each household. Fuel cell vehicles were filled with such hydrogen at refuelling stations.
- Surplus electricity was stored as hydrogen, and energy supply was managed using stored hydrogen and fuel cells.

Source: Komiyama (2012)

some projects were related to the transportation sector, mainly concerning privately owned vehicles. This characteristic may result from the fact that the Agency for Natural Resources and Energy managed the smart community policy. Therefore, the use of renewable energy was limited to PV and wind power. The utilization of biomass was not taken into account. For these reasons, neither the waste sector (including biomass rich sewage systems) nor the transportation sector (including public transportation systems using biogas generated from these sewage systems) was integrated into the Japanese smart community development program. The aforementioned future cities project may bridge the gap between Japanese smart community development and an ideal one including the waste and transportation sectors.

3.2 Project Evaluation

Regarding the evaluation of the projects, the goals of the four smart community projects were achieved overall. Table 7 displays the qualitative targets, the numerical targets, and the achievements of each smart community project. An evaluation of the results confirms that the smart community projects were successful as the achievements recorded in the four cities were greater than most of the numerical targets shown in the table.

3.3 User-Driven Innovation

Using the final reports of the four smart community projects, it was revealed that societies were not involved in developing innovations. Table 8 shows all project participants in the four smart community projects. This table includes the municipalities and prefectures where the smart community projects were implemented and several organizations involved in the government-academia-industry collaboration. While many private companies participated in the smart community projects, no university in either Keihanna City or Kitakyushu City was involved with the projects as academia. Regarding citizens' participation, PV panels, EVs, and HEMSs were newly installed in general houses and business establishments in the four project areas. It seems clear, then, that society played a part in the smart community projects. It is noteworthy that citizens and business establishments participated in the smart community project as production consumers (prosumers) in Kitakyushu City. However, it should be emphasized that citizens' participation in the four smart community projects was limited to the installation process of existing innovation as users, and did not extend to the creation process of new innovation as collaborators.

4. DISCUSSION AND CONCLUDING REMARKS

Using the quadruple helix model, the present study aimed to examine user-driven innovation in the smart community projects implemented in Japan between 2010 and 2014. Although all of the projects were evaluated as being successful overall, citizens' participation was not observed in the creation process of new innovation; therefore, user-driven innovation seemed to be limited regarding smart city development in Japan. Borkowska and Osborne (2018) examined the validity of

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Table 7. The qualitative targets, numerical targets, and achievements of each smart community project

1) Yokohama

Qualitative Targets

Targets	Achievements
To develop an EMS for every 15 PJ of electricity which the project participants consume.	The goal was achieved.
To establish DR (demand response) programs in the building sector.	Maximum peak cut: 23%, and the DR (demand response) achievement rate was more than 90%.
To conduct a HEMS social trial in the whole area of Yokohama City.	The positive effects of dynamic pricing in electricity and HEMS promotion measures were validated.

Numerical Targets

Items	Targets	Achievements
Carbon dioxide emissions	30,000 t-CO2	39,000 t-CO2
Carbon dioxide reduction	25%	29%
Peak cut	20%	Maximum peak cut: 23% (for buildings)
		Net peak cut: 15.7% (for households)
Energy saving	17%	17%
PV installation	27MW	37MW
HEMSs installed in houses	4,000	4,230
EV (newly purchased)	2,000	2,294

2) Toyota

Qualitative Targets

Targets	Achievements
To optimize energy use and traffic demand and supply in the household sector in consideration of consumer behavior.	The positive effects of HEMSs and other smart equipment, next-generation environmental automobiles, and new social technologies on infrastructure were all verified.
Models developed for the low-carbon society system should be transferred to domestic markets and overseas.	The Ecoful Town built during the smart community project highly attracted domestic and foreign visitors. The number of visitors was approximately 180,000 from over 100 countries.

Numerical Targets

Items	Targets	Achievements
Carbon dioxide reduction	30% (for the household and transport sectors)	30.1%

(Table 7 continued)

3) Keihanna	
Qualitative Targets	
Targets	**Achievements**
In response to the 2011 Tohoku Earthquake and Tsunami, to identify how to cope with demand response (DR) (namely, peak cut) in times of a limited supply of electricity.	The combination of the local battery with the shortened DR times had a significant effect on the peak cut.
In times of sharply increasing volumes of renewable energies, especially PV, to identify how to manage surplus renewable energy.	Confirmed that EVs, which are not normally charged during the daytime, are a resource for surpluses of renewable energy.
To identify how to manage dynamic pricing by 30 minutes?	The combination of DR and battery storage was effective for dynamic pricing.

Numerical Targets

Items	Targets	Achievements
Carbon dioxide reduction	35%	35%
Peak cut (1-4 PM, Summer)	28%	39%
Peak cut (6-9 PM, Winter)	42%	45%

4) Kitakyushu	
Qualitative Targets	
Targets	**Achievements**
[Citizen participation] Through the installation of energy efficient equipment and energy saving activities, to change regular consumers into production consumers (prosumers) that contribute to the supply of regional energy.	It was confirmed that members of the society joined the regional energy management, and the eco-tours and information disclosure enabled citizens to raise their awareness of energy.
[Hardware installation] To construct a new energy system, namely community energy management systems (CEMSs), for such "thinking" and "participating" prosumers.	Data gathered and analyzed through CEMS and smart meters were distributed to customers.
[Social system and institution] To establish a mechanism providing both residents' benefits and regional energy systems in terms of visualization of local energy information and dynamic pricing.	The demand response system based on past consumer electricity prices was examined, and an appropriate pricing system was set up. Statistically significant institutional analyses were performed using the CEMS data.

Numerical Targets

Items	Targets	Achievements
Carbon dioxide reduction	50%	51.50%
Energy saving	20%	40.50%
Peak cut	15%	102.60%

Source: Ministry of Economy, Trade, and Industry (2016)

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Table 8. Project participants in each smart community project

a) Yokohama Smart City Project (YSCP)	
Governments	City of Yokohama, Urban Renaissance Agency
Academia	Tokyo Institute of Technology
Industry	MM42 KaihatsuTMK (a subsidiary of Marubeni Corporation), Yokohama Smart Community, Accenture, NTT DoCoMo, NTT Facilities Inc., ORIX Corporation, ORIX Auto Corporation, Sharp Corporation, JX Nippon Oil & Energy Corporation, Sumitomo Electric Industries Ltd., Sekisui House Ltd., Sony Energy Devices Corporation, Daikyo Astage Inc., Taisei Corporation, Tokyo Gas Co. Ltd., TEPCO, Toshiba Corporation, Nissan Motor Co. Ltd., JGC Corporation, JGC Information Systems Company Ltd., NEC, Nomura Real Estate Development Co. Ltd., Panasonic Corporation, Hitachi, Ltd., Misawa Homes Co. Ltd., Mitsui Fudosan Co. Ltd., Mitsui Fudosan Residential Co. Ltd., Mitsubishi Estate Co. Ltd., Meidensha Corporation
Citizens	4,230 households
b) Toyota City Low-Carbon Society Verification Project (Smart Merit)	
Governments	Toyota City, Aichi Prefecture
Academia	Nagoya University
Industry	Aishin Seiki Co. Ltd., Eneres Co. Ltd., KDDI Corporation, Circle K Sunkus Co. Ltd., Sharp Corporation, Shinmei Engineering Consultants Co. Ltd., Chubu Electric Power Co. Inc., DENSO Corporation, Toshiba Corporation, Toho Gas Co. Ltd., Toyota Motor Corporation, Toyota Industries Corporation, Toyota Chamber of Commerce and Industry, Toyota Smile Life Inc., Toyota Tsusho Corporation, Toyota Home, Dream Incubator Inc., Central Nippon Expressway Company Ltd., Nagoya Railroad Co. Ltd., Development Bank of Japan Inc., Hewlett-Packard Japan Ltd., Hitachi Ltd., Fujitsu Ltd., Mitsubishi Corporation, YAZAKI Corporation, Yamato Transport Co. Ltd., Yamaha Motor Co. Ltd.
Citizens	67 households
c) Keihanna Eco City Next-Generation Energy and Social System	
Governments	Kyoto Prefecture, Kizugawa City, Kyotanabe City, Seika Town, Urban Renaissance Agency, (Kansai Research Institute), (Doshisha Yamate Sustainable Urban City Council)
Academia	(Kansai Research Institute), (Doshisha Yamate Sustainable Urban City Council)
Industry	(Kansai Research Institute), (Doshisha Yamate Sustainable Urban City Council), Kansai Economic Federation, Kyoto Center for Climate Actions, Enegates Co. Ltd., i-Energy WG, Osaka Gas Co. Ltd., Renesas Electronics Corporation, OMRON Corporation, The Kansai Electric Power Company Incorporated, Keihanna Interaction Plaza Inc., Sharp Corporation, Nihon Unisys Ltd., Mitsubishi Motors Corporation, Mitsubishi Heavy Industries, Ltd., Mitsubishi Corporation, Mitsubishi Electric Corporation, Fuji Electronic Co. Ltd., Furukawa Electric Co. Ltd., The Furukawa Battery Co. Ltd., Renesas Electronics Corporation
Citizens	Approximately 700 households
d) Kitakyushu Smart Community Project	
Governments	Kitakyushu City, (Human Media Creation Center/Kyushu)
Academia	(Human Media Creation Center/Kyushu)
Industry	(Human Media Creation Center/Kyushu), Azbil Corporation, Iwatani Corporation, Uchida Yoko Co. Ltd., ORIX Corporation, Saibugas Co. Ltd., JXN Engineering Co. Ltd., NS Solutions Corporation, Nippon Steel & Sumitomo Metal Corporation, Sekisui Chemical Co. Ltd., Softbank Telecom Corp., Daiwa House Industry Co. Ltd., DENSO Corporation, TOTO, Toppan Printing Co. Ltd., Toyota Motor Corporation, Toyota Industries Corporation, Toyota Tsusho Corporation, Toyoda Gosei Co. Ltd., Nippon Steel & Sumikin Texeng. Co. Ltd., IBM Japan, Japan Telecom Information Service Co. Ltd., Higashida-Clinic, FamilyMart Co. Ltd., Fuji Electric Co. Ltd., Furukawa Electric Co. Ltd., The Furukawa Battery Co. Ltd., Hohkohsya, Mitsubishi Heavy Industries Ltd., Yaskawa Electric Corporation, Yaskawa Information Systems Corporation
Citizens	Approximately 180 households

Source: Japan Smart Community Alliance (2015) the quadruple helix model for the smart city project implemented under the Future City Demonstrator Initiative in Glasgow. They revealed that various ICTs, such as smartphone apps and digital platforms, were introduced in this initiative; however, these technologies were not prepared to support citizen participation. Besides, a lack of digital literacy in a large part of Glasgow City led to citizens' having problems with the aforementioned technologies, and, consequently, the learning process among the four helixes, which is essential for innovation (Brown and Duguid, 1991; Powell et al., 1996), was also hindered in this initiative. Looking closely at the four smart community projects in Japan from the viewpoint of supportive ICTs for citizen participation, no ICTs were introduced to promote citizen participation. In these projects, citizens were regarded as users or prosumers in the energy management system solution proposed by private companies. Accordingly, citizens were not given a proactive role. For these reasons, it seems that neither learning processes were created, nor was the participation of citizens as co-creators observed in these projects. Thus, in future, when developing a smart city based on the conceptual framework of the quadruple helix model, the following two things may be necessary: First, technological support, namely ICTs encouraging citizens' participation; Second, organizational assistance such as living labs that foster the learning process.

REFERENCES

Albino, V., Berardi, U., and Dangelico, R. M. (2015) "Smart cities: Definitions, dimensions, performance, and initiatives," *Journal of Urban Technology* 22: 1-19.

Bibri, S. E., and Krogstie, J. (2017) "Smart sustainable cities of the future: An extensive interdisciplinary literature review," *Sustainable Cities and Society* 31: 183-212

Borkowska, K., and Osborne, M. (2018) "Locating the fourth helix: Rethinking the role of civil society in developing smart learning cities," *International Review of Education* 64: 355–372.

Brown, J.S., and Duguid, P. (1991) "Organizational learning and communities-of-practice: Toward a unified view of working, learning, and innovation," *Organization Science* 2: 40-57.

Caragliu, A., del Bo, C., and Nijkamp, P. (2009) "Smart cities in Europe," *Proceedings of the 3rd Central European Conference in Regional Science*, 45-59.

Carayannis, E., and Campbell, D. (2009) "'Mode 3' and 'Quadruple Helix': Toward a 21st century fractal innovation ecosystem," *International Journal of Technology Management* 46: 201-234.

Gibson, D.V., Kozmetsky, G., and Smilor, R.W. (eds.) (1992) *The Technopolis Phenomenon: Smart Cities, Fast Systems, Global Networks*, New York: Rowman & Littlefield.

Japan Smart Community Alliance (2015) *SMART COMMUNITY -Japan's Experience-*, Tokyo: Japan Smart Community Alliance.

Jorna, F., and Veenstra, M. (2015) "Setting-up smart cities ecosystems – Essential building blocks," in Kommer, P., and Peng, G. C. (Eds) *Proceedings of the International Conferences on ICT, Society and Human Being 2015, Web Based Communities and Social Media 2015 and Connected Smart Cities 2015*, Lisbon: IADIS Press, p. 140-146.

Komiyama, Y. (2012) "Smart communities, as a presentation of US-Japan Renewable Energy Policy Business Roundtable "New Opportunities for Renewable Energy in Japan & the United States"". Accessed on September 28, 2018 from http://www.enecho.meti.go.jp/notice/event/036/pdf/event036013.pdf

Komninos, N. (2011) "Intelligent cities: Variable geometries of spatial intelligence," *Intelligent Buildings International* 3: 172–188.

Komninos, N., Pallot, M., and Schaffers, H. (2013) "Special issue on smart cities and the future internet in Europe," *Journal of Knowledge Economy* 4: 119–134.

Lazaroiu, G. C., and Roscia, M. (2012) "Definition methodology for the smart cities model," *Energy* 47: 326-332.

Lea, R., Blackstock, M., Giang, N., and Vogt, D. (2015) "Smart Cities: Engaging users and developers to foster innovation ecosystems," *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing and the Proceedings of the 2015 ACM International Symposium on Wearable Computers7 September 2015*, New York: ACM, p. 1535-1542.

Martinez, S., Bjerkås, S., Ludvigsen, A.-E., Fensli, R. (2016) "Agder living lab: From ideas to large-scale deployment and long term user adoption of inclusive health solutions," *Advances in Intelligent Systems and Computing* 500: 391-399.

Ministry of Economy, Trade, and Industry (2011) "Documents of the 13th meeting of the next generation energy and social system council". Accessed on September 28, 2018 from http://www.meti.go.jp/committee/summary/0004633/013_haifu.html

Ministry of Economy, Trade, and Industry (2016) "Documents of the 18th meeting of the next generation energy and social system council". Accessed on September 28, 2018 from http://www.meti.go.jp/committee/summary/0004633/018_haifu.html

Ministry of Economy, Trade, and Industry (2017) "The concept of a smart community". Accessed on September 28, 2018 from http://www.meti.go.jp/english/policy/energy_environment/smart_community/index.html

Mora, L., Deakin, M., and Reid, A. (2018) "Strategic principles for smart city development: A multiple case study analysis of European best practices," *Technological Forecasting and Social Change* (in press).

OECD (2013) *Green Growth in Kitakyushu, Japan*, Paris: OECD.

Powell, W.W., Koput, K.W., and SmithDoerr, L. (1996) "Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology," *Administrative Science Quarterly* 41: 116-145.

Schaffers, H., Komninos, N., Pallot, M., Trousse, B., Nilsson, M., and Oliveira, A. (2011a) "Smart cities and the future internet: Towards cooperation frameworks for open innovation", in Domingue, J. et al. (Eds.), *The Future Internet*, (FIA 2011, Lecture Notes in Computer Science, vol. 6656), p. 431-446, Berlin, Heidelberg: Springer.

Schaffers, H., Sällström, A., Pallot, M., Hernández-Muñoz, J. M., Santoro, R. and Trousse, B. (2011b) "Integrating living labs with Future internet experimental platforms for co-creating services within smart cities," *Proceedings of 2011 17th International Conference on Concurrent Enterprising* 6041259: 1-10.

Shigematsu, C. (2015) "Creation of Smart Communities in Keihanna Science City -from demonstration to implementation-". Accessed on September 28, 2018 from https://www.smart-japan.org/english/vcms_cf/files/Keihanna_Project_English.pdf

Tobe, C. (2015) "Japan's policy on Smart Communities". Accessed on September 28, 2018 from https://sustainabledevelopment.un.org/content/documents/12634tobe.pdf

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