Review Article:
Smart Communities for Future Development: Lessons from Japan

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Abstract

This article aims to review and analyze a content of smart community development that widely used in many cities. The main key is to understand concepts, component, technological approach in various aspects based country's context. Smart community is able to apply for all development such a physical setting, social dimension, and government perspectives. It does not only focus on technological development approach. From reviewing, it found that smart city has been integrated and modified in terms of spatial planning with smart energy policy and technology application. However, this framework seems difficult to be handled in developing countries due to lacking and limited technology innovation, whereas a stakeholder from policy to practical is still not involved at local and national level.

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Introduction

The Smart Community was first used in 1993 in Silicon Valley, California, when the area experienced a recession that was deeper than the national economic downturn, and predicted to last longer. All stakeholders decided together to recover the region. Today the concept of Smart Community is widely used in many countries in different contexts (Helena, 2015). Especially, cities and communities are ongoing urbanization in urban and rural area, and the trend towards increasingly knowledge-intensive economies as well as their growing share of natural resource consumption and released emissions. To meet public policy objectives under these circumstances, cities and communities need to change and develop in a smart way (European Innovation Partnership [EIP], 2013). Japan has been facing three main challenges concerning ecological issues as many other countries: reducing CO_2 emissions in order to mitigate climate change; ensuring its energy independence and security (renewable energy, energy conservation and efficiency improvements); revitalizing its economy by strengthening its competitiveness and becoming a leader in future "green" markets. To deal with these issues, the Japanese government has been implementing various initiatives, among which regulations and subsidies, but also schemes such as a feed-in-tariff for renewable energy and eco-cities' experimentations since the Eco-Town program launched in 1997. More recently, in 2010, the Ministry of Economy, Trade and Industry (METI) selected four Smart Communities – Keihanna Science City, Kitakyushu Smart Community, Toyota Smart Melit (Mobility & Energy Life in Toyota City) and Yokohama Smart City – within the "Demonstration of Next Generation Energy and Social Systems" project. Smart Communities are based on smart grid technologies, which associate information flows to energy flows in order to optimizing the energy production and distribution, introducing safely as much renewable energy as possible and achieving peak shift through dynamic pricing or demand response schemes. However, Smart Communities aim at going further and beyond the mere smart grid, focusing not just on energy issues but also on the involvement of all the stakeholders. Another objective is to make "smart" not only the grid, but also industry, commerce, business and households' behaviors, including mobility issues. According to METI's call for projects and Smart Communities' master plans, a very innovative feature of Smart Communities is the participation of all the stakeholder among which the citizens, and the behavioral change through lifestyle innovation (Hiroko & Benoit, 2014).

Smart Community Concept and Definition

In the Smart Communities Guidebook, developed by the State University of San Diego (1997), Smart community is described as a geographical area ranging in size from neighborhood to a multi-county region whose residents, organizations, and governing institutions are using information technology to transform their region in significant ways. Co-operation among government, industry, educators, and the citizenry, instead of individual groups acting in isolation, is preferred. The technological enhancements undertaken as part of this effort should result in fundamental, rather than incremental, changes (Helena, 2015). For Europeans countries by The European Innovation Partnership on Smart Cities & Communities seeks to significantly accelerate the industrial-scale roll-out of smart city solutions integrating technologies from Energy, Transport and Information and Communication Technologies (ICT). This is where there is most untapped innovation potential and most environment and societal benefits to be gained. The partnership was launched in July 20121 and its overarching goal has hence been formulated thus: This partnership strives at a triple bottom line gain for Europe: a significant improvement of citizens' quality of life, an increased competitiveness of Europe's industry and innovative SMEs together with a strong contribution to sustainability and the EU's 20/20/20 energy and climate targets 2. This will beachieved through the wide-reaching roll out of integrated, scalable, sustainable Smart City solutions – specifically in areas where energy production, distribution and use; mobility and transport; and information and communication technologies are intimately linked. (EIP, 2013)

A smart community has defined as a community where various next-generation technologies and advanced social systems are effectively integrated and utilized, including the efficient use of energy, utilization of heat and unused energy sources, improvement of local transportation systems and transformation of the everyday lives of citizens (Hisatsugu, 2015).

According to Policy Planning Division, Energy Conservation and Renewable Energy Department, Agency for Natural Resources and Energy (ANRE) concludes that Smart Community is an initiative aiming at efficient energy utilization that is achieved by using certain technology, e.g., IT and accumulators, adequately combining distributed energy sources (distributed energy systems), e.g., cogeneration systems and renewable energy, and managing

energy in an area-wide manner. Smart communities generally consist of: cogeneration systems, facilities for generating electricity or using heat generated by renewable energy sources, those for energy creation, e.g., residential use fuel cell (Ene-Farm), those for energy storage, e.g., accumulators and electric vehicles (vehicle-mounted accumulators), and energy management systems (EMSs) that connect said facilities in a smart manner and realize the optimum operation of energy (ANRE, 2014). From above concept and definition, the key elements of Smart Community are (Stratigea, 2012):

1) ENERGY

The greater use of renewable and unused energy and local generation of heat energy for local consumption contribute to the improvement of energy self-sufficiency rates and reduction of CO_2 emissions. Smart grids provide stable power supply and optimize overall grid operations from power generation to the end user.

2) INFRASTRUCTURE

A smart community comprises innovative energy systems as well as overall social systems, such as transportation, water and sewer services, waste treatment, information and construction. Smart communities not only consist of infrastructure development but also contribute to shaping overall community planning.

3) ICT

Information and communication technology systems are basic infrastructures used in various social systems, such as communication networks that connect homes, buildings, factories, and transportation systems by using bidirectional information exchange. ICT systems also bring about the creation of various services by private companies and local governments to residents, and services between residents.

4) LIFESTYLE

Through the establishment of effective basic social infrastructures, a smart community offers new support services for everyday living and lifestyles, as well as develops disaster-response ready sustainable societies that actively respond to energy and environmental issues.
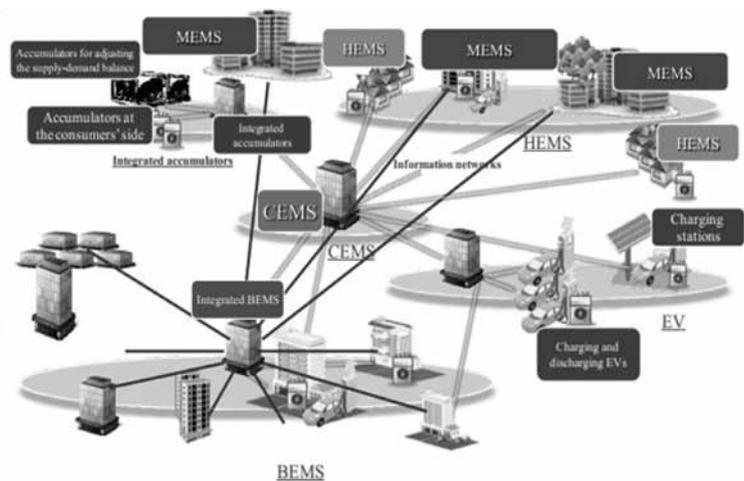


Figure 1. Smart Community Concept

Moreover, the significance of Smart Communities depending on regional characteristics, e.g., types (electricity, heat), scales and density of energy demand, the significance of smart communities is as follows (ANRE, 2014).:

1) Risk dispersion for stable energy supply
    - Smart communities are expected to disperse the risk of energy deficiency by retaining their own energy sources, when great earthquakes and other disasters threaten the stable supply of energy from concentrated energy systems.

2) Efficient energy utilization (energy-saving effect)
    - Introducing cogeneration systems makes it possible to realize high energy efficiency up to about 80% by combining electricity and heat, when energy from waste heat is utilized in a manner matching the demand in the surrounding areas.
    - Utilizing electricity and heat generated by renewable energy sources contributes to reducing the transmission loss of electricity, producing the effect of efficient energy use.

3) Reducing environmental loads
    - Utilizing renewable energy, as well as efficient energy use, is effective for energy-saving and reduction of carbon dioxide emissions.

4) Establishing efficient electricity systems through utilizing EMSs

- A demand-response program, an approach to using EMSs to manage the energy supply-demand balance in certain communities in a smart manner, will contribute to easing tightness of the supply-demand balance when consumers participate in the peak-cutting program on a short-term basis.

- In the mid- to long- term perspective, introducing smart communities will eliminate the need for thermal power generation, an inefficient energy source for addressing peak periods, and contribute to establishing efficient electricity systems.
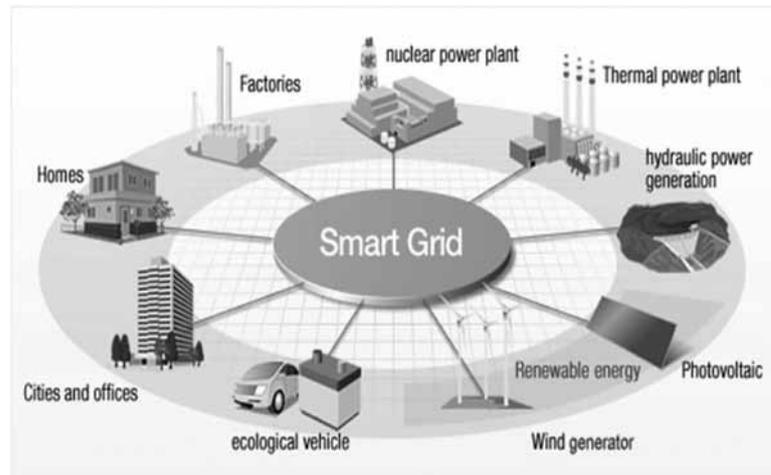
Smart Community through Smart Grid

To archive smart community under the low-carbon society policy would not be realized in order to reduce amount of emission without a fundamental shift in energy source alternatives as fossil fuels to renewable energy. New National Energy Strategy since 2006 has significant statement of Japanese energy policy in targeting 30% reduction in energy-related CO_2 emissions, all by 2030 [11]. According to Amy Poh Ai Ling (2012), it found that the Japanese smart grid concept aims to make the best use of local renewable energy with a view to maximizing total efficiency. The smart grid will promote the use of renewable energy by introducing a demand response system and moving toward introducing charging infrastructure for electric cars. In addition, PV and wind power plants have been installed across the country as clean energy sources that emit no CO_2 (Amy et al., 2012).

Japan's major power generation sources are list following Hydroelectric Power, Thermal Power, Nuclear Power. To overcome sudden energy shortages, PV Power Generation is set an efficient supply of energy to end users with zero emissions by the government's aim of becoming a leading nation in environmental and energy sustainability through green innovation. PV is to be installed completely by 2030 for domestic electricity demand. PV communities has been encouraging further development in line with smart community namely Kasukabe and Yoshikawa in Saitama, Matsudo in Chiba,

Figure 2. Example of Smart Grid of Hitachi.
(Source: http://www.hitachi.com/environment/showcase/solution/energy/smartgrid.html)

Smart office	Intelligent building design involving cabling, information services, and environmental controls, and envisages a desire for architecture with permanent capacity for EVs for office energy backup.
Smart schools	Grid modernization Energy supply from PVs
Smart house	Relate to smart houses interacting with smart grids to achieve next-generation energy efficiency and sustainability, and information and communication technology-enabled collaborative aggregations of smart houses that can achieve maximum energy efficiency. PVs and EVs
Smart stores	Refer to the charging outlets in parking areas and the deployment of public charging stations for EVs.
Smart factory	The PVs and EVs are supplied to support its production process.

Table 1. Community grid system approach.

Kasugai in Aichi, Kobe in Hyogo, Tajiri in Osaka,Ota in Gunma, Wakkanai in Hokkaido, Shimonoseki in Yamaguchi, and Kitakyushu in Fukuoka. In term of a community grid system, there are five elements to be effective energy development (Amy et al., 2012).

The potential benefits of smart houses include cheaper power, cleaner power, a more efficient and resilient grid, improved system reliability, and increased conservation and energy efficiency. Japan's smart community initiative is based on a systemic approach. The three Es (environment, energy security, and economy) requires the right mix and match of power sources through renewable and reusable energy (RE) utilizing storage. The development of Japan's smart community is divided into three stages: the first is the development plan for the current period up to 2020; the second is the development plan for 2020 to 2030; and the third is the development plan for 2030 onward. As for the development of houses, the remote reading of smart meters will start when the home EMS and the regional EMS are integrated and all power generated at houses will be used optimally. At the same time, the home EMS, followed by various services using home servers, will be disseminated. When the demonstration of EVs has started and when EVs are used for power storage, a fully automated home EMS will be achieved. In addition, zero-energy buildings (ZEBs) will be introduced from 2020 to 2030, initially for new public buildings. The introduction of ZEBs is expected to reduce emissions greatly for all new buildings as a group (Amy et al., 2012).

Smart Communities Imitative

In 2010, the Japanese government has decided pilot cities of Smart Community projects in four cities (20 cities were nominated) by different characteristics including:

- Yokohama City, as a large city, which is intensively a residential and business area.
- Toyota City, the automotive industry and crowded living area.
- Kansai Science City, Kyoto Prefecture, area of education and research center, technology and energy efficiency center.
- Kitakyushu City, Fukuoka Prefecture, a heavy industrial area has serious pollution problems. And the coexistence between heavy industry and households.

In addition, various countries are interested in developing cooperation with Japan, the use of renewable energy technologies effectively as Tunisia and Morocco are interested in the use of PV panels in the electricity industry. England and Singapore have started to build a Smart Community as pilot project. China has set up an ecological and industrial city. In addition, a consortium of Japanese companies is preparing a report on the feasibility of smart community development projects in Gujarat, India. The 6.23 million tons of hazardous waste generated in India annually, 22% comes from Gujarat. Kitakyushu Eco-Town' in Japan is selected to be the best practice of the 'reduce, reuse, and recycle' in oriented environmentally smart community development concepts prevalent in Japan for developing 'Surat' in Dahej area. Vietnam and Thailand which are both forms of cooperation between the government, which has NEDO (New Energy and Industrial Technology Development Organization) is the primary agency for cooperation. The private sector under the Japan Smart Community Alliance (JSCA) consists of more than 500 private companies, which support for Smart Communities implementation.
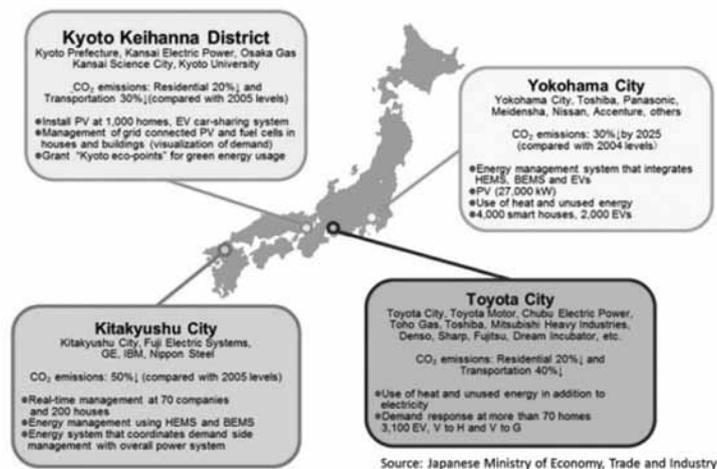
Figure 3. Four major Smart Communities Pilot Project in Japan.

Challenges

Elemental technology consisting of smart communities has been significantly developed. In addition, operating environment structural improvements are expected to be promoted to an appreciable extent by exercising the electricity system reform and other initiatives. Meanwhile, as the various components of such communities, e.g., facilities for renewable energy, Ene Farm, accumulators and energy management systems, are so expensive that they are few instances in which they display economic advantages compared to concentrated energy systems, a factor that hinders full-fledged introduction of such communities. However, it would be possible to further introduce smart communities if the following challenges are overcome and a favorable environment for the introduction of the communities is developed, leading to the establishment of a business model for building the communities. According to (ANRE, 2014), the following challenges of Smart Communities implementation are:

Challenge 1: Initiatives for realizing an inexpensive system
- Promoting technology development so as to reduce component price and running cost

Challenge 2: Promoting appropriate value assessment of the demand-response program
- Promoting development of the operating environment so as to appropriately assess the value of the supply capability realized by the demand-response programs

Challenge 3: Establishing a business model for smart communities
- Aiming at establishment of a business model for smart communities by clarifying the profit structure

In addition, using information communication technology (ICT) might improve the relationship between government and the citizen, empowering the latter to participate in the decision making processes as well as the service delivery processes of energy distribution. However, the result of the study Smart City projects in terms of promoting ICT strategy by focusing on changes the behavior of the residents was conducted by selecting the Smart Community in Kitakyushu, in particular, has revealed interesting features: behavior change of the residents in energy consumption, while they show little participation (Kudo & Granier, 2014). Thus, to success the Smart Communities, the Smart Citizen should more emphasize.

Discussions

In this article, the smart community can be defines in several terms depending researches perspective. However, a new approach of smart community can be mentioned that it integrates by using efficient resources, creating economy from community to nation scale, changing social lifestyles with technology application. These contribute a less harmful to the environments and natural resources. Dealing with a smart community implementation for the future development there are three main keys to be applied; smart energy, smart life, and smart society. Smart energy, using the electricity grid intelligent (Smart Grid) from alternative energy sources in terms of clean energy as well as renewable energy is appreciated. Different morphology and physical characteristics of each country in urban and rural might use different of renewable sources, for example wind, solar, biomass, small hydro and biomass and so on. The system features can be monitoring with two way communicate and supporting an electric device and building. Smart life, a place of people's living, working, learning, and leisure should be design with green development to supplement a smart grid intelligence system. This involves residents' participation in energy management as power consumption based on their behaviors and renewable energy system. Smart society, all citizens are able to communicate through digital social network with green infrastructures in term of utilities and facilities. Community and society is strongly network in sustainable development.

Conclusions

Japanese Smart Community is ongoing as an intelligent development using technology approach on demand and supply side of energy management. Managing renewable energy subjects to all agencies for attention due to the energy crisis and global warming issues. Dealing with a smart community implementation is the key of future development that has been successfully implemented in Japan. Therefore, the knowledge "Intelligent Grid and Renewable Energy" is an issue that various stakeholders in field of research and policy development should study and apply based on the context and environment of each country. Japanese Smart Community makes a great capacity for innovation learning with combine technology to increase the efficiency energy use. However, one of the challenges facing in developing country is how to design and adapt cities and communists into smart, intelligent, sustainable environments, whereas they are confronted with many problems such as efficient technologies and returns on investment with long-term emissions reductions. Additionally, using information and communications technology (ICT) will require a huge budget and consume electricity.

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