Chapter 3
From Smart City to Society 5.0

Atsushi Deguchi

Abstract This chapter overviews the history of smart city and smart community projects implemented in Japanese cities since Japanese national government had initiative through the subsidies and supports for the pilot projects promoted by municipalities following the Kyoto Protocol. It reviews that the original technologies of smart grids, microgrids, and smart house, which were created by integrating IT with the energy management system, have been implemented into the pilot projects of the first generation of smart community in 2000s under the condition that Japan has lagged behind in the electricity market liberalization compared with the EU and the USA.

Sections 3.3 and 3.4 review the social background and the process for national government to promote the pilot projects and the energy-conscious policymaking in the local cities in Japan. It summarizes the achievements of the first-generation pilot projects for constructing CEMS-based smart community in 2000s, and characterizes the next-generation smart city models based on the energy management system implemented in 2010s with initiative by private sectors. Section 3.4 explains that Japanese national government has had initiative to activate not only the pilot projects but also policymaking in municipalities following the concept of sustainable urban development and the SDGs.

Section 3.5 characterizes the trends of smart city in Japanese cases with the comparison of cases of the EU and the USA. It suggests on the directionality of the future smart city shifting from the top-down type with initiative by government or big companies to bottom-up type with citizen-oriented technology based on the concept of "Society 5.0."

Keywords Community Energy Management System (CEMS) · Connected community · Open data · Sensing city · Sustainable city

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3.1 What Is a Smart City?

Integrating IT into Urban Planning to Smartify Cities

So far, we have outlined the ideas related to Society 5.0. In this chapter, we look back at attempts to implement a smart city, a concept that involves integrating IT with urban planning. Society 5.0 aims to take us beyond the smart city to the supersmart society, but for now we will explore where and how the smart city has advanced. We will also consider how the smart city concept relates to Society 5.0. Various smart city initiatives have been implemented across the world (Nikkei BP Clean Tech Institute et al. 2011). Here, we look back at the smart city initiatives that have been conducted in Japan and Western countries since the turn of the century and examine how far they have come.

There are now countless examples of initiatives that integrate IT into urban community services or that use IT to enhance services or develop new businesses. Such initiatives are particularly numerous in the transport and energy sectors. Many of Japan's bus services, for instance, now use geo-positioning technology so that passengers can tell where the bus is and how long it will take to arrive at the bus stop. Within cyberspace, the bus's spatial information is progressively plotted out along with its movement, and the latest information is relayed to the smartphones of people waiting at the bus stop. Thanks to this information, the people at the bus stop can tell how near the bus is, just as people waiting for an elevator can see which floor the elevator is currently at. People can then mentally process this information, which makes the waiting process much less irritating than if they had no such information and thus no idea of how much longer they have to wait. Another example is automotive navigation systems that use digital mapping in cyberspace. Vehicles monitor or predict the conditions further down the road and relay the information to the driver so as to guide the driving. At an even more advanced level, automated driving is now ready for practical application.

These navigation systems help resolve or avoid traffic congestion and, in so doing, minimize the time and energy of travel. This does not just apply to cars and buses; IT integration will help solve congestion issues for many different transport services, including taxi and rail transport. With such integration, the existing systems underlying community services will be regenerated as highly intelligent, or "smart," systems. Once services are powered by such smart systems, the urban community as a whole becomes a smart city. In Society 5.0, these smart systems will be even more advanced. They not only make life more convenient and comfortable for each city dweller but also help to resolve issues affecting the population as a whole, such as global warming and aging of the population.

The idea that integrating IT with existing services will lead to a more advanced society, as well as the notion that societies advance in tandem with technological evolution (including progress in IT), is a key assumption in the vision of Society 5.0 as outlined in the government's Science and Technology Basic Plans. This literature mentions the "supersmart society," describing it as a society in which cyberspace is proactively used to successively create new value and services that enrich the lives of the society's members. The government's vision of Society 5.0 is shared by the Japan Business Federation (Keidanren). In *Revitalizing Japan by Realizing Society 5.0* (Japanese Business Federation 2017), Keidanren states that Society 5.0 goes beyond optimization of individual fields to the optimization of society as a whole by freeing people from spatial and temporal constraints, freeing them from complex social issues, and encouraging economic growth underpinned by new business models and worldwide proliferation of such models.

Common Urban Infrastructure: From Test Bed to Practical Application

One example of a new system that has resulted from integrating IT with existing services is smart energy. Following the turn of the century, smart city initiatives rapidly spread around the world. Although these initiatives initially focused on introducing new energy systems, they helped make the smart city concept more widely known, including in Japan.

Nowadays, the smart city initiatives of local governments and private businesses go beyond energy to encompass a breadth of community services, including those related to transport, healthcare, welfare, and waste disposal, such that the concept itself is now much broader. Many cities in Western and Asian countries have piloted and rolled out the smart city model, making the concept even more far-reaching.

As the name suggests, the smart city denotes an "intelligent" city. Smart cities integrate IT with various services, activities, and physical things (energy and rail systems being examples) to improve convenience, comfort, and safety in the city. Smart cities also integrate IT with services to address the issues the city is facing. Cities face their own particular problems; they also face problems that are common across society. Japan, for one, faces a myriad of problems. Suffice it to say, the solutions to these problems must take into account the particular conditions of the city in question, including its social and geographical conditions. Some strategies are applicable to multiple cities, but some measures are only relevant to certain cities.

Likewise, basic infrastructure, such as power systems, is applicable to multiple cities, and so the technology underlying the systems can be shared among them. That said, there are some discrepancies between countries. Western countries are ahead of Japan when it comes to solar and wind power and the liberalization of energy markets. These countries have pressed ahead in introducing smart grids and similar systems in an effort to diversify energy sources and accommodate diverse user preferences. The following section outlines some examples of smart city initiatives that have been implemented around the world since the turn of the century.

3.2 Smart Energy Management Systems

Smart Energy Supply Systems

One commonality of cities is that they rely on energy systems. It is no surprise that many smart city initiatives have focused on “smart” energy—energy systems that integrate IT with local power supply systems. The main roles of smart energy systems are played by smart grids, microgrids, and smart houses.

Smart grids, microgrids, and smart houses were the leading players in the first phase of smart city initiatives, and they have therefore become key terms associated with the smart city concept. Applications of “smart grid” and “microgrid” technologies have primarily involved the construction of an advanced energy management system, which in Japan is called “Community Energy Management System (CEMS).” The term “smart houses,” on the other hand, is associated with rows of detached houses that use a Home Energy Management System (HEMS) to achieve optimal energy management.

The practical application and proactive rollout of these new forms of energy management have been critical in advancing the smart city concept. In the next section, we explore each in more detail.

Smart Grids

A smart grid is an electrical grid that applies IT to power supply facilities so as to optimize energy supply. For example, it links energy supply and demand in an information network; it introduces control mechanisms that would be unfeasible under conventional, centrally controlled energy supplies; it cuts costs by enabling compatibility with diverse energy sources and by optimizing the supply–demand balance within the transmission network; and it controls load bearing so as to prevent power outages. Japan’s power grid has, over the years, been based upon a centralized power control system, in which the country’s power infrastructure is divided into several territories, each controlled by a major power company. This system has ensured a stable power supply. By contrast, the USA has liberalized energy markets. One problem with this fragmented power distribution system is infrastructure maintenance. As the infrastructure ages, major power outages increasingly occur. The USA has rolled out smart grids partly as a response to this problem. American smart grids use smart meters, which monitor and communicate information, and thus enable a greater level of control than that achievable in conventional grids. The greater level of control includes the ability to avoid excess load bearing or accidents in fragile transmissions as well as the ability to modify transmission routes. As for the EU, which has made headway in introducing renewable energy sources (such as solar and wind power), its smart grids integrate IT with grids (transmission networks) to enable compatibility with diverse energy sources and to optimize the supply–demand balance within the grid (transmission network).

Microgrids

Whereas smart grids are wide-area (macro) grids, microgrids are localized grids. Microgrids source energy from renewables such as solar, wind, and biomass, and use IT to monitor and control the supply. These grids do not rely on large power stations and thus avoid the problems associated with them, which include environmental problems and energy losses incurred from transmitting the power to remote locations. The energy in microgrids is both sourced and consumed locally. Hitachi has the following to say about the US microgrid market:

> Most of the time, microgrids operate in parallel with the utility grid but also have the unique feature of being able to operate independently of the main utility grid (island mode) in the event of a power outage. As dependence on technology has grown in all facets of society, tolerance for power outages has decreased markedly while at the same time in the USA, vulnerability to power outages has increased due to aging of the grid infrastructure and cyber and physical threats. This makes the ability to seamlessly "island" from the utility grid in the event of a power outage a key driver for many customers to consider a microgrid versus other less sophisticated distributed energy resource (DER) solutions. Additional customer benefits include reduced energy costs, less volatile energy costs, and reduced emissions.
>
> Microgrids strengthen energy stability and the ability to recover from outages. They also reduce the carbon footprint and, in many cases, reduce overall energy costs. The benefits to the public are formidable. All across America, there are efforts to increase communities' ability to recover from natural disasters, terrorist attacks, and other threats to national security (Aram 2017a, b).

Smart Houses

Smart houses are houses that connect appliances and equipment to communications lines to achieve optimal control. This concept was proposed back in the 1980s, but with the advent of the Internet and digital home appliances, as well as the spread of broadband, the concept was extended to control systems that use the home's Internet connection and systems for monitoring elderly people and children. Following the recent rollout of HEMS, there has been a rise in the number of smart houses equipped with unitary control systems—systems that coordinate all energy supply and consumption by integrating home appliances, solar power systems, batteries, and electric cars.

Many of the smart communities and smart cities presented in the next section have introduced the aforementioned CEMS and built smart house models that reflect the attributes of the community concerned. In the following section, we explore taxonomies and trends as they relate to Japan in a little more detail.

3.3 Japan's Smart Communities/Cities

Smart Communities That Use Community Energy Management Systems

As Western countries continue to roll out advanced energy supply systems such as smart grids and microgrids, Japan, which lags behind in energy liberalization, has started piloting such systems in certain communities. In these communities, local governments work with private businesses in implementing state-subsidized projects designed to reduce greenhouse emissions and contribute toward a carbon-free society.

These projects are anchored within government strategies such as the Kyoto Protocol Target Achievement Plan, which the Cabinet formulated in April 2005. The Kyoto Protocol Target Achievement Plan was designed to meet the 6% reduction in greenhouse gas emissions, to which Japan committed when it signed the Kyoto Protocol agreed to at the Conference of Parties III (COP3) in 1997 (the 6% reduction is relative to the 1990 level; reduction in hydrofluorocarbons is relative to the 1995 level). Under this plan (which was subsequently revised in March 2008), relevant government departments adopted a system for supporting national projects such as a test bed pilot program, which has spurred considerable action.

In November 2009, the Ministry of Economy, Trade and Industry (METI) launched the Council for Next-Generation Energy and Social Systems and developed a test bed pilot program titled the "Next-Generation Energy and Social Systems Demonstration" (Ministry of Economy 2019). This program outlined five objectives: (1) "Stable accommodation of large-scale roll-outs of renewable energy" (develop a robust power infrastructure that can handle large-scale expansion of renewable energy); (2) "IT-driven optimization and load distribution" (showcase next-generation lifestyles that use IT to balance QoL with energy saving); (3) "A growth strategy that markets the system" (showcase the system overseas as part of a growth strategy); (4) "Standardization" (lead the world in establishing next-generation international standards); and (5) "A business environment that will take the technology from testbed to practical application" (develop a financing system involving collaboration with relevant government departments [e.g., Ministry of Land, Infrastructure, Transport and Tourism; Ministry of Agriculture, Forestry and Fisheries; Ministry of Education, Culture, Sports, Science and Technology] and develop the frameworks for autonomous financing; review relevant systems). In April 2010, four municipalities were designated as test bed sites: Yokohama (Kanagawa Prefecture), Toyota (Aichi Prefecture), Keihanna Science City (Kyoto Prefecture), and Kitakyushu (Fukuoka Prefecture) (Tsuchiya 2015).

Over the next 5 years, these municipalities pursued their own projects with residents' participation and in collaboration with private businesses. Yokohama's project was titled Yokohama Smart Community, Keihanna Science City's (aka Kansai Science City) was titled Keihanna Eco-City Next-Generation Energy and Social System, Toyota's was called Smart Mobility and Energy Life in Toyota City ("Smart Melit"), and Kitakyushu's was called Kitakyushu Smart Community Creation Project (Ikeda and O'oka 2014; Architectural Institute of Japan 2014).

The aim of each project was to construct a CEMS in the existing urban areas and evaluate how effectively it operated, taking into account local attributes. The projects introduced technologies such as HEMS, Building Energy Management Systems (BEMS), storage batteries, and electric vehicles into houses and buildings in the existing urban areas. The aim was to integrate these systems with demand response and incentive point schemes so as to construct an organic CEMS. The rise of the CEMS is one of the products of Japan's efforts to build smart communities and cities.

In addition to these test bed programs, METI launched a public appeal for related projects and selected such projects as "smart community vision proliferation," "next-generation energy technology test bed," "smart community rollout facilitation," and "smart energy rollout facilitation." These projects are implemented by local governments, private businesses, or both collaboratively, at a nationwide scale.

The Smart City Concept in Large Urban Development Projects

Some urban development projects involve building upon the existing infrastructure. In other words, the city has its existing assets, such as the energy supply systems, core urban infrastructure, housing, and the like, and new systems are added to the neighborhoods situated among these facilities. By contrast, in large urban development projects, the city is built from scratch. This makes it much easier to introduce cutting-edge physical infrastructure, including that related to power transmission lines, roads, gas supply, and communications. Another advantage is that the high-tech infrastructure will enable new neighborhoods and innovative lifestyles, allowing the municipality to brand itself as a "new town."

During the 2010s, there have been a number of smart city projects in Japan's new towns. The key examples include Kashiwa-no-ha Smart City (Kashiwa, Chiba Prefecture) (Yamamura 2015; Mitsui Fudosan 2019) and Fujisawa Sustainable Smart Town (Fujisawa, Kanagawa Prefecture) (Fujisawa Sustainable Smart Town Association 2019). Kashiwa-no-ha Smart City is situated around Kashiwa-no-ha Campus Station (which is served by the Tsukuba Express) in a 273-hectare plot designated as a land readjustment project area (planned population: 26,000). During the 2011 Tohoku disaster, the smart city underwent a planned power outage. In the same year, the national government designated Kashiwa city as one of "FutureCities" (more on this in Sect. 3.4), making the new town eligible for government subsidies. As an eco-model city, Kashiwa works with Mitsui Fudosan in pursuit of three objectives: eco-friendly urban development, longer healthy life expectancy, and creation of new industries—including in new, economically invigorating growth sectors.

For the first objective (eco-friendly urban development), an "Area Energy Management System (AEMS)" was introduced to manage energy supply in four zones around the station (a mixed-zone housing commercial facilities, hotels, and offices; a zone housing large commercial facilities; and two zones housing high-rise apartment buildings). This system was developed by Hitachi. The town also introduced a business continuity plan for emergencies, which includes the use of large storage batteries and a gas-fired power generator, and it provided energy interchange between the different zones intersected by roads (see Figs. 3.1 and 3.2). Initiatives for the second objective (longer healthy life expectancy) include the opening and running of a healthcare station called Ashita ("tomorrow"). Initiatives for the third objective (creation of new industries) include the opening of the Kashiwa-no-ha Open Innovation Lab and the Kashiwa-no-ha IoT Business Co-Creation Lab.

Of note here is that these urban development initiatives have been coordinated by the Urban Design Center of Kashiwa-no-ha (UDCK, founded in 2006), a platform for government, business, and academic collaboration. Government–business–academic collaboration proved instrumental in developing the AEMS. It helped get Kashiwa-no-ha Smart City designated as both a "FutureCity" and a "special zone for local economic invigoration," which made the smart city eligible to apply for a special zone status. With special zone status, the smart city

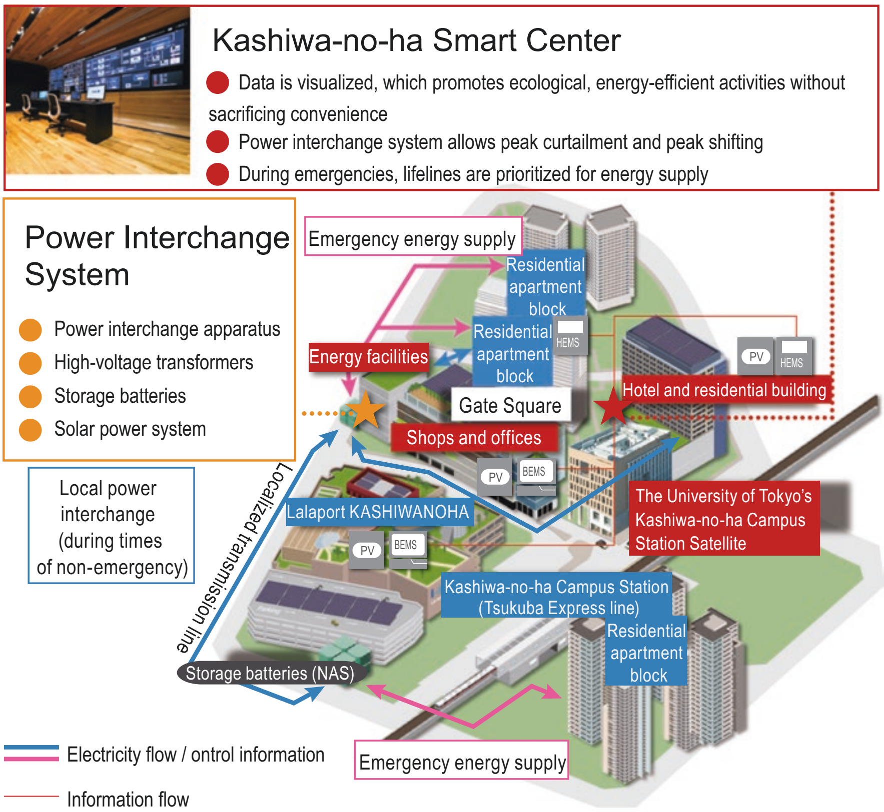

Fig. 3.1 Urban redevelopment area, including Kashiwa-no-ha Smart City. Source: Mitsui Fudosan, *Kashiwa-no-ha Smart City* (Mitsui Fudosan 2019)

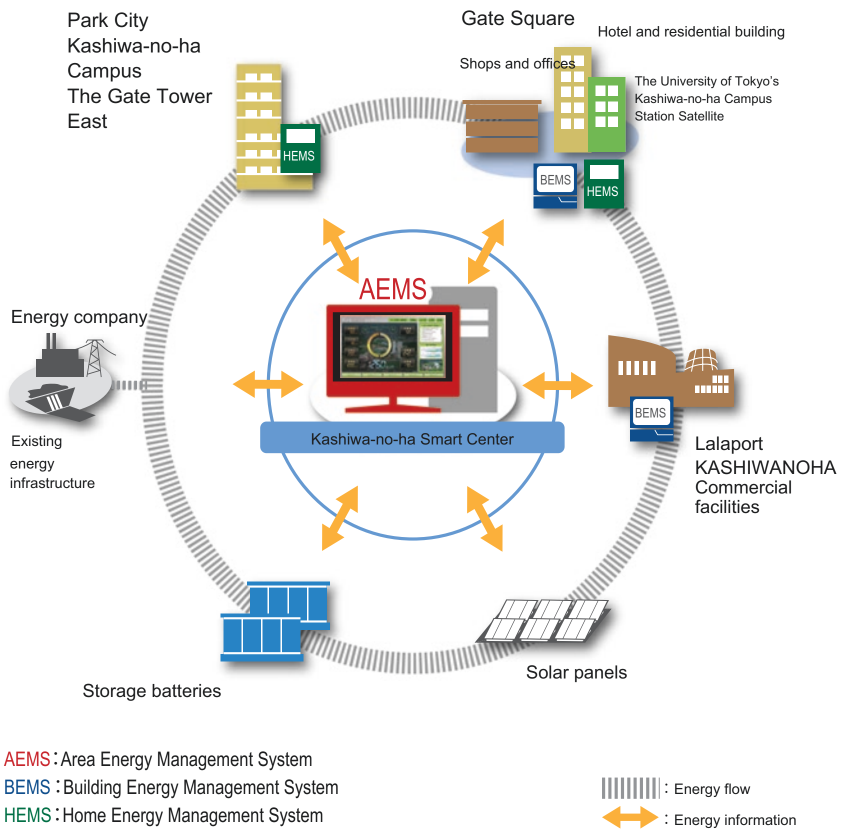

Fig. 3.2 Kashiwa-no-ha Smart City's Area Energy Management System (AEMS). Source: Mitsui Fudosan, *Kashiwa-no-ha Smart City* (Mitsui Fudosan 2019)

could provide energy interchange across an area spanning roads and railways, as well as roll out the system necessary to do so, without needing to apply for permission to provide power sharing under the Electricity Business Act.

Fujisawa Sustainable Smart Town is situated in what was once an industrial estate of approximately 19 hectares (planned population: 3000). The project is spearheaded by Panasonic. With a view to developing interdependent energy management, Panasonic equipped the area with 3 MW solar power systems and 3 MW storage batteries, and each (detached) house with a smart HEMS. Energy-saving technologies were also introduced. Each house stores energy using lithium storage batteries, generates energy using solar panels and energy farming, saves energy by using LED for all lighting, and uses water-efficient toilets and showers. Guidelines are distributed to ensure that the residents use these technologies effectively. Although area-wide energy management is the main focus, town management extends to a broad mix of services that support residents' quality of life. These services are designed to promote ecological sustainability and the well-being of residents. They are provided autonomously. The building blocks of a smart city in this case are formed using these services and systems.

The Smart City Concept in Business Continuity Planning for Urban Cores

An urban core houses clusters of offices and commercial facilities. As such, business continuity planning (BCP) is essential to ensure that businesses continue to operate if the urban core is exposed to a natural disaster. Following the 2011 Tohoku disaster, BCP became a major theme in relation to community energy supply systems, along with efforts to minimize carbon emissions and save energy.

One of Tokyo's key business districts is Chiyoda ward's Otemachi–Marunouchi–Yurakucho area (abbreviated as *dai-maru-yu* in Japanese and OMY in English). OMY has been undergoing redevelopment, and recently, the area has seen the development of swanky public spaces, including commercial facilities and customer attractions. This redevelopment is underpinned by an area management system driven forward by Mitsubishi Estate (The Council for Area Development 2019; OMY Area Management Association 2019). OMY has adopted the smart city concept in an effort to balance carbon reduction with BCP. Its smart city initiatives include energy saving in buildings, highly efficient community air-conditioning, fire-resistant architecture, and expanded rollouts of green energy (Inoue 2012).

Another example is Nihonbashi, a neighborhood in central Tokyo. Nihonbashi has a redevelopment zone, where redevelopment is led by Mitsui Fudosan. Mitsui Fudosan has introduced a cogeneration (combined heat and power) system as part of an effort to develop an energy infrastructure grounded in local power supply and heat generation. The building blocks of a smart city in this case are carbon-reducing physical infrastructure coupled with business continuity planning (Nakade 2017).

The Japanese Model of Smart Communities and Smart Cities

The above examples serve as models of the smart city in Japan. In the case of Yokohama, Kitakyushu, Keihanna Science City, and Toyota, there is a CEMS established in an existing urban environment, and there are locally anchored schemes for managing such a system. In the case of Kashiwa-no-ha Smart City and Fujisawa Sustainable Smart Town, there is a CEMS established as part of a large urban development project. In the case of Nihonbashi and OMY, there is a management system that extends to business continuity planning for the urban core's commercial cluster.

In each case, there is a CEMS tailored to the particular functions of the residential and commercial zones, under which innovative energy systems are introduced in accordance with the area's attributes and challenges. The above cases also suggest a smart city model that focuses on addressing local challenges; specifically, the above cases feature services designed to enhance residents' quality of life, and in the commercial areas, these services also include those designed to enhance safety and convenience.

On the one hand, we see energy management technologies (technologies that integrate IT with energy supply systems) being piloted, and we see the smart city model emerging with the practical implementation of these technologies. In non-energy sectors as well (such as in transport and healthcare), we see new services underpinned by IT-based management systems progressing from the test bed to the commercialization stage. That said, we have yet to identify any model to describe how these services and the management systems integrating different sectors can be commercially applied in multiple cities. As such, there is a need to reach out across different sectors, which requires us to go beyond the smart city framework.

3.4 Sustainable Cities and Smart Cities

Community Visions and Government-Led Projects

The smartification of urban/community energy management, including the Japanese cases described previously, has significantly propelled the evolution of smart cities. However, smart city initiatives in designated zones, such as new development zones, have limited ripple effects. Although there are no particular conditions on how large or populated a community or city should be to become a smart community or smart city, the selection of areas for smartification, as well as the scope of the system coverage (such as the CEMS), is arbitrary. As the selected areas become more energy efficient and their services improve, the task that arises is how to propagate the benefits of these technologies to areas beyond the existing smart cities. In an attempt to tackle this task, the government has focused on showcasing urban development models for others to imitate. This task requires communities to develop best practice models of urban (re)development. As it happens, many existing smart cities/communities took on this torchbearer role. Developing pioneering models for others to follow is arguably one of the social roles of smart community/city initiatives.

To position a smart community/city model project as part of a local community's overall strategy is essential for another reason: it helps clarify the community's general vision or master plan, identifies the roles to be played by each hard or soft initiative in this vision, and formulates strategies for implementing these initiatives. In this way, strategies can be implemented in a strategic and coordinated way, taking into account the ripple effects, including those related to addressing social issues such as global warming and aging population. This approach also ensures that the community uses government subsidies and grants as effectively as possible. The approach can be equated with government-led action in that government formulates a master plan for the community by clarifying its general approach and objectives, compiles an action plan outlining a specific strategy and concrete measures for accomplishing the master plan, and then works with residents and other local stakeholders in executing the plan.

Community Visions of Sustainable Development and Government Support

Government-led projects begin with a general vision for the community as a whole. When drafting this vision, it is crucial to understand the community's geographical and social attributes and incorporate them into the vision. It is also important to get a well-balanced big picture of the community and establish clear objectives related to sustainable development. The Sustainable Development Goals (SDGs), which the UN agreed to in September 2015, are relevant at the community as well as the national level, and these goals provide a universal framework that can be easily communicated globally.

The Japanese Government has indeed taken advantage of the SDG framework. In 2018, the Cabinet's Regional Revitalization Promotion Office solicited model projects under the "SDGs FutureCity" program and selected 29 municipalities. The office strengthened partnerships with a breadth of stakeholders, including communities already designated as an "eco-model city" or "FutureCity," and launched the "public–private platform for pursuing regional revitalization and SDGs" (Cabinet Office 2018).

Even before the UN established the SDGs in 2015 from 2000 onwards, the government had developed a program for supporting local initiatives; this was the program of designating communities as "eco-model cities" or "FutureCities." Under this program, 23 communities have been designated as "eco-model cities" and 11 as "FutureCities" (as of August 2018). These designers have established their own visions and strategies, and associated action plans (FutureCity Initiative 2019). Applications for FutureCity status began in 2011, the year of the Tohoku disaster. Of the 11 communities selected as FutureCities, 6 were in the disaster-hit areas. Some of the FutureCities have pursued smart community/city initiatives. For example, Kashiwa-no-ha (one of the smart cities discussed previously) used its FutureCity status to attract government funding toward the creation of an AEMS. Similarly, Higashi Matsushima used the funds to construct a "smart disaster-prepared eco town," which uses a CEMS to achieve energy self-sufficiency and enable energy supplies from neighboring communities in the event of an emergency.

Model Projects for Sustainable Urban Development

Ideally, such communities should take the initiative in analyzing their issues as well as their geographic and socioeconomic attributes. They should then address their issues, drawing on their particularities, underscoring their originality, and enhancing their appeal and vibrancy. In many cases, the communities should formulate a general vision and strategy and then advance concrete measures in partnership with private businesses, local organizations, and resident groups. On the other hand, when local governments take the lead in drawing up a vision, this vision may become overly dependent on bureaucratic processes. Accordingly, the Cabinet developed a platform to proactively support public–private partnerships and efforts to communicate the vision. Yet creating a vision alone is not sufficient; the key to its success lies in whether concrete measures are implemented effectively.

In the years ahead, it will be essential for public institutions, private businesses, and local residents to collaborate in implementing new initiatives. The government programs described above are, at least in part, intended to facilitate such public–private collaboration. Toyama City has implemented a series of measures intended to make the municipality a compact city. It introduced a light rail transit (LRT) system, which now forms the backbone of the city's infrastructure, and implemented road redevelopment projects based around the LRT. Additionally, the city has curtailed suburban expansion to make its urban environment more compact. Similarly, Kitakyushu City has implemented a smart community creation project in Higashida (Yahata-Higashi ward). Likewise, Shimokawa-cho (Hokkaido Prefecture) has advanced a renewable energy policy using its extensive forest resources as forest biomass. Earlier, we described such projects as "government-led." However, insofar as projects are supposed to demonstrate a framework for sustainable urban development, they should not just be government-led but rather be implemented collaboratively in public–private initiatives; they should also be conducted in a sustainable manner, so as to highlight the sustainable nature of the projects. The initiatives of the designated municipalities do indeed showcase successful models in each area; more importantly though, they serve as practical models describing how government, private businesses, and local residents can work together in implementing new transport or energy systems.

The Challenges of Japanese Smart Cities as Seen Through the Lens of Society 5.0

So far, we have identified two types of Japanese smart city initiatives: business-led initiatives conducted in conjunction with large-scale urban developments and government-led initiatives that are anchored within the vision statements of municipalities. How do these two types of smart city initiatives appear when viewed through the lens of Society 5.0? The key issue is whether these smart cities are, or can potentially become, compatible with the principle of the people-centric society. Can smart cities evolve to become capable of delivering goods and services that are highly customized to diversified and latent needs? To this end, smart cities require a new approach; rather than being led either by private businesses or by public institutions, they need to be led by citizens or based on citizen participation.

As mentioned in Sect. 3.3, the Japanese smart city model involves the use of a cutting-edge CEMS. The use of such a system as a means of practically implementing the smart city concept is certainly not without considerable value. However, it also exposes the fact that the Japanese smart city model is technology-led, being predicated upon the introduction of new technologies and systems. For smart cities to address the issues that urban populations commonly face, they need to be more citizen-friendly, use sensors and IoT-based technology, and be oriented more toward the vision of Society 5.0. On this score, we can look to examples of smart cities in the EU and the USA. These smart cities differ from the smart cities/communities in Japan, which are driven by the smartification of energy systems.

3.5 From Citizen-Led Smart City to Society 5.0

Smart Cities in the EU

The EU has supported the development and implementation of smart cities pursuant to the European Commission's medium-term vision "Europe 2020" (ratified in March 2010) and a program forming part of this vision, "Horizon 2020," which is the EU's largest program for supporting research and innovation, both financially and otherwise (Horizon 2020 runs from 2014 to 2020). In 2015, the European Commission launched the European Alliance for IoT Innovation (AIOTI) (Nomura 2017; NICT Europe Center 2017; Oshima 2016). Such institutional backing has yielded countless smart city models in Europe. These models feature a broad array of smartification—not only smart energy, but also smart transport, smart distribution, smart waste, and many other smart systems. In the following section, we focus on the example of Barcelona.

Smart City: Barcelona

Barcelona (population: 1.6 million) is the capital of Spain's Catalonia region. The city is renowned for its artistic heritage; it was the home to famous artists such as Pablo Picasso and Joan Miró, and it features many of Antoni Gaudí's buildings. Since hosting the 1992 Olympics, Barcelona has attracted attention for its subsequent economic growth and, more recently, has served as a model of a European smart city. The city uses sensors to monitor urban data. The data is relayed to citizens/users through apps or linked with community services such as transport systems and waste collection (see Fig. 3.3). This technology has enabled Barcelona to improve its traffic fumes and noise pollution, for which it was once notorious. Sensors installed around intersections monitor the air and noise pollution, and the readings are made freely accessible as open data. If readings in an intersection are high (indicating heavy pollution), the traffic signal patterns are adjusted so that vehicles flow through without stopping, thus lowering the traffic fumes around the intersection.

Unlike in Japan, many cities in the EU do not require people to obtain a parking certificate before owning a car. As these cities often lack adequate parking facilities, many parking spots are located by the sides of roads. Consequently, drivers who want to park on the side of the road must spend considerable time hunting for a space. To address this problem, Barcelona introduced a smart parking system. Asphalt-embedded sensors monitor whether the spaces are occupied, and drivers use apps to access this data and identify where the vacant spots are. These sensors are equipped with a battery and transmitter, and they emit signals indicating whether the space is vacant or occupied. These signals are overlaid on street maps in smartphone apps, allowing drivers to view the information in real time.

Other examples of smartification in Barcelona include smart lighting (streetlights that react to the presence of people), smart waste management (roadside waste containers use sensors that monitor when they are full), and smart cycling. An open-source platform called Sentilo connects the sensor data to the city's open data portal (Sentilo 2019). Sentilo has attracted attention for how it makes the data freely accessible globally. Barcelonan initiatives such as this have the potential to be adopted in other cities around the world.

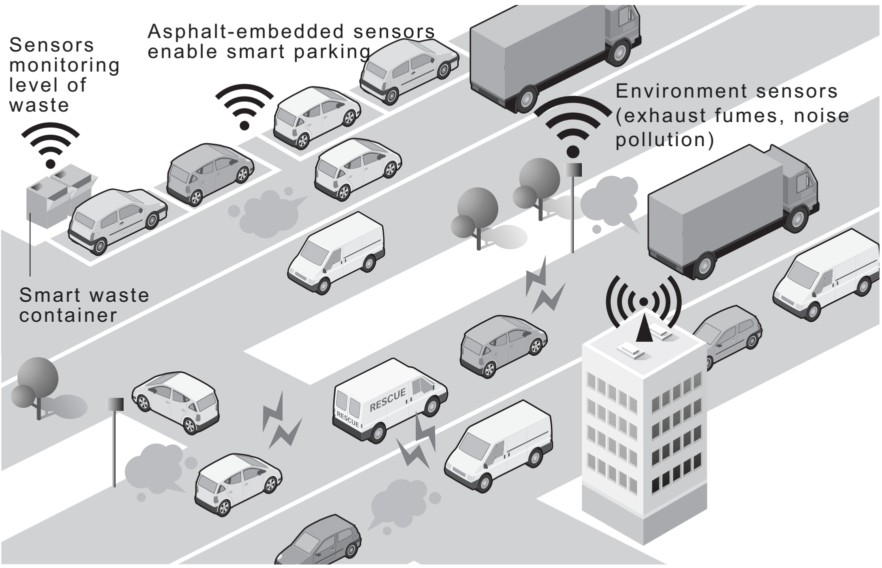

Fig. 3.3 Conceptual image of a sensing city

One intriguing Barcelonan initiative is Wallspot. Wallspot is an online tool that shows the locations of wall spaces available for legal graffiti. Barcelona had a problem with illegal graffiti. Some of the graffiti had artistic value, so the city released Wallspot to indicate legal graffiti spaces. Once artists have finished their work in these spaces, the painting is maintained for 1 week, after which it is removed and the wall space becomes available once again. Legal graffiti spaces are erected in public parks and their locations are advertised on Wallspot. The scheme has proven successful in reducing illegal graffiti in the city. Wallspot also helps graffiti artists connect with the local community; for example, it organizes graffiti events and displays works that have attracted interest among Barcelonans.

Transport is another area in which Barcelona has innovated. Tourists once complained about the city's confusing bus network. The city reorganized the network into vertical and horizontal lines, making the system much more intuitive. It also started displaying the waiting time for each bus service at bus stops. Additionally, Barcelona installed 500 free-charging stations for electric cars and scooters.

Smart City and Sensing City: Santander

Another Spanish city that has made an impact on the smart city scene is Santander (population of 180,000), the capital of the Cantabria region. Santander launched the "SmartSantander" project in 2010, earning the city EU funding. This funding was used to actively roll out sensor-based services that minimize personnel and service costs.

Santander is a key example of an EU city that uses a citizen-level approach to resolve local problems—more specifically, an approach that uses sensors to monitor conditions of concern and then makes the data freely accessible, allowing commercial application of the data and better services. The general thrust of this approach is to establish a citizen/user-led "sensing city." In a sensing city, data are gathered via sensors and IoT-based technology, becoming Big Data. The platform that organizes and manages this Big Data forms a cyberspace that feeds back the data to the physical space (real world) to improve real-world services.

A Marketplace for Trading Big Data Market: Copenhagen

An even more advanced example of smart city innovation can be found in Copenhagen, the capital city of Denmark. Copenhagen has created the City Data Exchange, a marketplace for trading Big Data. In the City Data Exchange, data related to different services (such as transport, energy, water, finance, and events) are exchanged in cyberspace between users in the city, including public institutions (such as the city council) and private companies (see Fig. 3.4). The aim is to facilitate the integrated use of the data, create new opportunities for businesses to trade in the data, and reduce the city's carbon footprint. The project emerged in the con-

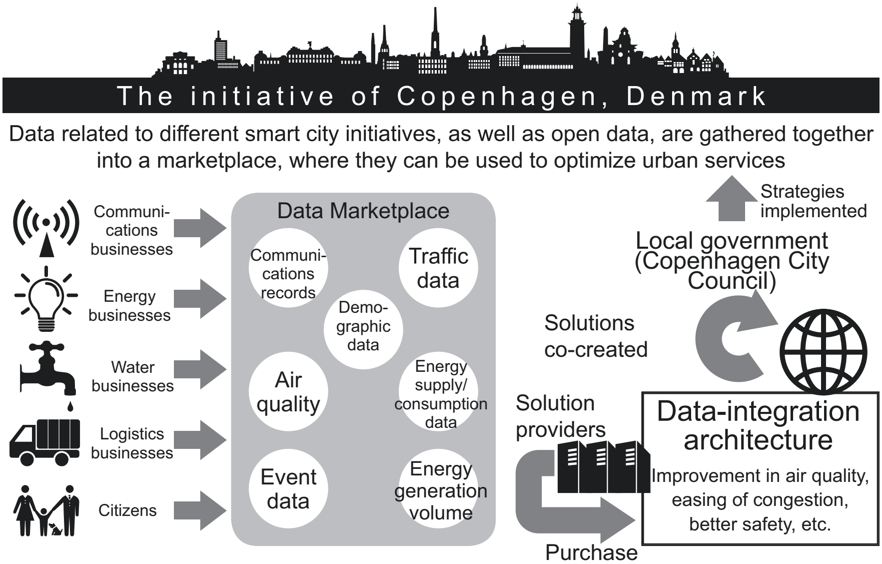

Fig. 3.4 Copenhagen's city data exchange

text of Copenhagen's policy objectives. Copenhagen set a goal of becoming the world's first carbon-neutral city by 2025. It then set a numerical target: to reduce its carbon emissions from the 2014 level of 2 million tons to 1.2 million tons.

To achieve this target, Denmark launched the Copenhagen Cleantech Cluster project (now known as CLEAN) to establish a cluster for introducing innovations in eco-technology. In 2014, CLEAN outlined a vision of digital infrastructure for gathering public–private data and analyzing Big Data in an ecologically effective way. In May 2016, the project launched a marketplace for trading data under a software-as-a-service model, allowing a wide range of organizations to purchase, sell, and share the data.

Although Northern European is a frontrunner in data sharing, even here, a data marketplace—businesses placing their data on the market and exchanging data with other companies—remains a new frontier. Businesses participating in consortiums have shown interest in a data marketplace, but they remain cautious about initiating trade in one. Hopefully, there will be more activity in the years ahead.

Smart Cities in the USA

In the USA, many of the smart city initiatives are driven by national policies and programs. Under the American Recovery and Reinvestment Act of 2009, the Obama Administration invested vast sums of federal money into the construction of a smart grid and energy-related digital technology, driving forward test beds and rollouts.

Since then, there has been a flurry of new initiatives to support R&D and infrastructural development in related fields. For example, in December 2013, White House Presidential Innovation Fellows (Geoff Mulligan and Sokwoo Rhee) launched SmartAmerica Challenge, a project that demonstrates the potential of IoT to create jobs and business opportunities, and deliver other socioeconomic benefits. Similarly, in August 2014, the National Institute of Standards and Technology (NIST) launched Global City Teams Challenge (GCTC) to promote the building of smart cities and the use of IoT. Under the GCTC program, NIST acts as a matchmaker matching different cities with common problems, matching common technological development projects, and matching cities with organizations, to develop a collaborative platform for developing smart city projects and IoT-based technology in multiple cities. In September 2015, Obama launched the Smart Cities Initiative, in which many different federal agencies are coordinated to support community efforts (Nomura 2017).

Reflecting these state-led actions, smart city projects are emerging across the USA and these projects cover a broad array of sectors, including energy and traffic.

Smart Cities in Maui, Hawaii

One example of a smart energy system is that of the Hawaiian island of Maui (population: approximately 150,000). From 2011 to 2016, energy stakeholders from Japan and Hawaii collaborated in a test bed project called JUMP Smart Maui ("the Japan–US Maui Project"). Hawaii was reliant on fossil fuel for around 90% of its energy, and it had set the goal of switching entirely to renewable energy sources by 2045. However, the state faced a challenge in relation to this task: because renewables fluctuate widely according to the weather, rolling them out on a large scale would destabilize the power grid. JUMP Smart Maui sought to demonstrate a method for stabilizing Maui's power grid in such a rollout. It integrated the island's wind power network with systems for charging and discharging all-electric vehicles in such a way that peak power use could be curtailed and vehicles could be charged during times of surplus energy. Eighty electric vehicles were used in the test bed, and electrical discharges from 14% to 31% of them yielded effective energy resources during peak times. Thus, the project managed to integrate electric vehicles as part of a flexibly dispersed power storage system. In doing so, it demonstrated that such a system is effective for stably managing renewable energy-sourced power in an enclosed locale such as a small island.

Sensing City: Chicago

Of all the American smart city models, the one that is most advanced in terms of open data is Chicago, Illinois (population: 2.7 million). In 2013, the city launched the Chicago Tech Plan. The Chicago Tech Plan consists of two foundational strategies: “next-generation infrastructure” and “every community a smart community.” It also consists of three growth strategies: “efficient, effective, and open government,” “civic innovation,” and “technological sector growth” (Chicago Tech Plan 2019). As part of the “next-generation infrastructure,” Chicago launched the Array of Things (AoT) initiative, in which the city installs sensors along the city streets to monitor real-time data on the urban environment and then makes the data freely accessible as open data. The data include temperature, humidity, barometric pressure, carbon monoxide level, ambient sound intensity, vibration, and pedestrian and vehicle traffic (Array of Things 2019). The sensors are mounted on light posts, and they house modules and other systems designed in a collaborative project, the leading members of which were the University of Chicago and the Argonne National Laboratory.

The data collected by the AoT sensors are open and freely accessible to businesses, researchers, citizens, and entrepreneurs. As of 2016, there were 42 sensors installed with plans to have 500 installed by 2018. To protect privacy and security, the data, together with the hardware and software, are regularly reviewed by an external, independent team (the Technical Security and Privacy Group). Because the Big Data yielded from the AoT enables real-time tracking of the urban environment, it empowers citizens to check conditions during disasters (such as floods) as well as the environmental conditions; it also has the potential to spawn new ideas for how to use the data. In this way, Chicago has cultivated a civic tech community, one in which Chicagoans take the initiative in leveraging cyberspace (in this case, sensor-based open data) in such a way as to benefit their physical space (real world).

Official Open Data Portal: San Francisco

San Francisco (population 0.8 million) is well known for its efforts to open up municipal data. In 2009, San Francisco launched an official open data portal called DataSF (DataSF 2019). DataSF contains a broad array of open data, including that related to urban planning, transport, housing, crime, and disasters. The city by the bay has also launched numerous apps for using this data, including an app that maps the city’s buildings in 3D and an app related to real estate information.

However, open data poses challenges to the city government. The data must be constantly updated, and there must be an ongoing process for evaluating performance metrics, such as the time it takes to update the data. Additionally, while the data are free to use, the task of managing the data puts a constant strain on municipal budgets. The city government is introducing measures to address these problems so that it can keep the data open.

Some Japanese cities have taken a similar route. Fukuoka and Aizuwakamatsu, for instance, have launched official open data portals together with apps that allow citizens to access municipal data (Fukuoka City 2019; Aizuwakamatsu City 2019).

Challenges in Getting from the Citizen-Led Smart City to Society 5.0

The above case illustrates the general trajectory of the Western smart city scene: data on the city/community's issues are gathered at the level of citizens, and solutions to these issues are implemented by citizens or with the engagement of citizens. In other words, data related to the city/community's issues are opened to the public in cyberspace (the data are collected using sensors and opened to the public, or government data are made accessible on an official open data portal), and these data are then used to benefit the physical space (real world) by creating new services and business opportunities geared toward improving the environment. Thus, pioneering Western cities are already making fledgling attempts at bringing about the cyber-physical convergence to which Society 5.0 aspires. However, these attempts are still contained within cities, and they are limited to a particular cluster or limited to a particular sector or service.

As for the Japanese smart city scene, many smart cities/communities have emerged from test bed pilot projects pertaining to a particular system (such as the energy system) in a particular city neighborhood or city. Stated differently, Japanese smart city initiatives are limited to a particular area and a particular sector or service (see Fig. 3.5).

To progress from these smart city initiatives to the supersmart society of Society 5.0, where cyber and physical spaces converge, we must overcome several hurdles. First, the scope of the test bed projects must be enlarged to encompass entire cities and the entire society, and the projects must be liberalized. To this end, the regulatory climate must be eased, and the test bed process must be clarified and streamlined. Assistance from across government departments will be necessary, along with financial support, where necessary.

More work needs to be done also to engage citizens and users and to prepare a climate that continuously facilitates bottom-up, grassroots initiatives. Moreover, as the Western case studies testify, it is essential to form a platform for facilitating public–private–academic collaboration.

In addition, there must be innovative schemes to collect data on local issues coupled with support for business startup ideas that use such data. The key factor that will determine whether the scope of individual initiatives can be expanded to the local community as a whole is whether the city in question creates a mechanism that integrates new business ideas within the local industrial ecosystem.

Once we see Society 5.0 as the logical extension of smart city initiatives, the technical and institutional challenge should become clear: we need an information integration architecture that integrates data and information related to multiple services (such as transport, energy, and social welfare). In other words, the challenge is to build an architecture that links information from different fields. This challenge is discussed in the next chapter.

In overcoming this challenge, we should find two routes for advancing the smart city concept, which in Japan is indelibly associated with the technological clout of

	Japan	USA	EU
2007			■ Strategic Energy Technology Plan
2008	□ Prooject for facilitating infrastructural measures in low-carbon-footprint urban development (MLIT, MOE) □ Ecological urban development project (MLIT) □ Eco-model cities (CO) Obihiro, Shimokawa, Iida, Yuzuhara, Minamata, etc.		
2009		■ American Recovery and Reinvestment Act of 2009) Dubuque 2.0 (Dubuque) DataSF (San Francisco)	■ Directive 2009/28/EC of the European Parliament and of the Council of April 23, 2009 on the promotion of the use of energy from renewable sources ■ EU climate and energy package Amsterdam Smart City (The Netherlands)
2010	□ Next-generation energy and social systems testbed (METI) Yokohama, Toyota, Keihanna, Kitakyushu		□ Europe 2020 Smart Santander (Spain)
2011	□ FutureCities (CO) Kashiwa-No-Ha, Shinchi, Higashi Matsushima, Toyama, etc. □ Smart community vision proliferation (METI)	JUMP Smart Maui (Hawaii)	■ Energy Efficiency Plan 2011 ○ EU Smart Cities Information System Smart City Lyon (France)
2012	■ Eco-City Act (Low Carbon City Act) □ Project to promote urban development, residential, and transport models that create, store, and save energy (MLIT) □ Project to promote ICT-based urban development (MIAC)	■ Digital Government Strategy	○ European Innovation Partnership on Smart Cities and Communities Copenhagen Connecting (Denmark)
2013	□ Project to promote models of resident-led carbon reduction planning (MOE) ○ Council to promote ICT-based urban development (MIAC) Smart City Aizuwakamatsu	□ Smart America Challenge ○ Smart Cities Council Chicago Tech Plan	
2014		□ Grobal City Teams Challenge ■ Digital Accountability and Transparency Act	□ Horizon 2020 ■ Digital Agenda for Europe 2020 Copenhagen Cleantech Cluster (Denmark)
2015	□ Project to promote ICT-based urban, human, and employment development (MIAC)	□ Smart Cities Initiative □ Smart City Challenge	○ Alliance for IoT Innovation (AIOTI) Paris intelligente et durable (France) Smart City Berlin (Germany)
2016	■ 5th Science and Technology Basic Plan ■ Comprehensive Strategy on Science, Technology, and Innovation ■ Basic Act on the Advancement of Public and Private Sector Data Utilization	Smart Cincy (Cincinnati)	
2017	□ Project to promote data-based smart cities (MIAC) Sapporo, Takamatsu, Kakogawa, Urawamisono, etc.	Smart Columbus	■ General Data Protection Regulation (GDPR)
2018	□ SDGs FutureCity (CO) Kanagawa Prefecture, Kamakura, Maniwa, Iki, Oguni, etc.		

General legend: (grey shading) Smart city case; ■ …Legislation, state plan, etc.; □ …Project; ○ …Other

Abbreviations for Japanese public institution:
METI = Ministry of Economy, Trade and Industry
MIAC = Ministry of Internal Affairs and Communicatinos
MLIT = Ministry of Land, Infrastructure, Transport and Tourism
MOE = Ministry of the Environment CO = Cabinet Office

Fig. 3.5 Synopsis of smart city trends in Japan, the USA, and the EU private businesses. First, there will be more business- and government-led progress. Second, we will see more citizen-led or citizen-involved progress. Simply put, overcoming the challenge will help pave these two tracks. Once the groundwork is laid, citizen groups can start gathering, analyzing, and applying urban data (such as sensor data). In other words, we will see a society where Big Data analytical tools are deployed to make life in the city more comfortable and convenient as well as to empower local communities to solve their issues. Such an outcome would signify that the smart cities of today are making progress in cultivating the society to which Society 5.0 aspires. In the not too distant future, we should see such activity in communities across the land.

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