Case Study: Smart Community Demonstration Project in Lyon, France

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1. Introduction

In Lyon, France, there was a smart community demonstration conducted as a joint project with Japan from 2011 to 2016, focusing on the construction of a future-oriented city where advanced energy technologies are utilized to achieve Europe's aggressive environmental target.

As one of NEDO International Smart Community Projects and part of Lyon Confluence district redevelopment project which Lyon Métropole had implemented based on commission to SPL Lyon Confluence, the project was jointly conducted by Toshiba of Japan and four major partner companies of France under the Implementation Agreement (IA), based on the Memorandum of Agreement (MoA) concluded between NEDO and Lyon Métropole (Figure 1).

The project was designed to demonstrate the introduction of energy saving technologies to new and existing houses, and the construction and evaluation of IT-based PV generation management system, EV car sharing system and the system supporting effective and efficient city planning through management of real time energy usage data of the city, bringing about some important implications.

This Case Study summarizes the smart community technology related lessons learnt from the demonstration and the social meaning of the project.

2. Overview of demonstration project in Lyon

Lyon Métropole and SPL Lyon Confluence have been engaged in the redevelopment of Lyon Confluence district (Figure 2) that started in 2003 and will finish in 2025, where a substantial population increase is anticipated. On the other hand, there are requirements by environmental policies such as "EU 20-20-20 Targets", "Grenelle laws" and "RT2012" for further introduction of renewable energy, enhancement of energy efficiency and reduction of CO2 emissions.

As population increases with the redevelopment, there arise concerns about traffic congestion, lack of parking spaces and environmental degradation due to exhaust gas. Under such circumstances, it becomes necessary to utilize advanced energy technology to achieve the CO2 emissions reduction goals set by environmental policy.

With such background, technical demonstrations were implemented as achieved in the following four tasks (Figure 3).

- Task 1: Positive Energy Building (PEB)
- Task 2: EV Car Sharing and Charging Management
- Task 3: Home Energy Consumption Visualization
- Task 4: Community Management System (CMS)

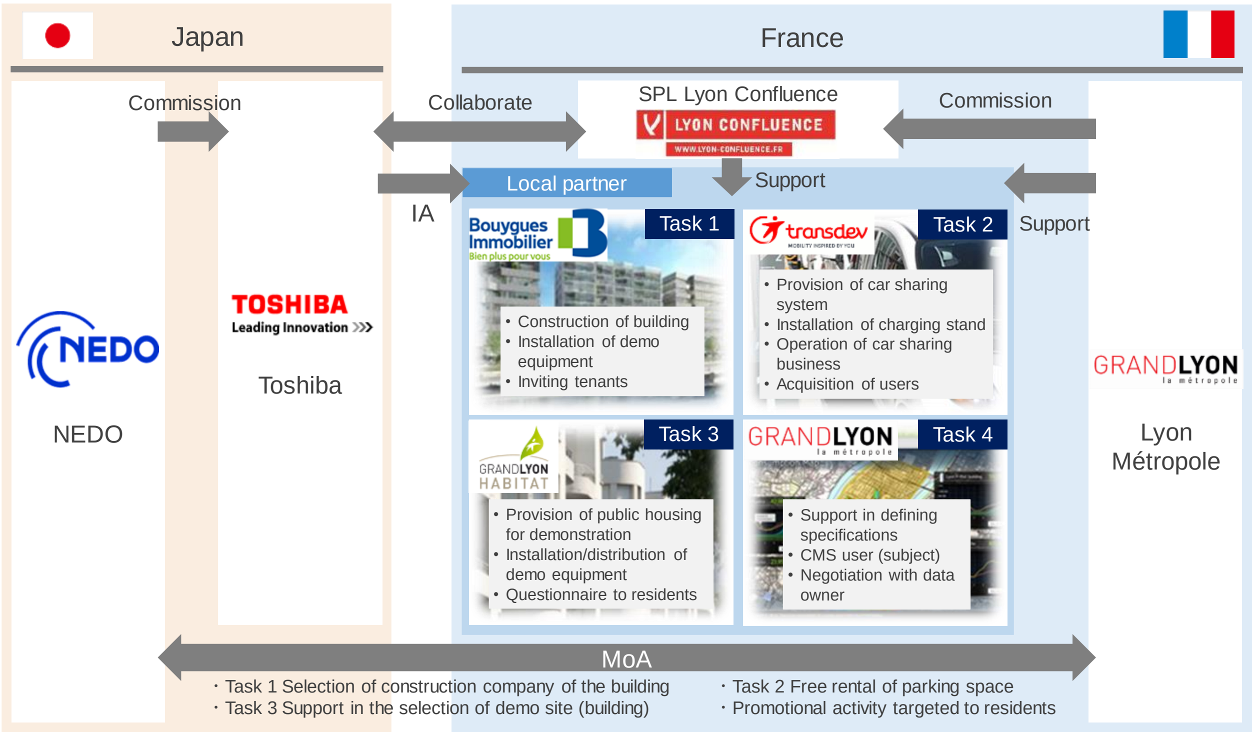

Figure 1 Organizational structure of the demonstration project

Figure 2 Bird-eye view of Lyon Confluence district after redevelopment

https://www.aderly.fr/2015/03/lyon-elue-ville-de-demain-2014-en-france/

(As of 25 July, 2017)

In Task 1, Japanese smart energy technologies were actively introduced to a new building complex (consisting of offices, shops and residential buildings) built in the redevelopment project so as to construct a building that offers advantages in energy saving, energy storage and energy creation. With the introduction of PV panels, BEMS (Building Energy Management System) / HEMS (Home Energy Management System) and energy-saving equipment, etc., verification of Positive Energy Building (PEB) that produces more energy than consumed by the entire building was conducted.

In order to establish zero emission transportation, EV car sharing system with PV as energy source was constructed in Task 2. PV is actively used to charge EV with the optimization of EV charging schedule, absorbing fluctuations of power supply by renewable energy to minimize the cost of social investment. The purpose is to address common transportation-related issues between cities, i.e. solve traffic and parking shortage issues by EV car sharing and reduce air polluted with exhaust gas.

Task 3 focused on installing energy data collection equipment in existing public housing in the redevelopment district to create a data collection network to visualize energy consumption and verify the effectiveness of energy saving by the visualization. Also, how the residents' behaviors changed by the provision of recommendations on energy use was examined.

In Task 4, the Community Management System (CMS) was built as a supporting tool of energy planning of Lyon Métropole. The CMS can manage the data obtained in Task 1 through Task 3, and other available data such as the energy data at other buildings within the redevelopment district, PV generation data, meteorological data and other real-time data in a comprehensive and integrated manner. The objective was to clarify requirements for creating a system for utilizing local administrative data on city planning.

As mentioned above, smart community combining the green city structure which Lyon Métropole aims for and the advanced energy technologies of Japan was constructed through the four Tasks in this demonstration project. The implementation detail of each Task as well as the results of the demonstration are described in the following chapters.

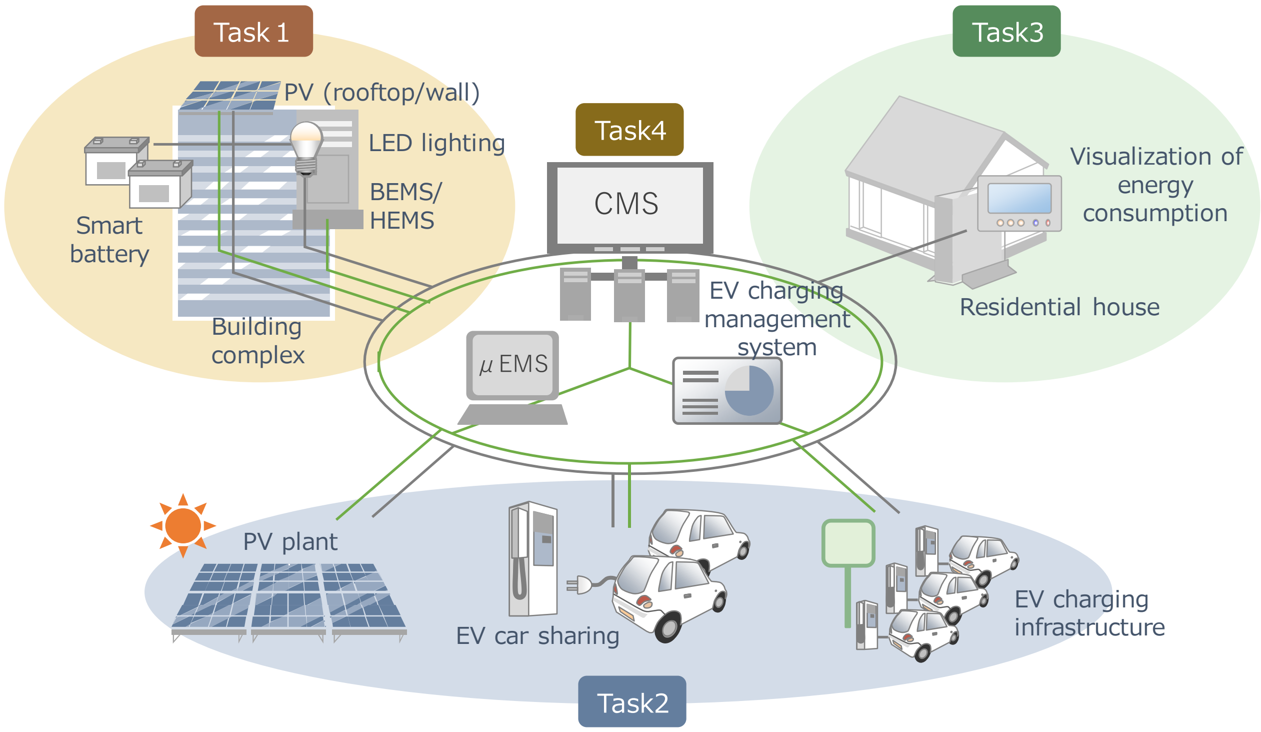

Figure 3 Whole picture of Lyon demonstration

3. Task1: Positive Energy Building (PEB)

Task 1, which was designed to realize PEB in building complex with offices, shops and residences, started with the design of buildings. The construction started in June 2013 and was completed in September 2015, allowing residents and tenants to move into their space. The building was named HIKARI (Figure 4) and the evaluation and verification of the PEB was performed here.

In this chapter, efforts taken in Task 1 are described from the following two viewpoints. PEB in this project is defined as “the building that produces more energy (electricity, heat, etc.) than energy consumed in terms of the cumulative annual value”.

- Design and system configuration
- Results of PEB Evaluation

3.1. Design and system configuration

Designed by Japanese architect Kengo Kuma, HIAKRI Building is a characteristic building that makes full use of natural light as symbolized by its name (HIKARI is a Japanese word for light).

Figure 4 Full view of HIKARI Building (From left: NISHI Building, MINAMI building and HIGASHI building)

The NISHI and HIGASHI buildings have large window surface and a structure with cut (notch) into it to take in natural light in order to reduce lighting load. The MINAMI building has PV panels installed on all over the wall to simultaneously pursue sufficient power generation and excellency in design.

In addition to design, it is worth noting that the state-of-the-art smart energy technologies were fully introduced. A list of technologies introduced and the features are summarized in Table 1 and Figure 5.

First, PV and rapeseed oil cogeneration system have been introduced as energy source to achieve PEB. Cogeneration with rapeseed oil is utilized also as a heat source, enabling production of hot water using exhaust heat and chilled water using absorption chiller. The electricity from the generator and hot and chilled water from the heat source equipment is stored in a smart battery and phase-change thermal storage by BEMS depending on the load condition of buildings and controlled to supply appropriate amounts as necessary. Reduction of energy consumption is also important in implementing PEB. From the viewpoint of energy saving, highly efficient LED lighting and radiation panel air conditioner that improves air conditioning efficiency with circulating hot or chilled water in pipes in ceilings have been adopted in the building.

Further, BEMS and HEMS have been employed in the HIKARI Building to optimally control energy creating, storing and saving equipment. In addition to the optimal control of energy and thermal storage mentioned above, BEMS has features to save energy without sacrificing comfort, e.g. LED lighting optimally controlled by motion sensor. HEMS is the system for residents with functions including condition checking, remote control, automatic control and schedule control, etc. of air conditioning, lighting and blinds, etc., promoting energy saving behavior as well as convenience for the residents.

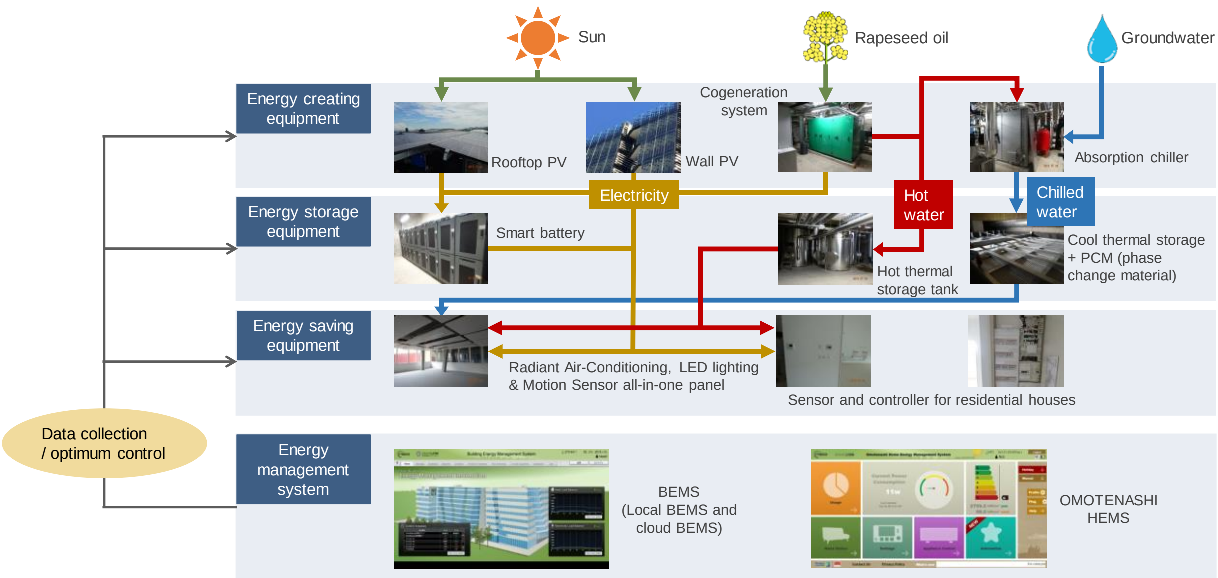

Figure 5 Task1 Structure of demonstration system

Table 1 Major smart energy technologies in HIKARI Building

Energy creating equipment	• PV panels: Installed on the roof and wall. • Rapeseed oil cogeneration system: Rapeseed oil, produced in France, is used as fuel of the system. • Absorption chiller: Chilled water is produced by making use of waste heat from cogeneration system.
Energy storage equipment	• Smart battery: Storage system combining lead and SCiB™. (secondary battery adopting Lithium Titanate on anode, characterized by safety, long life and low-temperature operation performance, etc.) • Phase change material for heat storage: Heat storage tank using substance with latent heat of fusion.
Energy saving equipment	• LED lighting: Introduced in the whole building. • Radiant air-conditioning panel: Air conditioning of the entire room becomes more effective by circulating hot / cool water in pipes in the ceiling.
Energy management system	• BEMS: Energy storage, energy-saving equipment, etc. are monitored and controlled to balance the energy supply / demand while saving energy of the building. • HEMS: Various functions such as power consumption visualization and remote / auto control of home appliances are provided.

Note: SCiB™ is a trademark or registered trademark of Toshiba Corporation.

In this way, the HIKARI Building was constructed based on unique design to realize high energy efficiency, adopting many state-of-the-art smart energy technologies.

3.2. Results of PEB evaluation

Once the specifications of the design and system configuration as described in the previous section were finalized, an annual energy balance simulation was conducted to check if the HIKARI Building could actually be defined as PEB. The results of the simulation held during design stage are shown in Figure 6.

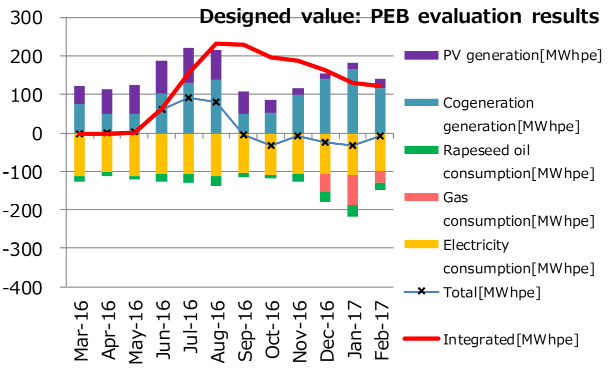

Figure 6 Annual energy balance simulation (during design)

You can see that the energy generated in the building (by PV, rapeseed oil cogeneration system) exceeds energy consumption (electricity, rapeseed oil and gas), providing +122MWhpe of margin for becoming PEB. In the actual operational stage, some deviations from the design conditions are anticipated to depend on various factors, which is why there is such a margin for PEB. As long as the amount of electricity consumption does not increase by more than 9.4% of the assumed value, PEB is achieved.

As a result of the simulation during design, it was confirmed by Japan and France that a PEB is possible in terms of design; the construction of the HIKARI Building was thus started. Figure 7 shows the evaluation result of PEB using actual data accumulated in a year (March 1, 2016 – February 28, 2017) after the commencement of actual operation in September 2015.

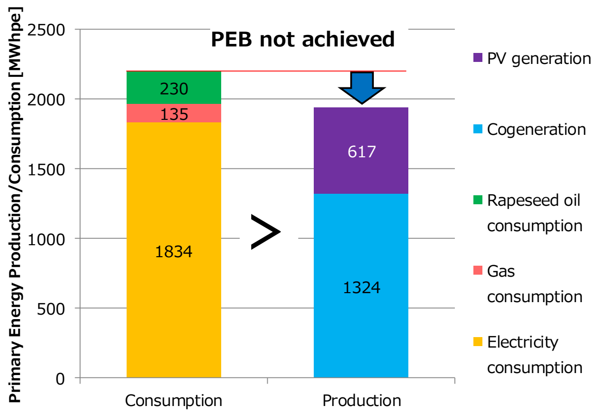

Figure 7 Result of PEB verification (actual value)

In the evaluation based on pure actual values, annual energy balance was −259MWhpe indicating that the PEB qualifications were not fulfilled. This was mainly due to the introduction of 24-hour servers and dedicated air conditioners in office system which resulted in drastic increase of power consumption (almost double) from the design stage.

Figure 8 shows the result of calibration when the power consumption of office system is set to be equal to that in the design stage.

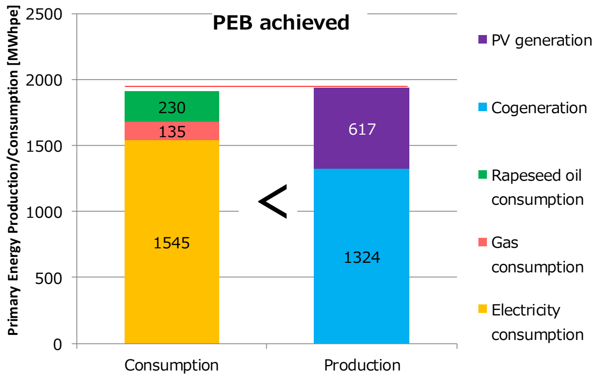

Figure 8 Result of PEB verification (after office system calibration)

In this case, the annual energy balance is +31MWhpe. The power consumption for office systems was about one-third of the total building; it proved difficult to accurately verify this information because part of the specifications was not met. Nevertheless, with respect to the remaining two-thirds of housing, lighting in common space and other power demands, it can be said that the building is qualified as PEB qualifications while taking into consideration deviations from setting conditions in actual operation.

～ Key Findings ～

Point (1): Value of HIKARI Building as PEB pioneer

The demonstration showed that PEB can be realized, even in a building complex or under other complicated environment, by adopting state-of-the-art smart energy technologies and design innovation. As one of the first buildings in the world to undertake this ambitious project, HIKARI is positioned as a PEB pioneer. The HIKARI Building is considered as a significant role model for the future development of PEB.

Mr. Bruno GAIDDON of Hespul, who served as a technical advisor to SPL Lyon Confluence to support the demonstration project from technical aspect mentioned:

Comment by Mr. Bruno GAIDDON, HESPUL

It was very significant that the PEB's performance, which was planned during the design phase of the HIKARI Building, was verified to be feasible.
Today, construction of buildings with the PEB concept have started one after another in the Lyon Confluence district, taking advantage of the HIKARI Building experience with PV installation, wall design, etc. The HIKARI Building experience has become invaluable and indispensable for PEBs to be built in the future.

On the other hand, issues to be addressed as PEB becomes widespread have become clear. The HIKARI Building is lavished with the most advanced smart energy technologies at the time, but, in practice, there were calls for improvements on the cost burden of users and the complexity in terms of management.

Mr. David CORGIER of Manaslu, who engaged in the construction of the HIKARI Building as a technical consultant, commented:

Comment by Mr. David CORGIER, Manaslu

The HIKARI Building is an ideal building in terms of the efficient use of energy, but because it is a collection of state-of-the-art technologies, hurdles on the budget, management and operation are a little bit high.
On the other hand, we were able to experience the maximum specifications of technologies in the HIKARI Building. If we appropriately choose and combine necessary functions and technologies from among them, we will be able to expand PEB to other cities.

It was possible to test various technologies for the HIKARI Building and accumulate the know-how because the project was positioned as a demonstration. It is expected that simpler and more sophisticated PEB will be realized with HIKARI Building as the starting point.

In this way, the HIKARI Building which embodied the PEB of building complex using state-of-the-art technologies at the time is attracting attention not only from France but from all countries in Europe. Mr. Edward WOODS from French developer Bouygues Immobilier, who took in charge of the construction of the HIKARI Building mentioned as follows:

Comment by Mr. Edward WOODS, Bouygues Immobilier

PEB of building complex was a pioneering project. And, in the sense that different technologies have been realized within a limited area; the HIKARI Building has been drawing attention from all over the world and many delegations have visited. We at Bouygues Immobilier also recognize the experience the HIKARI Building experience was extremely valuable and would like to utilize knowledge gained through the HIKARI Building in future new businesses.

In addition, Ms. Laetitia BOUSCARAT, who introduces redevelopment projects in Lyon Confluence district to visitors at show room in SPL Lyon Confluence, commented:

Comment by Ms. Laetitia BOUSCARAT at SPL Lyon Confluence Show room

We have many tours and visitors from abroad who wish to hear about redevelopment projects in the Lyon Confluence district. The highlight is the HIKARI Buildings, therefore we always introduce the HIKARI Buildings as a symbolic project. Since we never anticipated this dramatic increase in the number of visitors to Lyon Confluence, it is truly a pleasant surprise for us.

It can be argued that, in the context of becoming a symbol of Lyon Confluence district and raising the value as a community, the HIKARI Building assumes a great role.

Figure 9　Ceremony for the completion of HIKARI Building

Point (2): Simultaneous pursuit of energy efficiency, comfort and design

Not only smart energy technologies but also various new twists in design were added to improve energy efficiency, e.g. through maximizing natural light and improving ventilation. It was particularly characterized in that energy efficiency was realized without impairing comfort and design.

Residents and tenants of the HIKARI Building commented as follows on their life in the building:

Comment by residents/tenants of HIKARI Building

It is a perfectly wonderful living environment and we are very happy. Windows are arranged in the right direction to allow natural light to enter all day.
Walls are covered with PV panels but they are well matched with overall design, so we are not even aware of it.

What is impressive with the HIKARI Building is the design of the walls which are dynamically indented to maximize the amount of natural light entering each room. Ms. Élise FAUQUEMBERGE of KENGO KUMA & ASSOCIATES, who was in charge of design of the HIKARI Building, mentioned about her experience in designing the building as follows:

Comment by Ms. Élise FAUQUEMBERGE, KENGO KUMA & ASSOCIATES

We used to design buildings with the objective of blending in with the surrounding nature and "erase" their presence. However, the experience at the HIKARI Building has become a big turning point.
Because there is a canal in front of the HIKARI Building and a big skating rink behind, we had to exercise our ingenuity to meet energy efficiency requirement in the limited space. The dynamic design of walls with notches is an idea resulted from this constraint. In this way, we were able to experience the concept of making a building exist as a "living being" which was completely opposite to what we have done up to that time, and we are making use of this experience in other projects.

As described in Point (1), the HIKARI Building contributed to improving the attractiveness of the community as a symbol of Lyon Confluence district. In the background, however, there was a change in ways of thinking from the traditional concept. The project thus brought about significant implication to the extent of building design.

4.　Task2: EV Car Sharing & Charging Management

Task2 covered the EV car sharing service aimed at addressing common urban transport issues of traffic congestion and lack of parking. It also addressed the development and operation of a system that optimizes the charging schedule of EVs used in EV car sharing service with the objective of absorbing any fluctuations of renewable energy such as PV. After introduction of equipment including chargers and EVs and completion of system development, the demonstration was carried out between October 2013 and December 2015.

In this chapter, efforts related to Task 2 are introduced from the following two standpoints:

- EV Charging Management System
- Performance verification results of the system

4.1.　EV Charging Management System

Task 2 presented efforts aimed at charging EVs from more renewable energy while improving the turnover rate of EV car sharing. Functions of the systems developed to achieve this goal are summarized in Table 2 and the overall structure of the system is shown in Figure 10.

The EV charging management system is composed of charging optimization engine and μEMS plays an important role. It predicts PV output and EV charging time and has a function to optimize the schedule of EV car sharing taking into account information from distribution operators on grid constraints. The charging schedule optimization process of EV car sharing in EV charging management system is shown below (Figure 11):

1. PV output forecast (μEMS): Receive meteorological data, forecast information from Météo-France and PV generation data from PV remote monitoring system, predict half-hourly PV output and calculate charging timing to make maximum use of PV generation for charging.

2. Charging time prediction (Charging optimization engine): Estimate power consumption from driver data collected from car sharing system, EV rental period, applied driving distance, etc. to calculate necessary amount and time of charging.
3. Charging schedule optimization (Charging optimization engine): Based on the results of above 1 and 2, increase the turnover rate of an EV as much as possible and prepare a charging schedule to make maximum use of PV output. When a not-available charging schedule which is based on the load condition of the grid was sent from distribution operator (ENEDIS) via μEMS, this should also be taken into consideration.

Table 2 Functions of the systems developed in Task2

Car sharing system	Receive reservation requests from EV car sharing users, and send response to the user with the availability of EV and available hours based on the calculation result of EV charging management system.
Charging optimization engine	Calculate optimum EV charging schedule based on the data collected from car sharing system, charging controller and μEMS.
μEMS	Conduct PV forecast based on PV generation and meteorological data. Also, communicate with distribution operator (ENEDIS) to examine load condition of the grid.
Charging controller	Remotely control normal and fast chargers based on the charging schedule command received from EV charging management system.

Note: μEMS：Micro Energy Management System

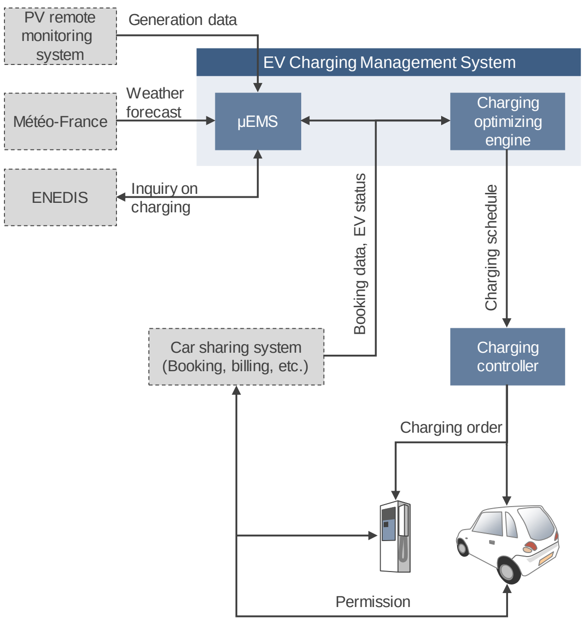

Figure 10 Overall structure of the system developed in Task2

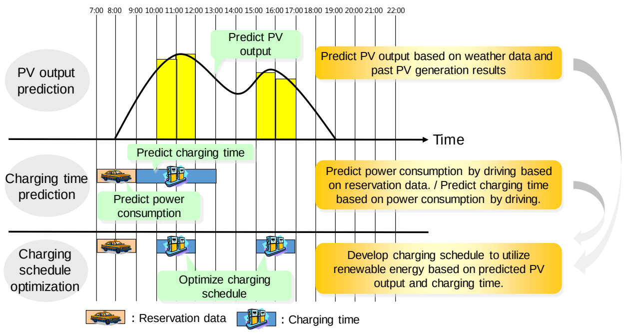

Figure 11 EV charging schedule optimization process

Figure 11 shows a simple example where there was an EV rental reservation from a user for the 7:00-9:00 slot. First, the charging timing to make maximum use of PV output is calculated by μEMS to be 10:00-12:00 and 15:00-17:00. Next, the power consumed by the use of EV is calculated by charging optimization engine and the charging time is estimated to be four hours. Based on these prediction results, a schedule that prompts the user to charge his/her EV in 10:00-12:00 and 15:00-17:00 is prepared, and the remote control is performed through the charging controller.

4.2. Performance verification results of the system

Based on the system configuration as mentioned in the previous section, demonstration was conducted by actually providing EV car sharing service under the environment and conditions as shown in Table 3.

Table 3 Environment and conditions of demonstration in Task2

Target area	Lyon Confluence district
Period	October 2013 to December 2015
Participants	General citizens who registered voluntarily
No. of EV used	30
Chargers	30 normal chargers and 3 fast chargers (CHAdeMO)
Charging stations	6 stations

The number of registered participants at the end of the demonstration was about 175, and the number of times of EV reservations was about 1,700 per year. As charging stations were installed only in the Lyon Confluence district, the scale of the demonstration was not large, however the participation rate was relatively high considering that the population of the district is 15,000.

In Task 2, verification of the following two effects were conducted, which are to be described in this section.

- Improvement of turnover rate of EV car sharing

- Improvement of rate of charge by PV

Verification on the improvement of turnover rate

In order to verify the improvement of turnover rate of EV car sharing by the constructed system, a simulation was conducted in the cases with and without charging schedule function using the data of 44 registrations which had actually been made during the period between November 2013 and March 2014. In the absence of charging schedule function, it was assumed that 3 hours of charging must be secured. Also, this simulation was conducted under the condition that all the 44 reservations were made in a single day and there were five EVs offered for car sharing.

Figure 12 shows the results of this simulation.

	Without Charging Schedule Optimization function	With Charging Schedule Optimization function
Reservation acceptance rate	29 / 44	44 / 44
EV car sharing turnover rate	5 times/day	9 times/day

Figure 12 Results of simulation on the improvement of turnover rate

The simulation results show that the reservation acceptance rate improved from 29/44 to 44/44, indicating that all reservations have become acceptable, with the use of charging schedule optimization function. Also, the turnover rate of EV car sharing (the number of reservation acceptable per EV per day) also improved from 5 times/day to 9 times/day, showing that an EV has become able to accept four more reservations per day.

This was because that the charging time could be predicted quite properly, and the charging time per EV could be shortened compared with the case where the charging time was fixed to three hours.

Verification on the rate of charge by PV

For the verification of the effectiveness of algorithm developed in this demonstration project, EV car sharing service was implemented with three different modes depending on charging station. The assumed three modes were: "Normal Mode (where the power required for the next EV will be charged immediately after EV is returned)" and "Night Mode (where more power will be charged during night time when charging cost is low)" in addition to "Renewable Energy Prioritized Mode" introduced in the previous section, where PV output is utilized for charging preferentially. The verification results are shown in Table 4.

It is not surprising that PV utilization rate of Night Mode is low, whereas the Renewable Energy Prioritized Mode realized improvement in PV utilization rate of about 6% on average compared to Normal Mode and about 8% at sunny summer time.

Table 4 PV utilization rate in three charging modes

Mode	Average PV utilization rate during demonstration period [%]	PV utilization rate during sunny summer time [%]
RE Prioritized	**67.1**	**82.0**
Normal	61.3	74.1
Night	35.7	N/A

Note: PV utilization rate [%] = (PV utilization volume [kWh]) ÷ (Total charge volume[kWh])

Prediction accuracy of PV output and EV charging time

In optimizing charging schedule of EV car sharing, there may be some trade-off in raising the turnover rate and the rate of charge from renewable energy, nevertheless, the demonstration was able to realize the improvement of them both. One of the reasons is the high prediction accuracy for PV output and EV charging time. The initial target value for prediction error of PV output and EV charging time was ±20%, whereas the actual value of error was about 10 to 15% and 12.6%, respectively. With the development of prediction system with less error, more detailed charging schedule optimization has become possible.

～ Key Findings ～

Point (3): Development of state-of-the-art EV Charging Management System at the time

Today, as there are control systems between electric power company and charging station being developed in some areas, it was decided to construct this kind of system ahead of others in this demonstration.

Mr. Patrick RAKOTONDRANAHY of ENEDIS, one of Europe's largest distribution operators covering 95% of French distribution network, mentioned about the development of state-of-the-art charging optimization system as follows:

Comment by Mr. Patrick RAKOTONDRANAHY, ENEDIS

I had a chance to win an award when I made a presentation on the system developed in this demonstration at ICCVE (International Conference on Connected Vehicles & Expo) in 2014. This honor reflected recognition of the novelty of the communication system between power grid operator and charging station, which had not existed in those days.

When the popularity of EV is established in near future, the system developed in this project will actively be used. I would like to contribute to having it widespread not only in Lyon Confluence but all over France.

As France set a goal of banning domestic sales of gasoline and diesel vehicles by 2040, more and more EVs are going to be introduced. Under such circumstances, ENEDIS is concerned about how the grid would be affected by large penetration of EV, and expects that the systems and technologies developed in this demonstration would be utilized in the near future.

Mr. Naoki Yamaguchi of Toshiba, who was responsible for the construction of the system thought back of his experience and commented:

> ***Comment by Mr. Naoki YAMAGUCHI, Toshiba***
>
> *We had a few difficulties during the demonstration period due to cultural differences, etc. in addition to unexpected accidents. For the construction of the system, we particularly put effort in preparing documents like use cases and scenarios and identifying the requirements in detail because the system was relevant to EV car sharing which was still unusual at the time. We could learn a lot about non-technical aspects such as restrictions and regulations on car sharing business, and related applications.*
> *This effort was definitely ahead of the times and is gaining attention these days. We at Toshiba, would like to use the experience and data obtained from the demonstration for further development of this field.*

Task 2 was a demonstration test conducted in the limited area and under limited conditions. However, this technology will be attracting more and more attention as a solution to output fluctuation of renewable energy, increased load of local distribution grid due to larger scale introduction of EV, etc. The effort taken in Task 2 was especially valuable in technical aspect for further development of this field.

5. Task3: Home Energy Consumption Visualization

In Task 3, energy data collection device was installed in housing complex in the redevelopment district to visualize energy consumption, so as to verify the effectiveness of energy saving with this energy use visualization.

Cité Perrache, the demonstration site located in the redevelopment area, is a public housing owned by Grand Lyon Habitat. The total number of households is 275, of which 165 participated in the demonstration (Figure 13).

Efforts in Task 3 are described in this chapter from the following standpoints:

- System configuration and the tablet's function
- Energy saving effect by visualization

Figure 13 Cité Perrache, the demonstration site for Task 3

5.1. System configuration and the tablet's function

The system is broadly consisted of four components: visualization device, data collection device, electric power data measuring device and gas & water meter data measuring device. Descriptions of the devices are summarized in Table 5 and the overall structure of the system is shown in Figure 14.

Table 5 Devices introduced to realize visualization of energy use

Visualization device	Energy consumption can be visualized with this device. Tablet terminal is used with the objective to provide energy data in an easy-to-understand manner.
Data collection device	The device stores energy data collected from measuring devices of electricity, gas and water meter data installed in each household, and processes the data to be used in the visualization.
Electric power data measuring device	Using clamp type current sensor, this device measures electric power data of each feeder from distribution board.
Gas & water meter data measuring device	The device collects gas and water usage data to visualize not only electricity but whole energy consumption of a household.

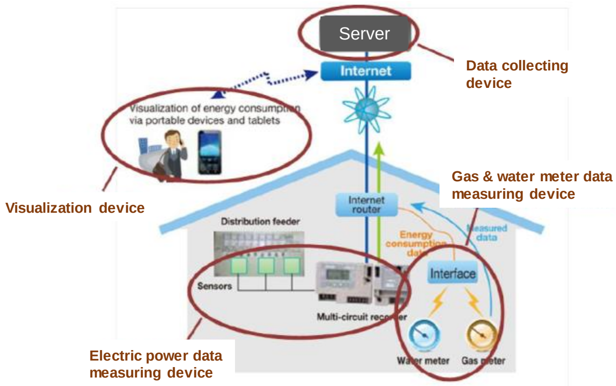

Figure 14 Image of the system developed in Task3

What is important in this system for encouraging residents to take energy saving actions is the interface of the visualization device. There are different types of screens depending on the purpose of the visualization. Here are four main screens (Figure 15):

- Top screen: Residents can check the total energy consumption of electricity, gas and water by value (Euro) at a glance. They can visually recognize their achievement of the target calculated based on the past records, e.g. green for good, red for bad, etc.
- Summary screen: Because electric power data measuring device allows monitoring of power consumption of each feeder from distribution board in detail, the user can identify bottleneck household appliances. The guidance function to display such appliances is also equipped.
- Ranking screen: In order to raise awareness of residents by making comparison with neighbors in the building, different colors are used to indicate the ranking.
- Detail screen: Past records of electricity, gas and water usage are displayed.

Figure 15　Screen examples of the visualization system

Without inviting people interested in participation in the demonstration, Task 3 was conducted in the area, Cité Perrache, therefore not every resident had an interest in the energy usage. The interface of the visualization device implemented in this demonstration was thus designed to make the screens as simple and effective as possible on the whole, having Euro instead kWh as the unit of power consumption on the Top screen, so that everyone including those who are not interested in the energy usage can easily understand.

5.2. Energy saving effect by visualization

Based on the system configuration shown in the previous section, verification test of energy saving effect by visualization of energy use was conducted from June 15, 2014 to December 31, 2015. In this section, the verification results of energy saving by the following functions are presented:

- Visualization of energy use (Visualization)
- Ranking
- Energy saving guidance (Guidance)

The evaluation was conducted by comparing the difference of energy consumption between the group of households with high usage frequency of each function which is mentioned above and the one with low usage frequency. Table 6 shows the results of actual verification of energy saving effect using each function.

Table 6　Results of verification of energy saving effect by function

Function	Energy-saving effect (entire period)	Energy-saving effect (winter only)
Visualization	+4.7%	+6.0%
Ranking	+5.0%	+6.4%
Guidance	+1.5%	**+10.3%**
Total	+7.8%	+11.5%

Note: "Energy saving effect ＝100 × (Energy Consumption2 – Energy Consumption 1)÷ Energy Consumption 2" Provided, that Energy Consumption 1 reflects the group of households with high usage frequency of the system and Energy Consumption 2 the group of households with low usage frequency.

Basically, energy consumption of high usage frequency group was lower regardless of function, indicating that the functions contribute to energy saving. In particular, the result of winter time when power consumption becomes highest in France suggests that the "Guidance" is a useful method to save energy.

～ Key Findings ～

Point (4): Importance of target-based appeal for energy-saving

For the HIKARI Building of Task 1, participants were recruited and the users who have much interest in energy use were targeted, whereas for Task 3, most of the targeted residents were not as interested in energy use as the demonstration was conducted only in Cité Perrache area. In fact, middle to heavy users who used the visualization system more than one day in a week stood at 10% (about 16 users) of the total users. On the other hand, there were discoveries that could be made only because the demonstration was carried out in such an environment where it was difficult to appeal to energy saving.

Ms. Cécile AUBERT and Mr. Mossen HALLALI, who operate public housing in Lyon and are in charge of eco-renovation of Cité Perrache, commented:

Comment by Ms. Cécile AUBERT and Mr. Mossen HALLALI, Grand Lyon Habitat

We tried to raise motivation for energy saving by having them compete with other residents, but they seemed to have been discouraged when they saw red colored indication which showed that the performance was poorer than the others. It should have been effective if the resident had been living in the HIKARI Building. We learned that we had to change our approach depending on the target. We believe that the idea can be deployed to other areas so we would like to continue using the basic concept while improving the interface.
Also, we think it was not bad at all that middle to heavy users accounted for about 10% because the demonstration this time was targeted to people who are not necessarily interested in energy use. We are really grateful to the technical staff of Toshiba who met with residents and worked hard to set up the visualization device in difficult circumstances.

Also, a resident of Cité Perrache who took part in the demonstration looked back on their days during the demonstration as follows:

Comment by Cité Perrache resident

When I noticed red indication in the tablet, I felt a little bit uneasy, so I checked energy consumption and compared with the past performance to feel the effect of energy saving. The euro-converted value was easy for me to understand and the "Guidance" was very helpful. I was able to save electricity and water bills from 40 euros/month to 20 euros/month by devotedly adopting energy saving practices in accordance with the "Guidance".
Regarding the installation of the visualization device, I had a pleasant time with Toshiba's technical staff who tried to communicate with me using simple French and gestures, which made me feel relieved.

As pointed out by Grand Lyon Habitat and the Cité Perrache resident, the successful completion of the demonstration is largely dependent on the technical staffs of Toshiba who gave the best service to set up the visualization system on the site. Mr. Mitsuyoshi AKIYAMA and Mr. Toshiyuki OKUMA of Toshiba who installed the systems on the site mentioned as follows:

Comment by Mr. Mitsuyoshi AKIYAMA and Mr. Toshiyuki Okuma, Toshiba

Of course, there was a language gap but we tried to communicate with heart using gestures. With courtesy as a Japanese person, but without being too conscious that the customer is a foreigner, we acted in good faith. We felt that our deepest sincerity would be very important in this kind of international project that includes direct contact with citizens.

In order to realize an ideal smart community, it is important to have active involvement of all residents of the area including those who are not necessarily interested in energy use. Task 3 showed a significance of combining appropriate approaches according to the resident's characteristics to raise energy saving consciousness of entire community and relating with citizens in good faith to gain public understanding of smart community.

Figure 16 Mr. Mitsuyoshi AKIYAMA explaining how to use a tablet to resident

6. Task 4: Community Management System (CMS)

Since Lyon Métropole carries out various measures simultaneously in the region, it is desirable to proceed with the redevelopment project efficiently while managing relevant data in an integrated manner and checking the progress and effects of the measures. Based on these backgrounds, in Task 4, Community Management System (CMS) was developed to integrate data obtained in Task 1 to 3 and other data that can be collected from the redevelopment area and visualize energy consumption in the area, etc. (Figure 17).

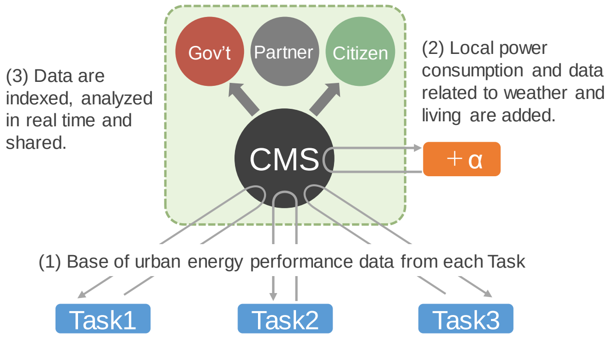

Figure 17 Concept of CMS

On the other hand, in the early stage of the project, there was no similar case for CMS and user needs were not clear. Also, it was assumed that the number of points from which data are collected might increase or decrease even after the system development was started, and that the type, volume and usage of data handled by the system might be changed in the middle. Therefore, it was decided to basically have a process that repeatedly executes Define (defining hypothetical requirements), Develop (system development) and Evaluate (evaluation by user) instead of a development process where a system development would be once and done (Figure 18).

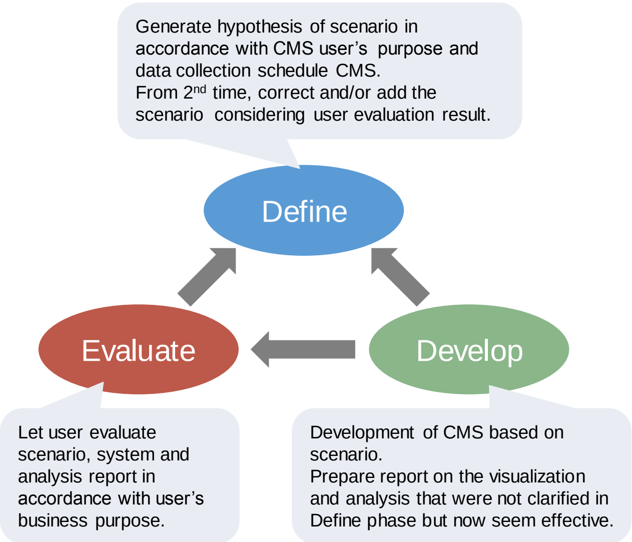

Figure 18 The process in Task 4

Efforts of developing CMS are described in this section in light of the development process consisting of three factors of Define, Develop and Evaluate. Eventually, the Define – Develop – Evaluate process was conducted twice in this demonstration.

Define

In the Define phase, hypothetic scenarios concerning the use of CMS were developed in accordance with the potential user's purpose and the data to be collected. In order to brush up the scenario, interview with project stakeholders were conducted in the second process.

Five scenarios concerning the use of CMS by a municipality defined in the Define phase are shown below:

- Scenario 1: Person In Charge (PIC) of energy checks energy consumption of local building, compares it with the target, grasps the trend, and evaluates and examines the policy.
- Scenario 2: PICs of energy and public housing check the effect of building renovation and evaluate and examine the policy.
- Scenario 3: PIC of public housing checks the effect of information provision to residents and evaluates and examines the measures regarding provision of information on energy saving.
- Scenario 4: PIC of energy checks local supply and demand of energy.
- Scenario 5: PICs of transportation and energy check status of utilization of EV car sharing and renewable energy.

Develop

In the Develop phase, the screens of CMS and the mechanism to collect necessary data were developed according to the scenarios defined in Define phase. As an example, the top screen of CMS is shown in Figure 19.

Figure 19 The developed top screen of CMS

From the pull-down at the top left of the screen, the user can switch the screen for each of the five scenarios, and view historical and real time data necessary for each scenario (energy consumption, CO2 emissions, PV output, weather, etc.) per building / facility.

Evaluate

In the Evaluate phase, the scenarios, system, evaluation report, etc., of the CMS constructed in the Develop phase were checked against the user's work purpose to further improve the CMS. The requirements for visualization of each work content, that have been clarified in such a process, are summarized in Table 7.

Through the Define – Develop – Evaluate approach under Task 4, the CMS was constructed to visualize regional energy use. The system, however, is not limited to this demonstration but lead to further development of Lyon Métropole in this field (Figure 20).

In EU, the strategy has been developed for EU's economic and social targets until 2020 as "Europe 2020 Growth Strategy". This strategy especially includes R&D and innovation framework called "Horizon 2020", in which the CMS developed in this demonstration will be used continuously. Specifically, there was a participation of Lyon Métropole with Toshiba in a joint program on the smart city construction called "Smarter Together", which is part of the "Horizon 2020" framework. Under this program, data on energy consumption, generation, transportation, etc. will be integrated, processed and visualized to be utilized in new services so that the CMS developed in this demonstration would be further expanded.

Table 7 Requirements for visualization in Lyon Métropole

Work	Issue (purpose)	Data requirement
Redevelopment management	Checking the effect of measures to curb energy consumption of building	Comparison of annual target value and actual value of the building / Breakdown of energy consumption
Energy management	Overview of region's energy consumption / Grasping real-time consumption of boilers for each building to control regional heat supply	Historical change of regional energy consumption / Breakdown of energy consumption by application / Real-time visualization of boiler consumption by building
Public housing	Viewing individual household data for the energy management of the house	Visualization of each household's real time data / Comparison of current and present year data
Transportation	Grasping use frequency of EV stations and power consumption of EV car sharing	EV usage count by EV station / Time series variation of power consumption of EV car sharing

～ Key Findings ～

Point (5): Significance of CMS in municipality

In Task 4, the CMS with functions to integrate, share and evaluate data collected in Task 1 to 3 was constructed as an urban energy planning tool.

Ms. Paméla VENNIN who had been a contact person of Lyon Métropole for the demonstration project has commented as follows on what she had realized from her experience in the CMS development:

> ***Comment by Ms. Paméla VENNIN, Lyon Métropole***
> *The ability to use a cross section of data for policy decisions to improve the effectiveness of government interventions is one of the key take aways of the Community Management System. Policy related to topics such as energy and mobility will no longer be treated separately; thanks to the learnings from the CMS demonstration project, Lyon Métropole will have the technical ability to connect data for important decisions. I am grateful to the project in helping us move on to the next step.*

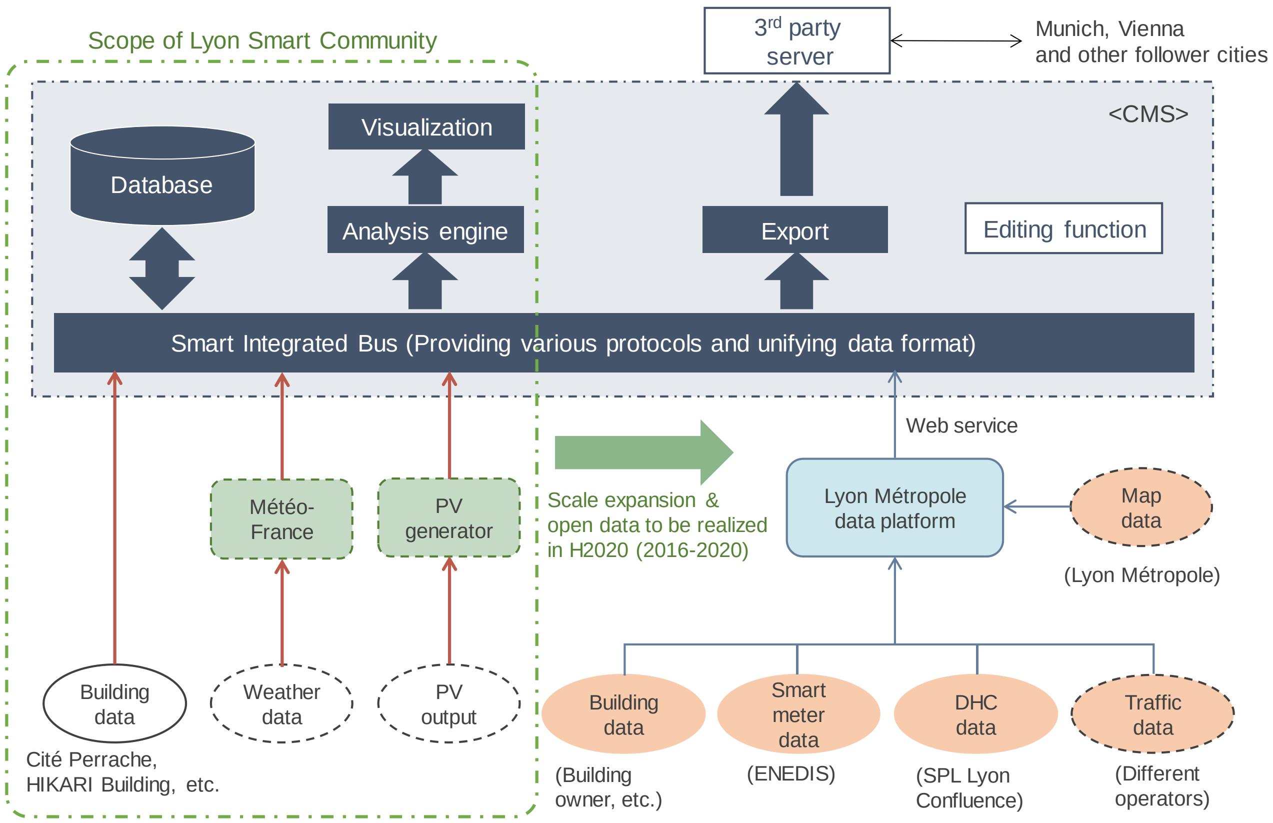

Figure 20 From Demonstration to Horizon 2020 (Smarter Together)

Demonstrations and studies related to the smart community have been carried out throughout the world, but each of the approaches is often implemented in a limited manner focusing on only a part of smart community technology e.g. EV, energy saving, battery, etc. For an organization promoting smart community including different technologies and concepts, such as municipality, the value of the system like the CMS that gathers various data is huge.

In fact, Lyon Métropole regards their experience in the CMS construction as irreplaceable in bringing about further development as described in this chapter. Mr. Hervé GROLÉAS who is responsible for management and development of information system at Lyon Métropole mentioned as follows on the CMS developed in the demonstration:

> ***Comment by Mr. Hervé GROLÉAS, Lyon Métropole***
>
> *The CMS developed in the demonstration period was specialized in energy, but now we are expanding the CMS for everything related to the policies of Lyon Métropole in the Smarter Together framework.*
> *This experience was extremely important not only from the technical standpoints including data management and interface specifications, but also from the point of awareness among local government level stakeholders. Without this demonstration test, there wouldn't have been this new CMS which is under development.*

Many other European cities are also involved in the Smarter Together. With Lyon Métropole, it is expected that a further developed version of the CMS developed in the demonstration will be implemented and the concept of CMS will be disseminated to other areas in Europe as well as in Lyon Confluence.

7. For further development of smart community

The contents and results of the four Tasks of the demonstration project have been explained as in previous chapters. What is really impressive is that participants of the four Tasks are trying to actively utilize the technologies used in the demonstration and the accumulated knowhow and experience in their next step.

Mr. Maxime VALENTIN of SPL Lyon Confluence who has been committed to the project from the beginning and engaged in promoting the redevelopment of Lyon Confluence commented:

> ***Comment by Mr. Maxime VALENTIN, SPL Lyon Confluence***
>
> *The demonstration served as a catalyst for the redevelopment of Lyon Confluence and created a framework for the urban development project and smart city strategy of Lyon. Whilst the demonstration project has finished, the purpose of this demonstration is to lead this experience to the next project rather than continuing it. The experience this time has added dynamism and given a big boost to the redevelopment project.*

It is hoped that an ideal smart community will be realized in Lyon Confluence with the utilization of experiences that have been built up throughout the demonstration project. Mr. Jacques de CHILLY, Deputy General Manager in Lyon Métropole stated:

> ***Comment by Mr. Jacques de CHILLY, Lyon Métropole***
>
> *Innovation has greatly accelerated thanks to the pioneering program and original approach of this demonstration project. Lyon Métropole's international reputation as a smart city where innovative solutions are offered is confirmed by over 100 innovative projects, 340M€ smart city public/private investment and top European ranking in smart subjects like mobility and smart grids.*

As stated above, this demonstration served as the base for the redevelopment and the future development of the smart community strategy of Lyon Confluence, made the district more attractive and added significant value to it. Behind such a success, however, there were lots of hardships and efforts that had to be gone through and addressed by those involved in the demonstration.

With good understanding of both Japanese and French cultures due to an experience of living in Japan, Ms. Jessica BOILLOT of Toshiba Systems France devoted herself to serve as a coordinator between stakeholders throughout the demonstration. Ms. Jessica BOILLOT looked back on the project as below:

> ***Comment by Ms. Jessica BOILLOT, Toshiba Systems France***
>
> *At the beginning, we had hard time due to the gap in the business manner and language between Japan and France, but I, as the demonstration coordinator, tried to improve the situation by planning a seminar to introduce Japanese culture and organizing various events to bring persons concerned and participants in the demonstration together.*
> *The mutual understanding between Japanese and French has deepened each time we had meeting or event, and I am so happy that the demonstration has eventually become a big successful project. I could really feel how important the relationship among people is important in this kind of project.*

The demonstration in which state-of-the-art smart community technology was introduced and operated overseas has turned out to be extremely complicated in terms of technology and communication. However, everyone involved has tried his/her best to overcome the difficulties and make the project successful. It also provided an opportunity to accumulate experiences and know-how necessary for the deployment of Japanese smart community technology abroad, but at the same time, it was also a demonstration project that made us realize that we need to understand foreign culture and take good care of human connection to develop infrastructure business like smart community in overseas.

Last but not least, here are the words by Mr. Nobutaka NISHIMURA of Toshiba who managed the project as the Project Leader:

Comment by Mr. Nobutaka NISHIMURA, Toshiba

This project was a demonstration for us, but for the Lyon side, it was a real business, therefore there were high expectations for the commercial viability. It was a very difficult project in terms of technology and communication, but thanks to the excellent cooperation we were able to complete the project successfully.
As those who got involved in the demonstration are taking further steps, making use of their experiences, I am truly happy that we could leave our technology, know-how and experiences in Lyon.
Some of the experiences and knowhow can be utilized right away and others have to be tackled on a mid to long term basis. At all events, I would definitely like to contribute to being helpful to people who seek the brighter future.

8. Acknowledgments

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