Case Study：Smart Grid Demonstration Project in Haryana State, India

1. Introduction

This demonstration project was conducted to improve the reliability and efficiency of the power distribution business by utilizing the smart grid technology of Japanese companies in the Republic of India, which is facing the challenge of improving the quality of its power supply as a result of its rapid economic growth. The demonstration was conducted in Panipat, a local city in the state of Haryana, from September 2015 to 2019. It is one of the "Smart Community International Demonstration Projects" of NEDO, and at same time, positioning as one of 14 smart grid pilot projects for improving profitability of power distribution public companies and constructing the next generation power distribution network, led by the Ministry of Power in India. This was also conducted with the cooperation of Uttar Haryana Bijli Vitran Nigam: UHBVN, a power distribution company (DISCOM) in the Northern region of Haryana and was led by a consortium consisting of Fuji Electric Co., Ltd., Sumitomo Electric Industries, Ltd., and THE Power Grid Solution (funded and established by Hitachi, Ltd. and Tokyo Electric Power Company Holdings, Inc. in 2013). Japanese companies developed smart meter system and Supervisory Control And Data Acquisition (SCADA), and they are aimed to contribute to the visualization of the electric grid data in Panipat and to the reduction of power outage time and AT&C loss through data analysis by simultaneously carrying out capacity building projects including operation and maintenance training.

NEDO, the Ministry of Power of India, the Ministry of Finance of India, the Electricity Bureau in Haryana State, and UHBVN signed MOU (Memorandum of Understanding), and Fuji Electric Co., Ltd., Sumitomo Electric Industries, Ltd., and THE Power Grid Solution signed ID (Implementation Document) with UHBVN.

This case study summarizes social significance of the demonstrations and suggestions of smart grid related technologies obtained in this demonstration project.

2. Background of the demonstration

In India, the demand for electric power has been increasing year by year, and the construction of new power plants and the improvement of transmission and distribution infrastructure have been promoted with the rapid economic growth in recent years. According to the electrification promotion project of the Modi administration "Saubhagya", almost all villages were supplied with electricity as of the end of March 2019, with the electrification rate in the villages achieving at 99.99%. However, power outages are frequent, especially in the suburbs, and the improvement of the supply quality remains an issue. There are more than 70 power DISCOMs in India, but with the exception of a few private DISCOMs operating in urban areas such as Delhi and Mumbai, many public DISCOMs are in difficult finance conditions. This is due in part to the fact that low electricity rate have been set in the agricultural and household sectors as a policy, but the poor management of the power distribution network has also been a major factor in the deterioration of business conditions, as seen in frequent power outages and the high AT&C loss (average loss is about 20% at 2019) in India, the grid operation will become more difficult due to the rapid and huge installation of electric vehicles and variable renewables（PV and Wind）.

In Japan, smart meters were installed in about 63.7% of all households as of the end of FY 2019, and Japanese utilities have made advanced distribution operation by using grid data. India also has a plan to introduce smart meters, and plans are under way to introduce SCADA starting in urban areas in India. It is expected that Japanese advanced technologies

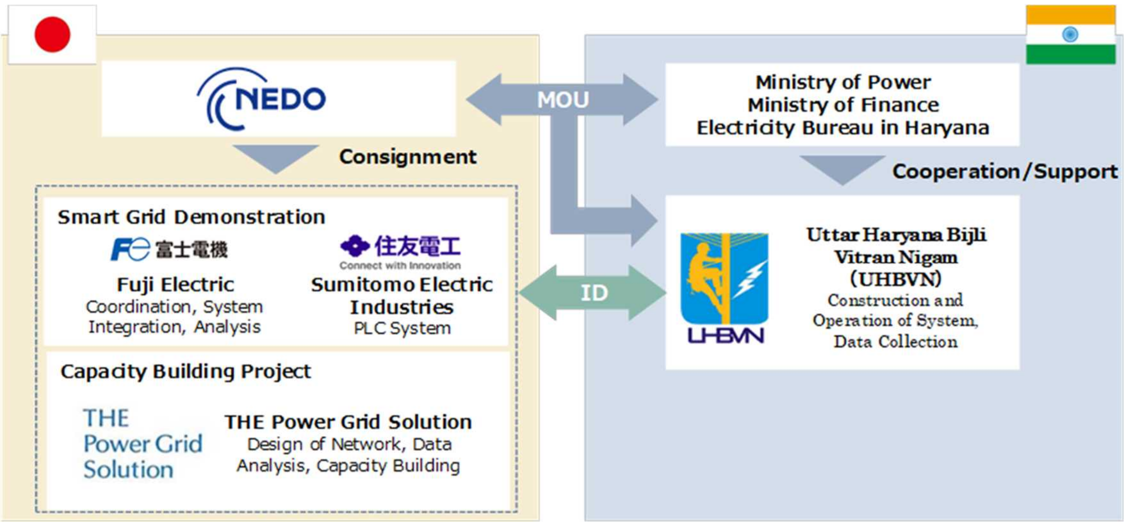


Figure 1: Demonstration System

are developed in the Indian market by showing the results of this demonstration.

3. Outline of activities in this demonstration

The outline of UHBVN, the partner of this demonstration, and the activities in the demonstration are summarized below.

3.1. Overview of UHBVN

Haryana State is located next to the western part of the Delhi and has a population of about 27 million (As of 2017). Industries are thriving in Haryana even in India as many Japanese companies are operated there. UHBVN sells about 11,000 GWh of electricity annually to about 2.5 million consumers, and its peak demand is over 8,000 MW. Panipat City was selected as the demonstration site anticipating results of the feasibility study because its AT&C loss rate is relatively high in the northern Haryana state and additional urban development is planned. UHBVN has a stable business situation compared with other public DISCOMs. UHBVN has plans to introduce smart meters in Cooperation with Energy Efficiency Services Limited (EESL) and to introduce SCADA in larger cities to reduce the time of power outage and to efficiently operate the distribution network.

3.2. Details of demonstration projects

The projects were conducted based on five demonstration items.

For each item, demonstration projects were conducted using two approaches: Smart Grid Demonstration for equipment installation and systems integration, and Capacity Building project, in which support and education are provided for grid design and maintenance work. As Figure 2 shows the relationship between each theme and the two projects, smart grid demonstration was conducted according to Item 1 to Item 4, and capacity building project was conducted according to Item 3 to Item 5 (Figure2).

The smart grid demonstration was conducted by Fuji Electric Co., Ltd. and Sumitomo Electric Industries, Ltd, and the capacity building business was conducted by THE Power Grid Solution, sharing the results and data. UHVBN was in charge of installation of each equipment, data collection, and system operation during and after the demonstration project.

4. Construction of a demonstration system

Details of the equipment and systems installed in the local area in this demonstration project are described below.

4.1. Installation equipment and systems for smart grid demonstration

In the smart grid demonstration, the smart meter system and the power distribution system for remote monitoring and controlling are mainly introduced, and the outline of each equipment and system linked with the existing location information system (Geographic Information System : GIS) and bill management system owned by UHBVN. The outline of the demonstration system and the sharing of roles of each company are described in Figure 3.

The smart meters installed at the Panipat demonstration site and distribution equipment such as VCB (Vacuum Circuit Breaker), LBS (Load Break Switch) and SCE (Substation Communication Equipment) exchange data with SCADA and HES (Head End System) installed at data center through each new communication system.

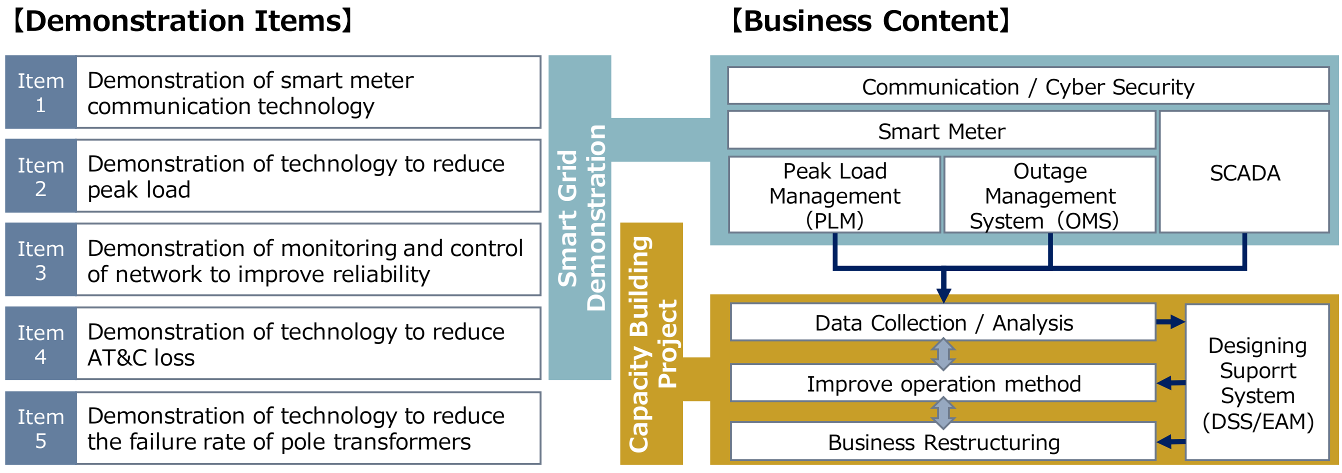


Figure 2: Relationship between Demonstration items and Business Content

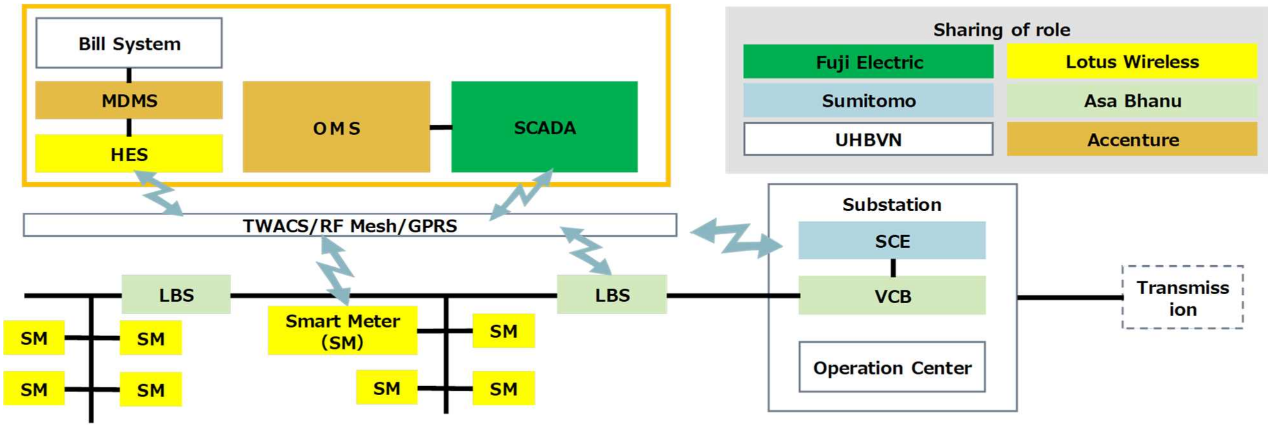


Figure 3: Demonstration System Configuration

In terms of system construction, Japanese project team examined whether the development of equipment and systems can be outsourced to local companies as much as possible, considering the diffusion and development of the local companies after the demonstration, and the policy of the Modi administration, "Make in India".

The company outsources the development and production of smart meters (Meters / RF Mesh Communication Unit / HES) to Lotus Wireless and VCB/LBS to Asa Bhanu. The details of each subcontractor are shown in Figure 4. UHBVN was in charge of the installation and construction, and the contractor was selected by bidding.

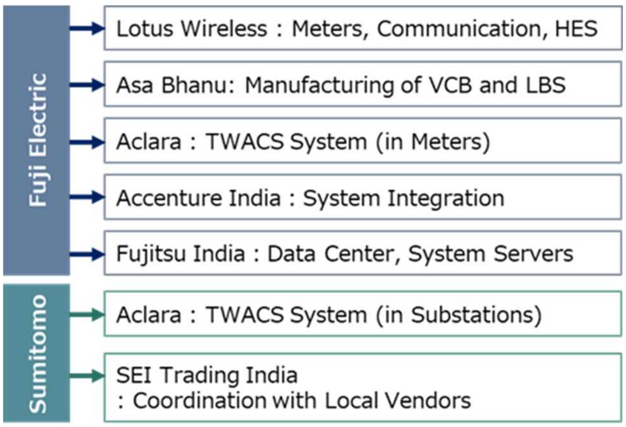


Figure 4: Outsourcing to Local Companies

4.2. Installed equipment and systems for capacity building

It was necessary to reconstruct the power grid in Panipat to the three divided three connected structure which is adopted in Japan to utilize SCADA, VCB, LBS and to highly operate the power grid（Figure5）. The three divided three connected is a concept of a power grid system to minimize the effect of power failure by dividing one feeder into multiple sections, blocking the power failure section in case of trouble, and supplying power from other feeders through a LBS.

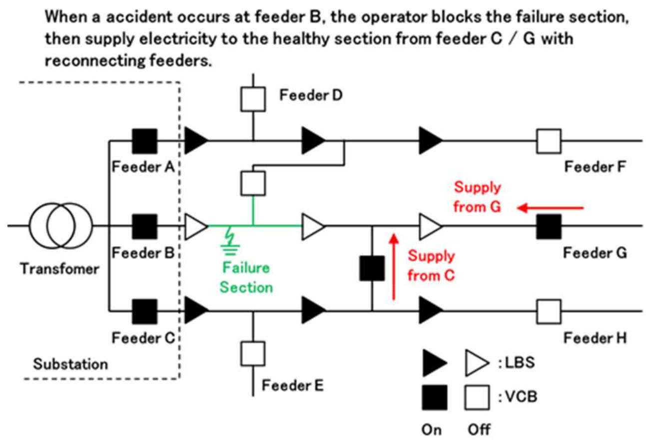


Figure 5: The Three Divided Three Connected Model (Sample)

In Indian distribution network, the loop Structure and the radial structure is normally adopted in India. In the radial structure, when a power failure occurs in one section within feeder, the entire feeder is cut off for a long time since it does not include a redundant configuration. Since the method of operation and design for the three divided three connected structure and normal Indian structure are drastically different, the support and education for UHBVN engineers were provided in the capacity building project.

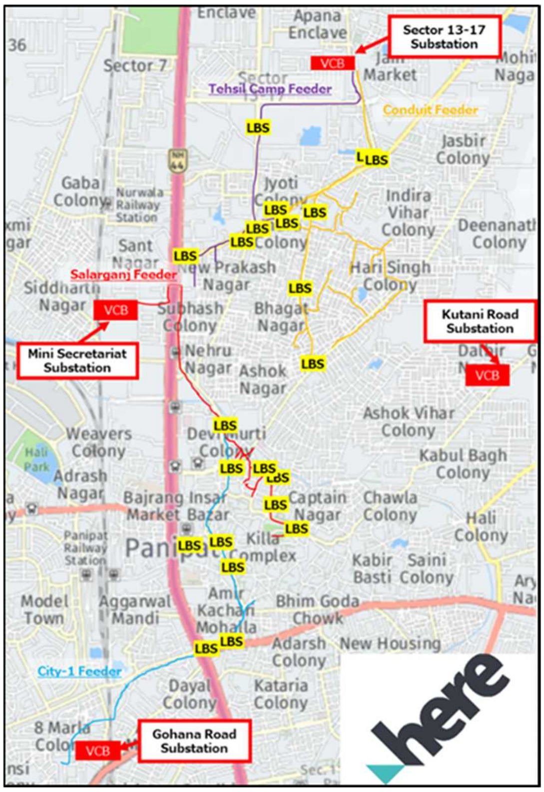
THE Power Grid Solution conducted a survey of the local distribution network in cooperation with UHBVN engineers. The additional poles and distribution lines were installed by a construction company selected by UHBVN, but the selection of division/interconnection points and the basic design of the entire system were performed under the leadership of THE Power Grid Solution.

In addition, a training center was constructed near the headquarters of UHBVN to educate operators so that UHBVN can continue to make use of the three divided three connected equipment installed at the demonstration site after the demonstration period. Two feeders are installed in the training center, so that engineers can experience a workflow similar to the actual grid operation. As part of the capacity building project, lectures on techniques to shorten the time of the recovery operation from a power failure and the response in the event of a failure by using a training facility were provided for key members of UHBVN.

Figure 6: Lecture at the Training Center/Operation Center

5. System introduction and installation

As a demonstration site of Panipat, 22 LBS and about 11,000 smart meters were installed in 4 feeders. The location of the demonstration facilities is shown in Figure 7.



(The map was licensed by HERE Technologies)

Figure 7: The Location of Facilities in the Demonstration

The Mini Secretariat Substation has an operation center to operate the SCADA. At the operation center, UHBVN operators monitored and controlled the demonstration facilities using the SCADA screen. In the operation center, a tool (Decision - making Support Software: DSS) which performs basic investigation of power distribution design was also introduced, and it was utilized for the power grid system design of the three divided three connected.

Figure 8: The Operation Center

For the smart meter, Japanese project team have developed the single-phase two-wire system and the three-phase four-wire system, and they have adopted TWACS communication, which is one of the PLC communication technologies, and RF Mesh communication. the also prepared a GPRS method using a mobile carrier network as a backup. PLC communication is a communication technology that uses power lines as communication lines, and its stable communication quality is expected even in the areas with poor wireless communication environments. RF Mesh, which is used to construct smart meter networks in Japan, is a technology for constructing an autonomous and distributed network. both of these technologies are assumed to have higher reliability than the GPRS method in consideration of the wireless communication environment in India.

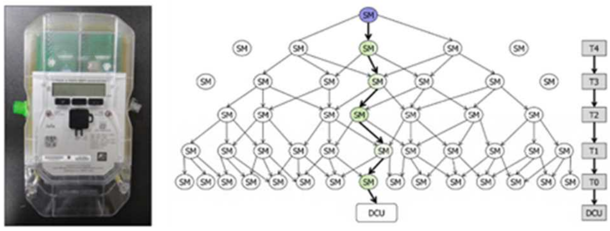


Figure 9: Smart Meter and RF Mesh Communication

The installation started from the summer of 2017, but the completion of the construction was delayed until May 2018, due to the delay in selecting the contractor by UHBVN and the delay in the work due to the product and construction quality. Issues related to the product and construction quality will be discussed later in Key Findings.

6. Result of demonstration

In this demonstration, verification was performed based on five demonstration items. The details and results of each items are summarized below.

6.1. Demonstration of smart meter communication technology

Japanese project team evaluated the communication success rate in the demonstration of smart meter communication technology. A total of 10,188 smart meters were installed. This includes 4,853 TWACS communications and 5,335 RF Mesh communications. The smart meter was designed in compliance with BIS (Bureau of Indian Standards), an industrial standard in India, and became the first smart meter to receive BIS certification in India.

The communication success rate of the smart meter was evaluated by measuring frequency of Scalar Read (once a day) and Interval Read (every 30 Minutes). Furthermore, the communication tests on TWACS communication with suburban areas about 5 km away were confirmed the quality of long-distance communication (once a day). The evaluation results are shown in Table 1. The success rate of TWACS exceeded 99% in all items, and TWACS was confirmed that the communication method was highly reliable in India. The success rate of the RF Mesh was slightly lower than that of the communication quality in Japan, as data loss occurred on Interval Read test. In this demonstration project, communication failures frequently occurred due to external factors such as malfunctions of smart meters, power outages, and communication failure of mobile phone networks, but external factors are excluded from the evaluation in Table 1.

Table 1： Evaluation of Smart Meter Communication Success Rate

Evaluation item	TWACS communication method	RF mesh communication method
Scalar Read	99% or more	99% or more
Interval Read	99% or more	85%～90%
Long-Distance	99% or more	(Not implemented)
Evaluation	✓ High success rate in every items ✓ Communication is possible outside of the cellular network area.	✓ Interval Read causes data loss ✓ The RF Mesh cannot communicate outside of the cellular network,

6.2. Demonstration of technology to reduce peak load

In the demonstration of peak load reduction technology, the electricity consumption per customer collected by a smart meter was analyzed to verify the possibility of introducing peak load reduction technology. It was confirmed that the peak of electricity demand occurred twice in the morning and afternoon (Figure10). If this peak can be suppressed or dispersed, the load on the distribution system can be reduced.

In this demonstration, a demand limit control function was implemented in the smart meter as a function to suppress electric power demand. This

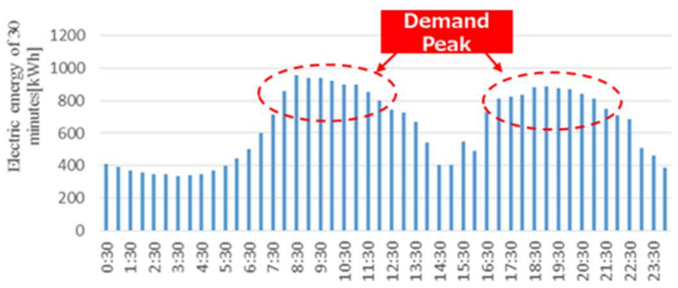


Figure 10: Electricity Demand Trend（January 10, 2019）

function checks the power consumption every 30 minutes, interrupts the power supply when the set limit value is exceeded, and automatically resumes the power supply after next 30 minutes. This function was implemented in the smart meter introduced in the demonstration, but it was not actually operated in demonstration, and only the simulation was conducted.

As a result of the simulation, it was found that when the peak cut target was 850 kWh (90% of current peak demand), it was possible to achieve the target by setting a demand limit value of 80% for each meter.

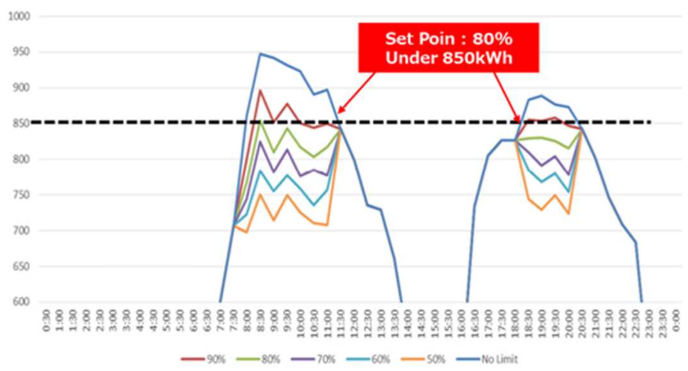


Figure 11: Simulation Results of Peak Load Reduction

Although the above simulation is performed when demand limit values are set for all meters, the simulation results are affected when a priority supply rate contract is set without setting limit values for consumers with a large demand for electric power. When the limit value established by the contract rate of the priority supply rate contract was calculated, it was found that the limit value should be set to 60% or less in the case of 40% contract rate and to 70% or less in the case of 20% contract rate. When the contract rate is 60% or more, it does not work even if the limit value is 50% or less. Although the demand limit control function and the priority supply rate contract will not actually be implemented, this result can be expected to be utilized as a possibility of a new efficiency improvement proposal utilizing smart meter data in the future.

Table 2: Trial Calculation with Priority Supply Contract

Demand limit value	Close rate of priority supply rate contract			
	80%	60%	40%	20%
80%	×	×	×	×
70%	×	×	×	○
60%	×	×	○	○
50%	×	×	○	○

○:Peak cut can be made　×: Peak cut cannot be made

6.3. Demonstration of monitoring and control of network to improve reliability

In the demonstration of monitoring and control of network to improve reliability, Japanese project team analyzed the data of the power grid system reconstructed into a three divided three connected system and verified the effect of the demonstration system in reducing the time of the accident power failure.

The demonstration system has 4 VCB and 22 LBS installed in 4 feeders, which are remotely monitored and controlled by the SCADA installed in the operation center. (Figure 12)

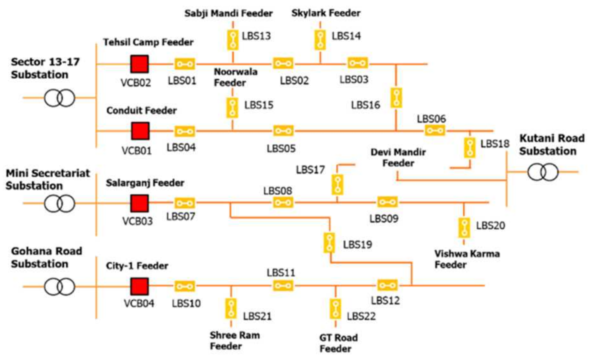


Figure 12: Distribution Structure in the Demonstration

In this study, in order to examine the effects of outage time reduction, we analyzed the frequency of outage that occurred between November 2018 and January 2019. The total outage occurred 51 times according to 4 feeders, but it was considered that more outage occurred by poor coordination with some communication facilities and SCADA.

The following three outage cases was selected for the case study in this demonstration project.

① November 8, 2018 7:11:42 on Conduit Feeder
② November 13, 2018 22:28:53 on Salarganji Feeder
③ January 25, 2019 2:32:33 on Salarganji feeder

In all three cases, short circuits occurred in specific sections of the feeders, causing power failures in the entire feeders. After that, the failure sections were identified and separated, and the supply from the adjacent feeder provided to realize the early restoration excluding the failure section. In this demonstration, the difference between the time it took to restore the affected section (Until now, outage had happened even in areas outside the accident zone until it was restored.) and the time it took to supply power to the sections excluding the affected section was considered to be the effect of the power failure time reduction. As a result, the improvement effect was confirmed: 1 hour 15 minutes 36 seconds in case 1, 20 minutes 29 seconds in case 2, and 9 hours 21 minutes 21 seconds in case 3.

Table 3: Effects of accident power failure time reduction

Items	Case 1	Case 2	Case 3
Date and time of the accident	11/8/2018 07:11:42	11/13/2018 23:28:53	1/25/2019 02:32:33
Recovered data and time outside the affected zone	11/8/2018 08:07:36	11/14/2018 00:26:00	1/25/2019 07:24:01
Recovered date and time	11/8/2018 09:23:12	11/14/2018 00:46:29	1/25/2019 16:45:22
Recovery time outside the affected area	00:55:54	00:57:07	04:51:28
Recovery time in the affected area	02:11:30	01:17:36	14:12:49
Effects of accident power failure time reduction	**01:15:36**	**00:20:29**	**09:21:21**

We also believe that there is the possibility for further improvements in the operation of SCADA, such as the use of automated functions and operational proficiency. If the following additional improvement measures are implemented, it is expected that the time required for the block of the accident point and the operation of grid reconnection will be significantly shortened. Therefore, it can be considered to restore from the accident within 4-5 minutes after the occurrence of the accident in all three cases.

<Details of improvement measures>

- The automatic reclosing function of the VCB, which was not used in the demonstration, shorten the detection time for instantaneous failure/continuous failure to about one minute.
- Skilled operation of the SCADA reduces its time to two minutes or less.
- Skilled operation of SCADA shortens the operation time of power interchange from isolating accident points to less than two minutes.

In order to confirm the reliability improvement of the power grid system by the demonstration system, comparison was made before and after the demonstration on the average power outage duration indicator (System Average Interruption Duration Index: SAIDI) and the average power outage frequency indicator (System Average Interruption Frequency Index: SAIFI). The annual averages values provided by UHBVN in 2017 are adopted as the values prior to the demonstration, and the values measured in January 2019.

The comparison results are shown in Table 4. Significant improvements were confirmed in both SAIDI (66.7%) and SAIFI (23.5%). Further improvement effects can be expected if additional improvement measures such as skilled operation of SCADA are implemented.

Table 4: Improvement of SAIDI and SAIFI

Indicator	UHBVN Supplied Value (Averaged value in 2017)	Measured value by SCADA (January 2019)	Improvement rate
SAIDI	54[hours/month]	18[hours/month]	66.7%
SAIFI	17[times/month]	13[times/month]	23.5%

6.4. Demonstration of technology to reduce AT&C loss

In the demonstration of AT&C loss reduction technology, it was verified whether it was possible to reduce power distribution loss by analyzing the data of the demonstration system and taking countermeasures. Power distribution loss refers to the difference between the electricity amount supplied to the grid and the actual consumption by the customer, which is often defined by dividing into technical loss and commercial loss. In this demonstration, technical loss and commercial loss are defined as follows.

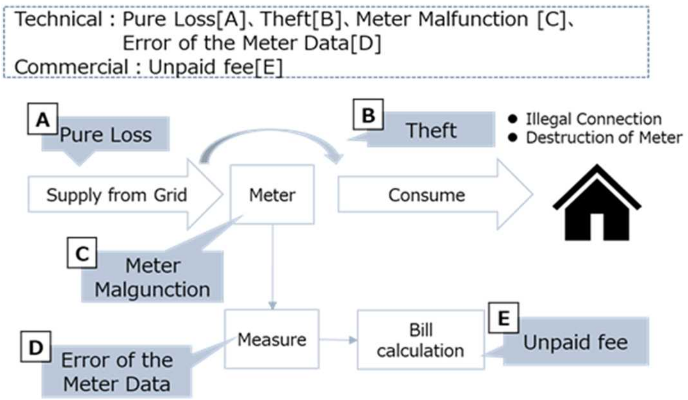


Figure 13: Define of Technical Loss and Commercial Loss

First, we estimated the demand forecast of the consumers by analyzing the data of consumer profile and distribution transformers using the power load prediction method (Customer Demand Curve Estimation Method: CDCE Method). If the discrepancy between the predicted value and the actual measured value is large, it is presumed that irregularity such as electricity theft occurs under the transformer.

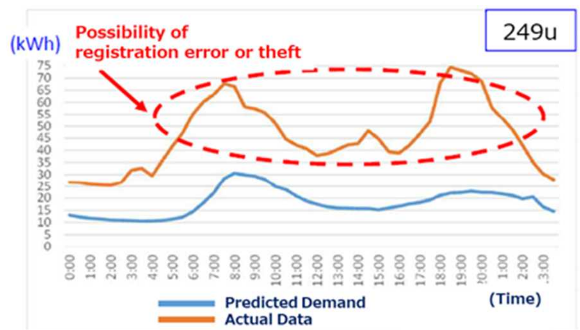


Figure 14: Predicted Value and Actual Measured Value

On-site surveys were conducted at points where there were large discrepancies between the predicted values and actual values. As a result of the on-site surveys, it was confirmed that there were several cases of meter ID registration errors, but it was found that electricity was stolen by customers at many points, and the effect of "visualization" using the above method was confirmed. As the means of electricity theft, the cases of illegal access to meters and illegal connection to distribution lines were seen. It was also confirmed from smart meter alarms that about 1% of meters were illegally opened every month. These theft points were frequently monitored and physical measures such as those shown in Figure 15 were implemented. As a result, the AT&C loss was reduced from about 36.1% (in 2014) before the demonstration to 18.6% in 2018 by these efforts.

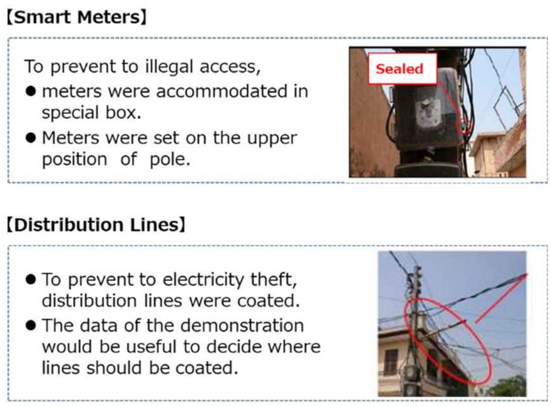


Figure 15: Example of Anti-Theft Method

It is necessary to thoroughly collect the unpaid electricity fee to improve the commercial loss. The smart meter introduced in this demonstration can be remotely shut off, it is possible to stop electricity supply to the customers who have not paid their electricity bills. The remote shut-off operations were mainly performed by UHBVN, and those were confirmed 1,274 times according to the data between October 1, 2018 and January 5, 2019. UHBVN records show that about 2.7 million INR (about 4.3 million yen) was additionally charged in 313 cases. If it is possible to collect the charges for all 1,274 cases, additional charges of approximately 11 million INR will be collected over four months, so that an annualized charge of approximately 33 million INR will be collected. It would contribute to the great improvement of the commercial loss.

6.5. Demonstration of technology to reduce the failure rate of pole transformers

In this demonstration, efforts were made to reduce the failure rate of pole transformers by analyzing the cause of failure of pole transformers and implementing those preventive maintenance through on-site inspection.

Generally, Japanese transmission and distribution companies such as TEPCO Power Grid, are engaged in conservation activities in line with the basic concept of the PDCA cycle that patrols and inspections shall be implemented(Do) based on the plan (Plan), and the results of the patrols and inspections shall be analyzed (Check) and maintenance measures shall be performed (Action). However, UHBVN did not conduct the patrols, inspections, and analysis of the causes of failures, and it was difficult to grasp the trends in the failure of the pole transformers and to consider the countermeasures.

Therefore, Japanese demonstration team analyzed the status of the failed transformers to grasp the current situation and found that 68% of them were caused by the breakdown of their primary winding due to flooding. they also found that transformers with repair histories malfunctioned faster than new ones. Based on the results of these analyses, they assumed that the cause of transformer failure was the quality of the repair and conducted airtightness tests of repaired transformers.

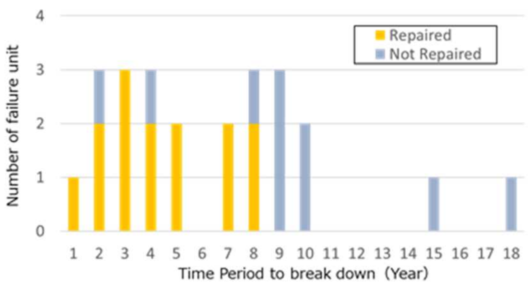


Figure 16: Trend of Transformer Failure (25 units)

It was also found that UHBVN did not perform preventive maintenance. In order to grasp the present situation, inspection by patrol was conducted, and preventive maintenance (repair/planned replacement) were performed for transformers. It was found that 22 out of 143 transformers installed in the four feeders in this demonstration malfunctioned over the last year (15.4% of failure rate). We were able to inspect 87 transformers in the demonstration. UHBVN engineers were trained on specific inspection and preventive maintenance methods when Japanese team was able to accompany them. As a result, appropriate measures were taken for those requiring preventive maintenance, and the possibility of failure is considered to be low for the time being. As the 56 units were not inspected, there is a possibility of failure. However, when the initial failure rate of 15.4% is applied to those units, the failed units shall be less than 9 even if failures occur. If this applies to the total of 143 units, the failure rate is about 6% (9/143≒6%), and it is greatly improved from before the demonstration.

6.6. Summary of demonstration results

The results of the demonstrations in the five promotion themes are summarized in Table 5.

Table 5：Demonstration Results（Summary）

Items	Results
[Item 1] Demonstration of smart meter communication technology	✓ The success rate of TWACS/RF Mesh communication was obtained. ✓ The success rate of TWACS communication was more than 99%, indicating the superiority of this method.
[Item 2] Demonstration of technology to reduce peak load	✓ The power consumption trend of the users of the demonstration feeder was obtained. ✓ Japanese team confirmed the effect of demand limit control on the reduction of users' power consumption.
[Item 3] Demonstration of monitoring and control of network to improve reliability	✓ The three divided three connected system was constructed through on-site survey and make use of support tool (DSS). ✓ UHBVN engineers were trained on the operation method of the three divided three connected systems and recovery procedures in case of outage. ✓ The accident detection function and remote-control function of the demonstration system were confirmed the effect of outage time reduction. ✓ It was confirmed that the SAIDI/SAIFI value was improved dramatically
[Item 4] Demonstration of technology to reduce AT&C loss	✓ Japanese team proposed measures to AT&C loss and theft, and we implemented measures at UHBVN. ✓ CDCE method was used to extract transformers that are assumed to have an abnormality (Theft, etc.). ✓ As a result of the on-site investigation, we found points where electricity was stolen. ✓ AT&C loss improved from about 36.1% before the demonstration to 18.6% (in 2018) by a series of measures. ✓ UHBVN would be able to collect electricity charges (equivalent to 53 million yen per year) by implementing remote shut-off for unpaid customers.
[Item 5] Demonstration of technology to reduce the failure rate of pole transformers	✓ The cause of the transformer failure was analyzed. ✓ Japanese team accompanied on-site inspection and preventive maintenance work and provided education. ✓ It is expected that the failure rate can be reduced by the on-site inspection using the inspection list.

The energy saving effect and CO2 reduction effect were also estimated as the result of this demonstration, based on the peak cut effect (10% of peak power in 4 feeders) by demand response using smart meters.

＜Reduction effect by demonstration＞

Energy saving effect: 51 kL/year

CO2 reduction effect: 198 ton/year

In the future, if smart meters are diffused with the increasing number of smart meters installation in India, the reduction effect will be improved further. When a total of 5.7 million units (1.5% of the Indian government's dissemination plan) are introduced in 2030, the reduction effect is as follows.

＜Reduction effect in 2030＞

Energy saving effect: 29,247 kL/year

CO2 reduction effect: 112,665 ton/ year

7. Key Findings

While we grasped the current situation of DISCOMs in India and examined the feasibility of introducing advanced smart grid technology by Japanese companies through this demonstration, we were able to learn various lessons and insights. The three major cases are described below.

＜Key Findings in this demonstration project＞

① Importance of digitization and visualization
② Combination of advanced technologies and operational know-how
③ Adapting to the local environment

① Importance of digitization and visualization

This demonstration project is considered to be one of the digitization projects of the grid by the introduction of the remote monitoring and control system of the power grid system centering on about 11,000 smart meters and SCADA.

By digitizing the data on the distribution network and customers' power consumption and making it analyzable, it becomes possible to provide added value that contributes to further efficiency improvement of the distribution network.

This demonstration was conducted under the environment of different facilities and operation systems from Japan. However, it was confirmed that the know-how and experiences in introducing digitization technology accumulated in Japan were highly evaluated in India, and these can be used as strong points for Japanese companies when they expand their business to other areas of India and Asian countries.

Especially, the communication quality of the smart meter is highly evaluated. It was a big challenge for the Japanese demonstration team to introduce TWACS communication and RF Mesh communication under the immature communication environment in Panipat, a suburban area of India, but it is worth praising that they achieved the very high communication success rate in cooperation with local companies. Deciphering the electricity demand trends in India from actual data will be valuable for the demonstration team to spread energy businesses in future market in India. Unfortunately, the GPRS communication method was appointed as the method of smart meters for bidding which started throughout India during the demonstration period, and successful bids for smart meters at considerably lower prices (The winning bid was 4,255 yen per unit in the initial open tender.). Therefore, it is difficult to make proposals using Japanese technology. However, adopting a highly reliable communication technology is essential to digitize distribution system, and the need for the reliable Japanese technology will increase as the distribution business in India develops and expands.

We also reaffirmed the importance of data accuracy for the effective data analysis. Although the database construction of the distribution facilities and the linkage with GIS data have been implemented in UHBVN, this demonstration has revealed a problem in accuracy. Even if the data is analyzed, if there is a discrepancy between the actual location and the data, the correct analysis cannot be performed. In this demonstration, as a result of the on-site investigations, there were ID registration errors which affected the result of data analysis. Therefore, the facility information was corrected on site and the analysis work had to be conducted again.

In order to develop a business in India, it is necessary to consider not only the creation of a mechanism to collect data, but also the creation of a habit of updating accurate data in detail or the automation of data input.

② Combination of advanced technologies and operational know-how

One of the features of this demonstration project is that it combines the smart grid demonstration, whose main theme is the introduction of advanced technology in Japan, and the capacity building project, which shares Japan's detailed design and operational know-how, into one project.

In the first Key Findings, it was stated that Japanese advanced technologies are effective in India, but it is also true that the technologies adopted in this demonstration, such as a three divided three connected power grid system model, are not familiar to Indian DISCOMs. In this demonstration, UHBVN engineers were grown enough to have designed a three divided three connected system by themselves and operated SCADA since Japanese engineers provided them with generous on-site support and detailed guidance from the design phase of the grid system in addition to the Japanese design and operational know-how such as holding training centers and workshops in Japan. Also, Indian parties have increased their trust in the Japanese demonstration team through such efforts to share the knowledge.

Global majors, such as ABB and Schneider Electric, already have their businesses in India, and Japanese companies need to seek ways to differentiate themselves from the Western counterparts to enter the market. Mr. Atsushi Honzawa of THE Power Grid Solution, felt the feasibility of the capacity building business through the demonstration, and commented, "The combination of technical and operational follow-ups may be a key point for Japanese companies to compete with global majors.". In addition, educational materials were prepared, and proposals for improving the operations of UHBVN (preparation of operation standard manuals) are implemented as part of the capacity building project in this demonstration.

- Manual for Grid Operation
- Manual for Loss Reduction Method
- Manual for Preventive Maintenance of Pole Transformer
- Manual for Repair of Pole Transformer

Figure 17: The Manuals Created in this Demonstration

③ Adapting to the local environment

In this demonstration, the Japanese demonstration team faced particular difficulties in adapting to the local ecosystem, such as Indian business practices. In this chapter, we describe the difficulties that Japanese companies faced in the demonstration and the challenges in adapting to the local environment, in particular, from the viewpoint of regulation and quality

＜Regulation＞

In India, applying BIS is required as an original standard for industrial products. Therefore, Fuji Electric worked with Lotus Wireless to jointly develop a smart meter, rather than the one Fuji Electric has commercialized in Japan. At the start of the demonstration, any smart meter manufacturer had not obtained BIS certification, so that Lotus Wireless became the first one. It is judged whether the product meets the standard to obtain the certification after electrical and environmental tests and factory audits at certification organizations as the certification process, established by the Electronics Regional Test Laboratory (ERTL) under the government of India.

The test at the certification organization was prolonged, and the time until certification was obtained was much longer than the initially expected six months, and the certification was finally granted about one year after the application. Besides, TWACS communication technology does not meet the BIS; for example, it requires a call from a smart meter, so that we have given up on obtaining the certification during the demonstration period.

It was confirmed whether other demonstration facilities are subject to BIS process. Estimating the period and cost is necessary to complete the process for the next business development in India.

＜Quality＞

In this demonstration, a lot of distribution equipment including smart meters was installed at the demonstration site. However, the problems in both manufacturing and construction quality frequently occurred, and countermeasures were not implemented, leading to a longer construction period.

We have outsourced the development and production of smart meters to Lotus Wireless and VCB/ LBS to Asa Bhanu. Although specifications of the equipment were confirmed in advance, water leakage, burnout, and other problems have occurred after the installation and operation of the equipment.

During the demonstration, we implemented measures such as installation of waterproof covers and fine adjustments of burned parts, but further enhancement of manufacturing quality is necessary in order to actually commercialize the equipment.

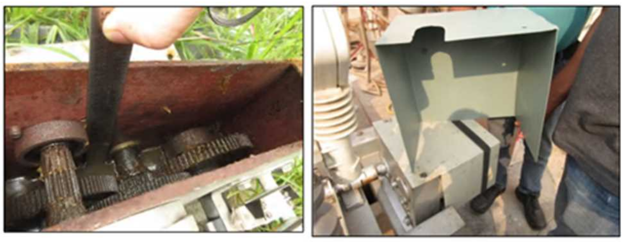


Figure 18: The Gearbox with Water Leakage (left) and Waterproof Cover (right)

The installation of each equipment was implemented by contractors selected by UHBVN. However, many quality problems occurred, such as the inability to tighten the bolts, poor connection of the distribution lines, and the equipment installation in wrong places. As for the division of roles in the demonstration, UHBVN was responsible for the construction management, so Japanese team repeatedly proposed improvements toward the construction teams, but improvements were not made. The quality of the contractor may be particularly low, but it has become clear that attention should be paid to the selection and quality control of the contractor when conducting facility construction in India.

Figure 19:Defectfive bolt（left）, tilted poll（right）

In the demonstration, the mobile phone network was adopted as a communication method between facilities and servers, but the communication quality was also a significant issue. The carrier selected in the demonstration was Airtel, one of the largest carriers in India. The operator was selected by UHBVN through bidding. The results of the demonstration project were affected because the data of each facility were not properly transmitted, and which made it impossible to control power failure and monitor daily conditions. In order to introduce the smart grids and digitalization technology, it is necessary to establish a high-capacity, high-speed and reliable communication environment. As India's economy develops, the communications environment is rapidly improving. However, in the suburbs, the confirmation of communication quality is an important factor in business development for the time being.

As mentioned above, the environment in India is very different from that in Japan in terms of regulations and quality. Mr. Koji Shinohara of Fuji Electric commented "To install advanced smart grid technology to Indian market, Indian companies should do obvious things, such as tighten the bolts, connect lines in correct way and manage construction schedule.". Many proposals for the improvement were made to UHBVN and other concerned parties during the demonstration, but great improvement was not made. “It would be faster for Japanese companies to cooperate with Indian companies than to learn Indian business practices." Reji Kumar of the India Smart Grid Forum said. Japanese companies often face a difficulty in adapting to local business practice when they expand their businesses overseas, not just in India. This demonstration project has revealed that collaboration and partnership with local companies are important elements to solve these problems.

Conclusion

This demonstration project was very significant to examine the applicability of advanced technologies of Japanese companies in Indian electric power market, which is rapidly changing with economic development.

As a result, it was found that the excellent technology and detailed operation of Japanese companies are effective regardless of the difference in the market environment and can greatly contribute to improving the distribution business in India. Concerned parties in India are grateful for the sincere response of Japanese companies and highly evaluate the results of the demonstration.

Comment by Mr. Manish Kumar and Mr. Himanshu Sheokand of UHBVN

The advanced technology of Japanese companies introduced in this project is very excellent. The communication quality of the smart meter is also high, and distribution loss in Panipat is greatly improved. Based on the results of this demonstration, UHBVN will expand similar efforts to develop the power distribution in its service area. As some companies have already started bidding, we would like Fuji Electric and other Japanese companies to participate in the bids.

Comment by Mr. Reji Kumar of ISGF

Concerned parties in India are very grateful for the sincere response of Japanese companies. Especially, the guidance of design and maintenance work in the capacity building business was very high quality. Although there were some differences from Japan, such as the system configuration, it would have been beneficial for Indian engineers to share the information.

Comment by Mr. Vishal Kapoor of MOP

MOP also highly values the results of the demonstration in Panipat. It is noticed that the advanced technology in Japan contributes to developing the distribution system in India. The market for the technologies adopted in Panipat is expected to grow with plans to introduce SCADA and the Distribution Management System (DMS) in about 60 cities.

In addition, while Japanese companies received comments that valued the project, there were also comments on issues in adapting to the local ecosystem and forming partnerships with local companies in the business development. The concerned parties in India were impressed by the technological prowess of Japanese companies, and the above advice came from their warm thought that they hoped to continue working with Japanese companies in the future. In this case study, we would like to describe the challenge that Japanese companies which aim to expand their business in India should recognize.

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Figure 20: Pictures of operation center opening ceremony

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