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National Grid's Approach to Commissioning of Smart Grid Pilot Devices

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SUMMARY

National Grid is currently in the final stages of the implementation of its Smart Grid Pilot in the city of Worcester, Massachusetts. The deployment required the installation and commissioning of 188 devices including 65 advanced distribution switching devices, 44 advanced capacitor controls, 13 remote fault indicators and 34 monitoring devices. Such task required the creation of commissioning processes that could accommodate the features and characteristics of equipment that, in some cases, was to be installed for the first time in National Grid's territory. The present work will describe the philosophy, experience and learnings that National Grid gained during the development and implementation of the commissioning processes used in the deployment of the grid facing portion of the Worcester Smart Grid Pilot.

KEYWORDS

Smart Grid, Equipment Commissioning, Pilot

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1. INTRODUCTION

National Grid received approval in August of 2012 [1] for the implementation of a Smart Grid Pilot in the city of Worcester, MA, The proposal, included two main aspects for the deployment: a customer oriented program and a grid facing solution. The grid facing solution was designed to test the benefits of adding equipment to the distribution system with enhanced functionality to improve power quality, visibility and system reliability for National Grid's customers in Worcester, MA. This represented a challenge that required an analysis of our current installation and commissioning practices. Several devices included in the implementation were new or introduced new functionality to National Grid's system. This required the design of new work methods, training material, configuration files and commissioning procedures to ensure a proper integration to National Grid's system. In addition, the new functionality of the devices was designed to work under an overarching communication network that was being developed in parallel. All these aspects represented a long list of challenges that needed to be tackled throughout the duration of the pilot.

This paper presents the approach that National Grid took for the commissioning of the grid facing devices of the Smart Grid Pilot and the experience gained during the process.

2. SMART GRID PILOT OVERVIEW

As defined by National Grid on its initial design, the grid facing portion of the pilot includes several features and/or experiments, which are described in Table 1.

Table 1 Features and experiments included in the grid facing portion of the Smart Grid Pilot

Feature/Experiment	General Description
Distribution Automation	Installation of approximately 65 Advanced Distribution Automation (ADA) switches across the 11 feeder Pilot's area. This functionality enabled FLISR (Fault Location, Isolation and Service Restoration) functionality in the area
Advanced Capacitor Control	Capacitors with centralized communications and local controls that can be fully integrated into the future OMS/DMS system for centralized control
Advanced Monitoring	Installation of monitors in critical locations (capacity bottlenecks, distributed generation sources, electric vehicle charging installations, etc.) to collect and report detailed information to be used in modeling and analysis
Remote Fault Indication	Installation of Faulted Circuit Indicators with communication capabilities to improve reliability by reducing the time required to patrol feeders looking for the cause of the interruption
Advanced Recloser Technology	Installation of several reclosers with advanced reclosing capabilities

These experiments include more than 180 distribution line devices deployed along 11 13.8kV feeders, involving 5 substations and covering 160 miles of UG and OH primaries, serving 15,000 customers.

The features were implemented using a communication network based on WiMAX infrastructure. As shown in Figure 1, the system was designed to have devices communicating with National Grid and each other through a 3.65GHz WiMAX network consisting of several base stations in the pilot's territory.

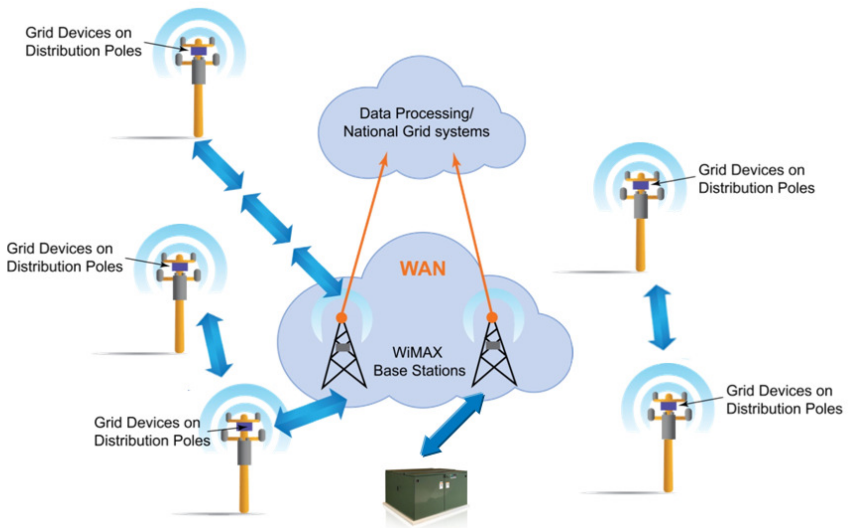


Figure 1 General diagram of the Communication's Architecture

The data is then integrated into the National Grid EMS system to provide visibility and control of the devices to the operators. Such integration was supported by the creation of a separate internal communication network dedicated to the Smart Grid Pilot, where National Grid EMS can request data from concentrators installed for the pilot. For some of the features implemented, certain devices required high speed peer-to-peer communication to ensure coordinated switching operation. This was achieved by prioritizing information packets within the dedicated network, making it virtually transparent to the EMS system.

3. COMMISSIONING PROCESS

The implementation of the grid facing portion of the pilot required the coordination of activities from several National Grid departments. In particular, given the timeline specified during the filing of the pilot proposal, the commissioning phase required the coordination of technical resources to ensure a timely and efficient use of its availability. Since most of the equipment to be deployed was non-standard to National Grid's system and a new communication solution was specified for the implementation, a different and novel approach to the regular commissioning process had to be developed. Figure 2 shows a general diagram of the progression towards commissioning during the pilot implementation.

The activities can be summarized as follows:

Step 1 - Training

An initial set of training sessions was designed for all personnel involved in the commissioning process. The training covered the essential functionality of the devices and included all the necessary steps to have a fully functional integrated device. Since most of the installed devices have components of different nature, training needed to be customized for each device and type of worker performing the task. For example: due to their functionality, the commissioning process for a Faulted Circuit Indicator was significantly different than a recloser but both shared some of the same communication equipment (WiMAX radio and antenna). This type of arrangement required the involvement of technicians from different departments (ex: Operation and Maintenance vs Protection and Telecomm Operations), creating an additional layer of complexity to the scheduling and training process.

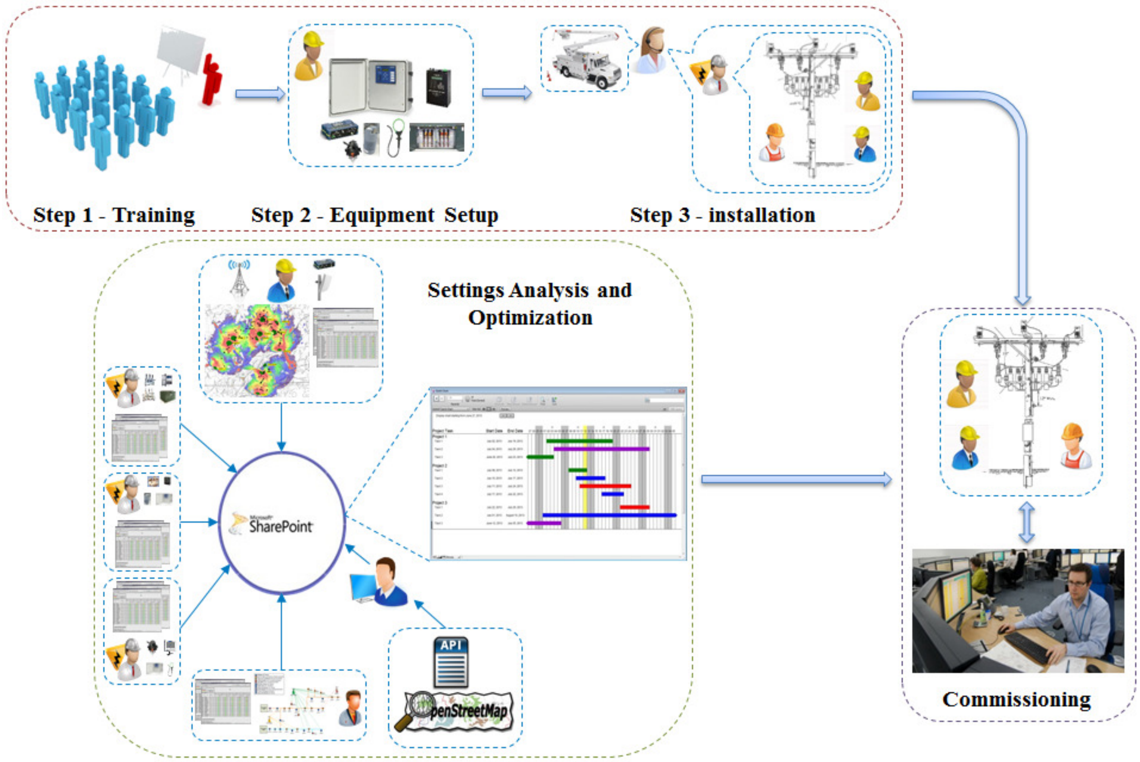


Figure 2 General diagram of progression followed by National Grid towards the commissioning phase of the Worcester's Smart Grid Pilot devices

Step 2 - Equipment Setup

Prior to field installation, each device was prepared, configured and tested in a lab environment. In many cases, this required the integration of components with diverse functionality, such as sensors and communication equipment. To make efficient use of the resources, a systematic assembly and set up approach was created. During this period, most of the same type of devices were assembled and configured in a sequential way to take advantage of the experience and familiarity gained by the technicians. Once the installation of devices started to progress, this equipment setup was prioritized based on the available resources, scheduling constraints and communication infrastructure availability. By testing and preparing the equipment in a lab environment, the field installation and commissioning process was significantly expedited.

Step 3 - Installation

During this step, crews and contractors were assigned the installation of the devices. Some of the work required for commissioning was performed during this stage as a way to expedite the integration. For example: WiMAX antennas were installed pointing towards their assigned base station. The installation process was carried out by Overhead, Underground and O&M crews. The main objective of this step was to electrically install the device and leave it ready for commissioning. During this step, the devices were left without working communication capabilities and its interactive functions deactivated (ex: Capacitors Off, Reclosers to be operated manually, etc.). As the pilot progressed, some of the remaining installations were prioritized based on communication infrastructure development and resources availability.

Settings' Analysis and Optimization

Although significant engineering work was completed before Step 1, additional review and optimization continued as a way to prepare for commissioning. During this period, extensive testing and optimization of advanced functionalities was conducted at one of National Grid's laboratories (created for this purpose) to ensure that the most complex schemes were going to work as designed. This exercise resulted in considerable modifications to the original settings and features included in the pilot. This optimization phase provided significant value to the commissioning process and showed the tremendous benefits of having a well-developed laboratory environment for testing of new technology. The activities performed in this phase resulted in improved setting files, essential firmware changes and updated drawings to be used during the commissioning process.

Commissioning

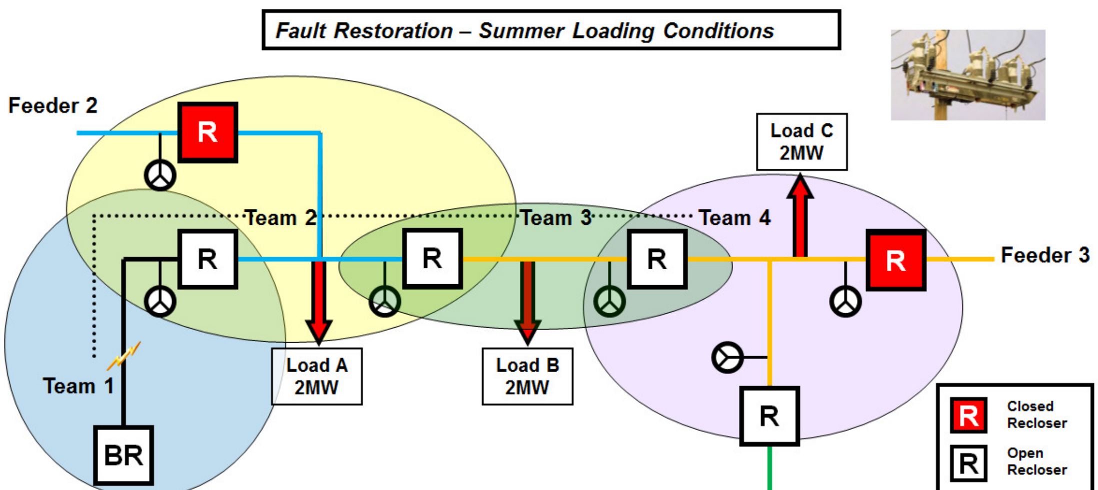
All the tasks previously mentioned were being conducted while another significant component of the implementation- the communication infrastructure -was being deployed. As the pilot implementation progressed, the commissioning of devices became subject to the communication availability for the particular area where the device was located, dictating the way that the commissioning tasks were scheduled. This became particularly challenging during the late stages of the implementation process due to some public opposition [2] to the installation of certain base stations, which required the search for viable alternatives. During this period, all the devices previously installed were reviewed to ensure that the installation was performed as designed, implementing the modifications needed in instances where deviations were found.

When the communication infrastructure started to be activated, the scheduling of device commissioning required coordination of activities between several departments to ensure that all the different components were operational at the time of interaction with EMS personnel. The locations were then prioritized using the centralized tracking tool internally developed [3] making it simpler to schedule the visit of different group of technicians to the commissioning locations.

The commissioning process can be summarized in the following steps:

- Installation review and final construction adjustments: The process started by paying a preliminary visit to the scheduled installations and verifying that all the equipment was installed according to engineering documents. This requirement was particularly enforced for units that were installed by contracting resources and was established due to the time difference between installation and commissioning observed for some devices.

- "Tiger" teams' visits: Due to the a number of communication related issues found during the first round of commissioning, due mainly to communication infrastructure modifications and/or unforeseen vegetation changes, it was determined that a small dedicated team would triage each location to ensure that all communication was operating properly. This was accomplished by making changes to the settings in the controller on the pole, or by modifying the configuration of the proper data concentrator. Only when there was enough confidence that the communication was operating properly, a crew and EMS operator would be scheduled to validate the functionality.
- EMS integration: This part of the process is similar to the one used by National Grid for any other monitoring/protecting device. Involves the testing of data and control points from EMS with visual and logical verification on the field. This included the separate integration of individual Distribution Automation devices without the advanced features.
- FLISR commissioning: Comprehensive field test of the FLISR scheme. As Figure 3 shows, a scheme like this is normally composed by "teams" containing a number of reclosers sharing information and a set of common functionalities.



Feeder	Load Served		Excess Capacity	
	Summer	Winter	Summer	Winter
1	6MW	6MW	1MW	1MW
2	4MW	6MW	3MW	1MW
3	3MW	3MW	4MW	4MW
4	6MW	1MW	1MW	6MW
*For simplicity, load fluctuation related to time of day is ignored.				

Figure 3 General functional diagram of the FLISR system used in the pilot

The "teams" are coordinated by a distributed logic that shares instructions to follow a certain strategy pre-established by the user. As this is another layer of communication having a direct effect on the operation of all the members of the team, it is essential for the commissioning process to verify that all the devices that are part of a "team" receive the right instructions in a timely manner. Therefore, the commissioning process established for this section of the pilot included the operators' ability to remotely monitor and control the teams' devices, enable/disable FLISR functionality, confirm the proper operation of the FLISR teams by observing the cascading of team messages between FLISR devices and verification of correct operation of custom algorithms (group FLISR enable/disable, Under frequency FLISR enable/disable, etc.). Under this procedure all the settings, functionalities and behavior specified for the FLISR scheme, such as team communications and custom program operation are tested to ensure the proper operation of the scheme. During the first couple of "teams" commissioning, crews visited each switch in the field to confirm the status of the FLISR controls and to initiate FLISR control commands locally. As this process was found to be slow and resource intensive, the subsequent verification of local control commands was done remotely by accessing the units through the network. This allowed the control center operators to see status changes and control actions on the local control without having to send a crew to the location. This change in procedure resulted in the subsequent reduction on crews' personnel (O&M and OH) and police details from the commissioning process.

4. RESULTS

The commissioning process of the distribution line devices of the Worcester Smart Grid Pilot was long and complex. During a year, several teams engaged in a combination of installation and commissioning of devices of diverse nature. As mentioned in the previous section, one of the main components that dictated the pace of commissioning was the availability of functional communication at locations where the devices were installed. As Figure 4 shows, the commissioning process suffered from certain stagnation at times (ex: from the end of April to mid-July) due to lack of communication availability in the required areas, mostly as a result of zoning and permitting delays.

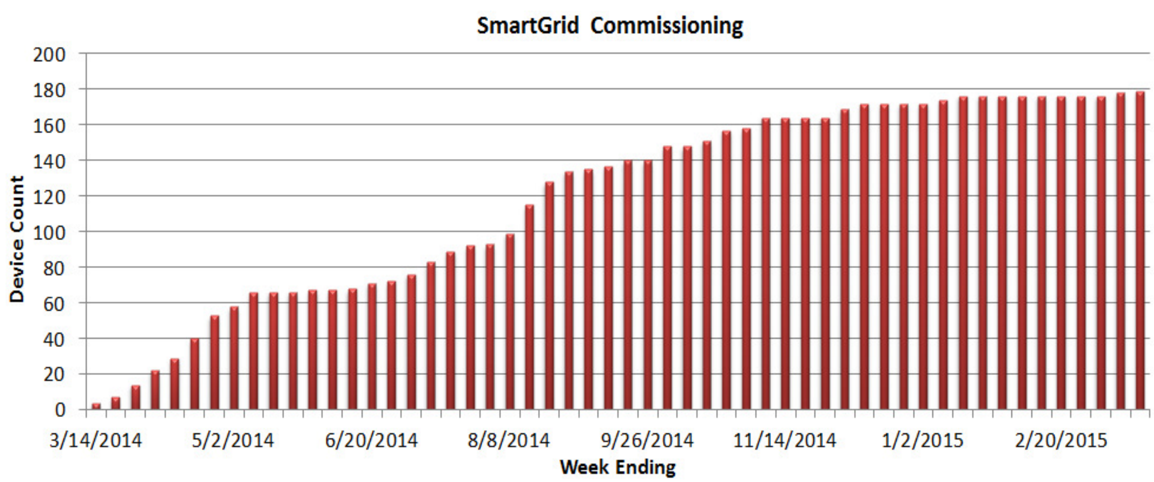


Figure 4 Progression of commissioning through time

However, the model established for commissioning proved to be extremely successful on the initial part of the process. As the graph shows, crews had the opportunity to commission more than a third of the devices in a two month period. This was considerably faster than expected, and showed an efficient coordination of resources from different departments (OH Line, O&M, Telecomm, control room operators, etc.). The success of the pilot was also a result of personal ownership many participants made to the project. They often worked beyond their usual working hours to ensure that problems didn't slip through the cracks and got resolved.

In addition, the use of network capabilities to gain visibility of devices during commissioning, increased efficiency by limiting the resources required to complete the process. So far, there have been three successful operations of sections of the Distribution Automation scheme. The confidence on the system stems from the extensive testing performed in the lab and the exhaustive process followed during commissioning.

5. CONCLUSIONS

The implementation of the grid facing portion of the Smart Grid Pilot in the city of Worcester presented a wide variety of challenges to National Grid. Ranging from the technical to the managerial, National Grid personnel had to create new sets of procedures to be able to incorporate this new technology and functionality into the system in a safe, efficient and reliable manner. Given the complexity of the project, efficient coordination of diverse resources was necessary to maintain the pace required by the timeline that National Grid proposed for the pilot.

The successful and timely progression of the commissioning phase of the project was substantially due to the creation of:

- a centralized application to manage and share the progress, store critical information and coordinate work across departments
- a streamlined procedure to prepare and test equipment in the lab ahead of installation
- a proactive inspection program for verification of installed equipment ahead of commissioning
- a comprehensive testing lab environment to debug and optimize advanced schemes
- a methodology to support commissioning of advanced schemes through the communication network

All these activities were not explicitly planned during the initial stages of the project, but were naturally conceived as a way to efficiently anticipate and solve problems in the implementation phase.

As National Grid moves forward towards the modernization efforts necessary to satisfy the increasing expectations in New York, Rhode Island and Massachusetts, the success and experience provided by the implementation of these ideas will shape the way that future pilots will be executed.

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