Technology Performance Report

Award Number: DE-OE-0000197

Project Type: Regional Demonstration

Secure Interoperable Open Smart Grid Demonstration Project

Consolidated Edison Company of New York, Inc.
4 Irving Place
New York, NY 10003

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Revisions Page

Revision History

Revision Number	Revision Date	Reviewed By	Description of Changes
0.1	June 18-July 5, 2012	DR, PR, AW	Initial draft
0.3	October 5 – October 12, 2012	TM	Replace the word "Grant" with "project" Replace "SGDO" with "SGDP" on page 15 Update March 12 date with March 27 Replace "SIOSG" with "SGDP" on page 31 Replace underscores on pages 39-41 with dashes

Approvals

This document requires the following approvals.

Name	Title
Andre Wellington	Project Specialist, Smart Grid Demonstration Group
Patricia Robison	Project Manager, Smart Grid Demonstration Group
Thomas Magee	General Manager, Smart Grid Implementation Group

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1 Introduction

This document represents an interim Regional Demonstration Project Technical Performance Report for Consolidated Edison Company of NY, Inc.'s Secure Interoperable Open Smart Grid Demonstration Project ("SGDP") DE-OE-0000197. The SGDP focuses on establishing secure open services to support enhanced monitoring and control from Distribution Control Centers.

The project incorporates systems and data provided by Con Edison and Orange & Rockland Utilities, Inc., as well as other subawardees and participants including Siemens, TIBCO, Green Charge Networks, CALM Energy Inc., the New York City Economic Development Corporation, Columbia University, Viridity Energy, Inc., and SoftStuf.

The following interim technical performance report summarizes the Con Edison, Inc. Smart Grid Demonstration Project ("SGDP") DE-OE-0000197 as of July 5, 2012 and includes an analysis based on the initial design and the first demonstration.

2 Scope

2.1 Project Abstract

The SGDP was authorized by the Energy Independence and Security Act (EISA) of 2007, Title XII, Section 1304, and later amended by the American Recovery and Reinvestment Act of 2009. The Funding Opportunity Announcement (FOA), DE-FOA-0000036, was issued to provide financial support to demonstrate how a suite of existing and emerging smart grid technologies could be innovatively applied and integrated to prove technical, operational and business-model feasibility. Under this FOA, Con Edison of New York (CECONY) was awarded a cooperative agreement, DE-OE0000197, with the Department of Energy (DOE) on January 4, 2010.

The SGDP focuses on establishing a secure interoperable services framework to support monitoring and control of distributed resources including battery storage, electric vehicle charging stations, building management systems, as well as intelligent analysis tools. Control Center operator dashboards will facilitate efficient operations that aggregate electricity supply data and integrate decision and risk management through load flow analysis extended to external distributed energy response and generation resources.

The objectives of the SGDP include:

1. Deliver intelligent, autonomous, adaptive, control capabilities for distributed operations to minimize peak load growth and drive energy efficiency savings throughout the electrical grid.
2. Provide world-class cyber security for the Smart Grid.
3. Demonstrate open standards and interoperability scalable to vendors of commercially available products in the relevant markets, and to customers and suppliers.
4. Maintain electrical system reliability while increasing the utilization of existing equipment.
5. The Team will monitor, measure, & verify actual costs versus benefits throughout the project.
6. Quantify the cost to access the economic viability and business case of the Smart Grid.
7. Be the national blueprint for urban underground network Smart Grid deployment.
8. Proactively gain public acceptance and educate a new generation of Smart Grid operators, engineers, and managers while executing the project on time, on budget, and with the promised results.

Based on these objectives, Con Edison developed use cases and designed the secure interoperable technology solutions in accordance with existing and evolving DOE, NIST, IEC, and IEEE smart grid frameworks, standards, guidelines, and recommendations. The secure services design and the integration of the smart grid technologies will be demonstrated and measured to determine the viability and cost of the smart grid solutions for replication across the country.

2.2 Consolidated Edison Company of NY, Inc. Overview

Consolidated Edison, Inc is one of the nation's largest investor-owned, energy-delivery companies, with approximately $13 billion in annual revenues and $40 billion in assets. The company provides a wide range of energy-related products and services to its customers primarily through its two regulated utility subsidiaries, Consolidated Edison Company of NY, Inc. and Orange & Rockland Utilities, Inc., and its three competitive businesses. For additional financial, operations, and customer service information, visit Consolidated Edison, Inc's website at www.conedison.com. Consolidated Edison Company of NY, Inc. is the prime recipient of the SGDP award.

2.2.1 Partners/Subawardees Overview

Siemens and TIBCO have partnered to support the implementation of smart grid application functionality and the secure interoperable services framework.

- **Siemens** Smart Grid (SG) division is part of Siemens Infrastructure & Cities sector. The SG Enterprise Architecture Solutions (SOL) group is executing the Con Edison SGDP integration project. SOL business unit has extensive experience in deploying commercial product solutions for the electric utility industry including: Substation Automation, Metering, Energy Management Systems Distribution Management Systems, Energy Market Management applications, Demand Response Management Systems, Common Model Management Systems, and Enterprise Integration.

- **TIBCO** is a technology leader in providing commercial products for interoperable secure services to real-time systems. TIBCO is partnering with Siemens to integrate and interconnect existing applications, new smart grid applications, and external service connections in a secure industry and standard compliant design. The TIBCO solution products are highly available, scalable, secure and compliant with standard government compliant regulations.

- **Viridity Energy** provides its clients (which are mostly university, commercial and industrial customers) with intelligent decision tools that increase energy savings while creating new revenue streams obtained by participating in various utility and RTO/ISO energy markets. Viridity's unique and flexible VPower™ platform enables customers to dynamically shift, shave and balance energy load; integrate advanced energy technologies; and convert existing energy investments into new revenue streams through integration with power markets. Headquartered in Philadelphia, Pennsylvania, Viridity Energy was founded in 2008.

- **Green Charge Networks (formerly The Prosser Group)** is a company that specializes in energy storage solutions that enable the usage of electrical equipment without causing extreme energy consumption peaks. GCN's systems accommodate local demand for electricity under existing generation and storage capacity restraints. GCN works directly with utility companies and public and private sector organizations. With a special focus on electric vehicle charging, GCN is building practical and deployable advanced electric technologies to reduce energy spending and achieve increased efficiency. Headquartered in Brooklyn, New York, with an office in Huntington Beach, CA, Green Charge Networks was founded in 2007.

- **Softstuf,** founded in 1991, is a Philadelphia based corporation that specializes in the design of advanced analysis systems for measuring performance of large electrical power systems during fault and disturbance conditions. Softstuf is the home of the Wavewin® software and the Sniffer data acquisition tools. Softstuff did not participate in the Phase I demonstration held in March 2012.

- **CALM Energy**, a spinout of Columbia University's Center for Computational Learning Systems, has been developing and deploying Computer-Aided Lean Management (CALM) to help optimize grid operations. CALM Energy is a subawardee in the CECONY Smart Grid Demonstration Project. They did not participate in the Phase Idemonstration held in March 2012.

- **Columbia University's Center for Computational Learning Systems** has been working on research and development projects at Con Edison for over ten years. Columbia University dedicated research resources to develop the Adaptive Stochastic Controller (ASC) for equipment failure prediction, day-ahead load and price forecasts, and optimization of the real options for maximizing energy efficiency and minimizing costs within the Smart Grid. Columbia University is a sub-recipient in the CECONY Smart Grid Demonstration Project. They did not participate in the Phase I demonstration held in March 2012.

- **NYCEDC**, The New York City Economic Development Corporation (NYCEDC) is New York City's primary agent for economic development. Acting under annual contracts with the City of New York, NYCEDC serves as the catalyst for promoting economic development and business growth. The organization's principal mandate is to encourage investment and attract, retain, and create jobs. NYCEDC manages over 17 million square feet of office and industrial space owned by the city. NYCEDC is a subawardee in the CECONY Smart Grid Demonstration Project. NYCEDC will install photovoltaics, battery storage equipment at one of their sites. They did not participate in the Phase I demonstration held in March 2012.

- **Orange and Rockland** - Orange and Rockland Utilities, Inc., a wholly owned subsidiary of Consolidated Edison, Inc., is an electric and gas utility headquartered in Pearl River, NY. O&R and its two utility subsidiaries, Rockland Electric Company and Pike County Light & Power Co., serve a population of approximately 750,000 in seven counties in New York, northern New Jersey and northeastern Pennsylvania. Its system features more than 4,000 miles of overhead electric wires and approximately 2,000 miles of underground cable to accommodate a suburban and agricultural customer base. Orange & Rockland did not participate in the March 2012 demonstration will be participating in the Phase II demonstration only.

2.3 Smart Grid Demonstration Project Overview

The SGDP at Con Edison and O&R intends to demonstrate that the reliability of the grid can be improved through a combination of enhanced monitoring and control capabilities using systems and resources that interoperate over a secure services framework.

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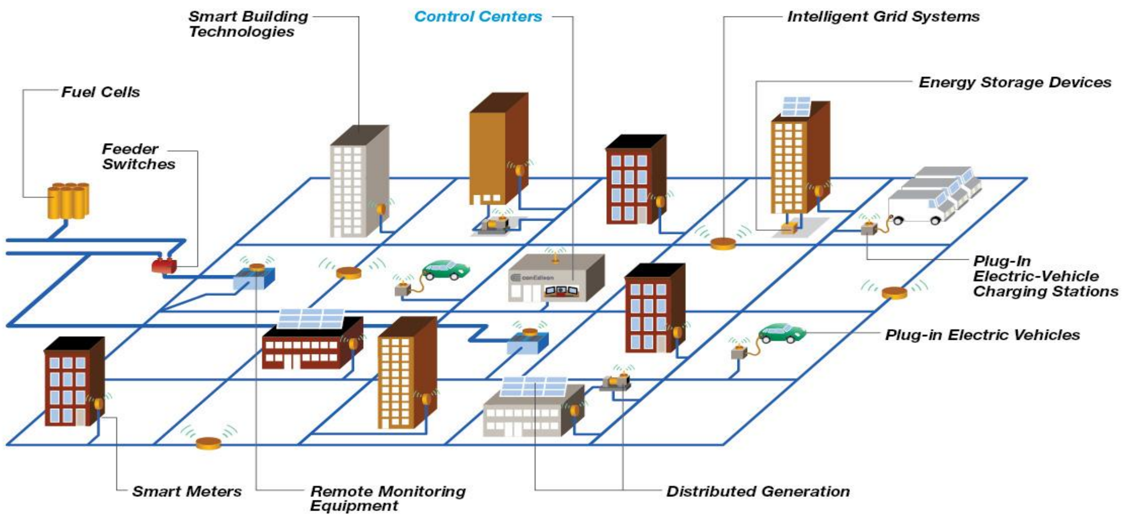


Figure 1: Interoperability of Smart Grid Resources

2.3.1 Coverage Area

The SGDP will be demonstrated within the service territories of Con Edison and Orange & Rockland. Specifically, the project will be demonstrated in boroughs of Manhattan, Queens, and Brooklyn in NYC, as well as in the Orange & Rockland service territory.

Figure 2: Con Edison Service Area

Additional service territory information for Con Edison, Inc. is presented in Table 1.

Con Edison's Service Territory (2010 data)			
Category	**Con Edison Company**	**Orange & Rockland**	**Total**
Total number of customers:			
Residential	2,832,764	260,547	3,093,311
Commercial and Industrial	494,817	40,562	535,379
Other	4,726	630	5356
Electric Transmission and Distribution			
Underground (cable miles)	96,661	1,772	98,433
Overhead (wire miles)	36,818		
Overhead distribution (circuit miles)		3,779	

Table 1 Con Edison's Service Territory

2.3.2 Project Objectives

The objectives stated of the SGDP include:

- Deliver intelligent, autonomous, adaptive, stochastic control capabilities for distributed operations to minimize peak load growth and drive energy efficiency savings throughout the electrical grid.
- Provide world-class cyber security for the Smart Grid.
- Demonstrate open standards and interoperability scalable to vendors of commercially available products in the relevant markets, and to customers and suppliers.
- Maintain electrical system reliability while increasing the utilization of existing equipment.
- Monitor, measure, and verify actual costs versus benefits throughout the project.
- Quantify the cost to access the economic viability and business case of the Smart Grid.
- Be the national blueprint for urban underground network Smart Grid deployment
- Proactively gain public acceptance and educate a new generation of Smart Grid operators, engineers, and managers while executing the project on time, on budget, and with the promised results.

Furthermore, the SGDP Statement of Project Objectives (SOPO) identified the following goals related to Architecture, Interoperability and Cyber Security:

- Improve control capabilities for existing grid assets,
- Determine how to best apply newly developing technologies,
- Minimize peak load growth,
- Improve grid reliability, and
- Provide customers with greater visibility, flexibility and value

The SGDP will demonstrate the capabilities by applying smart grid principles and building upon the existing infrastructure assets via a scalable smart grid prototype, based on open standards, that promotes cyber security.

2.3.3 Project Milestones and Schedule

The following table shows the phases, a brief description and target demonstration dates.

Phase #	Demonstration Name	Demonstration Purpose	Date
Phase I	Demonstration of Integrated System with Long Island City (LIC 1)	Demonstrate strength of preliminary system design	March 27, 2012 (completed)
Phase II	Demonstration of Integrated System at Orange & Rockland	Demonstration of Integrated System at Orange & Rockland	August 30, 2012
Phase III	Demonstration of Integrated System with Long Island City 2 (LIC 2)	Demonstrate feasibility of a truly scalable, secure, interoperable, open Smart Grid.	September, 2012
Phase IV	Demonstration of Integrated System with Con Edison's Energy Control Center Systems	Demonstrate situational awareness across the full energy grid	October, 2012
Phase V	Demonstration of Integrated System with Con Edison's Bowling Green Distribution Network	Demonstrate the optimization recommendations from decision aids	October, 2012
Phase VI	Capstone – Demonstration of Integrated System	Demonstration of previous phases combined	April 1, 2013

Table 2: Project Phases

2.4 Technologies and Systems to Be Demonstrated

The SGDP focuses on interconnecting distributed resources to the distribution system for enhanced monitoring and control with grid benefits to the customer, the utility, and the environment.

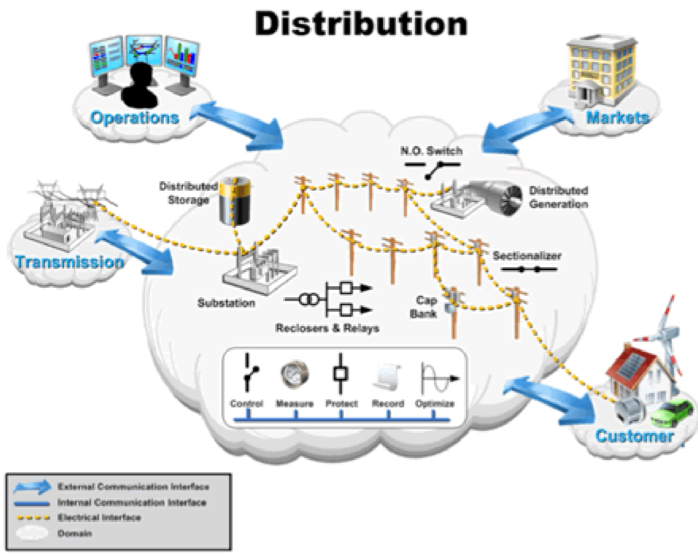


Figure 3 - NIST Smart Grid Conceptual Distribution Domain

The SGDP will demonstrate distribution system monitoring and control by leveraging the advancement in distributed, storage, distributed generation, demand response and load controls using the following Smart Grid technologies:

1) Wide Area Networking Communications Technologies

   The SDGP will demonstrate wide area networking communications technologies from the Distribution system Control Centers to Third Party Providers, and from Third Party Providers to customer sites.

2) Sensor Networking Technologies

   The SGDP has deployed sensor networking technologies at a transmission substation.

3) Demand Response Systems

   The SGDP will deploy a central demand response systems within Con Edison Distribution Conter Centes that will interoperate with Third Party (Network Operations Centers) based demand response systems, that will then interoperate with demand response systems at customer sites.

4) Energy Storage

   SGDP will deploy energy storage solutions at customer sites that will interoperate through a Network Operations Center to Con Edison's Distribution Control Center SGDP systems

The Secure Services Platform at Con Edison has been designed to interface up to 100 Third Party Service Provider NOCs and to support up to 1,000 Demand Response (DR) sites for the SGDP project.

The participants that are focusing on DR sites participated in the Phase I Demonstration. The costs for each site will be derived based on the individual site, the configurations, and the type of interconnectivity needed for the site. Viridity Energy is focused on building a NOC that will interoperate with controllers at buildings to support demand response using load reduction. Viridity Energy is expected to model and connect to 14 buildings as part of the project. Green Charge Networks is focused on establishing NOC and connecting sites with EV charging, PV and battery storage. Green Charge Networks has connected two sites and is expected to connect up to six more sites depending on site requirements.

Technology and Systems that were demonstrated in Phase I – Integrated System with Long Island City

The Phase I SGDP Milestone Demonstration held on March 27, 2012 demonstrated the following functionality:

- Existing Operational Support Systems extended with Smart Grid Demand Response and Distributed Energy Resource Status and Control Capabilities
- Visualization of Smart Grid Functions
- Integrated Building Management Systems, EV Charging Stations, and standby generators
- Secure communications to and from Long Island City, Borden, and Grand Central network curtailable customers

More specifically the March 27, 2012 SGDP Demonstration presented the following functionality and technical solutions.

Smart Grid System functionality:

- Network Distribution System Situational Awareness status integrated with Demand Response Resources
- Network Summary and one-line view of Distribution Network with interconnected DR
- Target Demand Response Curtailment
- Standard Secure Communications to Third Party Service DR providers

Third Party Service Provider functionality

- Demand Response Operations Control Centers
- Standard Secure Communications to Electric Utilities
- Demand Response Curtailment at customer sites
    - Building Management Systems
    - Standby Generation
    - Control of site load with Electric Vehicle Charging, Battery Storage, Photovoltaic

The March 27, 2012 Demonstration showed the following technologies:

- Smart Grid Standards Based Service Oriented Architecture
    - Interfaces
    - Services
    - Communications
- Integration of existing Control Center Information Systems
- Secure Interfaces to external Demand Response Third Party Service Providers
- Secure service interfaces from Demand Response Third Party Service Providers to Controllers and equipment at Customers Sites

- Standards leveraged for Service Oriented Architecture
    - NIST Logical Reference Model
    - IEC Framework
    - Common Information Model (CIM)
    - Third Party Service Provider Interfacing Specifications
- Commercial Off the Shelf Products – non proprietary, standard operating systems, application platforms, service oriented solutions
    - Siemens Web based Visualization
    - TIBCO Business Works
    - EMS (TIBCO Enterprise Messaging Service)
    - Oracle Database
    - Linux, Windows Operating Systems

The March 27, 2012 Demonstration included participation from the following vendors and subawardees:

- Con Edison
- Siemens / TIBCO
- Viridity Energy
- Green Charge Networks
- Innoventive

2.4.1 System Design

The initial SGDP System Design was developed with a secure interoperable services framework that aligns with industry standards (e.g. DOE, NIST, IEC, IEEE) to support interoperating smart grid technologies in support of the SGDP and DOE Smart Grid Regional Demonstration Project Grant objectives.

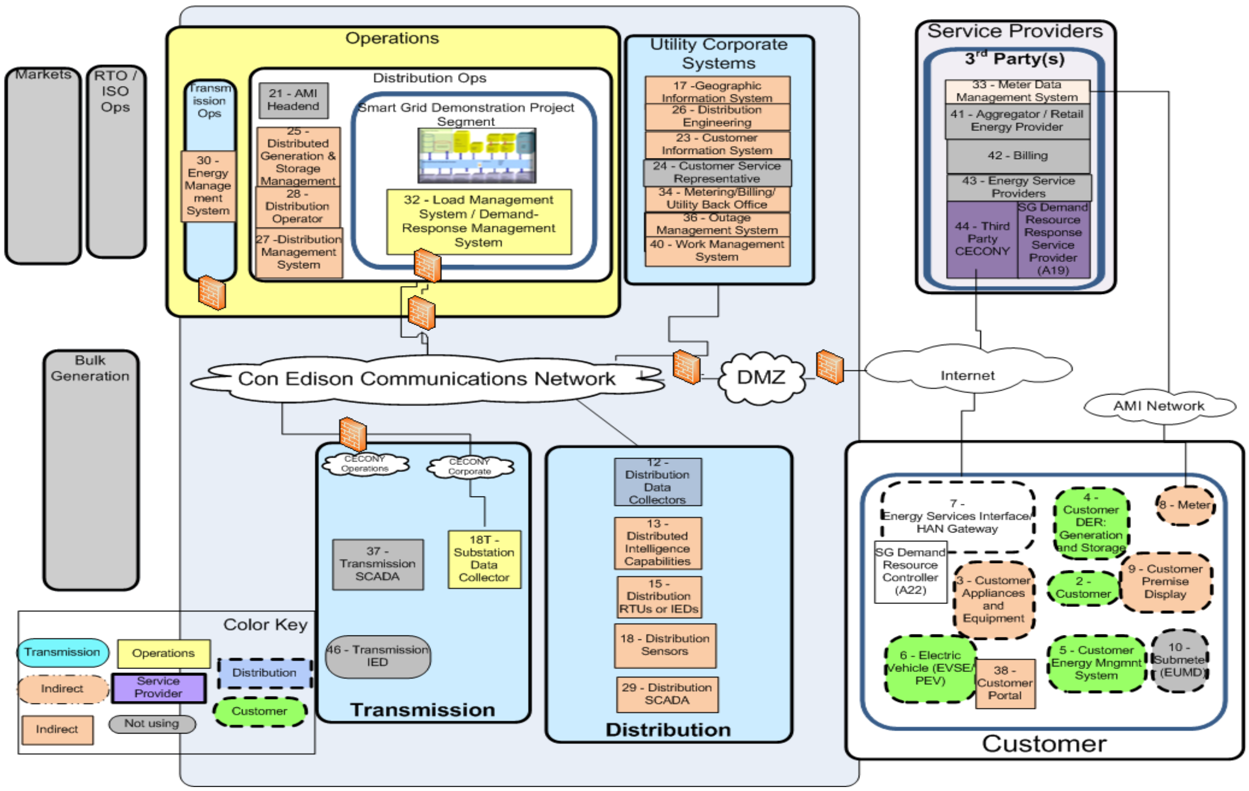


Figure 4 NIST Alignment with System Components

The system design focuses on establishing a secure interoperable service bus that supports a service architecture with new smart grid functionality and legacy systems, as wellas interconnectivity to external resources. The design also supports using virtualization for new smart grid applications where possible and integrating legacy systems on the service bus to enable a service framework.

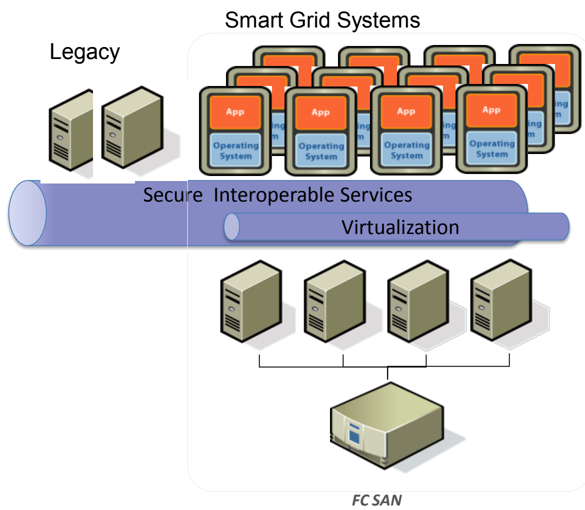


Figure 5 System Design

2.5 DOE Smart Grid Functions and Energy Storage Applications

The SGDP will verify smart grid viability, quantify smart grid costs and benefits and validate new smart grid business models that support interoperability. The central solution of SGDP focuses on establishing a secure services framework within the electric utility that interoperates with external distributed resources at customer sites, directly or through Third Party Service Providers. These solutions allow for a smart grid that interconnects external resources to the existing electric utility controlled distribution system for grid status awareness, targeted curtailment, integrated load flow analysis and capacity planning.

The DOE Smart Grid Functions within the electric utility domain and at customer sites include:

2.5.1 DOE Smart Grid Functions

a. Wide Area Monitoring, Visualization & Control
b. Real-time load measurement & management
c. Real-time load transfer
d. Customer electricity use optimization

2.5.2 Energy Storage Applications

SGDP also interoperates with energy storage applications at customer sites to support has design and will implementing a secure services framework model to support interoperability. These Energy Storage Applications include:

a. Electric Energy Time Shift
b. Electric Supply Capacity
c. Time-of-Use Energy Cost Management
d. Demand Charge Management
e. Renewables Energy Time Shift

2.6 DOE Smart Grid Benefits

The Smart Grid Demonstration Project will offer economic, reliability, environmental, and security benefits based on impact metrics as described in the approved Metrics and Benefits Reporting Plan.

2.6.1 Economic

a. Meet demand growth while reducing need for massive infrastructure expansion
b. Increase customer engagement
c. Transmission & Distribution (T&D) capital and O&M savings
d. Energy efficiency and electricity cost savings
e. Reduced ancillary service costs and capital and OEM expenditures
f. Reduced congestion costs
g. Optimized generator operations

2.6.2 Reliability

a. Enable targeted curtailment
b. Sustain unparalleled reliability
c. Reduced:
   - power interruptions
   - equipment failures
   - distribution operations costs
   - sustained outages
   - restoration costs
   - momentary outages
d. Improved
   - power quality
   - asset utilization

2.6.3 Environmental

- Reduced air emissions
- Reduced carbon dioxide emissions
- Reduced SOx, NOx, and PM-2.5 emissions
- Reduced oil usage

2.6.4 Security

- Provide world-class cyber security for the Smart Grid
- Provide secure interoperable services between Electric Utility Distribution Systems and Distributed Response Resources at customer sites

2.7 Technical Approach for Achieving Interoperability and Cyber Security

The SGDP technical approach for achieving interoperability and cyber security initiated with the development of services architecture to meet the project objectives. The architecture design started with SGDP use cases derived from the project objectives. Stakeholders drove the services architecture and technical and functional requirements. The process aligned the architecture with the NIST 1108 conceptual framework and IEC smart grid roadmap to identify domains, actors, and services within the Smart Grid domains. The SGDP interoperability requirements were aligned with NIST 7628 and IEC specifications, and cyber security requirements were driven by NIST 7628 Guidelines for Smart Grid Cyber Security, NIST 800-30 risk management, secure controls and monitoring.

This process resulted in a SGDP Architecture, Interoperability, and Cyber Security framework that was shared, reviewed and updated by Con Edison technology departments, the SGDP subawardees/vendors and the DOE. (Refer to Appendix C)

2.7.1 SGDP Architecture

The SGDP project team focused on developing an architecture design based on open services architecture support interconnectivity between legacy systems and new smart grid applications, interoperability with external demand response resources. As noted above, the approach for achieving interoperability and cyber security was based on aligning the SGDP applications, functions, services and interfaces with the NIST and IEC reference architectures to develop SGDP reference architecture. This process identified smart grid functions, common services and data flows in alignment with the reference architectures so that available standards could be identified and applied.

The SGDP architecture integrates standardization using the electric power transmission and distribution Common Information Model (CIM) adopted by the IEC with the transmission components defined within IEC 61970-301 and extensions for distribution system under development within IEC 61968 and substation automation within IEC 61850.

The SGDP services architecture was defined by the SGDP team in concurrence with Con Edison Technology Services, internal stakeholders, the SGDP subawardees/vendors, NIST, DOE, and vendors.

The SGDP architecture design is based upon open services architecture to support interconnectivity between systems and services. The implementation requires a Smart Grid Secure Interoperable Service bus to support standard service interoperability between Smart Grid Systems. As noted above the approach for achieving interoperability and cyber security was based on aligning the SGDP applications, services and interfaces with the NIST and IEC reference architecture to develop a SGDP reference architecture. This process identified smart grid functions, common services and data flows in alignment with the reference architectures so that available standards could be identified and applied. The SGDP architecture integrates standardization using the electric power transmission and distribution Common Information Model (CIM) adopted by the IEC with the transmission components defined within IEC 61970 and extensions for distribution system under development within IEC 61968. Interface definitions will be based upon the IEC CIM data model where possible. This includes discovery of interface attributes, mapping into the IEC CIM data model attributes and generation of concrete service implementation artifacts such as XSDs and WSDLs.

These service definition artifacts are implemented as services within the ESB services integration layer, and within application adapters where applicable, which abstract application business functions and makes them available as services for use by other external applications. The web services implemented follow standards defined by standards organizations such as the W3C (World Wide Web Consortium) and OASIS (Organization for the Advancement of Structured Information Standards), SOAP (Simple Object Access Protocol), XML (Extensible Markup Language), etc.

The goal of such standards compliant services are to help integrate legacy control center applications, new smart grid applications, external IT applications and other external participating entities. As these services are well defined and standards compliant, other applications who wish to use them are free to implement them. Note however, that testing and security are controlled and coordinated with our approved subawardees/vendors.

SGDP Technical Approach Overview

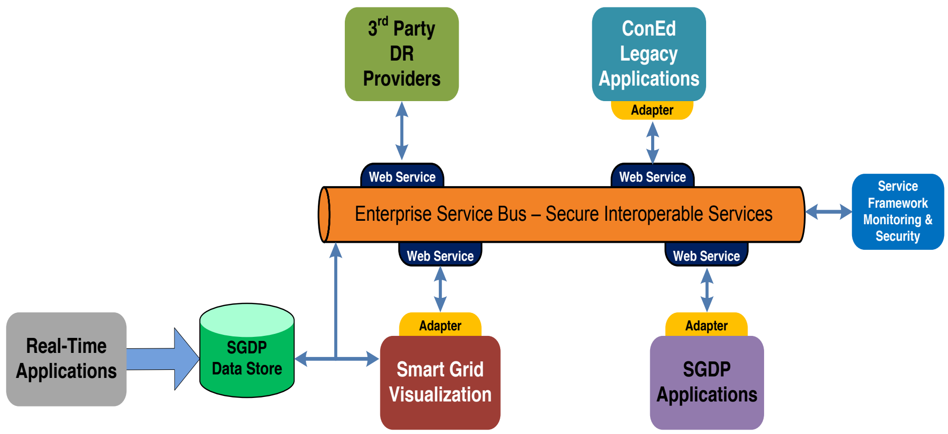


Figure 6: SGDP Technical Approach Overview

The technical approach for the smart grid systems within Con Edison were then extended to external systems outside of Con Edison.

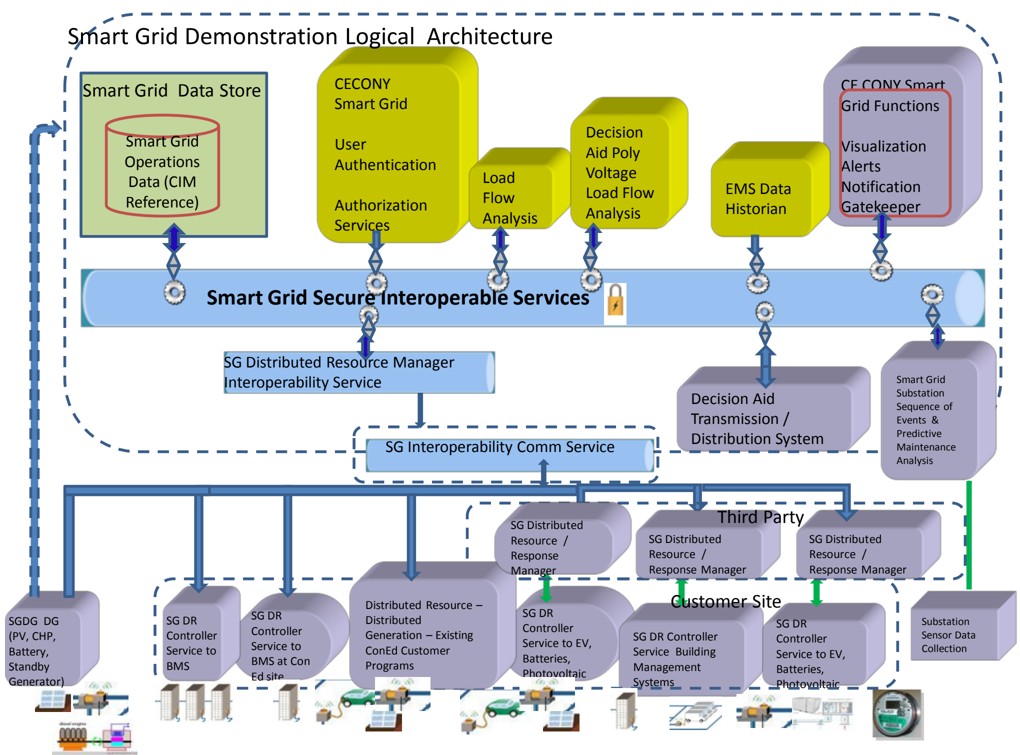


Figure 7: SGDP Logical Architecture

The applications and services defined within the architecture were mapped to the applications and services in NIST and then mapped to vendor solutions. See Appendix G Applications and Services.

The interoperability and cyber security requirements were integrated into the design of the system.

2.7.2 SGDP Interoperability

The SGDP Interoperability was designed based on a service oriented framework with extensions to the existing Con Edison enterprise platform. The interoperability requirements were aligned with the NIST and IEC Smart Grid Frameworks identified. The applications and services identified within the Smart Grid Demonstration logical architecture were mapped to the Applications/Actors in NIST 7628. The interoperability framework was then defined based on the interfaces between Applications/Actors within the NIST 7628 and the IEC Frameworks. This enabled SGDP to apply the guidance from 7628 to the interfaces and services and to utilize existing standards.

2.7.3 Cyber Security

Cyber Security solutions were identified based on the service oriented framework aligned with NIST 7628 guidance, Con Edison cyber security policies and procedures, and cyber security guidance from DOE, NIST, NERC, NETL, and other standards bodies. Smart Grid cyber security risk management processes have been developed and will be hardened as smart grid standards and smart grid cyber security frameworks are further defined by the DOE and NIST.

A high level risk analysis was applied to SGDP architecture, and the connectivity to Third Party Service Providers and Customer sites was determined to be of highest risk. Consequently, for the first phase, the SGDP retained Booz, Allen Hamilton to develop a SGDP cyber security framework for the implementations. Third Party Service Providers utilized the Third Party cyber security framework to design and implement cyber security solutions from Third Party Network Operations Centers to customer sites, and at customer sites. Subsequent reviews will be performed to ensure cyber security compliance.

2.8 Stakeholder Interaction During Project

The SGDP stakeholders in this project include the subawardees and vendors identified in Section **Error! Reference source not found. Error! Reference source not found.**, as well as internal partments at Con Edison including Energy Efficiency, Electric Operations, Distribution Engineering, Information Resources, and Systems Operations. In addition, the SGDP team is interacting with the Department of Energy, NIST, and other organizations participating in Smart Grid standards development.

3 Technical Approach

Con Edison's SGDP team leads the functional and technical design of SGDP with collaboration from all participants, stakeholders, standards bodies, and customer sites. The SGDP Architecture, Interoperability and Cyber Security Plan provided the overall secure services framework for designing the applications, services and interfaces necessary for SGDP deployment.

The SGDP participants focused on developing and building their applications, services, and interfaces in accordance with the overall design. Within Con Edison, the application, services, and data owners support the SGDP implementation by extending, integrating or interconnecting their existing applications, services, and data into the SGDP service framework. Most importantly, existing systems and data are leveraged to integrate with new smart grid functions and systems. For example, existing Distribution System Network Maps are used with elements displayed on standard SVG graphic displays. In addition, real time status of Distribution System components are received from real-time systems and integrated with the status of the new Smart Grid interconnected Distributed Resources.

SGDP participants focused on deploying Third Party Service Provider applications built out their network operations control centers to meet SGDP requirements including status notification and curtailment requests. In additional the Third Party Service providers built their site specific DR deployment with controllers that interact with site resources including building management systems, electric vehicle charging and battery storage. We also integrate standby generation from DOE Demonstration project DE-FC26-08NT0689.

Development and test environments have been designed to support concurrent development efforts by participants. The demonstrations will add functionality and technical capabilities incrementally to support the demonstration objectives. In the first demonstration held on March 27th 2012, we were able to show the integration efforts of Con Edison and its partners. During the demonstration a control room operator was able to view a newly developed visualization platform that integrated existing operational support systems with Smart Grid control capability. Through this platform the operator was able to initiate demand response at customer facilities through three newly developed network operations centers.

Con Edison's SGDP deployment plan includes the following key steps:

1. Initial steps
    a. Use Cases developed to support SGDP Statement of Project Objectives
    b. SGDP Architecture, Interoperability, and Cyber Security Plan developed based on use cases, project objectives, NIST 1108, NIST 7628, IEC 61850 frameworks within a service oriented framework
    c. Participants developed architecture, interoperability, and cyber security solutions and preliminary designs to interoperate with SGDP Architecture, Interoperability, and Cyber Security Frameworks
2. Model or simulation design and development
    a. Con Edison and key participants developed models and simulated designs based on initial architecture, interoperability, cyber security and application requirements in alignment with NIST 7628 and IEC Frameworks
    b. Design and model reviews held to support iterative design solutions
    c. Preliminary model and design developed and tested for three DR sites in support of LIC 1 Demonstration 1 held on March 27, 2012
    d. Design reviewed and updated
3. Communications system design and development
    a. Communications systems initial design derived from architecture, interoperability and cyber security framework
    b. Communications systems design mapped to interfaces defined in NIST 7628 and IEC 61850
    c. Communications design further mapped to service oriented framework defined within IEC Smart Grid Service Oriented Architecture
    d. SGDP internal communications requirements mapped for SGDP segment service offering
    e. SGDP internal to external Third Party and Customer sites mapped to support DR status and DR curtailment functions
4. Interoperability considerations
    a. SGDP interoperability design was based on SGDP Architecture, Interoperability, and Cyber Security Plan

   b. Interoperability between Smart Grid Actors, Applications, and Interfaces were mapped in accordance with NIST 7628 and IEC Smart grid roadmaps
   c. Interoperability standards were identified and applied where applicable
5. Data management considerations
   a. Data management considerations have been derived from the SGDP Architecture, Interoperability and data sourcing requirements
   b. Data management was further refined in alignment with NIST 7628 data flow solutions
6. Cyber Security considerations
   a. Cyber Security is a major factor in SGDP design. The SGDP Architecture, Interoperability, and Cyber Security Plan addresses cyber security within the SGDP
   b. Cyber security has been integrated into all aspects of the software development lifecycle (SDLC)
   c. Cyber Security requirements in support of authentication, authorization, and all access controls are being identified and designed within a Cyber Security Architecture Framework that supports inter-domain security in accordance with NIST 7628 and IEC, etc.

Test Plans

SGDP will be testing all technologies and systems identified for deployment within the SGDP solution set. The initial verification of the technical design and test of technologies was presented during the first demonstration conducted on March 27, 2012. During the next phases of the project we will refine the design, technologies, and solutions and develop test plans for each technology and system.

SGDP Project Plan

The SGDP Project Plans monitor all participant project plans and track critical milestones and dependencies to support the SGDP System development.

SGDP Test Plan

The SGDP project team leads Smart Grid System testing for integrated functionality while each participant develops test plans to support independent system efforts.

SGDP Benefits and Results

SGDP benefits and results are collected at the SGDP project level as well as for each SGDP Participant.

3.1 Con Edison

3.1.1 Con Edison Project Plan

Smart Grid Scoping, Functional, Technical Design

The Con Edison SGDP team leads the overall SGDP scoping, functional and technical design of SGDP systems and functionality required for the Con Edison demonstrations. O&R leads the overall SGDP scoping, functional and technical design of SGDP systems and functionality associated with the O&R demonstrations.

3.1.1.1 Smart Grid Functional Requirements

Con Edison SGDP team leads the functional requirements gathering with Con Edison internal stakeholders (e.g. Energy Efficiency, Electric Operations, Engineering, etc.) and Participants for Smart Grid functionality within Con Edison. Participants from Third Party Service Providers lead the functional requirements and designs for Third Party NOC and customer sites.

3.1.1.2 Smart Grid Technical Requirements

Con Edison SGDP team leads the technical requirements Con Edison internal Information Resources Technology Services and support teams, and Participants to develop technical designs to support Smart Grid functions within Con Edison. Participants from Third Party Service Providers lead the technical requirements and designs for Third Party NOCs and customer sites.

3.1.1.3 Smart Grid Development Environments

SGDP Development Environments will be established at all SGDP sites

3.1.1.4 Smart Grid Technical Design, Interoperability and Cyber Security

SGDP Technical Design, Interoperability and Cyber Security solutions and designs are reviewed at every stage of the project for all systems within the SGDP framework

3.1.1.5 Smart Grid Test Environment

SGDP Test will be established at all SGDP sites

3.1.1.6 Smart Grid Testing

SGDP Testing of Smart Grid Functions and Systems will be planned and results will be analyzed

3.1.2 Data Collection and Benefit Analysis

As systems are enabled in the test environment preliminary test data is collected and analyzed to verify system design and to initiate benefit analysis.

After facilities are made operational, project data will be collected for analysis and validation of the project. Real-Time Load Measurement & Management and Customer Electricity Use Optimization are the two main benefits that will be achieved through Viridity's VPower's system.

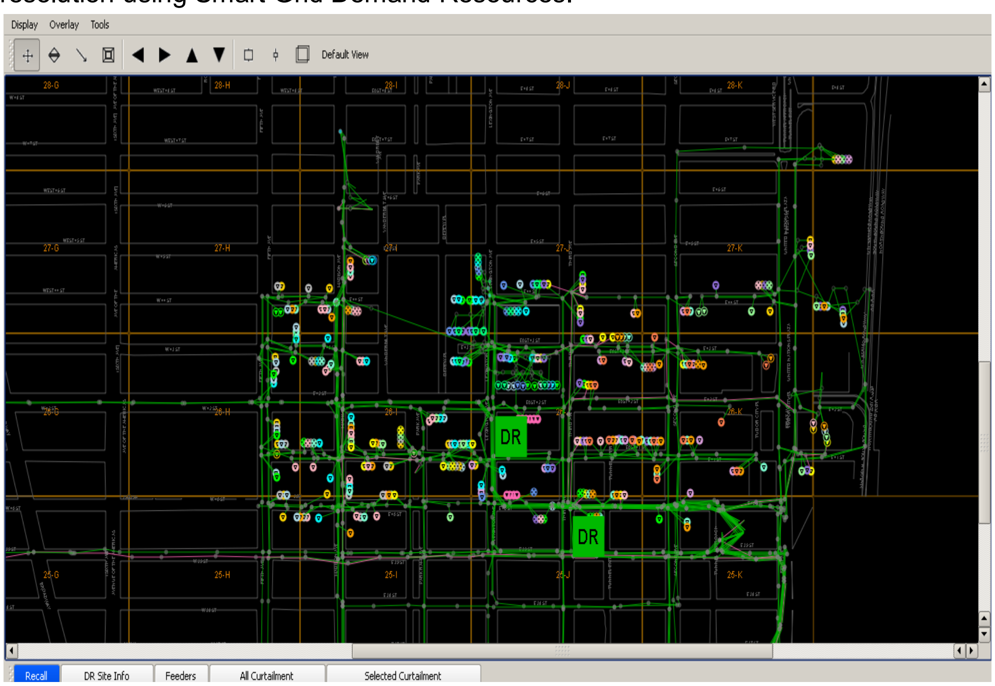
3.2 Siemens/TIBCO

The Siemens/TIBCO commercial products provide the vendor solutions for the supporting secure services framework and the Smart Grid Functions within Con Edison's Distribution Control Center. These products consist of commercially available software and technologies. In addition, Siemens and TIBCO are using adapters to help bridge the interfaces between legacy applications and the TIBCO ESB environment. Siemens / TIBCO solutions provide the vendors solutions to support the framework for the SGDP technology

3.2.1 Siemens / TIBCO Project Plan

3.2.1.1 Develop Visualization

The Smart Grid Visualization provides Control Center Operators with a visual representation of Smart Grid options for analysis or for contingency load resolution using Smart Grid Demand Resources.



3.2.1.2 Develop Smart Grid DR Interoperability Service

Smart Grid DR Secure Interoperable Services interoperate with Third Party Providers that provide Smart Grid Demand Resource Status and handle curtail load requests.

This service was designed using CIM utilizing communications protocol that can be utilized by our three Smart Grid Demand Resource Service Providers - Viridity, Prosser, and Innoventive.

3.2.1.3 Develop Authentication and Authorization Service

The Smart Grid Authentication service support Smart Grid system user and system authentication. This service interoperates with existing corporate and control center authentication systems. Authorization supports role-based access controls and profile based system authorization.

3.2.2 Data Collection

The SGDP architecture design also includes a SG Data Store for operational smart grid data generated by the Smart Grid systems and data loaded from external systems including corporate, distribution and transmission system generated data. In addition, system monitoring data will also be stored and used in future analysis.

For example, all data required for Visualization (i.e. GIS data, DR/DG status, DR/DG curtailment data, corporate data, customer data, etc.) will be stored in the Shared Data Store operational database.

3.3 Viridity Energy

Through their VPower system, Viridity provides commercial customers with opportunities for supply savings and new revenue streams from retail and wholesale energy programs while at the same time allowing these customers to support Con Edison for grid relief at the distribution feeder level.

3.3.1 Project Plan

Viridity is modeling multiple sites for the project. Those sites include the New York City Economic Development Facilities (Brooklyn Army Terminal, Brooklyn Cruise Terminal), Rudin Management and Paramount Group office complexes, and CUNY facilities (LaGuardia Community College). The steps taken in this process are listed below.

3.3.1.1 Develop Building and Resource Models

Gather building data as input to the thermodynamic building models for all buildings in the project. Capture the building model in VPower™ as a key input to the optimization process. Data from these sites is being collected for development of the model in the VPower™ system. The models are being validated by running a number of optimization scenarios against real-time, day ahead and weather forecasts, comparing the resulting optimized schedule against the business as usual load profile and validating the same against actual meter data.

3.3.1.2 VPower to Building Management System (BMS) Integration

Viridity is designing and implementing a communication interface between VPower™ and the building management system (BMS). Data exchange requirements are identified and the interface is being implemented and tested. Also included in this task is the development and implementation of any additional user interface screens or displays required for the operation of the VPower™ system. The communications interface between VPower and Building Management System (BMS) at each building must be integrated to capture building data (return air temperature, meter data) and send curtailment signals as shown in Figure 4 below.

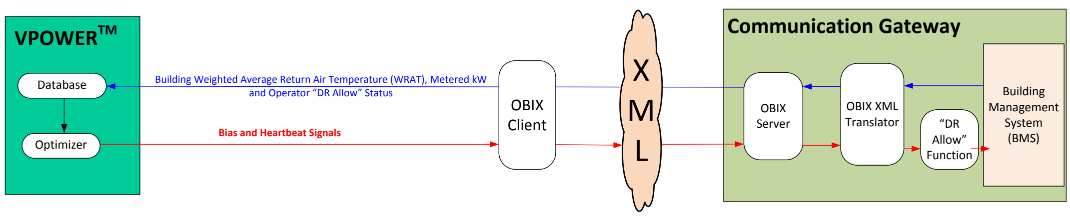


Figure 8: VPower BMS Interface

3.3.1.3 Configure VPower to Con Edison Messaging Interface

A key deliverable for this project is the integration of the messaging interface between Viridity Operations and the VPower™ system and Con Edison's Control Center. The interface involves generating a design, defining all data elements and data maps required in order for the systems to operate together, followed by the development, testing and implementation of the interface itself. Viridity will expose an external SOAP web service interface that will provide a two-way message exchange between Viridity and Con Edison for the purpose of executing various demand response related tasks. The message exchange will employ the use of message encryption and decryption (through VeriSign certificates, public and private keys), secure transport (HTTPS), and user authentication to ensure a secure message exchange and to verify the identity of the participating parties. Encryption and decryption algorithms employed for the message exchange will be specified by Con Edison.

3.3.1.4 VPower to NYISO Interface for Price Forecasting

Viridity is developing the components necessary to interact with the NYISO Market and to have the selected sites participate in NYISO's demand response offering. This involves developing requirements and implementing the necessary components and price forecasting algorithms that will allow Viridity to interact with various NYISO Market programs. Proprietary algorithms and software applications are used within VPower to generate energy market forecast prices in VPower's optimization process.

3.3.1.5 Conduct Routine Operations of VPower System with all locations

Viridity's Network Operations Center (NOC) will use VPower to facilitate the operation of these locations from the time we interface through the duration of the project. During that time it is anticipated that there will be refinements to the model integration points (BMS, Con Edison Control Center, NYISO and reporting tools). Viridity will use VPower to optimize all the project buildings energy opportunities for a revenue stream from wholesale and retail energy market programs. During this Viridity will be gathering data and analyzing and reporting on the economic benefit to the customers.

3.3.2 Data Collection and Benefit Analysis

As facilities are made operational, project data will be collected for analysis and validation of the project. Real-Time Load Measurement & Management and Customer Electricity Use Optimization are the two main benefits that will be achieved through Viridity's VPower's system.

To evaluate an individual client's market opportunity, Viridity uses a forward predicting baseline methodology to determine approximate load. Viridity also calculates the client's optimized load based on their available energy assets and operational limitations and constraints. As displayed in Figure 9 below, the economic benefit occurs at the points when the optimize load (green) runs below the forecasted business as usual load (orange). Figure 9 also overlays LBMPs (blue) since the greatest economic value has a strong correlation with higher prices. Viridity then tracks the clients' total economic benefit as the estimated avoided cost through energy savings plus any market revenue achieved.

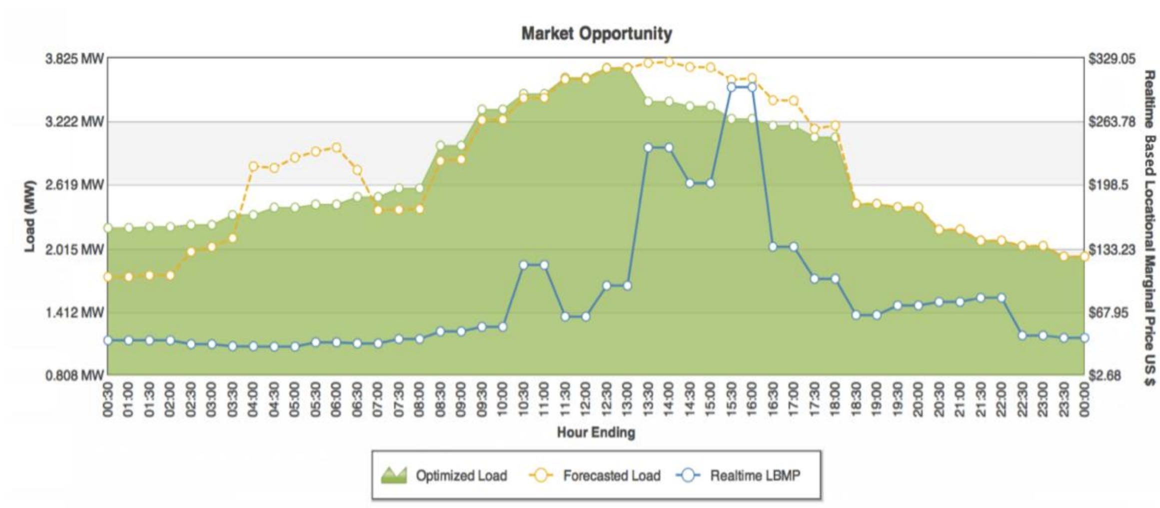


Figure 9: Economic Benefits of Data Collection

Viridity is collecting data continuously as buildings are modeled and analyzed for potential smart grid connectivity. Detailed data for all modeled buildings is used for analysis. Currently Viridity is monitoring six buildings and is in the process of modeling and analyzing new building sites.

3.4 Green Charge Networks / Prosser

GCN's technical approach looks to address the issue of peak demand as it affects utilities as well as commercial consumers. Among the core questions being addressed is whether or not a commercial system can be developed to compliment both the business' desire for lower energy costs and the utility's need limit peak demand and costly upgrades while providing reliable service.

3.4.1 Project Plan – Green Charge Networks/The Prosser Group

To solve these problems, GCN is installing a system of integrated customer energy storage systems. They will operate these systems utilizing their Business Rules Knowledge Engine (BRKE). The steps required to achieve effective deployment include:

3.4.1.1 GCN NOC and site design

GCN developed a NOC to support Third Party Service interfacing between Con Edison and GCN sites equipped with EV charging, battery storage and PV. GCN monitored and modeled facility power loads to determine battery size and inverter sizes required. GCN/Prosser implemented a decision aid at the site to support load leveling and to avoid demand charges.

3.4.1.2 Communications system design and development

GCN uses standards-based communication frameworks, such as CANOpen and Modbus, for internal communication between hardware modules. The design principal is to maximize reusability and compatibility with current and future hardware modules.

3.4.1.3 Interoperability Considerations

GCN uses open standards wherever possible for hardware and software modules in its solution. Standards implemented in the overall solution include: CANopen, Modbus, XML RPC and others.

3.4.1.4 Data Management considerations

GCN's Network Operations Center is a cloud-based solution that scales upwards as installation footprint increases.

3.4.1.5 Cyber security considerations

GCN designed its communications system by following NIST 7628 guidelines and the cyber security framework developed by the Con Edison SGDP team with Booz Allen Hamilton in accordance with the Security Profile for Demand Response v. 1.0.

GCN Systems that support interoperability with distributed resources include: GS Network Operations Center (GSNOC) and SSGU Field Assets.

SSGU Load Leveling Test	15 min	Issue Load Leveling command from GSNOC. Input Parameter: Duration, Load Set Point (kW)	Data: SSGU site building load data, SSGU Dpg output data, SSGU EVSE output data. System Logs.
Demand Response GSNOC with SSGU Integration Test	15 min	Issue Curtailment request from GSNOC. Input Parameter: Duration, Curtailment Amount (kW)	Data: SSGU site building load data, SSGU Dpg output data, SSGU EVSE output data. System Logs.
Full Demand Response Con Edison Secure interoperability Test	15 min	Con Edison to issue Curtailment request from Con Edison operations center Input Parameter: Duration, Curtailment Amount (kW)	Data: SSGU Curtailment Status, SSGU site building load data, SSGU Dpg output data, SSGU EVSE output data. System Logs.

Table 3: GCN Smart Grid Functional Interoperability Tests

3.4.2 Data Collection and Benefit Analysis

GCN stores all performance metrics from Smart Storage Generation Units (SSGUs) in the lab as well as in the field. Raw data is collected from Energy Monitoring Systems (Power Consumption), EVSEs (Power Consumption), and Distributed Power Generation units (Power Output/Consumption, Operating Temperature, Operating Voltage, State of Charge). The raw data is stored in GCN's proprietary data warehouse and is available for consumption and analytics.

There is currently only one SSGU that is in operation, and it has been in operation for approximately one month thus there is no significant continuous operational data. The Demand Response operational capabilities have only been used in demonstration of the Smart Grid project.

In its grid-connected lab setting, GCN has demonstrated the benefits of operating the energy storage system to offset the charging impact from a vehicle charger. Figure 10 below shows how the energy storage unit discharge can offset a Level III charger. The Eguage curve (in blue) represents the Lab building load while the red curve represents the load drawn by the Level III charger.

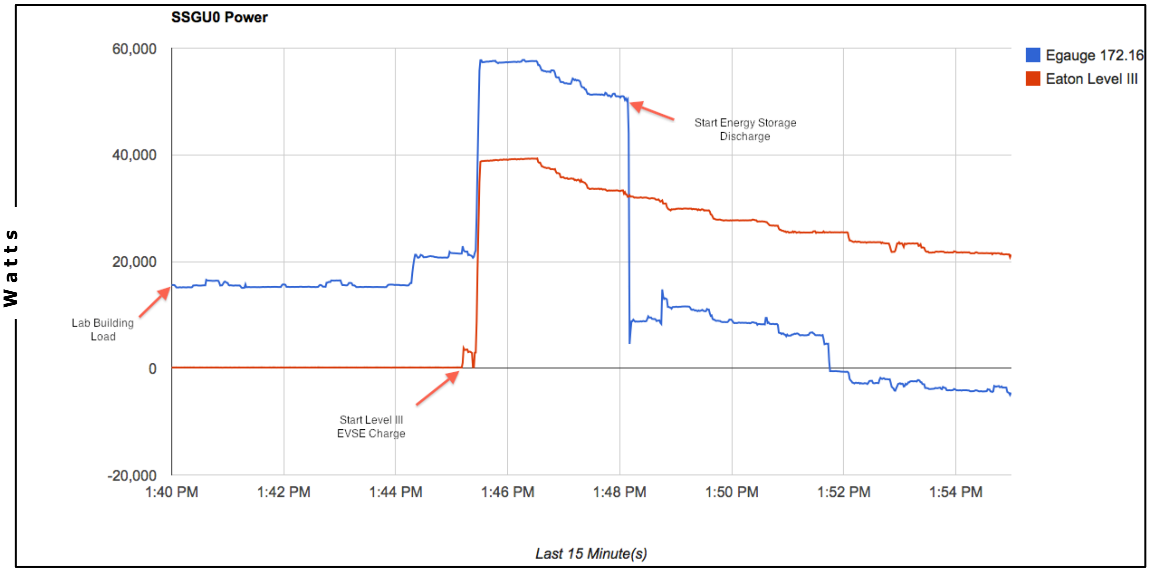


Figure 10: Preliminary testing of SSGU integrated energy storage system

The offsetting feature shown is meant to benefit the customer in terms of controlling demand charges so as not to negatively affect the customer's billing. As more data is collected from the continuous operation of this technology we will be able to better quantify all the effects to customers.

3.5 Softstuf

Softstuf is providing Con Edison with an Artificial Intelligence (AI) system for automated analysis of waveform captures from TIS sensors at Farragut (hereinafter, Disturbance Monitor). The Disturbance Monitor will provide accurate, informative sequence of events reports to support system operators in providing rapid responses to power system events. The Monitor will also provide predictive maintenance reports to alert operators of potential equipment failures permitting early intervention by equipment engineers and technicians. In addition, the Monitor will integrate with the Con Edison Wavewin program to allow for collection and analysis of waveform captures from sources other than the TIS sensors including but not limited to numerical relays, digital fault recorders, phasor measurement units, and power quality monitors.

3.5.1 Project Plan - Softstuf

The Disturbance Monitor monitors CTs, fault currents, circuit breakers, transformers, open autos, and three phase metering. The following subsections provide a high level overview of these applications.

1) CT Saturation:

AC captures from protective relay systems will be analyzed for CT saturation. The captured waveform signatures will be compared against manufacturer specifications and against other CTs on common equipment. A deviation report will be created alerting operators of potential trouble. A severity level would be assigned as an aid to determining response.

A summary report and the corresponding waveform plots will be created for review by the equipment engineer. An "on demand" analysis process will also be added to permit periodic assessment of CT behavior. This would facilitate manual CT testing under outage conditions (during trip checks) for a more thorough assessment in determining saturation characteristics.

2) Circuit Breaker Monitor:

The Monitor will automatically extract, align, and merge all of the relevant waveform signature captures from the TIS sensors each time a breaker is operated. The resulting waveform will be cataloged and analyzed for breaker dynamic timing.

The Monitor will maintain a library of trip and close coil signatures for comparison over time to detect deviation and identify slow breaker operations.

Some breakers have individual phase trip and close coils. The time between phase operations can cause imbalances and is indicative of poor breaker performance. The Monitor will calculate the delta time between phases and will provide an exception report along with the waveform captures for evaluation by the equipment engineers whenever the delta time exceeds the preset triggers.

Currents through breaker ancillary equipment such as compressors and heaters will be measured and compared against manufacturer specifications. An exception report will be created along with the corresponding waveforms for evaluation by equipment engineers whenever the measurements are not within specification.

Phase currents through the breaker will be monitored during trip/close operations in order to determine the state of the main contact integrity.

The Monitor will maintain a record of fault current interruption waveforms. This will serve as an evaluation tool for equipment engineers to determine breaker wear.

3) Open Auto Events:

Protective relays are designed to operate for equipment fault conditions. However, open auto events may be caused inadvertently by personnel or may be caused by malfunctioning protective systems and failed equipment. To that extent, accurate and timely reporting of protective relay targets is of primary importance in reliable, safe, and efficient operation of the power system. The Disturbance Monitor will provide system operators with sequence of events reports including but not limited to relay targets and fault location information.

The trip event notification interface will provide system operators and relay protection engineers with drill down capabilities to quickly retrieve sequence of events reports or waveform signatures with accurate time stamps. The Disturbance Monitor will also provide advanced waveform analysis capabilities to assist relay and equipment engineers in manually determining the root cause of each event (fault, no fault).

3.5.2 Data Collection and Benefit Analysis - Softstuf

Upon installation of the needed sensors and supporting equipment and pending completion of the AI development campaign, the proposed Disturbance Monitor will be installed and commissioned at Farragut. After a successful installation at Farragut, reports and waveform captures from the Disturbance Monitor will be automatically transferred, in near real time, to a shared file server on the Con Edison network. Access to the shared file server contents will be provided to a selected group of operators and engineers for initial evaluation and validation purposes. As this data becomes available the achieved benefits can be analyzed.

4 Results – SGDP

On March 27, 2012 the Con Edison Smart Grid project team and participants hosted the Secure Interoperable Services DOE DE-OE0000197 Demonstration of Integrated System with Long Island City at Con Edison's 4 Irving Place headquarters building for Con Edison stakeholders, the Department of Energy, the NYS Public Service Commission and NYSERDA.

In this first demonstration, Con Edison and Participants demonstrated operator situational awareness and targeted response for Smart Grid interconnected Demand Response Resources on the Con Edison Distribution Network. The Operator demonstrated Smart Grid targeted curtailment by selecting and requesting load curtailment for specific Demand Response Resources and monitoring near-real time status of the load curtailment and the impact on the grid. The SGDP Third Party Service Providers Demonstrated the communications processing of the requests for curtailment at their Operational Control Centers and the resulting load reduction at the customer site.

The demonstration tested the technology that had been designed and implemented at Con Edison, the Third Party Service Providers and Customer Sites.

Con Edison collected the data for the distribution system and the network loads and status of the networks associated with the three specific sites that were tested.

Each Third Party Service Provider collected data at their respective NOCs and the customer sites. The communications of the DR status messages to Con Edison were verified and the demand response request messages that were sent to the Third Party Service Providers were also verified. The load at the customer site was monitored and the demand response was measure for load reduction and in at the two sites where local site load generation started to off set generation the generation load was measured.

The metrics were collected and the benefits for the specific sites were analyzed.

The benefits for Con Edison's distribution system networks were not tallied as there were only three DR sites that were tested in three networks and these represented a small fraction of network load. However, the ability to leverage existing systems to monitor and control DR resources was demonstrated. In future demonstrations, the technology will be extended to support functionality identified within the functional requirements and services will be extended to support additional capabilities within Con Edison, at Third Party Service Provider NOCs, and Customer Sites.

As additional DR sites are connected, the technical design will be tested and extended and after the Phase IV demonstration measurements will be collected to support capacity estimates, and response times, etc. In addition, Cyber Security will be monitored and reviewed to ensure the technical solutions meet the cyber security requirements identified in the design.

5 Conclusions

The initial SGDP design was verified during the Phase I Demonstration on March 27, 2012 that presented the SGDP secure services interoperability framework with interconnectivity to external demand response resources through Third Party Interface Providers.

Additional functionality and technical capabilities will be built out from the initial design and verified in subsequent demonstrations.

6 Contacts

Key Recipient:
Con Edison, Inc.
4 Irving Place
New York, NY 10003
Thomas Magee, General Manager, Smart Grid Implementation Group, mageet@coned.com
Patricia Robison, Project Manager, robisonp@coned.com
Andre Wellington, Project Specialist, wellingtona@coned.com

DOE project contact:
Tom George
National Department of Energy, Technical Project Officer
Thomas George
Project Manager
National Energy Technology Laboratory
3610 Collins Ferry Road
Morgantown, WV 26507-0880
304-285-4825
Tom.George@netl.doe.gov

Appendix A: References

Con Ed Corporate Documents
Con Edison and O&R Information Security Policy
Con Edison Smart Grid Regional Demonstration Project Cyber Security Plan
COMPUTER DATA SECURITY Corporate Instruction -310-2 September 14, 2009
310-4 Use of Technology Systems (May 17, 2010)
Information Security Policy
Cyber Security Program Manual
LAN Administrators Guide

Document
21 Steps to Improve Cyber Security of SCADA Networks, The President's Critical Infrastructure Protection Board; Office of Energy Assurance U.S. Department of Energy 202/287-1808 Office of Independent Oversight and Performance Assurance U.S. Department of Energy 301/903-3777
310-2 Computer Data Security (September 14, 2009)
310-4 Use of Technology Systems (May 17, 2010)
American Recovery Act & Reinvestment Act
American Recovery & Reinvestment Act Cyber Program Elements/Cyber Risk Management & Assessment
American Recovery & Reinvestment Act Cyber Program Elements/Development Lifecycle
Announcement Type: Initial Announcement CFDA Number: 81.122 - Electricity Delivery and Energy Reliability Research, Development and Analysis Issue Date: June 25, 2009
Catalog of Federal Domestic Assistance: Announcement Type: Initial Announcement CFDA Number: 81.122 – Electricity delivery and Energy Reliability Research, Development, and Analysis Issue Date: June 25, 2009
Catalog of Control Systems Security: Recommendations for Standards Developers U.S. Department of Homeland Security, June 2010
COSO ERM Risk Management Framework
Computer Fraud and Abuse Act of 1986 (Pub. L. 99-474)
Critical Infrastructure Protection Reliability Standards (CIP 002 through CIP 009)
Cyber Space Policy Review National Infrastructure Advisory Council "A Framework for Establishing Critical Infrastructure Resilience Goals" "Final Report and Recommendations by the Council" October 19, 2010 "Assuring a Trusted and Resilient Information and Communications Infrastructure"
Energy Independence and Security Act (EISA) of 2007, Title XIII, Section 1304 Amended by American Recovery and Reinvestment Act of 2009
EPRI: Smart Grid Security Architecture Development based on IntelliGrid Methodologies by Joe Hughes, Technical manager and Madhava Sushilendra, Sr. Project Manager
Federal Information Security Management Act 2002
IEC 60870-6: Facilitating exchanges of information between control centers.
IEC 61850: Facilitating substation automation and communication as well as interoperability through a common data format.
IEC 61970 and IEC 61968: Providing a Common Information Model (CIM), necessary for exchanges of data between devices and networks, primarily in the transmission (IEC 61970)

Document
and distribution (IEC 61968) domains.
IEC 62351: Addressing the cyber security of the communication protocols defined by the preceding IEC standards. (Parts 1-8)
Interoperability and Cyber Security Plan; NRECA CRN Smart Grid Regional Demonstration Grant DE-OE-0000222; National Rural Electric Cooperative Association 4301 Wilson Boulevard Arlington, VA 22203 May 20, 2010
ISO 27002: Information technology. Security techniques. Code of Practice for Information Security Management
National Information Infrastructure Protection Act of 1996 (Pub. L. 104-294), (18 U.S.C. 1030), or other applicable criminal laws.
National Vulnerability Database
NIST SP 800-12 - "An Introduction to Computer Security: The NIST Handbook " October 1995
NIST SP 800-14 - "Generally Accepted Principles and Practices for Securing Information Technology Systems" September 1996
NIST SP 800-30 - "Risk Management Guide for Information Technology Systems" July 2002
NIST SP 800-39 – "Managing Information Security Risk Organization, Mission, and Information System View" March 2011
NIST SP 800-50 - "Building an Information Technology Security Awareness and Training Program" October 2003
NIST SP 800-53 - Recommended Security Controls for Federal Information Systems and Organizations Rev. 3, August 2009
NIST SP 800-64 Rev. 2 - "Security Considerations in the System Development Life Cycle" October 2008
NIST SP 800-82 – "Guide to Industrial Control Systems (ICS)" September 2008
NIST SP 800-83 – "Guide to Malware Incident Prevention and Handling" November 2005
NIST SP 800-95 – "Guide to Secure Web Services" Recommendations of the National Institute of Standards and Technology"
NISTIR 1108: "NIST Framework and Roadmap for Smart Grid Interoperability Standards", Release 1.0 January 2010
NISTIR 7628: "Guidelines for Smart Grid Cyber Security: Vol. 1, Smart Grid Cyber Security Strategy, Architecture, and High-Level Requirements" The Smart Grid Interoperability Panel – Cyber Security Working Group August 2010
NISTIR 7628: "Guidelines for Smart Grid Cyber Security: Vol. 2, Privacy and the Smart Grid"
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RECOVERY ACT FINANCIAL ASSISTANCE FUNDING OPPORTUNITY ANNOUNCEMENT U. S. Department of Energy Office of Electricity Delivery and Energy Reliability Smart Grid Investment Grant Program Funding Opportunity Number: DE-FOA-0000058
"Roadmap to Secure Energy Delivery Systems" Draft January 11, 2011 Energy Sector Control Systems Working Group
Supporting the Electricity Sector Coordinating Council, "Oil & Natural Gas Sector Coordinating Council, and Government Coordinating Council for Energy"
The US-CCU Cyber-Security Check List By John Bumgarner and Scott Borg Final Version 2007
Electricity Subsector Cybersecurity Maturity Model (ES-C2M2), Version 1.0, 2012, Carnegie Mellon University

Appendix B: Technologies and Systems Demonstrated by Phase/Milestone

Technologies and Systems to Be Demonstrated by Phase/Milestone

Phase I – Demonstration of Integrated System with Long Island City

The Phase I SGDP Milestone Demonstration held on March 27, 2012 presented the following functionality:

- Existing Operational Support Systems extended with Smart Grid Demand Response and Distributed Energy Resource Status and Control Capabilities
- Visualization of Smart Grid Functions
- Integrated Building Management Systems, EV Charging Stations, and standby generators
- Secure communications to and from Long Island City, Borden, and Grand Central network curtailable customers

More specifically the March 27, 2012 SGDP Demonstration presented the following functionality and technical solutions.

Smart Grid System functionality:

- Network Distribution System Situational Awareness status integrated with Demand Response Resources
- Network Summary and one-line view of Distribution Network with interconnected DR
- Target Demand Response Curtailment
- Standard Secure Communications to Third Party Service DR providers

Third Party Service Provider functionality

- Demand Response Operations Control Centers
- Standard Secure Communications to Electric Utilities
- Demand Response Curtailment at customer sites
    - Building Management Systems
    - Standby Generation
    - Control of site load with Electric Vehicle Charging, Battery, Photovoltaic

The SGDP demonstration showed the following technologies:

- Smart Grid Standards Based Service Oriented Architecture
    - Interfaces
    - Services
    - Communications
- Integration of existing Control Center Systems
- Secure Interfaces to external Demand Response Third Party Service Providers

- Secure service interfaces from Demand Response Third Party Service Providers to Controllers and equipment at Customers Sites
- Standards leveraged for Service Oriented Architecture
  - NIST Logical Reference Model
  - IEC Framework
  - Common Information Model (CIM)
  - Third Party Service Provider Interfacing Specifications
- Commercial Off the Shelf Products – non proprietary, standard operating systems, application platforms, service oriented solutions
  - Siemens Web based Visualization
  - TIBCO Business Works
  - EMS (TIBCO Enterprise Messaging Service)
  - Oracle Database
  - Linux, Windows Operating Systems

Phase II – Demonstration of Integrated System with O & R Systems

The overall goal will be to provide a demonstration of Smart Grid System secure interoperability at O&R of the following functions:

i. Intelligent Storm Impact Analysis
ii. Distribution System Interoperability
iii. Multilevel security

Phase III – LIC-II - Demonstration of Integrated System with Long Island City

LIC-2 Demonstration will build upon the functionality demonstrated in LIC-1 by providing a demonstration of the following functions:

- Load Flow Analysis extended with Demand Response
- Smart Grid Control Capabilities to:

iv. Integrated Building Management Systems
v. Demand Response Customers
vi. Electric Vehicles for Charging and Incremental Generation Supply

Phase IV – Demonstration of Integrated System with Con Edison's Energy Control Center

ECC demonstration will build upon the functionality in LIC-1 and LIC-2 and demonstrate the following functions:

- Smart Grid Control Options to address:

vii. Area Substation Load

- Transmission Substation Analysis tools:

viii. fault and disturbance
ix. dynamic relay testing
x. intelligent predictive maintenance

Phase V – Demonstration of Integrated System with Con Edison's Bowling Green Distribution Network

Bowling Green Distribution Network Demonstration will build upon the functionality demonstrated in LIC-1 by providing a demonstration of the following functions:

- Smart Grid Control Capabilities to:
    - xi. Integrated Building Management Systems in Bowling Green
    - xii. Demand Response Customers in Bowling Green

Phase VI – Capstone

Summary of above functionalities

Appendix C: Technical Approach from Project Objectives to Architecture

Technical Approach for Achieving Interoperability and Cyber Security

The SGDP technical approach for achieving interoperability and cyber security initiated with develop a services architecture to meet SOPO objectives. The architecture design started with SGDP use cases derived from the SGDP objectives and stakeholders that drove the services architecture and technical and functional requirements. The process aligned the architecture with the NIST 1108 conceptual framework and IEC smart grid roadmap to identify common services within the Smart Grid domains. The process resulted in a SGDP Architecture, Interoperability, and Cyber Security framework that was shared, reviewed and updated by Con Edison technology departments, participants and DOE.

SGDP Architecture

The SGDP project team focused on developing an architecture design based on an open services architecture top support interconnectivity between legacy systems, new smart grid applications, and interoperability with external demand response resources. As noted above the approach for achieving interoperability and cyber security was based on aligning the SGDP applications, functions, services and interfaces with the NIST and IEC reference architectures to develop a SGDP reference architecture . This process identified smart grid functions, common services and data flows in alignment with the reference architectures so that available standards could be identified and applied.

The SGDP architecture integrates standardization using the electric power transmission and distribution Common Information Model (CIM) adopted by the IEC with the transmission components defined within IEC 61970-301 and extensions for distribution system under development within IEC 61968 and substation automation within IEC 61850.

The SGDP services architecture was defined by the SGDP team in concurrence with Con Edison Technology Services, and internal stakeholders, the SGDP participants, NIST, DOE, and vendors.

The Applications and services defined within the architecture were mapped to the applications and services in NIST and then mapped to vendor solutions. See Appendix G Applications and Services.

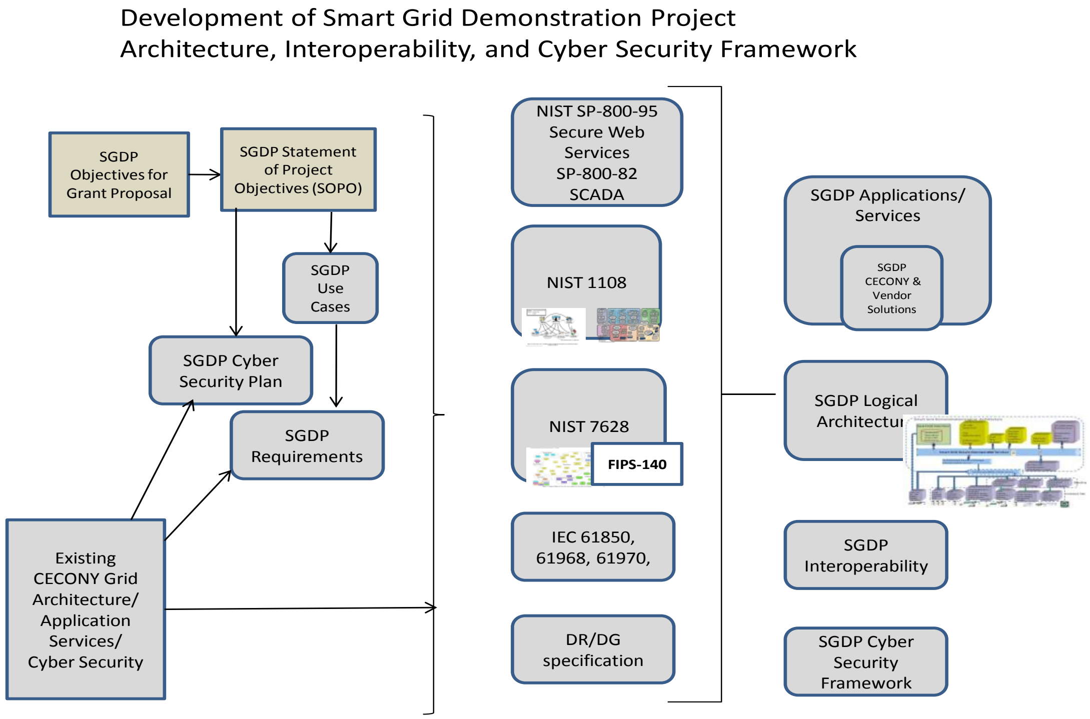

Figure 11: Development of Smart Grid Demonstration Project

The CECONY Smart Grid Demonstration Project Conceptual Architecture was developed based on application/services identified as part of the Smart Grid Demonstration Project Process and using the Smart Grid Conceptual Reference framework developed by NIST[1] and the IEC Smart Grid Framework. NIST developed the Smart Grid Conceptual Reference Model as a tool for describing, discussing and developing the architecture of the Smart Grid and for supporting the development of open standards as applied to the Smart Grid.

The high level NIST conceptual reference model provides an overview of the seven defined domains relevant to the smart grid and the communications and electric flows among the domains.

[1] National Institute of Standards and Technology, NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0, NIST Special Publication 1108, January 2010.

SGDG Components within the NIST Conceptual Smart Grid Networks NIST SP 1108

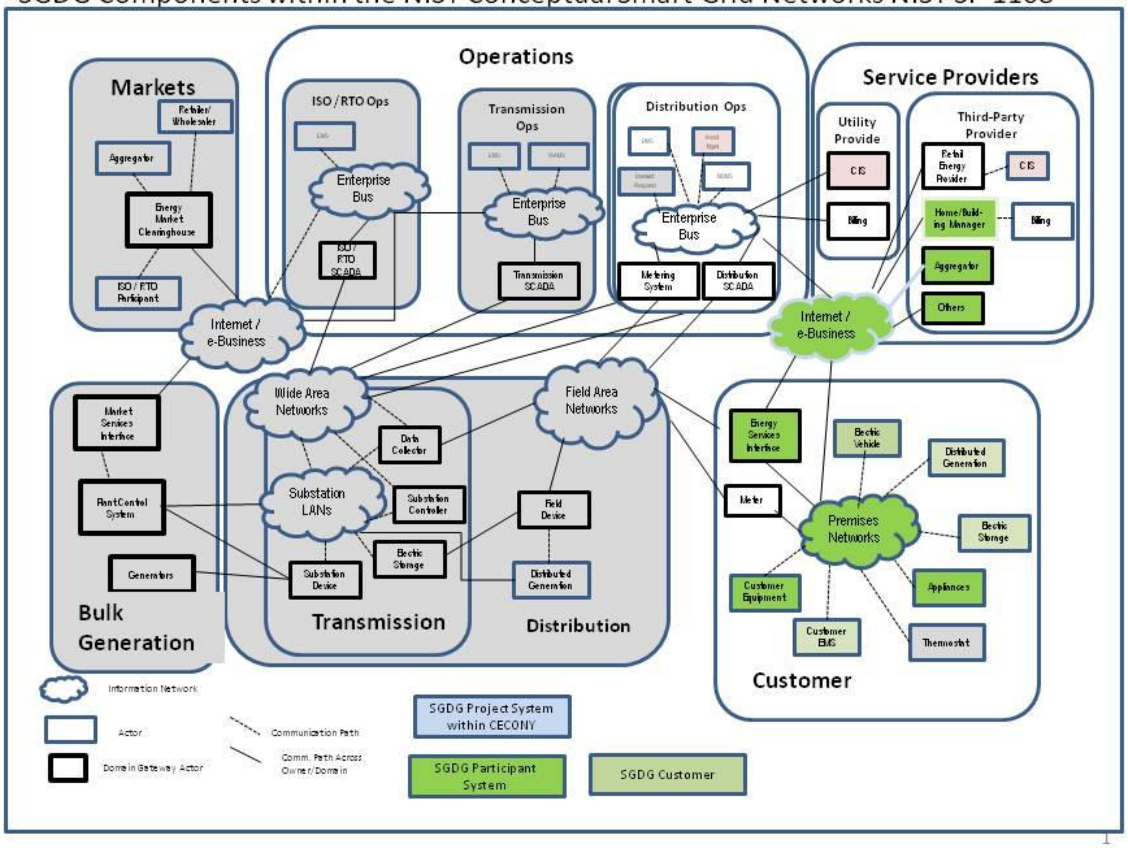

Figure 12: SGDP Components within NIST Conceptual

Con Edison SGDP team aligned the SGDP Objectives, Use Cases and Objectives to the NIST Conceptual Model and the IEC service framework to derive an architecture design based on open services architecture to support interconnectivity between systems and services. The IEC Smart Grid Roadmap service oriented architecture has been formulated with standardized process and interlace and communications standards to form the basis for integrating the network control systems in the enterprise service environment.

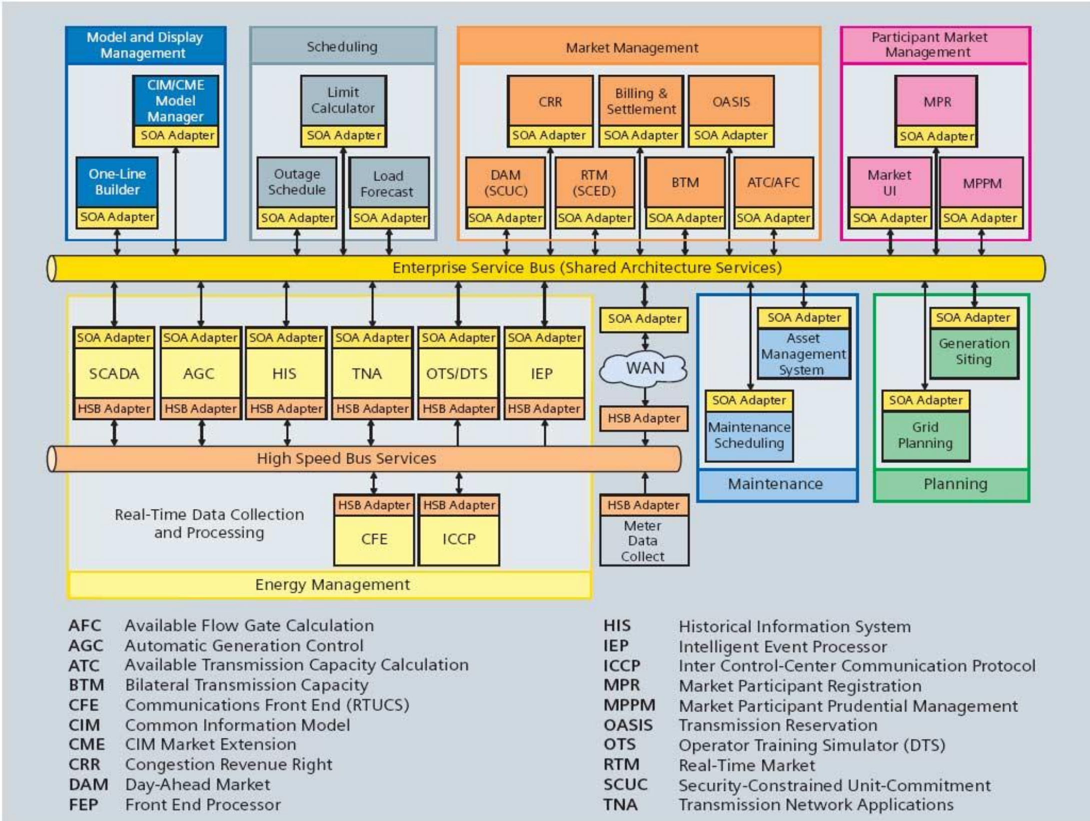

Figure 13: IEC Smart Grid Roadmap

The SGDP Secure Interoperable Services framework was derived based on the system components, services, data, and existing environments needed to support the SGDP objectives within the standard frameworks defined by NIST, IEC and IEEE.

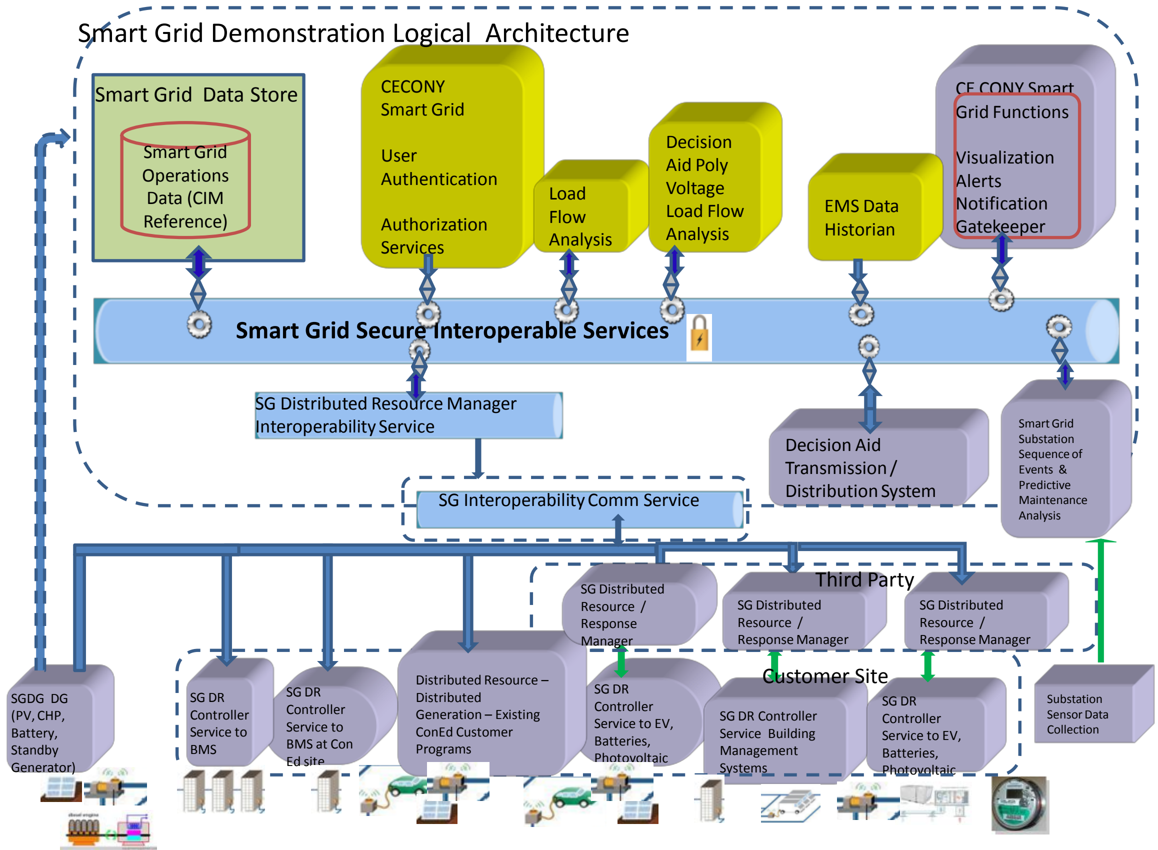

Figure 14: SGDP Logical Architecture

The interoperability and cyber security requirements were integrated into the design of the system.

Appendix D: SGDP Applications and Services

The Smart Grid Demonstration Project identified the key applications/services that will be implemented to meet the Smart Grid Demonstration Project Objectives and to fulfill the requirements identified in the use cases.

See logical architecture diagram after the tables for the depiction of the SGDP applications and services.

#	Application	Description
A-01	Smart Grid Visualization	Provides Distribution Operators with a visual representation of situational awareness and Smart Grid Options for analysis or for contingency load resolution using Smart Grid Demand Response Resources.
A-02	Smart Grid Alerts	Provides capability of system to send and receive alerts about abnormal conditions where Smart Grid resources could be deployed
A-03	Smart Grid Notification	Application that transmits and receives messages (i.e., email, text, etc.) to customers (or Smart Grid Demand Response Resource Managers) enrolled in a Demand Response program requesting they take action.
A-04	Smart Grid Decision Aid Functions	Applications that will provide recommendations for actions that utilize Smart Grid resources in response to network load conditions and grid optimization options.
A-05	Smart Grid Curtailable Load Option Functions	Smart Grid application functions that support curtailable load requests and responses between Con Edison and Smart Grid Demand Response Resource Managers.
A-06	SG Demand Response Resource Manager Interoperability Service	SG DR interface service applications that support transmit and receive SG Demand Response Resource status data (e.g. Battery load available, EV charge status) and transmit and receive curtailable load requests from the Con Edison to the Smart Grid Demand Response Resource Manager.
A-07	Smart Grid Optimization	Applications that perform visualization of network analysis to show grid optimization options that incorporate Smart Grid Demand Response Resources.
A-08	Smart Grid Reporting	Application that generates reports from Smart Grid system data in the Shared data store.
A-09	Smart Grid Decision Aid Gatekeeper Administrator	Application that provides the ability to enable or disable recommendations from the various decision aids displaying the options to the Distribution Operator.
A-10	Smart Grid Shared Data Store Legacy/Operations data	Corporate and operations data from external systems outside the Smart Grid system
A-11	Smart Grid Shared Data Store SGDP data	The Smart Grid Secure Interoperable Service will enable interoperability between the Smart Grid Systems using a standard set of services and interfaces.
A-12	Smart Grid Secure Interoperable Service	Will enable Smart Grid applications to publish decision aid results to the Smart Grid Data Store, enable Smart Grid applications to access Smart Grid data on the data store, access Smart Grid CECONY Authentication Services, and other Smart Grid CECONY applications such as Visualization.
A-13	Smart Grid Load Flow Analysis Tool	The Smart Grid Load flow Analysis Applications performs load flow analysis of distribution networks for existing conditions and hypothetical grid configurations with Smart Grid Demand Response Resources.

#	Application	Description
A-14	Smart Grid Authentication	Smart Grid Authentication services will support Smart Grid system user and system authentication. SG Authentication service will interoperate with existing corporate and control center authentication systems.
A-15	Smart Grid Authorization	Supports role-based access controls and profile-based System Authorization
A-16	Smart Grid System Administration	Application that provides setup or configuration information for system components
A-17	Smart Grid System Monitoring	Application that provides performance and monitoring of system components
A-18	Participant Smart Grid Resource Status Update	Application that sends participant-controlled smart grid resource updates to Shared data store
A-19	Smart Grid Demand Response Resource / Response Manager	Smart Grid Demand Response Resource/ Response Manager Systems at Third Party Service Providers that interoperate with SG Demand Response Resource Manager Interoperability Service to provide SG Demand Response Resource status and to process SG Demand response resource requests
A-20	Smart Grid Decision Aid System	Decision Aid applications provided by participants that can be invoked from the Con Edison Smart Grid Visualization system to allow drill down capability for the user.
A-21	Participant Smart Grid Alert System	Application that allows a Smart Grid participant to generate alerts and send them to Smart Grid system.
A-22	SG DR Controller Service	Smart Grid Demand Response Resource Controller Service Systems provided at Customer Sites and controlled by Third Party Service Providers that interoperate with the Third Party's SG Demand Response Resource / Response
A-23	Smart Grid Substation Sequence of Events & Predictive Maintenance Analysis	Smart Grid Sequence of Events & Predictive Maintenance Analysis System
A-24	Substation Data Sensor Collector	Substation Data Sensor Collector from TIS sensors at the substations.
A-25	Smart Grid Demand Response Resource Manager Interoperability Service	The Smart Grid Demand Response Resource Manager Interoperability Service is a Service Application that supports the Interface between the CECCONY Smart Grid Secure Interoperable Service to the SG Demand Response Resource Manager Services provided at Third Party Resource Managers. The Service will support registration of SG Demand Response Resource Service Providers and logging. This service will be designed with the Secure Interoperable Service and the Smart Grid Functionality.

The SGDP has identified solutions for each application / service based on existing CECONY applications and the Participant product solutions and development:

#	Application	Application Solution
A-01	Smart Grid Visualization	Siemens
A-02	Smart Grid Alerts	Siemens
A-03	Smart Grid Notification	Siemens
A-04	Smart Grid Decision Aid Functions	Siemens
A-05	Smart Grid Curtailable Load Option Functions	Siemens
A-06	SG Demand Response Resource Manager Interoperability Service	Siemens/TIBCO
A-07	Smart Grid Optimization	Siemens
A-08	Smart Grid Reporting	Oracle
A-09	Smart Grid Decision Aid Gatekeeper Administrator	Siemens
A-10	Smart Grid Shared Data Store Legacy/Operations data	Oracle
A-11	Smart Grid Shared Data Store SGDP data	Oracle
A-12	Smart Grid Secure Interoperable Services	TIBCO
A-13	Smart Grid Load Flow Analysis Tool	PVL Wolf
A-14	Smart Grid Authentication	LDAP/Active Directory
A-15	Smart Grid Authorization	LDAP/Active Directory
A-16	Smart Grid System Administration	Siemens/TIBCO
A-17	Smart Grid System Monitoring	Siemens/TIBCO
A-18	Participant Smart Grid Resource Status Update	GCN SSGU, Viridity VPower, Innoventive
A-19	Smart Grid Demand Response Resource / Response Manager	GCN SSGU, Viridity VPower, Innoventive
A-20	Smart Grid Decision Aid System	GCN BRKE, Columbia DTC, CALM
A-21	Participant Smart Grid Alert System	GCN BRKE, Columbia DTC, CALM
A-22	SG DR Controller Service	GCN SSGU, Viridity VPower, Innoventive
A-23	Smart Grid Substation Sequence of Events & Predictive Maintenance Analysis	Wavewin
A-24	Substation Data Sensor Collector	TIS
A-25	SG Demand Resource Manager Interoperability Service	Siemens/TIBCO

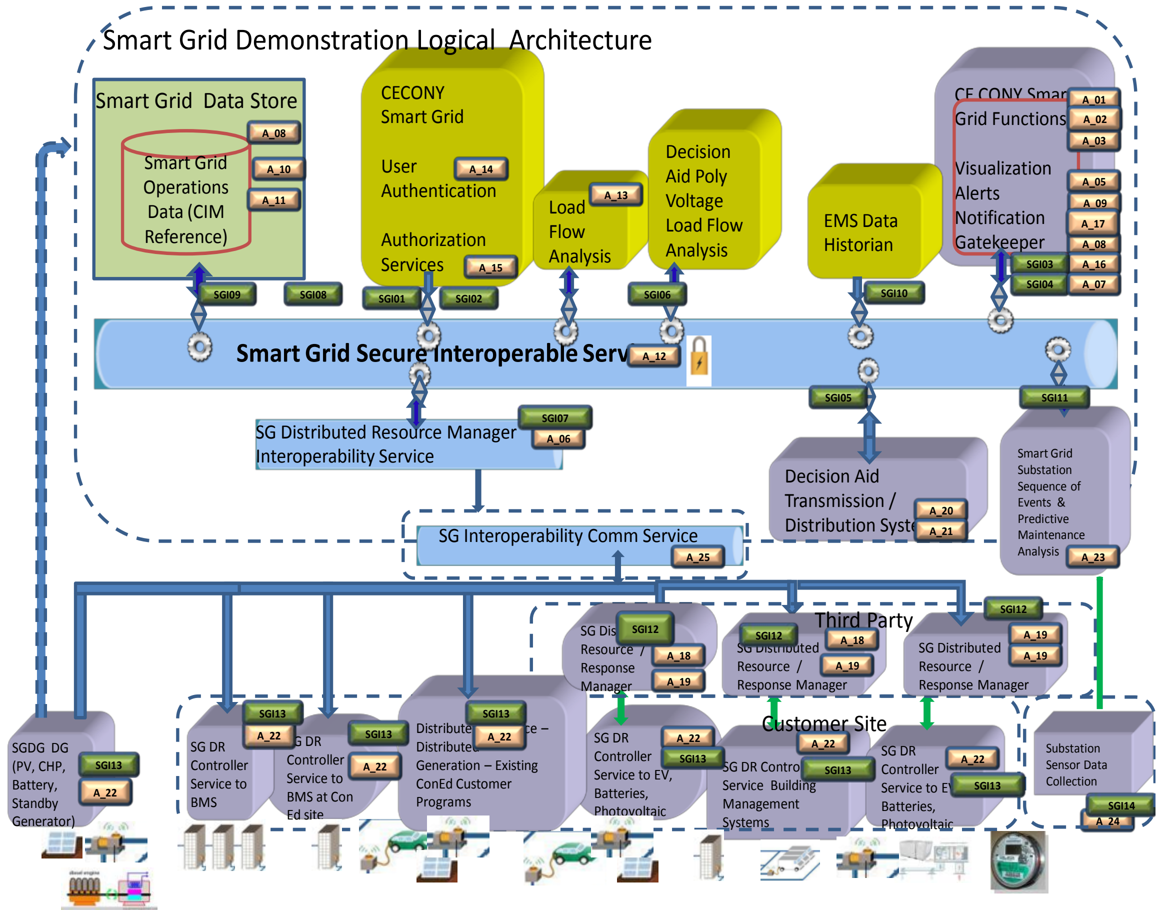

Figure 15: SGDP Logical Architecture with SGDP Applications and Interfaces

Appendix E – Technologies and Systems Demonstrated in Phase I Demonstration

1. Introduction

During this demonstration, Con Edison displayed interconnected Demand Response Resources on Con Edison Distribution Networks and targeted curtailment of the DRs to support load grid management. Three specific networks were chosen to show the status of the network with status of interconnected DR and targeted curtailment functionality:

- Grand Central (Manhattan)
- Borden (Brooklyn/Queens)
- Long Island City (Brooklyn/Queens).

The types of DR Resources included a Building Management System, a Standby Generator, and an Electric Vehicle Charging Station connected to addition types of Energy Resources.

2. Smart Grid System – Situational Awareness of Smart Grid System with DR for Operations

Mark Mastrocinque, Manager of Distribution System Operations Training and former Distribution Operator, demonstrated how the Smart Grid Demonstration Project Visualization could be displayed and used by an Operator or a Demand Response Program Manager.

3. Network Summary & one line view of Distribution Network with interconnected DR

Con Edison displayed the network summary for all networks belonging to area Manhattan and Brooklyn queens. A filter capability on the area (region) allowed displaying all networks on selected area. The network summary showed the current network load and the available curtailable DR load for the networks. From this summary, one line view of the selected network was opened to show visually the selected distribution network with overview of network data. Scrolling on one line view displayed the interconnected DRs visually on that network with a color code to identify the DR status.

4. Targeted Demand Resource Curtailment

Con Edison demonstrated Demand Resource curtailment showing explicitly live data for available load for curtailment, current DR status, and site load for the DR site before and after curtailment. The effect of curtailment resulting in site load drop was demonstrated successfully on network view for the selected network where the DR was located. On one line display of distribution network, the DR status change was visually perceived by change of color from green (available for curtailment) to yellow (in process to curtail) to red (already curtailed).

Con Edison also demonstrated the capability of stopping all curtailment for the network, once the curtailment was executed successfully, showing the availability of DR load again and slow back up of site load value to original value in a time period of 5-10 minutes. DR status change was visually displayed by color of DR back to green.

The demonstration was done in 3 steps for 3 selected networks.

Grand Central - Targeted demand resource curtailment

From the network Summary on area Manhattan, the one line view of Grand Central was brought up with network overview data showing the network load, the site load and the amount available for load curtailment at the Demand Response resource site, a Building Management System for a large commercial building.

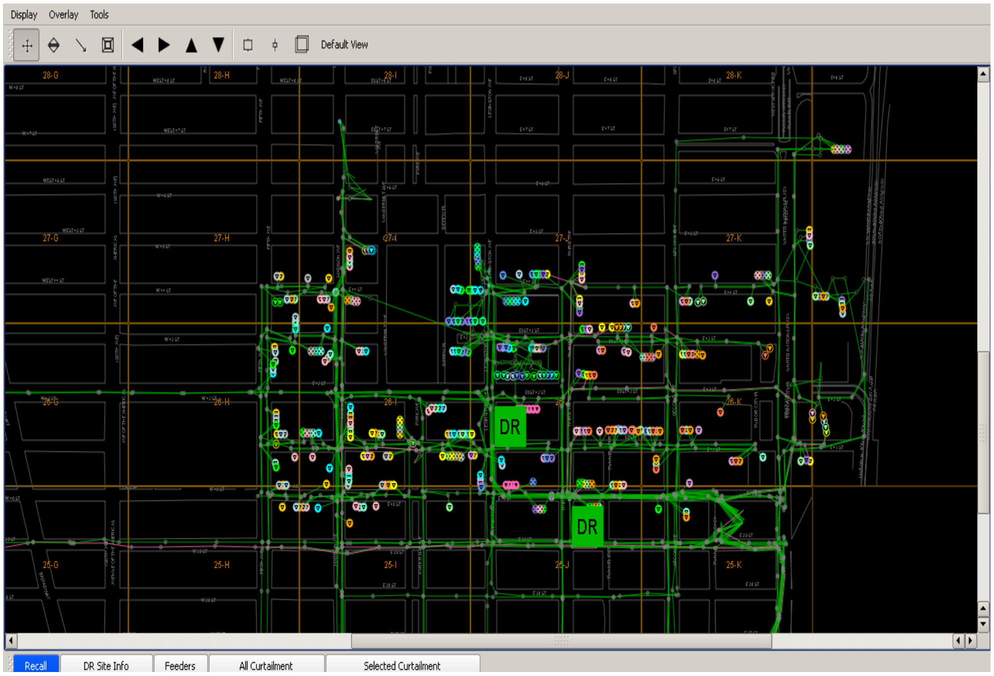

Figure 16 Section of Grand Central Distribution network with interconnected DRs

The DR resource selected - SG4GC26J10009 was a Building Management System (monitored and connected to Viridity Power) located at an avenue in the Grand Central Network. Once the curtailment request was sent, the request message was received and seen visible on screen of 3rd party provider Viridity Power. Vridity started the curtailment by shutting off fans. Available load for curtailment was seen to be dropped to 0 and DR status was changed to ‘inprocess’. After a short time of 30secs, DR status changed to ‘curtailed’ and Coned Distribution Network showed the DR colored to red. Site load started dropping based on real metered values starting from 612KW to 600KW, then to 576KW to 476KW and so on.

A stop curtailment request was then sent from the Grand Central network and a stop was issued by Viridity power to the Viridity BMS DR Site. DR status was quickly restored back to available with color green. Site load started slowly backing up based on real meter reading values.

Borden - Targeted demand resource curtailment

From the network Summary on area Brooklyn Queens, the one line view of Borden was brought up with network overview showing network load, site load, and the available curtailment.

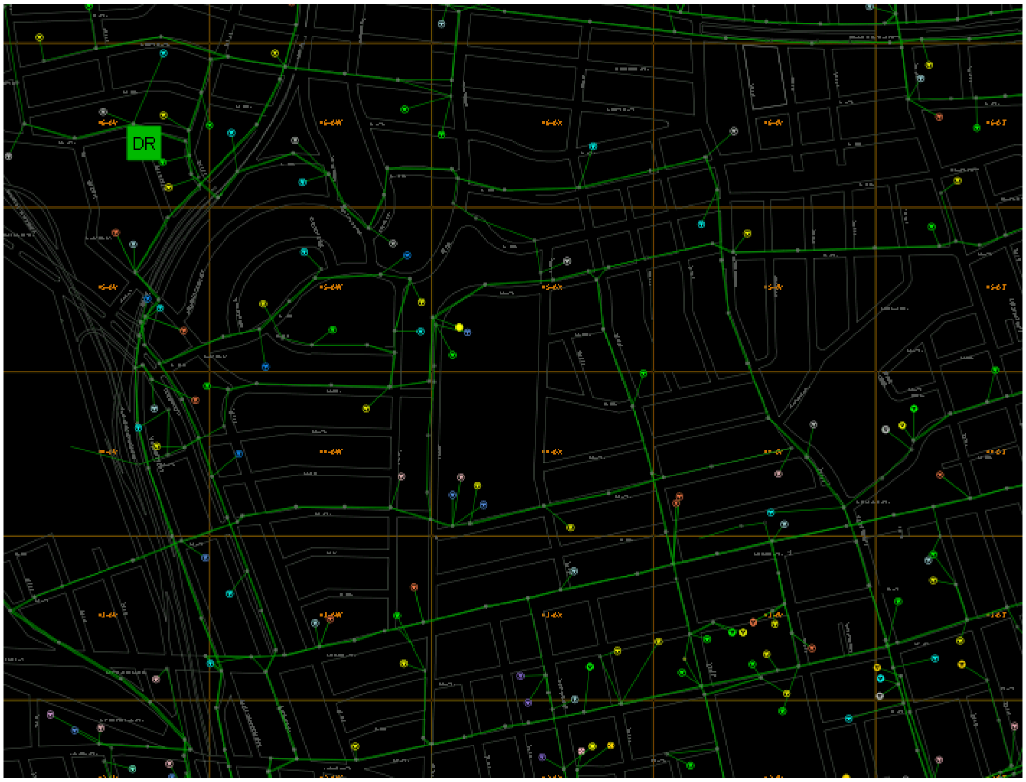

Figure 17 Section of Borden Distribution network with interconnected DR

The DR resource was a customer owned diesel generator resource in Queens Region on Borden network monitored and connected Innoventive Power's Demand Resource Control Center (DRCC) Once the curtailment request was sent to Innoventive's DRCC, the request message was received and seen visible on screen of 3rd party provider Innoventive. The DRCC directed a curtailment message to the assigned Facility Manager's smart phone. Upon acknowledgment by the Facility manager, a signal was sent from the customer Central Curtailment Control Server to the Customer Facility to start a diesel generator and transfer the facility load from the commercial bus to the generator. Available load for curtailment was seen to be dropped to 0 and DR status was changed to 'curtailed' and Coned Distribution Network showed the DR colored to red. Site load started dropping based on real metered values starting from 771KW to approx 200 KW.

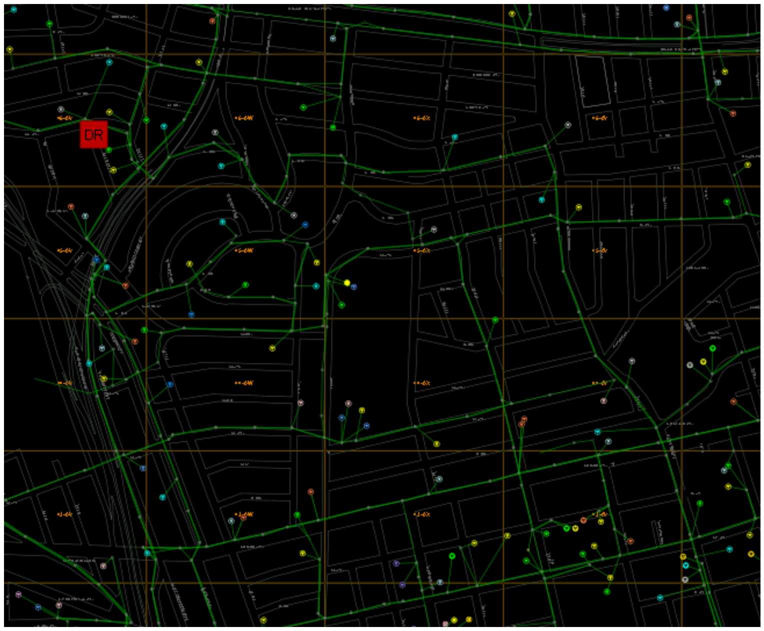

Figure 18 Section of Borden network showing curtailment done successfully

A stop curtailment request was then sent after 7 minutes of curtailing and the generator continued for another 15 minutes to perform a normal transfer of load to commercial power before DR curtailment was halted, and the site load increased.

Long Island City - Targeted demand resource curtailment

From the network Summary on area Brooklyn Queens, the one line view of Long Island City was brought up with network overview data showing network load, site load, and available load for curtailment.

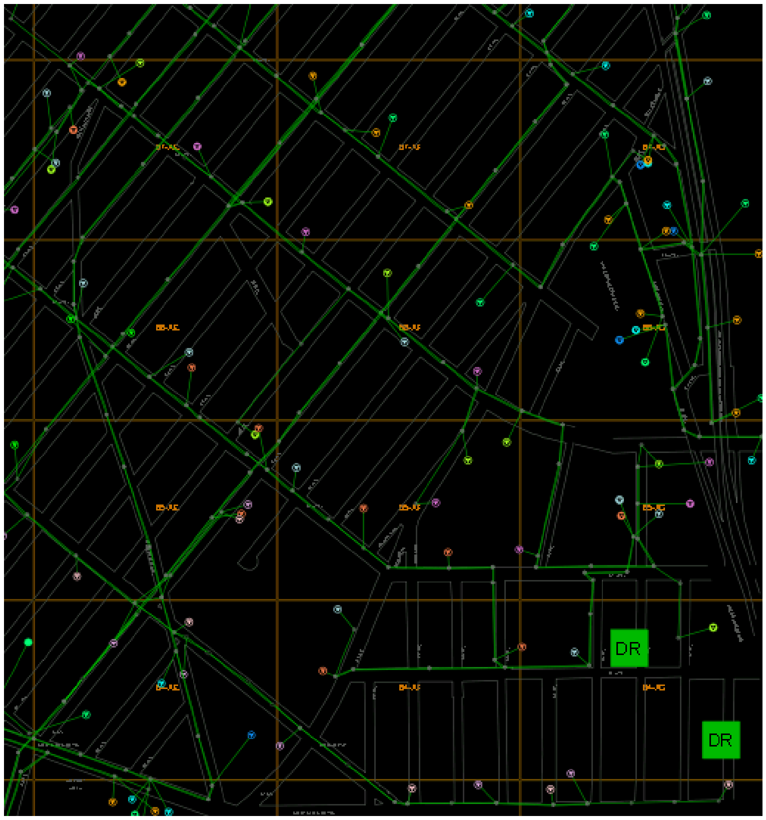

Figure 19 Section of Long Island City distribution network with interconnected DRs

The DR resource selected was an electric vehicle charging station and energy storage resource deployed at a DR site in Queens, NY on the Long Island City network monitored and connected via 3rd party provider GreenCharge Station controller located at the site where electric vehicle chargers, photovoltaic equipment and a battery are located. Once the curtailment request was sent controller reduced load through an optimized combination of a reduction of the electric vehicle charge rate and battery discharge. The load curtailed was approximately 15 kW. Available load for curtailment was seen to be dropped to 0 and DR status was changed to 'curtailed' and Coned Distribution Network showed the DR colored to red. Site load started dropping based on real metered values starting from 25KW to approx 11 KW.

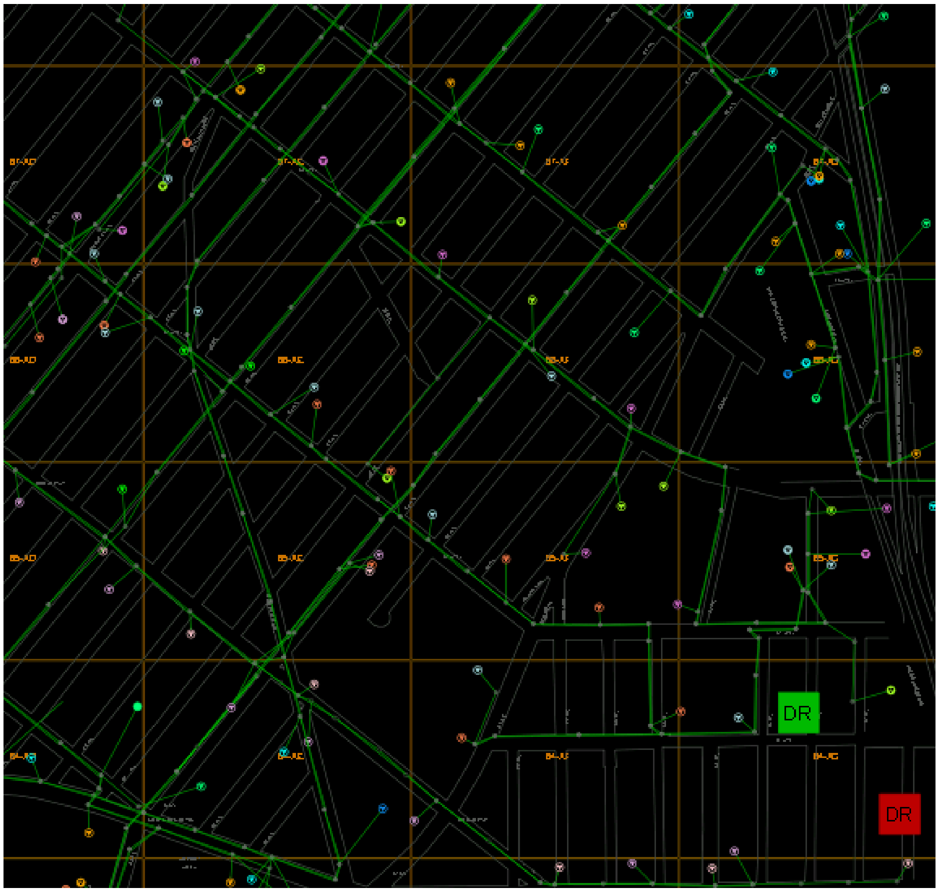

Figure 20 Section of Long Island City network DR showing curtailment done successfully

A stop curtailment request was then sent after 5 minutes of curtailing and the resource status messages were sent back through the Green Charge Network's NOC to Con Edison.