U.S. DEPARTMENT OF ENERGY

Electricity Delivery & Energy Reliability

American Recovery and Reinvestment Act of 2009

Control Center and Data Management Improvements Modernize Bulk Power Operations in Georgia

Smart Grid Investment Grant Program

August 2014

SMARTGRID.GOV

RECOVERY ACT SMART GRID PROGRAMS

1. Summary

Georgia System Operations Corporation's (GSOC) Smart Grid Investment Grant (SGIG) project modernized bulk power management and control center operations for 38 electric membership corporations (EMCs) in Georgia. The EMCs serve mostly rural and suburban customers and their service territories cover about 70% of the state. As the system operator, GSOC is responsible for controlling and monitoring electric generation, transmission, and distribution assets owned by Oglethorpe Power Corporation, Georgia Transmission Corporation, and the other EMCs.

Under the American Recovery and Reinvestment Act of 2009, the U.S. Department of Energy and the electricity industry have jointly invested over $7.9 billion in 99 cost-shared Smart Grid Investment Grant projects to modernize the electric grid, strengthen cybersecurity, improve interoperability, and collect an unprecedented level of data on smart grid and customer operations.

The project added a dual-path fiber optic network for enhanced communications, developed new models and data management tools for outage management and cybersecurity, and implemented a new integrated transmission network model for enhanced state estimation and dispatcher training. Table 1 is a summary of the project's key results.

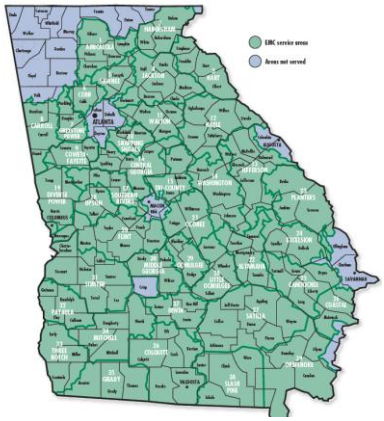
Table 1. Summary of Key Results

New Control Center Capabilities Enable More Reliable and Efficient Operations	i.	Faster and easier to operate energy control systems.
	ii.	Redundant fiber links between the primary and backup operations control centers boost reliability and effectiveness.
	iii.	Enhanced situational awareness via color coding of alarms and new alarm priorities for major, minor, and miscellaneous alarm groups.
Enhanced Data Management Improves Operational Flexibility	iv.	Faster access to real-time data by GSOC and member cooperatives via web-enabled interfaces to assist with energy scheduling and operational planning.
	v.	Enhanced reliability by eliminating manual processes for updating critical Energy Management System operational databases.
New Measures Enhance Cyber and System Security	vi.	Strengthened systems for both detecting and responding to any malicious cyber activities that could potentially threaten the bulk electric system.
	vii.	New tools (e.g., "Industrial Defender" and "Network Intrusion Detection") to reduce risks of cyber-attacks and unauthorized access to servers, workstations, physical security devices, and network equipment.

2. Introduction

GSOC's SGIG project upgrades and enhances communications equipment, hardware, software, and data collection systems. These investments are designed to improve energy management and control room operations and more securely and reliably deliver bulk power to member EMCs. The project improves the information GSOC provides to its members to help make more informed decisions on power purchases and improve scheduling of power generation, transmission, and distribution facility maintenance and feeder switching.

GSOC is an independent, not-for-profit system operator owned by its 38 member EMCs. As such, GSOC doesn't own or operate generation, transmission, or distribution facilities. Instead, they help manage and coordinate open and efficient bulk power system operations. Member services include controlling and monitoring electric generation and transmission assets owned by Oglethorpe Power Corporation (an EMC generating company), the Georgia Transmission Corporation (an EMC transmission company), and the remaining EMCs and their supplemental power suppliers.



Green areas represent the service territories of GSOC's 38 member EMCs in the state of Georgia.

The total budget for GSOC's project is $12.9 million, including $6.4 million in funding from the U.S. Department of Energy (DOE) under the American Recovery and Reinvestment Act of 2009. The primary aim is to upgrade of GSOC's control central operations and support member smart grid initiatives and applications to improve monitoring and control of generation, transmission, and distribution assets owned by member EMCs. Key project objectives include:

- Deploy infrastructure improvements that more effectively communicate information about disruptions or shifts in power flows and enable operators and engineers to make better decisions to maintain grid reliability and security,
- Improve the economics of power purchases and scheduling of transactions by member cooperatives, and
- Detect, prevent, communicate, respond to, and recover from cybersecurity threats.

Table 2 provides a detailed summary of the improvements to bulk power system operations from GSOC's SGIG project.

Table 2. Grid Operational Improvements from GSOC's SGIG Project		
Control Center Capability Upgrades		
1. Telecommunications Upgrades	i. ii.	Redundant fiber links between the primary and backup operations control centers. New routers and direct links with field devices and a redesign of GSOC and member internet architectures to eliminate single points of failure.
2. Energy Management System (EMS) Alarm Enhancements	iii.	Enhanced situational awareness via color coding of alarms and new alarm priorities for major, minor, and miscellaneous alarm groups.
3. Energy Control System (ECS) Upgrades	iv. v.	More rapid access to operational data to increase system resiliency in response to security threats. Better integration of new security and smart technologies through interoperability achieved via use of compatible communications protocols.
4. Transmission System Modeling	vi. vii. viii.	New integrated transmission network model, functional state estimator, and dispatcher training simulator. Increased situational awareness for operators across the Georgia Integrated Transmission System (GSOC and other transmission entities). Training operators using a variety of actual historical events.
Data Management Enhancements		
5. Centralized Database Editing and Data Historian	ix. x.	Enhanced reliability by eliminating manual processes for updating critical EMS operational databases. Faster access to real-time data by to GSOC and member cooperatives via web-enabled interfaces.
6. Scheduling Hardware and Software Upgrades	xi. xii.	Improved scheduling of energy transactions by members. Upgraded disaster recovery capabilities to improve system reliability and resilience.
7. Transmission Outage Management Tool	xiii. xiv.	Greater integration of switching-order management and switching operations that reduce the likelihood of field errors. Documented outage restoration histories and logs and outage tracking for both transmission and generation disruptions.
8. Real-Time Production Cost Data	xv. xvi. xvii.	Keeping members fully apprised of actual and expected costs Providing updated marginal costs each hour with member access via e GSOC's web portal. Enabling better operator decisions for generation unit commitment and dispatch scheduling.
Cyber and System Security Enhancements		
9. Critical Infrastructure Protection Tools	xviii. xix.	Stronger cybersecurity via firewall, anti-virus, and anti-malware protections that restrict user access to those responsible for system operations. New Critical Infrastructure Protection tools (e.g., "Industrial Defender" ASM™) to reduce the risk of cyber-attacks and unauthorized access to servers, workstations, physical security devices, and network equipment.

3. New Control Center Capabilities Improve the Reliability and Efficiency of Operations

GSOC developed and upgraded new capabilities to increase the amount of real-time and historical system data available to member co-ops to enhance energy scheduling and operational planning, improve efficiency and reliability, and lower costs.

- Communications are improved through installation of fiber optic systems and updates and redesigns of internet routing equipment.
- EMS alarm enhancements for improved outage management include a calendar view of outages that is color coded by outage type.
- The new ECS is both much faster and easier to use, according to grid operators and engineers, and has greater reliability due to increased redundancy[1].
- A transmission system model and state estimator are now available to operators and engineers. GSOC expects to add new model features to increase functionalities and improve state estimation results.[2]

To expand communications capabilities, GSOC installed a dual path fiber network between its primary control center and its backup control center. GSOC also updated its internet routing equipment and redesigned the architectural layout of the internet network to reduce single points of failure. They also installed new internet border routers, to expand security features, add routing options, and increase efficiency. New gateway routers allow GSOC's energy control system to directly connect with field equipment. Together, these new communications systems increase reliability, improve security, and add functionality and scalability.

GSOC's Control Center.

[1] One specific enhancement that makes it easier for grid operators is the direct input from the relay data system is now fully integrated into the ECS.

[2] A recent event involved identification of a manually tagged switch that SCADA reported as open, but the state estimator indicated it should have been closed, thereby enabling operators to take action that avoided a potential outage or equipment damage.

An EMS is a set of computer-aided tools used by grid operators to monitor, control, and optimize the performance of the generation and/or transmission systems. The EMS alarm enhancements give system operators greater situational awareness and enhanced "alarm prioritization" (i.e., major, minor, and miscellaneous alarm groups). The new capabilities enable operators to conduct enhanced filtering within each alarm group and standardize alarm priorities across control centers by color groupings within each alarm group.

This improved situational awareness allows operators to sort and filter the various alarms so they can respond to the most important ones first. This enables operators and engineers to prevent and/or respond to system disturbances and equipment problems more efficiently and accurately, and reduce operations and maintenance costs.

The ECS upgrades are part of GSOC's EMS approach to increase operational data collection and increase system resiliency to security threats. ECS testing showed that the system met strict standards of performance even when 50% of the memory was disabled. In addition, simulations of inclement weather alarm conditions showed the system was able to operate as expected even when faced with extreme conditions.

Implementing an integrated transmission network model, a functional state estimator, and a dispatcher training simulator has boosted capabilities and situational awareness. The state estimator is available to operators and engineers, and is already providing benefits. In one case, a manually tagged switch was reported open in the SCADA system, but the state estimator suggested it should have been closed. The discrepancy was evaluated and it was confirmed that the switch was in fact closed. The switch status was then updated in SCADA. Had it not been for the state estimator, this discrepancy could have led to delays in future switching orders or outage restoration efforts involving this switch.

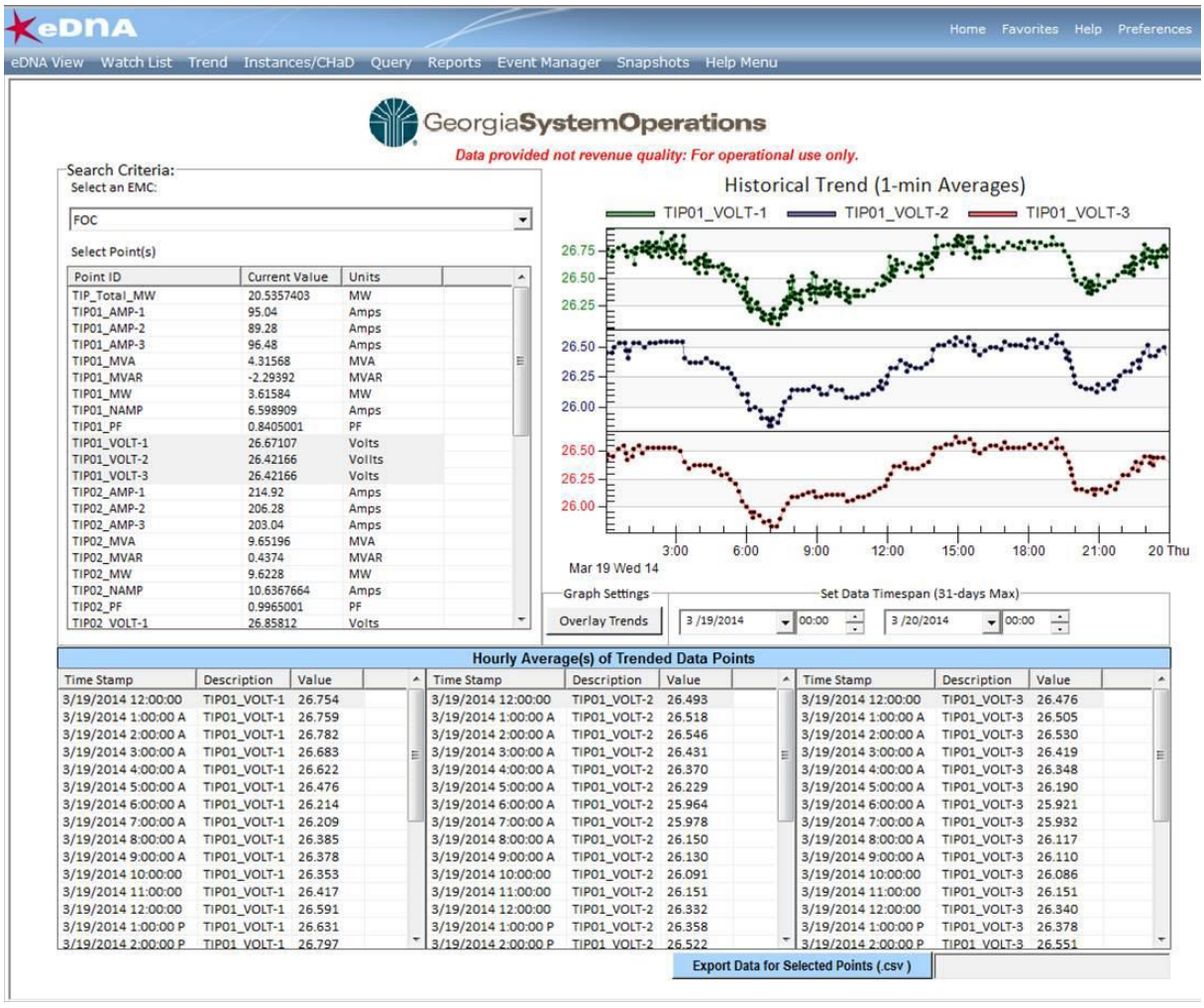
The dispatcher training simulator is already being used to train GSOC's system operators in monitoring power system conditions, analyzing impact of planned changes and responding effectively to problems or changes.

4. Enhanced Data Management Improves Operational Flexibility

GSOC has strengthened its data management and exchange capabilities by implementing centralized database editing and data historian functions within the ECS and upgrading scheduling hardware and software, production cost databases, and transmission outage management tools. Results from these changes include:

- A new tool that now provides members web-based access to key operational and cost data,

- Data historian systems that are fully redundant and eliminate the potential loss of data used by GSOC and its members,
- Web-enabled interfaces to the data historian which provide higher levels of both security and availability, and
- System architectures designed for maximum interoperability that include common communications protocols to enable ready ECS expansion and integration of existing and future smart systems by GSOC members.



GSOC's new "eDNA" tool provides grid operators with 1-minute and hourly data trends for three power lines.

For example, with new centralized database editing functions, updates are now fully tested on two separate systems. Accuracy has increased because required database changes using manual file-copying processes are now kept to a minimum. Database administrators are now able to accept or reject updates prior to pushing the updates to all systems. By fully testing

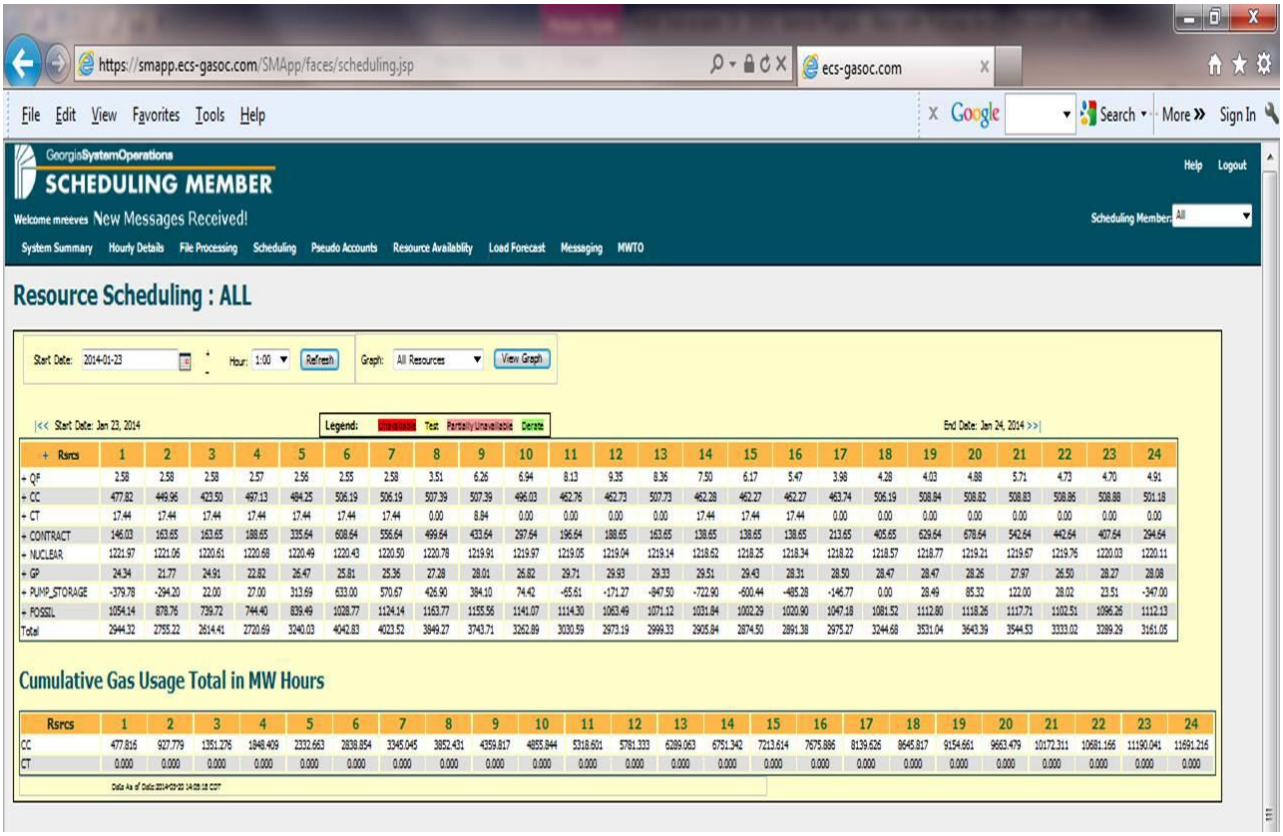
updates on two separate systems, rather than having to install the changes on the entire production system, the centralized database editor has increased the stability of the production systems and minimized the likelihood of any disruption to them.

GSOC's data historian – an application that captures, stores, and analyzes operational data on power flows across the system – has been replaced with a more robust tool that provides real-time data to both GSOC and its members through web-based interfaces. The new "eDNA" tool provides more data on a real-time basis to GSOC's operators and members and the ability to evaluate more data trends than were available from the previous data historian system. As shown in the sidebar above, the data trends from eDNA can be used to manage day-to-day grid operations and longer-term system planning studies.

The outage management enhancements provide a tool to assist GSOC with editing and managing switching orders, arranging for planned outages, managing concurrent outages, deploying efficient workspace designs, and supplying tracking documentation. It provides a means of tracking the life/status of bulk electric system switching orders from request to approval to execution. It provides better coordination with other transmission operators on the Georgia Interconnected Transmission System, and provides documentation of GSOC's compliance with NERC reliability standards. Rather than having to rely on separate databases for information regarding transmission issues, all documentation is now accessible via a single application. The outage management tool provides a color-coded, calendar view of outages by outage type and notifies operators of any changes in the status of transmission components. All of this information is now automatically provided to all relevant parties.

GSOC upgraded production costing tools in order to adequately capture all of the complexities associated with resource scheduling including pumped storage modeling, real-time data capture for use as a starting condition in short-term commitment and dispatch studies, and planning for changing system conditions in a multi-provider business model. These upgrades enable GSOC to keep its members informed about current actual and expected electricity costs, which they could use in developing time-based rate programs and evaluations of distributed energy resources.

The production costing tool runs automatically each hour, taking into account the most recent unit generation data and the most current transaction information from GSOC's ECS and other data sources. Using this data, the tool re-optimizes GSOC's unit commitment and dispatch for the next several days, providing GSOC and its members with updated expected cost information. The tool can also be used by grid operators and engineers to analyze resource plans and conduct "what if" scenarios.



GSOC's new grid operator display for scheduling and dispatching all resource types.

5. New Protective Measures Enhance Cyber and System Security

GSOC took several steps to better manage the risks of potential cyber-attacks and other threats to the reliability and security of their systems. For example, implementation of "Industrial Defender," their primary tool for Critical Infrastructure Protection, enables GSOC cybersecurity engineers to monitor and manage events on servers, workstations, physical security devices, and network equipment. Cybersecurity measures are now available through a new host-based firewall that includes additional anti-virus and anti-malware protections, more stringent user access controls, and simplified audit logging. The new "Network Intrusion Detection" tool monitors the system from within for suspicious activity such as abnormal communications and broadcasts and failed login attempts. With these tools GSOC is now able to react quicker to potential cybersecurity threats or vulnerabilities.

The telecommunications upgrades mentioned above also provide more cyber-secure fiber connections to the backup control center, more reliable and secure links to members, and more direct connections between the EMS and field devices. The resiliency of the ECS upgrades was confirmed by tests that demonstrated GSOC can meet NERC security requirements with 50% of the system memory disabled and during extreme weather events.

Grid operators participate in new GSOC training sessions.

Other security measures include installation of a state-of-the-art fire protection system for control rooms and data centers which improves the overall reliability of the EMS and shortens recovery times in the event of a fire. The system involves separate fire protection zones which allow for continued operations in the event of a fire disabling one of the two control centers.

6. Future Directions

With these upgrades, GSOC is positioned to scale-up and address future smart grid requirements, including advancements in software, hardware, and "big data" analytics. GSOC expects to implement near- and long-term enhancements. In the near-term, GSOC expects to work with member cooperatives to inform them of the benefits they can capture through more effective utilization of the new data being provided, including information on power flows across the bulk power system and more accurate energy cost estimates for power purchasing decisions. Over the longer-term, GSOC plans to continue implementation of EMS and control room enhancements, including expanding the state estimator to model the entirety of the Georgia Integrated Transmission System, and moving ahead with further education and training programs for grid operators and engineers.

7. Where to Find More Information

To learn more about national efforts to modernize the electric grid, visit the Office of Electricity Delivery and Energy Reliability's website and www.smartgrid.gov. DOE has published several reports that contain findings on topics similar to those addressed in GSOC's SGIG project and this case study. Web links to these reports are listed in Table 4.

Table 4. Web Links to Related DOE SGIG Reports and Case Studies		
SGIG Program and Progress	**i.**	**Progress Report II, October 2013**
	ii.	**Progress Report I, October 2012**
	iii.	**ConEd SGIG Project Description**
	iv.	**SGIG Case Studies**
Recent Publications	**i.**	**Smart Meter Investments Yield Positive Results in Maine, January 2014**
	ii.	**Smart Meter Investments Benefit Rural Customers in Three Southern States, March 2014**
Transmission and Synchrophasor Technologies	**iii.**	**Synchrophasor Technologies and their Deployment in Recovery Act Smart Grid Projects, August 2013**
	iv.	**Model Validation Using Synchrophasors NASPI Technical Workshop, October 2013**
	v.	**Phasor Tools Visualization NASPI Technical Workshop, June 2012**
	vi.	**Synchrophasor Technologies and Renewables Integration, June 2012**
Voltage and Reactive Power Management	**vii.**	**Application of Automated Controls for Voltage and Reactive Power Management – Initial Results, December, 2012**
Distribution Automation	viii.	**Reliability Improvements from Application of Distribution Automation Technologies – Initial Results, December, 2012**