SEL Engineering Services
Project Solution Portfolio
Professional Support, Design Expertise, and Comprehensive Knowledge

SEL Engineering Services, Inc. (SEL ES) has the expertise and experience to solve power system problems around the world. A strong foundation in protection principles means SEL ES understands complex power systems and applies that knowledge to provide solutions that increase reliability, lower cost, and make it easier to meet industry regulations. Combining multidisciplinary strengths in protection, automation, control, communications, and cybersecurity, SEL ES works with you to design standard or custom solutions, including:

- Protection and Automation Services
- Model Power System Testing
- Arc-Flash Hazard Services
- POWERMAX® Remedial Action Schemes and Power Management Systems
- Synchronizing Systems
- DNA® (Distribution Network Automation)
- Communications and Networking Solutions
- Cybersecurity Solutions

Visit our website at selinc.com/engineeringservices or email us at es-info@selinc.com for additional information.
Protection and Automation Services

SEL protection and automation services have been implemented in power systems around the world. Your project will be staffed with engineers who have years of experience and a broad knowledge base, ensuring that you’ll get the best solution for your system.

SEL protection and automation services include relay settings, scheme design, communications architecture design and programming, fault and coordination studies, documentation, and more.

Merck West Point

Relay Settings Review
Merck & Co., Inc., is a healthcare company known for such innovations as the first measles vaccine, discovery of vitamin B1, and developing the first statins to treat high cholesterol. Merck’s researchers have helped find new ways to treat and prevent illnesses since 1891, with roots that reach into the mid-1600s.

SEL was contracted with KTR Associates to perform a review of multiple relay settings designed by others. SEL performed a review of the SEL relay settings by using the existing ABB relay settings as a basis. We made reference to the drawings, protection report, and existing settings documentation, and transmitted a review document. SEL also traveled to the end user’s location to participate in a settings review meeting.

Luminant Power

Automation Services
A subsidiary of Energy Future Holdings, Luminant is the largest competitive power generation business in Texas, with more than 15,400 megawatts of capacity.

Luminant requested SEL automation engineering services and onsite commissioning support for 19 SEL-2032 Communications Processors and 4 SEL-2411 Programmable Automation Controllers, primarily located at their Oak Grove Power Plant—a 1,600-megawatt coal-fueled generation plant. The SEL-2032 Processors and the SEL-2411 Controllers were installed on the 34.5 kV switchgear and the 138 kV circuit, respectively. All work had to be completed during a two-week outage period.

SEL assisted in reconfiguring the SEL-2032 Processors as well as the SEL-2411 Controllers, all geared toward Luminant standards. We reviewed and assisted Luminant in the communications architecture design for the 19 SEL-2032 Processors and in creating standards for data retrieval from the relays. SEL provided recommendations that improved performance and operation of the SEL-2032 Processors, SEL-2411 Controllers, and Modbus® RTU communications network.

SEL provided onsite support during the reconfiguration as well as during the startup commissioning of the plant. Afterwards, SEL continued to offer support through remote assistance by reviewing SEL-2032 settings and helping with testing and commissioning the settings.
Sinclair Oil Corp

Coordination and Relay Settings

Founded by Harry Sinclair in 1916, Sinclair Oil Corporation operates two refineries in Wyoming and more than 2,700 service stations in 22 states. The Sinclair Wyoming Refinery is one of the largest high-conversion refineries in the Rocky Mountain region, producing more than 80,000 barrels per day.

Sinclair requested SEL to develop settings for two SEL-710 Motor Protection Relays and three SEL-751 Feeder Protection Relays for the Sinclair Wyoming Refinery. SEL also provided a coordination study report and a system model.

SEL developed the settings for the relays based on the data provided by the Sinclair Refinery. We modeled the system using EasyPower® software, then used the model to perform a short-circuit study and calculate the relay settings. The two SEL-710 Motor Protection Relays provided protection for one 250 HP motor and one 150 HP motor, while two of the SEL-751 Feeder Protection Relays provided overcurrent protection for two 2400–4800 V transformers. Another SEL-751 Feeder Protection Relay provided overcurrent protection for the main bus associated with the main breaker. SEL performed a coordination study using the EasyPower model to ensure proper coordination between the relays and other protective devices in the system. We discussed recommendations for breaker settings and fuse rating selection with Sinclair, and changes were made accordingly.

SCE&G

Relay Settings Review

SCE&G generates and supplies electricity and natural gas services to South Carolina businesses and residents.

SEL was contracted with Eaton Corporation to review relay settings for four low-voltage (LV) and two medium-voltage (MV) switchgear units. Each LV switchgear unit contained one SEL-351 Protection System. The MV switchgear lineups included a total of eight SEL-351 Protection System Relays and two SEL-587Z High-Impedance Differential Relays. SEL performed factory acceptance tests (FATs) for the four SEL-351 Relays on the LV switchgear in Asheville, North Carolina, and tested the remaining equipment at the Greenwood, North Carolina, facility. SEL was also responsible for configuring two SEL-3354 Embedded Automation Computing Platforms and providing an FAT report documenting the tests. SEL sent an automation engineer and a protection engineer to conduct the testing.

The SEL engineers reviewed the settings of each relay prior to arriving onsite for testing. The FATs they performed consisted of several different types of testing. They used an Omicron test unit to verify that the relays were operating correctly for the settings Eaton was using. The engineers also conducted functional testing to ensure that the relays and other components were wired correctly. They documented and compiled the results of each FAT into a report that SEL delivered to the customer at the end of the project. The SEL engineers found no major issues during the tests, and they concluded that each relay was performing as expected.
Haviland Plastics

System Study and Relay Settings
Haviland Plastic Products (HPP), located in Haviland, Ohio, uses recycled plastics to manufacture superior-quality nursery containers made entirely of 100 percent recycled material. In their effort to promote a positive environmental footprint, HPP built an in-house renewable energy facility that at the time of construction was the largest private wind project in the United States.

SEL was contracted with One Energy to provide relay settings and relay testing at the Haviland wind turbine facility. SEL performed a coordination study with upstream and downstream protective devices, developed and tested SEL-351A Feeder Protection Relay settings, and commissioned an SEL-351A Relay onsite.

Xcel Energy

Relay Settings and Fault Studies
Xcel Energy is a major U.S. electric and natural gas company with the fourth largest transmission system in the United States and more than 17,000 MW of electricity generation capacity. Based in Minneapolis, Minnesota, the company has operations in eight states, serving 3.4 million electricity customers and 1.9 million natural gas customers.

Xcel was upgrading their Jones Substation in Amarillo, Texas, from a main bus transfer arrangement to a breaker-and-a-half configuration. All existing relays were replaced with new SEL relays, including transmission line, breaker failure, and bus differential relays.

SEL was responsible for completing the relay settings for 11 terminals and 5 remote terminals as different projects. Four of the terminals were for generators, one was for a plant power transformer, and one was for a feed to Lubbock Power and Light, a neighboring municipal utility. SEL calculated the relay settings with Mathcad® software, and we used Cape Software validation software for fault studies and a relay database.

PSE&G serves 1.8 million gas and 2.2 million electric customers.
PSE&G

Distribution SCADA and Asset Management System

Established in 1903, Public Service Electric and Gas Company (PSE&G) is the largest and oldest publicly owned utility in New Jersey, serving 1.8 million gas customers and 2.2 million electric customers across a 2,600-square-mile service area.

SEL has provided design, fabrication, programming, commissioning, and testing services for PSE&G on 179 transformers at 68 different substations. SEL performed design and fabrication services for these projects, such as retrofit design of modern microprocessor-based protective relaying to replace legacy electromechanical relaying for transformer protection; fabrication of replacement relay plates; substation SCADA remote terminal unit (RTU) rack design and fabrication; and transformer monitoring cabinet enclosure design and fabrication. SEL also performed programming services, including transformer thermal, status, and alarm monitoring for an asset management system; SCADA RTU programming; SCADA Master programming; and Ethernet network design and programming. In addition, SEL provided commissioning and testing services for these systems as well as training to PSE&G personnel, including technicians and engineers, on the installed systems.

SEL was contracted with Fluor Corporation to provide electrical support services for a USACE project in Afghanistan. This project included the purchase and shipment of an SEL-3530 Real-Time Automation Controller (RTAC) with a human-machine interface (HMI), an SEL-3354 Embedded Automation Computing Platform, a 17-inch rack-mount touchscreen LCD monitor, and a rack-mount keyboard drawer. The scope of the work included programming by SEL Government Engineering Solutions (GES) for the RTAC, ten SEL-2411 Programmable Automation Controllers (PACs), and the RTAC HMI for the control and monitoring of the primary switching center at the power plant and substation at BAF MILCON II (Bagram Airfield Military Construction II), Afghanistan. SEL also provided commissioning and testing support as well as two days of onsite training on the proper operation of the SEL equipment.

USACE

Electrical Support Services

Established in 1802, the U.S. Army Corps of Engineers (USACE) is currently comprised of approximately 37,000 civilians and soldiers who deliver engineering services to customers in more than 130 countries worldwide.

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Central Virginia Electric Cooperative

Automation Settings and Commissioning

Formed in 1937, Central Virginia Electric Cooperative (CVEC) is a member-owned electric distribution cooperative that provides electric service for 35,000 customers across 14 counties in Central Virginia.

CVEC asked SEL to replace an existing QEI Remote Terminal Unit (RTU) with an SEL-3530 Real-Time Automation Controller (RTAC). For this project, the RTAC polled and issued control commands to three Cooper Form 5 Recloser Controls and nine Siemens MJXL Voltage Regulators that were communicating via the Cooper 2179 protocol. Additionally, the RTAC monitored 16 hard-wired inputs and sent all data to the customer’s Survant Technology master system.

This project involved the first implementation of the Cooper 2179 flex-parsing protocol into the SEL RTAC. This required dedicated SEL R&D and ES resources to write and test the new driver, library, and programming required to support this protocol. In addition to the new code, the data points desired by the customer were parsed individually. The RTAC acted as a client polling the 2179 servers and then translated the data to DNP3 to report to the customer’s Survant Technology master.

NMIC

Automatic Transfer Scheme

The National Maritime Intelligence Center (NMIC) facility, located in Suitland, Maryland, houses the Office of Naval Intelligence, the U.S. Coast Guard Intelligence Coordination Center, and the National Maritime Intelligence-Integration Office.

SEL was contracted with M.C. Dean to provide engineering services for the design and programming of an automatic transfer system for a temporary generator paralleling switchgear at the NMIC. The project scope included purchasing, programming, testing, shipping, and commissioning. SEL designed the scheme to comply with the sequence of operations provided by M.C. Dean, and we factory-tested it prior to installation.

SEL engineering support included designing and programming an automatic transfer system for a temporary paralleling switchgear. SEL also purchased, programmed, and shipped one SEL-3505 Automation Controller, one SEL-2440 Discrete Programmable Automation Controller, four SEL-751A Feeder Protection Relays, and four SEL-C272A 50-foot serial communications cables. SEL engineers provided two days of onsite testing and commissioning support for the automatic transfer system.
Nucor Steel

500 kV Substation Upgrade

With a production capacity that exceeds 27 million tons, Nucor is the largest producer of steel in the United States.

Nucor Steel Decatur, in Trinity, Alabama, contracted SEL to implement a total upgrade of their 500 kV Hot Mill Substation, including a new drop-in control house. To coordinate the project, SEL provided a quality assurance plan, weekly project meetings via conference calls with the customer, an onsite project kickoff meeting, and a site assessment visit for photos, cable schedule verification, and equipment drawings.

The SEL solution included IEC 61850 and DNP3 communications as the backbone for both automation and protection needs; overlapping differential protection zones; Fast Bus Tripping schemes using IEC 61850 GOOSE messages; and coordinated overcurrent protection zones. SEL also provided complete redundancy for the system, including dc battery systems, protective relaying for each piece of high-voltage equipment, power supplies on all SEL-2730M Managed 24-Port Ethernet Switches, and a network fiber loop.

As part of the solution, SEL performed a protection system review with Nucor Steel’s SKM system model as well as extensive onsite commissioning and testing that involved an SEL-2240 Axion®-based breaker simulator to simulate ~20 breakers. SEL also developed a new tool for organizing and assigning GOOSE messages.

Gulf Power Company

Protection and Control Application for 137 Feeders

A subsidiary of Southern Company, Gulf Power Company was established in 1925 as an electric generation, transmission, and distribution utility in the Florida Panhandle. Gulf Power currently serves more than 395,000 customers across 7,500 square miles and ten counties.

Gulf Power contacted SEL to perform a coordination study for 137 feeders in their system because of a downstream recloser addition. SEL provided new settings for each feeder along with a separate copy of the Cape Software database file. A 24-cycle minimum coordination margin with upstream protection was verified, and work orders were created for the settings changes.

SEL performed the coordination studies for each feeder using Cape Software validation software. We verified the new settings based on the provided customer criteria for close-in three-phase, phase-to-phase, and single-line-to-ground faults. In the case of multibank substations, coordination was verified with either bank. SEL then provided these verified settings to the field engineer technician, applications engineer, and distribution engineer as Microsoft® Access® database (.mdb) files for the SEL relay settings and as settings change sheets for the electromechanical relays. Wherever applicable, the engineers also modified bank settings to coordinate with the requested feeder settings. For all relays with settings changes (feeders and banks), they created an Rweb file for the new pending settings.
Covanta Energy

Relay Panels, Settings, and Commissioning
Covanta is one of the largest owners and operators of energy-from-waste (EFW) infrastructure in the world, with over 40 EFW facilities in North America, Italy, and China as well as other complementary waste management businesses. The Delaware Valley Resource Recovery facility generates approximately 80 megawatts of electricity at maximum output.

Covanta contracted SEL to provide relay panels, settings, and commissioning support for their Delaware Valley location. The project involved replacing existing electromechanical relays with SEL 751A Feeder Protection Relays. SEL provided panels in time to meet Covanta’s outage schedule. The relay settings were developed based on Covanta drawings and the existing electromechanical relay settings. Lastly, SEL provided commissioning support, including the supply of a Doble test set and expertise on the testing of directional elements.

Northern Virginia Electric Coop

Relay Settings and Coordination
Northern Virginia Electric Cooperative (NOVEC) is a locally based, locally owned electric distribution cooperative headquartered in Manassas, Virginia. NOVEC’s service territory covers over 650 square miles, and they provide power to more than 154,000 customers.

NOVEC requested SEL protection engineering services and onsite commissioning support for the Arcola Substation in Manassas. SEL performed protection relay programming for one SEL-487B Bus Differential and Breaker Failure Relay and completed a settings review for two SEL-787 Transformer Protection Relays and three SEL-751A Feeder Protection Relays. The project involved onsite testing of the relay settings, with the final deliverables, which included the SEL-487B test report and bus differential calculation settings, submitted electronically to NOVEC.

Seattle City Light

HMI Upgrade
Seattle City Light, established in 1902 as a municipally owned public power system, serves over 400,000 customers in the Seattle area and is the tenth largest public utility in the United States in terms of retail energy sales.

Seattle City Light hired SEL to add three generator units into the existing human-machine interface (HMI) system for their Boundary Hydroelectric Project. SEL provided integration and commissioning services, including programming the SEL-3530 Real-Time Automation Controller (RTAC), SEL-2032 Communications Processor, and SEL-2030 Communications Processors with aSELERATOR QuickSet® SEL-5030 Software. SEL engineers designed and installed the HMI, adding Units 52, 53, and 54, and performed communications testing and data validation for all the generator units included in the HMI. In addition, the engineers updated the HMI screens for Unit 51, as requested by Seattle City Light.
Model Power System Testing

SEL can create a computer model of your power system with the Real-Time Digital Simulator (RTDS®), enabling endless possibilities for testing control systems under realistic conditions on a variety of power system applications and apparatus.
BC Hydro

Relay Settings Validation
BC Hydro is a commercial Crown corporation owned by the Province of British Columbia and is one of North America’s leading providers of clean, renewable energy. With a generation capacity of 43,000 to 56,000 gigawatt hours of electricity per year, BC Hydro is the largest electric utility in British Columbia and serves approximately 1.9 million customers.

BC Hydro commissioned SEL to provide five days of model power system (MPS) testing to validate relay settings for the 287 kV line 2L102 in the BC Hydro transmission system. SEL developed a Real Time Digital Simulator (RTDS) simulation of the 287 kV transmission line network. Representatives from BC Hydro traveled to SEL facilities in Pullman, Washington, to witness the MPS testing. SEL sent a final test report to BC Hydro with the test findings.

Dominion Nuclear Ct.

Open-Phase Detection
One of the nation’s largest producers and transporters of energy, Dominion generates approximately 23,600 megawatts of electricity and has a natural gas storage capacity of 947 billion cubic feet. Dominion serves nearly 6 million customers in 15 states. Exelon has operations in 48 states, the District of Columbia, and Canada, with 35,000 megawatts of owned capacity. Exelon utilities serve 7.8 million customers across Central Maryland, Northern Illinois, and Southeastern Pennsylvania.

Dominion and Exelon utilities partnered with SEL to develop an algorithm to detect open-phase and open-phase-to-ground events on the load side of startup transformers using a microprocessor-based relay.

SEL performed Real Time Digital Simulator (RTDS) modeling for the Dominion plants, with hardware-in-loop handled by the SEL Charlotte ES team and EMTP-RV for the Exelon plants handled by the SEL Houston ES team. Dominion provided RSCAD files, and Exelon provided EMTP-RV COMTRADE files.

SEL ran all the positive and negative test scenarios specified by both utilities to validate the algorithm and proved the security and reliability of the algorithm under these scenarios. Proof-of-concept testing took place in Charlotte for the Dominion plants and in Houston for the Exelon plants.

At the end of the project, SEL delivered a functional design specification document explaining each algorithm’s theory of operation. We also delivered a proof-of-concept testing document explaining the testing methodology and scenarios that were run for the specified transformers at each plant as well as the test results.
Arc-Flash Hazard Services

SEL conducts flexible, customized arc-flash hazard services to mitigate arc-flash hazard risk and improve employee safety. Using proven methods to calculate flash protection boundaries and to classify each area into proper personal protective equipment (PPE) categories, SEL offers many services to provide complete, cost-effective arc-flash solutions for your facility.
Bureau of Reclamation

Arc-Flash Peer Review

Established in 1902, the U.S. Bureau of Reclamation has constructed more than 600 dams and reservoirs, including Hoover Dam on the Colorado River and Grand Coulee on the Columbia River. Davis Dam and Power Plant, 67 miles downstream from Hoover Dam, was completed by the Bureau in 1953 and serves to re-regulate Hoover Dam releases to meet downstream needs.

SEL was contracted with Power Pros to perform an arc-flash peer review study on the Bureau of Reclamation's Davis Dam facility. The facility consisted of 15 kV class generators stepped up to 230 kV. From there the voltage was stepped down to 4,160 V for distribution and then down to 480 V for the main facility operating voltage. The specific items SEL investigated were apparatus duty ratings, arc-flash incident energies, breaker coordination, and model accuracy.

First, SEL engineers compared nameplate data supplied by the customer against an EasyPower software model. They checked all high-voltage breakers and transformers for accuracy. Because of the large volume, only 15 percent of the medium- and low-voltage breakers were checked.

Next, the engineers calculated the available fault current at each bus and compared this with the values in the customer's review. As part of this task, they also checked the breaker duty rating against the customer's data. Then, SEL performed a coordination check between upstream and downstream devices. Finally, incident energies for each bus were calculated and compared against the customer's findings.

The one major item SEL found was that the customer calculated the arc-flash incident energies using a maximum simulation time of two seconds. This was because IEEE 1584 states that a worker should be able to evacuate the danger area within these two seconds. However, the SEL engineers set the simulation time to a maximum of 1,000 seconds for the SEL review and found that many three-phase faults had no tripping protection and some had excessively long time-overcurrent protection. These findings were included in the SEL report and acknowledged by the customer.
POWERMAX Remedial Action Schemes and Power Management Systems

SEL POWERMAX® remedial action schemes (RAS) will maintain system stability by detecting abnormal conditions in power systems and taking automatic corrective actions, including generation and load shedding, reactive compensation, and customized solutions.

For customers with onsite generation and/or significant import/export power, the SEL POWERMAX Power Management System is an ideal solution.

The Jim Bridger Plant in Wyoming is a coal-fired generation facility with a capacity of 2,120 MW.
PacifiCorp

Remedial Action Scheme

Formed in 1984, PacifiCorp is an electric utility that serves 1.8 million customers across 136,000 square miles in Utah, Oregon, Wyoming, Washington, Idaho, and California. PacifiCorp operates approximately 75 generation facilities with over 10,500 MW of combined generation capacity from a variety of fuel sources. The Jim Bridger Plant in Wyoming is a coal-fired generation facility with a capacity of 2,120 MW.

PacifiCorp contracted SEL to implement a remedial action scheme (RAS) for the Jim Bridger Plant to maximize power transfer and ensure power system stability of the adjacent transmission system. This RAS allowed PacifiCorp to operate their system very close to their stability limit, thereby increasing the amount of low-cost power that could be shipped from the Jim Bridger Plant in Wyoming to Portland, Oregon, and to Salt Lake City, Utah. SEL designed the RAS to protect the power system from subsynchronous resonance (SSR) by bypassing one or more series capacitors, thereby changing the damped natural frequency of the electric grid around the Jim Bridger Plant away from several shaft modes of the generators in the PacifiCorp system. This protected the shafts from damage during situations that are known to cause SSR. The RAS was also configured to shed generators (one or more 500 MW units) in response to changing system conditions to prevent the generation at the Jim Bridger Plant from exceeding the dynamic stability limits of several major transmission corridors.

SEL provided a PowerMax Power Management and Control System RAS control scheme, configured as a triple modular redundant (TMR) control scheme. This system was similar to systems used for emergency shutdowns and in the nuclear power industry. It employed a full two-out-of-three voting architecture (input and output voting) for all analog inputs (MW and MVAR), digital inputs (statuses), control outputs (output trips), and the SEL Crosspoint Switch Advanced Application Logic. SEL provided two TMR systems, making it a dual-primary TMR scheme. The maximum response time from input assertion to output contacts was less than 16 milliseconds. SEL also designed and delivered a simulator to the customer to test the functionality of the RAS. We designed a supervision system to monitor the decisions of the two TMRs. The supervision system provided contingency-based suppression or complete TMR suppression if the two TMR systems make different decisions.

Black Hills Power

Remedial Action Scheme

An investor-owned electric utility that began in 1883 and a subsidiary of the Black Hills Corporation since 1941, Black Hills Power serves nearly 70,000 customers throughout western South Dakota, northern Wyoming, and southeastern Montana.

Black Hills Power approached SEL to provide the architecture for the implementation of a remedial action scheme (RAS) on their 200 MW ac-to-dc-to-ac intertie. The purpose of the scheme was to monitor the status of a Black Hills Power transmission system, area generation, and area load, and to match the combination of these parameters to the power transfer capability of the installed 200 MW ac-to-dc-to-ac intertie station that connects the eastern and western U.S. power grids. The RAS would limit (run back) the intertie's power transfer capability based on the output of the logic scheme.

SEL developed special application logic in the logic processor to accommodate the complex scheme. In addition, SEL provided real-time monitoring and event viewing tools to monitor the system conditions and the runback signals. SEL also assisted the customer onsite with the installation of the system.
MOTIVA Enterprises

Power Management System

Motiva Enterprises is a refiner, distributor, and marketer of fuels in the eastern and Gulf Coast regions of the United States. Their refinery complex in Port Arthur, Texas, is one of the largest oil manufacturing plants in the world, producing 40,000 barrels per day.

SEL was contracted by Jacobs Engineering in Houston, Texas, to provide a complete generation and load management system for the Motiva Port Arthur refinery.

The scope of work included dual redundant SEL POWERMAX® “Generation” Control System (GCS) hardware, a ClearView-based human-machine interface (HMI) system running on SEL-3354 Embedded Automation Computing Platforms, and an SEL-2407® Satellite-Synchronized Clock at the main substation. SEL-3530 Real-Time Automation Controllers (RTACs) were used as data gateways to gather data from the existing SEL-2032 Communications Processor and SEL relays located throughout several substations. Included in the GCS was an automatic synchronization control system; redundant SEL-451 Protection, Automation, and Bay Control Systems were used to automatically resynchronize the plant back to the local utility grid. SEL-2411 Programmable Automation Controllers mounted in small wall-mounted racks were placed adjacent to the GE Mark VI governor and exciters controls. These SEL-2411 Controllers provided a hardwired interface for the POWERMAX System to dispatch set points and monitor status of the GE governor and exciters.

Idaho Power Company

Remedial Action Scheme

Idaho Power was formed in 1916 as a generation, transmission, and distribution company serving over 500,000 customers across 24,000 square miles in southern Idaho and eastern Oregon. The company operates 17 hydroelectric generation facilities along the Snake River and its tributaries.

Idaho Power contracted SEL to design a remedial action scheme (RAS) for their Borah West Transmission Station to maximize the operating transfer capability while protecting against cascading outages on several key transmission corridors in the Idaho Power grid, both under normal and derated operating conditions. By remotely monitoring the state of all associated lines, transformers, and capacitors (shunt and series) for the specified path, the control system was designed to take predetermined actions to prevent overloading transmission lines beyond their design level for all credible outages impacting the transfer capability of the path. The algorithm used current state information to continually adapt the control’s response for every possible future contingency.

SEL designed the RAS to trip generators, insert shunt capacitors, and bypass series capacitors throughout the Idaho Power transmission system in response to the present system state and major system events (e.g., faults and line outages). SEL-2506 Rack-Mount I/O Modules are used to collect breaker status information and communicate via the Mirrored Bits® communications protocol back to the SEL-1102 Computing Platforms located in the Borah West Substation. The SEL-2506 Modules are also used for output trips to remote substations.

SEL provided a POWERMAX Power Management and Control System RAS control scheme and configured in a dual-primary redundant control scheme. The maximum response time from input assertion to output contact is less than 20 milliseconds transferred over several hundred kilometers.
North American Oil Platform

Power Management System

In early 2010, SEL’s client was looking for a solution for a modern, fast power-monitoring and load-shedding system for the design of an oil platform. The project was designed by the end user and a consulting firm. The present SCADA and load-shedding systems were required to be functioning as one system in order to simplify the day-to-day operation and increase accessibility. The load-shedding system is fast enough to issue trip commands to a list of user-prioritized loads within 70 milliseconds. The preferred SCADA human-machine interface (HMI) package was Wonderware InTouch® and was required to minimize the maintenance effort. Data concentration to several non-SEL devices and systems was required to be in the scope of the power management and load-shedding (PMLS) system vendor (SEL) scope. Automatic synchronization for the emergency generator buses and hurricane generator buses was required to be incorporated into the PMLS system. SEL Engineering Services participated in the front-end engineering design (FEED) stage of the project and officially kicked off the project in early 2011. Later in 2011, our client approved the scope expansion to have SEL provide protective relays.

SEL implemented a Wonderware InTouch-based SCADA system, including one-line screens, breaker detail screens, alarm screens, trending screens, and load-shedding screens. The HMI system monitors the live data of the power distribution system and displays them in an easy-to-understand fashion with the assistance of graphic animation and color codes. It also provides a historical, discrete-alarm database and analog trending screens. Five user levels were defined on the HMI system to grant different privileges to individual users. The breaker control function is not only protected by a user credential, but also supervised by electrical building location. Besides SEL intelligent electronic devices (IEDs), the SCADA system also integrates non-SEL devices, such as turbine control panels, 480 V MCCs, 480 V solid-state trip units, UPS, HRGs, and others. The system provides two redundant Modbus interfaces to process the automation system and also provides onshore connectivity for remote monitoring and event analysis at the client’s onshore control center.

SEL delivered the contingency-based fast load-shedding system. The dual, hot-redundant SEL-1102 Computing Platform for value-added resellers load-shedding processors provide reliable operation of the system. The 2-millisecond processor interval and the pre-event calculation feature ensure minimal time used in detecting, analyzing, and the system taking action. IEC 61850 GOOSE protocols are used for fast data communication.

SEL designed and constructed the PMLS communications panels, which are located in every electrical building. Two desktop computers were configured as engineering workstations. The workstations provide an HMI screen, manage a relay settings database, provide remote access to SEL IEDs, and allow users to manage and modify HMIs, add/edit/delete users, analyze events, etc. An offline static simulator was configured for the project. The simulator is ideal for new operator training and engineering study of system behavior.

There were three automatic synchronization systems implemented on the project: one for the 13.8 kV bus-tie breaker main generator switchgear bus, one for the 480 V emergency generation system, and one for the 480 V hurricane generation system. The automatic synchronization system allows the operator to select which breaker to synchronize and matches the voltage magnitude, phase angle, and frequency by adjusting the corresponding generator. Custom logic was built into the SEL-451 Protection, Automation, and Bay Control System to meet the unique logic scheme requirements for this project. SEL also provided the protective relay settings database according to the customer ETAP® system study and coordination report.
Synchronizing Systems

SEL Synchronizing Systems send control signals to a generator’s governor and exciter to bring slip and voltage difference across an open breaker into permissive band. Then, the system initiates a close command at the slip rate compensated advanced angle to close the circuit breaker at precisely zero degrees angle difference.
Southwestern Power Administration

Custom Automatic Synchronizer
Southwestern Power Administration, established in 1943 by the U.S. Secretary of the Interior, is a federal agency that operates within the Department of Energy to market hydroelectric power in Arkansas, Kansas, Louisiana, Missouri, Oklahoma, and Texas from 24 U.S. Army Corps of Engineers multipurpose dams.

Southwestern was upgrading automatic synchronizing systems at their generating stations when Southwestern’s consultant, Woodward and Associates, contacted SEL for a solution. SEL proposed a system based on our pre-engineered automatic synchronizer that uses SELogic® control equations on the SEL-451 Protection, Automation, and Bay Control System platform. The scope included modifying the pre-engineered automatic synchronizer to meet the exact requirements specified by Woodward and Associates.

SEL provided programming, design documentation, and testing for the system. The design documentation included a custom instruction manual and an acSELerator QuickSet Designer® SEL-5031 Software template.

East Bay Municipal Utility District

Autosynchronization System
Founded in 1923, the East Bay Municipal Utility District (EBMUD) provides high-quality drinking water for 1.3 million customers in Alameda and Contra Costa counties in California. Their award-winning wastewater treatment plant protects San Francisco Bay and serves 650,000 customers, treating approximately 75 million gallons of water per day.

With the primary goal to prevent system blackouts that could result in untreated wastewater being discharged into the San Francisco Bay, EBMUD wanted a complete load shedding, SCADA, and protective relaying system for their wastewater treatment plant. The project consisted of a comprehensive protection, automation, monitoring, and control solution for all of the electric power systems within the treatment plant. This included protective relays and SCADA for three substations, four generators, two utility ties, and distribution feeders as well as load shedding for islanding segments of the plant. As part of the solution, SEL provided autosynchronization and main-tie-main systems and performed real-time digital simulation to validate the entire control system.
DNA® (Distribution Network Automation)

SEL’s complete DNA technology combines fast protection with flexible automation and communications for a customized distribution automation solution that makes your system safer, more reliable, and more economical.
Fort Hood

Substation Upgrade and Automation
Covering 340 square miles in central Texas and hosting approximately 50,000 military personnel, Fort Hood is the largest active-duty armored post in the U.S. Armed Services.

SEL was contracted with Premier Technical Services to provide model option table (MOT) configuration, settings, programming, testing, and shipment for 20 SEL-751A Feeder Protection Relays and retrofit bezels to replace existing GE MDP protective relays in the Military Family Housing (MFH) Substation at Fort Hood. The project also entailed a human-machine interface (HMI) system design, which included programming, testing, and shipping. Onsite commissioning support for the HMI and training were included.

Fort Hood specified that the SEL-751A protection settings match their existing GE MDP protection settings. The logic within the relay allowed them to use the relay pushbuttons instead of their manual rotary switches. SEL developed an HMI system (based on the Fort Hood North Substation Upgrade) that allowed remote monitoring and control of each circuit breaker as well as the relay pushbuttons. SEL engineers performed a thorough factory acceptance test of both protection and automation functions and traveled to Fort Hood to perform onsite commissioning of the HMI system. They verified the communications architecture onsite after installation by Premier Technical Services. SEL provided relay and HMI operation training to Fort Hood personnel. In addition, the SEL engineers went beyond the scope of the project by suggesting that additional control wiring be pulled from the bus-tie switches to enable the HMI system to monitor and display the respective switch status (open or closed) on the one-line diagram.

Mississippi Power Company

Automated Switchgear
A subsidiary of Southern Company, Mississippi Power Company (MPC) was established in 1924 and is now an investor-owned utility that serves electric power to 186,000 customers located in 23 counties in southeast Mississippi.

MPC contacted SEL to install a fast transfer scheme for a new G&W Electric four-way pad-mounted switch to quickly transfer a new General Electric (GE) plant in Ellisville, Mississippi, to a backup feeder if the primary feeder failed. MPC also requested commissioning support for this scheme and associated integration equipment.

SEL provided commissioning support for an SEL-451 Protection, Automation, and Control System automatic fast transfer scheme for MPC to use with G&W magnetic-actuated four-way switchgear at the GE plant. This scheme was a further development of MPC’s standard transfer scheme. The automatic fast transfer scheme was designed to detect loss of voltage on the primary source and rapidly transfer to the secondary source. In addition to the transfer scheme, SEL provided an ACCELERATOR QuickSet Designer template that greatly simplifies the setup of the scheme. This particular installation included an SEL-751A Feeder Protection Relay on each load way and an SEL-3505 Automation Controller with distributed network protocol (DNP) concentration and peak demand monitoring for the load ways. SEL also assisted in G&W gear troubleshooting and supervisory control and data acquisition (SCADA) checkout of the scheme.
**Marshall Municipal Utilities**

**SEL-651R Advanced Recloser Control Settings**

Established in 1914, Marshall Municipal Utilities provides Internet, electric, natural gas, sewer, and water utility services to the City of Marshall, Missouri.

SEL was contracted with Thomas & Betts to develop an automatic transfer scheme for a water treatment facility in Marshall, so that the electrical source would be transferred from the utility to a backup generator in the event of utility voltage loss. The system included the SEL-651R Advanced Recloser Control and Elastimold® MVR recloser. The customer requested modifications to the standard design template, including the necessary logic and user-programmable inputs for the source transfer scheme.

SEL developed logic so that when the source-side voltage fell below the user-programmable value for a set amount of time, the SEL-651R would open the Elastimold MVR recloser. Once an open condition was confirmed by the 52A contact, an output contact would close, which started the backup generator. After a user-programmable time delay, when healthy voltage was detected on the source side of the recloser and the source- and load-side voltages were in sync, the recloser would close. Then the SEL-651R output contact would open to stop the generator. In addition, SEL simplified the design template to allow only three-phase opening/closing and a single settings group.

SEL tested the scheme using the SEL-4000 Relay Test System, and the project didn’t require any onsite testing or commissioning support.

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**Arnold Air Force Base**

**Transfer Control**

Constructed in 1941, Arnold Air Force Base is a United States Air Force base located in Tennessee. Although the base no longer contains an active airfield, it is home to the Arnold Engineering and Development Complex, the largest and most advanced flight simulation test facilities in the world.

SEL was contracted with Siemens on a transformer control project at Arnold Air Force Base. SEL developed relay logic and communications settings for two SEL-2440 DPAC Discrete Programmable Automation Controllers and one SEL-2414 Transformer Monitor per the I/O list provided by Siemens. SEL delivered the relay settings to the customer in .rdb and .selaprj formats for downloading into the relays. SEL also provided time and expense support for completing the project commissioning, including onsite support for system troubleshooting and programming.
EPB of Chattanooga

Distribution Automation Control System

Established in 1935, Chattanooga Electric Power Board (EPB) is a nonprofit agency of the City of Chattanooga, Tennessee, and provides electric power to the people of the greater Chattanooga area. As one of the largest publicly owned providers of electric power in the country, EPB serves more than 169,000 residents in a 600-square-mile area.

EPB requested SEL to design, configure, and commission an SEL Distribution Automation Control (DAC) System for the EPB 46 kV closed-loop subtransmission system as well as to design and construct an estimated 75 custom single or dual SEL-700GT Intertie Protection Relay cabinets.

The SEL DAC System was installed to detect, locate, and isolate faults, and then to restore power where possible. The system consisted of two SEL-3530 Real-Time Automation Controller (RTAC)-based DACs as well as three RTAC-based front-end processors (FEPs). The FEPs communicated via DNP3 over a fiber-optic network to an estimated 250 field devices, including substation remote terminal units (RTUs), Telvent RTUs, SEL-2411 Programmable Automation Controllers, and SEL-700GT Relays. The FEPs concentrated all data collected from the field devices and provided them via DNP3 to the two DACs. The DACs divided the 46 kV system evenly and shared information with each other by means of the Network Global Variables List (NGVL) capability in the RTACs.

The custom cabinet designs contained two SEL-700GT Relays, batteries, battery charger, optical network terminal, two sets of SEECO sensors, and all associated terminal blocks, fusing, and wiring.
Communications and Networking Solutions

SEL engineers perform communications and network architecture design, prepare schematics and diagrams, program settings, and provide onsite factory acceptance testing, commissioning support, and training.
**PPL Corporation**

**Disturbance Monitoring**

Founded in 1920, PPL Corporation is an electric generation, transmission, and distribution company headquartered in Allentown, Pennsylvania, and serving over 10 million customers in the United States and the United Kingdom. PPL Generation, a subsidiary of PPL Corporation, controls or owns about 11,000 MW of generation capacity in the northeastern and western United States.

PPL Generation contracted SEL to develop a disturbance monitoring equipment (DME) solution for North American Electric Reliability Corporation (NERC) PRC-002 regulation compliance efforts. The DME was necessary to meet the Sequence of Events (SOE) and digital fault recorder (DFR) capabilities required by the NERC standard. The scope of the project included design, installation, and commissioning.

The SEL -487E Transformer Protection Relay was well suited for this application due to the hardwired inputs for SOE recording as well as the large number of current transformer (CT) and potential transformer (PT) inputs for DFR channels with a high-resolution COMTRADE recording format. The SEL -2407® Satellite-Synchronized Clock provided high-accuracy time stamping of SOE records using the IRIG-B protocol. The SEL -3354 Embedded Automation Computing Platform running acSELerator TEAM® SEL-5045 Software pulled back the SOE records and event reports for long-term archiving. The SEL-3354 also provided graphical visualization of the event report oscillography waveforms with acSELerator Analytic Assistant® SEL-5601 Software.

SEL was responsible for panel design and construction, managing the installation subcontractor, and commissioning the system as well as training the customer to use our solution for ongoing NERC reporting compliance requirements.

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**SunWize Solar**

**RTAC Metering and Communications**

Based in San Jose, California, SunWize Technologies finances and builds sustainable energy systems for the public, private, and residential sectors. SEL worked with SunWize on a project for the VA Loma Linda Healthcare System, a U.S. Department of Veterans Affairs healthcare facility in Loma Linda, California.

The scope of this project was to configure an SEL-3505 Automation Controller so that it polled metering data using Modbus TCP/IP from seven PowerLogic® ION meters that were part of a solar photovoltaic (PV) system. The SEL-3505 then provided that data as a Modbus slave to an SCE remote terminal unit (RTU) as the Modbus master.

The SEL-3505 configuration had seven Modbus devices, which were configured per the ION7650 meter that was provided by the client. After verifying the instruction manual with the manufacturer, SEL tested the project using a Modbus master/slave emulator (MBSIM). This was run as a slave, and the SEL-3505 was able to poll the MBSIM slave and vice versa. We found that a Moxa® Modbus TCP/IP device was converting the ION meters’ serial Modbus interface into an Ethernet one. A connection could not be made to the meters, and only the SCE RTU was able to connect.

SEL discovered that the Modbus device configurations in the SEL-3505 for the ION meters were set as serial tunneling Ethernet Modbus. We changed this configuration to Ethernet direct Modbus. Additionally, we discovered that, per a separate instruction manual just for Modbus configuration for the ION meters, the addresses given in the meter manual needed an offset of –1. When these changes were made, communications were established between the SEL-3505 and ION meters.
Cybersecurity Solutions

Cybersecurity isn’t something that can be achieved by one person, product, or technology. Real system-wide protection starts with the understanding that it takes teamwork to achieve success. SEL believes that combining layered security protection with the efforts of protection engineers, information technology personnel, and compliance managers leads to a secure and compliant solution.

North American Utility

Secure Access and Password Management of Substation Relays

A North American utility requested SEL to help them implement strong access controls and password management for their substation relays by using the SEL-3620 Ethernet Security Gateway. SEL configured the SEL-3620 to work with the utility’s Microsoft® Active Directory® infrastructure, providing accessibility based on familiar user credentials. The SEL-3620 generated strong random passwords for 3 communications processors and 48 relays in the substations. The SEL solution also included documenting the password management process, making NERC CIP audits easier, and custom hands-on training for the engineers and operators of the substation. These services helped the utility exceed the NERC CIP requirements and ensure safe, secure operation of their substation. All services provided by SEL are covered by a one-year warranty and are ISO 9001-certified.