



St. Charles' LDC #1 sits on landscaped area provided by the industrial customer. The components (left to right) include three pad-mounted voltage regulators, a 34.5-kV to 12.47-kV dead-front transformer and the 34.5-kV switchgear.

# Substation in a Box 2.0

City of St. Charles delivers a local distribution center to solve capacity and reliability issues.

By **Glynn Amburgey** and **Thomas Bruhl**, *City of St. Charles*

**S**erving citizens since 1892, the St. Charles Municipal Electric Utility is the third largest in the state of Illinois. Power is delivered to the city's six substations by Commonwealth Edison's (ComEd) 34.5-kV sub-transmission system. Reliability in the city is enhanced by a city-owned network of 34.5-kV lines that tie the substations together. This gives the city the ability to restore power internally when there is an interruption on one of the ComEd lines.

St. Charles is located approximately 35 miles (56 km) west of Chicago in northern Illinois. The Fox River flows through the middle of this city of 35,000 people, which was flagged in 2010 by *Family Circle* magazine as the best place in the United States to raise a family. The St. Charles Municipal Electric Utility is doing its part to ensure the city continues to be a great place to live, work and visit.

## The Need for More Capacity

About a year ago, a major publishing company expressed interest in the purchase of a large warehouse facility in the industrial park on the east side of St. Charles. The intent was to convert the space to manufacturing. The total electrical load of the facility was estimated at 7 MW with full production.

Although the facility is located near a major substation, with adequate reserves, the 12-kV distribution system in place could not handle this level of increased load. Another significant issue, a duct bank coming out of the substation was already nearing full thermal capacity.

Several years ago, anticipating there eventually would be a need for additional substation capacity in this area, the utility purchased a 5-acre (2-hectare) parcel when open property was quickly being bought. This site is less than 0.25 mile (0.4 km) away, but a major substation investment did not seem to be a prudent move solely for this customer since other load in the area was not increasing significantly. The St. Charles Municipal Electric Utility needed a new plan to serve the additional load.

## The LDC Solution

The building in question is on a major regional connector, Kirk Road. Under the road, a duct bank is home to one of the city's 34.5-kV lines. An additional 34.5-kV line runs immediately behind the building. The customer was interested in having dual feeds into the facility and was willing to support efforts to increase reliability. So, as city staff reviewed the

options, it became clear a direct connection to the 34.5-kV system had considerable merit.

The St. Charles Municipal Electric Utility engineers went to the drawing board. ComEd had been using 34.5-kV to 12-kV transformers, referred to as substations in a box, around its system for several years. Over a period of about two months, with assistance from various vendors and in consultation with ComEd engineers, St. Charles produced a specification that took the ComEd idea to the next level.

The city's idea was a local distribution center (LDC), and it solved the needs of the customer, who agreed to provide easement space on its property and do extensive site preparation work, including grading and a retaining wall, to expedite this project.

### Equipment Specifications

The LDC project consisted of a transformer, 34.5-kV switchgear and single-phase 12-kV regulators. A relay and communications cabinet was included as part of the switchgear, and 12-kV vacuum reclosers were located inside the transformer cabinet. The specifications were sent out with a request for bids on the equipment. The evolutionary elements, over and above the original design, included the following:

- Dead-front design for the 35-kV switchgear, the primary and secondary sides of the transformer, and the 12-kV reclosers within the transformer secondary compartment



The crew set the 50,000-lb transformer pad just minutes before the transformer.

- Precast foundations for all of the equipment
- Upstream 34.5-kV gear with a differential relay to provide additional transformer protection.

Safety and reliability are cornerstones of the St. Charles' utility, so advancing dead-front technology to the greatest extent was a goal. Improved safety related to the dead-front technology was an obvious goal, but reliability also was expected to be improved by a lower probability of bushing flashovers as a result of contamination or wildlife. Dead-front also provided

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The 34.5-kV to 12.47-kV dead-front transformer is lowered onto the precast pad as crew members prepare for proper placement.

the ability to deploy elbow arresters at multiple points on the system for increased system protection.

The city challenged transformer bidders to provide a dead-front option in both the 35-kV and 12-kV compartments. CG Power Systems accepted the challenge and was the successful bidder for the transformer. CG partnered with G&W Electric to use its Viper-ST recloser, with dead-front terminations, to meet the secondary compartment recloser requirement of the specification.

For the power transformer manufacturer, the main challenge was integrating the recloser and its associated controls in a small space using off-the-shelf dead-front connectors. The transformer also had to contain less than 1,320 gal (4,997 l) of mineral oil to eliminate the need for spill containment at the site. A 7,200/120-V single-phase potential transformer — to provide power to the recloser controller — was included above the transformer’s low-voltage bushings and connected to the transformer’s secondary using fused dead-front elbow connectors.

An upstream 34.5-kV switchgear was needed to tap the existing transmission feed line and provide an interrupter with a differential relay to protect the transformer. The custom switchgear also had to contain a separate communications area so all status and analog values would be available for the city’s supervisory control and data acquisition (SCADA) system.

After a thorough investigation, G&W Electric was selected to supply the dead-front switchgear because it offered a custom solution and agreed to work with the utility on the specific requirements. The particular switch supplied was a 35-kV, four-way, TNI-style pad-mount switch.

Ways 1 and 2 were 600-A source ways, incorporating an integral ground position operable through the external operating handle. The source ways had provisions for mounting a portable motor actuator, permitting remote operation if required. Auxiliary switches were mounted to each open and close position to monitor contact status to a remote SCADA master.

Way 3 was connected to the transformer and included overcurrent protection provided by a three-phase vacuum inter-

rupter in the switch. A motor actuator was installed on the external operating mechanism, permitting the vacuum interrupter to be reset remotely. Auxiliary switches were included for remote monitoring of contact position. Way 4 was connected to two 1.5-kVA potential transformers mounted inside the switch tank to supply 120-Vac power to the control devices and to measure voltage. The potential transformers were protected through a manually resettable vacuum interrupter. Both Ways 3 and 4 were equipped with 500:1 current transformers mounted inside the switch tank for monitoring current.

The switch was equipped with a control enclosure that included one SEL-787 relay, one SEL-751A relay and one SEL-8300 (RadioRANGER) communication device. The SEL-787 provided overcurrent and differential protection for the transformer on Way 3. The SEL-751A provided overcurrent protection for the potential transformers on Way 4. G&W provided the relays, auxiliary power supply and all control wiring. Also included was a communications rack for the city SCADA switches.

### LDC Requirements

The LDC concept is based on the transformer and recloser being packaged together in a single pad-mount enclosure while still providing dead-front construction. This required a custom solution from both the transformer and recloser manufacturer.

G&W provided a solution incorporating its Viper-ST solid dielectric recloser. The modular construction of the recloser permitted the unit to be reconfigured from a conventional overhead design to a dead-front pad-mount construction, providing single-side access and elbow-style connections to the transformer. The enclosure incorporated a side compartment that housed an SEL-651R recloser control. The recloser provided 12.5-kA symmetrical fault current protection of the system.

The city used dead-front regulators and the T-Op II products from Cooper Power Systems. Elbow arresters were de-



The 35-kV switchgear has a remote switch mechanism to allow the operator to switch from up to 50 ft away from the gear. Lineman Merrill Colby attaches the mechanism to the gear.



St. Charles substation engineer Erika Drennen uses a laptop to program the relays in the control enclosure attached to the 35-kV gear.

ployed on the 35-kV switchgear, on the high side of the transformer, on the low side of the transformer and at the 12-kV pad-mounted sectionalizer downstream of the regulators. Fault indicators were liberally applied using the test point on the T-Op II.

**Construction**

On the civil side, construction of a substation on approximately 30 ft by 80 ft (9 m by 24 m) of significant sloping terrain



All cable connections are dead-front inside the 34.5-kV (left) to 12.47-kV (right) pad-mounted transformer.

required a 9-ft (2.7-m)-tall retaining wall and detailed ground grid design. Jacob & Hefner Associates Inc. and Electrical Design Systems Corp. (EDS) developed the civil plans. Power System Engineering provided the ground grid study and design.

The equipment foundations were another element that differentiated the LDC design. The customer schedule was aggressive with a service date of June 20, 2011, with civil work not starting until spring 2011. Thirty days of concrete cure time

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Viper-ST reclosers, adapted for dead-front, are in the 12-kV side of the transformer enclosure; elbow arresters are connected to the T-Ops.

created significant scheduling challenges for the general contractor, Pepper Construction. Therefore, a precast foundation was decided as the way to proceed.

EDS contracted with Utility Concrete Products to precast the foundations for the transformer and regulators. A Concast fibercrete custom foundation with trough was designed for the 35-kV switchgear. Precasting the foundations allowed all five foundations and all five pieces of equipment (the 35-kV switchgear, transformer and three regulators) to be set by a

single crane in a single day. The pipe work had to be precise in the X, Y and Z planes for the pads to be square to each other and in line. The EDS conduit work on-site also needed to be coordinated with a manhole installation and pipe work being installed by Meade Electric.

**A Complete Solution**

The LDC concept is a complete substation package that has emerged as a potential way for St. Charles to provide for long-range planning initiatives without having to upgrade its existing substation facilities. LDCs are advantageous with respect to the expense and logistics of substation expansion, along with the cost to bring feeders from the station to the load. By altering the original design to dead-front, safety and reliability were enhanced. **TDW**

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**Thomas Bruhl** (tbruhl@stcharlesil.gov) graduated from Purdue University in 1992 with a BSME degree and started working at ComEd, now Exelon. In 2002, he joined the city of St. Charles, Illinois, U.S., as a distribution engineer. He now manages the planning and maintenance activities for the transmission, distribution and substations for St. Charles. His focus on safety was the inspiration for an entirely dead-front design for the local distribution center. Bruhl is a professional engineer.



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