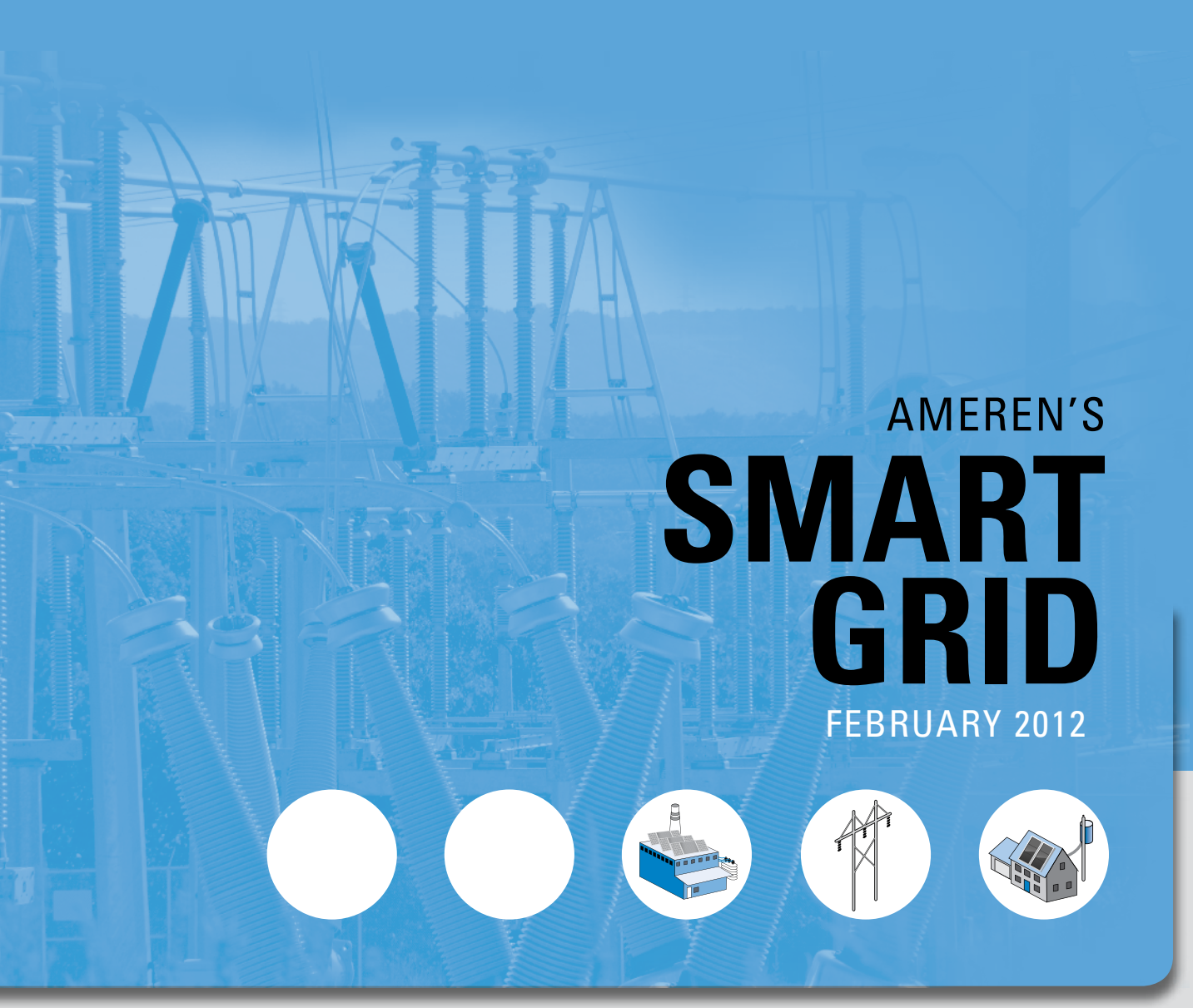


AMEREN'S

SMART GRID

FEBRUARY 2012

DEPLOYING TECHNOLOGY AND INTELLIGENCE
FROM THE GENERATOR TO THE CUSTOMER

Ameren
FOCUSED ENERGY. For life.

TABLE OF CONTENTS

AMEREN'S **SMART GRID** Vision Statement:

Transform Ameren's electric grid to create a secure, reliable and more efficient infrastructure for the 21st century, enabling customers' use of "energy smart" technologies.

There are many technological, operational and societal benefits identified in the U.S. Department of Energy's vision for the Smart Grid. Ameren's Smart Grid vision focuses on the continued pursuit of service reliability, operating efficiency, and on building a secure, robust energy delivery infrastructure as a means of enabling other Smart Grid elements. Among these elements are emerging technologies owned and operated by customers who are motivated by the prospect of becoming more active participants in energy-related decisions.

The following pages highlight current technology used in Ameren's Smart Grid, and outline a plan for where Ameren's Smart Grid is headed. As an examination of the current state, this document outlines what is installed and the benefits derived from those systems. As a plan for the future, it also describes how the system is intended to be scaled up, enhanced and improved.

Ameren views the Smart Grid as the infusion of technology into an otherwise passive system of delivering electricity. More importantly, Ameren interprets it as more of a "direction" than a "destination." Given the digital nature of the technology being referenced by the term and the frequency with which it turns over relative to the more robust hardware it attempts to automate, the Smart Grid will never represent a discrete state of existence that, once arrived at, signals the end of the effort. Simply put – in the same way that few people will ever have their "last" cell phone or their "last" personal computer, the electric grid will likely never achieve what can be considered a "final state" of automation or intelligence.

Ameren's current activities in electric infrastructure technology are driven by deliberate and intended benefits associated with its adoption of the Smart Grid:

Reliability Improvement – Deploy smart technologies across the energy delivery infrastructure in order to improve electric service reliability for Ameren customers.

Efficiency, Optimization and Integration – Improve the operating efficiency of the energy delivery infrastructure and further integrate Ameren's existing Smart Grid applications.

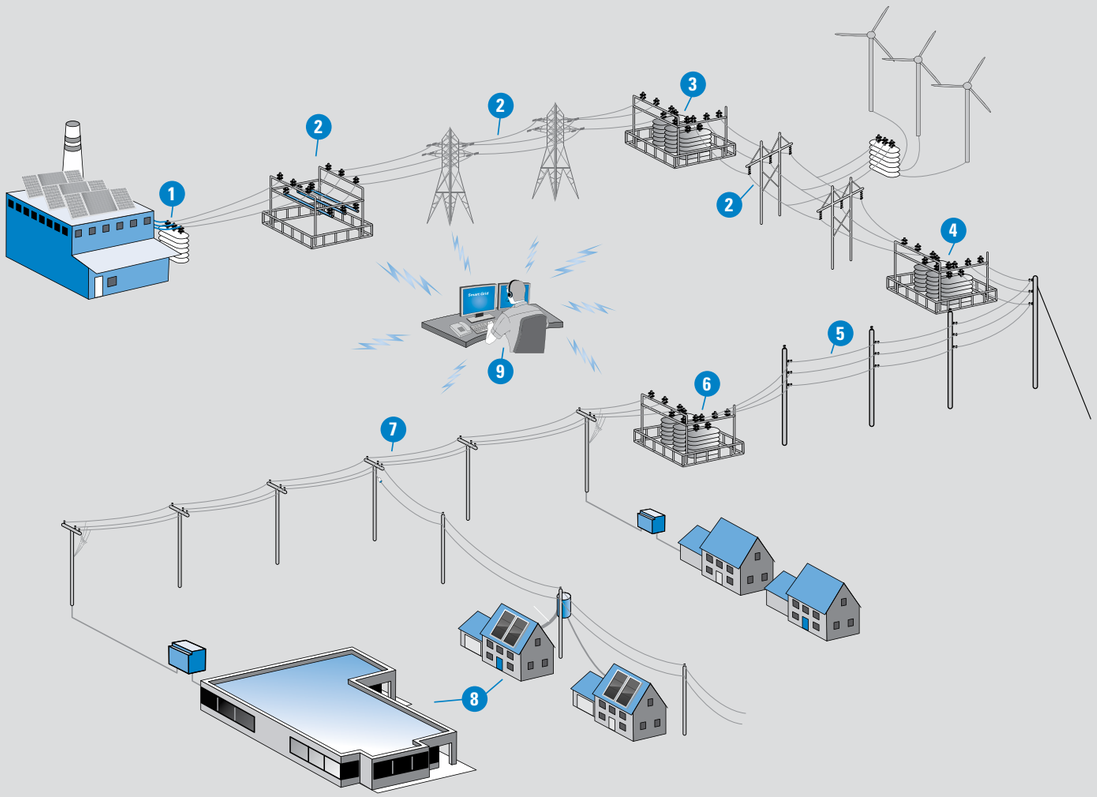
Customer Enablement – Provide the necessary resources to both prepare the electric grid for emerging customer technologies and enable motivated electric customers to make use of those technologies and become more active participants in energy decisions.

Ameren sees its role as one of leading its employees, customers, regulators and other stakeholders to a greater understanding of Smart Grid concepts and applications. Ameren fosters an environment of continuous learning for leaders and subject matter experts around Smart Grid topics through its participation in pilot installations and research projects. And through it all, as Ameren evaluates new technologies and deploys others with which it has developed an expertise, the focus of its innovation remains the same – on improving the electric quality of life for Missouri and Illinois customers.

January 2012

AMEREN'S **SMART GRID**

The infusion of digital technology—communications technology, automation technology, and end device intelligence—into the electric grid. Societal benefits include improved reliability, greater operating efficiency, reduced environmental impact, and new consumer product integration.



1 Generator Step-Up Transformer

- Dissolved Gas Monitors
- High Voltage Bushing Monitors

2 Transmission Switchyard & Lines

- Wide Area Network (WAN)
- Phasor Measurement Units
- Microprocessor Relaying
- Supervisory Control & Data Acquisition (SCADA)

3 Transmission Substation

- Dissolved Gas Monitors
- High Voltage Bushing Monitors
- Fiber Optic Winding Temperature Sensor
- Multi-Function Transformer Temperature Monitors
- Microprocessor Relaying
- Supervisory Control & Data Acquisiton (SCADA)
- Comprehensive Analysis Monitor
- Phasor Measurement Units
- Wide Area Network (WAN)

4 Subtransmission Substation

- Dissolved Gas Monitors
- High Voltage Bushing Monitors
- Automatic Voltage Regulation & Control
- Fiber Optic Winding Temperature Sensor
- Microprocessor Relaying
- Multi-Function Transformer Temperature Monitors
- Supervisory Control & Data Acquisition (SCADA)
- Local Area Network (LAN)

5 Subtransmission Lines

- Smart Line Switches
- Faulted Circuit Indicators (FCI)
- Smart Line Capacitors
- Field Area Network (FAN)

6 Distribution Substation

- Dissolved Gas Monitors
- High Voltage Bushing Monitors
- Control Battery Monitors
- Microprocessor Relaying
- Multi-Function Transformer Temperature Monitors
- Supervisory Control & Data Acquisition (SCADA)
- Automatic Voltage Regulation & Control
- Local Area Network (LAN)
- Automatic Supply Line Transfer

7 Distribution Lines

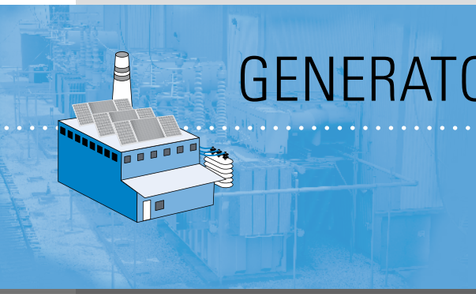
- Smart Line Switches
- Faulted Circuit Indicators (FCI)
- Smart Line Capacitors
- Smart Line Regulators
- Field Area Network (FAN)

8 Automated Meter Reading

- Collector (Illinois)
- Concentrator (IIIlinois)
- Revenue Meter
- Cellmaster (Missouri)
- Micro Cell Controller (Missouri)

9 Advanced Distribution Management System

- Volt-VAR Optimization
- Outage Management System
- Automated Line Switching & Restoration
- Distribution Switching Orders
- Supervisory Control & Data Acquisition (SCADA)
- Distribution Network Model & Mapping



GENERATOR STEP-UP **TRANSFORMER**

A very large transformer at the energy center that steps up the voltage from the generator inside (usually less than 20 kV) to a higher transmission level voltage (138 kV or 345 kV).

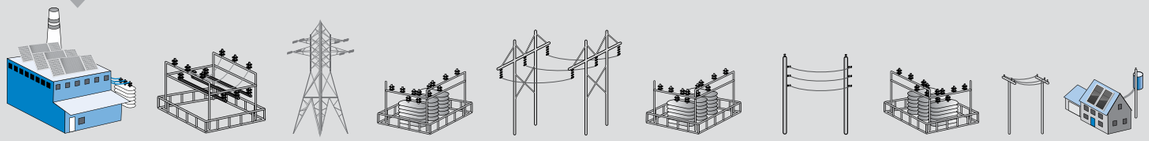
	Technology and Maturity Level	*Description*	*Benefit*	*Technology Cost*	*Current Deployment*	*Future Deployment Plan*
1	**Dissolved Gas Monitor —** *Brand New*	Monitors the content of moisture and combustible gases that are dissolved in the oil of the transformer	- 50% reduction in substation outages due to unforeseen transformer failures - Extensions in operating life of seven years or more	$23,000 per transformer	MO - 4 of 16 transformers outfitted (25%) IL - 8 of 26 transformers outfitted (31%)	Deploy in MO and IL as part of periodic maintenace schedules that take the transformers out of service
2	**High Voltage Bushing Monitors —** *Brand New*	Monitors the insulating quality of the bushings on the transmission voltage side of the transformer	- Ability to predict a bushing failure before it occurs - Avoidance of collateral damage to the rest of the transformer	$19,000 per transformer (for a set of three)	MO - 4 of 16 transformers outfitted (25%) IL - 5 of 26 transformers outfitted (19%)	Deploy in MO and IL as part of periodic maintenace schedules that take the transformers out of service

"The use of diagnostic monitoring technology on substation transformers mitigates the loss of these large assets, which can cost up to $3-4 million to replace."

Generator Step-Up Transformer


2 High Voltage Bushing Monitors


1 Dissolved Gas Monitors

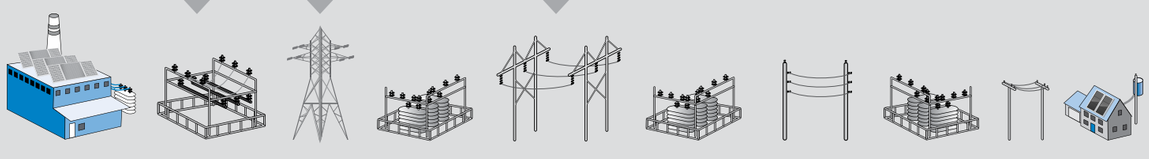


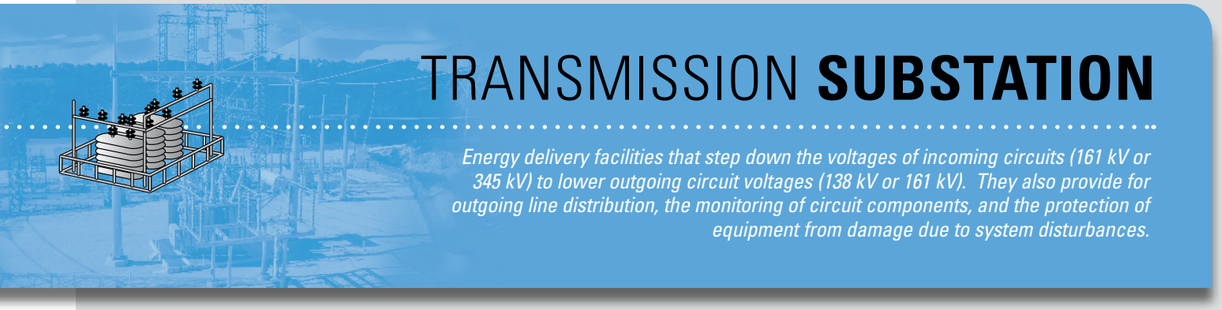
TRANSMISSION
SWITCHYARD & LINES

Energy delivery facilities that allow for the distribution of transmission circuits (over 100 kV), monitor the loading of equipment and circuitry, and protect components from damage due to system disturbances.

	Technology and Maturity Level	*Description*	*Benefit*	*Technology Cost*	*Current Deployment*	*Future Deployment Plan*
1	**Wide Area Network**— *New*	A high-bandwidth communications backbone that transports large quantities of smart field application data to Ameren control centers	Diverse portfolio of data transport systems results in a reliable, secure, and scalable network architecture that supports thousands of intelligent end devices	Varies depending on proximity to existing fiber and availability of other private and public infrastructure	MO - 5 of 20 switchyards have T1-equivalent communications (25%) IL - No switchyards have T1-equivalent communications	- Deploy fiber with new or upgraded transmission projects - Long-term goal is to establish T3-equivalent communications at all MO and IL transmission switchyards
2	**Phasor Measurement Units (PMU)** — *New*	Digital high-resolution voltage, current, and frequency monitoring packages located at strategic points on the transmission system	- Greater wide-area situational awareness - Enhanced dynamic visibility into and synchronization with the nation's transmission grid	$20,000 per line terminal outfitted	MO - 9 of 319 line terminals outfitted (3%) IL - 1 of 439 line terminals outfitted (< 1%)	7 additional MO locations and 14 additional IL locations to be outfitted by 2012 as part of a Smart Grid Investment Grant project
3	**Microprocessor Relaying** — *Mature*	- Collects equipment loading data - Reports occurrences and locations of disturbances - Executes transfer schemes that isolate damage points and switches around them	- Improved operating performance - Reduced maintenance due to self-diagnostic checks - Fewer physical failure points	$150,000 per line terminal converted	MO - 228 of 319 line terminals converted (72%) IL - 217 of 439 line terminals converted (49%)	- Upgrade 12 line terminals and four 69kV network terminals annually in MO and 10 line terminals annually in IL - Goal is to have legacy technology extinct by 2020 in MO and by 2033 in IL
4	**Supervisory Control & Data Acquisition (SCADA)** — *Very Mature*	- Provides data on equipment and circuit loading, system voltages, equipment status and alarms - Provides for the remote control of switching devices	- Capital project deferral - Prevention of overloads - Improved operating flexibility - Real-time outage notification - Enhanced outage response	Up to $250,000 per switchyard site, depending on type of equipment and number of circuits involved	100% of all switchyards and line terminals in MO and IL	- Deploy at all new switchyards in MO and IL - Deploy on all new line terminals introduced in new or existing switchyards in MO and IL

"Ameren's 30 years of experience with substation SCADA has shown that remote metering enables automatic line transfer and various optimization schemes at the circuit level."

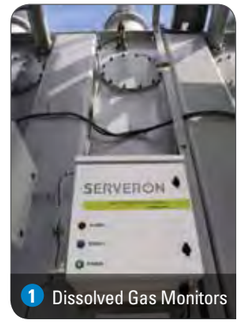


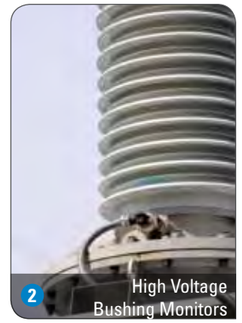


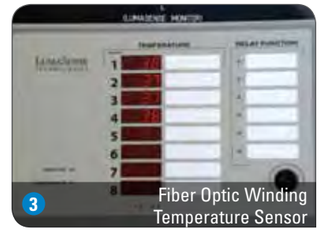
TRANSMISSION **SUBSTATION**

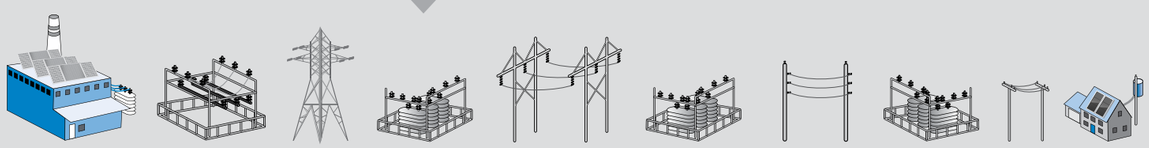
Energy delivery facilities that step down the voltages of incoming circuits (161 kV or 345 kV) to lower outgoing circuit voltages (138 kV or 161 kV). They also provide for outgoing line distribution, the monitoring of circuit components, and the protection of equipment from damage due to system disturbances.

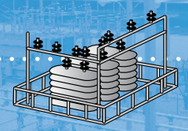
	Technology and Maturity Level	*Description*	*Benefit*	*Technology Cost*	*Current Deployment*	*Future Deployment Plan*
1	**Dissolved Gas Monitor** — *Brand New*	Monitors the content of moisture and combustible gases that are dissolved in the oil of the autotransformer	- 50% reduction in unforeseen autotransformer failures - Extensions in operating life of seven years or more	$23,000 per autotransformer	MO - 1 of 19 autotransformers (5%) IL - None to date	Deploy in MO and IL as part of 4-year maintenance schedules
2	**High Voltage Bushing Monitors** — *Brand New*	Monitors the insulating quality of the bushings on both sides of the autotransformer	- Ability to predict a bushing failure before it occurs - Avoidance of collateral damage to the autotransformer	$24,000 per autotransformer	MO - 1 of 19 autotransformers (5%) IL - None to date	Deploy in MO and IL as part of 4-year maintenance schedules
3	**Fiber Optic Winding Temperature Sensor** — *Brand New*	Monitors the condition of the autotransformer's cooling system	Ability to better match transformer loading to actual operating capability	$35,000 per autotransformer	MO - 1 of 19 autotransformers (5%) IL - None to date	Deploy with all new auto-transformer additions and replacements in MO and IL (avg 1/yr per state)
4	**Multi-Function Transformer Temperature Monitor** — *New*	Simulates several autotransformer oil and winding temperatures for purposes of cooling system control	- Cooler asset operating temperatures during high load - Ability to predict unstable temperature conditions	$3,000 per autotransformer	MO - 8 of 19 autotransformers (42%) IL - None to date	Deploy with all new autotransformer additions and replacements in MO and IL (avg 1/yr per state)
5	**Microprocessor Relaying** — *Mature*	- Collects loading data - Reports occurrences and locations of disturbances - Executes transfer schemes to restore power	- Improved operating performance - Reduced maintenance due to self-diagnostic checks - Fewer physical failure points	$150,000 per line terminal converted	MO - 228 of 319 line terminals (72%) IL - 217 of 439 line terminals (49%)	Upgrade 12 line terminals and four 69kV network terminals annually in MO and 10 line terminals annually in IL
6	**Supervisory Control & Data Acquisition (SCADA)** — *Very Mature*	- Provides data on circuit loading, system voltages, equipment status and alarms - Remote controled switching	- Capital project deferral - Prevention of overloads - Improved operating flexibility - Real-time outage notification - Enhanced outage response	Up to $250,000 per substation site	100% of all substations in MO and IL	- Deploy at all new substations in MO and IL - Deploy on all new line terminals introduced in MO and IL
7	**Comprehensive Analysis Monitor** — *Brand New*	Uses weather data and on-line sensor outputs to calculate dynamic autotransformer ratings	Closer operating margins and more reliable contingency plans during heavy transmission interchange activity	$50,000 per autotransformer	MO - 1 of 19 autotransformers (5%) IL - None to date	Deploy with all new auto-transformer additions and replacements in MO and IL (avg 1/yr per state)
8	**Phasor Measurement Units** — *New*	High-resolution voltage, current and frequency monitors located at strategic transmission points	- Greater wide-area situational awareness - Enhanced visibility into the nation's transmission grid	$20,000 per line terminal outfitted	MO - 9 of 319 line terminals (3%) IL - 1 of 439 line terminals (< 1%)	7 MO locations and 14 IL locations to be added by 2012 as part of DOE project
9	**Wide Area Network (WAN)** — *New*	A high-bandwidth communications backbone that transports large quantities of smart field application data to Ameren control centers	Reliable, secure, and scalable network architecture that supports thousands of smart field devices	Varies depending on proximity to existing fiber or other available infrastructure	MO - 6 of 12 substations with T1 communica-tions (50%) IL - 4 of 36 sub-stations with T1 communications (11%)	- Deploy fiber with new or upgraded transmission projects - Long-term goal is to establish T3 communications at all MO and IL substations







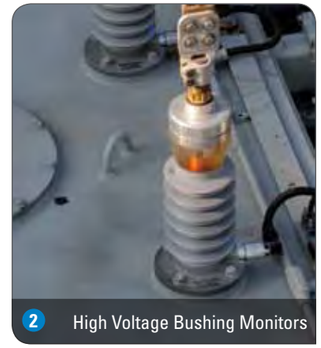


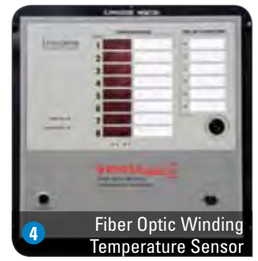


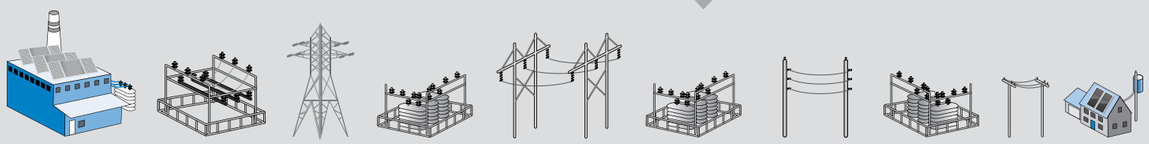
SUBTRANSMISSION **SUBSTATION**

Energy delivery facilities that step down the voltages of incoming circuits (138 kV or 345 kV) to lower outgoing circuit voltages (34.5 kV or 69 kV). They also provide for outgoing line distribution, the monitoring of circuit components, and the protection of equipment from damage due to system disturbances.

	Technology and Maturity Level	*Description*	*Benefit*	*Technology Cost*	*Current Deployment*	*Future Deployment Plan*
1	**Dissolved Gas Monitor** — *Brand New*	Monitors the content of moisture and combustible gases that are dissolved in the oil of the transformer	- 50% reduction in unforeseen transformer failures - Extensions in operating life of seven years or more	$23,000 per transformer	MO - 2 of 113 substations (2%) IL - None to date	Deploy with all new transformer additions and replacements in MO (3-5/yr) and on a case-by-case basis in IL
2	**High Voltage Bushing Monitors** — *Brand New*	Monitors the insulating quality of the bushings on both sides of the transformer	- Ability to predict a bushing failure before it occurs - Avoidance of collateral damage to the transformer	$24,000 per transformer	MO - 2 of 113 substations (2%) IL - None to date	Deploy with all new transformer additions and replacements in MO (3-5/yr) and on a case-by-case basis in IL
3	**Automatic Voltage Regulation & Control** — *Very Mature*	Monitors and regulates system voltages via remote control of subtransmission capacitors and the transformer's tap-changer	- System voltage stability - Reduced system losses - Improved customer service reliability and power quality - Transmission system support	$200,000 per transformer tap-changing mechanism	MO - 82 of 113 substations (73%) IL - 66 of 160 substations (41%)	Deploy at new MO and IL substations as dictated by projected loads and customer concentrations
4	**Fiber Optic Winding Temperature Sensor** — *Brand New*	Monitors the condition of the transformer's cooling system	Ability to better match transformer loading to actual operating capability	$35,000 per transformer	MO - 2 of 113 substations (2%) IL - None to date	Deploy with all new transformer additions and replacements in MO (3-5/yr) and on a case-by-case basis in IL
5	**Microprocessor Relaying** — *Mature*	- Collects loading data - Reports occurrences and locations of disturbances - Executes transfer schemes to restore power	- Improved operating performance - Reduced maintenance due to self-diagnostic checks - Fewer physical failure points	$50,000 per line terminal converted	MO - 153 of 501 line terminals (31%) IL - 265 of 736 line terminals (36%)	Deploy with all new substation, control house, and feeder additions and replacements in MO and IL (6-10/yr per state), and upgrade an average of 20 existing line terminals annually in IL
6	**Multi-Function Transformer Temperature Monitor** — *New*	Simulates several transformer oil and winding temperatures for purposes of cooling system control	- Cooler asset operating temperatures during high load - Ability to predict unstable temperature conditions	$3,000 per transformer	MO - 40 of 113 substations (35%) IL - None to date	Deploy with all new transformer additions and replacements in MO (3-5/yr) and on a case-by-case basis in IL
7	**Supervisory Control & Data Acquisition (SCADA)** — *Very Mature*	- Provides data on circuit loading, system voltages, equipment status and alarms - Remote controlled switching	- Capital project deferral - Prevention of overloads - Improved operating flexibility - Real-time outage notification - Enhanced outage response	Up to $250,000 per substation site	MO - 100 of 113 substations (89%) IL - All 160 substations (100%)	- Deploy at all new substations in MO and IL - Deploy on all new line terminals introduced in MO and IL
8	**Local Area Network (LAN)** — *New*	- Provides data aggregation points for smart field devices in surrounding area - Provides data take-out points to the larger WAN	- Communications from smart substation and smart line devices can be consolidated - Investment requires no additional real estate	$25,000 per site plus cost of infrastructure extension	MO - 2 of 113 substations (2%) IL - None to date	Deploy at MO and IL substations as they are identified as effective aggregation points for smart field devices in surrounding area







SUBTRANSMISSION **LINES**

Overhead or underground circuits that deliver electricity at voltages between 20 kV and 100 kV to distribution substations and directly to large industrial customers. They are typically seen running down major streets and thoroughfares.

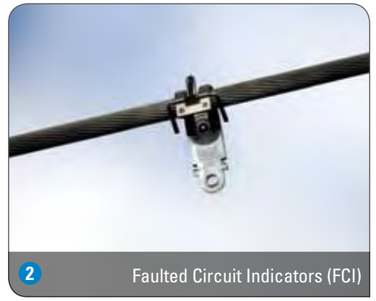
Technology and Maturity Level	Description	Benefit	Technology Cost	Current Deployment	Future Deployment Plan
1 **Smart Line Switches** — *Mature*	- Detects line disturbances - Communicates events to operators - Isolates damage points and restores power via alternate routes	- Reduction in average customer outage frequency - Reduction in average customer outage duration - Reduced operating costs due to remote switching	$70,000 per automated switch	MO - 250 switches, automating 84 of 501 feeders (17%) IL - 113 switches, automating 30 of 520 feeders (6%)	- Deploy annually in MO and IL by circuit, according to greatest customer density and reliability improvement for the cost - Goal is to reduce the effect of feeder outages to less than 10 MVA
2 **Faulted Circuit Indicators (FCI)** — *Brand New*	- Detects line disturbances - Communicates events to operators in near-real time	- Increased reliability and reduced operating costs through a reduction in average patrol times of circuits by first responders - Reduced operating costs due to remote switching	$3,000 per set of three indicators	MO - 40 indicator sets, automating 25 of 501 feeders (5%) IL - 10 indicator sets, automating 10 of 520 feeders (2%)	Deploy with smart line switches in MO and IL to address feeder patrolling issues on lengthy circuits
3 **Smart Line Capacitors** — *Mature*	Operate as high voltage "energy efficiency" devices by enabling circuits to serve load with the least amount of line capacity	- Line voltage stability - System line losses under 7% - Improved customer power quality - Provides transmission and subtransmission support	$5,000 per line capacitor control	MO - 14 of 501 feeders outfitted (3%) IL - 25 of 520 feeders outfitted (5%)	Deploy in MO and IL to address specific line voltage stability issues on subtransmission circuits
4 **Field Area Network (FAN)** — *New*	- Dynamically routes data along a "mesh" of communication paths that wirelessly connect smart devices - Moves data "serially" along fixed routes in more traditional radio/cellular-based networks	- Reductions in overlapping communication networks - Scalable capacity for large smart device populations - Greater speed to support large file transfers and data analytics	Up to $2,500 per end device, depending on geography and proximity to existing LAN, radio, or cellular network infrastructure	MO - nearly 400 intelligent subtransmission line devices IL - nearly 150 intelligent subtransmission line devices	- Deploy smart devices in MO and IL that are configurable for "mesh" and "serial" operation - Allows for flexibility when device deployments outpace area communications

"Deploying smart switches and faulted circuit indicators together combine the technologies to minimize the impact of line disturbances on customer interruptions and outage duration."

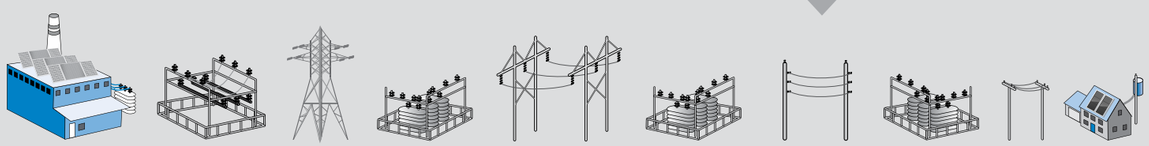
1 Smart Line Switches

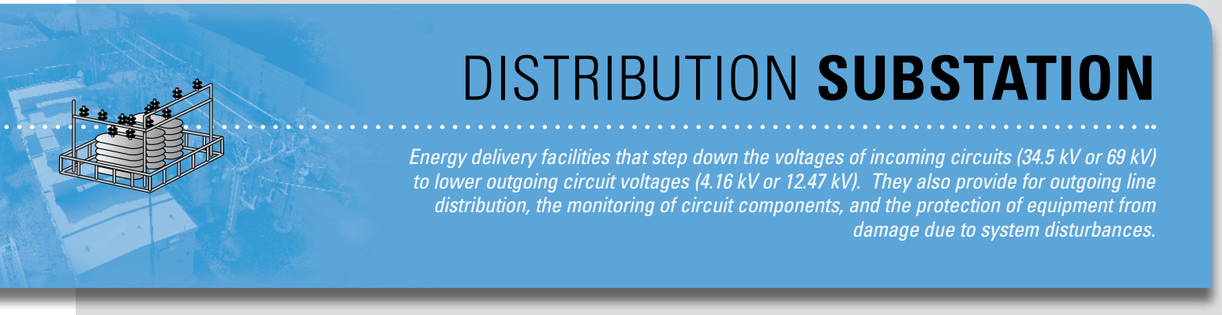
4 Field Area Network (FAN)

3 Smart Line Capacitors



2 Faulted Circuit Indicators (FCI)

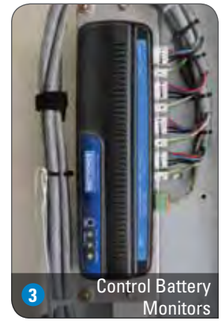


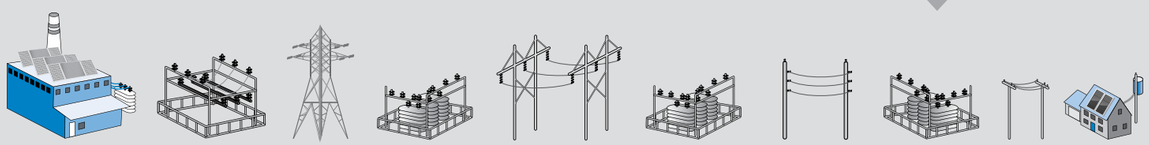


DISTRIBUTION **SUBSTATION**

Energy delivery facilities that step down the voltages of incoming circuits (34.5 kV or 69 kV) to lower outgoing circuit voltages (4.16 kV or 12.47 kV). They also provide for outgoing line distribution, the monitoring of circuit components, and the protection of equipment from damage due to system disturbances.

	Technology and Maturity Level	Description	Benefit	Technology Cost	Current Deployment	Future Deployment Plan
1	**Dissolved Gas Monitor** — *Brand New*	Monitors the content of moisture and combustible gases that are dissolved in the oil of the transformer	- 50% reduction in unforeseen transformer failures - Extensions in operating life of seven years or more	$23,000 per transformer	MO - 10 of 758 substation units (1%) IL - None to date	Deploy with all new transformer installations in MO (10-15/yr) and on a case-by-case basis in IL
2	**High Voltage Bushing Monitors** — *Brand New*	Monitors the insulating quality of the bushings on the subtransmission side of the transformer	- Ability to predict a bushing failure before it occurs - Avoidance of collateral damage to the transformer	$19,000 per transformer	MO - 10 of 758 substation units (1%) IL - None to date	Deploy with all new transformer installations in MO (10-15/yr) and on a case-by-case basis in IL
3	**Control Battery Monitors** — *Brand New*	Monitors the health of the battery cells that provide control power during substation outages	- Ability to predict a battery failure before it occurs - Reduced battery maintenance	$1,000 per battery set	MO - 6 of 524 substations (1%) IL - None to date	Deploy with all new substation switchgear installations in MO and on a case-by-case basis in IL
4	**Microprocessor Relaying** — *Mature*	- Collects loading data - Reports occurrences and locations of disturbances - Executes transfer schemes to restore power	- Improved operating performance - Reduced maintenance due to self-diagnostic checks - Fewer physical failure points	$25,000 to $40,000 average per feeder position	MO - 132 of 758 substation units (17%) IL - 12 of 784 substations (2%)	Deploy with all new substation and switchgear installations in MO and IL (25-35 feeders/yr in MO)
5	**Multi-Function Transformer Temperature Monitor** — *New*	Simulates several transformer oil and winding temperatures for purposes of cooling system control	- Cooler asset operating temperatures during high load - Ability to predict unstable temperature conditions	$3,000 per transformer	MO - 190 of 758 substation units (25%) IL - None to date	Deploy with all new transformer installations in MO (10-15/yr) and on a case-by-case basis in IL
6	**Supervisory Control & Data Acquisition (SCADA)** — *Very Mature*	- Provides data on circuit loading, system voltages, equipment status and alarms - Remote controlled switching	- Capital project deferral - Prevention of overloads - Improved operating flexibility - Real-time outage notification - Enhanced outage response	Up to $250,000 per substation site	MO - 353 of 524 substations (67%) IL - 180 of 784 substations (23%)	Deploy at all new MO and IL substations and upgrade an average of 45 existing substations annually in IL
7	**Automatic Voltage Regulation & Control** — *Very Mature*	Monitors and regulates system voltages through the remote control of the transformer's tap-changer	- System voltage stability - Reduced system losses - Improved customer service reliability and power quality	$125,000 per transformer tap-changer	MO - 493 of 758 substation units (65%) IL - 1 of 784 substations (< 1%)	Deploy at new MO and IL substations as dictated by projected loads and customer concentrations
8	**Local Area Network (LAN)** — *New*	- Provides data aggregation points for smart field devices in surrounding area - Provides data take-out points to the larger WAN	- Communications from smart substation and smart line devices can be consolidated - Investment requires no additional real estate	$25,000 per site plus cost of infrastructure extension	MO - 2 of 524 substations (< 1%) IL - None to date	Deploy MO and IL substations as they are identified as effective aggregation points for smart field devices in surrounding area
9	**Automatic Supply Line Transfer** — *Very Mature*	- Detects supply line disturbances - Automatically reconfigures substation switching to restore power after an outage	- Increased reliability through less extended outages and shorter outage durations - Little or no human intervention required - Reduced operating costs due to automated switching	$75,000 to $100,000 per substation switch	MO - 268 of 524 substations (51%) IL - 187 of 784 substations (24%)	Deploy at new and existing substations in MO and IL with multiple supplies to reduce the effect of supply line outages to less than 10 MVA





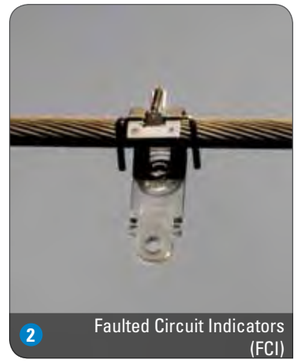
DISTRIBUTION **LINES**

Overhead or underground circuits that deliver electricity at voltages under 20 kV to homes and businesses. They are typically seen running along streets and through residential areas.

	Technology and Maturity Level	*Description*	*Benefit*	*Technology Cost*	*Current Deployment*	*Future Deployment Plan*
1	**Smart Line Switches** — *Mature*	- Detects line disturbances - Communicates events to operators - Isolates damage points and restores power via alternate routes	- Reduction in average customer outage frequency - Reduction in average customer outage duration - Reduced operating costs due to remote switching	$55,000 per automated switch	MO - 250 switches, automating 96 of 2,184 feeders (4%) IL - 9 switches, automating 6 of 2,181 feeders (< 1%)	- Deploy annually in MO and IL by circuit groups, according to greatest customer density and reliability improvement for the cost - Goal is to reduce the effect of feeder outages to half the feeder or less
2	**Faulted Circuit Indicators (FCI)** — *Brand New*	- Detects line disturbances - Communicates events to operators in near-real time	- Increased reliability and reduced operating costs through a reduction in average patrol times of circuits by first responders - Reduced operating costs due to remote switching	$3,000 per set of three indicators	MO - 10 indicator sets, automating 5 of 2,184 distribution feeders (<1%) IL - None installed currently	Deploy with smart line switches in MO and IL to address feeder patrolling issues on lengthy circuits
3	**Smart Line Capacitors** — *Mature*	Operate as high voltage "energy efficiency" devices by enabling circuits to serve load with the least amount of line capacity	- Line voltage stability - System line losses under 7% - Improved customer power quality - Supports transmission and subtransmission systems	$5,000 per line capacitor control	MO - 2,300 capacitors, automating 1,087 of 2,184 feeders (50%) IL - 140 capacitors, automating 97 of 2181 feeders (4%)	- Upgrade 2,300 controls in MO by 2014 to accomodate new control scheme - Deploy new controls annually in MO and IL in circuit groups, coincident with smart switch deployment
4	**Smart Line Regulators** — *Brand New*	Monitors and regulates the local line voltage through the remote control of the regulator's tap-changing mechanism	- Improved customer power quality - Local voltage stability on very long rural distribution circuits	$5,000 per line regulator control	MO - 1 of 2,184 feeders outfitted (< 1%) IL - 1 of 2181 feeders outfitted (< 1%)	Deploy in MO and IL to address specific line voltage stability issues on very long rural distribution circuits
5	**Field Area Network (FAN)** — *New*	- Dynamically routes data along a "mesh" of communication paths that wirelessly connect numerous smart devices - Moves data "serially" along fixed routes in more traditional radio/cellular-based networks	- Reductions in overlapping communication networks - Scalable capacity for large smart device populations - Greater speed to support large file transfers and data analytics	Up to $2,500 per end device, depending on geography and proximity to existing LAN, radio, or cellular network infrastructure	MO - over 2,500 intelligent distribution line devices IL - nearly 150 intelligent distribution line devices	- Deploy smart devices in MO and IL that are configurable for "mesh" and "serial" operation - Allows for flexibility when device deployments outpace area communications

Distribution Lines


1 Smart Line Switches


2 Faulted Circuit Indicators (FCI)


5 Field Area Network (FAN)


4 Smart Line Regulators


3 Smart Line Capacitors

AUTOMATED **METER READING** (AMR)

A central system that collects and processes customer energy usage histories and transmits them wirelessly from automated gas and electric meters using one-way radio frequency communications.

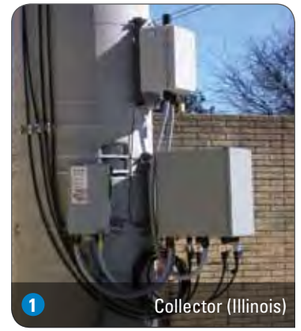
	Technology and Maturity Level	Description	Benefit	Technology Cost	Current Deployment	Future Deployment Plan
1	**Collector** — *New*	- Receives radio broadcasts from local Concentrators - Transmits digital energy usage packets collected from Concentrators to the vendor's central operating system - Prominent in Illinois	- Large bandwidth, varying from dozens to hundreds of Concentrators' worth of meter reading data - Large data take-out points can process readings from tens of thousands of meters	Vendor-owned - Installation and maintenance are included in contract for meter reading services in IL	MO - 3 Collectors in service IL - 56 Collectors in service	Vendor will deploy as necessary to maintain the current Concentrator coverage area in IL
2	**Concentrator** — *New*	- Receives radio broadcasts from electric and gas meters - Transmits digital energy usage packets collected from revenue meters to Collectors - Prominent in Illinois	- Capacity of up to 2,000 meters - Does not require a direct "line of sight" with communicating meters - Peer-to-peer communications with other Concentrators	Vendor-owned - Installation and maintenance are included in contract for meter reading services in IL	MO - 226 Concentrators in service IL - 5,586 Concentrators in service	Vendor will deploy as necessary to maintain the current automated meter coverage area in IL
3	**Automated Meter** — *Mature*	- Measures, records, and periodically reports customer energy usage histories to a MicroCell Controller (MCC) or Concentrator - Communicates via a one-way radio frequency module built into the meter	- Revenue generation - Elimination of manual meter reads and estimated bills - Outage notification and restoration verifications - Energy theft prevention - Equipment load management	- $35 for residential meter, shared between Ameren (meter owner) and vendor (module owner)	MO - 1,180,000 electric meters (100% of customers) IL - 670,000 electric meters (55% of customers)	Deploy with every new MO and IL customer situated in the automated meter coverage area
4	**Cell Master** — *Mature*	- Receives radio broadcasts from local MCCs - Transmits digital energy usage packets collected from MCCs to the vendor's central operating system - Prominent in Missouri	- Large bandwidth, varying from dozens to hundreds of MCCs' worth of meter reading data - Large data take-out points can process readings from tens of thousands of meters	Vendor-owned - Installation and maintenance are included in contract for meter reading services in MO	MO - 90 Cell Masters in service IL - 7 Cell Masters in service	Vendor will deploy as necessary to maintain the current MCC coverage area in MO
5	**Micro Cell Controller (MCC)** — *Mature*	- Receives radio broadcasts from electric and gas meters - Transmits digital energy usage packets collected from meters to Cell Masters - Prominent in Missouri	- Capacity of up to 2,000 meters - Does not require a direct "line of sight" with communicating meters	Vendor-owned - Installation and maintenance are included in contract for meter reading services in MO	MO - 8,155 Controllers in service IL - 487 Controllers in service	Vendor will deploy as necessary to maintain the current automated meter coverage area in MO

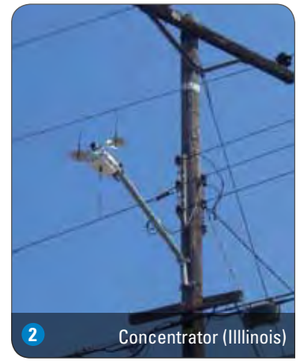
"Wireless meter communications open the door to enabling home technologies for customers interested in becoming more active participants in energy decision-making."

Ameren has automated meters in Missouri and Illinois, as opposed to "smart" meters, which are characterized by two-way communication – Ameren realizes most of the benefits of a two-way system with the one-way AMR system it has. However, the industry is trending toward two-way communicating "smart meters," otherwise referred to as Advanced Meter Infrastructure (AMI). While the Missouri network infrastructure can only support one-way meter communications, the Illinois network (being a more recent vintage) is capable of supporting both one-way and two-way metering. With the recent passage of the Illinois Energy Infrastucture Modernization Act, Ameren Illinois is now developing an AMI deployment plan to satisfy the 10-year, 62% AMI requirement in the law.

Meters generally exist on every house and building. One Concentrator or Micro Cell Controller exists per 1,000-2,000 meters. One Collector or Cell Master exists per 50-250 Concentrators or Micro Cell Controllers.


Automated Meter Reading

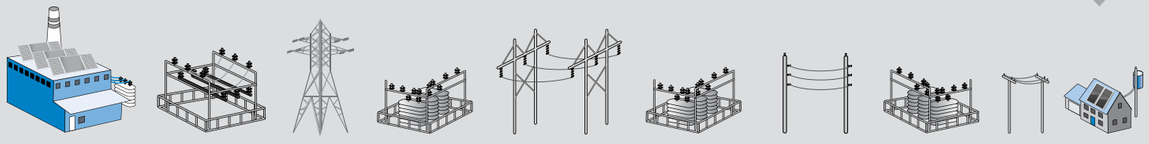

1 Collector (Illinois)


2 Concentrator (Illinois)


5 Micro Cell Controller (Missouri)


4 Cellmaster (Missouri)

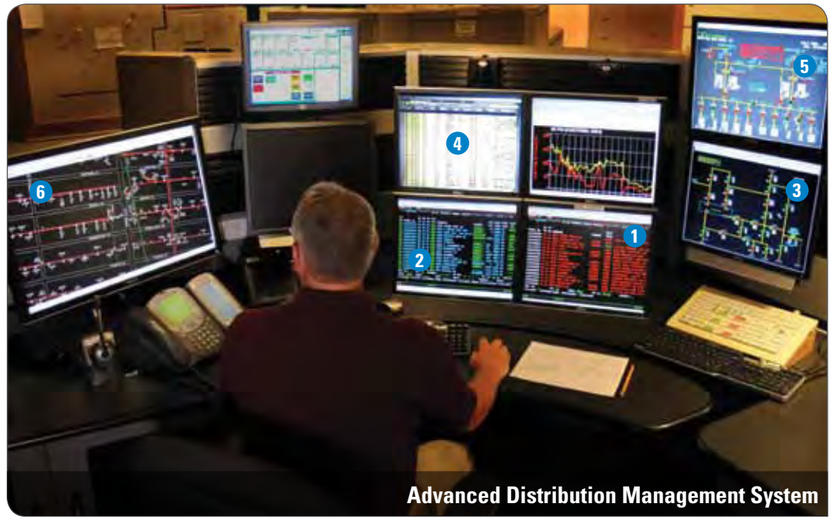

3 Revenue Meter

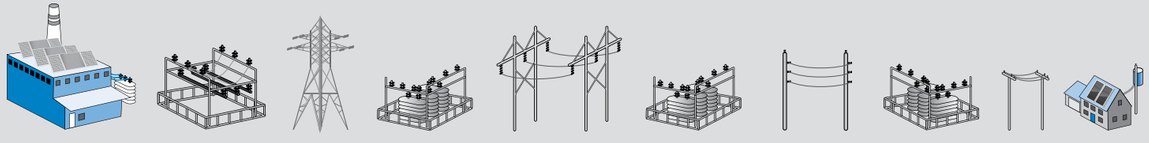


ADVANCED DISTRIBUTION **MANAGEMENT SYSTEM** (ADMS)

A complex suite of software applications that enhance an operator's ability to monitor, control and manage the distribution system on a daily basis.

	Technology and Maturity Level	*Description*	*Benefit*	*Current Deployment*	*Future Deployment Plan*
1	**Volt-VAR Optimization —** *Brand New*	- Operates line capacitors using two-way radio or cellular communications - Controls them automatically on a combination of circuit loading and voltage stabilization parameters	- Feeder level optimization - System loss minimization - Maximum voltage stability - Improved customer power quality - Enables voltage reduction for demand conservation	- Operating in MO and IL on a first-generation system circa 1986 that switches line capacitors on and off using one-way paging technology - Upgrade necessary to accomodate advanced controls	- New central controller goes in service in MO and IL in 2011 as a pilot program - Testing occurs on select distribution feeders in 2012 - Application to be placed on the ADMS platform after 2013
2	**Outage Management System —** *Very Mature*	- Provides outage aggregation and work order management by collecting and analyzing customer "light out" calls - Relates calls to the customer's electrical location on a circuit	- Shorter outage durations - More efficient daily outage and emergency response - Estimated restoration times - Improved workforce management and tracking - Customer restoration alerts	- Operating in MO and IL on a first-generation system circa 1996 built on a mainframe computing platform - No graphical user interface, but has limited data-sharing with other applications	- New system will go in service in 2013 in MO and IL as the final phase of the new ADMS platform implemnetation - Complete integration with SCADA and other advanced applications
3	**Automated Switching & Restoration —** *New*	- Processes system disturbance data received from smart line switches - Automatically reconfigures the distribution system by isolating damage points and switching around them	- Shorter outage durations - Minimization of customers affected by a single event - Dynamic modeling auto-synchronizes the system model with outages and other switching operations	The first distribution automation central controller went in service in 2010 as a MO pilot program in association with the Dorsett Automation project	The second phase of the ADMS platform implementation in early 2013 will fully enable this central automation capability
4	**Distribution Switching Orders —** *New*	- Receives switching requests from operating personnel - Allows for development and review of switching sequences based on present circuit model - Tracks and manages approval and execution of switching sequence by field personnel	- Improved safety, service reliability, and field switching performance - Greater operating efficiencies - Enhanced mobile workforce management - Complete integration with outage management system	- Operating in MO and IL on a first-generation switching request system originally developed in-house in 2005 - Provides switching order management, but lacks integration with outage management system	New system will go in service in late 2012 during the second phase of ADMS platform implementation
5	**Supervisory Control & Data Aquisition (SCADA) —** *Very Mature*	- Provides data on equipment and circuit loading, system voltages, equipment status and alarms - Provides for the remote control of switching devices	- Capital project deferral - Prevention of overloads - Reduced operational margins - Real-time outage notification - Enhanced outage response	- Operating on a second-generation central data collection and processing system in MO and IL - Upgrade necessary to accomodate expansion	New system will go in service in 2012 in MO and IL as one of the initial phases of the new ADMS platform implementation
6	**Distribution Network Model & Mapping —** *Mature*	- Provides a virtual representation of the distribution system and network connectivity - Makes circuit models and maps available for outage management, engineering analysis, and planning	- Avoided customer outages - Improved worker safety - More effective management of the distribution system - Complete integration of circuit models and mapping with outage management and switching order systems	- Operating in MO and IL on a mapping system that provides basic circuit viewing and locating functionality - Little or no integration with other applications	The ADMS will provide an integrated mapping and distribution system model as the basis for its advanced applications in second phase of the new platform deployment in early 2013





GLOSSARY

Advanced Distribution Management System (ADMS) – A complex suite of software applications that operators use to monitor, control and manage the distribution system on a daily basis. Foundational to widespread smart grid deployment, it enables advanced applications that rely on the integration of distribution functions formerly separate and distinct. It also allows for growth and scalability that is not feasible on traditional software platforms and provides the flexibility to add and integrate future applications.

Automated Meter – A meter that measures, records and periodically reports customer energy usage histories to a central meter data management system via a one-way radio frequency module built into the meter.

Automated Meter Reading (AMR) – A central system that collects and processes customer energy usage histories that are transmitted wirelessly from automated electric meters using one-way radio communications. Ameren has automated meters in Missouri and Illinois, as opposed to "smart" meters, which are characterized by two-way communication – Ameren realizes most of the benefits of a two-way system with the one-way AMR system it has. However, the industry is trending toward two-way communicating "smart meters," otherwise referred to as Advanced Meter Infrastructure (AMI). While the Missouri network infrastructure can only support one-way meter communications, the Illinois network (being a more recent vintage) is capable of supporting both one-way and two-way metering.

Automatic Supply Line Transfer – The ability of a substation to detect and diagnose disturbances on the distribution system, and automatically reconfigure itself to restore power immediately after a substation outage event, with little or no human intervention.

Automated Switching & Restoration – A central controller that processes line disturbance data received from smart line switches and faulted circuit indicators and automatically reconfigures the distribution system by isolating damage points and restoring power via alternate routes, all with little or no human intervention.

Automatic Voltage Regulation & Control – The ability of a substation to monitor and regulate the system voltage it provides, through both the automatic and remote control of the substation transformer's tap-changing mechanism.

Autotransformer – A transformer that, instead of using two sets of windings to change voltage levels, does so using one set with multiple connection points.

Cell Master – A meter reading communications device that receives digital energy usage packets from several local Micro Cell Controllers. It then re-transmits these packets to the meter reading vendor's central operating system. Prominent in Missouri and owned by Ameren's meter reading vendor, Cell Masters are infrastructure components with very large bandwidths, capable of handling meter reading data from dozens to hundreds of Micro Cell Controllers.

Collector – A meter reading communications device that receives digital energy usage packets from several local Concentrators. It then retransmits these packets to the meter reading vendor's central operating system. Prominent in Illinois and owned by Ameren's meter reading vendor, Collectors are infrastructure components with very large bandwidths, capable of handling meter reading data from dozens to hundreds of Concentrators.

Comprehensive Analysis Monitor – Analyzers that use weather data and outputs from several on-line sensors to calculate capacity ratings for transmission substation autotransformers on a periodic basis. The most expensive substation technology currently being deployed, it enables closer daily operating margins and more reliable contingency plans during heavy transmission interchange activity.

Concentrator – A meter reading communications device that receives radio frequency broadcasts of energy usages from electric and gas meters. It then transmits this information to Collectors. Prominent in Illinois and owned by Ameren's meter reading vendor, Concentrators are infrastructure components with capacities of up to 2,000 meters.

Control Battery Monitors – Sensors that continuously monitor the health of the individual battery cells that provide control power during substation outage conditions. They help eliminate substation outages that are due to battery failures and reduce battery maintenance, the single most frequent substation maintenance activity.

Dissolved Gas Monitor – Sensors that continuously monitor the content of moisture and combustible gases in a substation transformer, which are indicators of its oil and insulation system breaking down. Dissolved gas levels and associated alarms brought back to a central process allows for pre-emptive avoidance of large substation outages and life extensions of these large transformer assets.

Distribution Lines – Overhead or underground circuits that leave distribution substations to deliver electricity to homes and businesses. Ameren's most common distribution line voltages are 4.16 kV and 12.47 kV. These are the lines most frequently seen running along streets and into the residential areas of a community.

Distribution Network Model & Mapping – A central land-based mapping system that provides virtual representations of the subtransmission and distribution systems, as well as network connectivity. It generally makes circuit models and maps available for outage management, engineering analysis and planning.

Distribution Substations – Energy delivery facilities that reduce the voltage of incoming circuits, provide for the distribution of outgoing circuits, monitor equipment loading and protect this equipment from damage due to system disturbances. A typical distribution substation steps down incoming subtransmission line voltages (34.5 kV or 69 kV) to outgoing distribution line voltages of 4.16 kV or 12.47 kV and can serve up to several thousand customers.

Faulted Circuit Indicators (FCI) – Line devices that detect electrical disturbances and communicate these events to operators in near-real time. They have no switching capability and hence do not directly prevent outages, however they do provide valuable fault location information that help reduce circuit patrol times for first responders.

Feeder – An overhead or underground circuit that originates from a subtransmission or distribution substation. There can be up to a dozen or more feeders leaving a large substation.

Fiber Optic Winding Temperature Sensor – Sensors that continuously monitor the temperature at up to eight locations on each winding (or coil) of a substation transformer. The windings represent the heart of a substation transformer, and these sensors directly measure their temperatures, providing solid information on the condition of the transformer's cooling system and the effect its electrical loading has on it.

Field Area Network (FAN) – The lowest tier in the communications network, the FAN collects and communicates data from individual end devices (e.g. "smart" switches or capacitors) to the Local Area Network. In dense areas, the FAN automatically routes data along a wireless mesh connecting numerous smart devices, while in sparse areas, it moves data "serially" along fixed routes using more traditional radio or cellular-based networks.

Generator Step-Up Transformer – A large transformer located immediately outside the power plant building that steps up the voltage from the generator inside (usually less than 20 kV) to a higher transmission level voltage (138 kV or 345 kV). There is typically one step-up transformer per generating unit. The transformer's outgoing line runs directly into a transmission switchyard or substation for purposes of distributing the large amount of energy it carries.

High Voltage Bushing Monitors – Sensors that continuously monitor the insulating quality of a transformer's bushings – the pieces of equipment that manage the high-voltage line's physical transition from outside the transformer to inside. Bushing failures can be violent in nature and can cause collateral damage to the rest of the transformer. The data these sensors bring back provide the ability to predict a bushing failure before it occurs.

kV – An acronym for kilovolt, or 1,000 volts, a unit of electrical pressure.

Local Area Network (LAN) – The middle tier in the communications network, the LAN provides a common data collection point for smart field devices in a given area. It also provides a data take-out point to the larger Wide Area Network. Substations are good locations for LAN investment because of the opportunity to consolidate the data communications from smart devices both inside the substation and on outlying circuits.

Maturity Level – A reference to how old or new a technology is, in combination with Ameren's degree of expertise with it. The technologies described in this book are classified as either: (1) Brand New - deploying the technology now for the first time; (2) New - having deployed for the past 5-10 years; (3) Mature - having deployed for the past 10-20 years; or (4) Very Mature - having deployed for over 20 years.

Micro Cell Controller (MCC) – A meter reading communications device that receives radio frequency broadcasts of energy usages from electric and gas meters. It then transmits this information to Cell Masters. Prominent in Missouri and owned by Ameren's meter reading vendor, Micro Cell Controllers can receive communications from up to 2,000 meters.

Microprocessor Relaying – Digital substation technology that collects equipment and circuit loading data, reports the occurrences and locations of system disturbances, and executes transfer schemes to switch around damage points and restore power after outage events. This technology is far more reliable than the legacy electro-mechanical and solid state technology.

Multi-Function Transformer Temperature Monitor – A monitor that simulates several substation transformer oil and winding temperatures for purposes of controlling the transformer's cooling system. This provides for cooler operating temperatures during high demand periods and the ability to predict unstable temperature conditions and intervene as necessary.

MVA – An acronym for megavolt-ampere, or 1,000,000 volt-amperes, a unit of electric power representing the equivalent of roughly 250 average-size homes.

Outage Management System – A central outage analysis system that collects and groups customer "light out" calls, relates those calls to electrical locations on the circuits involved, and creates a manageable list of orders to be worked. Among the benefits of this are shorter outage durations, improved workforce management and tracking, and more efficient emergency response.

Phasor Measurement Units (PMU) – High-resolution voltage, current and frequency monitors outfitted at strategic locations on the transmission system. PMUs sample these electrical parameters many times a second and provide operators with information to better manage the transmission system, improve reliability and create greater wide-area visibility into the rest of the nation's grid.

Smart Grid – The infusion of digital technology – communications technology, automation technology and end device intelligence – into the electric grid. Capabilities like communicating with end devices, controlling them remotely, configuring them to operate automatically, receiving reports back on what they did, and the central control and back office systems necessary to integrate and support these functions, all represent features of a "smart" grid. Among the societal benefits are improved reliability, greater operating efficiencies, reduced environmental impact, and new consumer product integration.

Smart Line Capacitors – Subtransmission and distribution line devices that operate as high voltage "energy efficiency" devices by enabling circuits to serve electrical load with the least amount of line capacity. They are critical to keeping system voltages stable, minimizing line losses, and maintaining a high level of customer power quality.

Smart Line Regulators – Distribution line devices that monitor and regulate local line voltages through the automatic and remote control of the regulator's tap-changing mechanism. They are used specifically to maintain local voltage stability and customer power quality on very long rural distribution circuits.

Smart Line Switches – Subtransmission and distribution line devices that detect line disturbances, communicate these events to operators, and automatically open or close to isolate damage points on the system and restore power via alternate routes. These devices reduce the scope of outage events and provide valuable location information that help first responders find damage more quickly.

Subtransmission Lines – Overhead or underground circuits that leave subtransmission substations to deliver electricity to distribution substations or directly to large industrial customers. Ameren's subtransmission line voltages are 34.5 kV and 69 kV. These lines are most frequently seen running down the larger streets and thoroughfares of a community.

Subtransmission Substation – Energy delivery facilities that reduce the voltage of incoming circuits, provide for the distribution of outgoing circuits, monitor equipment loading, and protect this equipment from damage due to system disturbances. A typical subtransmission substation steps down incoming transmission line voltages (e.g. 138 kV or 345 kV) to outgoing subtransmission line voltages of 34.5 kV or 69 kV and can serve up to tens of thousands of customers.

Supervisory Control and Data Acquisition (SCADA) – A reference to the central system that provides for the remote monitoring and control of the electric grid. SCADA provides operating personnel with data on substation equipment and circuit loading, system voltages, equipment status, and associated alarms. It also provides for the remote control of substation and line switching devices across the entire system. One of the oldest smart grid technologies at Ameren, the benefits include capital project deferral, identification of overloads, enhanced system management, real-time outage notification, and improved outage response.

Tap-Changer – A mechanism on a substation transformer that provides for the capability to automatically switch between multiple connection points on the transformer's internal windings, for purposes of controlling system voltage.

Transformer – An energy delivery device situated on a pole, a pad or in a substation, that is used to step the incoming line voltage (i.e. the electrical pressure) up or down for the lines that are going out.

Transmission Substation – Energy delivery facilities that reduce the voltage of incoming circuits, provide for the distribution of outgoing circuits, monitor equipment loading, and protect this equipment from damage due to system disturbances. A typical transmission substation steps down incoming transmission line voltages (e.g. 161 kV or 345 kV) to outgoing transmission line voltages of 138 kV or 161 kV and serves a large regional area.

Transmission Switchyard and Lines – Energy delivery facilities that provide for the long-range distribution of transmission circuits, monitor equipment loading, and protect this equipment from damage due to system disturbances. Typical transmission lines and switchyards involve voltages of 138 kV, 161 kV, and 345 kV and feature large wood or steel structures along lengthy rights-of-way.

Voltage – The electrical "pressure" used to push electrical energy down a conductor or circuit.

Volt-VAR Optimization – An advanced distribution application involving a central controller that automatically operates line capacitors via two-way communications. This helps optimize circuit performance using a combination of loading and voltage stabilization parameters. Benefits include feeder level optimization, minimization of system losses, maximum voltage stability, improved customer power quality, and the use of voltage reduction for demand conservation.

Wide Area Network (WAN) – The highest tier in the communications network, the WAN is a high-capacity communications backbone that transports large quantities of smart field application data to Ameren control centers. Ameren's WAN leverages data transport systems such as fiber optic cable, digital microwave, and common carrier leased services, and features a mix of private and public infrastructure.

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