Xanthus Consulting International

369 Fairview Ave, Boulder Creek, CA 95006
Phone 831 338-3175; Cell 831 229-1043
Email: fcleve@xanthus-consulting.com
Web: xanthus-consulting.com

Frances M. Cleveland

President & Principal Consultant, Xanthus Consulting International

Key Qualifications:

Ms. Cleveland has managed and consulted on Smart Grid information and control system projects in the electric power industry for over 35 years. Her expertise has focused primarily on ***Smart Grid information interoperability standards***, ***smart inverter functionalities for Distributed Energy Resources, cyber security issues, resilience, and integration of systems***, including Distributed Energy Resources (DER), plug-in electric vehicles (PEV), Advanced Metering Infrastructures (AMI), Distribution Automation (DA), substation automation, SCADA systems, and energy market operations. Recent work includes consulting on the following projects:

- **California Energy Commission (CEC) and California Public Utilities Commission (CPUC):** Leading the Smart Inverter Working Group (SIWG) which has developed the Phase 1 recommendations to the CPUC on key autonomous DER smart inverter functions for California utilities in order to update the California DER Interconnection Rule 21. Currently leading the SIWG Phase 2 effort in developing the communications and cyber security recommendations for these DER smart inverters. Shortly will start the Phase 3 effort on additional smart inverter functions.
- **Western Interstate Energy Board (WIEB)**: Developed a report and web site on "*Emerging Changes in Electric Distribution Systems in Western States and Provinces"* that provides WIEB stakeholders, particularly regulators and utilities, with the current status and emerging issues of distribution systems. It focuses on the regulatory and utility challenges of integrating high penetrations of Distributed Energy Resources (DER) systems, as well as the opportunities posed by the smart inverter functions. The report covers the recent California DER and distribution challenges and opportunities, as well as Hawaii, Europe, and other locations.
- **National Institute of Standards and Technology (NIST):** Technical Champion for the SGIP Priority Action Plan (PAP) 7 and working group on Distributed Renewables, Generation, & Storage (DRGS), including participation as lead Subgroup on DER Use Cases and Information Standards. Developed the "*SGIP DRGS Subgroup B White Paper: Categorizing Use Cases in Hierarchical DER Systems*".
- **Smart Grid Interoperability Panel (SGIP):** Major participant in the development of the NISTIR 7628 "*Guidelines for Smart Grid Cyber Security*". Lead of the NIST Smart Grid Cyber Security Working Group (SGCC) Standards Subgroup which assesses communication standards for their cybersecurity capabilities and gaps based on the NISTIR 7628 Guidelines for Smart Grid Cyber Security. In conjunction with the SGIP DRGS, developed the "*Resiliency and Security Recommendations for Power Systems with Distributed Energy Resources (DER) Cyber-Physical Systems*", which is being submitted to the IEC TC57 WG15 as IEC/TR 62351-12.
- **San Diego Gas & Electric (SDG&E):** Development of EPIC and GRC RFPs for demonstrating advanced DER functions and communications to assist SDG&E in evaluating the benefits, costs, and challenges of integrating smart inverters in distribution system operations.
- **EPRI:** "*Standard Communication Interface and Certification Test Program for Smart Inverters*" to develop a smart inverter communications test program for meeting California's proposed smart inverter functions. This test program will include the test procedures, software, and facilities needed to validate inverter functional and communications capabilities, based on the IEC 61850 communications standard information model, mappings to different communications protocols, and cyber security.

- **Electric Power Research Institute (EPRI):** "*Advanced DER Inverter Functions*" to develop the functional requirements for volt/var, frequency/watt, high/low voltage ride-through, and other inverter functions, including the development of the IEC 61850 object models for these functions, which are now IEC standards: IEC/TR 61850-90-7 and IEC 61850-7-420. These formed the basis of the smart inverter functions now recommended by California's SIWG to the CPUC for Rule 21 updates.
- **San Diego Gas & Electric (SDG&E):** Developed "*Scoping Study on SDG&E Application Experiments and Demonstrations (Pilot Projects) for Integration of Customer Distributed Energy Resources (DER) with Smart Distribution System Operations*". Assisting SDG&E to prioritize the pilot projects and develop their specifications, including for California's smart inverter requirements.
- **Value of Distribution Automation (CEC)**, to provide the California Energy Commission (CEC) with descriptions of DA functions, possible scenarios for implementing these functions, the potential utility, customer, and societal benefits from these functions, and the technical challenges to implement them.
- **IEEE 1547.8** as lead of the IEEE 1547.8 communications task force to develop updated DER interconnection recommendations for high penetrations of DER systems.
- **EPRI/DOE National Energy Sector Cybersecurity Organization Research (NESCOR):** Team lead for developing cybersecurity requirements and failure scenarios for DER systems, covered in the document "*Cyber Security for DER Systems based on the NISTIR 7628*".
- **TEIAŞ, Turkey:** Developing recommendations for telecommunications, communication protocols, information exchanges, and cyber security for the TEIAŞ national transmission system operator (TSO) in Turkey (subcontract with ESTA).

Professional Memberships:

In the International Electrotechnical Commission (IEC), she is:

- **Convenor** of IEC TC57 WG15 for IEC 62351 cybersecurity standards for power system operations and IEC ACSEC (cyber security)
- **Editor** for IEC TC57 WG17 for IEC 61850-7-420 and IEC 61850-90-7 information standards for DER systems, electric vehicles, and distribution automation
- **Technical Advisor** to the IEC TC 57 for WG17 (Distributed Resources), WG14 (CIM for Distribution and AMI Integration), WG 03 (RTU telecontrol), WG07 (ICCP), WG15 (Information Security), WG16 (Market Operations), WG19 (Harmonization of TC57 standards)
- **Technical Advisor** to the IEC TC8 WG5 (Use Case template) and IEC TC8 WG6 (DER Use Cases)

In the IEEE, she is a Life Member:

- Past Chair of the IEEE PES PSCC
- Chair of the PSCC Security Subcommittee
- Lead of the Communications Writing Group for IEEE 1547.8 and member of the Communications Writing Group for IEEE 1547 revision

Professional Background:

- **Xanthus Consulting International**, President & Principal Consultant, WBE – Sept 2005 to present
- **Utility Consulting International (UCI)**, Vice President & Principal Consultant – Sept 1992 to Sept 2005
- **ECC** (now Kema/DNV GL), Lead Consultant – Jan 1984 to Sept 1992
- **Systems Control** (now ABB), Senior Consultant – 1975 to Dec 1983

Brief Experience Record:

Ms. Cleveland's consulting experience and major projects can be found on the Xanthus Web Site: http://xanthus-consulting.com. They cover:

- **Smart Grid System Integration**: CEC/CPUC Smart Inverter recommendations, EPRI DER integration with the Smart Grid, NIST-SGIP PAPs, NIST-SGIP CSWG, CEC Smart Grid Pathway, Cyber Security standards assessment and Privacy, Smart Grid Use Cases, IEC 61850, IEC CIM, ZigBee SEPv2
- **Distributed Energy Resources (DER)**: SGIP DRGS White Paper on Hierarchical DER Architecture, SDG&E Pilot Project Study and Specifications, SGIP DER Use Cases, IEC 61850-7-420 DER standards, DER integration in distribution system, DER Use Cases for IEC TC8 WG6
- **Cyber Security**: SGIP Smart Grid Cyber Security (SGCC), National Energy Sector Cybersecurity Organization Research (NESCOR), NIST CSWG NISTIR 7628, CSWG Standards subgroup, AMI and HAN security requirements, AMI-SEC, NERC's CIP 002-009, IEC 62351 security standards, security risk assessment
- **Plug-in Electric Vehicles**: IEC TC57 WG17 on EV, EPRI/NIST Roadmap for Electric Transportation, NIST PAP 11, NIST PAP 17, USB PEV Payment and Settlement Options
- **Substation Automation**: IEC 61850 for substations, tutorials, substation applications, communications, substation technologies
- **Automated Metering Infrastructure (AMI)**: Use Cases, demand response, MultiSpeak, CIM standards
- **Distribution Automation**: DMS, SCADA, Use Cases, IEC 61850, applications, benefits, technologies
- **Energy Management Systems**: EMS, SCADA, requirements, specifications, tender evaluation, contract support
- **System Automation**: Smart Grid Architecture, distribution automation, substation automation
- **Market operations**: Market operations systems, FERC's OASIS transmission open access
- **Telecommunications media**: Fiber optics, WiFi/ZigBee wireless, MAS, telecom provider systems, security
- **Smart Grid Patent Assessments**: Patent assessments of Smart Grid technologies

Education:

- **MBA**, San Jose State University (1987)
- **M.S**. in Electrical Engineering and Computer Science (EECS), University of California at Berkeley (1975)
- **B.A.** in Electrical Engineering and Applied Physics, Harvard University (1969)

Detailed Experience Record

Summaries of Ms. Cleveland's major projects include:

1. Smart Grid Architectures and System Integration for Utilities

a. **California Energy Commission (CEC) and California Public Utilities Commission (CPUC):** Leading the Smart Inverter Working Group (SIWG) to develop recommendations on DER smart inverter functions for California utilities for updating Rule 21, including testing plan and communication requirements.

b. **San Diego Gas & Electric (SDG&E):** Developed "Scoping Study on SDG&E Application Experiments and Demonstrations (Pilot Projects) for Integration of Customer Distributed Energy Resources (DER) with Smart Distribution System Operations". Assisted SDG&E to prioritize the pilot projects and develop their specifications, including for California's smart inverter requirements.

c. **NIST Support for Smart Grid Interoperability Panel (SGIP) and Priority Action Plans (PAPs) (NIST/SGIP)**as a subcontractor to EnerNex, assisting in the establishment of the SGIP and its governing board, as well as technical support of the NIST Priority Action Plans and the Cyber Security Working Group (CSWG).

d. **NISTIR 7628 Guidelines for Smart Grid Cyber Security (NIST):** instrumental in the development of the concepts and structure of the NISTIR 7628 which is used as a major cyber security reference for stakeholders of the electric power industry.

e. **NIST Smart Grid Interim Roadmap (EPRI/NIST/SGIP)**, as a subcontractor to EPRI in developing a roadmap and action plan for NIST to identify the appropriate standards and to coordinate any needed standards development. This process has included two Smart Grid workshops to gather input from stakeholders and provide direction to NIST.

f. **California Energy Commission (CEC):** Smart Grid Pathway: worked with EPRI and California utilities to define the vision for 2020 communications, cyber security, and demand response.

g. **Specification for PV & Storage Inverter Interactions using IEC 61850 Object Models (SGIP),** to develop the interactions between utilities and inverters for energy management, var support, and other functions, and develop object models for these functions in IEC 61850-90-7 standard, which will be used to update the IEC 61850-7-420 object models. These have also been submitted to NIST's PAP 7 as DER and Energy Storage information models.

h. **AMI and HAN Cyber Security Requirements (EPRI/NIST/SGIP)**, to develop the security requirements and methodology for utilities to utilize for developing implementation-specific security requirements, based on NIST/EPRI FERC4+2 diagrams, the NIST CSWG efforts, and the DHS Catalog of Control System Security.

i. **Smart Grid Projects Assessment (EPRI)**, to provide EPRI with a methodology and accompanying spreadsheet for evaluating the "Smart Gridedness" of Smart Grid projects. The report, "Smart Grid DER Projects Assessment" develops a methodology and quantitative metrics to evaluate Smart Grid projects related to integrating Distributed Energy Resources (DER) into the grid and market operations, including distributed generation, storage, demand response, and renewables. This project includes a Smart Grid Project Assessment spreadsheet that identifies the important characteristics of Smart Grid projects to achieve integration of distributed resources. i.e. those characteristics that indicate the extent to which these projects can fulfill the Smart Grid objectives.

j. **Smart Grid: Distributed Generation using IEC 61850-7-420 (CEC),** to implement this international communication standards for distributed energy resources such as photovoltaic systems and other renewable systems in a project for the California Energy Commission (CEC).

k. **Utility Standards Board (USB)**, a group of many of the largest North American utilities, to develop the *PEV Payment and Settlement Options* white paper, to develop de facto standards for the interface between AMI systems and the many functions on the utility's "Enterprise Bus", such as meter data management systems, billing systems, revenue protection systems, maintenance systems, outage management systems, and other utility systems. The USB de facto standards for Meter Headend Event Codes and for Remote Connect/Disconnect have been accepted by the IEC TC57 WG14 as part of the Common Information Modeling (CIM) for AMI interfaces in IEC 61968-9 to be standardized shortly. MultiSpeak has also accepted

the Meter Headend Event Codes and will review the Remote Connect Disconnect models shortly. The USB de facto standards for Outage Detection and Restoration will be submitted to the IEC and MultiSpeak shortly.

l. **Value of Distribution Automation (CEC)**, to provide the California Energy Commission (CEC) with descriptions of distribution automation functions, possible scenarios for implementing these functions, the potential utility, customer, and societal benefits from these functions, and the technical challenges to implement them. The CEC has made it public as a draft document.

m. **IEC DER Object Model Standards (IEC 61850-7-420) (IEC)**, which includes communication object models for Distributed Energy Resources (DER). The DER device types covered are reciprocating (diesel) engines, fuel cells, photovoltaic systems, and combined heat and power (CHP). IEC 61850 is the international communications protocol standard for field communications. It has been expanded to include DER communications, hydro plant communications, inter-substation communications, and substation-to-control center communications. It will be expanded for distribution automation.

n. **Sterling Energy Systems (SES),** SES developed two solar thermal power plants in California. The two plants - Solar One and Solar Two - are significant first steps in deploying large-scale renewable solar technology as a commercial energy project. Solar Two is the first to be implemented and will provide 750 MW of energy when fully deployed. The management of the SES power plant needed a SCADA system, and the decision was to implement IEC 61850 for the plant communications.

o. **IntelliGrid Architecture (EPRI)** to develop a power system industry communications architecture, based on a complete set of power system functional requirements for supporting self-healing power systems, energy marketplace transactions, sharing and synergy among all types of utility operational functions, and integrated customer services. The project results are being contributed as appropriate to relevant Standards Development Organizations and industry consortia to effectively move the development of key open standards forward to develop a robust industry infrastructure. In the area of customer services, extensive Use Cases were developed on Real-Time Pricing (RTP), Time-of-Use (TOU), market opportunities for customers using distributed energy resources (DER) for both energy and ancillary services, direct and indirect load control, and customer portals as “gateways” to implement these functions. Innovative communications technologies were discussed, ranging from Broadband Powerline Carrier (BPL) within the customer premises, to telephone, wireless solutions, the Internet, and certain proprietary radio systems. See http://IntelliGrid.info or http://intelligrid.ipower.com/IntelliGrid_Architecture/Overview_Guidelines/index.htm

p. **Convenor of IEC TC57 WG15 (IEC)**, led the development of security standards for utility operations protocols, including ICCP, IEC 61850, and DNP. In addition, the development of Network and System Management data objects for power system operations, to help ensure security and reliability of end-to-end systems. These security standards, most of which have just been approved by the international committees, consist of IEC 62351: Data and Communication Security – Part 1: Introduction, Part 2: Glossary, Part 3: Profiles Including TCP/IP, Part 4: Profiles Including MMS, Part 5: Security for IEC 60870-5 and Derivatives (i.e. DNP3), Part 6: Security for IEC 61850 Profiles, Part 7: Security Through Network and System Management, and Part 8: Role-Based Access Control.

q. **On-going participation in IEC TC57 WG17 to develop IEC 61850-7-420 standards for Distributed Energy Resources and Distribution Automation (IEC)**. The DER IEC 61850-7-420 became a standard in March 2009. The DA standardization effort is on-going.

r. **On-going participation in IEC TC57 WG14 to develop standards for distribution information exchange models (IEC)** for the exchange of information between distribution operational systems.

s. **On-going participation in IEC TC57 WG19 for the harmonization of international standards (IEC)**, with the focus of integrating IEC 61850 with the Common Information Model (IEC 61970).

t. **(Past) Chair of IEEE PES PSCC Security Assessment WG (IEEE)**, heading the development for the IEEE of Recommended Practices, educational material, and other information related to the assessment of information security risks in power system operations.

u. **AMI-SEC** participation to develop the security requirements and potential security solutions for AMI systems. The “AMI System Security Requirements - v1_01” has been recently completed.

v. **Guidelines for Implementing Distribution Automation (DA) using IEC 61850,** which provide guidelines for developing requirements for, and implementing, IEC 61850 for advanced DA. The IEC 61850 requirements for DA will be based on the existing IEC 61850 object models and design criteria, but will be extended as necessary to meet advanced distribution automation requirements, including interactions with DER, real-time pricing, market demand-response, and other functions of the future.

w. **System Integration Assessment**, to provide the California Energy Commission (CEC) with support and recommendations for system integration projects and R&D efforts that would benefit the electric power consumers.

x. **Meshed Wireless Sensor System for Substation Monitoring Applications**, to demonstrate the feasibility and benefits of meshed wireless communications network for retrieving sensor information in a substation environment.

y. **Assessment of Wireless Capabilities within Substations,** EPRI 1011751, March 2006. The possible use of wireless communications in substations has raised a number of issues and concerns. This report determines that wireless communications is already being used in some applications, and that they could be used safely, reliably, and securely in many more applications, so long as the required data exchanges are not very time-sensitive and proper security measures have been applied. In addition, new standards and new product developments are underway to improve the performance, reliability, and security of these technologies in industrial settings.

z. **Guidelines for Implementing Substation Automation using IEC 61850,** which provide guidelines for implementing IEC61850 for substation automation. These guidelines were developed for EPRI clients.

aa. **Communications Technology Assessment**, which is a web-based product covering all aspects of utility business areas, telecommunications media, communications protocols, security, and R&D requirements for utilities.

bb. **Network and System Management** for utilities, which analyzes network management requirements for distribution automation, describes existing network management capabilities, and recommends network management approaches for distribution utilities. This was the basis for the IEC 62351-7 standard on network and system management.

2. Distributed Energy Resources (DER)

a. **DER Object Model Standards (IEC 61850-7-420) (IEC)**, which includes communication object models for DER system management, DER devices, and facility DER energy management systems for use in TOU, RTP, and other schemes. The DER device types covered are reciprocating (diesel) engines, fuel cells, photovoltaic systems, combined heat and power (CHP), energy storage, and electric vehicles (V2G). IEC 61850 is the international communications protocol standard for DER systems, Electric Vehicles V2G interactions, distribution automation, as well as its original focus on substation automation. It is being expanded to include XML-based DER communications (XER encoding of MMS format from the 61850 UML model), hydro plant communications, inter-substation communications, and substation-to-control center communications.

b. **DER/ADA Project: Utility Communications Architecture© (UCA) – Object Models for Distributed Energy Resources (UCA-DER) (EPRI)**, to develop the object models of DER information that can be exchanged between DER devices and any systems which monitor, control, maintain, audit, and generally operate the DER devices. These object models will be based on IEC61850 components and concepts, with extensions as necessary.

c. **Distributed Energy Resources (DER) communications and control requirements (EPRI)**, which assessed the requirements of the stakeholders and the potential roles of distributed resources for distribution utilities in the new, deregulated environment. Included assessment of customers bidding DER into the electricity market for both energy and ancillary services.

d. **Distributed Energy Resources and Advanced Distribution Automation (DER/ADA) (EPRI),** for determining the information needs of advanced distribution automation for DER devices, such as diesel generators, microturbines, fuel cells, and other resources.

e. **Open Communications Architecture for DER**, to develop standard object models for integrating DER into utility distribution networks.

3. Security Issues

a. **NIST Cyber Security Working Group (CSWG):** Chair of the CSWG Standards subgroup. Support for other CSWG subgroups, covering high level security requirements, cybersecurity design principles, security architecture and diagrams, privacy, logical interface categories, and other security issues.

b. **Metropolitan Electricity Authority (MEA), Thailand**: Updated the cyber security requirements in the MEA specifications for a new SCADA/EMS system.

c. **National Energy Sector Cybersecurity Organization Research (NESCOR)**: Supporting cybersecurity issues related to standards, security architecture, security requirements of functions. Specific focus is on DER and distribution automation cybersecurity failure scenarios, architectures, cyber-physical security requirements, security standards assessments, and gap analysis.

d. **Distribution System Security Guidelines**, to identify the security requirements, and to describe the different security technologies and procedures that utilities could utilize for meeting those requirements, based on NIST/EPRI FERC4+2 diagrams, the NIST CSWG efforts, and the NIST Catalog of Control System Security.

e. **AMI and HAN Cyber Security Requirements**, to develop the security requirements and methodology for utilities to utilize for developing implementation-specific security requirements, based on NIST/EPRI FERC4+2 diagrams, the NIST CSWG efforts, and the NIST Catalog of Control System Security.

a. As **Convenor of IEC TC57 WG15**, have led the development of security standards for utility operations protocols, including ICCP, IEC 61850, and DNP. In addition, the development of Network and System Management data objects for power system operations, to help ensure security and reliability of end-to-end systems. These security standards, most of which have just been approved by the international committees, consist of IEC 62351: Data and Communication Security – Part 1: Introduction, Part 2: Glossary, Part 3: Profiles Including TCP/IP, Part 4: Profiles Including MMS, Part 5: Security for IEC 60870-5 and Derivatives (i.e. DNP3), Part 6: Security for IEC 61850 Profiles, and Part 7: Security Through Network and System Management. New security efforts will include security requirements for wireless communications as well as additional profiles of protocols used in the power system industry.

b. As **Chair of IEEE PES PSCC Security WG**, am heading the development for the IEEE of Recommended Practices, educational material, and other information related to the assessment of information security risks in power system operations.

c. **Assessment of Substation Physical Security Measures within Substations,** EPRI 1011752, March 2006. The need for physical security of substations is becoming more urgent as power systems are operated closer to their limits, as information systems become increasingly important to power system operations, and as sophisticated substation equipment becomes more vulnerable to physical threats due not only to deliberate attacks but also to inadvertent mistakes, failures, and natural catastrophes. This requirement for physical security affects all substation assets to one degree or another. The key is the tradeoff between the costs (monetary and some reduced efficiency) of implementing security measures and the probabilistic benefits associated with avoided costs (monetary, social, political, and legal).

d. **Security Risk Assessment and Mitigation Procedure for TVA Operational Information Assets**, March 2005. Cyber security has undoubtedly become a major issue for almost all electric utilities. This is partly due to the competitive environment, where crucial information (gathered legally or illegally) can translate into millions of dollars, but mainly due to the increased vulnerability brought about by the integration of networking technologies within the systems and equipment used on the power system. It is particularly true for the United States that a loss of electrical power for any extended time and over a large area can have serious consequences for the economy, for the safety of people, and for the legal and financial status of the utilities affected. PowerWAN will be a vital part of TVA's future. Physical infrastructure alone is not enough to meet the challenge. To be successful, sound security policy, risk assessment practices, and mitigation procedures must be developed. These requirements were analyzed and discussed in the report.

e. **Scoping Study on Security Processes and Impacts**, July 2003, EPRI 057144. The primary objective of this Scoping Study was the assessment of the financial and societal costs of implementing security measures.

Financial costs include the costs for developing security policies and implementing security countermeasure technologies. Societal costs include the impact of security policies and technologies on the efficiency of personnel and systems.

f. **Security Enhancements for Utility Information Architectures**, August, 2002, EPRI EP-P10074. Cyber security has become a major issue in utilities due partly to the increased vulnerability of utilities as they network their computer systems and power system equipment; and partly due to the competitive environment where crucial information (gathered legally or illegally) can translate into millions of dollars. A number of technology solutions have been proposed for improving the security of the communications protocols used in power system operations, mostly based on encryption which does have an impact on performance. These solutions go a long way to increasing the information security. However, they are not the complete story – for end-to-end security beyond the protocols, additional types of security are needed. The objectives of this project was to assess the impact on performance of the security measures being proposed for the common protocols used for digital control of power system equipment, and to determine what additional security measures outside the domain of protocols may be needed for complete end-to-end security.

g. **Security Primer** on communication network security requirements for utility T&D operations. The primary focus of this work was to describe the potential areas of vulnerability of utility SCADA systems, substation automation, and other power system operational automation.

4. Automated Metering Infrastructure (AMI)

a. **Utility Standards Board (USB)**, a group of the largest North American utilities, to develop de facto standards for the interface between AMI systems and the many functions on the utility's "Enterprise Bus", such as meter data management systems, billing systems, revenue protection systems, maintenance systems, outage management systems, and other utility systems. The USB de facto standards for Meter Headend Event Codes and for Remote Connect/Disconnect have been accepted by the IEC TC57 WG14 as "informative" models to be validated during interoperability testing on Common Information Modeling (CIM) for AMI interfaces. MultiSpeak has also accepted the Meter Headend Event Codes and will review the Remote Connect Disconnect models shortly. The USB de facto standards for Outage Detection and Restoration will be submitted to the IEC and MultiSpeak shortly.

b. **AMI-SEC** participation to develop the security requirements and potential security solutions for AMI systems. The "AMI System Security Requirements - v1_01" has been recently completed.

c. **OpenAMI** participation to develop design principles for Automated Metering Infrastructure (AMI) and Demand Response (DR), primarily in response to the CEC's call for demand response technologies. Metering interfaces are the main focus, addressing the capabilities and possible enhancements, interpretations, and/or protocol mappings of the ANSI C12 series of metering standards.

d. **Omaha Public Power District (OPPD)** to performed an Automatic Meter Reading and Load Control (AMR/LC) benefit-cost analysis, comparing the costs between current meter reading methods and a variety of automatic meter reading and load control methods. These AMR technologies included proprietary radio-based, power line carrier, telephone, the Internet, and other public telecommunications media. The vendors and their products assessed included Itron (manual, remote, and fixed AMR), CellNet (Schlumberger), DCSI TWACS, Hunt Technologies Turtle, Nexus, Hexagram, Nertec, American Innovations, and others. Three customer environments (industrial/commercial, urban residential, and rural residential) were modeled. Different levels of customer tariff incentives were also assessed.

e. **Puerto Rico Electric Power Authority,** to perform AMR and Load Control benefit cost analysis, covering radio-based systems and power line carrier systems. Quantitative data was collected from PREPA and analyzed related to meter reading, load surveying, theft, possibilities of deferring construction with load control, and other electrical and financial information. After performing a detailed analysis, it was concluded that the power line carrier TWACS system would have the shortest payback period. Most of the benefits were related to losses due to theft, inaccurately estimated meter readings, and on-demand meter readings. Because Puerto Rico is so mountainous and because many of the meters are not easily accessible by short-range radio systems, the radio-based systems were not as feasible as the power line carrier system.

f. **City Public Service of San Antonio, AMR and Load Control** to undertake a system-wide Distribution Automation and Customer Site communications project using state-of-the-art telecommunications

networking using fiber optic cables and radio-based systems, while integrating the AMR/Load Control with Distribution Automation using the UCA 2 technology (now known as IEC 61850). AMR/LC capabilities were analyzed, including: automatic meter reading for electric, gas, and water meters, load control, tamper detection, automatic detection and reporting of power outages and restorations of service, call-back of customers after restoration of power, remote service connect and disconnect, end-use load surveys of electric, gas, and water usage, providing billing information to customers on-line or over the Internet, real-time pricing, retail wheeling, and leasing/sharing of AMR infrastructure for use with other companies.

g. **IEEE P1777 – Recommended Practices for Wireless Communications in Power System Operations**, co-chair of working group to issue a questionnaire to potential and actual users of wireless communications, which will be used as a base for developing recommended practices for using wireless communications in power system operations.

h. **City Public Service, San Antonio (CPS):** Developed requirements and functional specifications, assisted in Tender Evaluation, and participated in project implementation for CPS's Distribution Automation Pilot Project (DAPP) using UCA Version 2.

i. Development of UCA object models for the **Water Industry** and the **Gas Industry**

j. Development of the original **Utility Communications Architecture (UCA),** in particular the UCA version 2 CASM and GOMSFE for Substation Automation and Distribution Automation.

k. **Utility Telecommunication System Costs**, EPRI 2001

l. **Omaha Public Power District (OPPD) Mobile Computing Study**, July 2001

5. Distribution Automation and SCADA Systems

a. **Value of Distribution Automation**, to provide the California Energy Commission (CEC) with descriptions of DA functions, possible scenarios for implementing these functions, the potential utility, customer, and societal benefits from these functions, and the technical challenges to implement them.

b. **Guidelines for Implementing Distribution Automation (DA) using IEC 61850,** which provide guidelines for developing requirements for, and implementing, IEC 61850 for advanced DA. The IEC 61850 requirements for DA will be based on the existing IEC 61850 object models and design criteria, but will be extended as necessary to meet advanced distribution automation requirements, including interactions with DER, real-time pricing, market demand-response, and other functions of the future.

c. **Distribution SCADA System** requirements and project implementation support for Metropolitan Electricity Authority (MEA) in Thailand. This effort included the factory acceptance tests for the MEA SDH fiber optic network.

d. **Client-Side Requirements for Data Acquisition and Control Subsystems for Distribution Automation Communications**, to develop the client-side requirements for communication systems for Data Acquisition and Control (DAC) subsystems. In future systems, the functions which need to interact with field end devices are becoming significantly more complex and extensive, and are therefore driving the need for new DAC capabilities, particularly data management capabilities.

e. **Tutorial on IEC 61850 for Substation and Distribution Automation**, which provides 2 to 4 days of presentations covering the concepts, benefits, case studies, and practical experience in implementing IEC 61850. This tutorial has been presented to Power Link in Australia and Metropolitan Electricity Authority (MEA) in Thailand.

f. **SCADA and EMS Specifications Review** for State Power East China Corporation, covering the City of Shanghai and three neighboring provinces, Zhejiang, Jiangsu and Anhui.

g. **Participation in IEC TC57 WG14 to develop standards for distribution information exchange models** for the exchange of information between distribution operational systems.

h. **Participation in IEC TC57 WG19 for the harmonization of international standards**, with the focus of integrating IEC 61850 with the Common Information Model (IEC 61970).

i. **Participation in the extension of the Common Information Model (CIM)** to distribution and market operations.

j. **Omaha Public Power District (OPPD):** Developed an Automation Plan covering SCADA, EMS, Distribution Automation, Substation Automation, Automatic Meter Reading, Integration Standards, and Communication Protocols.

k. **City Public Service (CPS) of San Antonio, Texas**, the second largest municipal in the United States, undertook a system-wide Distribution Automation project using state-of-the-art telecommunications networking and integration technology, starting in 1995. This project was the first implementations of the Utility Communications Architecture (UCA®) which eventually led to the international standard, IEC 61850. The first phase of this project was the Distribution Automation Pilot Project (DAPP). The DAPP comprised the design, specification, and implementation of automated switches, voltage regulators, capacitor bank switches, reclosers, LTC controllers, and substation RTUs, which were either interfaced to a loop of fiber optic telecommunication cables strung along two distribution feeders or directly linked to CPS's fiber optic backbone telecommunications network in the two pilot substations. In conjunction with the development of a new EMS/SCADA system for CPS, Distribution Management System (DMS) applications were specified to manage the field devices, not only for the DAPP pilot project, but for the system-wide implementation of automated switches and other field devices. These automated switches are being installed up to a possible total of 1000 switches.

l. **Los Angeles Department of Water and Power, Distribution Management System Study**. This study analyzed the management structure of distribution operations, and recommended changes in the organization to reflect the increased importance of customer satisfaction in the strategic objectives of the Department. The Department's CAIDI and SAIFI statistics were also assessed. These needs were then translated into specific requirements for computerized systems and functions for each type of requirement, potential alternative solutions were examined, and for each alternative, the advantages, disadvantages, costs, and paybacks were analyzed.

6. Deregulation

a. **EGAT (Thailand)**: Assisted in determining EMS and market operation requirements as EGAT was separated into a market operations company and a transmission operations company.

b. **Coordination of Western RTOs/ISOs**: Assisted the three western RTOs/ISOs in determining requirements for coordinating market and power system operations if the FERC standard market design were to require a common interface to all western RTOs.

c. **DStar (WestConnect) RTO**: Developed Unified Modeling Language (UML) Use Cases for the proposed DStar market rules. Also developed specifications for a SCADA/EMS and a Market Operations System to operate the RTO and implement the market rules.

d. **California ISO**: Assisted in the startup of the CAISO EMS system when it was developed to manage the California transmission operations.

e. **Participation in IEC TC57 WG16 on Market Operations**: development of international standards for market operations between utilities, based on the concepts of the United Nations CE/FACT business-to-business model, ebXML.

f. **Transaction Management System (TMS):** Developing alternative architectures for the continent-wide TMS system for managing transactions for transmission services and ancillary services, and analyzing power system security.

g. **Open Access Same-Time Information System (OASIS):** Contributor and Editor of the Open Access Same-Time Information System (OASIS) Standards and Communication Protocol for the EPRI-sponsored "How" Working Group, which developed the Internet-based design for implementing FERC's Order 889 for Transmission Open Access.

7. Smart Grid Patent Assessment

a. **Patent Assessment for Law Firm**: Provided technical Smart Grid expertise to a law firm on patent infringement issues.

b. Patent Assessment for Communication Standards: Supported assessment of patents to avoid patent infringement related to technologies that were to be included in communication standards.