Title

Control and Communications Integration Project Mappings

Authors

Gunther, Erich W.
King, Jack

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CONTROL AND COMMUNICATIONS INTEGRATION PROJECT MAPPING

DRAFT

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Prepared By:
EnerNex Corporation
http://www.enernex.com/
Erich W. Gunther, Principal Investigator
Jack King, Researcher
Knoxville, Tennessee
Contract No. C-03-06

Prepared For:

California Energy Commission

Michael Magaletti
Contract Manager

Mark Rawson
Project Manager

Laurie ten Hope
Program Team Lead
Pier Energy Systems Integration

Name,
Terry Surles
Pier Program Director

Robert L. Therkelsen
Executive Director

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Introduction

PIER has a program in Distributed Energy Resources (DER) that has been underway for several years. This program has a well defined roadmap, has been funding part of the Rule 21 efforts in California, and is co-funding a DG equipment test bed with DOE and others. In contrast, the PIER Demand Response (DR) Program initiated its first 4 projects last fall, the largest of which is the DR ETD (Enabling Technologies Development) Project which had its first "public" workshop on June 4. Ultimately, some projects in the DR Program may become part of the DER umbrella and/or be included in more traditional PIER Areas such as Buildings and the California Energy Commissions (CEC) energy efficiency efforts. However, DR is currently a very hot topic in California and the DR Program is designed to provide R&D support for Commissioner Rosenfeld's dynamic pricing initiatives.

One area of common interest to the DER and DR Programs is the topic of "Control and Communications Integration" (C&CI). In this regard, the DER and DR program managers have joined forces to develop an agenda that meets the needs of both programs. Their main effort to date has been to follow DOE and EPRI activities in related areas in order to develop an agenda in such a way that it leverages their efforts and does not duplicate already funded work.

The objective of this project is to create a map between PIER DER and DR C&CI objectives and DOE, EPRI and other related program activities. This map has taken the form of a matrix that shows research and industry standards that apply to a number of areas with ongoing PIER projects and general technology areas of interest. In the matrix, each research project or relevant standard is referenced through an index that guides the reader to a summary of that work in sections following the matrix.

The matrix is divided vertically in a hierarchical manner by major PIER program areas that include DR, DER, Transmission and Distribution, and Additional Resources. These are highlighted in blue. Under each program area, the matrix is further divided into research areas such as Demand Response Enabling Technology Development (DRETD) or Measuring Demand Response to Market Prices which area formatted in red print. Finally, under each research area, characteristics or attributes applicable to that research area are listed in black print (e.g., Network Management, System Integration, etc.). At this lowest level in this hierarchical format, there is duplication between major PIER program areas because each program area shares these characteristics or attributes. Across the top of the matrix are external PIER organizations such as national labs, DOE, standards organizations, etc. In each column, a particular organization’s research activity is mapped to the respective PIER program area/research area/attribute that is uniquely relevant.

Section 2 contains a set of articles that describe various research projects and reports covering the topics of DER and Demand Response. Each article is numbered sequentially with a prefix of ‘R’ to differentiate that article from the Standards references in Section 3.

The articles in Section 3 describe various standards and standards groups that relate to DER and Demand Response. The standards are organized by the overall standard number and then by working group or subordinate documents. Matrix references with only the overall standard number imply that the entire or substantially all of the body of the standard applies to the item in the matrix. When one or more of the sub-sections of the standard apply in a more specific way, the reference is shown as a “dotted” reference, say “1.1”, etc.

Finally, the entries in the matrix are color coded to indicate the degree of relevance for each item. The key can be found at the bottom of the matrix.

Section 1 – Reference Matrix

PIER Activities		National Labs				DOE				E2I/CEIDS		Standards				
	EPRI	LBNL	ORNL	NREL	PNNL	DER C&C	Ind. Wireless	Bld. Controls	Other	IECSA	DER/ ADA	IEC TC 57	IEC TC 88-25	ANSI	IEEE	Other Sources
Demand Response Research Programs																
Demand Response Enabling Technology Development (DRETD)																
Network Management	R14				R41	R3	R6			R10					S12	R20
System Integration	R14	R25		R30 R32 R33	R41 R42 R40					R10					S12	R20
Electric Meter	R14													S1		
Thermostat	R14				R42										S12	
Generic Controllers	R14			R33	R40 R41		R6								S12	
Measuring Demand Response to Market Prices																
Customer Response	R11	R25 R26		R30 R33												R28
Pricing	R12		R38	R32 R33 R30												R21 R28 R29
Technology																
Technology Overviews	R14		R38		R40 R42		R7									R22 R28
AMR										R10				S1.2 S1.3	S9.2	R20
Data Communications	R14			R30	R41 R42	R3	R6 R7			R10		S5		S1.3 S1.4	S9	R20

PIER Activities	EPRI	National Labs				DOE				E2I/CEIDS		Standards				
		LBNL	ORNL	NREL	PNNL	DER C&C	Ind. Wireless	Bld. Controls	Other	IECSA	DER/ ADA	IEC TC 57	IEC TC 88-25	ANSI	IEEE	Other Sources
Distributed Energy Resources Research																
General																
Technology Overviews	R13			R34	R39 R41	R3										
Smart*DER																
Communications Protocols				R30 R32 R31		R3				R10	R9	S5	S6	S2	S7	R1
System Integration				R30 R31 R32 R33 R34 R36		R3		R2			R9					R1
Command and Control				R30 R31 R32 R33 R36		R3 R4 R5				R10	R9		S6	S2		R1
Microgrid EMS																
Communications Protocols				R30 R33 R35		R3				R10	R9		S6	S2		R1
Communication Gateway Equipment				R30 R31 R33		R3							S6			R1 R20

PIER Activities	EPRI	National Labs				DOE				E2I/CEIDS		Standards				
		LBNL	ORNL	NREL	PNNL	DER C&C	Ind. Wireless	Bld. Controls	Other	IECSA	DER/ ADA	IEC TC 57	IEC TC 88-25	ANSI	IEEE	Other Sources
Command and Control				R30 R33 R35 R36 / R31 R32 R33		R16 / R4 R5					R9	S5	S6	S3 S2		R1 S13
Network Management		R27		R30 R33 / R30												
System Integration		R27		R30 R33 R36 / R5 R10 R11				R2			R9					R1
DUIT (Distributed Utility Integration Testing)																
Communication Gateway									R8					S2		R19
System Integration				R36					R8						S10.1	R19
R21 Interconnection Monitoring																
Monitoring															S10.3	
DER Equipment																
Reliability				R34 R36												
Performance			R37	R30 R33 R36												
Cost/Financing		R23 R24	R37	R30 R32 R33												

PIER Activities	EPRI	National Labs				DOE				E2I/CEIDS		Standards				
		LBNL	ORNL	NREL	PNNL	DER C&C	Ind. Wireless	Bld. Controls	Other	IECSA	DER/ADA	IEC TC 57	IEC TC 88-25	ANSI	IEEE	Other Sources
Safety				R34												
Benefits		R23		R30	R39											
Enabling Technology																
Communications Protocols	R18			R35 R31	R39 R41	R3			R8	R10	R9	S5			S7 S11	R20
Command And Control	R18			R31 R32 R33 R35	R39 R40 R41 R42 R40	R3				R10	R9	S5	S6		S10.3	R20
Interconnection Equipment	R15			R31 R32 R36											S10.3	R20
Communications and Communications Gatways	R18			R31	R39 R42	R3			R8	R10		S5.4			S10.3 S9	
Transmission and Distribution																
Enabling Technology																
Communication Protocols										R10						
System Integration																
Command and Control										R10						
Equipment/Infrastructure																
Reliability				R30 R36												
Cost/Financing				R30												
Security				R30												
Communication Gateway Equipment										R10						

PIER Activities		National Labs				DOE				E2I/CEIDS		Standards				
	EPRI	LBNL	ORNL	NREL	PNNL	DER C&C	Ind. Wireless	Bld. Controls	Other	IECSA	DER/ ADA	IEC TC 57	IEC TC 88-25	ANSI	IEEE	Other Sources
Additional Resources																
Building Integration																
Building Integration				R30 R32			R6 R7	R2								
Databases																
DER Installations			R37													R22
Energy Use	R16 R17															
Data Modeling																
Data Modeling											R9	S5.2		S4	S8 S10.3	

(orange)	Closely Related Activity
(green)	Somewhat Related
(gray)	General Interest

Section 2 – Research Articles

The articles in this section describe various research projects and reports covering the topics of DER and Demand Response. Each article is numbered sequentially with a prefix of ‘R’ to differentiate that article from the Standards references in Section 2.

Article #R1
Organization: ASHRAE
Title: Utility/Energy Management and Controls System (EMCS) Communication Protocol Requirements - ASHRAE Research Project 1011-RP
Contact: Michael Kintner-Meyer
Website: http://www.nist.gov/tc75/
Status: Report Completed 1999

ASHRAE research project 1011-RP, titled "*Utility/Energy Management and Controls System (EMCS) Communication Protocol Requirements*" focused on the definition of information services and the analysis of data requirements to enable these services. The following nine information services were defined, and their communication and data requirements were analyzed: (1) revenue meter reading (electricity, gas, water, heating and cooling energy); (2) quality of service monitoring; (3) real-time-pricing transmission; (4) load management service; (5) on-site generation supervisory control; (6) energy efficiency monitoring; (7) weather reporting and forecasting services; (8) indoor-air quality monitoring; and (9) dynamic demand bidding into a power exchange.

The result of the service definition and data requirements analysis is a series of proposed data object models that define a set of data and their relation to each other. These data sets are necessary and sufficient for the implementation of the proposed services. The research provides a brief discussion on a mapping approach to transfer the data object model proposed into a BACnet environment.

Article #R2
Title: Utility System Integration Issues and Integration of DER into Building Control Systems
Organization: DOE/EERE/DER
Partner NiSource
Contact: Pat Hoffman Email: patricia.hoffman@hq.doe.gov
Status Unknown

A leading proponent of utility use of distributed generation, NiSource Energy Technologies Inc., supplies power and distribution services throughout the Midwest and Mid-Atlantic regions. NiSource will work with subsidiary utilities to identify the system integration and implementation issues for distributed generation and to develop and test potential solutions to these issues. The long-term goal is to design ways to extend distributed generation into the physical design and controls of a building itself. This work will provide data to identify the range of issues for integrated distributed generation to determine solutions to for a range of power users — from small industry to residences

Article #R3
Organization: DOE
Title: Communications and Control Program
DOE Program Contact: Eric Lightner eric.lightner@ee.doe.gov
Website: http://www.eere.energy.gov/der/pdfs/tech_briefs/comm_controls.pdf
Status: Research In progress

Communications and Control (C&C) is a new program within the DER that is chartered to provide enabling communications and control technologies to optimize the off- and on-grid operations of distributed energy components, subsystems, and systems. As a new program, the C&C sets out to establish an industry/government partnership to jointly pursue research, development, demonstration, and deployment of emerging technologies to address needs and opportunities relating to communications and control of integrated DER systems. Through these enabling communication and control technologies, various DER hardware and software components can be aggregated into an integrated operation with scalability to meet individual user, facility, and utility requirements. Further, the enhanced information flow and system control capabilities will allow practice of demand-side management. When this demand management is combined with an increased supply from aggregated capacities of DER systems, true values and benefits of DER can be fully realized to meet the nation's power generation, transmission, and distribution challenges.

Article #R4
Organization: DOE DER C&C
Title: Distributed Intelligent Agents for Decision Making at Local DER Levels
Contact: Gerald L. Gibson gibsonj@aesc-inc.com
Website: http://www.science.doe.gov/sbir/awards_abstracts/sbirsttr/cycle21/phase1/107.htm
Status: Ongoing, Stage 1 SBIR contract

The benefits of integrating Distributed Energy Resources (DER) into the U.S. electric power system are well documented. Unfortunately, electric utilities view DER as potentially disruptive to existing grid protection systems, and the increased use of DER would be hampered by the centralized control infrastructure currently in place. A new control and communication approach is needed for the full benefits of DER to be realized. Intelligent software agents could provide the needed communications, controls, and prognostics/diagnostics. However, to gain acceptance in the electric industry, intelligent agents must be shown to be stable and capable of responding to common system disturbances. This project will lay the groundwork for a hierarchy of intelligent power system agents that will enable DER to be more fully integrated into the U.S. power system. Feasibility will be demonstrated by developing and testing DER agents that respond to DER level disturbances, thereby facilitating acceptance within the power industry. Phase I will develop the high level requirements for a basic hierarchy of intelligent agents to coordinate the operation of the electric grid system by communicating and collaborating with one another. The DER level agents, operating at the bottom-most level of the hierarchy, will be further specified and minimal agents will be developed and tested.

Commercial Applications and Other Benefits as described by awardee: Intelligent software agents could be utilized in a variety of applications throughout the energy industry. Agents operating within the distribution and transmission systems could minimize the risk of terrorist attack.

Article #R5
Organization: DOE DER C&C
Title: Distributed Intelligent Agents for Decision Making at Local Distributed Energy Resource (DER) Levels
Contact: David A. Cohen Email: dave@infotility.com
Website: http://www.science.doe.gov/sbir/awards_abstracts/sbirsttr/cycle21/phase1/109.htm
Status: Ongoing, Stage 1 SBIR contract

This project will develop an adaptive, intelligent-agent-based information system to provide real-time, two-way communication and decision making between nodes in a distributed energy resources (DER) system. The design will consist of a collection of reusable intelligent agents that will interoperate within the many interfaces and devices on the power delivery infrastructure. The agents will provide not only analysis and response to electrical grid contingencies but also coordination with power electronics and grid protection schemes to enhance grid reliability. Phase I will assess key system issues (software user needs, intelligent agent structure, object-oriented design, overall software system architecture, data models, communications requirements, decision logic, analytics, and business rules development), resulting in a detailed software development plan. This plan will be used in Phase II to create a commercialized version of the software, which will be tested in a real environment with actual DER devices connected to a major U.S. electrical system.

Commercial Applications and Other Benefits as described by awardee: The DER intelligent information system should provide a mechanism to increase grid reliability and grid stability; enhance the ability of security agencies to respond to emergencies and contingencies; and unify the requirements of energy end users, energy system operators, and energy providers.

Article #R6
Organization: DOE Industrial Wireless
Title: DOE Industrial Wireless Sensor Program
Contact: Paul Ewing Email: ewingpd@ornl.gov
Website: DOE Industrial Wireless
Status: Ongoing

Reliable Ubiquitous Sensing to Improve Efficiency, Reduce Waste and Emissions, and Improve Raw Material Utilization

Objective:

ORNL is working with U.S. Department of Energy to develop next-generation untethered, robust, reliable sensor networks that improve the energy efficiency of industrial processes. Advanced wireless communications techniques are being developed to improve the performance of sensors systems in harsh industrial environments. Wireless sensor technology is being Demonstrated in industrial plants and performance merits for energy savings, process efficiencies and product quality are being evaluated.

These technologies could be used in advanced demand response systems, allowing real-time control of loads in response to price signals.

Article #R7
Organization: DOE Industrial Wireless
Title: Industrial Wireless Technology for the 21st Century
Contact: Eric Lightner Email: eric.lightner@ee.doe.gov
Website: http://www.oit.doe.gov/sens_cont/pdfs/wireless_technology.pdf
Status: December 2002

Wireless sensor systems hold the potential to help U.S. industry use energy and materials more efficiently, lower production costs, and increase productivity. Although wireless technology has taken a major leap forward with the boom in wireless personal communications, applications to industrial sensor systems must meet some distinctly different challenges. Some of the technology development needed to expand industrial applications and markets will require coordinated efforts in multiple disciplines and would benefit from a clear identification of industrial requirements and goals.

In July 2002, the U.S. Department of Energy's Industrial Technologies Program sponsored the Industrial Wireless Workshop as a forum for articulating some long-term goals that may help guide the development of industrial wireless sensor systems. Over 30 individuals, representing manufacturers and suppliers, end users, universities, and national laboratories, attended the workshop in San Francisco and participated in a series of facilitated sessions.

The workshop participants cooperatively developed a unified vision for the future and defined specific goals and challenges. This document presents the results of the workshop as well as some context for non-experts. Discussions of today's technology are intended to serve as a rough baseline for decision makers and government funding agencies; descriptions necessarily represent a "snapshot" in time as new developments emerge almost daily. Energetics, Inc. of Columbia, Maryland, facilitated the workshop and prepared this summary of the proceedings. Wayne Manges of Oak Ridge National Laboratory and Dr. Peter Fuhr of San Jose State University provided valuable technical information and advice.

Article #R8
Organization: DOE
Title: Monitoring and Data Collection Protocol Development for CHP Projects
Program Manager: Merrill Smith merrill.smith@hq.doe.gov
Status: Research In progress

The New York State Energy Research and Development Administration (NYSERDA) has initiated an aggressive development program to encourage the development of efficient combined heat and power (CHP) systems in the state. In 2001, NYSERDA awarded contracts to 35 facilities to install innovative CHP systems representing over 40 MW of electric capacity. NYSERDA is investing an additional $10 million for CHP demonstrations in 2002, with plans to continue annual demonstration support over the next several years. Key to maximizing the benefits of NYSERDA's demonstration program is the development of consistent and comparable performance data from the various demonstration sites. This proposed effort seeks to apply a low-cost data monitoring approach to two similar demonstration sites to be selected from the existing NYSERDA demonstration portfolio, gather data on electrical and thermal performance of the systems, allow real-time access to CHP operating performance data from a centralized location, and develop a standardized protocol for data collection that could be used at remaining NYSERDA demonstration facilities or be replicated in other states.

Article #R9
Organization: E2I/CEIDS
Title: Open Communications Architecture for Distributed Energy Resources in Distribution Automation
Program Director: Frank Goodman Email: fgoodman@epri.com
Website: http://www.e2i.org/ceids/technical/DER.html
Status: Ongoing

Distributed Energy Resources Integration is subpart of larger advances in Distributed Automation. Changes to the electrical system and communication system are needed in order to improve the power delivery system. Individual equipment types, such as DER, must be made interoperable with overall infrastructure. This project addresses one key piece of such interoperability, namely object models for DER devices.
Project Goals

- Improve the strategic value of DER in a system context
- Create the ability to use DER as a valuable resource in DA
- Enable interoperability of DER with a variety of other new distribution system and customer equipment
- Provide improved quality of service to end users (cost, reliability, power quality)

Project Objectives

- Develop, validate and pilot test DER device communication object models that will enable the strategic use of DER in DA for functions such as
- Routine energy supply, peaking capacity, voltage regulation, power factor control
- Emergency power supply, harmonic suppression, and disaster recovery operations (e.g., intentional islanding)
- Promulgate the object models as industry standards
- Coordinate with other related work, identify gaps and implement plans for filling the gap

Article #R10
Organization: E2I/CEIDS
Title: Integrated Energy and Communications System Architecture (IECSA)
Project Manager: Peter Sanza sanza@research.ge.com
Website: http://www.iecsa.org/
Status: Research In progress

The scope of the IECSA spans the entire power industry. The Integrated Energy and Communications System Architecture will form the foundation for a digital society. This architecture will enable new levels of automation, open new vertical markets, and provide new ways for business to reach the customer. It will include advancements in existing power systems as well as future power system operation scenarios. Concepts such as a "self-healing grid" that is self-aware and better able to respond to fault conditions will be incorporated, among other scenarios of how grid operations can be improved through distributed computing technologies.

The IECSA project has set forth the following high-level objectives in defining an Enterprise Architecture:

- Develop a complete set of systems requirements and architecture documents to support industry-wide enterprise architecture for the self-healing grid and integrated consumer communications interface.
- Contribute project results as appropriate to relevant Standards Development Organizations (SDO's) and industry consortia to effectively move the development of key open standards forward to develop a robust industry infrastructure.
- Apply Systems Engineering to the development of the architecture including but not limited to: the elicitation and management of system requirements, analysis of requirements and development of proposed architectural designs, evaluation of architectural designs and the use of standardized industry notation for documentation of architectural views.
- Identify the potential for infrastructure sharing and synergy between power engineering operations and other application domains.

Article #R11
Organization: EPRI
Title: Measuring Demand Response to Market Prices
Contact: askepri@epri.com
Website: http://www.epri.com
Date Published Sep 2000

Description: If you are developing new pricing designs without accounting for demand response, you are setting yourself up for a 4-10 percent error in revenue forecast, and that's under normal conditions. Your margin of error is likely to jump to 100 percent when prices are volatile. This project provides knowledge of customers' demand response profiles, with special attention to curtailable rate options, as a stable foundation for retail pricing, resource procurement, resource planning, and system operations.

Article #R12
Organization: EPRI
Title: P08.005 Creating Value from Demand-Responsive Customer Pricing (052143)
Contact: askepri@epri.com
Website: http://www.epri.com
Results in 2003

Description: Standard fixed-price retail rates sever any link between the customer and the wholesale market, leaving retail providers highly exposed to wholesale market volatility. This exposure is very hard to manage due to the uncertainty in loads that need to be covered, the correlation of loads with wholesale spot prices, and the limited set of forward and option wholesale products available for hedging. This product area will provide technology to help energy service providers craft retail offerings that reconnect the link between customer demands and wholesale prices, thus reducing the wholesale price risk to the ESP and giving the customers the incentive to create value by shifting load. In addition, this product area will provide tools to help ESPs optimally hedge their wholesale market exposure.

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Article #R13
Organization: EPRI
Title: P90.001 Overcoming Capacity Constraints (051858)
Contact: askepri@epri.com
Website: http://www.epri.com
Results in 2003

Description: Overcoming Capacity Constraints offers specific information, tools, and methods to pursue targeted demand reductions that alleviate capacity constraints through the load management and/or pricing components of demand response. Participants will obtain tools for developing their own innovative targeted programs, forecasting technical potential and customer acceptance, identifying the most appropriate technologies for each situation, performing equitable load relief settlements, and evaluating program results.

Article #R14
Organization: EPRI
Title: P90.003 Technology Solutions for Maximizing Demand Response Benefits
Contact: askepri@epri.com
Website: http://www.epri.com
Status: Results in 2004/2005

Benefits: This project will provide benefits in the millions of dollars to demand response providers with respect to making appropriate technology investments that best suit the application. These benefits would include assuring customer satisfaction with the operational characteristics of the demand response system, and verifiable demand reductions to assure earning maximum incentive compensation.

Description: Technology Solutions for Maximizing Demand Response Benefits will provide data and insights to support applying appropriate combinations of central station hardware/software, communications platform, and remote devices for specific demand response programs - including connectivity with customer energy management & controls systems. This would include assuring timely notification of customers regarding market signals, monitoring of demand status and performance during active demand response periods, and automating the link between the demand response system and the customer's internal energy systems. In addition, tools will be provided that enable demand reduction verification alternatives to costly metering solutions that rely on low-cost model-based estimation methodologies and platforms.

Article #R15
Organization: EPRI
Title: Paths to Plug&Play Distributed Energy Resources: Plausible Scenarios of Increased Ease of Deployment in the Market
Contact: askepri@epri.com
Website: http://www.epri.com
Status: Published July 2003

The research found that few industry observers believe that complete plug&play DER will occur in the next 10 to 15 years. However, the most likely scenario for plug&play to progress is one in which C/I customers increasingly adopt manufacturers' offerings of building systems technologies – HVAC, for instance – that are embedded with DER units. Manufacturers are also beginning to package DER units with the hardware and software necessary for interconnection protection and dispatching. In the meantime, political pressure from the C/I sector could prompt the government to step in even more aggressively to remove barriers to DER deployment.

EPRI Perspective This report provides utilities with an outlook on how DER might evolve over the next 10 to 15 years, and the likelihood for DER to become more plug&play. As such, utilities are better able to anticipate what regulators and others might expect of them, as well as be able to identify and anticipate ways DER evolution might impact their businesses, for better or for worse. It also identifies opportunities in which utilities might influence how DER becomes plug&play. Lastly, this intelligence can impact utility efforts in the near term in creating programs that have a DER component, for example, demand response efforts or backup generation services.

Article #R16
Organization: EPRI
Title: S28.002 2003 National Business Energy DataMart Project (056123)
Contact: askepri@epri.com
Website: http://www.epri.com
Status: Results in 2003

Benefits: Up-to-date data on actual commercial and industrial customer energy-use characteristics.

Description: This project provides for a new multi-client study designed to acquire energy-use characteristics and billing information from commercial and industrial customers, to refresh the 1999 "National Business Energy DataMart" project. While the 1999 DataMart had a broad scope covering energy-use and customer attitudes about a wide variety of issues, the 2003 DataMart will focus on energy efficiency and load management as specific areas of inquiry. It will address recent actions that have been taken and the likelihood that further actions will be taken in the near future. (The final scope will depend on subscriber input.) Deliverables will include detailed analysis reports, Energy Market Segment profiles, a summary PowerPoint presentation, and access to the survey database (including customer characteristics, end-use estimates and load shapes).

Article #R17
Organization: EPRI
Title: S28.003 National Residential Energy DataMart Project (056124)
Contact: askepri@epri.com
Website: http://www.epri.com
Status: Results in 2003

Benefits: Up-to-date data on actual residential customer energy-use characteristics.

Description: This project provides for a new multi-client study designed to acquire energy-use characteristics and billing information from residential customers, to create a new "National Residential Energy DataMart" project. Like the business study, the Residential DataMart will focus on energy efficiency and load management as specific areas of inquiry. It will also be designed to facilitate targeting of related products and services to the residential market. The Residential DataMart will be designed, with subscriber input, to augment the information provided by other national surveys. It will provide an opportunity for oversampling for specific geographic areas. Deliverables will include detailed analysis reports, Energy Market Segment profiles, a summary PowerPoint presentation, and access to the survey database (including customer characteristics, end-use estimates and load shapes).

Article #R18
Organization: EPRI
Title: S90.002 End-to-End Solution for Distributed Buying and Selling of Electricity (051868)
Contact: askepri@epri.com
Website: http://www.epri.com
Status: Supplemental Project for 2003

Description: Develop enabling technologies in response to the following questions: 1) What if there were LCD displays of the real-time price on our light switches and outlets? and 2) How would various customers respond to on-line pricing and price-sensitive control mechanisms enabled through new communication protocols and distributed, adaptive software agents that buy and sell power?

The goal of this project is to enable the commercialization of a number of interrelated technologies in the form of an end-to-end solution for the distributed buying and selling of electricity. Four necessary technologies can be integrated to create this system of exchange:

- A communications protocol for relating supply and demand information back and forth across a network.
- A hardware communications platform, examples being radio broadcasting, wireless internet, or power line communications.
- A buying/selling agent, that speaks the protocol, and interfaces to the network. The agent acts as a client to a market server.

- A market server, that speaks the protocol, interfaces with the network, accepts supply and demand information and clears it. These markets can be organized in a hierarchy, so that local, low-power transactions are handled locally, while aggregated load or supply can be handed up to markets over larger regions. In this sense, lower markets act as clients to higher markets.

Article #R19
Organization: Integrated Energy Systems Test Center at the University of Maryland
Website: http://www.enme.umd.edu/ceee/bchp/
Contact: Email ceee@eng.umd.edu
Status: Research Center, Ongoing

The IES Test Center at the University of Maryland was designed to create a new understanding of how to integrate equipment into IES and integrate IES into buildings.

Sponsors of the Test Center include the U.S. DOE, manufacturers, and utilities. Program management is provided by Oak Ridge National Laboratory (ORNL). The Test Center is examining energy efficiency from the perspective of the Second Law of Thermodynamics — securing the highest level of energy performance from each BTU of fuel.

Article #R20
Organization: International Energy Agency Demand-Side Management Programme (IEADSM)
Title: Communications Technologies for Demand-Side Management
Contact the Operating Agent: Mr Richard Formby, EA Technology, UK email: richard.formby@eatechnology.com
Website http://dsm.iea.org/
Status: Ongoing

This Task is to assess the best available options and strategies for applying communications to DSM and customer services programmes in the Participants' countries, develop models to carry out evaluations and specify and develop the technology and demonstration efforts to bring these options to fruition. To date the assessment has covered communications technologies for load control, data transmission, data processing, load management, automated meter reading and billing, customer alarm services, customer generation management, remote diagnostics and audits. Separate Subtasks have been to specify and implement in prototype form a customer, flexible gateway, through which the identified services can be provided. A business case evaluation has been completed which identified the most likely actors to provide bundles of services and infrastructure and assessed the commercial viability. The study showed that bundled services were required for financial viability. A field trial of the provision of advanced customer services is planned. A Subtask to define the scope and contents of co-ordinated Field Trials of bundled services in partner countries has been completed.

Article #R21

Organization: International Energy Agency Demand-Side Management Programme (IEADSM)
Title: Demand-Side Bidding in a Competitive Electricity Market
Contact the Operating Agent: Mrs Linda Hull, EA Technology, UK Email: Linda.Hull@eatechnology.com
Website http://dsm.iea.org/
Status: Ongoing

Evaluating and promoting Demand-Side Bidding as a means to improve the global environment

Objectives
The objective of Task VIII is to evaluate and promote Demand Side Bidding (DSB) as a means of improving the efficiency of the operation of the electricity supply chain. This aim will be fulfilled by evaluating the characteristics, strengths and weaknesses of existing DSB schemes and creating guidelines for the development and enhancement of new schemes. DSB is a mechanism that enables the demand side of the electricity market to participate in energy trading. More specifically, DSB allows electricity consumers to offer a specific reduction in demand, at a given time, in return for a specified income. DSB can improve the efficiency of the electricity supply chain by increasing competition in the wholesale energy market and by acting as an alternative to conventional generation. For example, DSB can be used to balance electricity supply and demand and also maintain the quality and security of supply. In addition, DSB could have important environmental and energy efficiency benefits in some situations when it is used as an alternative to conventional generation.

Article #R22
Organization: International Energy Agency Demand-Side Management Programme (IEADSM)
Title: International Database on Energy Efficient Demand-Side Management (EE-DSM) Technologies and Programmes
Contact the Operating Agent: Mr Harry Vreuls, NOVEM, The Netherlands email: H.Vreuls@Novem.NL
Website http://dsm.iea.org/
Status: Ongoing

Task I realised the objectives, stated in 1994, to develop a database on DSM programmes, the International Database on Energy Effiency Programmes (INDEEP) and to analyse the data (two analysis reports). The task started in 1994 and has continually developed a methodology to collect data and present it in order to aid utilities and governments to design EE-DSM programmes which reach more customers and save more energy at lower cost.

The objective now is to maintain this database, update the data and include new actual programme data and to prepare a transfer of the database to an other organisation than the IEA DSM Agreement by the year 2004.

INDEEP is on-line to the public: http://dsm.iea.org/indeep

Article #R23
Organization: LBNL
Title: An Engineering-Economic Analysis of Combined Heat and PowerTechnologies in a µGrid Application
Contact: Owen Bailey Email: OCBailey@lbl.gov
Website: http://eetd.lbl.gov/ea/EMS/reports/50023.pdf
Status: March 2002

This report describes an investigation at Ernesto Orlando Lawrence Berkeley National Laboratory (Berkeley Lab) of the potential for coupling combined heat and power (CHP) with on-site electricity generation to provide power and heating, and cooling services to customers. This research into distributed energy resources (DER) builds on the concept of the microgrid (µGrid), a semiautonomous grouping of power-generating sources that are placed and operated by and for the benefit of its members. For this investigation, a hypothetical small shopping mall ("Microgrid Oaks") was developed and analyzed for the cost effectiveness of installing CHP to provide the µGrid's energy needs.

Article #R24
Organization: LBNL
Title: Assessment of µGrid Distributed Energy Resource Potential Using DER-CAM and GIS
Contact: Jennifer L. Edwards Email: jedwards@socrates.berkeley.edu
Website: http://www-library.lbl.gov/docs/LBNL/501/32/PDF/LBNL-50132.pdf
Status: January 2002

This report outlines a method to assess the local potential for deployment of distributed energy resources (DER), small power-generation installations located close to the point where the energy they produce will be consumed. This methodology combines established economic optimization techniques with a geographic information system (GIS) analysis of local land-use constraints that limit the use of distributed generation (DG) systems. This methodology was developed using an example case in the San Diego area. Our work approaches DER adoption from a customer perspective, based on the premise that future development of DER may take the form of microgrids (µGrids), where multiple neighboring end users are aggregated, and energy loads and generation are jointly managed using standardized "plug and play" power electronics. Previous work in the field of power system planning has focused on the electrical requirements and economic feasibility of incorporating µGrids into the current power-supply infrastructure. However, although local restraints such as zoning codes and on-site physical barriers are well-known frustrations in the field of DER, no analysis method has been developed to address them. The need for such a method is the inspiration for this work. By incorporating established DER analysis techniques with a GIS, local spatial constraints on DER can be readily addressed and analyzed. GIS currently plays an essential role in transportation and city infrastructure planning; we propose that it can play a similarly important role in future DER deployment.

Article #R25
Organization: LBNL/PNNL
Title: Do "Enabling Technologies" Affect Customer Performance in Price-Responsive Load Programs? LBNL-50328

Principle Authors Charles A. Goldman, LBNL, Michael Kintner-Meyer, PNNL, Grayson Heffner, LBNL
Contact: Charles A. Goldman email:CAGoldman@lbl.gov
Website: http://certs.lbl.gov/PDF/LBNL_50328.pdf
Published 2002

We found preliminary evidence that DR enabling technology has a positive effect on load curtailment potential. Many customers indicated that web-based energy information tools were useful for facilitating demand response (e.g., assessing actual performance compared to load reduction contract commitments), that multiple notification channels facilitated timely response, and that support for and use of backup generation allowed customers to achieve significant and predictable load curtailments. We also found that 60-70% of the customers relied on manual approaches to implementing load reductions/curtailments, rather than automated load control response. The long-term sustainability of customer load curtailments would be significantly enhanced by automated load response capabilities, such as optimizing EMCS systems to respond to day-ahead energy market prices or load curtailments in response to system emergencies.

Article #R26
Organization: LBNL/PNNL
Title: Impact of Enabling Technologies on Customer Load Curtailment Performance: Summer 2001 Results from NYSERDA's PON 585 and 577 Programs and NYISO's Emergency Demand Response Program
Principle Authors: Charles Goldman, LBNL, Grayson Heffner, LBNL, Michael Kintner-Meyer, PNNL
Contact: Charles A. Goldman email:CAGoldman@lbl.gov
Website: http://eetd.lbl.gov/ea/EMS/reports/49858.pdf
Status: Report Issued February 2002

This report describes a market and load research study on a small group of participants in the NYISO Emergency Demand Response Program (EDRP) and the NYSERDA Peak Load Reduction and Enabling Technology Programs. In-depth interviews were conducted with 14 individual customers that participated in the NYISO EDRP program through New York State Electric and Gas (NYSEG), AES NewEnergy, and through eBidenergy/ConsumerPowerLine. These contractors used funding from NYSERDA to apply enabling technologies that were hypothesized to improve customers' ability to curtail load. Both NYSEG and eBidenergy/ConsumerPowerLine offered their customers access to their hourly load data on a day-after basis and, during curtailment events, on a near-real-time basis. Phone interviews were conducted with most customers, however 25% of customers provided initial responses to the survey protocol via email. We then combined the market research information with load data during the curtailment events of August 7-10, 2001 to evaluate the impact of technology on curtailment responses.

Article #R27
Organization: LBNL
Title: Integration of Distributed Energy Resources The CERTS MicroGrid Concept
Contact: Joseph Eto Email jheto@lbl.gov
Website: http://eetd.lbl.gov/ea/CERTS/pdf/LBNL_50829.pdf
Status: April 2002

Evolutionary changes in the regulatory and operational climate of traditional electric utilities and the emergence of smaller generating systems such as microturbines have opened new opportunities for on-site power generation by electricity users. In this context, distributed energy resources (DER) - small power generators typically located at users' sites where the energy (both electric and thermal) they generate is used - have emerged as a promising option to meet growing customer needs for electric power with an emphasis on reliability and power quality. The portfolio of DER includes generators, energy storage, load control, and, for certain classes of systems, advanced power electronic interfaces between the generators and the bulk power provider. This white paper proposes that the significant potential of smaller DER to meet customers' and utilities' needs can be best captured by organizing these resources into MicroGrids.

The Consortium for Electric Reliability Technology Solutions (CERTS) MicroGrid concept assumes an aggregation of loads and microsources operating as a single system providing both power and heat. The majority of the microsources must be power electronic based to provide the required flexibility to insure operation as a single aggregated system. This control flexibility allows the CERTS MicroGrid to present itself to the bulk power system as a single controlled unit that meets local needs for reliability and security.

The CERTS MicroGrid represents an entirely new approach to integrating DER. Traditional approaches for integrating DER focus on the impacts on grid performance of one, two, or a relatively small number of microsources. An example of the traditional approach to DER is found in the Institute of Electrical and Electronics Engineers (IEEE) Draft Standard P1547 for Distributed Resources Interconnected with Electric Power Systems. This standard focuses on ensuring that interconnected generators will shut down automatically if problems arise on the grid. By contrast, the CERTS MicroGrid would be designed to seamlessly separate or island from the grid and, reconnecting to the grid once they are resolved.

Article #R28
Organization: NEDRI - New England Demand Response Initiative
Title: Dimensions of Demand Response: Capturing Customer Based Resources in New England's Power Systems and Markets
Contact: Richard Cowart, NEDRI Policy Director Email: rapcowart@aol.com
Website: http://nedri.raabassociates.org/
Status: Report Issued July 23, 2003

The New England Demand Response Initiative (NEDRI) was established to develop a comprehensive, coordinated set of demand response (DR) programs and policies for power markets and systems throughout the New England region. This effort grew out of a growing realization among market participants and policy makers that the efficient integration of demand response resources (DRR) would be central to the long-term success of restructured electricity markets, power portfolios, and delivery systems. This realization was based in part on early experience with wholesale power markets in New England, but to a greater extent was based on market and reliability problems in other regions, especially those in 2001-02 throughout the Western United States.
A principal lesson from this experience is that competition among electricity suppliers alone (without an active demand response) is not enough to create efficiently competitive electricity markets. Electric systems face two challenges not faced by other commodity markets: (a) because storage is impracticable,

load must be served instantaneously, even though demands on the grid vary considerably across time and geography; and (b) because customers are physically interconnected, and because electric service is central to economic and social well-being, continuous, universal service without interruptions has an extremely high value. Thus, the balance between demand and supply is critical *at all times*, and this balance must be assured over a *sustained period of time*. Moreover, the electric power system has a large environmental footprint, and is crucial to the general public good. Demand response resources are an important response to these essential features of electric systems

Volatility, price spikes, worsened environmental impacts, and diminished reliability can be moderated through **actions on the demand side** of the market. Actions are needed to address two complementary needs: First, it is essential to develop active responses to market prices and system conditions on the demand side in order to enhance market efficiency and system reliability – that is, ***active load management*** by customers. Second, enhanced ***energy efficiency investments*** could lower market clearing prices, improve reliability and environmental quality, and lower the region's total cost of electric service over the long term. Furthermore, significant market barriers to cost-effective *active load management* and *energy efficiency investments* will remain, even in conditions of active wholesale competition. Thus, market and policy reforms that will call forth economic demand responses – both short-term load curtailments and longer-term reductions in consumption patterns – are needed.

Article #R29
Organization: NEDRI - New England Demand Response Initiative
Title: Retail Pricing and Metering Program Strategies
Contact: Richard Cowart, NEDRI Policy Director Email: rapcowart@aol.com
Website: http://nedri.raabassociates.org/
Status: Report Issued September 3, 2002

This document describes seven pricing and metering strategy options that have been developed by the NEDRI consultant team. Additional strategies, reserved for later action by the NEDRI participants, are described in the appendix

Article #R30
Organization: NREL
Title: Aggregated Distributed Generation for Demand Response
NREL Technical Monitor: Ben Kroposki Email: benjamin_kroposki@nrel.gov
Website: http://www.nrel.gov/docs/fy03osti/34779.pdf
Status: September 2003

Demand response programs, developed by several independent system operators in recent years to help them meet summer peak, have created a new market opportunity for distributed generation (DG). To sell into demand response programs, DGs need to be aggregated to a more useful size, typically a megawatt or more.
The New York State Energy Research and Development Authority (NYSERDA) and its subcontractor, Electrotek Concepts, are developing and testing a control and communications system to aggregate

distributed resources in a way that maximizes benefits for all parties involved. The objectives of this project are to:

• Design and build a monitoring and control system to facilitate aggregating multiple DG units
• Quantify the costs and values of services supplied by system aggregators
• Develop and conduct a pilot field test on Long Island, New York, to demonstrate an aggregation of 30 MW of DG.

Article #R31
Organization: NREL
Title: Development of Innovative Distributed Power Interconnection and Control Systems
NREL Technical Monitor: Thomas Basso Email: thomas_basso@nrel.gov
Website: http://www.nrel.gov/docs/fy03osti/32864.pdf
Status: Report Issued November 2002

This report covers the first year's work performed by the Gas Technology Institute and Encorp Inc. under subcontract to the National Renewable Energy Laboratory. The objective of this three-year contract is to develop innovative grid interconnection and control systems. This supports the advancement of distributed generation in the marketplace by making installations more cost-effective and compatible across the electric power and energy management systems. Specifically, the goals are: 1) To develop and demonstrate cost-effective distributed power grid interconnection products and software and communication solutions applicable to improving the economics of a broad range of distributed power systems, including existing, emerging, and other power generation technologies. 2) To enhance the features and capabilities of distributed power products to integrate, interact, and provide operational benefits to the electric power and advanced energy management systems. This includes features and capabilities for participating in resource planning, the provision of ancillary services, and energy management. Specific topics of this report include the development of an advanced controller, a power sensing board, expanded communication capabilities, a revenue-grade meter interface, and a case study of an interconnection distributed power system application that is a model for demonstrating the functionalities of the design of the advanced controller.

Article #R32
Organization: NREL
Title: Development, Demonstration, and Field Testing of Enterprise-Wide Distributed Generation Energy Management System
NREL Technical Monitor: Holly Thomas Email: holly_thomas@nrel.gov
Website: http://www.nrel.gov/docs/fy03osti/33581.pdf
Status: Progress Report Issued April 2003

This report, submitted by RealEnergy (RE), is in fulfillment of deliverable D-1.4 of subcontract NAD-1-30605-11, the "Annual Technical Progress Report." It is a description of RE's evolving command and control system, called the "Distributed Energy Information System" (DEIS).

This report is divided into six tasks. The first five describe the DEIS; the sixth describes RE's regulatory and contractual obligations.

• Task 1: Define Information and Communications Requirements
• Task 2: Develop Command and Control Algorithms for Optimal Dispatch
• Task 3: Develop Codes and Modules for Optimal Dispatch Algorithms
• Task 4: Test Codes Using Simulated Data
• Task 5: Install and Test Energy Management Software
• Task 6: Contractual and Regulatory Issues

Each task represents one chapter in this annual technical progress report.

Article #R33
Organization: NREL
Title: Distributed Energy Neural Network Integration System
NREL Technical Monitor: Holly Thomas Email: holly_thomas@nrel.gov
Website: http://www.nrel.gov/docs/fy03osti/33404.pdf
Status: Research In progress

This report describes the work of Orion Engineering Corp. to develop a DER household controller module and demonstrate the ability of a group of these controllers to operate through an intelligent, neighborhood controller. The controllers will provide a smart, technologically advanced, simple, efficient, and economic solution for aggregating a community of small distributed generators into a larger single, virtual generator capable of selling power or other services to a utility, independent system operator (ISO), or other entity in a coordinated manner.

Article # R34
Organization: NREL
Title: Distributed Energy Resources Interconnection Systems: Technology Review and Research Needs
NREL Technical Monitor: Thomas Basso Email: thomas_basso@nrel.gov
Website: http://www.nrel.gov/docs/fy02osti/32459.pdf
Status: Report Issued September 2002

Interconnecting distributed energy resources (DER) to the electric utility grid (or Area Electric Power System, Area EPS) involves system engineering, safety, and reliability considerations. This report documents US DOE Distribution and Interconnection R&D (formerly Distributed Power Program) activities, furthering the development and safe and reliable integration of DER interconnected with our nation's electric power systems. The key to that is system integration and technology development of the interconnection devices that perform the functions necessary to maintain the safety, power quality, and reliability of the EPS when DER are connected to it.

Article # R35
Organization: NREL
Title: Enterprise-Wide Distributed Generation Energy Management System
NREL Technical Monitor: Holly Thomas Email: holly_thomas@nrel.gov
Website: http://www.nrel.gov/docs/fy03osti/33401.pdf
Status: Ongoing

To apply distributed generation (DG) across an enterprise or as a virtual utility for reliable and economic power generation, effective tools for management and control are required. The goal of this project is to develop and perfect a system to monitor and control DG for optimal performance and operation.

This work examines design and operational issues, communications standards, and experience with regulatory and market barriers while implementing this business approach.

Article # R36
Organization: NREL/DEER
Title: Integrating Distributed Generation with Electric Power
NREL Technical Monitor: Ben Kroposki Email: benjamin_kroposki@nrel.gov
Website: http://www.nrel.gov/docs/fy03osti/33402.pdf
Status: Ongoing

To make large-scale system integration feasible for distributed generators (DGs), a cost-effective, mass-produced universal interconnection (UI) system must be developed. General Electric (GE) is examining the technical issues associated with interconnecting DG with the electric grid to develop a UI system to facilitate DG interconnection.

The GE approach is to:

- Develop a virtual simulation test bed (VTB) for DGs and their interface to a utility, incorporating models of the DG, its loads, and the affected EPS components
- Conduct case studies to evaluate the DG effect on EPS power quality, protection, reliability, and stability
- Determine the effect to the utility network of increased DG penetration relative to existing network hardware, such as reclosers, and the ability to respond to faults
- Develop, build, and test an interface for safe and reliable DG interconnection.

Article #R37
Organization: ORNL
Title: CHP Applications and DG Analytical Support
Program Manager: Merrill Smith merrill.smith@hq.doe.gov
EEA Contact : Bruce Hedman bhedman@eea-inc.com
Status: Research In progress

CHP Facility Database: Collect basic information on existing CHP facilities and track new installations over time. Installation Cost Analysis for Small CHP: Quantify the range of small CHP installation (<3 MW) costs experienced in the field. DG/CHP Financing and Ownership Options: Evaluate the role of innovative financing and ownership options in CHP Deployment. Electric Rate Primer: Identify primary types of rate structures and categorize their impact on on-site generation. Lessons Learned from Small Packaged CHP Systems: Evaluate successful and unsuccessful marketing approaches of small cogeneration/CHP packagers and developers.

Article #R38 Organization: ORNL
Title: Technical Potential For Peak Load Management Programs in New Jersey
Authors: B.J. Kirby, R.H. Staunton
Contact: B. J. Kirby email: kirbybj@ornl.gov
Website: http://www.ornl.gov/sci/btc/apps/Restructuring/ORNLTM2002271.pdf
Status: Report issued October 18, 2002

Restructuring is attempting to bring the economic efficiency of competitive markets to the electric power industry. To at least some extent it is succeeding. New generation is being built in most areas of the country reversing the decades-long trend of declining reserve margins. Competition among generators is typically robust, holding down wholesale energy prices. Generators have shown that they are very responsive to price signals in both the short and long term. But a market that is responsive only on the supply side is only half a market. Demand response (elasticity) is necessary to gain the full economic advantages that restructuring can offer.

Electricity is a form of energy that is difficult to store economically in large quantities. However, loads often have some ability to (1) conveniently store thermal energy and (2) defer electricity consumption. These inherent storage and control capabilities can be exploited to help reduce peak electric system consumption. In some cases they can also be used to provide system reliability reserves.

Fortunately too, technology is helping. Advances in communications and control technologies are making it possible for loads ranging from residential through commercial and industrial to respond to economic signals. When we buy bananas, we don’t simply take a dozen and wait a month to find out what the price was. We always ask about the price before we decide how many bananas we want. Technology is beginning to allow at least some customers to think about their electricity consumption the same way they think about most of their other purchases. And power system operators and regulators are beginning to understand that customers need to remain in control of their own destinies. Many customers (residential through industrial) are willing to respond to price signals. Most customers are not able to commit to specific responses months or years in advance. Electricity is a fluid market commodity with a volatile value to both producers *and* consumers. Fortunately too, only a percentage of loads need to respond elastically for all customers to benefit. This report explores mechanisms to reduce, when necessary, the peak load in New Jersey’s electricity market. It examines load pricing and technical load reduction programs used in recent years in New Jersey and discuss how they can be made more effective in controlling summer peaks and attendant high prices of electricity. Particular attention is given to load curtailment programs now in place and utility opinions relating to them.

Article #R39
Organization: PNNL
Title: Advanced Communications/Controls for Integrated Energy System Operations
DOE Program Contact: Eric Lightner eric.lightner@ee.doe.gov
Principal Investigator: Steve Hauser steven.hauser@pnl.gov
Status: Research In progress

In FY02, PNNL with input from a broad range of industry will conduct a study of potential benefits of developing and deploying technology enabling universal communications and control among energy generating, distributing, and consuming equipment. The study will identify the primary potential benefits, such as better fuel utilization, lower capital investment costs for energy system expansion, reduced spinning reserve requirements, and more stable energy prices. It will then quantify the more significant of these potential benefits by conducting engineering and economic analyses estimating the range of their impacts.

Article #R40
Organization: PNNL
Title: Grid Friendly™ Controller
Technical Contact: David Chassin david.chassin@pnl.gov
Status: Ongoing

The Grid Friendly™ controller, a two by two-and-a-half inch circuit board, is at the heart of Grid Friendly™ appliances. Installed in refrigerators, air conditioners, water heaters and various other household appliances, this device would monitor the power grid and turn appliances off for a few seconds to a few minutes in response to power grid overload. When power plants cannot generate enough power to meet customer needs, Grid Friendly™ appliances reduce some of the load on the system to balance supply and demand.

The Grid Friendly™ controller is expected to be part of the U.S. Department of Energy's efforts to transform the U.S. energy system into a more interactive and dynamic system where power plants and consumers communicate automatically, making self-regulating adjustments in real time. The results of such a system would be greater customer efficiency and load management as well as enhanced stability, security and crisis management.

Article #R41
Organization: PNNL
Title: GRIDWISE
Contact: Staci Maloof Email: staci.maloof@pnl.gov
Status: Research In progress

This program, called GridWise™, draws upon new technologies enabling collaboration among generators, the grid and customer loads to collectively increase the stability and cost-effectiveness of the power system beyond what is possible today. The project foresees solutions that involve adapting and influencing information, and control technology approaches to deliver a reliable energy infrastructure that's in step with the information revolution in the nation's economy in general. Major corporations like IBM, Alstom, PJM Interconnect and Sempra have created an alliance to jointly define this vision for the smart grid of the future with DOE's Office of Electric Transmission and Distribution.

As part of GridWise™, PNNL engineers are designing smart chips that would be fitted onto household appliances and would continually monitor fluctuations in the power grid. When the grid is under high periods of stress, a grid-friendly appliance would identify these fluctuations and, within milliseconds, automatically shut down for a short period of time to give the grid operators time to stabilize the system. It could even turn on momentarily to absorb excess power from fluctuations during a crisis.

Article #R42
Organization: PNNL
Title: Wireless Sensors and Controls
Contact: Michael Kintner-Meyer Email: Michael.Kintner-Meyer@pnl.gov,
Website: http://www.eere.energy.gov/buildings/research/controls/wirelesscontrols.cfm
Status: Ongoing

EERE Building Technologies Program
Objective: Wireless controls have the potential to significantly reduce the cost of advanced sensing and control systems, particularly in existing buildings where installation of wiring can represent 20% to 80% of control project costs. Wireless sensors and controls offer greater flexibility since they can be installed and moved without re-wiring. This option supports the more flexible work spaces desired by businesses today. Ultimately, wireless controls could support personalized control, offering improved thermal comfort, individually-adjusted lighting levels, and other personalized indoor environmental conditions.

Section 3 - Standards and Standards Committee References

The articles in this section describe various standards and standards groups that relate to DER and Demand Response. The standards are organized by the overall standard number and then by working group or subordinate documents. Grid references with only the overall standard number imply that the entire or substantially all of the body of the standard applies to the item in the grid. When one or more of the sub-sections of the standard apply in a more specific way, the reference is shown as a “dotted” reference, say “1.1”, etc.

Standard Reference #S1
ANSI C-12 Electric Metering
http://www.ansi.org
http://www.nertec.com/standards/main/index.htm

Standard Reference #S1.1
ANSI C12.10-1997 American National Standard for Watthour Meters

This standard covers the physical aspects of both detachable and bottom-connected watthour meters and associated registers. These include ratings, internal wiring arrangements, pertinent dimensions, markings, and other general specifications.

Standard Reference #S1.2
ANSI C12.18-1996 Protocol Specification for ANSI Type 2 Optical Port

Details the criteria required for communications with an electric power metering device by another device via an optical port. It also provides details for a complete implementation of an OSI 7-layer model.

Standard Reference #S1.3
ANSI C12.19-1997, IEEE Std 1377-1997 Utility Industry End Device Data Tables

Abstract: Functionally related utility application data elements, grouped into a single data structure for transport are described. Data may be utilized peer-to-peer or upstream to readers or billing systems by being carried by one lower layered protocol to another stack of lower layered protocol. The data structure does not change from end device to the user of the data.

Standard Reference #S1.4
ANSI C12.21-1999 Protocol Specification for Telephone Modem Communication

The standard details the criteria required for communications between an electric power metering device and a utility host via a modem connected to the switched telephone network. The utility host could be a laptop computer, a master station system, an electric power metering device, or some other electronic communications device. The standard does not specify implementation requirements of the telephone switch network to the modem, nor does it include definitions for the establishment of the communication channel.

Standard Reference #S1.5
ANSI C12.22-200x Protocol Specification for Interfacing to Data Communications Networks

This working draft for a standard extends C12.18 and C12.19 to support data network communications at the meter. The work is currently advancing under the joint involvement of NEMA/ANSI, AMRA/IEEE and Measurement Canada.

This document defines interfaces between ANSI C12.19 compliant devices and network protocols.

Standard Reference #S1.6
ANSI C12.23-200x COMPLIANCE TESTING FOR STANDARD PROTOCOLS AND TABLES (C12.18, C12.19, C12.21, C12.22)

This document is a collection of compliance test procedures that aim to validate the implementation correctness of ANSI C12.19-1997/IEEE-1377 devices that communicate using ANSI C12.18-1996 Standard communication protocol ANSI Std C12.21-1999, Protocol Specification for Telephone Modem Communications, and ANSI Std C12.22-200x, Protocol Specification for Interfacing to Data Communication Networks.

Standard Reference #S2
ANSI/ASHRAE Standard 135-2001, BACnet
ISO 16484-5 and as European standard EN/ISO 16484-5
Contact: Claire Ramspeck Email: cramspeck@ashrae.org
Website: http://www.ashrae.org/

A Data Communication Protocol for Building Automation and Control Networks

The purpose of this standard is to define data communication services and protocols for computer equipment used for monitoring and control of HVAC&R and other building systems and to define, in addition, an abstract, object-oriented representation of information communicated between such equipment, thereby facilitating the application and use of digital control technology in buildings.

Standard Reference #S3
ANSI/IEEE C37.1-200x Standard for SCADA and Automation Systems
Contact: John D. McDonald Email: jmcdonald@kemaconsulting.com
Website: http://grouper.ieee.org/groups/sub/wgc3/c371_mn.htm

Rewrite is in progress.

This standard applies to systems used for monitoring, switching, and controlling electric apparatus in unattended or attended stations, generating stations, and power utilization and conversion facilities. It does not apply to equipment designed for the automatic protection of power system apparatus or for switching of communication circuits. The requirements of this standard are in addition to those contained in standards related to the individual devices (e.g., switchgear).

This is a significant revision of IEEE Std C37.1-1994. This revision reflects current technology that is generally being provided to meet the requirements of utilities today. Originally, this standard was a section of ANSI 37.2, which also contained device function numbers. ANSI C37.2-1970 was revised into two standards: IEEE C37.1-1979, Standard Definition, Specification, and Analysis of Manual, Automatic, and Supervisory Station Control and Data Acquisition, and IEEE Std C37.2-1979, Electric Power System Device Numbers.

Standard Reference #S4
C37.111-1999 IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems
Contact: Bob Ryan, Email:bob_ryan@selinc.com
Website: http://standards.ieee.org/reading/ieee/std_public/description/relaying/C37.111-1999_desc.html

Purpose: Provide a common format for the data files and exchange medium needed for the interchange of various types of fault, test, or simulation data is defined. Sources of transient data are described, and the case of diskettes as an exchange medium is recommended. Issues of sampling rates, filters, and sample rate conversions for transient data being exchanged are discussed. Files for data exchange are specified, as is the organization of the data. A sample file is given.

Standard Reference #S5
IEC TC-57 Power System Control and Associated Communication
Web site: IEC TC-57 Website
Chairman: Monsieur Thierry LEFEBVRE Email: Thierry.Lefebvre@rte-france.com

Scope:
To prepare international standards for power system control equipment and systems including EMS (Energy Management Systems), SCADA (Supervisory Control And Data Acquisition), distribution automation, teleprotection, and associated communications such as power line carrier, used in the planning, operation and maintenance of electric power systems. Power systems control comprises control within control centres, RTU's (Remote Terminal Units) and substations including telecontrol and interfaces to equipment, systems and databases outside the scope of TC 57.

Note 1: Standards prepared by other technical committees of the IEC and organizations such as ITU and ISO shall be used where applicable.

Note 2: Although the work of TC 57 is chiefly concerned with standards for electric power systems, these standards may also be useful for application by the relevant bodies to other geographical widespread processes.

Note 3: Whereas standards related to measuring and protection relays and to the control and monitoring equipment used with these systems are treated by TC 95, TC 57 deals with the interface to the control systems and the transmission aspects for teleprotection systems. Whereas standards related to equipment for electrical measurement and load control are treated by TC 13, TC 57 deals with the interface of equipment for interconnection lines and industrial consumers and producers requiring energy management type interfaces to the control system.

Standard Reference #S5.1
WG 3: Telecontrol protocols

IEC TC57 Working Group 3 was one of the first organizations formed with the goal of developing a common protocol for the utility industry. It initially focused on producing an extremely reliable data link layer protocol for slow serial links. This data link layer was designed to be used in either *balanced* point-to-point links or *unbalanced* multi-drop links, with several levels of reliability. A number of specifications have been produced under IEC 60870-5:

60870-5-1 Transmission Frame Formats
60870-5-2 Link Transmission Procedures
60870-5-3 General Structure of Application Data
60870-5-4 Definition and Coding of Application Information Elements
60870-5-5 Basic Application Functions
60870-5-101 Telecontrol (referred to as SCADA in North America)
60870-5-102 Load Profiling (energy measurement through accumulators)
60870-5-103 Protection Equipment (monitoring and control of relays)
60870-5-104 Telecontrol over TCP/IP

Although the 60870-5 companion standards can technically be used within a substation, TC57 has designated IEC 61850 (Working Groups 10, 11 and 12) as the primary standard within substations, while 60870-5 is to be used for telecontrol (to remote sites) only.

Standard Reference #S5.2
WG 7: Telecontrol protocols compatible with ISO standards and ITU-T recommendations

The Telecontrol Application Service Elements 1 and 2 (TASE.1 and TASE.2) protocols allow for data exchange over Wide Area Networks (WANs) between a utility control center and other control centers, other utilities, power plants and substations.
60870-6-503 Services and Protocol - This part of IEC 60870 defines a mechanism for exchanging time-critical data between control centers. In addition, it provides support for device control, general messaging and control of programs at a remote control center. It defines a standardized method of using the ISO 9506 Manufacturing Message Specification (MMS) services to implement the exchange of data. The definition of TASE.2 consists of three documents. This part of IEC 60870 defines the TASE.2 application modeling and service definitions.

Standard Reference #S5.3
WG 9: Distribution automation using distribution line carrier systems

This working group is responsible for two IEC standards:
IEC 61334-4-41, 1996-03, Distributed Automation Using Distribution Line Carrier Systems Part 4: Data Communication Protocols; Section 4: Application Protocol; Clause 1: Distribution Line Message Specification (DLMS)
IEC 61334-6 (2000-06), Distribution automation using distribution line carrier systems - *Part 6: A-XDR encoding rule*

Standard Reference #S5.4
WG 10: Communication standards for substations: Functional architecture and general requirements

Standard Reference #S5.5
WG 11: Communication standards for substations: Communications within and between unit and station levels

Standard Reference #S5.6
WG 12: Communications standards for substations: Communication within and between process and unit level

Working Groups 10, 11 and 12 were formed to focus on communications within substations, as opposed to distributed Telecontrol, which was the focus of Working Group 3, or communications between control centers, as in Working Group 7. Communications within the substation was divided into three levels: *station*, *process*, and *unit*. Initially each Working Group handled a different part of the architecture, but in later years they formed joint task forces to address mutual issues. These working groups have produced the 61850 standards:

61850-1 Introduction and Overview
61850-2 Glossary
61850-3 General Requirements
61850-4 System and Product Management
61850-5 Communications Requirements
61850-7-1 Principles and Models
61850-7-2 Abstract Communications Service Interface
61850-7-3 Common Data Classes (Object Models)
61850-7-4 Compatible Logical Node Classes and Data Classes (Object Models)
61850-8 Protocol Mapping
61850-9 Sampled Measured Values
61850-10 Certification Test Procedures

IEC Technical Committee 57, Working Groups 10, 11 and 12, administers IEC 61850.

Globally, IEC 61850 provides:

- Standardized information models for things like circuit breakers, transformers, and so forth;
- Information exchange methods to access the data of the information models, report sequences-of-events (SoE), log historical data, control devices, sampled value distribution, fast peer-to-peer process data exchange, etc.;
- A unified system configuration language (XML based) and device online self-description.

It does this for the following applications:

- protection and control;
- integration of innovative sensor and switch technologies;
- metering, supervisory control and data acquisition (SCADA);
- remote monitoring and fault diagnosis;
- automated dispatch and control;
- asset management;
- condition monitoring and diagnosis.

Standard Reference #S5.7
WG 13: Energy management system application program interface (EMS - API)

To produce standard interface specifications for "plug-in" applications for an electric utility power control center Energy Management System (EMS) or other system performing the same or similar functions. A "plug-in" application is defined to be software that may be installed on a system with minimal effort and no modification of source code. This standard facilitates installation of the same application program on different platforms by reducing the efforts currently required.

Standard Reference #S5.8
WG 14: System interfaces for distribution management (SIDM)

Identify and establish requirements for standard interfaces of a Distribution Management System (DMS) based on an interface architecture. The standard is the first in a series of standards that, taken as a whole, define interfaces for the major elements of Distribution Management Systems. Subsequent standards will be developed in accordance with the interfaces defined in this task

Standard Reference #S5.9
WG 15: Data and communication security

Working Group 15 is tasked with making recommendations and standards for securing the other protocols developed within TC57. While the Working Groups in charge of those protocols control the specifications, WG15 is the source of technical leadership for security. WG15 also has scope to deal with protocols, like DNP3, that have been derived from the TC57 protocols.

Standard Reference #S5.10
WG 16: Deregulated energy market communications

Standard Reference #S6
IEC WG-88/PT 61400-25 Communications for monitoring and control of wind power plants
Contact: Mr. P.B. SIMPSON Email: simpson@garradhassan.co.uk
Website: IEC TC-88 Website

To prepare international standards for wind turbines that convert wind energy into electrical energy. These standards address design requirements, engineering integrity, measurement techniques and test procedures. Their purpose is to provide a basis for design, quality assurance and certification. The standards are concerned with all subsystems of wind turbines, such as mechanical and internal electrical systems, support structures and control and protection systems. They are intended to be used together with appropriate IEC/ISO standards.

Standard Reference #S7
IEEE 1379-2000 Recommended Practice for Data Communications Between Remote Terminal Units and Intelligent Electronic Devices in a Substation
Contact: John T Tengdin, Email:j.t.tengdin@ieee.org
Website: http://standards.ieee.org/cgi-bin/tatus?1379-1997

Purpose: This document recommends a particular subset of DNP3 or IEC 60870-5-101 for RTU to IED communications. The intent of this recommended practice was to give guidance to utilities that were having difficulty choosing between the many protocols available. In addition to specifying a recommended subset, it provides a comparison of the protocols and recommends methods for utilities to expand on the recommended subset as needed. It was updated in 2000 to include the LAN versions of these protocols. Besides its usefulness as a recommendation, IEEE 1379 is significant because it constitutes recognition of DNP3, which is otherwise a de facto standard only, by a standards organization.

Standard Reference #S8
IEEE 1159.3 - Recommended Practice for the Transfer of Power Quality Data
Contact: Scott Peele Email: scott.peele@cplc.com
Website: http://grouper.ieee.org/groups/1159/3/

Scope: Develop a recommended practice for a file format suitable for exchanging power quality related measurement and simulation data in a vendor independent manner. Appropriate definitions and event categories to be developed by other task forces under SC22 and The Working Group on Power Quality Monitoring.

Purpose: A variety of simulation, measurement and analysis tools for power quality engineers are now available from many vendors. Generally, they data created, measured, and analyzed by these tools are incompatible between vendors. The proposed file format will provide a common ground that all vendors could export to, import from to allow the end user maximum flexibility in choice of tool and vendor.

Standard Reference #S9
IEEE 1390-1995 IEEE Standard for Utility Telemetry Service Architecture for Switched Telephone Network 1995
Contact: Paul Aubin, Email:paul@nertec.com
Website: http://standards.ieee.org/reading/ieee/std_public/description/comm/1390-1995_desc.html

This standard describes a utility telemetry service architecture operated over the telephone network. The architecture described is a basic transport architecture capable of supporting many different applications. The text is described in terms of a utility meter reading application, but any enhanced service provider (ESP) communication can be transported. Telemetry calls may be initiated by either the utility/service provider (outbound) or the telemetry interface unit (TIU)/CPE (inbound) on the end user's premise.

Standard Reference #S9.1
IEEE 1390.2-1999 Standard for Utility Telemetry Service - Telemetry Interface Unit (TIU) to Telephone Network 1999

The telephone network interface to a telemetry interface unit operating under the utility telemetry service architecture is described. The interface is described in terms of a utility meter reading application, but any enhanced service provider communication can be transported. Telemetry calls may be initiated by either the utility/enhanced service provider (outbound) or the telemetry Interface unit/customer premise equipment (inbound) on the end user's premise.

Standard Reference #9.2
IEEE 1390.3-1999 Standard for Automatic Meter Reading via Telephone - Network to Utility Controller 1999

The telephone network interface to a utility controller operating under the utility telemetry service architecture is described. The interface is described in terms of a utility meter reading application but any enhanced service provider communication can be transported. Telemetry calls may be initiated by either the utility/service provider (outbound) or the telemetry interface unit (TIU)/ CPE (inbound) on the end user's premises.

Standard Reference #S10
IEEE 1547 - Standard for Interconnecting Distributed Resources with Electric Power Systems
Contact: Richard DeBlasio, Email: deblasid@tcplink.nrel.gov
Website: http://grouper.ieee.org/groups/scc21/dr_shared/

This document provides a uniform standard for interconnection of distributed resources with electric power systems. It provides requirements relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection

Standard Reference #S10.1
IEEE P1547.1 Draft Standard for Conformance Tests Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems

Scope: This standard specifies the type, production, and commissioning tests that shall be performed to demonstrate that the interconnection functions and equipment of a distributed resource (DR) conform to IEEE Standard P1547.

Purpose: Interconnection equipment that connects distributed resources (DR) to an electric power system (EPS) must meet the requirements specified in IEEE Standard P1547. Standardized test procedures are necessary to establish and verify compliance with those requirements. These test procedures must provide both repeatable results, independent of test location, and flexibility to accommodate a variety of DR technologies

Standard Reference #S10.2
IEEE P1547.2 Draft Application Guide for IEEE P1547 Draft Standard For Interconnecting Distributed Resources with Electric Power Systems

Scope: This guide provides technical background and application details to support the understanding of IEEE P1547, Draft Standard for Interconnecting Distributed Resources with Electric Power Systems.

Purpose: This document facilitates the use of IEEE P1547 by characterizing the various forms of distributed resource technologies and the associated interconnection issues. Additionally, the background and rationale of the technical requirements are discussed in terms of the operation of the distributed resource interconnection with the electric power system. Presented in the document are technical descriptions and schematics, applications guidance and interconnection examples to enhance the use of IEEE P1547.

Standard Reference #S10.3
IEEE P1547.3 Draft Guide For Monitoring, Information Exchange, and Control of Distributed Resources Interconnected with Electric Power Systems

Scope: This document provides guidelines for monitoring, information exchange, and control for distributed resources (DR) interconnected with electric power systems (EPS).
Purpose: This document facilitates the interoperability of a one or more distributed resources interconnected with electric power systems. It describes functionality, parameters and methodologies for monitoring, information exchange and control for the interconnected distributed resources with or associated with electric power systems. Distributed resources include systems in the areas of fuel cells, photovoltaics, wind turbines, microturbines, other distributed generators, and distributed energy storage systems

Standard Reference #S11
IEEE 1588 Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems
Contact: Kang Lee, NIST, kang.lee@nist.gov
Website: http://ieee1588.nist.gov/

The objective of IEEE 1588 is defined in the 'Scope' section of the Project Authorization Request approved by the Standard Board of the IEEE as follows.

"This standard defines a protocol enabling precise synchronization of clocks in measurement and control systems implemented with technologies such as network communication, local computing and distributed objects. The protocol will be applicable to systems communicating by local area networks supporting multicast messaging including but not limited to Ethernet. The protocol will enable heterogeneous systems that include clocks of various inherent precision, resolution and stability to synchronize. The protocol will support system-wide synchronization accuracy in the sub-microsecond range with minimal network and local clock computing resources. The default behavior of the protocol will allow simple systems to be installed and operated without requiring the administrative attention of users."

Standard Reference #S12
IEEE P1451.5 Draft Standard for A Smart Transducer Interface for Sensors and Actuators
Contact: Kang Lee, NIST, kang.lee@nist.gov
Website: http://grouper.ieee.org/groups/1451/5/

Scope: This project will establish a standard for wireless communication methods and data format for transducers (sensors and actuators). The standard will define a TEDS based on the IEEE 1451 concept, and protocols to access TEDS and transducer data. It will adopt necessary wireless interfaces and protocols to facilitate the use of technically differentiated, existing wireless technology solutions. It will not specify transducer design, signal conditioning, wireless system physical design or use, or use of TEDS.
Purpose: Many companies are developing various wireless communication interfaces and protocols for sensors. An openly defined wireless transducer communication standard, that can accommodate various existing wireless technologies, will reduce risk for users, transducer manufacturers, and system integrators. It will enhance the acceptance of the wireless technology for transducers connectivity.

Standard Reference #S13
OPC Foundation – OPC
Contact: Michael Bryant Email: michael.bryant@opcfoundation.org
Website: http://www.opcfoundation.org/

OPC is an industry standard based on Microsoft's COM (component object model) and .Net technologies. OPC (originally OLE for Process Control) consists of a standard set of interfaces, properties, and methods for use in process-control and manufacturing-automation applications. The .Net/COM technologies define how individual software components can interact and share data. OPC provides a common interface for communicating with diverse process-control devices and applications, regardless of the controlling software or devices in the process.

Some portions of the OPC specification are being incorporated into IEC 61970, Energy Management System Application Program Interface, parts of which are in ballot now.

Current and emerging OPC Specifications include:

OPC Data Access
Used to move real-time data from PLCs, DCSs, and other control devices to HMIs and other display clients. The Data Access 3 specification is now a Release Candidate. It leverages earlier versions while improving the browsing capabilities and incorporating XML-DA Schema.

OPC Alarms & Events
Provides alarm and event notifications on demand (in contrast to the continuous data flow of Data Access). These include process alarms, operator actions, informational messages, and tracking/auditing messages.

OPC Batch
This spec carries the OPC philosophy to the specialized needs of batch processes. It provides interfaces for the exchange of equipment capabilities (corresponding to the S88.01 Physical Model) and current operating conditions.

OPC Data eXchange
This specification takes us from client/server to server-to-server with communication across Ethernet fieldbus networks. This provides multi-vendor interoperability! And, oh by the way, adds remote configuration, diagnostic and monitoring/management services.

OPC Historical Data Access
Where OPC Data Access provides access to real-time, continually changing data, OPC Historical Data Access provides access to data already stored. From a simple serial data logging system to a complex SCADA system, historical archives can be retrieved in a uniform manner.

OPC Security
All the OPC servers provide information that is valuable to the enterprise and if improperly updated, could have significant consequences to plant processes. OPC Security specifies how to control client access to these servers in order to protect this sensitive information and to guard against unauthorized modification of process parameters.

OPC XML-DA
Provides flexible, consistent rules and formats for exposing plant floor data using XML, leveraging the work done by Microsoft and others on SOAP and Web Services.

OPC Complex Data
A companion specification to Data Access and XML-DA that allows servers to expose and describe more complicated data types such as binary structures and XML documents.

OPC Commands
A Working Group has been formed to develop a new set of interfaces that allow OPC clients and servers to identify, send and monitor control commands which execute on a device.