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PACE-D TECHNICAL ASSISTANCE PROGRAM

Smart Grid Study Tour Report: January 2014

April 09, 2014

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PARTNERSHIP TO ADVANCE CLEAN ENERGY DEPLOYMENT (PACE-D)

Technical Assistance Program

SMART GRID STUDY TOUR REPORT

Submitted to USAID/India on April 09, 2014

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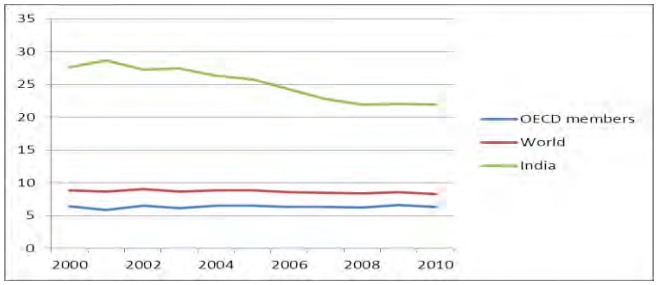
BACKGROUND

The Indian power sector has come a long way since the introduction of the second wave of reforms heralded by the Electricity Act of 2003 (EA03). The Act provided a major fillip to the power sector by creating conducive environment for enhanced private sector participation. It also ushered in reforms that aim at providing affordable, good quality and reliable power to consumers, making electricity sector segments commercially viable and promoting efficiency improvements across the electricity supply chain.

The capacity addition in the power sector has accelerated largely due to the entry of private players. The magnitude of capacity being added each year has increased manifold when compared with the previous Five-Year Plan periods. Also, with the use of new and more advanced technologies, efficiency of thermal generation has been improving with corresponding reduction in emission levels. Stringent grid requirements related to scheduling and dispatch are driving automation across the industry, including those in the generation plants. The new plants have already incorporated such systems into their plans; while the existing generation fleet is slowly upgrading its IT capabilities.

Renewable Energy (RE)-based electricity generation has also gained prominence over the years. Several fiscal and policy measures have been introduced that promote RE-based electricity generation. Solar energy is gaining momentum through the Jawaharlal Nehru National Solar Mission (JNNSM) and state policies. Approximately, 3 GW of RE-based capacity has been added every year, and the targets specify even higher capacity additions.

The Indian transmission sector is moving towards higher voltage levels of 1200 kV and higher degrees of automation. Power Grid Corporation of India Ltd. (PGCIL), India's central transmission utility, has already installed Phasor Measurement Units (PMUs) for Wide Area Monitoring Systems (WAMS) on a pilot basis in select regions and is now pursuing a plan to install ~1700 PMUs all across the country. Significant technological advancements such as increase in the capacity of transmission corridors through High Surge Impedance Loading (HSIL) and re-conducting with High Temperature Low Sag (HTLS) wire are being taken up. The private sector will also play a significant role in the near future through the Public Private Partnership (PPP) model, to improve efficiency.



T&D losses
Source: World Bank

Distribution is the weakest link in the Indian power sector and is plagued by a high level of network losses, both technical and commercial. Despite severe fuel and energy challenges, a sizeable proportion of the electricity generated in the Indian coal-dominated electrical grid does not even reach the paying end-consumer.

Aggregate Technical and Commercial (AT&C) losses, which include technical losses (from weak, overloaded and inefficient infrastructure) and commercial losses (due to power theft and unmetered supply), amount to an average 27.1 percent as compared to world average transmission and distribution losses of 8percent.There is an urgent need in the distribution sector to bring in new technologies and systems to arrest these leaks. Also, collection efficiency has to be increased significantly if the utilities are to come out of the apocalyptic financial situation they are entangled in. In addition, there is a need for improving the quality and reliability of power supply, and service. The Restructured Accelerated Power Development and Reforms Program (R-APDRP) introduced by the Government of India (GOI) was aimed at reducing AT&C losses to 15 percent, along with several other associated interventions. Part-A of the program was aimed at creating IT infrastructure and automation systems in utility operations, which was largely missing in most of the power distribution utilities in the country.

Building upon the base provided by the R-APDRP, the GOI introduced the smart grid pilot project initiative, under which 14 utilities across the country were selected to implement various smart grid interventions in their areas. Learning from these smart grid pilots will lay the foundation for future technological reforms. However, the electricity distribution utilities, the key implementers of the programs, lack IT knowledge and IT-savvy manpower to take the initiatives forward.

Further, due to limited implementation experience in the country, it was recognized that an international study trip to the United States (U.S.) would be the best way to clearly understand the relevant technologies, associated issues/challenges and implementation strategies that could be taken back by the participants for use in their respective utilities. The study tour was organized in January 2014. The participants of the study tour primarily comprised of key officers of the distribution utilities and are directly responsible for carrying out the implementation activities under the smart grid program. This report provides details of this study tour.

AGENDA

Agenda

Smart Grid Study Tour to U.S.

January 20-30, 2013

DAY	Topic	Lodging City	Travel Information
January 19, 2014 (Sunday)	Depart India for U.S.		Various possible flights from Delhi and other Indian cities to NYC/Newark airports depart Jan 19 or 20
January 20, 2014 (Monday)	Arrive in NYC Rest Day and Martin Luther. Day Holiday 7 PM Per diem distribution, briefing by PACE-D regarding agenda and logistics.	Arrive to hotel in New York City area for Check in by 4:00 PM.	Arrival to NYC airport in the morning. Taxi shuttle to hotel
January 21, 2014 (Tuesday)	AM (9:30 – 11:30): New York State Energy Research and Development Authority (NYSERDA) Boardroom, New York City, PM (1:00 – 3:00): Consolidated Edison Company of New York (ConEd), New York City	Check out from hotel in New York City in AM. Stay the night in Philadelphia, PA	Leave for Philadelphia around 3:30 PM – driving time is about 2 hours
January 22, 2014 (Wednesday)	AM (9-12): PJM Interconnection, Norristown, PA PM (2– 4): Pennsylvania Public Utility Commission (PA-PUC), Harrisburg, PA	Check out from hotel in Philadelphia. Stay the night in Baltimore.	Philadelphia to Norristown is about half hour drive. Drive to Harrisburg for Pa-PUC meeting. Drive time from Norristown to Harrisburg is hour and a half. Drive to Baltimore/Washington around 4:00 PM. Drive time from Harrisburg to Baltimore is about 1 hour and 20 minutes

DAY	Topic	Lodging City	Travel Information
January 23, 2014 (Thursday)	AM (9-12): Baltimore Gas and Electric (BG&E), PM (2:30-4:30): National Institute of Standards and Technology (NIST), Gaithersburg, MD	Check out from hotel in Baltimore. Stay in Washington DC	Drive to BG&E and to NIST. Drive to Gaithersburg around 12:30 PM. Drive time from Baltimore to Gaithersburg is about 45 minutes. Drive to Washington DC around 5:00 PM. Drive time from Gaithersburg to Washington DC is about 35 minutes.
January 24, 2014 (Friday)	AM (8:30-10): U.S. Trade and Development Agency (USTDA) at DOE, Washington, DC (10 AM -12): U.S. Department of Energy (DOE), Washington, DC PM (2 – 4): National Rural Electric Coop. Assoc., NRECA, Arlington, VA	Stay in Washington DC	Arlington is half hour drive from Washington DC.
January 25-26, 2014 (Saturday & Sunday)	Rest day Saturday Washington and Sunday San Francisco. Reception Sunday at Nexant San Francisco office.	Sat Check out from hotel in Washington. Lodging in San Francisco, CA.	Saturday Fly from Washington to San Francisco, CA
January 27, 2014 (Monday)	AM (9-11:30): Pacific Gas & Electric's Pacific Energy Center (PEC) - *Smart Grid Program large AMI, Distribution Automation, substation automation* PM (1-5): Lawrence Berkeley National Lab (LBNL) Demand Response Research Center	Check out from hotel in San Francisco. Stay in Sacramento.	Drive to PEC in San Francisco and to LBNL in Berkeley. Drive from Berkeley to hotel in Sacramento.

DAY	Topic	Lodging City	Travel Information
January 28, 2014 (Tuesday)	AM (9-12): California ISO (CAISO) - *SG, DR, and renewable integration* PM (1-2:30): California Energy Commission (CEC) PM (3-4:30): Sacramento Municipal Utility District (SMUD) – *SG project includes test bed for PHEV vehicle charging stations and impact on electric distribution system*	Check out of Sacramento hotel. Stay in Los Angeles area.	Drive to CAISO, SMUD and the airport. Fly from Sacramento to Los Angeles.
January 29, 2014 (Wednesday)	AM (10-12): Visit University of California Los Angeles (UCLA) Smart Grid Energy Research Center (SMERC) PM (2-4) Visit Los Angeles Department of Water and Power (LADWP)	Stay in Los Angeles area.	Drive to UCLA and LADWP
January 30, 2014 (Thursday)	AM (10-12): Visit Burbank Water and Power Debrief and tour evaluation. Depart to India	Check out of hotel in Los Angeles. Depart to India	Drive to Burbank Fly Los Angeles to India. Depart after 4:00 PM. Various possible flights from Los Angeles to Delhi and other Indian cities depart Jan 30.

SMART GRID STUDY TOUR: PURPOSE AND ITINERARY

The primary objective of the study tour was to facilitate knowledge transfer of industry best practices, smart grid project implementation methodologies, and firsthand experience of the latest smart grid technologies. Implementation of the study tour program is the outcome of a joint effort undertaken by a team of U.S. and Indian experts including the India Smart Grid Task Force (ISGTF) and the India Smart Grid Forum (ISGF).

The objective of the study tour was to provide the participants with an opportunity to observe live demonstrations of smart grid international best practices through site visits to utilities and interactions with utility personnel, and visits to power system operators, research institutions, regulators, and government authorities active in smart grid development and implementation. Subject to the constraints of schedule and travel logistics, host sites were chosen such that their respective smart grid programs are relevant to those being implemented by the Indian utilities. The key benefits to be gained from the study tour were envisioned to include a clear understanding of:

- Various smart grid technologies in place and their functionalities
- Costs and benefits of the technologies adopted
- Smart grid interventions such as demand response (DR), outage management system (OMS), synchrophasor measurement unit, asset management, etc.
- Practical implementation issues/challenges through interactions with utility personnel
- Regulatory and policy-level challenges encountered during implementation
- Customer expectations and strategies for customer engagement
- Advanced smart grid technologies and their applicability
- Exposure and access to good practices, new technologies and data analytics
- Networking opportunities

Itinerary: The Smart Grid Study Tour is shown graphically on this map of the U.S. (refer next few pages for full forms of acronyms in map).

Host Sites and Presentations

To learn about smart grid programs that provide a diverse range of implementation experience and perspectives, the Smart Grid Study Tour participants visited and met with personnel of a variety of utilities, power system operators, research institutions, and regulators and governmental authorities, as well as with vendors of smart grid solutions and services. Copies of presentations during the Smart Grid Study Tour have been made available to participants in electronic format on a flash drive and for download from Nexant's FTP site. The login details have been shared with all participants.

Utilities visited included both private Investor Owned Utilities (IOUs) and governmental Municipal Utilities (Munis).

- **IOUs**: The Smart Grid Study Tour participants visited and interacted with personnel from four IOUs: Consolidated Edison (ConEd) in New York, Pennsylvania Power and Light (PPL) in Pennsylvania, Baltimore Gas & Electric (BGE) in Maryland, and Pacific Gas and Electric Company (PG&E) in California.
- **Munis**: The tour participants visited three Munis in California ranging from large to small in size: City of Los Angeles Department of Water and Power (LADWP), Sacramento Municipal Utility District (SMUD), and City of Burbank Water and Power (BWP).

System Operators: The tour participants visited the PJM Interconnect Regional Transmission Operator (RTO) headquartered in Pennsylvania serving multiple states in the U.S. Eastern Interconnect, which operates the world's largest competitive electric wholesale market, and the California Independent System Operator (CAISO), which serves both Northern and Southern California.

Research Institutions: The tour participants visited research institutions, service organizations, and university facilities. The research, service, and planning institutions visited included National Institute of Standards and Technology (NIST), National Rural Electric Cooperative Association (NRECA), Lawrence Berkeley National Laboratory (LBNL), and University of California Los Angeles (UCLA).

Regulators and Governmental Authorities: The tour participants visited state power system regulators, Pennsylvania Public Utility Commission (PA-PUC), and state and federal governmental organizations with authority for power system planning, research, and development: the New York State Energy Research and Development Authority (NYSERDA), U.S. Department of Energy (DOE), U.S. Trade Development Agency (USTDA), and the California Energy Commission (CEC).

Vendors: Representatives of vendors of smart grid solutions and services, Siemens and Innovari, made presentations to and met with the tour participants.

Schedule

Week One- East Coast: The Smart Grid Study Tour itinerary began on the East coast with an initial organizational meeting on Monday evening, January 20, Martin Luther King Day holiday, for a briefing regarding the agenda and logistics, at a hotel in New York City. The tour continued Tuesday with visits to NYSERDA and Con Ed in New York. It proceeded to Pennsylvania for a visit on Wednesday to PJM and PA-PUC, followed by a meeting with PPL

staff. The group went on to Maryland for visits on Thursday to BGE and NIST, and then to Washington DC for meetings on Friday with DOE, USTDA, and NRECA. On Saturday January 25, the Smart Grid Study Tour participants flew to San Francisco, California.

Week Two - California: On Sunday, January 26, senior Nexant experts made presentations at Nexant offices in San Francisco on Demand Response (DR) and smart grids. On Monday, the tour visited the PG&E Pacific Energy Center (PEC) and LBNL. It proceeded to Sacramento for visits on Tuesday to CAISO, CEC, and SMUD. The tour participants flew on Tuesday evening to Los Angeles, California. The tour continued with visits Wednesday to UCLA Smart Grid Energy Research Center (SMERC) and LADWP in Los Angeles[1]. The tour finished on Thursday, January 30, with a visit to BWP in Burbank, with meetings at a hotel in Los Angeles with representatives of Siemens and Innovari, followed by a final de-briefing of tour participants.

[1]Hartinder Bhatia, Director Energy, Itron India, joined the visits to UCLA and LADWP.

LIST OF THE SMART GRID STUDY TOUR PARTICIPANTS[2]

Sl. #	Name/Designation	Name & Address of Organization
1	Mr. Badri Narayan Sharma, Joint Secretary(Distribution)	GOVERNMENT OF INDIA, MINISTRY OF POWER, SHRAM SHAKTI BHAWAN, NEW DELHI;+91-9810050123
2	Mr. Anil Kumar Grover, Director Projects	UTTAR HARYANA BIJLIVITRAN NIGAM/DAKSHIN HARYANA BIJLIVITRAN NIGAM,VIDYUT SADAN,C-16, SECTOR-6, PANCHKULA, HARYANA -134109, +91-0172-2583740
3	Mr. Anurag Goel, Commissioner & Secretary (Power)	GOVERNMENT OF ASSAM, PERSONNEL DEPARTMENT, BLOCK A, ASSAM SECRETARIAT (CIVIL), DISPUR, GUWAHATI – 781006, ASSAM, INDIA, +91-9435540400
4	Mr. Avkash Saxena, General Manager	POWER FINANCE CORP. LTD. 1BARAKHAMBA LANE, CONAUGHT PLACE, N.DELHI, +919868549055
6	Mr. Kulwant Lal Sharma, Director (District)	PUNJAB STATE POWER CORPORATION LTD, THE MALL, PATIALA, +91-75895-00018
7	Mr. Muhammedali Rawther Mohamed Mustafa, Member	KERALA STATE ELECTRICITY BOARD,VYDYUTHI BHAVANAM, PATTOM, TRIVANDRUM.695004, 0471-2445658, 9446008899
8	Ms. Shanthi Muthoo, Chief Engineer	CHAMUNDESHWARI ELECTRICITY SUPPLY CORPORATION LIMITED, #927, L.J AVENUE COMMERCIAL COMPLEX, NEW KANTHARAJURS ROAD, SARASWATHIPURAM, MYSORE 570009, 0821-2417104/110
9	Ms. Pushpa Ramcharan Chavan, Superintending Engineer	MAHARASHTRA STATE ELECTRICITY DISTRIBUTION COMPANY LIMITED,PRAKASHGAD , A K MARG, BANDRA-EAST, MUMBAI, +919619077000
10	Mr. Sibes Kumar Deb, Regional Manager, Darjeeling Region	WEST BENGAL STATE ELECTRICITY DISTRIBUTION COMPANY LIMITED, BIDYUTBHABAN, SALT LAKE CITY, KOLKATA - 700091,03323599078
11	Mr. Subhash Y Thakur, Executive Director (Projects)	MAHARASHTRA STATE ELECTRICITY DISTRIBUTION COMPANY LIMITED,PRAKASHGAD , A K MARG, BANDRA-EAST, MUMBAI, +919619077000
12	Mr. Subir Sen, General Manager	POWER GRID CORPORATION OF INDIA LTD., "SAUDAMINI", PLOT-2, SECTOR-29, GURGAON 122001,+91 9650293185
13	Mr. Subodh Kumar Singh, Managing Director	CHHATTISGARH STATE POWER DISTRIBUTION COMPANY LIMITED VIDYUT SEWA BHAWAN, DAGANIA, RAIPUR, CHHATTISGARH, INDIA , +91 9893001010
14	Mr. Vijay Laxmanrao Sonavane, Member	MAHARASHTRA ELECTRICITY REGULATORY COMMISSION, +91 09833362062
15	Mr. Vijay Menghani, Joint Chief Engineer	CENTRAL ELECTRICITY REGULATORY COMMISSION, III FLOOR ,CHANDERLOK BUILDING , 36-AJANPATH, NEW DELHI 11001, +91 9999035484
16	Mr. Vikas Gaba, Associate Director	MERCADOS ENERGY MARKETS INDIA PVT. LTD, 1202, TOWER B, MILLENNIUM PLAZA, SECTOR 27 GURGAON, HARYANA - 122002, INDIA, +91 124 4241750
17	Ms. Monali Zeya Hazra, Program Management Specialist	U S AGENCY FOR INTERNATIONAL DEVELOPMENT (USAID), AMERICAN EMBASSY, SHANTIPATH, CHANKYAPURI, NEW DELHI -110021 ,+91-11-24198000 ; 24198683 (DIRECT)
18	Ms. Amritha Chandramouli, Business Analyst	INDIA SMART GRID FORUM , CBIP BUILDING, MALCHA MARG, CHANAKYAPURI, NEW DELHI – 110023, +91 11 41030398
19	Dr. Ajit Kulkarni, Vice President, Head of Grid Management	NEXANT, INC. 101 2ND STREET #1000, SAN FRANCISCO, CA 94105, 415 - 369 - 1170
20	Dr. Lawrence Risman, Principal Consultant	NEXANT, INC. 101 2ND STREET #1000, SAN FRANCISCO, CA 94105, 415 - 369 - 1067
21	Ms. Laliya B. Agrawal, Principal Consultant	NEXANT, INC. 101 2ND STREET #1000, SAN FRANCISCO, CA 94105, 480- 722-2322

[2]Mr. Sachin Shukla of the India Smart Grid Task Force missed the study tour due to a medical emergency.

In addition to the above listed participants, Mr. Reji Kumar Pillai, President of the ISGF, a PPP initiative for deployment of smart grid technologies in India, participated in the visits to DOE and NRECA in Washington DC.

PROFILES OF THE SMART GRID STUDY TOUR PARTICIPANTS

	BADRI NARAYAN SHARMA Mr. Sharma is an Indian Administrative Service (IAS) officer of 1985 from the Rajasthan cadre and has been in civil services for about 30 years. He holds a Bachelor's and a Master's degree in financial management. Mr. Sharma is presently working as Joint Secretary in the Ministry of Power (Government of India), where he is in charge of distribution sector.
	ANIL KUMAR GROVER Mr. Grover is currently serving as Director of Projects, Uttar Haryana Bijli Vitran Nigam Ltd. He has been with the Department of Power in the state of Haryana for the past 34 years. Mr. Grover received a Bachelor of Science degree in Electronics and Electrical Communications.
	ANURAG GOEL Mr. Goel is an Indian Administrative Service (IAS) Officer of the 1996 batch and deputed to work in the State Government of Assam. He has been working in the energy sector in the state of Assam since June 2012 as Commissioner & Secretary of the Power department. Mr. Goel has a Bachelor's degree in Electronics & Communication Engineering.
	AVKASH SAXENA Mr. Saxena is currently serving as Executive Director (RAPDRP), Power Finance Corporation (PFC) and was responsible for conceptualization of the Restructured Accelerated Power & Reform Programme (R-APDRP) of the Indian government in 2008. Mr. Saxena has 33.5 years' experience in the oil and power sector. He holds an MBA (Finance) degree from IGNOU, New Delhi and is a graduate in Electrical Engineering from IIT BHU. .

	KULWANT LAL SHARMA Mr. Sharma is currently serving as Director/Distribution, Punjab State Power Corporation Ltd. Prior to this, he served in other distribution organizations in various capacities in his career spanning over 30 years. Mr. Sharma holds a B.Sc. (Electrical Engineering) degree from Guru Nanak Engg. College Ludhiana, Punjab University, Chandigarh.
	MOHD. ALI RAWTHER Mr. Rawther graduated from Kerala University in Electrical Engineering in 1981 and with an MBA in 2002. He joined the Kerala State Electricity (KSE) Board in 1986. Currently, he is working as Member (Distribution & Generation-Electrical) at KSEB.
	SHANTHI MUTHOO Mrs. Shanthi has over 25 years of experience in operation and maintenance of transmission and distribution system, managing quality power supply to five districts both for industrial and agricultural sectors in Karnataka. She currently works as Chief Engineer (Electrical), Chamundeshwari Electricity Supply Corporation Limited. She holds a Bachelor's degree in Electrical Engineering.
	PUSHPA RAMCHARAN CHAVAN Mrs. Chavan started her career in Maharashtra State Electricity Distribution Company Limited (MSEDCL) in1989. She has 24 years of experience in the utility industry. At present she is Superintending Engineer at the corporate office and is mainly responsible for procurement of electrical equipment in MSEDCL (Asia's largest utility with 20 million consumers and annual turnover of USD 70 billion). Mrs. Chavan has a Bachelor's degree in Electrical Engineering.

	SIBES KUMAR DEB Mr. Deb, Superintending Engineer (Electrical), is presently working as Regional Manager, Darjeeling Region, of West Bengal State Electricity Distribution Company Limited. He joined the same organization (erstwhile West Bengal State Electricity Board) in the year 1992. He obtained his Bachelor's Degree in Electrical Engineering from Calcutta University and his Master's in Power System from Jadavpur University in 1992.
	SUBHASH YADAVRAO THAKUR Mr. Thakur started his career in Maharashtra State Electricity Distribution Company Limited (MSEDCL) in 1982. At present he is Executive Director (Projects) at the corporate office and is mainly responsible for Electrical Infra Projects in MSEDCL. He has overall 31 years of experience in the utility industry. . He holds a Bachelor's degree in Electrical Engineering.
	SUBIR SEN Dr. Sen is currently working as General Manager (Smart Grid) in Power Grid Corporation of India Ltd. He started his professional career with NTPC, a central generation utility in India in 1989 and subsequently joined POWERGRID in 1991. He has more than 23 years of professional experience in the power sector. Dr. Sen holds a PhD degree in Electrical Engineering from Indian Institute of Technology (IIT), Delhi.
	SUBODH KUMAR SINGH Mr. Singh is serving as Managing Director of Chhattisgarh State Power Distribution Company Limited (CSPDCL) and is looking after the Power Distribution and O&M activities of the entire State of Chhattisgarh . . . He is an Indian Administrative Service officer of the 1997 batch and holds the rank of Secretary in Chhattisgarh cadre . . . . . He is a post-graduate in Electrical Engineering from IIT, Roorkee and holds an MBA in Financial Management.
	VIJAY LAXMANRAO SONAVANE M. Vijay Sonavane has a Master's degree in Electrical Engineering from Pune University. He joined Maharashtra State Electricity Board (MSEB) as Assistant Engineer in 1976 and has been working at MSEB/MSEDCL for 33 years. . He has undergone training in several countries on power sector projects/management. In 2009, he was appointed by Govt. of Maharashtra as Member (Technical) in Maharashtra Electricity Regulatory Commission (MERC) for a period of five years. .

	VIJAY MENGHANI Mr. Menghani is an Indian Engineering Service Officer of the 1990 batch and joined Central Electricity Authority as Assistant Director in 1992. He has working experience of 21 years in the Indian Power Sector, particularly in power system and grid operation. Since June 2009 he has been working as Joint Chief (Engineering) in the Central Electricity Regulation Commission of India. He has a Bachelor's degree in Electrical Engineering and an MBA from Faculty of Management Studies, University of Delhi.
	VIKAS GABA Mr. Gaba is an Associate Director with Mercado's Energy Markets India Private Limited, specializing in reform and restructuring, policy, regulatory and commercial aspects in the power sector. Mercado's EMI is part of the Swedish-based AF Group, one of the largest European Consulting firms with over 7,000 employees across 23 countries and 101 offices. Mr. Gaba is part of the South Asia practice. During his ten-year work tenure, Mr. Gaba has extensive global experience. He is presently working on the USAID-funded PACE-D (Partnership to Advance Clean Energy-Deployment) program. He holds an undergraduate degree in Mechanical Engineering and a Master in Business Economics.
	MONALI ZEYA HAZRA Ms. Hazra, a clean energy specialist at United States Agency for International Development (USAID)'s India mission, has over 14 years of experience. She is a Program Management Specialist with USAID and the Program Manager for Partnership to Clean Energy - Deployment (PACE-D) TA Program.
	AMRITHA CHANDRAMOULI Ms. Chandramouli joined the India Smart Grid Forum in April 2013 where she handles the working groups on Advanced Transmission and Renewables & Microgrids. She hosts a webinar series on smart grids and has been instrumental in making ISGF more social-media friendly. Ms. Chandramouli is a post-graduate in Energy Management and an electronics and communications engineer,

	REJI KUMAR PILLAI Mr. Pillai is the President of the India Smart Grid Forum. He has over 30 years of global experience in the electricity and power industry. Mr. Pillai has been a key member of multidisciplinary teams in reform and restructuring of power and water utilities in Asia, Middle East, and Africa. He has advanced education in Engineering, Finance, Management and Law; and has worked with NTPC and IBM, and been a senior consultant with ADB, the World Bank and USAID.

DETAILS OF SITE VISITS

Site locations visited by the delegation and the description of visits by date and time are detailed below:

Monday, January 20, 2014:

- Participants arrived at the Spring Hill Suites – Marriott Midtown Manhattan hotel, New York City at different times as per their flight schedules in New York City.
- In the evening, the program overview meeting was conducted with all participants in the study tour program.
- Dr. Ajit Kulkarni, VP, Nexant, provided the opening remarks and kicked off the meeting, following which Laliya Agrawal went through the technical program agenda and plan of action for the east coast entities to be visited. Vikas Gaba provided the delegation with the program training manual. The meeting ended with Brian Gould providing the per diem expenses for the east coast visits.
- The meeting ended with the participants signing the trip sign-up sheets.

Tuesday, January 21, 2014, 9:30 – 11:30 AM, New York State Energy Research and Development Authority (NYSERDA) Boardroom, 485 7th Avenue, 10th Floor, Suite 1006, Atrium Building, NY, NY 10018.

Note: All pictures/photographs in this section are courtesy of NYSERDA.

The meeting was conducted remotely, with the PACE-D team in NYSERDA Boardroom in New York City joined by the NYSERDA representatives in Albany office via video conferencing technology. The meeting started with introductions on both sides, followed by an overview of NYSERDA by Don Lavada that is summarized below. The NYSERDA team consisted of:

Name/Designation	Presentation Topic
Don Lavada, Director, Consumer Service and Event Management	NYSERDA's Smart Grid Initiative
John Love, Senior Project Manager	T&D Demonstration Projects with Monitory and Verification (M&V)

Founded in 1975 as Atomic Space Commission, NYSERDA is a public benefit corporation with about 330 people that oversees USD 700 million in energy programs and reports to the Governor of New York State. The organization is led by 13 board director members across utilities, environment, transport departments, etc., and has representatives from multiple disciplines and backgrounds. .

NYSERDA's main goal is to help New York meet its energy goals: reducing energy consumption, promoting the use of renewable energy sources, and protecting the environment. NYSERDA also supports new start-ups/clean energy companies in NY for testing and commercializing new technologies and thus serves as an incubator. It has six incubators across NY State, typically through university affiliations, creating non-hostile environment to conduct proof of concept projects. The organization has a robust energy analysis unit for strategic planning that includes: NYSERDA's mission, expected outcomes and long-term vision; Strategic planning context including State policy imperatives; Strategic initiatives for the planning period; Discussion of priorities for each NYSERDA program portfolio during 2013–2016; NYSERDA funding sources and allocations; Accomplishments from the last planning year; Proposed future benefits of NYSERDA program activities; and NYSERDA's organizational and operational means of achieving these goals. The strategic plan is prepared every three years. The last plan "A Three-Year Strategic Outlook 2013-2016" was issued in July 2013.

NYSERDA is primarily funded by state rate payers through the System Benefits Charge (SBC). Large industrial and commercial consumers and users generally pay most of it, with a small portion (typically USD 25-30 per year) paid by the residential customers. The SBC funds are allocated towards energy-efficiency programs, research and development initiatives, low-income energy programs, and environmental disclosure activities. Although NYSERDA has the lion's share of the SBC funds, utility initiatives also have access to these funds for funding specific research initiatives.

New York's current Renewable Portfolio Standard (RPS) seeks to increase the proportion of renewable electricity used by retail customers to 30 percent of the generation mix by 2015. The renewable portfolio, originally started with hydro, now has wind, biomass, and solar energy. Currently, New York State has 2,000 MW of wind farm generating capacity, with 2,000 MW more under development by independent power producers. The NY-Sun Initiative program administered by NYSERDA, Long Island Power Authority (LIPA), and the New York Power Authority (NYPA) ensures a coordinated, well-funded solar energy expansion plan.

John Love talked about NYSERDA's smart grid initiative (focused on the New York market), which is a part of its R&D program. The smart grid program is funded by the SBC, paid by the rate payers with the exception of Long Island. New York Independent System Operator (NYISO) oversees 11,000 miles of transmission in the state and 34,000 MW generation capacities from 300 generators, with summer peaking demand that could reach 34,000 MW, but typically varies between 17,000 – 26,000 MW. The state is interconnected with New England (through NEISO), PJM, and Canada. New York's generation mix is 18 percent hydro, 16 percent import from Canada, 27 percent nuclear and 26-30 percent natural gas. Coal is gradually on the decline as gas and solar/wind resources are increasing.

The smart grid program that works with seven utilities in the state has a goal to improve transmission/distribution grid reliability and security. Another goal is to promote diversified generation such as distributed generation (DG), fuel cells, battery storage with large building load, while keeping focus on emerging technology (e.g., super conducting technology). One of the key goals has been to reduce the pressure on the grid. If the system peak demand can be reduced in August (peak month) by distributed initiatives, it will reduce overall system cost resulting in meaningful savings.

Renewable energy integration is also on the agenda, particularly with the New York Sun program in mid-2020 that will lead to substantial solar generation. Any project for smart grids has to have partnership with the utility, either through direct participation or through knowledge sharing and endorsement of the utility. Smart grid programs should enable customers to reduce cost and energy consumption by being efficient, and by minimizing environmental impact. More and more requests are being received on electric vehicles (EVs) and renewable integration. NYSERDA issues periodic solicitation on cost-sharing basis with the proposer.

Program opportunity notices are posted so anyone can respond to the need and avail the opportunity. Program categories range from research and engineering; engineering studies, product development in the area of smart grids (least responded category); to demonstration projects (most funded). NYSERDA insists on 50 percent cost sharing (in cash/kind) from the proposer. The smart grid areas currently covered are – WAMS using PMUs, grid-scale

energy storage, distributed clean energy integration, and T&D automation. Proposals are called for in broad categories (e.g., energy storage and non-energy storage).

List of solicitations that have come out in the smart grid areas are posted on the website. Also listed are 60 projects in smart grid areas, which are either completed or are ongoing or in the contract phase. Among current projects are:

Super conducting technology – ConEd is looking at a super-conducting cable connecting two substations to back-feed power if one cable goes down; has fault line limiter.

Communication technology – New York Power Authority (NYPA) has been involved with fiber optics installed in the system, which are unused and need to be utilized.

Distribution System – ConEd is implementing an integrated system model (ISM) – built out of a number of circuits and has installed a number of smart equipment on the line. Central Hudson Utility will be integrating into their transmission system – so will defer building a new substation. Southern Rockland Utility is also looking at integrating this system into their transmission network.

Transmission System – (1) PMUs with NYISO across the grid are strategically located. Readings are GPS time-stamped. Grid operators can detect any perturbation on the grid and take preventive action. This can be useful in prediction of blackouts, etc., at the time of exigency. It gives much greater detail of grid operation. (2) Dynamic line rating – transmission lines are constrained by physical characteristics. Grid operators operate up to a static limit based on the ambient temperature. However, this is only possible if weather and temperature variations allow these lines to operate beyond their static limits. Hence, line limits can be raised depending on weather conditions. (3) Congestion management and optimum power flow – through automation of equipment. The NYSERDA website has the project updates. The system is proving to be extremely useful to prevent outages and system black-outs during extreme conditions such as those faced during hurricane Sandy.

EVs/PHEVs (Plug-in Hybrid EVs) – EVs are increasingly being adopted in NY City. Although right now there is no major EV project (though DOE does have pilots across the country), this area is to be assessed and considered, especially from the point of view of shifting the peak, with V2G/G2V in EV deployment in urban areas. The transportation group is focused on EV integration. Not a whole lot of NYSERDA-supported research activities have been seen in this area. There is a CHARGE NEW YORK program with a goal to put in excess of 4,000 EV stations in NY State. NYSERDA is conducting independent studies of TOU and TOD impact, to assess dynamic pricing frameworks.

Micro-grid – During hurricane Sandy, when a large portion of NY grid was down for two weeks, New York University still had power because of their micro-grid and combined heat and power. They kept their 40 buildings powered up during the storm. As a result, micro grids have generated lot of interest. NYSERDA is looking at how micro-grids and distributed resources can help in critical situations. Micro-grids have become a subject of legislative study, and a popular technology under solicitation. There is currently a project in a hospital in lower Manhattan, and another project for a medical campus in Buffalo. For solar rooftops, New York has net metering legislation.

AMI – Advanced Metering Infrastructure (AMI) with two-way communications between the utility's IT and data systems, and smart meters and energy management devices are key components of smart grid technologies. AMI enables Automatic Meter Reading (AMR), and replaces earlier AMR and remote meter reading technologies. AMI is not a focus of NYSERDA, as there is already a large amount of funding and activity in this area.

Data analytics – NYSERDA works with a utility in partnership and there is an academic partner also. Pilot projects are linked to clear output requirements. The utility learns from the project, and NYSERDA calls for transfer of knowledge by the proposer to the utility.

NYSERDA projects generally have a review process by outside experts.

Tuesday, January 21, 2014, 1:00 – 3:00 PM, Consolidated Edison (ConEd) at 4 Irving Place, NY, NY 10003.

Note: All pictures/photographs in this section are courtesy of ConEd.

The visit was coordinated by Andre Wellington, Project Specialist - Smart Grid Implementation Group, ConEd. The topics of discussion were ConEd's energy market and policy, smart grid investments, demonstration project, and 3G system of the future.

Consolidated Edison Company of New York and Orange and Rockland Utilities are subsidiaries of Consolidated Edison, Inc. (Con Edison, or ConEd), one of U.S.' largest investor-owned energy companies, with approximately USD 14 billion in annual revenues, USD 34 billion in assets, and over 15,000 employees. The utility provides electric, gas and steam service to more than 3 million customers in New York City and Westchester County, New York, and serves a peak demand of over 13,000 MW.

The agenda for the presentation/discussion was organized as follows:

1. Demand Response (DR) program
2. Stimulus project
3. Project Details
4. Investment Grant project
5. Future SG Development
6. Q&A

The following presenters/speakers from ConEd were present:

Name/Designation	Presentation Topic
Andre Wellington, Project Manager	Smart Grid Demonstration Project
Aseem Kapur, Department Manager	Smart Grid Investment Grant
Kiley Rode, Project Manager	3G System of the Future
Margaret Jolly, Director, Research & Development	Energy Markets and Policy
Raghu Sudhakar, Project Specialist	Demand Response
Thomas Magee, General Manager	Smart Grid Implementation

ConEd's DR Program was presented by Raghu Sudhakar, who went over general market information, followed by ConEd's current program and its development.

In New York and most of the U.S., transmission (100 kV and above) is under federal jurisdiction. On the wholesale level, one MW decrease in load is equivalent to one MW increase in generation. System reserve margin is 15-17 percent. At the transmission level, NYISO manages a capacity market, and retains hourly data for the last 30 days. The NYISO has four DR programs that fall under the categories of reliability and economic DR programs. These are: Emergency Demand Response Program (EDRP), ICAP Special Case Resources (SCR) Program, Day Ahead Demand Response Program (DADRP) and Demand Side Ancillary Services Program (DSASP).

Both the EDRP and SCR programs can be deployed in energy shortage situations to maintain the reliability of the bulk power grid. Reductions are voluntary for EDRP participants, whereas SCR participants are required to reduce power usage and as part of their agreement, are paid in advance for agreeing to cut power usage upon request.

DADRP allows energy users to bid their load reductions, or "negawatts", into the Day-Ahead energy market as generators do. Offers determined to be economic are paid at the market

clearing price. DADRP allows flexible loads to effectively increase the amount of supply in the market and moderate prices. DSASP provides retail customers that can meet telemetry and other qualification requirements, with an opportunity to bid their load curtailment capability into the DAM and/or Real-Time Market to provide Operating Reserves and regulation service.

New York has policies that mandate DR programs. Due to the growth in retail load in several pockets (e.g., Brooklyn), the ConEd network is stressed. DR helps reduce peak load that results in deferring investments on substations. Capital deferment is the core concept of DR. ConEd's DR programs are designed specifically to support the operation of the electric distribution system, whose voltage is below 100 kV and consists of lines, transformers and other equipment. It offers two types of DR programs – contingency and peak shaving, which focus on supporting reliability at peak hours, and reducing costs of operating the electric distribution system. The programs operate during the prescribed summer period of May through October. DR options include load curtailment; or having behind the meter generation. ConEd has more than 1,000 MW of DR on a system of 34 GW. In PJM, there is 15,000 MW DR load on a five times larger system. The DR target is in the range of 3-10 percent of the peak demand. Large consumers can participate directly in the program; small consumers can go through aggregators.

ConEd's DR programs designed for larger commercial customers are: (1) Distribution Load Relief Program (DLRP) for NYC and Westchester County; and (2) Commercial System Relief Program (CSRP) for NYC only. DLRP runs through the summer months and needs a 2 hour notification. It is required to run for a minimum period of 4 hours. DLRP is a network contingency DR program applicable to individual customers who can reduce demand by greater than 50 kW during an event and Curtailment Service Providers (CSPs) who aggregate greater than 100 kW of demand reduction. DLRP has two program options, mandatory and voluntary. The mandatory option is also referred to as the Summer Reservation Payments option.

CSRP is open to participants who can curtail load or bring on certain on-site generation to reduce their demand by a minimum of 50 kW individually, or to Aggregators/CSPs who aggregate greater than 100 kW of demand reduction with a minimum of 21 hour notice before a planned event. CSRP includes both a mandatory and a voluntary option. Participants enrolled in the mandatory option receive monthly reservation payments of USD 5 per kW per month. During summer periods that include five or more planned events, the reservation payment is USD 10 per kW per month during months in which by the end of the month there have five or more cumulative planned events in the network since the summer period began.

DR programs designed for smaller commercial and residential customers are: (1) Direct Load Control ((DLC) for NYC and Westchester County; and (2) Residential Smart Appliance Program (RSAP) for NYC only. DLC has two components: Residential and Business. ConEd provides and installs free of charge a thermostat with Internet-enabled technology that becomes the property of the enrolling business/residential customer. In addition, participants receive a one-time incentive of USD 25 or USD 50 for enrollment in the business/residential program. The thermostats allow customers to remotely control their central air-conditioning

units. Customers have the ability at all times to over-ride any event the company has called. Customers are able to program their thermostats online through a personal computer or smart phone. Approximately 25,000 customers participate in the program, using 31,000 thermostats that provide 35 MW of peak load reduction.

RSAP Participants receive a rebate for each smart or DR-ready appliance, and in return, the company curtails the appliances as needed during system critical conditions. RSAP targets peak shaving DR from a wide cross-section of residential customers with ACs. This program is activated when the Day Ahead forecast is 96 percent (or greater) of the forecasted summer peak demand.

DLRP and DLC are contingency programs, whereas CSRP and RSAP are considered to be part of the peak shaving programs.

Measurement and verification (M&V) on all programs are conducted by outside consultants through performance analysis. Individual and aggregate results for events and tests are calculated, and reports are generated as necessary. The demand reduction results are used to determine appropriate payment for customers and the aggregate effect on the ConEd system. DR is assessed using the customer baseline (CBL) methodology. Starting with the last 30 days' demand data, baseline calculation removes low usage days (e.g., weekends and holidays), then develops an average load curve with the rest of the data. Deriving a realistic baseline calculation is a non-trivial issue. DNV KEMA is a leader in this area for a lot of countries.

Metering requirement – Interval meters with data collection every 15 minutes is mandatory for DR customers. ConEd provides free interval meters to customers with peak demand above 500 KW.

Compensation – Federal Energy Regulatory Commission (FERC) in the U.S. has done a net benefit test and stated that DR has to be dispatched if it benefits customers.

Comparability issue – NYISO has a supply comparability issue. For example, 1 MW demand reduction is the same as saving 1 MW of power generation. Similar rules must govern generation and DR. If a plant has a start-up time of 6 hours for a steam unit or 60 minutes/30 minutes for a gas turbine, then DR should also be available within that time.

Communication technologies – ConEd has some challenging issues in this area. Currently, the program is looking at Wi-Fi capabilities, different DR strategies, and integration with other company offerings, to expand the program's technology range.

Consumer education – A Demand Response Forum was held to invite aggregators, consumers, etc. for discussion and several participants attended and received information. ConEd also has advertising on its website (on the Federal side, there is no advertising campaign). Community-based programs also exist.

Settlement issue – There are disputes on settlement. But generally on the Federal side, no disputes remain and market settlements are arranged.

The Smart Grid Stimulus Program presentation was made by Andre Wellington, who is a Project Specialist - Smart Grid Implementation Group.

The ConEd Smart Grid Program consists of:

- Leveraging existing Smart Grid components
- Comprehensive demonstration in UG distribution network
- DOE Stimulus Smart Grid Deployment Program
- DOE Stimulus Smart Grid Demonstration Program
- Recommendation for future Smart Grid implementation

ConEd won support for multiple projects under the ARRA stimulus fund from DOE that include expansion of transmission and distribution smart grid investments (USD 280 million); a smart grid demonstration pilot in Queens (USD 6 million), and participation in a New York State demonstration project (USD 111 million). The stimulus funds broaden the scope of ConEd's existing smart grid efforts to modernize the electric grid in the most complex energy market in America and add self-healing capability with increasing resiliency, and enhance customer resources including renewable energy in grid management, as well as interoperability. The company is testing various technologies in a smart grid pilot project in Queens.

The Smart Grid Investment Grant presentation was made by Aseem Kapur, Department Manager of Smart Grid Implementation Group.

ConEd operates the world's largest underground electric distribution system in New York City and neighboring Westchester County. 86 percent of its system is underground, with 94,000 miles of underground electric cables and 36,000 miles of overhead electric wires. There are 26000 underground transformers, all with remote monitoring capabilities. Pressure, Temperature and Oil (PTO sensing) are monitored to provide New York City with more reliable and affordable power. ConEd is upgrading its distribution system to reduce the frequency and duration of outages and improve power quality. Some of the underground equipment is submersible now – in order to operate in a flooding situation.

The USD 280 million federal grant has been allocated as: distribution automation (82 percent); modeling and simulation (8 percent); and energy efficiency and loss reduction (10 percent). Close to USD 400 million has been funded in the New York area, out of which USD 280 million is in investment projects and the rest in demonstration projects. As ConEd's projects near completion, the value of the investments has become clear. As of Fall 2013, ConEd has demonstrated the following benefits from the Stimulus Act projects:

Increased System Reliability is demonstrated in: (1) 57 percent reduction in risk of major outages in targeted underground distribution networks. (2) Deferral of CapEx investments, and (3) 28 percent reduction in customer interruption rate (SAIFI) on targeted overhead circuits. Ability to segment the Flushing network into three smaller networks (Sub-Networks A, B and C) through the installation of automated underground switches with 900/220 MHz RF wireless communication has been introduced to reduce the risk of a large network outage, and to improve operational flexibility and reliability. Underground sectionalizing switches enable isolation of sections during contingency situations like in hurricane Sandy.

Expanded System Monitoring & Control shown in: (1) 300 percent increase in feeder sectionalizing capability across the underground distribution system, (2) 230 percent

increase in underground transformer monitoring capability, (3) 75 percent increase in distribution SCADA system capacity, and (4) 35 percent increase in automated feeder restoration capability on overhead distribution system.

Increased cybersecurity established by: (1) implementing new cybersecure SCADA systems to enable two-way communication and control, and (2) implementing comprehensive cybersecurity controls and risk assessment methodologies for smart grid investments.

Also, new jobs have been created and over 3,000 metric tons of carbon emission reduction achieved.

ConEd's proof of concept/smart grid pilot project that started in northwestern Queens area to test a range of technologies to modernize the grid, will also be expanded. Select number of assets and consumers are to be mapped on GIS for this project, but not all were mapped. The PACE-D team mentioned that in India, GIS mapping in all APDRP towns is complete (24 out of 64 underground network mapped in the visualization platform), though it is yet to be put to use. On the visualization platform, the system operator can see zones with overload elements, current network status, and available resources (e.g., DR, etc.). Complete mapping of the city is in the plan, including EV controllers and charging stations, and building management systems. Although it is not available for the entire city of New York, the platform introduced as of now is to test that it works. As the grant projects come close to completion (in the next three months), ConEd is planning to roll out more project initiatives.

ConEd's communication network has been designed and constructed to support smart grid technologies. The communication backbone is based on network infrastructure with convenient access points for member companies and other communications carriers. It also allows the physical network to route traffic around the core business district if necessary. ConEd uses Silver Spring Networks, Gridscape, Master e-bridge, relays, Remotee-bridge providing wireless communication mesh network with high security, high performance wireless solutions and data management. Lessons learned from ConEd project experience include: 1) integration of 2-way SCADA communication systems is important for interoperability, (2) communication platform has to be reliable and cost-effective, (3) standardization of cybersecurity control is essential, (4) project documentation should include detailed system description, (5) maturity of selected technology should be a prerequisite, and (6) use of graphic screen manager (GSM) meter helps in monitoring.

To provide diverse paths, ConEd uses a ring-based topology over its 100 percent fiber network. This network architecture creates self-healing, diverse network routes with the highest possible reliability and availability along with nearly unlimited bandwidth and scale.

As mentioned earlier, during hurricane Sandy, key buildings on New York University's campus stayed alight because of a self-sufficient micro-grid system, designed to distribute electricity independently of ConEd's main grid network. A self-contained grid system equipped with on-site power generation, micro-grids can keep operating as isolated entities even when the interconnected grid is under emergency conditions with critical shortage of power. Funded by NYSERDA, ConEd will investigate how distributed energy resources (DER), including micro-grids, can be integrated to increase resilience. It will look at two

target areas of the electrical distribution grid within ConEd's service territory. The assignment will include grid analysis and gathering stakeholder input to create recommendations on how power systems technologies – including Active Network Management – can be used to create future smart grid and smart city infrastructure through the facilitation of micro-grids.

As added smart grid project benefits are realized, ConEd will share lessons learned and system improvements with utilities around the country as well as the federal government. This is also required under the program monitoring framework set by the DOE.

Although ConEd team was willing to spend more time on Q&A and discussion, the PACE-D team had to leave by 3:30 PM, since New York was in the midst of a severe snow storm and snow emergency, and the team had to leave for Pennsylvania where their meeting was scheduled the next day at PJM, in Norristown, PA. Due to the snow storm, two normal hour bus trips ended up to be close to six hours in duration.

Wednesday, January 22, 2014, 9:30 – 11:30 AM, PJM Conference and Training Center at 2750 Monroe Boulevard, Valley Forge Corporate Center, and Norristown, PA19403.

Note: All pictures/photographs in this section are courtesy of PJM

The PJM coordinator was Tracy Miehlke. Due to abnormally cold weather increasing demand for electricity, and stress on generation, PJM issued a cold weather alert during the PACE-D team visit that kept key people being tied up at the control center. Some presenters originally scheduled could not be present for the meeting. The PJM team consisted of:

Name/Designation	Presentation Topic
Tracy Miehlke, Senior Analyst/International Relations Liaison	Overview of PJM System
James Kirby, Senior Engineer	PJM Markets, Operations, and Smart Grid Initiatives

Tracy Miehlke provided an overview of the PJM system, followed by Jim Kirby who discussed the PJM market, operations, and smart grid initiatives. Founded in 1927, PJM is a regional transmission organization (RTO) with more than 850 member companies. Governed by an independent board and member committee, it coordinates the movement of wholesale electricity in all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia. A revenue neutral non-profit organization, PJM's job is to ensure there is enough electricity for the 61 million people under its region. PJM monitors and coordinates more than 1,376 electric generators and 62,566 miles of high-voltage transmission lines. But it does not own transmission and generation assets, or stock, and does not take ownership of energy. PJM's vision is to be the electric industry leader in reliable operations and efficient wholesale markets. It is responsible for market operations (energy, capacity, and ancillary services), system reliability, and long-term regional planning (15 years' outlook). The organization has grown in 10 years from 200 to 800 employees. All public information is available on the PJM website except for the proprietary data of individual companies.

PJM controls the operation of about 183 MW of generating capacity in its territory. There are 1,376 generating units that serve the demand. The capacity from generating units is supplemented by power purchases from other sources, when needed.

To manage the electric system, PJM acts as a data clearinghouse and decision-maker. Using sophisticated computer programs, it forecasts how much electricity will be needed each hour and arranges to meet that demand from the available generation and other sources. As the actual demand changes in real-time, PJM adjusts the generation and other sources to balance the demand while maintaining the transmission system at safe operating levels. Transmission system maintenance is coordinated by the transmission system operating companies with PJM through outage scheduling. The 1965 blackout in PJM was caused by the low-relay settings that had caused the line to trip and drop generation and load.

PJM continuously monitors the electrical system 24 hours a day, reacting to changes in demand, equipment problems, weather conditions and other factors to maintain safe and reliable service, while meeting customer needs for electricity when and where it is needed. In order to maintain a smooth and transparent operation, PJM maintains two parallel control centers: one in Valley Forge/Norristown, and the other in Milford. This is done to ensure

redundant and continuous communication between the two control centers, as well as continuous communication and operational awareness of PJM member companies. In protecting the reliability of the electric system, PJM experts study tens of thousands of “what if” scenarios, assisted by computer simulation programs that help them prepare for almost any event.

PJM administers competitive wholesale markets for large blocks of electricity. PJM markets attract alternative power sources, such as wind, to the region. A DR program is administered to help keep electricity prices as low as possible. DR allows customers to be paid for reducing their electricity usage during periods of higher power prices.

Managing the future needs of the electric system is an integral part of PJM’s role as an RTO. PJM conducts a long-range Regional Transmission Expansion Planning (RTEP) process that identifies the changes and additions needed in the grid to ensure reliability and successful operation of the wholesale markets. PJM’s open and extensive review process ensures that all interested parties, including state regulatory agencies, have an active role in planning for future electricity supply and reliability needs.

A developer wanting to explore business opportunities as a power producer in PJM has to enter into a planning "queue" of PJM's interconnection process. The queues reflect a period of time for which a group of projects begins the process. The process entails three major interconnection studies and the completion of several milestones before a generating plant is deemed "in-service."

PJM has wind energy generation at 30 percent capacity factor in its system and solar at 38 percent capacity factor. Solar comes with its own unique set of requirements. It is under distribution for most part of the country; because it is small (1-1.5 MW solar energy farms are typical). Renewable energy credits do exist in PJM. It has a procedure for wind forecasting, based on a tool from Germany. There is also a meteorologist on the team. Volatility in wind generation is handled through allowable adjustments in the wind forecasting (NREL data). A typical problem with higher wind power production in the off-peak (night-time) hours is that it forces electricity prices into the negative range. During low-load periods, keeping renewable generation operating could force power reductions on baseload units like nuclear and coal plants. The storage of electricity through flywheel, pumped and compressed air storage, and electric vehicle has gained grounds and generated a lot of interest in order to provide the grid operators with better tools in dealing with fluctuations in the output of these power sources.

Electric transmission network with interconnections such as the North American transmission grid connecting Canada, U.S., and Mexico, provide enough redundant and alternative power flow paths that can help avoid major power failures. To improve the reliability of the North American bulk power grid, the North American Electric Reliability Corporation (NERC) oversees the operation of the eight North American regional entities. The members of the NERC regional entities are: investor-owned utilities; federal power agencies; rural electric cooperatives; state, municipal and provincial utilities; independent power producers; power marketers; and end-use customers. These entities account for virtually all the electricity supplied in the U.S., Canada, and a portion of Baja California Norte, Mexico. The North American electric grid is divided into three major interconnections:

the Western Interconnection, the Eastern Interconnection, and the Electric Reliability Council of Texas (ERCOT). These interconnections operate independently from one another, although there are a few DC ties that link them with one another. The NERC regions within each interconnection conform to established operating and planning standards to ensure the reliable operation of the grid within each region. PJM is part of the eastern interconnection. Of the three interconnections, ERCOT is a self-contained market on a standalone grid with only 1,100 MW of transfer capability through asynchronous DC ties with the Southwest Power Pool (SPP) and Commission Federal de Electricidad (CFE) in Mexico.

PJM operates energy, capacity, ancillary services, and financial transmission rights (FTR) markets. It uses locational marginal pricing (LMP) to establish the price of energy purchases and sales in the PJM wholesale electricity market. LMP takes into account the effect of actual operating conditions on the transmission system in determining the price of electricity at different locations in the PJM territory. LMPs at more than 10,000 nodes are calculated every 5 minutes, taking into account electricity demand, generation costs and the use of and limits on the transmission system. The formula for LMP is the sum total of generation marginal cost (cost of serving the next MW), transmission congestion cost and marginal cost of losses. The use of actual operating conditions and energy flows in determining LMPs encourages the efficient use of the electric grid and enhances reliability. LMP also lets the wholesale market participants see when and where the system is stressed (due to transmission congestion). The FTR provides a hedging mechanism (financial instrument) that is traded separately from transmission service in order to provide the market participants with the ability to mitigate transmission congestion risk and gain price certainty when delivering energy across PJM. Other than the real-time market, PJM has a day-ahead market, which is a forward market in which hourly LMPs are calculated for the next operating day based on generation offers, demand bids and scheduled bilateral transactions.

PJM's energy scheduling practices are governed by the open access transmission tariff (OATT). The 2,700 page OATT document is available on the PJM website. With PJM's current systems becoming limited in applying data mining, need for state-of-the-art technology for processing massive quantities of real-time data (20,000 + data points in 2-10 seconds) that provides immediate and accurate results from analyses and transactions became necessary, leading its way to smart grid technology.

PJM received a DOE smart grid investment grant (SGIG) to install phasor measurement unit (PMU) devices and robust network to enable wide area situational awareness (includes: off-line data analysis, real-time wide area monitoring, system dynamics monitoring, and system control/protection/reliability). The project started with installing PMUs at 84 substations, and building support for 150+ substations. All generators 20 MW or higher are currently required to install synchrophasors within 2 years. For synchrophasors on the retail side, PJM will have to gain acceptance of the public and state regulator to promote it.

Wednesday, January 22, 2014, 1:30 – 4:00 PM, Pennsylvania Public Utilities Commission (PA-PUC), 400 North Street, Keystone Building, Harrisburg, PA 17120.

Note: All pictures/photographs in this section are courtesy of PA-PUC

The PA-PUC coordinator was Daniel Searforce. The host team included a PA-PUC commissioner and PPL Electric Utilities staff.

Name/Designation	Presentation Topic
Daniel Searforce, Reliability and Emergency Preparedness Supervisor, PA-PUC	Smart Grid Overview and Energy Efficiency Program
Pam Witmer, Commissioner, PA-PUC	Cybersecurity efforts by the PUC
Bill Keller, Distribution Planning, PPL	PPL Transmission and Distribution System, Smart Grid Pilot Projects
Beth Johnson, Regulatory Compliance, PPL	

Daniel Searfoorce started the meeting with instructions and opening remarks. Commissioner Witmer described cybersecurity efforts by the Pennsylvania PUC (PA-PUC). The latter has 500 employees in its staff to oversee commission activities.

The PA-PUC role in cybersecurity is to ensure compliance with law and regulations with an annual review/test/alteration process. The key elements include: (1) Cybersecurity legislation has an exemption from the RIGHT TO KNOW requests and confidential security information; (2) penalty for the commission employees for disclosing covered information; and (3) legislation for customer privacy protection and data sharing[3]. PA-PUC cybersecurity regulation requires utilities to: (1) identify mission-critical functions and equipment; (2) develop plans covering physical security, cybersecurity, emergency response, and continuity of business operations; (3) adopt an all-hazards approach to security planning; and (4) submit self-certification.

PA-PUC is also facilitating the development of a voluntary cybersecurity contact list for regulated and non-regulated companies, initiating workshops and multi-state commission working groups, putting together a set of best practices, developing cybersecurity training for

[3] **Statute:** 66 Pa. Cons. Stat. § 2807 **Regulation:** 52 Pa. Code § 54.8. In Pennsylvania, a utility must notify the customer of the company's intent to share the data with a third party. Additionally, it must provide a convenient method of notifying the entity of the customer's desire to restrict the release of the private information before providing customer information to a third party. Customers may restrict the information in three ways: by returning a signed form, orally, or electronically.

the commission staff, releasing draft policy statement regarding its Critical Infrastructure Interdependency Working Group, and working with internal IT to review and harden the commission's system.

Daniel Searforce gave an overview of PA-PUC's smart grid initiative. PA-PUC does not have a formal state Smart Grid policy. PA Act 129 of 2008 has some smart grid aspects for smart meter deployment and energy efficiency and conservation program requirements for the 11 electric distribution companies (EDC) in the state. PA-PUC encouraged EDCs to apply for Federal Smart Grid project monies. American Recovery and Reinvestment Act of 2009 provided USD 4 billion in Federal support with roughly 50/50 project cost split. Currently there are four EDCs participating – PPL, PECO, Met-Ed and Wellsboro. EDC investments in smart grids are recovered through the normal rate-making process. Smart meter deployment investments may be recovered via rate cases or on a current basis via a surcharge reconcilable each year. PA-PUC has consumer data protection regulations. It requires all utilities to have 4 emergency plans (Physical Security, Cybersecurity, Emergency Response, and Business Continuity).

Pennsylvania's ACT 129 was signed into law on October 15, 2008. It impacts PA's largest electric utilities (100,000 or more customers). Phase 1 spans from 6/1/09-5/31/13 and requires 3 percent consumption reduction by 5/31/13 and 4.5 percent peak demand reduction by 5/31/13. Phase 2 started from June 2013 and will end in May 2016. It will have utility-specific consumption reduction targets. ACT 129 has a M&V process. It requires the Technical Reference Manual (TRM) to be updated annually. TRM provides protocols outlining how a utility will determine savings for a measure. Some protocols provide deemed savings (set amount of savings for a measure). Others provide equations to determine savings (variables to be changed based on the scenario).

PECO received USD 200 million from federal grants out of its total budget of USD 415 million for smart meters and supporting network technologies (1.2 million smart meters by the end of 2014). PPL received USD 19 million out of a total budget of USD 38 million for smart grid projects. Met-Ed received USD 16 million for direct load control devices and USD 2 million for DA equipment. Wellsboro received USD 430K out of a total budget of USD 961K

for smart meters and a pilot program for in-home displays. About ½ (3,000) customers have been provided with smart meters, although Wellsboro is not required by Act 129 to install them.

The commission currently has appointed a state wide evaluator (SWE) contracted through Phase 2, selected through a request for proposal (RFP) process to provide evaluation, measurement and verification of utility programs. The current SWE is a consortium of: GDS Associates, Inc. with Nexant Inc., Research Into Action Inc., and Apex Analytics. Among the SWE duties are: (1) Review utility reports/filings for technical merit; (2) Provide reports to the commission regarding utility performance, (3) Perform annual TRM updates, and (4) Perform studies to aid the commission in determining future Act 129 mandates.

All 7 large EDCs (over 100,000 customers) have submitted smart meter deployment plans for all customers as required. PECO has largely completed their deployment as well. PPL has previously installed advanced meter infrastructure, but not all required functionalities can be met currently. Duquesne will begin deployment in 2014 with full deployment by 2020. First Energy (Met-Ed, Penelec, Penn Power and West Penn Power) may begin in 2014 with 99 percent deployment by 2019.

Smart grid investment recovery options are: (1) through base rates, and (2) a reconcilable automatic adjustment clause on a full and current basis. All EDCs in Pennsylvania are using Option 2. Other smart grid investment recoveries will be through normal rate case process. Another possible Smart Grid Investment Recovery is: Distribution System Improvement Charge (DSIC). DSIC filing must include a Long-Term Infrastructure Improvement Plan.

Consumer Data Protection –In Pennsylvania, utilities cannot release private customer information to third parties without notification and ability to opt-out. Utilities must ensure the privacy and confidentiality of identification information provided by customers. Also, customers are given the option to withhold all data from eligible customer lists.

EDCs are required to abide by national industry standards for electronic data interchange. There is an Electronic Data Exchange Working Group (EDEWG) process for consumer data protection. National Institute of Standards and Technology (NIST), North American Energy Standards Board (NAESB) and Utility Communications Architecture International Users Group (UCAIUG) are developing data protection standards. Development standards are currently being completed for: (1) historical interval usage data, and (2) bill quality (verified, estimated and edited) interval usage data.

Data protection is also ensured through: (1) restriction on third-party access to meter data (access only to customers or their authorized agent); (2) encryption on meter wireless communications; (3) requirement of installing a cybersecurity component on any federal grant-funded smart grid projects; and (4) reporting by EDCs of any cyber-attacks that cause customer outage and/or USD 50,000 in damage.

Cybersecurity – Cybersecurity plans need to be written, updated and tested. Every 3-5 years, there will be an audit review. PA-PUC partners with state, and federal agencies for ensuring cybersecurity.

Consumer Education – Pennsylvania law requires companies to institute education programs for customers.

PPL Presentation

PPL Electric Utilities is a part of PPL Corporation, headquartered in Allentown, Pennsylvania. It has 1.4 million customers in Pennsylvania and a service territory of 10,000 square miles. The company has 358 distribution substations, 45,000 miles of distribution lines, and 1,191 distribution circuits – 4,918 miles of transmission lines and 59 transmission substations.

PPL Electric Utilities Smart Grid consists of automated switching on the distribution system with remotely operable devices (switches, reclosers, intelligent switches) and ultimately self-healing circuits. It has 500 customer blocks.

The company's USD 38 million (half from U.S. Department of Energy) smart grid pilot program Harrisburg 2010-12 consisted of building a WiMax network to communicate to nearly 300 devices (included automated capacitors, switches and reclosers). The company began developing a Distribution Management System (DMS). More than 60,000 customers are benefitting from 50 percent improvement in service reliability (SAIDI) has been considerably lowered in smart grid feeders. They also monitor SAIFI and Customer Average Interruption Duration Index (CAIDI). PPL has ultimately switched to cellular from WiMax because of the cost issue (WiMax is very expensive). PPL implemented the Green button[4] initiative for customers to download data in spreadsheet format from their website.

Among the lessons learned from the pilot were: (1) Communication is the key to success (individual devices rather than geographic); (2) Distribution circuit load capacities are important; (3) Choose local vs. centralized control or a hybrid of the two; implementing DMS was a challenge; (4) Transmission system is also important – PPL Electric Utilities is adding "smart-grid transmission circuits; (5) Smart meters helped in detecting and improving non-technical losses (e.g., theft); and (6) Staff are required to analyze the data from the smart meters to detect data anomalies.

PPL will carry out cost recovery through distribution base rate cases. It will use Pennsylvania Act 11 of 2012 - Long-Term Infrastructure Improvement Plan (LTIIP), Opportunity to use a Distribution System Improvement Charge (DSIC) accelerated recovery of eligible investment. Accelerated recovery in DSIC has been a great incentive.

[4]The Green Button initiative is a DOE supported industry-led effort that responds to a White House call to provide utility customers with easy and secure access to their energy usage information in a consumer-friendly and computer-friendly format. Customers are able to securely download their own detailed energy usage with a simple click of a literal "Green Button" on electric utilities' websites. See http://energy.gov/data/green-button

Thursday, January 23, 2014, 9:00 – 11:30 PM, Baltimore Gas & Electric (BGE), Baltimore Gas & Electric, 110 W. Fayette St, Baltimore MD 21201.

Note: All pictures/photographs in this section are courtesy of BGE

The coordinator from BGE was Ruth C. Kiselewich. The BGE team consisted of:

Name/Designation	Topic
Ruth Kiselewich, Director, Demand Side Management Programs	BGE Smart Grid and Demand Side Management, Smart Grid Overview
Heather Anderson, Residential Demand Response	Dynamic Pricing Pilot, Smart Energy Rewards enabled through Smart Grid

Key aspects covered included:

- Introduction to BGE
- Rationale for Demand Side Management & Smart Grid programs
- Dynamic Pricing Pilot
- Smart Grid overview (including outage management)
- BGE Smart Energy Rewards® – BGE's dynamic pricing program
- BGE Smart Energy Manager® – BGE's behavioral program using smart meters

Ruth Kiselewich started the presentation with an introduction to BGE. It is Maryland's largest utility with 3,400 employees. It has been in business for 200 years, and is owned by Exelon. It is the first gas utility of Baltimore, with currently 650,000 gas customers, and 1.2 million electric customers, serving 31 million MWh in energy and 7,200 MW in peak load. BGE buys power from the market on wholesale basis to serve their retail customers. BGE does not have long-term power purchase contracts; all purchases are short-term from the market. Avoided cost is calculated at the cost of PJM and forwards (it becomes a proxy).

Maryland has EmPOWER Maryland Energy Efficiency Act of 2008 that requires an aggressive 15 percent per capita reduction in electric consumption and peak demand by 2015. Maryland utilities are required to implement programs to achieve most of the savings programs that must be cost-effective and applicable to all customer groups. Each electric company has to file with the Maryland Public Service Commission (PSC) an electricity savings and demand reduction plan every three years, which is overseen by the PSC.

In 2012, BGE added a smart grid component to the energy efficiency and DR programs to create the BGE Smart Energy Savers Program. The BGE energy efficiency program

includes residential (lighting, appliances & HVAC, retrofits, ENERGY STAR® New Construction, and Smart Energy Manager – Behavioral) and industrial & commercial (Small Business Energy Solutions, Energy Solutions for Business, Retro-commissioning, and Combined Heat & Power). BGE's DR program is only provided for the residential customers (PeakRewards^{SM}, Smart Energy Rewards® – Peak Time Rebate).

BGE piloted Dynamic Peak Pricing as well as Peak Time Rebates beginning in June 2008 with 1,300 randomly selected customers with day-ahead notification of a peak event. Advanced meters were provided to collect 15-minute interval data. Test groups for the pilot included: (1) Price incentive only, (2) Price incentive with in-home display (Orb), and (3) Price incentive with direct load control and Orb. Dynamic peak pricing (DPP) all-in rate included critical (USD1.30/kWh), peak (USD 0.14/kWh), and off peak pricings (USD 0.09/kWh).

BGE's peak time rebate (PTR) program has the same rates as the DPP. Up to 12 critical peak days will be called by 6 p.m. the prior day. Customers who use less during the critical period (2 – 7 p.m.) on any critical peak day will receive a rebate. Customers show the same responsiveness to dynamic pricing whether it is expressed as a price increase during the critical hours or as the availability of a peak time rebate. BGE appointed Brattle Group for an external assessment. Results of the evaluations were found statistically significant, persistent savings over the 4 summer periods of 2008 – 2012. BGE has reduced customer power outages by 32 percent and the average power-out length by 7 percent between 2006 and 2012. Both SAIFI and CAIDI performances have improved. Customers have been very happy and want to stay on the program. BGE believes that:

- Customer communication is the key to success of this program (customers are given a welcome package with pertinent information). BGE performed a large awareness program on TV and mass media at the start of their program. For systems like HVAC, gas furnace, etc., BGE works through dealers.
- Timely feedback on savings is essential to a successful program (customers receive a savings report a few days after each event).

The conclusion from the pilot is that the DPP works if it is implemented thoughtfully by: (1) Developing a simple program design, (2) Engaging and educating participants, (3) Providing robust pricing signals, (4) Providing timely feedback, showing value to participants, and (5) Obtaining feedback from participants.

<u>Smart grid implementation Issues -</u> BGE has full deployment with 800,000 electric meters, and 200,000 gas meters, 90 percent of which are completed. There is a total of 1 million smart meters (already completed - geographical roll-out). Issues related to access to indoor meters at the customer-end is becoming an issue for the remaining 10 percent. Since the commission monitors the situation, BGE does not control it.

BGE has used RF mesh for deploying meters. They are working with Silver Springs. Benefits are assessed on customer, grid, operational, and social issues. Web tools and in-home monitoring tools have been launched to ensure consumers can see their consumption. BGE has fixed the baseline definition for administrative cost. Re-baseline is done for every event.

BGE's Smart Grid Objectives are to: enable alternative pricing structures to reduce peak demand, provide customers with energy management tools, and improve customer service.

The components in smart grid implementation are:

- Remote two-way communication system to all BGE meters
- Meter Data Management System (MDMS) that centrally validates all meter data
- System interfaces to several BGE applications
- Web portal and other tools to provide customers' consumption data and conservation tools

Key Meter Functionality includes: (1) remote reading and control at any time, (2) automatic collection and storage of hourly gas and electric consumption data on a daily basis, (3) remote monitoring of meters for malfunctions, theft and consumption on inactive meters, (4) communications with Peak Rewards devices (i.e., air-conditioner load control switches, remote thermostats, etc.), (5) outage detection, notification, restoration verification, and (6) obtaining data for monitoring power quality.

BGE has four DR programs:

1. Peak Rewards^{SM} Direct Load Control – Started in 2008, this program is currently available to residential customers with central air-conditioning, electric heat pumps and/or electric water heaters. It controls load by smart cycling of air-conditioning and water heaters for bill credits. The former program includes: switch or thermostat option, three levels of cycling: 50/75/100 percent, 315,000 customers (38 percent of eligible), 348,000 devices, and 418 MW demand reduction. The water heater program includes: 100 percent cycling, 79,000 devices, and 15 MW demand reduction. This program was offered to commercial customers, but they did not take

any time to pursue (e.g., disconnected the smart thermostat, etc.). Also, there is not enough incentive for industrial customers because industrial tariff is less.

2. Smart Grid Deployment – Meter installations began in April 2012, all residential customers receive an AMI meter.
3. Smart Energy Manager (SEM) – Launched in October 2012, customers with certified AMI meters can view energy consumption on BGE.com and learn more ways to save energy. It enables customers to receive alerts also. SEM will identify areas for residential customers where energy savings can be made.
4. Smart Energy Rewards – Launched on July 8, 2013 with a default tariff that is applicable to all residential customers with a smart meter. Peak Time Rebate program is available to all customers who have smart meters installed. Customers earn bill credits for reducing electric consumption on approximately 5-10 peak event days each summer called Energy Savings Days. There is no penalty for not reducing consumption.

BGE's multi-phase customer education involves:

Phase 1 (Create Awareness - Q1 2013): High-level program messaging to reinforce Smart Meter communications (Educational Direct Mail and program overview video Educational E-mail Community Meetings), Customer segment (Smart meter installed customers)

Phase 2 (Generate Engagement - Q2 2013): Opportunity for customers to learn about SER and ask questions (Program 'Preview' Postcard and E-mail, 'What to do' video, Outbound Telemarketing Campaign), Customer segment (Smart meter installed customers eligible for SER starting July 2013)

Phase 3 (Encourage Action - Q3 2013): Program details (Welcome Kit Direct Mail (SER and SER/PR versions), Move-in Move-out Direct Mail (SER and SER/PR versions), Event notifications: Phone, Email and/or Text), Customer segment (Smart meter installed customers enrolled in SER).

BGE Smart Energy Rewards Process consisting of behavioral feedback and reinforcement includes the following steps:

- Customer education - Prior to summer season, educate customers
- Call event (day before event) - based on market condition
- Notify customers (day before event) - All residential customers notified via preferred channel (e-mail, phone, SMS, web) within 3 hours
- Calculate baseline (day of event) - Overnight calculate up to 1.1 million baselines in Oracle MDM
- Customers take action (day of event)
- Calculate rebate (the day of event) – kWh reduction * USD 1.25
- Provide feedback - Savings summaries provided via preferred channels (e-mail, phone, SMS, web) within 2 days, Paper versions provided to maximize engagement
- Credit bills – up to 30 days after event

Smart Grid Customer Benefits are summarized as: (1) Track, analyze usage and cost data, (2) Estimate bills, (3) Unusual usage alerts, (4) Compare to "like" customers, (5)

Personalized usage and savings tips, (5) Printed and electronic home energy reports, (6) Access to interval usage data.

The key results of the program were as follows:

- Four Energy Savings Days on 7/10, 7/17, 7/18 and 9/11
- Customer rebates ranged from USD 8.00 to USD 11.00 per event
- Percentage of customers who earned a rebate ranged from 75-93 percent
- Open rates on event e-mails were 57-65 percent - 3 to 4 times higher than industry standards and other BGE e-mails at 20 percent
- SER event call-back rates of .5-1 percent were less than the 3 percent modeled
- High customer satisfaction with the program

Thursday, January 23, 2014, 1:30 – 3:30 PM, Visited National Institute Standards and Technology (NIST), 100 Bureau Drive, Stop 1090, Gaithersburg, MD 20899-1090.

Note: All pictures/photographs in this section are courtesy of NIST.

The NIST team consisted of:

Name/Designation	Presentation Topic
V. Joy Foster, International Specialist, International and Academic Affairs Office	Visit Coordinator
Cuong Nguyen, Program Manager	Background of NIST
Dean Prochaska, National Coordinator for Smart Grid Conformance	NIST Smart Grid Interoperability Standards Program
Jeffrey Mazer, Physical Scientist	Technology and measurement challenges in implementing smart grid projects
Vicky Yan Pillitteri, Acting Smart Grid Interoperability Panel (SGIP) Cybersecurity Committee (SGCC) Chair and Cybersecurity Advisor	Smart grid cybersecurity guidelines

Cuong Nguyen started the discussion. NIST has two campuses: one in Gaithersburg and the other in Boulder, Colorado. NIST's mission is to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve quality of life. Operating under U.S. Department of Commerce, NIST has 3,000 employees and 2,800 associates. There are three sections: Laboratory program; management part/external facing; and inward services. NIST's focus areas are: energy, environment, health, IT and cybersecurity, physical infra, and manufacturing. Primary charge to NIST has been given under the Energy Independence and Security Act.

Standards solutions for national priorities include smart grids, electronic health records, cloud computing, etc. NIST is improving U.S. government engagement in standards in the areas of: Federal interagency coordination, Conformity assessment (800+ laboratories accredited by National Voluntary Laboratory Accreditation Program - NVLAP), and Technical underpinnings. NIST researchers lend their expertise to 1,000+ standards-related activities and 100+ technical committees. There are approximately 400 staff researchers. NIT provides leadership in ASTM International, Institute of Electrical and Electronics Engineers (IEEE), International Organization for Standardization (ISO), International Electrotechnical Commission (IEC), etc.

Focus areas in energy include: Alternative, Renewable Energy (Photovoltaics, Biofuels), Specially-tuned LEDs match solar spectrum providing more accurate testing and power output ratings for PVs, Electric Power Metrology (Accurate metering), Energy conservation (Net-zero-energy and "smart" buildings built with the latest energy-saving and producing technologies – the NIST Net- Zero House will support a simulated family of four with "net-zero" energy usage), Energy conversion, storage, and transport (High temperature superconductors, hydrogen pipelines).

Information technology/cybersecurity is another key area of research.

Dean Prochaska went over a brief background of the North American electric grid (3,200 utilities, 17,000 plants, 800 GW peak demand; USD 350 billion revenues) and an overview of smart grid with definitions [smart grids are not greenfield, hence inter-operability is essential - 2 hours per year of outage (drivers for grid modernization) vs Japan where it is only 16 minutes]. Power outage costs the US economy USD 80 billion per year.

Smart grid is a U.S. national policy. Congress directed that:

- The framework should be "flexible, uniform, and technology-neutral"
- Use of these standards is a criteria for federal Smart Grid Investment Grants
- Input to federal and state regulators

The NIST Smart Grid Interoperability Plan consists of:

PHASE 1 – Initial Framework and Standards based on summer 2009 workshops, finalized in Jan 2010

PHASE 2 - Public-Private Smart Grid Interoperability Panel (SGIP)

PHASE 3 - Testing & Certification

Stakeholder outreach, NIST staff and research standards, and NIST grassroots support are all essential in this process.

NIST Priority Use Cases are:

- Demand Response and Consumer Energy Efficiency
- Wide Area Situational Awareness
- Electric Storage
- Electric Transportation
- Advanced Metering Infrastructure
- Distribution Grid Management
- Cybersecurity
- Network Communications

Initial NIST smart grid workshops in summer 2009 accomplished the following:

- Identification and review of relevant standards
- Use cases to support gap analysis
- Prioritization of gaps
- 16 Priority Actions Plans – structured efforts to fill gaps
    - Requirements phase
    - Standards development organization handoff
    - Review of delivered standards against original requirements
    - Catalog of Standards review
    - Program Management Office tracking of progress, issues
- Ongoing review, new Priority Action Plans (PAPs) within Smart Grid Interoperability Panel (now 22 PAPs, 9 fully completed).

NIST Smart Grid Framework and Roadmap

- Release 1 - January 2010
- Release 2 - February 2012
- Release 3 – under development
- Smart Grid vision & reference model
- Identifies 100 key standards
- Cybersecurity guidelines
- Testing and certification framework
- Provided a foundation for IEC, IEEE, ITU, and other national and regional standardization efforts

The smart grid interoperability panel (SGIP) was established to provide a framework in support of NIST that is mandated by for coordinating all Smart Grid stakeholders in an effort to accelerate standards harmonization and advance the interoperability of Smart Grid devices and systems. SGIP fulfills this by:

- Facilitating standards development for Smart Grid interoperability
- Identifying necessary testing and certification requirements
- Overseeing the performance of these activities and continuing momentum
- Informing and educating Smart Grid industry stakeholders on interoperability
- Conducting outreach to establish global interoperability alignment

SGIP brings together stakeholders to achieve consensus and supports NIST to fulfill its responsibilities under EISA. NIST and SGIP signed a Memorandum of Understanding (MOU) in December 2012 to continue their collaborative relationship. SGIP submitted a proposal for a Federal Funding Opportunity; selected through competitive process. The cooperative agreement was executed in April 2013.

NIST Framework "Lists": – Attributes of identified standards and standards for further review in Framework, 98 standards in Release 2 (37 identified standards plus 61 for further review), 75 standards in Release 1 (25 identified standards plus 50 for further review)

SGIP Catalog of Standards (CoS) is similar to "Physician's desk reference guide". It is a review process based on the standards information form. It includes architecture, cybersecurity and (in future) testing/certification. The SGIP Governing Board advisory votes before the SGIP plenary vote. Inclusion is based on 75 percent majority of SGIP plenary members voting (50 percent quorum is required). The last SGIP plenary vote was on January 31, 2013 when 13 of 14 new standards were approved. The SGIP CoS now includes 56 standards. The CoS process has moved to SGIP 2.0, Inc.

Cybersecurity and privacy is based on coordination with stakeholders. The role of NIST is that of a tech expert/neutral convener.

The SGIP Smart Grid Cybersecurity Committee (SGCC) has an NIST chair, and industry co-chairs, Over 800 industry participants and multiple subgroups, including privacy. NISTIR 7628 Guidelines for Smart Grid Cybersecurity (3 volumes, V2 privacy) is the latest. It provides initial security architecture, analysis of standards for SGIP Catalog of Standards, leverages NIST IT security expertise (IT security guidelines and standards for federal government systems, cryptography, identity management, and industrial control systems security). SGCC facilitates coordination with other cybersecurity efforts [Department of Energy, National Electric Sector Cybersecurity Organization, Department of Homeland Security, Federal Energy Regulatory Commission, – North American Electric Reliability Corporation Critical Infrastructure Protection standards (NERC CIPs), North American Energy Standards Board (privacy).

The NIST smart grid program consists of: Smart Grid Coordination, Smart Grid System Performance, Transmission and Distribution Operations. Dean also discussed International Smart Grid Action Network (ISGAN) in which India is a partner.

<u>Technology and Measurement Challenges, Jeff Mazer</u>

NIST and Renewable and Sustainable Energy Institute (RASEI) cosponsored a workshop to identify technology and measurement challenges for the smart grid. Integration of renewables and distributed generation, energy efficiency, DR, and load control, efficiency, reliability, security, and stability of the grid were the key topics at the workshop. Focus areas and challenges in all were identified. It is also in the process of setting up a test bed - including PMUs, power conditioning, storage, etc., which is at a nascent stage as of now. Another workshop is being fixed for issues in setting up smart grid test beds.

Smart Grid Cybersecurity, Vicky Yan Pillitteri

NIST established the Cybersecurity Coordination Task Group (CSCTG) in March 2009 to address cybersecurity issues. It moved under the SGIP as a standing working group and was renamed the Cybersecurity Working Group (SGIP–CSWG) in January 2010. It became the Smart Grid Cybersecurity Committee (SGCC) during the changes to the SGIP in January 2013.

SGCC reviews indicated gaps in cybersecurity in the existing standards. These have been referred to respective organizations who will take these into account in the next round of updates. The NIST interagency report 7629 guidelines for cybersecurity are being updated now. (The 2010 version is available for public comments on their website).

The meeting ended at 3:30 pm since the NIST team had to leave for a committee meeting, and the Smart Grid Study Tour proceeded to Washington DC.

January 24, 2014, 8:00 AM – 1:00 PM, Department of Energy (DOE), Forrestal Building, 1000 Independence Ave., SW, Washington DC 20585, Room 1E-245.

Note: All pictures/photographs in this section are courtesy of DOE

There were two back-to-back meetings at DOE – starting with U.S. Trade Development Agency (USTDA) at 8 AM, followed by DOE beginning at 10 AM. Both meetings were coordinated by Russell Conklin, Policy Analyst and Vice Chair, Executive Committee, International Smart Grid Action Network (ISGAN), DOE. The USTDA team consisted of:

Name/Designation	Presentation Topic
Henry Steingass, Regional Director, South and Southeast Asia, USTDA	Introduction to USTDA programs and its activities in India on Energy Efficiency and Smart Grid
Jamie Merriman, Country Manager, India, USTDA	

The meeting started with presentations by Henry Steingass and Jamie Merriman of USTDA. Jamie is responsible for the Agency's energy and information technology portfolios in India. USTDA has supported 100+ activities generating more than USD 1.6 billion in exports of U.S. goods and services to India. Priorities include energy and climate change, transportation (especially aviation), and information and communication technology. USTDA has two key public-private partnership programs: (1) U.S. - India Aviation Cooperation, and (2) U.S. - India Energy Cooperation. The USTDA list showed about thirteen major U.S. companies associated with these programs. However, the list is not all-inclusive. USTDA is involved in several smart grid projects in India such as: Mumbai Demand Side Management Pilot Project – Reliance, Smart Grid Feasibility Study – CESC, Smart Grid Feasibility Study – BESCOM, Smart Grid Feasibility Study – Tata Power DDL, Smart Grid Test Bed Technical Assistance - CPRI, Efficiency and Clean Energy Exchange Program, and Smart Grid Reverse Trade Mission.

While helping companies create U.S. jobs through the export of U.S. goods and services for priority development projects in emerging economies, USTDA links U.S. businesses to

export opportunities by funding project planning activities, pilot projects, and reverse trade missions while creating sustainable infrastructure and economic growth in partner countries. Clean Energy and Transportation are typically large sectors for the agency's activity. During fiscal year 2012, they accounted for more than 75 percent of USTDA's work. Other key sectors include telecommunications, water and the environment, and services. Among USTDA's international business partnership programs (geared to connect U.S. firms with foreign buyers) are: reverse trade missions (foreign project sponsors are brought to the United States to gain exposure to U.S. products and services), conferences, and workshops. Project development programs (designed to demonstrate the effectiveness of commercially-proven U.S. technologies and equipment in the foreign buyer's setting) include: feasibility studies, pilot projects, and technical assistance. Under the project development program, USTDA is partially funding Azure Power to develop Rural Micro-Grid Solar Power pilots that will be deployed in remote non-electrified villages in the states of Chhattisgarh and Gujarat.

USTDA evaluates projects based on: developmental priority in the host country, likelihood of success in receiving implementation financing, and mutual benefits for the U.S. and partner country, including commercial opportunities for U.S. firms.

USTDA's current focus is on renewable energy integration. There is an online data collection project in Gujarat. How to estimate the balancing requirement is an issue. If results from current projects are available with USTDA, bringing in the viewpoints of all the actors (regulators) will be helpful for future workshops.

The DOE team coordinated by Russell Conklin consisted of:

Name/Designation	Presentation Topic
Phyllis Yoshida, Deputy Assistant Secretary, Office of International Affairs, DOE	Welcome Address
Cary Bloyd, Senior Staff Scientist, Pacific Northwest National Laboratory (PNNL)	DOE Smart Grid R&D Program
Dan Ton, Program Manager. Smart Grid R&D, DOE	Smart Grid Research and Development, DOE
Akhlesh Kaushiva, Technical Project Officer, DOE	Smart Grid Investment Grant projects, DOE
Christopher Irwin, Program Analyst, DOE	Interoperability Standards, Consumer Energy Data, and the "Green Button" Initiative – DOE Perspectives
Phil Overholt, Program Manager, Transmission Reliability, DOE	Synchrophasor Technology Development and Deployment, and Other Transmission Issues
Mackay Miller, Research Analyst, National Renewable Energy Laboratory (NREL)	21st Century Power Partnership (21CPP)
Russell Conklin, Policy Analyst, DOE, Vice Chair, ISGAN Executive Committee	International Smart Grid Action Network (ISGAN)

The DOE meeting started with an introduction of all participants, followed by opening remarks from Mr. B.N. Sharma, Joint Secretary, Indian Ministry of Power, and Ms. Phyllis Yoshida, Deputy Assistant Secretary, Office of International Affairs, U.S. Department of Energy (DOE). Mr. Sharma remarked that the entire country of India is one grid now. Integration of the grid has been achieved finally after a lot of effort and persuasion. Pilots are going at a fast pace; the Government of India is running the Restructured Accelerated Power Development Programme (R-APDP). Towns with 30,000 plus population (1,400 overall) will be micro smart grid. Many IT-related diagnostic tools have been implemented. Importance of international cooperation to achieve the goal was emphasized. The East Asia summit is an example, where such collaboration can be further enhanced. Areas of collaboration that now need to move are Cybersecurity and Micro-grids. Core issues are: how to involve common consumers in the smart grid and how to develop distributed generation given the challenges India faces. Lessons learnt in the U.S. will be very helpful.

Cary Bloyd, Pacific Northwest National Laboratory (PNNL) presented DOE's smart grid R&D programs on behalf of Dan Ton. DOE is working on almost all the elements to support new research and development including large-scale renewable energy projects. DOE's analytical approach to assess smart grid benefits was discussed. Example of cost-benefit framework covers assets (what are the technologies?), functions (what does the smart grid do?), mechanisms (how does it do?), benefits (results?), and monetary value (what is it worth?). The following were also covered: Micro-grid definition (a group of interconnected loads and distributed resources) and key attributes (e.g., grouping interconnected loads and DERs; can operate in both island and grid-connected mode; ability to connect/disconnect from the grid). DOE's 2020 micro-grid performance targets include: (1) workshops to engage stakeholders for R&D planning, (2) re-scoping lab agent oriented programming (AOP) to address workshop priority, and (3) financial year (FY) 2014 micro-grid R&D funding opportunity announcements (FOA). RD&D should reach 2020 micro-grid performance targets* on costs, reliability, system energy efficiencies, and emissions. Several demonstration projects (e.g., Consortium for Electric Reliability Technology Solutions (CERTS), Distributed Energy Resources Customer Adoption Model (DER-CAM), and Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDER) have been planned. A DOE micro-grid workshop will be held in India in 2015. The PACE-D team will be invited.

DOE's goal is to have a micro-grid enhanced distribution system with increased efficiency, reduced losses, reduced peak price and price volatility, strengthened grid stability, and prevention and mitigation of external disruptions. Full substation/full feeder/partial feeder micro-grid implementations are possible for residential/small and large commercial customers with micro turbines, fuel cells, internal combustion engines, small hydro, wind and solar power resources, storage batteries, plug-in hybrid vehicles, etc. Successfully deployed micro-grids will verify the benefits and decrease implementation risks. In the U.S., DOE and Department of Defense (DOD) jointly fund Sandia National Laboratory to work with military bases to develop energy surety micro-grid conceptual designs. With distributed generation

and storage, electric power can be provided when the grid is down. Micro-grids also support communities in preparing for climate impacts.

DOE Smart Grid Investment Grants under ARRA Progress - Mr. Akhlesh Kaushiva gave an overview of the grid modernization programs under American Recovery and reinvestment (ARRA) Act. Funds have been allocated for Smart Grid Investment Grants (SGIG) – USD 3.4 billion; Smart Grid Regional Demonstrations (SGDP) - USD 620 million; Workforce Training – USD100 million; Interconnection-wide Transmission Planning and Resource Analysis – USD 80 million; Interoperability Standards (with NIST) – USD 12 million ; Technical Assistance to States on Electricity Policy – USD 44 million; and Local Energy Assurance Planning – USD 10 million. DOE requires the grantees to submit their cybersecurity plans. In the U.S., Chattanooga has set up robust infrastructure and is attracting a lot of businesses through its smart grid.

Key Technologies and Systems for Smarter Grids are: (1) Transmission system – synchrophasors, wide area monitoring, communications infrastructure, (2) Distribution system – automatic switches, capacitors, distribution system management, (3) Advanced metering infrastructure – smart meters, communications infrastructure, data management, back-office integration, and (4) Customer systems – in-home displays, programmable communicating thermostats, home area networks, web portals, direct load control, small appliances.

The Interoperability Standards, Consumer Energy Data, and the “Green Button” Initiative presentations were made by Christopher Irwin. (See footnote on PPL presentation at PA-PUC visit and http://energy.gov/data/green-button.) Green Button Initiative enables electricity customers to be able to download and transmit their own energy usage information in a standard consumer- and computer-friendly format. Green Button is also a data standard that can be used to represent and transmit energy usage and cost information into any system. Green Button can be used for Innovation (entrepreneur-created web portals and apps to analyze energy usage and savings); Heating and Cooling (customized heating and cooling activities for savings and comfort); Solar (significantly better accuracy of quotes); Verification (measurement of energy efficiency investments); Real Estate (provide cost info to tenants/buyers); and Education (community and student energy efficiency competitions). Utilities and electricity suppliers in 32 states and DC across various regulatory regimes have committed to Green Button initiatives. Canada has also adopted Green Button.

Synchrophasor Technology Development and Deployment, and Other Transmission Issues - Phil Overholt went over synchrophasors and related issues. The 2003 blackout revealed power system reliability analysis gaps in the areas of: wide area visibility, situational awareness, and time-synchronized data recording. Synchrophasor measurement was identified as a solution. About 1,700 phasor measurement units (PMU) are currently funded by federal grants. Synchrophasor project applications could range from Wide-Area Visualization and Monitoring, Angle and Frequency Monitoring, Inter-area Oscillation Detection & Analysis, Proximity to Voltage Collapse, to State Estimation, Dynamic Model Validation, and Fast Frequency Regulation.

The 21st Century Power Partnership (CPP) presentation was made by Mackay Miller from National Renewable Energy Laboratory (NREL). There is an urgent need to advance comprehensive power system policy frameworks. The 21CPP is a multilateral effort of the Clean Energy Ministerial (CEM) that serves as a platform for international efforts to advance integrated policy, regulatory, financial, and technical solutions for the deployment of renewable energy in combination with large-scale energy efficiency and smart grid solutions. CPP extends expert consultation to stakeholders in India (Planning Commission, CERC, MOP, and MNRE) for: (1) Forecasting, scheduling, and dispatch for wind integration; (2) Market design for hour-ahead and real-time markets; (3) Demand response participation in power markets; (4) Transmission planning in support of Green Corridors.

The last presentation at DOE was on ISGAN, which is a platform to bring high-level government attention and action to accelerate the development and deployment of smarter, cleaner electricity grids around the world. It is managed by its Executive Committee (ExCo), which meets twice a year, and is supported by a Secretariat at the Korea Smart Grid Institute (KSGI).There are three primary forums for U.S. – India smart grid initiatives:

1. U.S.-India Energy Dialogue (Power & Energy Efficiency Working Group - PEEWG). USAID PACE-D TA, 21CPP and ISGAN cooperation are all included as tasks under the Energy Dialogue PEEWG;
2. U.S.-India Partnership to Advance Clean Energy (PACE); and
3. Clean Energy Ministerial (CEM). CEM includes 21st Century Power Partnership and International Smart Grid Action Network.

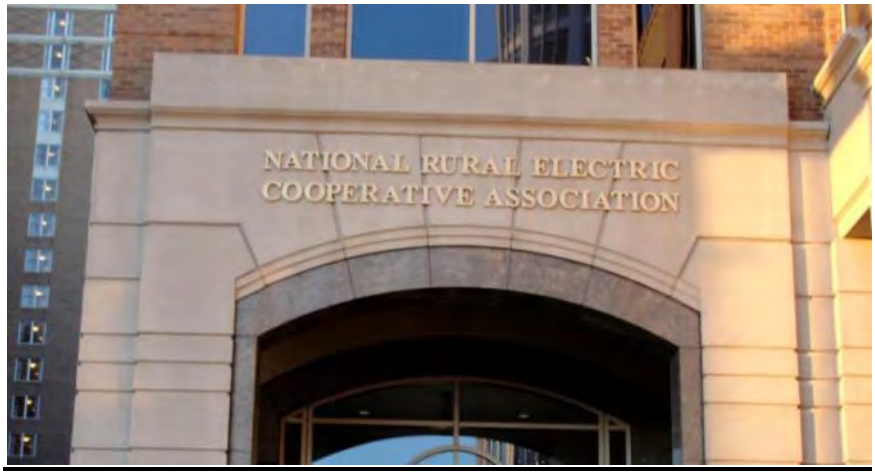
There are 7 annexes:

- Annex 1 – Global smart grid inventory
- Annex 2 – Smart grid case studies
- Annex 3 – Benefit cost analysis and toolkit
- Annex 4 – Synthesis of insights for decision-makers
- Annex 5 – Smart grid international research facilities network (SIRFN)
- Annex 6 – Power T&D systems
- Annex 7 – Smart grid transitions – institutional change

India is an active participant in ISGAN, taking part in 6 of 7 work programs/annexes. PGCIL has delivered discussion papers in the annexes. DOE would like to have case studies of Indian implementation in the case book. The ISGAN award of excellence has been launched to attract more involved participation. Emphasis for the first award is in Consumer Engagement and Empowerment.

January 24, 2014, 2:00 – 4:30 PM, National Rural Electric Cooperative Association (NRECA), 4301 Wilson Blvd, Arlington, VA 22203; CEO Conference Room, 11th Floor.

Note: All pictures/photographs in this section are courtesy of NRECA.



The NRECA team consisted of:

Name/Designation	Presentation Topic
Dan Waddle, Senior Vice President	Loss prevention in Southern Asia
Mike Casper, Senior Principal Engineer	Micro-grid renewable generation
Doug Lambert, Associate Director	Smart Grid Technology implementations, Outage Management and AMI

Dan Waddle, Senior Vice President, NRECA International Programs started the meeting. There are 940 electric transmission and distribution (T&D) coops that serve about 10 percent of the total load. All U.S. coops are self-sustained. They are granted loans at low interest rates. NRECA facilitates rural economic development through provision of reliable and affordable electric service. It works on community partnership in ownership and operation. The focus is to strengthen indigenous capacity to plan, finance and expand rural electric infrastructure. NRECA International was established in 1962 in partnership with USAID. It has been working in low-income/high-risk environments in Haiti, sub-Saharan Africa, Afghanistan, Pakistan (Power Distribution Improvement Program), and Bangladesh (Rural Electrification Board). It was involved in projects in India as well. Its renewable energy program has been very successful. Previously, NRECA provided assistance to Assam and West Bengal State Electricity Boards to evaluate how to improve quality of service and

support initiation of franchisees to improve customer service and collections. Projects in India include balancing tariffs that support full-cost recovery with poverty concerns.

Role of The Next Generation Interoperability in Smart Grid Technologies was presented by Doug Lambert, who manages NRECA's MultiSpeak program. The MultiSpeak® Standard is recognized as one of the leading standards for enterprise application interoperability. It is used by more than 725 electric cooperatives, investor-owned utilities, municipals, and public power districts in at least 19 different countries. An example of MultiSpeak use case is:

AMI/AMR to Outage Management System (OMS) - Most of the coops in the U.S. have 25,000 meters. The largest coop in Texas has 200,000 meters.

The interoperability implementation is non-trivial.

- Pinging meters to ask if they are out of power
- Self-reporting meters to OMS on some AMI
- Power quality alarms

This was demonstrated through video presentation. Connectivity backhaul is radio frequency. WiMax is very expensive for infrastructure, while Cellular is a great solution for small cities or rural areas.

Benefits of MultiSpeak are: Improved customer service, Real-time outage self-reporting, Real-time theft/tamper detection, Elimination of unnecessary trips, Cost savings, Rested linemen, Improved accuracy of OMS, and Accurate reliability indices (SAIDI, SAIFI, CAIDI). MultiSpeak has interoperability between: AMI, OMS, Interactive Voice Response System, SCADA, and Automatic Vehicle Location (AVL).

Implementers of MultiSpeak systems should follow these steps:

- Evaluate existing enterprise systems
- How can existing systems improve by exchanging information?
- Keep information exchange and synchronize?
- Proven solutions?

- Evaluate proposed new technology
- What do you want to accomplish?
- What information exchange is needed?
- What functionality is required?

Start with developing a technology plan, followed by implementation strategy, vision, setting interoperability standards, selecting technologies that will grow with your vision – then invest in people (training/consultants).

Micro-grid renewable generation was presented by Mike Casper.

The Cooperative Research Network™ (CRN), the technology research arm of NRECA, conducts collaborative research to accelerate technological innovation that can be applied by electric cooperatives worldwide. Research areas are: Solar and Wind Energy, Biomass and other Renewables, System Integration, Advanced Power Electronics, and Energy Storage.

NRECA has several smart grid demonstration projects on AMI, meter data management, advanced communications architecture, and Open Modeling Framework (OMF) which is a coop-led effort to create a system modeling tool that incorporates coop systems with a common user and data interface. It models many things from new distribution equipment/controls to impact of distributed generation and new energy efficient appliances on the distribution system. OMF will be available to industry towards the end of 2014. NRECA has several projects in collaboration with DOE in renewable energy integration (e.g., solar Sun Shot, SUNDA programs). NRECA is doing energy storage research jointly with Sandia National Laboratory

NRECA also has documents on cybersecurity that has received a lot of attention from Electric Power Research Institute (EPRI), IBM, and Homeland Security. A utility can customize their cybersecurity plan using the NRECA document (drop down list).

For communication infrastructure, to lower the cost, a coop can build a fiber network, and then sell bundled service using the infrastructure.

January 26, 2014, 4:00 – 6:30 PM, Nexant, 101 Second St, San Francisco, CA

Name/Designation	Presentation Topic
Terry Fry, Nexant Senior Vice President	Demand Response and Management - Pennsylvania Act 129 Statewide Evaluation (SWE)
M Kemal Celik, Nexant Vice President	Distribution System and Smart Grid - Nexant Grid360 Distribution Manager

- The Nexant presentations are available to participants in electronic format.
- Briefing for California schedule; distribution of second week's per diem expenses.

January 27, 2014, 9:00 – 11:00AM, Pacific Gas and Electric (PG&E) Pacific Energy Center (PEC), 851 Howard St, San Francisco, CA

Name/Designation	Presentation Topic
Dan Pearson, Manager, Smart Grid and Technology Integration	Smart Grid Implementation Lessons Learned
Peter Shoemaker, Renewables Program Coordinator, PEC	View PEC Facility

The Smart Grid Implementation Approach presentation by Dan Pearson was based upon PG&E's experience and lessons learned.

Dan Pearson recommended testing smart grid technologies fully "end to end" before widespread implementation. PG&E is now targeting deployment of its Outage Management System (OMS) with Automatic Switching of distribution circuits in denser areas where there are the highest benefits. His full presentation is available to participants in electronic format.

Standards definition:

- Shape and validate the standards that will underlie future Smart grid implementations
  Testing

- Prototyping and testing of smart grid technologies before piloting

- Accelerate technology development and ensure standards compliance early on
- Develop preliminary customer communications to support pilots

Controlled pilots

- Implement tested technologies in real-world, controlled setting to demonstrate value
- Work with customers to prepare for new technologies and services

Targeted deployment

- Extend pilots to targeted roll-outs based on benefits
- Insights used to feed the next cycle of technology deployment

Decoupling: Dan Pearson described the regulatory mechanism in California that encourages energy efficiency and smart grid programs by separating utility profits from the quantity of energy sold. He provided a one-page description of decoupling and referred to www.pge.com/rates for further information. Decoupling is a policy enacted by the State of California that disconnects the amount of energy a utility company sells from how much it makes.

Background: PG&E is one of the largest power utilities in California, providing electricity and natural gas to most of northern California. PG&E is one of the earliest and largest adopters of Advanced Metering Infrastructure (AMI) in North America—with more than nine million electric and gas Smart Meters™ deployed across its 70,000-square-mile service area. PG&E is implementing a system-wide Smart Grid plan for modernizing the electric grid to improve safety and reliability while delivering a host of energy and cost savings to customers.

Smart Grid projects enable the grid to accommodate new technologies that integrate a wide range of advanced communications, computing, sensing and control technologies on its electric grid, and to provide customers with more control of their energy bill while enabling the company to more quickly respond to outages and service requests. In its Smart Grid Deployment Plan, PG&E stated that its vision for the Smart Grid was “to provide customers safe, reliable, secure, cost-effective, sustainable and flexible energy services through the integration of advanced communications and control technologies to transform the operations of our electric network, from generation to the customer’s premise.”

Dan Pearson discussed PG&E’s Smart Grid program experience and some challenges faced in undertaking one of the largest overhauls of the electric system in the U.S. in over 70 years. Grid improvements include PG&E's outage detection program, which can check individual meters to determine whether or not power has been restored; "self-healing" circuits that significantly reduce the average length of an outage by re-routing power flows; and high-tech monitoring equipment on the transmission system that provides early warning of potential problems so grid operators can take corrective action before widespread outages occur.

Dan Pearson discussed developments in renewable energy integration and battery storage systems, including PG&E's 2 MW sodium-sulfur battery pilot project at the Vaca-Dixon substation, pictured here, which is associated with its 2 MW PV solar panel installation.

This battery pilot project[5] is designed to test the feasibility of three major goals: storing energy when customer demand is low and releasing it to meet peaks in demand; helping PG&E integrate more renewable energy into the distribution system by smoothing the minute-by-minute fluctuations in output; and providing "ancillary services" like helping to stabilize frequency.

Dan Pearson discussed cybersecurity on PG&E's transmission and distribution systems. PG&E's cybersecurity framework provides a baseline for risk management and informs controls implementation involving people, process, and technology. He stated cybersecurity systems developed for AMI are more advanced than the older "legacy" distribution systems.

Regulatory Approval: Dan Pearson provided a copy (in electronic format) of PG&E's November 21, 2011 application to the California Public Utilities Commission (CPUC) to approve its proposal to implement the Smart Grid Pilot Deployment project.

PEC Facility: Peter Shoemaker showed the participants PG&E's Pacific Energy Center (PEC) which offers educational programs, design tools, advice, and support to create energy efficient buildings and comfortable indoor environments, focused around commercial buildings and advice and information for residential buildings. PEC services include performance measurement tools for building systems evaluation and efficiency enhancements, advice on site orientation and electric lighting systems, daylighting and shading analysis of physical building models, electric lighting system demonstrations, and identifying applicable incentive programs for energy-related measures.

PG&E Smart Grid Brochures: In response to requests from Smart Grid Study Tour participants, PG&E provided electronic copies of various PG&E brochures available at the PEC which are related to aspects of Smart Grid and Energy Efficiency.

[5] Results and cost-benefit analyses from this pilot project are not yet available. A December 2013 news report by Richard Harris of NPR quotes Dave Fribush who manages battery storage integration and Todd Strauss senior director for energy policy planning and analysis at PG&E: http://tpr.org/post/big-batteries-needed-make-fickle-wind-and-solar-power-work.

- PGE 2014 Residential rebates
- PGE AC Quality installation
- PGE Comfortable room temperature
- PGE Cool roofs
- PGE CTM-0113-1819
- PGE CTM-0113-1836
- PGE Energy-wise rebates
- PGE Foodservice rebate catalog
- PGE Home insulation
- PGE HVAC rebate catalog
- PGE Integrated energy management for your business
- PGE Plug-in vehicles
- PGE Save energy at your business
- PGE Solar water circulation
- PGE Summer pricing plan

Notes on PG&E Visit Presentations and Q&A: Some highlights of the presentations and discussions at the PG&E visit are as follows.

PEC is funded by a rate payers surcharge. All bill payers have a surcharge that funds several programs, including PEC and other programs related to EE. Classes at PEC are free for the public; there are regulations' sessions. PEC has some expensive tools, which it demonstrates and can lend to the public for free.

Dan Pearson discussed the fact that utilities do not make more money in California by selling more power; this concept is called decoupling. California has decoupled sales and profits. Decoupling is spreading across utilities in the U.S. and is the basis of collaboration of utilities on EE programs. Smart grid depreciation is negotiated with the regulator. Investment life and other parameters are all determined on the basis of industry standards, information from vendors, PG&E and stakeholder views.

Smart grid implementation has been ongoing at PG&E for several years, since 2008. The first activity carried out was smart meter installation and the AMI set-up, which has been completed for five million users. PG&E uses Silver Spring Networks equipment for wireless mesh networks. The initial focus was to stabilize workings; correct revenue displays, and develop settlement processes. Peak pricing is being introduced; while time-of-use pricing is already in place.

Current work is exploring additional uses of AMI and Smart Grids. Initiatives include smart substations and consumer-level initiatives such as being able to give data to consumers, so that they can decide on spending. PG&E is implementing the Green Button initiative (see discussion of DOE visit and http://energy.gov/data/green-button). In the home energy report program, roughly 15 percent (660,000 consumers) have received Green Button reports.

The focus of Dan Pearson's presentation was PG&E's current implementation approach, which has been developed as a result of lessons learned and consumer controversies surrounding the installation of smart meters. As described in his presentation, this implementation approach includes:

- Standards definition to ensure interoperability and prevent vendor lock-in.
- R&D testing end to end. PG&E aims to implement and test each system at the lab before moving it out into the field. This was a key lesson from the AMI experience where they went back and forth.
- Controlled pilots to prove benefits and feasibility.
- Targeted deployment of full-scale roll-out after full cost-benefit analysis and approval from PUC.

Outage management and load management are also being implemented. PG&E is planning to implement automated Demand Response (DR) as another application of its AMI wireless network. This will include an air-conditioning DR program, such as turning off air-conditioners for a half hour during summer peak demand periods. PG&E has an old air-conditioner program using paging messages and it is working on a move to new programs after the AMI deployment. PG&E has completed an auto DR intermittent resource integration pilot, which is working for air-conditioners.

PG&E is working on a Home Area Network (HAN) enablement program - to allow customers to select HAN devices instead of logging into Green Button. A customer data access platform will allow third-party access to customer usage data once authorized by the customer.

PG&E is looking at synchrophasors for transmission through other utilities and learning from what they have been doing with the data generated.

Dan discussed new smart grid programs being implemented in 2013 through 2016: smart grid line sensors (wireless) on overhead networks, voltage and reactive power optimization, detecting and locating line faults, and short-term demand forecasting.

Customer education is important. People have been complaining about smart meters and health issues. As a result, an opt-out program has been established, though the percentage usage of opt-out is small.

Peter Shoemaker showed the group a variety of building energy efficiency equipment at the PEC facility, which is available to PG&E customers, including:

- Solar roof-top panels and their orientation, as well as micro invertors and their use, to reduce conversion losses. Micro inverters cost 4 to 5 percent more than a single large inverter for a PV system, but can make up the added cost through benefits.
- Glass reflectors that preserve inside ambient temperature.
- The PEC heliodor is a tool for identifying opportunities for energy savings through climate-responsive architectural design, by understanding solar orientation and light conditions in building assessment.

January 27, 2014, 1:00–5:00 PM, Lawrence Berkeley National Laboratory (LBNL), 1 Cyclotron Rd, Bldg 90, Berkeley, CA

LBNL is a U.S. DOE's national laboratory conducting unclassified scientific research. The LBNL Demand Response Research Center (DRRC) plans and conducts multi-disciplinary research to advance DR within Smart Grid infrastructure in California, in other parts of the U.S, and abroad. The main objective of the Center is to develop, prioritize, conduct, and disseminate multi-institutional research that develops broad knowledge to facilitate DR.

DRRC is part of the DOE's LBNL:

- LBNL is supported by the U.S. Department of Energy through its Office of Science.
- LBNL is managed by the University of California (UC).
- LBNL conducts unclassified research across a wide range of scientific disciplines.
- LBNL employs approximately 4,200 scientists, engineers, support staff and students.

LBNL is an incubator for ideas, innovations and products that help society and explain how the universe works:

- Renewable energy sources such as biofuels and artificial photosynthesis
- Energy efficiency at home, at work, and around the world
- The ability to observe, probe, and assemble materials atom by atom
- Climate change research, environmental science, and connections between them

- The chemistry and physics of matter and force—from the infinite to the infinitesimal
- Computational science and networking to enable discovery and remote collaborations
- Biological sciences for human health and energy research.

The DRRC research agenda covers three major DR research categories – (i) Energy Systems Integration, Communications, and Grid Integration; (ii) Residential and Commercial Buildings and (iii) Industrial, Agricultural and Water. One of the major accomplishments of the DRRC is the development and commercialization of the Open Automated Demand Response Communications technology.

During the Smart Grid Study Tour visit LBNL staff made presentations and discussed with participants a variety of LBNL projects and their relevance to Smart Grid planning and implementation, Demand Response, and Peak Load Management (PLM). For presentations and discussion on LBNL Smart Grid project work - see web-links listed below and the files containing presentations provided in electronic format. This visit included a tour of the LBNL Facility for Low Energy Experiments – FLEXLAB.

Name/Designation	Presentation Topic
Dr. Vince Battaglia, Deputy Leader, Energy Storage and Distributed Resources Department	From LBNL to ESDR - Energy Storage and Distributed Resources Environmental Energy Technologies Division (EETD) overview and Q&A (http://eetd.lbl.gov)
Girish Ghatikar, Grid Integration Group (GIG)	Smart Grid and Links to India (http://gig.lbl.gov)
Dr. Annika Todd, Electricity Markets and Policy Group	Advanced Metering Infrastructure (AMI) Enabled Consumer Behavior Study (http://emp.lbl.gov)
Dr. Nikit Abhyankar, International Energy Studies Group (IES)	Smart Grid Opportunities in India (http://ies.lbl.gov)
Dr. Jayant Sathaye, Senior Scientist and Strategic Advisor	DSM Programs at MSEDCL – Maharashtra
Dr. Michael Stadler	Economic and Environmental Optimization of Micro-grids and Distributed Energy Resources (http://der.lbl.gov)
Chuck McParland, Demand Response Research Center (DRRC)	Demand to Grid (D2G) Lab and Smart Appliances (http://drrc.lbl.gov/demand-grid-d2g-lab)
Cindy Regnier	Tour of Facility for Low Energy Experiments – FLEXLAB (http://flexlab.lbl.gov)
Dr. Emma Stewart, Grid Integration Group and Sila Kiliccote	Grid Integration of DER and Distribution System Modeling
All	Discussions: Wrap-up, next steps, and key takeaways

Notes on LBNL Visit Presentations and Q&A: Some highlights of the presentations and discussions during the LBNL visit are as follows:

From LBNL to ESDR - Energy Storage and Distributed Resources - Dr. Vince Battaglia

Vince provided an introduction to LBNL, which has 4,200 scientists, engineers, and support staff, a budget of 2011 – USD 735 million with additional USD 101 million from ARRA

totaling to USD 836 million. Thirteen 13 Nobel prizes are associated with LBNL, including the 2007 Nobel Peace Prize on Climate Change with the work of LBNL's Jayant Sathaye who made a presentation to the PACE-D Smart Grid Study Tour. 57 lab scientists are members of National Academy of Scientists.

Vince presented the LBNL organization chart including Energy and Environmental Technologies Division (EETD) and the EETD Vision and Mission. The three departments of EETD are Buildings Technology and Urban Systems, Energy Analysis and Environment Impacts, and Energy Storage and Distributed Resources (ESDR). He described some research projects of these departments. The Grid Integration Group (GIG) is part of ESDR.

Grid Integration Group (GIG), Smart Grid and Links to India – Rish Ghatikar

Rish Ghatikar presented the work of the GIG. Grid integration of end-uses and electrical vehicle fleets represent a key efficiency and energy security objective for the federal and state agencies. GIG develops technologies and tools to: Facilitate dynamic interaction between grid operators and energy consumers, Support GI of intermittent RE, and Foster participation of distributed energy resources.

Three key areas of GIG work are Demand Response (load as a resource), Micro-grids–with Distributed Energy Resources (DER), and Electricity Reliability. GIG projects include Linking Energy Efficiency and DR as well as Building to Grid (B2G) Integration.

The U.S. national assessment of Demand Response potential - FERC study in 2009 found a total potential of 14-20 percent of the peak load. The U.S. has a mix of regulation and de-regulation. California is highly regulated and has RPS of 33 percent by 2020. (2013-20 percent; 2016-25 percent; and 2020 -33 percent), which is among the most aggressive RPS in the U.S. California has a mandate to have grid scale storage, and is looking at distributed generation to see that the grid scale storage requirement does not become too large since it is expensive.

Rish presented the results of the July 2013 LBNL study "Expanding Buildings-to-Grid (B2G) Objectives in India". That study is provided in electronic form, and available on the internet: http://gig.lbl.gov/publications/expanding-buildings-grid-b2g-objectives-india. The DR and EE potential scope in India is huge. It is projected that 66 percent of commercial buildings in India in 2030 are yet to be built[6]. Rish discussed Building to Grid (B2G) potential in India and B2G Integration and the Buildings to Grid collaboration with India. Integrating EE and DR provides a framework for the B2G.

Rish discussed the Open ADB initiatives and the Open ADB Alliance. There is a pilot in Tata Power in Delhi looking at this. Open ADB to enable standardized framework and processes and templates.

Rish discussed LBNL's Demand Response Quick Assessment Tool (DRQAT) to estimate and optimize DR strategies in facilities, as load analysis tools to pre-screen loads for participations in various timescales of DR, critical for micro-grid design.

[6] This projection is based on the 2011 USAID-India sponsored "ECO-III" study by Kapoor, Ravi, Aalok Deshmukh, and Swati Lal, "Strategy Roadmap for Net Zero Energy Buildings in India"

AMI Enabled Consumer Behavior Studies Analysis - Annika Todd and Peter Cappers

Annika Todd presented the results of the AMI Enabled Consumer Behavior Studies Analysis. DOE initiatives funded 11 studies that asked the question:

- What consumer behaviors does the modernization of the country's electricity infrastructure, AMI and other technologies enable?

Goal of studies was to examine time based rates:

- Focus on studying dynamic pricing tariffs enabled by smart meters
- Rigorously test the tariffs through randomized controlled trials
- Deliver highly granular customer-level data for subsequent DOE cross-project analysis

The LBNL analysis called for further research on a policy issue raised by these studies: the difference in results from Opt-in vs. Opt-out Enrollment in Time-Based Electric Rates.

When Flat Rate was the default, only 11 percent of consumers Opt-in and chooses Critical Peak Pricing.

When Critical Peak Pricing was the default, only 16 percent of consumers Opt-out and chooses a Flat Rate.

Smart Grid Opportunities in India (International Energy Studies Group) –

Dr. Nikit Abhyanker

Nikit Abhyanker presented the work of the International Energy Studies Group. He focused on two topics related to opportunities in India: Air-Conditioning and Clean Transport and discussed the challenges facing grid integration of wind generation in India.

Air-Conditioning: Indian cites are hot and populous. Compared to other regions, the climate in India has higher cooling requirements as shown by comparing cooling degree days across Indian cities and cities around the world. A huge increase in air-conditioning load in India is expected by 2030-2040. In China, within a span of 15 years, air-conditioner penetration went from zero to every household having more than one AC. AC penetration is supported by falling appliance prices in real terms. Space cooling is a major contributor to the peak demand in India. Hourly patterns across cities indicate significant overlap increasing the peak demand.

DR for space cooling is critical for peak load management. For space cooling equipment, DR capabilities can be installed at the manufacturing stage. With GSM enabled chip, the temperature setting can be increased by few degrees. Cost of this technology is very small, with enormous potential benefits.

Clean Transport: Challenges - oil demand, import dependence, urban air pollution. Significant benefits for hybrid vehicles in India. Nikit discussed EVs related grid scale storage research and using EVs for grid support: exploring smart charging infrastructure, Vehicle-to-Grid (V2G), and EV participation in the ancillary service markets (Voltage and VAR support). The LBNL study indicated that HEVs yield proportionally better fuel economy

improvements in India than in the US. Power-split hybrid power- trains make the internal combustion engines more efficient at low speeds, and the efficiency improvements of energy recovered through regenerative braking and by engine shutdown at idle have greater impact on short trips. Similar results are likely for PHEVs and EVs.

DSM Programs at MSEDCL – Maharashtra – Jayant Sathey

Jayant Sathey presented DSM programs implemented and recommendations for future work in India. MSEDCL initiated three activities:

- Pilot Agricultural DSM Program: Replacement of old agricultural pumps by 4 star rated pumps with BEE support.
- Replacement of 5000 old ceiling fans by 5 Star rated ceiling fans with LBNL support
  - These were 80-105 watts, whereas new BEE star rated fans have 55 watts.
  - Ongoing M&V being carried out in 520 cites.
- Coating roofs with white color to reduce room temperatures and energy use with LBNL support.
  - He presented examples in Hyderabad and several examples in Nagpur.

This study recommended future work is to expand the projects to government public buildings.

Economic and Environmental Optimization of Micro-grids and Distributed Energy Resources - Dr. Michael Stadler

Michael presented the economic and environmental optimization of Micro-grids and Distributed Energy by application of the LBNL Distributed Energy Resources Customer Adoption Model (DER-CAM). DER-CAM is a deterministic and stochastic Mixed Integer Linear Program (MILP). The model can handle non-linear effects as efficiency curves. DER-CAM minimizes annual energy costs, CO_2 emissions, or multiple objectives of providing services on the building level, typically buildings with 100-2000 kW peak.

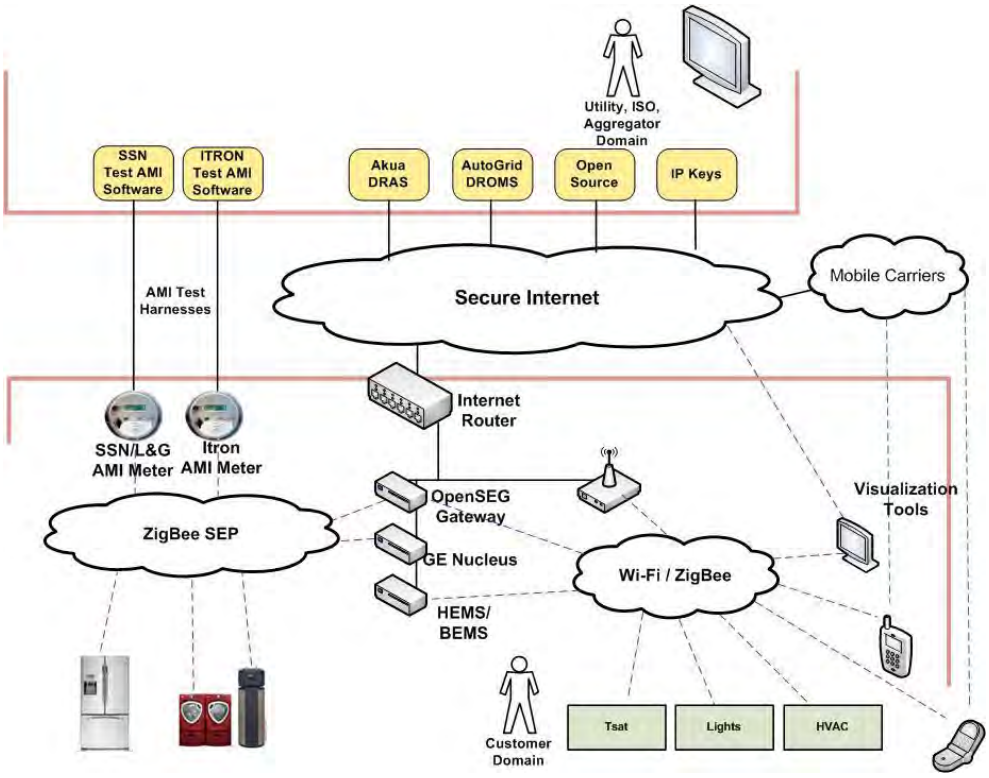
Michael presented various examples applying DER-CAM to Micro-grid Investment and Planning, to generate optimized scheduling of building cooling equipment, and to critical load prioritization and outage management.

Demand Response in the Residential Sector, Demand to Grid (D2G) Lab and Smart Appliances - Chuck McParland

Demand Response Research Activities: In 2002, Open Automated Demand Response (OpenADR) research planning was initiated in LBNL.

The LBNL Demand to Grid (D2G) Lab in the LBNL Demand Response Research Center (DRRC) is a place to explore and test emerging DR technologies. The presentation listed four key Demonstration and Testing Areas:

1. Residential appliances and home automation network (HAN) integration, data analysis.
2. Lighting controllers and systems.
3. OpenADR technologies, systems, and end use strategies.
4. Data analytics and visualization.



The D2G Lab works with various vendors testing residential appliances, smart thermostats; lighting controllers, dimmable LED lights, and various kinds of equipment, including under TOU/DR events. Devices with wi-fi setting that are Auto ADR compliant are available. Various equipment respond differently and display different granularity of data - GE, Itron, etc.

The LBNL Guest House is the testing site and one of the demonstration sites for the D2G Lab. The D2G Lab has been testing and improving strategies and standards for demand-side interoperability, wired and wireless communications, communication architectures, devices, and monitoring and controls technologies. All of these strategies and standards are part of research that will improve the efficiency of the nation's electric grid and the way it responds to fluctuations in demand or supply of electricity.

Demonstrations include communication between a multitude of end-use devices such as smart appliances, revenue-grade smart meters, and a home area network (HAN) gateway to receive DR reliability pricing signals using OpenADR. Within the demonstration test bed, wireless and wired Internet (Wi-Fi), and in-home protocols and standards such as ZigBee Smart Energy Profile 1.0 and other proprietary protocols are used to interoperate with OpenADR and respond with a change in energy use.

Preliminary Conclusions: Data access methods and standards will be critical to market development. The path forward is a standardized Open Residential Energy Gateway (OpenSEG).

- Enhance utility Smart Meter security by limiting access.
- Secure Proxy for Smart Meter reads: kW and price info. (rates up to once in 4 sec.)
- Promote use of residential HAN.
- Provide standardized API for meter, DR and energy usage data access.

FLEXLAB - Facility for Low Energy Experiments in Buildings – Cindy Regnier

Cindy Regnier guided the Study Tour participants through the FLEXLAB, the Facility for Low Energy Experiments in Buildings, and she made a presentation on FLEXLAB. FLEXLAB consists of custom built facilities, each designed for specific research development and demonstration. Construction was funded by DOE – USD 16 million. Recovery is through user charge (12k per month).

FLEXLAB develops new test methods and solutions for low energy buildings including low-energy, integrated building systems under realistic operating conditions. It focuses on:

- Comprehensive whole building systems integration.
- Specific end use integration and component interactions (e.g. HVAC, lighting, windows, envelope, plug loads control systems).
- Controls hardware and sensors.
- Simulation and tools for design through operations.

FLEXLAB involves simulating the building conditions under review and taking decisions for introducing new solutions. Walls can be removed; every socket is backed by separate CT/PT. All points can be separately monitored, and varying heat conditions can be created.

Grid Integration of DER and Distribution System Modeling - Emma Stewart

Emma Stewart made a presentation on Grid Integration of DER and distribution system modeling and analysis, discussing these points:

- Improving observability and visualization.
- Commercial power systems analysis packages.
- Micro-synchrophasors for Distribution (ARPA-E project).
- VirGIL: Virtual Grid-Integration Laboratory.

LBNL models and simulates events on the grid to plan for future changes. LBNL simulates events to provide grid operators intelligence to react to outages and emergency conditions. This is completed with a combination of GIS, Distribution planning tools and measure data.

At present, visibility of the distribution level is low, even in the most advanced utilities. Some utilities still rely on paper maps. Enough major events have not yet occurred on distribution level that were seen to justify the investment in modern data systems. Emma discussed data measurement and analysis timescales for data ranging from days to microseconds: SCADA - weather data, customer data; time series, gen dispatch, transient response, dynamic response, steady state analysis.

Emma discussed commercial options for power systems software available for four areas: distribution planning, transmission planning, operations and protections. She discussed the example of the interconnection of DG, analysis and software options.

Emma discussed micro-synchrophasor development of a network of high-precision phasor measurement units (uPMUs - power quality sensors) for distribution systems:

- Pilot site at LBNL for uPMU devices.
- Installing uPMU devices in 4 locations at LBNL – from substation to Building 90.
- Will measure high fidelity phase angle data, voltage and current to validate the LBNL CymDist Model.
- Challenges: communications, calibration, and commissioning.

Emma discussed the LBNL VirGIL model that will bind different modeling tools in order to emulate real life phenomena, for example the interaction of continuous and discrete dynamics – trip a line due to a fault and simulate the resulting transients.

January 28, 2014, 8:45 – 11:30 AM, California Independent System Operator (CAISO), 250 Outcropping Way, Folsom, CA

Note: All pictures/photographs in this section are courtesy of CAISO.

CAISO is the Independent System Operator that provides open and non-discriminatory access to the bulk of the state's wholesale transmission grid, supported by a competitive energy market and comprehensive infrastructure planning efforts. The ISO is providing Transmission Services to PG&E, SCE, SDG&E and other utilities in California that are

actively deploying Smart Grid programs. The ISO is actively engaged in smart grid activities and is also engaging with various stakeholders to bring in technologies such as DR.

CAISO staff made presentations and discussed these topics with the Smart Grid Study Tour participants. CAISO provided a copy in electronic format these three presentations and provided the CAISO Smart Grid Roadmap and Architecture, which is excerpted below.

Name/Designation	Presentation Topic
Erin Johnson, Technical Assistant, Communications & Public Relations	Visit Coordinator
Clyde Loutan, Senior Advisor	Intelligent Energy Solutions - Renewable Energy Integration
James Blatchford, Manager	Short Term Forecasting
Jim Hiebert, Senior Engineering Specialist	Synchrophasors and PMU

The CAISO Synchrophasor Project replaced legacy systems by redundant production grade synchrophasor system hardware. CAISO staff discussed the role of the Phasor Monitoring System in detecting and responding to oscillations caused by a substation short circuit on the 1,700 MW DC line. During the Smart Grid Study Tour to the CAISO we viewed the CAISO control center and discussed its operations with CAISO staff.

SMART GRID Roadmap and Architecture - December 2010 – California ISO

Excerpts

> "Emerging and maturing technologies will maximize the use of the transmission system, strengthen the safe and reliable operation of the grid, improve overall market efficiency and advance environmental policy objectives. This is the vision for the California ISO Smart Grid.
>
> The Smart Grid Roadmap and Architecture helps implement this vision by projecting a forward-looking strategy through 2020 from a technology perspective that includes advanced transmission efficiencies as well as the anticipated progress of measurement devices and automation. It offers a technical architecture based on business requirements driven from an understanding of federal and state policies and assumptions concerning the evolution of key technologies and standards. Substantial changes in federal or state policy or unexpected developments in technology, standards and other issues could alter this roadmap significantly. Because of this, the ISO considers the Roadmap a living document that will undergo frequent reviews and modifications.
>
> The California ISO envisions the 2020 grid of the future to be one brimming with cost-efficient, clean wind and solar energy that responds to grid operator instructions and dependably contributes to system reliability. The ISO, the power industry and manufacturers are rapidly developing the smart devices and software systems needed for grid evolution. This surge of innovation is driven by California's energy and environmental policy goals, as highlighted in (CAISO) Figure 1, which include procuring 33 percent of the state's retail energy needs from renewable sources by

2020, promoting energy efficiency, increasing levels of distributed generation and reducing greenhouse gas emission levels to 1990 levels.

(CAISO) Figure 1: Key Smart Grid Drivers

The 2020 grid has the potential to use storage technologies to store or discharge energy that firms up the variability of renewable resources. Storage could, if developed as hoped, supply ancillary services products as well, such as regulation, which is critical in maintaining system frequency within very narrow limits. Another feature of the smart grid is the everyday use of DR. Smart technologies are expected to make available the information residential and commercial consumers require curtailing or shifting their power use to a time when prices and supply are most favorable. The absence of these technologies developing as expected could result in further reliance on conventional generation to balance renewable variable generation, which may be contrary to the goal of diversifying our generation fuels.

California's modern grid will leverage existing technologies, such as synchrophasors, to perform at its peak capabilities. Up until now, synchrophasor data had been used for offline analysis, but in the smart grid rollout, it will be used for near real-time on-line monitoring and possibly control. New technologies including smart meters and smart substations will help the local distribution system, owned and operated by utilities, to match the sophistication of the high-voltage transmission system. These specialized functions, if developed, could communicate demand levels, output from distributed generation and system conditions that aid the ISO in managing a grid that is more complex than any time in history. The result would be a thriving electricity sector that is competitive and cost efficient — all to the benefit of our wholesale customers and ultimately retail consumers."

January 28, 2014, 1:00– 2:30 PM, California Energy Commission (CEC), 1516 Ninth Street, MS-29, Sacramento, CA

CEC is the state's primary energy policy and planning agency. The CEC supports research that combines the electricity grid with intelligent communications and control systems to create a highly automated, responsive, and resilient power delivery system that optimizes services and empowers customers to make informed energy decisions. During the Smart Grid Study Tour visit to the CEC, Commissioner Karen Douglas and CEC staff discussed California Smart Grid with tour participants. CEC participants were the following:

Name/Designation	Presentation Topic
Brenda Sturdivant, Associate Energy Specialist	Visit Coordinator
Karen Douglas, Commissioner	California Energy Commission Role and Smart Grid Development
David Hungerford, Ph.D., Senior Scientist, Lead for Demand Response and Behavior Research, Energy Efficiency Research Office	The California Smart Grid discussion covered these topics: • Peak Load Management • Outage Management • Power Quality • Distributed Generation • Smart Micro-grid
Jamie Patterson, Senior Electrical Engineer, Energy Systems Research Office, Energy Research and Development Division	
Linda Kelly, DG and Distribution Team Lead	
John Mathias, Energy Commission Specialist, Electricity Analysis Office, Electricity Supply Analysis Division	

The CEC provided an electronic copy of the annual Report to the Governor and the Legislature on the California Smart Grid by the California Public Utilities Commission, dated May 2013. An excerpt is included here:

The Evolution of California's Smarter Grid (Excerpt)

> "In some respects California's electric grid is operated in the same way that it has been for decades. However, since the Smart Grid legislation was passed in 2008, significant progress has been made to take advantage of innovative technologies, accommodate new supply resources, and meet consumer demands.
>
> The creation of a smarter grid results in a safer, more reliable, efficient, affordable, and interoperable system. This is a "system of systems" which is hugely complex and multi-faceted, covering everything from customer data access to cybersecurity and substation automation. The CPUC and the IOUs have confronted this enormous task by developing Smart Grid Deployment Plans, which outline the steps that need to be taken by 2020 in order to make significant progress.
>
> These plans are already becoming reality through pilots, demonstrations, and full-scale deployment of some technologies. The solutions that have already been implemented, such as smart meters, grid sensors, and optimization tools are already providing measurable benefits of over USD 120 million a year, as well as supporting the California job market and green economy. Although the majority of the investment in Smart Grid by the utilities has been in smart meter deployment, which has been ongoing since 2006, it is clear that the benefits will become even more significant as the deployment of Smart Grid features becomes more pervasive."

Notes on CEC Visit Presentations and Q&A: Some highlights of the presentations and discussions at the CEC visit are the following.

The role of the California Energy Commission (CEC) is energy policy and planning for state of California, including building standards, plant siting, and electricity system technology advancement. The CEC responsibilities differ from the California Public Utilities Commission, CPUC, which sets regulated rates.

CPUC determines the rates and authorizes a rate of return**.** Rate cases involve special consideration given to SG. Special accounts have been created that help in bringing the risks down. CPUC allows the utilities guaranteed rate of return on SG investments (which are identified as such in rate cases).Utilities bear some risk. Metrics are also developed for various plans proposed by the utilities - these are monitored and updated every year.

The CEC discussed the Smart Grid annual plan by the CPUC, excerpt of introduction above. The CPUC has a base Smart Grid deployment plan and every year an update is filed which is tied to the rate cases. The CEC also mentioned the decoupling of sales from profits.

Remote meter reading has led to clear benefits. All meters here meet the Federal Communication Commission rules (FFC). CEC is working on development of communication protocols, along with national laboratory, required for SG applications and transactions. The need for an open source protocol was considered important, through the NIST.

New concepts for appliances with intelligence and smart homes are being studied and promoted. Forecasting is considered important and efforts include weather data forecasts as

well. The CEC is exploring aggregate DR, so that demand can participate in the grid, and experiments include EVs responding to DR signals (storage on wheels).

January 28, 2014, 3:00 – 4:30 PM, Sacramento Municipal Utility District (SMUD), 6201 S Street, Sacramento, CA

Note: All pictures/photographs in this section are courtesy of SMUD

SMUD provides electricity to Sacramento County, California, and a small portion of adjacent Placer County. SMUD's smart grid project involves system-wide deployment of an advanced metering system integrated with existing enterprise and information technology systems as well as a partial deployment of advanced distribution grid assets that equip SMUD's distribution circuits with automated control and operation capabilities. The project also involves customer systems that provide usage and cost information to customers that educate and enable more control over their consumption. The project includes a field test of plug-in electric vehicle (EV) charging stations to assess their technical performance, vehicle charging patterns, and effects on electric distribution system operations. SMUD staff made presentations and discussed Smart Grid implementation experience with tour participants.

Name/Designation	Presentation Topic
Anita Clay, Economic Development and Leadership	Welcome, Visit Coordinator
Erik Krause, Enterprise Performance	Smart Meters Project Overview
Ed Sanchez, Energy Research and Development	Anatolia Project Study: PV with Residential Energy Storage vs. PV with Community Energy Storage
Jennifer Potter, Pricing and Resource Planning	Smart Pricing Option Dynamic Pricing Review
Craig Sherman, Energy Research and Development	Demand Response Overview

SMUD staff made and discussed these presentations, provided tour participants printouts of each presentation, and provided copies in electronic format.

Operational savings from SMUD's system wide Smart Meter installation are expected to pay for the system over 10-15 years. It provides improved service including quicker reconnects in between tenants and daily/hourly usage information available online. From an environmental perspective, SMUD is reducing truck rolls for meter reading, and field services. This leads to less fuel/less greenhouse gas emissions. SMUD is leveraging the data from smart meters to better manage outages, identify system improvements and to move toward distribution automation.

DOE sponsored projects (See DOE web-link and descriptions in electronic format): http://www.smartgrid.gov/project/sacramento_municipal_utility_district_smartsacramento

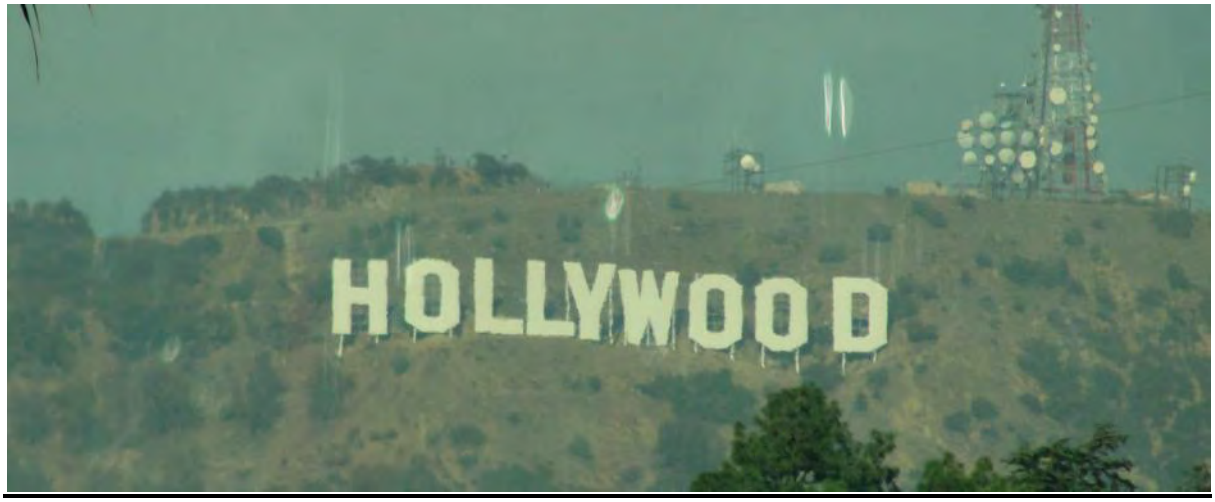
- Smart Sacramento Project
    - Communications Infrastructure
    - Advanced Metering Infrastructure (AMI)
- SG Consumer Behavior Study
    - Time-based rates and enabling technologies
    - Impacts on energy consumption and peak demand
    - Critical Peak Pricing (CPP)

Smart Sacramento Project (Abstract): SMUD's Smart Sacramento Project involves system--wide deployment of an advanced metering system integrated with existing enterprise and information technology systems as well as a partial deployment of advanced distribution grid assets that equip SMUD's distribution circuits with automated control and operation capabilities. The project also involves customer systems that provide usage and cost information to customers that educate and enable more control over their consumption. These systems enable more informed participation by customers and more effective management by SMUD to improve reliability and efficiency of grid operations and better optimize the use of assets. The project includes a field test of plug- in electric vehicle charging stations to assess their technical performance, vehicle charging patterns, and effects on electric distribution system operations.

SG Consumer Behavior Study (Abstract): SMUD's Smart Sacramento project includes a consumer behavior study evaluating the impacts of time-based rates, enabling technologies, and recruitment treatments on energy consumption and peak demand.

January 28, 2014,6:20 PM – 7:55 PM, Flight from Sacramento, CA, to Los Angeles, CA

- American Airlines flight from SMF to LAX



January 29, 2014,10:00 AM – 12:00noon, UCLA Smart Grid Energy Research Center (SMERC), 420 Westwood Plaza LA

Note: All pictures/photographs in this section are courtesy of UCLA SMERC.

Name/Designation	Presentation Topic
Victoria Velasquez	Visit Coordinator
Professor Rajit Gadh, Director, UCLA SMERC	Smart Grid Energy Research Center projects and laboratory

SMERC performs research, creates innovations, and, demonstrates advanced wireless communications, Internet and sense-and-control technologies to enable the development of the next generation of the electric utility grid - The Smart Grid. SMERC also provides thought leadership via partnership between utilities, government, policy makers, technology providers, electric vehicle and electric appliance manufacturers, DOE research labs and universities, so as to collectively work on vision, planning and execution towards a smart grid

of the future. The Smart Grid of the future would allow integration of renewable energy sources, reduce losses, improve efficiencies, increase grid flexibility, reduce power outages, allow for competitive electricity pricing, allow for integration of electric vehicles and overall become more responsive to market, consumer and societal needs. SMERC is currently working on the topics of Automated Demand Response, Electric Vehicle Integration (G2V and V2G), Micro-grids, Distributed and renewable integration, and Cybersecurity.

Some key SMERC key projects include the following:

- The **UCLA WINSmartGrid™** is a network platform technology that allows electricity operated appliances such as plug-in automobile, washer, dryer, or, air conditioner to be wirelessly monitored, connected and controlled via a Smart Wireless hub.
- The **Automated Demand-Response (ADR)** technology research program aims to showcase different levels and modalities of automation in load curtailment, control models and secure messaging schemes, leveraging multiple communication technologies and maintaining interoperability between the Smart Grid automation architecture layers.
- **Microgrid Technologies** - The micro-grid, as part of the smart grid realization, consists of renewable generation, energy storage units and demand management through a low-voltage distribution network. At SMERC, a micro-grid platform based on WINSmartGrid™ and WINSmartEV™ is being developed to control and communicate with smart devices in the micro-grid using various standards. Research being conducted based on the micro-grid platform include solar power generation forecasting, smart lighting control, and load control algorithms.

Meeting with Professor Rajit Gadh, Director

- Presentation and discussion on SMERC project work (SMERC provided presentation in electronic format.)
    - UCLA WINSmartGrid Network platform

- Automated Demand-Response (ADR)
- Micro-grid Technologies
- Cybersecurity for HAN, EVSE infrastructure, and Demand Response (DR)

- Tour of SMERC laboratory facilities

Notes on UCLA SMERC Visit Presentations and Q&A: Hartinder Bhatia, Director Energy, Itron India, a smart metering and AMI solutions vendor, joined the visits to UCLA and LADWP. Some highlights of the presentation and discussions with Professor Rajit Gadh at the UCLA visit are the following.

SMERC brings all stakeholders together to building new technologies. Several members include national and international utilities, and industry, labs, and NIST. Major sponsors and projects include DOE funded project with LW&PD, Korea SG Grant, California Energy Commission (CEC) - DR and Bi-directional Electric Vehicle (EV) charging, EPRI - Smart Grid Security. SMERC holds on Industry Thought Leadership Forums

Professor Gadh guided the Study Tour participants to view the UCLA SMERC Smart Grid Living Lab and to one of several WINSmartEV™ charging stations on the UCLA campus.

A variety of hardware is installed in the lab for experiments with grid wireless communication networks, DR, smart appliances, smart homes, and smart offices. In discussing Demand Response, Professor Gadh discussed SMREC work on smart thermostats and creating mobile apps to monitor and control appliances and work on signaling. He mentioned that driers are heavy loads in India (6 kW per clothes dryer), SMERC's work creating a mobile app for driers.

As a car can be charged in two hours when it is parked at a charging station for 8 hours, each station has multiple charging points at same basic charge box. These stations use Clipper Creek charge boxes; WINSmartEV™ works with any chargers. There is a garage and utility interface; the garage owner manages a fleet of EVs with the controls using an iPad. SMERC has developed related WINSmartEV™ mobile web applications. Data privacy standards do not permit identification of cars with personal identities. Power quality parameters are also monitored.

Professor Gadh discussed SMERC EV research and the UCLA EV Integration demonstration project, including V2G and G2V issues. In V2G, the EV can provide power to micro-grid during high priced intervals and during shortages. V2G issues include matching the voltage, phase, and frequency. Studies of impact on EV battery life have shown that if discharging is fast it does impact the battery life, and if a threshold level is maintained there is minimal impact. Ongoing research involves study of EV - solar micro-grid, a Li-Ion phosphate test bed and a solar test bed, andV2G experiments using the MitsubishiI-MIEC.

January 29, 2014,2:30 – 4:30 PM, Los Angeles Department of Water and Power (LADWP), 111 N. Hope St. LA

Note: All pictures/photographs in this section are courtesy of LADWP

Name/Designation	Presentation Topic
Stephanie Spicer, Intergovernmental Affairs & Community Relations	Visit coordinator
Marvin Moon, Director of Power System Engineering Division	Welcome & Introductions
Sungly Chiu, Power Engineering Manager, Power System Information & Advanced Technology, Smart Grid Director	Power System Overview
Surrender (Sam) Vohra, Smart Grid Project Manager	Smart Grid Pilot Project

LADWP staff presentations and discussion covered these topics, and LADWP provided their presentations in electronic format.

- LADWP Smart Grid project work
  - Power System Information & Advanced Technology
- Smart Grid Pilot Project
  - Demand Response
  - Electric Vehicle Integration
  - Customer Behavior
  - Cybersecurity

Smart Grid Regional Demonstration Program (SGRDP)

- Funded by a DOE grant, Smart Grid technology will be demonstrated on a regional electric grid. This program will create the foundation for the SGIP with implementation of Advanced metering Infrastructure (AMI).

Smart Grid Roadmap

- The Smart Grid Roadmap developed by LADWP consists of twelve separately identified projects, with planned implementation over a ten-year (2014-2024) time horizon.
- Seven of the twelve projects are dependent on the implementation of an advanced metering infrastructure (AMI) of smart electric and water meters connected to centralized data acquisition and management systems.

LADWP is collaborating with a consortium of research institutions to develop new Smart Grid technologies, quantify costs and benefits, validate new models, and create prototypes to be adapted nationally. The project consists of four broad initiatives including:

- **Demand Response (DR)**: perform an integrated demonstration of Smart Grid operations and technology as applied to DR. Test bed sites will investigate a full range of user environments: residential, commercial, light industrial, and institutional.
- **Electric Vehicle (EV) Integration** into the LADWP Grid: demonstrate aspects such as smart charging and battery aggregation; renewables and EV battery integration; an operational micro-grid; demonstration of a ride/car share program at LADWP; and EV test bed sites at USC and UCLA.
- **Customer Behavior**: demonstrate a comprehensive portfolio of studies and focused surveys related to the impact of Smart Grid communications systems and processes on customer usage; energy savings from using Smart Grid enabled interfaces; pricing options and programs; and effective messaging and incentives regarding electric vehicles.
- **Next-Generation Cybersecurity**: demonstrate technologies to show grid resilience against physical and cyber-attack, an operational testing approach for components and installed systems, and redefine the security perimeter to address Smart Grid technologies to the meter in residential and commercial sites.

Goals/Objectives

- Decrease in consumer electric costs
- Decrease in power interruption costs
- Reduction in peak power loads
- Improve grid resilience against cyber-attack and system integrity

Notes on LADWP Visit Presentations and Q&A: Some highlights of the presentations and discussions at the LADWP visit are the following.

Power System Overview - Marvin Moon and Singly Chiu

Los Angeles Department of Water and Power (LADWP) is a vertically integrated, municipal utility, owning and operating assets. LADWP is the nation's largest municipal utility and has an obligation to serve its consumers, providing water and power to the 3.9 million residents and businesses of Los Angeles and Owens Valley, California. LADWP serves a peak load of 6,142 MW, and supplies over 23 million MWh annually. LADWP has a net capability of 7,266 MW and 14,000 miles of transmission and distribution lines. LADWP has 8,800, with approximately 5,800 working on power. Marvu and Singly discussed LADWP objectives and policy mandates related to generation, including a 33 percent Renewable Portfolio Standard expected to be achieved by 2020 and meeting California's Greenhouse Gas Emissions Performance Standard.

Smart Grid at LADWP - Surender Vohra of LADWP and Dr. Shiv Prabhu of UCLA

Surendra Vohra presented the LADWP Smart Grid Regional Demonstration Program (SGRDP) and the LADWP Smart Grid Roadmap. The SGRDP is 50 percent funded by the DOE and managed by LADWP with the University of Southern California (USC), UCLA and

the Jet Propulsion Laboratory (JPL) as subs. Experts from UCLA took part in the discussion. A goal of SGRP is to demonstrate Smart Grid technology on a regional electric grid with implementation of Advanced metering Infrastructure (AMI).

Lessons learned in this pilot project will be applied in scale up and implementation of the Smart Grid Roadmap over the next decade. Surendra discussed elements of smart grids and benefits for utility- DR, workforce, and reliability; for customer - energy management, customer satisfaction, and two-way communication infrastructure. Approximately 47,400 AMI meters have been installed to date and 50 Cell Grid Routers (CGR) have been installed. A Cisco network management system has been implemented, and 38,000 meters communicate with Head-End. An asset management system is implemented to keep track of the meter installation process. Surendra discussed theft reduction, events and outage management, and AMR.

Surendra and Dr. Prabhu discussed Smart Grid pilot projects. For Demand Response the program has tested open ADB signaling and can control 45 buildings on the LADWP campus. A HAN interface with meter Zigbee, has been completed. DRAS is complete and ready to deploy. Meter tracking and asset management GUI has been completed. They discussed DDS implementation and deployment at USC micro-grid and Customer Behavior studies using the USC Campus test bed. A website is available to students and faculty at USC at an internal portal and a dashboard has been developed that is deployed in the customer households.

For Cybersecurity critical aspects are privacy of customer data and confidentiality, data integrity, system integrity, the ability to manage updates, availability, resilience, and the ability of the system to meet its operational needs. Techniques include traditional IT tests. Multiple federal and state authorities and regulators are involved, including the FCC, ISOs, FERC and NERC. Security is a matter of costs and benefits, with impact on the overall system. It is a broad topic and has many layers.

January 30, 2014,9:00 – 10:30AM, Burbank Water and Power (BWP), 164 W. Magnolia Blvd, Burbank

Name/Designation	Presentation Topic
Frederic Fletcher, Assistant General Manager/Power Supply	Presentation and discussion on BWP Smart Grid Program and Lessons Learned • Communications Infrastructure • Advanced Metering Infrastructure • Time-based rates and pricing for Electric Vehicles
Himanshu Pandey, Principal Electrical Engineer	
Bruce Hamer, Smart Grid Program Manager	Author of Smart Grid presentations and white paper

BWP provided in electronic format a presentation with an overview of its Smart Grid program and lessons learned, and a white paper discussing the communications systems BWP developed as the foundation of its Smart Grid program.

BWP's Smart Grid Program includes smart meters, communications infrastructure, outage management system, distribution automation, time-based rate programs, advanced customer service options, DR, and electric vehicle charging stations. BWP began with smart meters and found an immediate benefit from AMR, which reduced labor costs and yielded more reliable results for meter reading. The project implements two-way communications and metering to enable customers to view their energy consumption at their convenience through systems such as Web portals. The project also includes distribution automation to

enhance the reliability and quality of electric delivery and reduce operations and maintenance costs. In addition, the project includes controls for distributed energy resources to manage peak electric demand and integrate renewable resources into grid operations.

Smart Grid Features

- Communications infrastructure includes a fiber optic network and a city-wide secure wi-fi mesh radio frequency network. The fiber optic ethernet network allows for monitoring and control of the electric distribution system. Radio devices in smart meters transmit data through a new wi-fi network. The new meter data management and outage management systems use data and notifications from smart meters and automated distribution equipment. These networks provide two-way communication between BWP and customers and enable DR and advanced electric service options.
- Advanced metering infrastructure (AMI) includes smart meters for all 52,257 residential, commercial, and industrial customers. AMI enables time-based rate programs and electric service options for customers. BWP expects lower operational costs from remote meter reading and more frequent identification of electricity theft. New AMI features such as outage notification and remote service switches enable BWP to respond to outages and customer requests quickly and efficiently.
- Time-based rate programs include time-of-use pricing for commercial and electric vehicle owners, critical peak pricing (under consideration), and related information services in conjunction with advanced metering to encourage consumers to shift their energy consumption from on- to off-peak periods.

January 30, 2014,11:30 AM – 1:30 PM, LA – Airport Marriott Century Blvd

Met with vendors and viewed presentations on Smart Grid solutions and services.

Name/Designation	Presentation Topic
Laura Raymond, Chief Commercial Officer, Innovari	Innovari Smart Grid Solutions and Services
Chris King, Global Chief Regulatory Officer, Siemens	Siemens Smart Grid Solutions and Services

- Each vendor provided a copy of their presentation in electronic format.
- Final de-briefing of Smart Grid Study Tour participants.

CONCLUSIONS AND RESULTS

Lessons Learned

Several of the utilities and institutions visited recommended great care and thorough planning in Smart Grid implementation as a result of lessons learned and consumer controversies surrounding the installation of smart meters. This is exemplified in PG&E's implementation approach which includes:

- Standards definition to ensure interoperability and prevent vendor lock-in.
- R&D testing end to end. PG&E aims to implement and test each system at lab before moving it out into the field.
- Controlled pilots to prove benefits and feasibility.
- Targeted deployment of full-scale roll-out after a cost-benefit analysis and approval from regulators.

Key Results and Next Steps

AMR has yielded the first significant benefits of Smart Grid and AMI, including reduced labor costs and more reliable results for meter reading and reduced opportunities for energy theft. Improved outage management and response are also early benefits of AMI. Pilot projects are exploring other Smart Grid technologies applications of significant real time data capabilities of AMI.

1. Communication infrastructure – Mesh network with RF is a technology to consider. Cellular technology should be considered for rural areas. If fiber optics is considered as communication infrastructure, then bundled service can be sold for unused portion to reduce the cost of implementation. Wi-max has not been successful from cost point of view.
2. Customer Engagement – Most important for success of the program. Education/training prior to project start and timely feedback are very important for customer acceptance. Green Button initiative is an important aspect of customer engagement.
3. Micro-grid Projects – Should be considered with the option of switching on and out of the grid to minimize burden on the transmission grid and reducing generation reserve requirement.
4. Dynamic pricing programs for DR can be successful if properly implemented (technical requirement: interval metering).
5. Smart Meters – Helps system reliability, tamper detection, outage reduction.

What Needs To Be Done

- Maintain communication and sharing of information among utilities, government, and stakeholders in India related to Smart Grid implementation and developments.
- Encourage utilities to organize dissemination workshops to:
  - (i) share the information and lessons learnt;
  - (ii) raise awareness of tools and technologies available for project implementation;
  - (iii) identify commonalities and synergies and relevance for in-house applications;
  - (iv) identify areas needing further exposure and more detailed information; and
  - (v) Find most effective ways of customer engagement in regional context.
- Regulators need to determine domestic compliance models taking into account the lessons learnt from U.S. regulators.
- Engage in technical exchanges and participate in the technical forums to keep abreast of the latest tools and technologies.
- Reach out to the host entities through Nexant as primary point of contact for in-depth information on specific areas of implementation.

ACRONYMS

Acronym	Definition
21CPP	21st Century Power Partnership
ADB	Asian Development Bank
ADR	Automated Demand-Response
AMI	Advanced Metering Infrastructure
AMR	Automatic Meter Reading
AOP	Agent oriented programming
ARRA	American Recovery and reinvestment Act.
AT&C	Aggregate Technical and Commercial
AVL	Automatic Vehicle Location
B2G	Building to Grid
BEE	Bureau of Energy Efficiency
BESCOM	Bangalore Electricity Supply Company Ltd.
BGE	Baltimore Gas & Electric
BHU	Banaras Hindu University
BWP	Burbank Water and Power
CAIDI	Customer Average Interruption Duration Index
CAISO	California Independent System Operator
CBL	Customer Baseline
CEC	California Energy Commission
CEM	Clean Energy Ministerial
CERC	Central Electricity Regulatory Commission
CERTS	Consortium for Electric Reliability Technology Solutions
CESC	Chamundeshwari Electricity Supply Corporation Limited
CFE	Commission Federal de Electricidad
CGR	Cell Grid Routers
CO_2	Carbon Dioxide
ConED	Consolidated Edison
CPP	Critical Peak Pricing
CPRI	Central Power Research Institute
CPUC	California Public Utilities Commission
CRN	Cooperative Research Network™
CSPDCL	Chhattisgarh State Power Distribution Company Limited
CSPs	Curtailment Service Providers
CSRP	Commercial System Relief Program
CSWG	Cybersecurity Working Group
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D2G	Demand to Grid
DADRP	Day Ahead Demand Response Program
DDS	Data Distribution Service
DER	Distributed Energy Resources
DER-CAM	Distributed Energy Resources Customer Adoption Model

DG	Distributed Generation
DLC	Direct Load Control
DLRP	Distribution Load Relief Program
DMS	Distribution Management System
DOD	Department of Defense
DOE	Department of Energy
DPP	Dynamic peak pricing
DR	Demand Response
DRAS	Demand Response Automation Server
DRQAT	Demand Response Quick Assessment Tool
DRRC	Demand Response Research Center
DSASP	Demand Side Ancillary Services Program
DSIC	Distribution System Improvement Charge
EA 2003	Electricity Act 2003
EDC	Electric distribution companies
EDEWG	Electronic Data Exchange Working Group
EDRP	Emergency Demand Response Program
EE	Energy Efficiency
EETD	Energy and Environmental Technologies Division
EISA	Energy Independence and Security Act of 2007
EPRI	Electric Power Research Institute
ERCOT	Electric Reliability Council of Texas
ESDR	Energy Storage and Distributed Resources
EVs	Electric Vehicles
ExCo	Executive Committee
FCC	Federal Communications Commission
FERC	Federal Energy Regulatory Commission
FFC	Federal Communication Commission rules
FLEXLAB	Facility for Low Energy Experiments
FOA	Funding opportunity announcements
FTR	Financial transmission rights
FY	Financial year
GIG	Grid Integration Group
GIS	Geographic Information System
GOI	Government of India
GPS	Global Positioning System
GUI	Graphical User Interface
HAN	Home Area Network
HEVs	Hybrid Electric Vehicle
HSIL	High Surge Impedance Loading
HTLS	High Temperature Low Sag
IAS	Indian Administrative Service
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IES	International Energy Studies Group

IGNOU	Indira Gandhi National Open University
IOUs	Investor Owned Utilities
ISGAN	Smart Grid Action Network
ISGF	India Smart Grid Forum
ISGTF	India Smart Grid Task Force
ISM	Integrated System Model
ISO	International Organization for Standardization
ITU	International Telecommunication Union
JNNSM	Jawaharlal Nehru National Solar Mission
JPL	Jet Propulsion Laboratory
KSGI	Korea Smart Grid Institute
LADWP	Los Angeles Department of Water and Power
LBNL	Lawrence Berkeley National Laboratory
LEAD	Low Emissions Asian Development Program
LIPA	Long Island Power Authority
LMP	locational marginal pricing
LTIIP	Long-Term Infrastructure Improvement Plan
M&V	Monitory and Verification
MBA	Master of Business Administration
MDMS	Meter Data Management System
MERC	Maharashtra Electricity Regulatory Commission
MNRE	Ministry of New and Renewable Energy
MOP	Ministry of Power
MOU	Memorandum of Understanding
MSEB	Maharashtra State Electricity Board
MSEDCL	Maharashtra State Electricity Distribution Company Limited
MUNIS	Municipal Utilities
MW	Megawatt
NAESB	North American Energy Standards Board
NERC	North American Electric Reliability Corporation
NIST	National Institute Standards and Technology
NRECA	National Rural Electric Cooperative Association
NREL	National Renewable Energy Laboratory
NTPC	NTPC Limited (formerly National Thermal Power Corporation)
NVLAP	National Voluntary Laboratory Accreditation Program
NY	New York
NYISO	New York Independent System Operator
NYPA	New York Power Authority
NYSERDA	New York State Energy Research and Development Authority
O & M	Operations and Maintenance
OATT	Open access transmission tariff
OMF	Open Modeling Framework
OMS	Outage Management System
OpenADR	Open Automated Demand Response
OpenSEG	Open Residential Energy Gateway

PACE-D	Partnership to Advance Clean Energy – Deployment
PAPs	Priority Action Plans
PA-PUC	Pennsylvania Public Utility Commission
PEC	Pacific Energy Center
PEEWG	Power & Energy Efficiency Working Group
PFC	Power Finance Corporation
PG&E	Pacific Gas and Electric Company
PGCIL	Power Grid Corporation of India Ltd
PLM	Peak Load Management
PMUs	Phasor Measurement Units
PNNL	Pacific Northwest National Laboratory
PPL	Pennsylvania Power and Light
PPP	Public Private Partnership
PSC	Public Service Commission
PTO	Pressure, Temperature and Oil
PTR	Peak time rebate
Q&A	Question and Answers
R & D	Research & Development
R & M	Renovation and Modernization
R-APDRP	Restructured Accelerated Power Development and Reforms Program
RASEI	Renewable and Sustainable Energy Institute
RFP	Request for proposal
RPS	Renewable Portfolio Standard
RSAP	Residential Smart Appliance Program
RTEP	Regional Transmission Expansion Planning
RTO	Regional Transmission Operator
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SBC	System Benefits Charge
SCR	Special Case Resources
SEM	Smart Energy Manager
SER	Smart Energy Rewards
SG	Smart Grid
SGCC	Smart Grid Cybersecurity Committee
SGDP	Smart Grid Regional Demonstrations
SGIG	smart grid investment grant
SGIP	Smart Grid Interoperability Panel
SMERC	Smart Grid Energy Research Center
SMUD	Sacramento Municipal Utility District
SPIDER	Smart Power Infrastructure Demonstration for Energy Reliability and Security
SPP	Southwest Power Pool
SWE	Statewide Evaluation
T&D	Transmission and distribution
TRM	Technical Reference Manual
U.S.	United States

UC	University of California
UCAIUG	Utility Communications Architecture International Users Group
UCLA	University of California Los Angeles
UCS	University of Southern California
USAID	United States Agency for International Development
USC	University of Southern California
USTDA	U.S. Trade Development Agency
V2G	Vehicle-to-Grid
VirGIL	VirGIL
WAMS	Wide Area Monitoring Systems

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