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Proceedings of the
Distributed Utility Valuation Project

Research Results and Utility Experience Workshop

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Baltimore, Maryland

EPRI
Electric Power Research Institute

NREL
National Renewable Energy Laboratory

PG&E
Pacific Gas & Electric Company

Pacific Northwest Laboratory

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OVERVIEW

Workshop Purpose And Objectives

This workshop was sponsored by the Distributed Utility Valuation (DUV) Project—a joint effort of the National Renewable Energy Laboratory (NREL) Department of Energy (DOE), Electric Power Research Institute (EPRI), Pacific Northwest Laboratory (PNL) Department of Energy (DOE), and Pacific Gas & Electric Company (PG&E). The purpose of the workshop is to provide a forum for utilities, other research organizations, and regulatory agencies to share results and data on Distributed Utility (DU)-related research and applications.

Up-to-date information provided insight into the various technologies available to utilities, the methods used to select the technologies, and case study results. The workshop was divided into three sessions:

- Planning Tools
- Utility Experience
- Policy and Technology Implications.

Brief summaries of the individual presentations from each session are attached as appendices.

Background

A number of factors and recent trends will affect future electric utility operations:

- Industry financial and economic climate
- Technological advances
- Difficulties in siting new central-station power plants and transmission lines
- Limitations to utility power plant economies of scale
- High cost and relatively poor utilization of distribution systems
- Potential savings of small modular generation and storage technologies.

The DU approach attempts to address many of these issues. Distributed generation and storage systems in conjunction with demand-side technologies and programs may be able to cost-effectively defer or displace a portion of new central-station generation, transmission, and distribution upgrades.

Early studies by PG&E, EPRI, DOE, and others have indicated that certain distributed power supply, storage, and demand-side technologies, if carefully located, could derive additional transmission, distribution and reliability benefits to offset their initial cost and become desirable alternatives to traditional utility expansion options.

The mission of the DUV Project is to lead and assist the U.S. utility industry in fully evaluating the costs and benefits of distributed generation, storage, and demand-side technologies through:

- Development of valuation methods, planning models, and information
- Improved characterization of technical issues and research and development (R&D) requirements
- Analyses of institutional/stakeholder issues and opportunities.

PLANNING TOOLS

Current system planning models do not provide sufficient detail for a utility to determine if DU technologies can play an economic role in meeting future demand and supply needs. New planning tools need to be developed to integrate distribution system planning into generation and transmission system planning. Several projects are currently underway to develop and refine the planning tools and methods needed by utilities to determine where, how, when, and to what extent DU technologies should be implemented on the utility system. The papers presented during this session address several key issues involved in the utility planning process. A brief synopsis of each of these papers is presented in Appendix A.

Key Findings—Planning Tools Session

- Effective planning tools necessary to incorporate DU into existing utility structures do not yet exist.
- The Delta model, while a significant step in the right direction, needs to be refined to incorporate intertemporal investment decisions, dispatching problems, uncertainty, and modularity.
- Development of Integrated Generation Transmission and Distribution (IGTD) models is moving forward but needs further work to achieve full integration.
- Conventional DU technologies, such as gas-fired gensets, have greater applicability in the near term.
- Detailed site-specific evaluations are essential for cost-effective DU implementation.
- Considerable detail is needed to perform adequate DU analysis, much of which is not currently available.
- Because of the modularity and flexibility of DU technologies, a utility contemplating additions to its generating or transmission and distribution capacity can reduce risk created by uncertain conditions such as changing load patterns and operating environments.

UTILITY EXPERIENCE

Several site-specific applications of DU technologies have been or are in the process of being built by various utilities and/or research organizations. Because the DU concept is still in an early stage, utility applications have been limited to high-value niche applications. As more information is gathered from current applications, and planning tools become more precise, more applications will probably be implemented. Several presentations were made at the workshop, ranging from programs that target demand-side management (DSM) to programs using superconducting magnetic energy storage (SMES) for power quality enhancement. A brief synopsis of each presentation appears in Appendix B.

Key Findings — Utility Experience Session

- Photovoltaic (PV) applications can be cost effective when restrictive siting and permitting requirements limit conventional options such as gas-fired gensets.
- PV and wind applications need back-up systems, such as batteries, to attain deferral benefits if output does not match distribution peak.
- Distributed PV benefits are higher under low-growth scenarios.
- Targeted DSM, to defer T&D expenditures, is a growing utility interest area.
- High-temperature fuel cells *can be* competitive with conventional technologies such as reciprocating engines, internal combustion engines, and gas turbines (under restrictive study parameters, using utility economic factors and busbar cost as the primary basis).
- Battery storage applications have advanced, but benefit assessments and hardware maintenance need further advancement.
- DU may reduce the risks of long-term power plant investment.
- DU assessments must be site specific.
- Modular transportable design features can increase the value of DU when compared to site-dedicated designs.
- SMES technology can provide the customer with high-quality service in certain applications such as momentary loss of power, adjustable speed drives, programmable logic controllers, and computers.
- Engine-driven generators may provide a reliable near-term DU resource.

POLICY AND TECHNOLOGY IMPLICATIONS

As DU technologies prove themselves in real-world settings and establish their economic viability, the policy and technological implications become more relevant. Myriad institutional, legal, and technological issues arise when a utility considers implementing DU technologies on its system. The presentations during this session of the workshop address several of these issues. A brief synopsis of each presentation appears in Appendix C.

Key Findings—Policy and Technical Implications Session

- The legal, institutional, and regulatory issues involved in DU will have a significant impact on the success of the concept.
- Utility managers will need to develop strategies to cope with or benefit from the implications of distributed resources.
- DU technologies can have a considerable impact on the distribution system, which planners and engineers need to take into account when implementing DU.

CONCLUSIONS

Increased R&D is being done on the DU issue as evidenced by the presentations of research and DU applications at this workshop. While the presentations at the Baltimore workshop do not go into detail on all issues related to the DU concept, the DUV Project sponsors attempted to present a representative cross section of current activities in the topic areas.

The majority of the research findings and conclusions presented at this workshop are preliminary. As final results and findings become known, additional research and project applications will probably be undertaken by the DUV Project sponsors and others. Additionally, as technological changes occur and regulatory parameters change to meet the demands of stakeholders (e.g., retail wheeling), DU research and information will need to be updated to incorporate these changes.

ADDITIONAL INFORMATION

To assist the utility industry, research organizations, and regulatory agencies, the DUV Project is creating a data base of DU-related project research and applications. It is the intent of the DUV Project that this be in place by the beginning of 1995.

As more organizations delve into the DU concept, it is important that DU-related information be coordinated so that the information can be disseminated. This will help further the understanding of the DU concept and its applicability to various utility scenarios. Contact the DUV Project Coordinator, at the National Renewable Energy Laboratory in Golden, Colorado, at the following address for more information:

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Appendix A
Planning Tools
Summary of Presentations

"Overview of Distributed Utility Planning Issues"
Joseph Iannucci, *Distributed Utility Associates*

This presentation provided an overview of the myriad issues involved with attempting to plan and eventually implement the distributed utility (DU) concept. It compared the relative benefits and costs of traditional centralized utility planning to the DU planning approach. It defines the distributed utility as "one which incorporates energy-significant distributed generation, storage and feeder-specific DSM/CEE in its T&D system to augment its central station plants and allow better utilization of its T&D assets." It identifies several factors and/or methods that could be used to achieve this, such as integrating the generation, transmission, and distribution planning functions; incorporating uncertainty into the planning models; and incorporating the modular advantages of the DU approach. Throughout his presentation Mr. Iannucci stressed the value of "Keeping It Simple."

"The Effects of DSM/DG&S on the Bottom Line"
Dr. Roger Pupp, *Energy and Environmental Economics*

Dr. Pupp reported on a study at Pacific Gas & Electric (PG&E) to determine if local transmission and distribution expenditures could be reduced by adopting cost-effective demand-side management (DSM) programs and distributed generation and storage (DG&S) devices. The Enhanced Delta Model was used to estimate cost-effective penetrations of DSM and DG&S in selected distribution planning areas (DPA) at PG&E. Once the test results are calculated, they will be extrapolated to all DPAs on the PG&E system to estimate systemwide cost savings. Through this analysis PG&E will be able to ascertain the effectiveness of these approaches on differing planning area configurations to determine where DSM and DG&S can be most effective.

"Integrated Planning Models and Enhancements to the Delta Model"
Dr. Charles Feinstein, *Santa Clara University*

Dr. Feinstein discussed efforts to create a methodology for integrated planning using an approach to integrate generation, transmission, and distribution planning models into one comprehensive planning tool. This will provide a means to evaluate DU applications that is realistic and easy to use. Dr. Feinstein presented the challenges associated with building links between generation, transmission, and planning models, and the next steps to improve the model capabilities to better evaluate the effects of DU.

"A Market-Based Framework for Evaluating High Value Applications for Distributed Generation"
Dan Rastler, *Electric Power Research Institute*

In his paper Mr. Rastler introduces the market-based framework developed at the Electric Power Research Institute (EPRI) for identifying high-value applications for distributed generation and for benchmarking costs compared to traditional sources of bulk power. He presented key findings from several EPRI studies involving natural-gas-fueled resources, photovoltaic arrays, and battery systems. The key findings in his presentation were:

- T&D upgrade deferrals have value but may be limited to feeders, transformers, and substations.
- Focus should be on areas with high-value industrial and commercial customers.
- Distributed generation is applicable in special service situations such as high outage or hard-to-serve areas and areas where alternative fuel opportunities may be attractive.
- Detailed site-specific evaluations are essential for meaningful results.

"Distributed Utility Feeder Data Analysis: Project Summary"
Rob Pratt, *Pacific Northwest Laboratory*

The Feeder Analysis study attempts to model algorithms for DU impacts on feeder loads, simulate DU impacts on the utility system, and perform a cluster analysis of feeder load duration curves for the PG&E system. Future goals are to apply multiple scenario analyses and to improve the analysis by including specific DU technologies, central generation, T&D and DU resource economics, and by using more realistic feeder load growth and reconfiguration strategies.

"Value of Modularity and Flexibility"
Steve Chapel, *Electric Power Research Institute*

This study extends an earlier analysis by PG&E, which developed a methodology to estimate the value of distributed generation technologies, and estimates the additional value that flexibility and modularity can provide a utility. By using flexible and modular technologies, the utility can plan for and react to changing local-area conditions and avoid becoming locked into alternatives that are no longer cost-effective, which can significantly add to the overall value.

Appendix B
Utility Experience
Summary of Presentations

"Interfacing Local Demand Side Management/Distributed Generation and Storage with Integrated Resource Planning"
Mark Griffith, Kansas City Power & Light Company

Kansas City Power & Light Company (KCPL) conducted a study to determine what the cumulative cost savings of distributed utilities (DU) might be for its entire utility system using limited data that can potentially serve as an impediment to DU implementation. The results from this project will be used to determine the potential benefits to the KCPL system, identify additional data required to assess the value of those benefits more accurately, and identify issues related to DU.

"Issues in Developing a Targeted DSM Project: A Case Study"
Mark Kumm, *Potomac Electric Power Company*

Potomac Electric Power Company (PepCo), recently solicited bids on the development of a plan to operate a pilot targeted demand-side management (DSM) initiative to delay or defer future transmission and distribution (T&D) expenditures. Responses to the request of proposal (RFP) focused on developing area-specific marginal costs, identifying cost-effective DSM measures for specific areas, and potentially operating area-specific DSM programs. In light of the responses received, PepCo has redesigned its RFP and is examining the companywide implications of the proposals received.

"Kerman PV Grid-Support Valuation"
Jay Raggio, *Pacific Gas & Electric Company*

In 1988, it was hypothesized that strategically sited photovoltaics (PV) could benefit parts of the T&D systems near or at overload conditions. To obtain empirical data, a 500 kW PV plant was constructed at Kerman, California, as part of the PVUSA project. The Kerman plant began operation in June 1993, and the traditional bulk system and distributed local value components are currently under review with expected final results by the end of 1994.

"Distributed Photovoltaic Benefits: Four Case Studies"
John Stevens, *Sandia National Laboratories*

With the Kerman study as a precursor, Sandia National Laboratories has issued four contracts to investigate the "target" cost for PV systems to Arizona Public Service (APS), Austin Electric, Plains Electric (PE), and the Salt River Project. To date only APS and PE have completed their work. APS has identified a site where a PV system of 1 MW could be installed at a breakeven cost of between $3.50 and $4.50 per watt. PE has identified a site where a 50 kW system can break even at $10.50 per watt. The PE photovoltaic installation provides needed voltage support rather than reducing thermal loading on facilities. Preliminary results from Austin Electric and the Salt River Project indicate lower breakeven costs than APS and PE, possibly because of the density characteristics of Salt River and Austin Electric. (NOTE: Current PV cost installed is approximately $9/W and projected 1996 costs are approximately $6/W.)

"Impact of Distributed Generation on Salt River Project's Urban T&D System"
Ken Alteneder, *Salt River Project*

In conjunction with the Sandia National Laboratories work, the Salt River Project (SRP) has begun investigation of its system to determine potential sites for implementing DU. SRP is in the process of determining information needs, loading capabilities, contingencies, and generation requirements to defer T&D. The research has determined that assessment of distributed PV generation in an urban environment is complex and requires determination of future electrical system load shape and PV impact on this load shape. Future integrated resource plans will probably include various distributed generation and DSM technologies.

"Integrating Distributed Renewable Energy Sources into Distribution Systems"
H. W. Zaininger, *Zaininger Engineering Company*

Mr. Zaininger has performed case studies for seven utilities on integration of renewable energy sources into electric power distribution systems. The value of the benefits quantified varies significantly for the seven utilities because of different utility distribution system characteristics, cost assumptions, financial parameters, and renewable energy source performance characteristics. Conclusions and observations were:

- Wind technology is cost effective at good wind sites.
- Distributed PV benefits can approach $4,000/kW for slow growing distribution systems.
- PV output has excellent time-of-day correlation with commercial and mixed commercial-residential distribution system load shapes for some utilities.
- Battery storage is needed to back up PV or wind turbine systems to obtain distribution deferral benefits in cases where there is poor time-of-day correlation between PV or wind output and distribution peak.
- Tracking PV may not be the most economical design, even though the benefit-to-cost ratio may be higher.

"Distributed Utility Case Study"
R. A. Figueroa, *San Diego Gas & Electric Company*

San Diego Gas & Electric Company (SDG&E) conducted a case study to identify the likelihood that small energy generation technology (<20 MW) can be implemented cost effectively in the 1998-2000 time frame. The results of the study showed that, when allowances are made for site-related constraints, customer requirements, and institutional issues, the most common unit size is likely to be less than or equal to 5 MW. The study found that high-temperature fuel cells *can be* potentially competitive with other technologies such as reciprocating engines, internal combustion engines, and gas turbines (under restrictive study parameters, using utility economic factors and busbar cost as the primary basis). It also determined that DU may reduce the risks of long-term power plant investment.

"Distributed Generation Utility Case Studies: Lessons Learned and Research Needs"
Mohammed El-Gasseir, *Rumla, Inc.*

Twelve studies undertaken as a collaborative effort between the Electric Power Research Institute (EPRI) and member utilities served as the developing ground for Dan Rastler's paper presented earlier. Options investigated included commercial off-the-shelf and non-commercial developing renewable and gas-fired technologies. The results were mostly favorable to certain distributed generation (DG) technologies, but some uncertainties concerning permitting and performance need to be resolved. Major conclusions were:

- DG assessments must be site specific to be meaningful.
- DG poses both opportunities and risks for the electric utility industry.
- Distribution and subtransmission deferral benefits can, under certain conditions, be helpful in bridging the gap between distributed and centralized supply options.
- Research should be focused on evaluating DG performance and cost characteristics, and on DG impacts as a market-driven phenomenon.
- Technology development efforts should be centered on low-emission generating packages, cogeneration options, and improving fuel economy and reliability.

"Ignacio 1 MW Peak Shaving Demonstration"
Jay Raggio, *Pacific Gas & Electric Company*

The modular genset sited at Pacific Gas & Electric's (PG&E's) Ignacio Substation is a natural gas-fired, 16 cylinder, 1 MW generator with switchgear that fits into a standard 40 foot trailer. The objectives of the demonstration project are to determine system requirements/performance/cost; to test a remote, unattended modular system; to develop and test-smart control systems; and to promote acceptance of DG among planners and system operators. The installation was not yet in place at the time of the workshop. Future PG&E plans include documentation of the unit's field performance; impact on feeder conditions; system attributes and limitations; and development of guidelines on permitting, siting, grid protection, and supervisory control and data acquisition (SCADA) applications.

"Battery Storage Projects at PG&E"
Ben Norris, *Pacific Gas & Electric Company*

The Battery Storage Projects studies, conducted by PG&E, have four components:

1. GNB Battery Study, January 1992-June 1993, Benefits Assessment
2. AC Battery Testing, August 1990-June 1995, Hardware Evaluation
3. Utility Scale Battery Demonstration, January 1993-December 1996, Field Demonstration
4. Zinc Bromine Testing, July 1994-June 1995, Advanced Battery Evaluation.

While all technologies have advantages and disadvantages, the utility-scale demonstrations are expected to further define the parameters for successful utility applications.

"Ten MW Chino Battery Plant: Operational Results"
Robert Scheffler & Lorn Ellico, *Southern California Edison*

The Chino Battery Plant was installed several years ago and has been superseded by more modern designs. Although SCE has had its share of problems with the Chino plant, the plant has also provided valuable insight into battery technology. The results of the project are:

- Various modes of operation were successfully demonstrated, but technical/economic issues persist.
- Benefits are currently limited because of economic factors, excess generation capacity, and operational costs.
- System damping is a high-value benefit but requires upgrades to the power conditioning system. A research project to test this concept is underway.
- Maintenance requirements are a major issue for costs as well as reliability and performance.

Key problem areas with the Chino plant and attendant implications are:

- Electronics problems: downtime, costs
- Battery leakage, weak cells: cost, reduced performance
- Watering fixtures: costs, cells out of service
- Air conditioning, ventilation fans and air compressors for electrolyte agitation system: high parasitic losses, maintenance costs.

"Update on Distributed Aspects of Battery Storage Technology"
Abbas Akhil, *Sandia National Laboratories*
Paula Taylor, *Energetics, Inc.*

Battery storage technology is changing rapidly. In 1988, Puerto Rico Electric Power Authority (PREPA) installed a 20 MW/14.1 MWh battery storage facility in San Juan. This installation provides PREPA with spinning reserve, voltage regulation, reactive power control, and black-start operation. In 1991, DOE funded development of a 250 kW/167 kWh modular, transportable battery system in a transportable container. The modular design allows production-line assembly and grouping of modules to obtain power ranges in the megawatts. The modular design and transportability provide for potential DU application of the technology. The Utility-Scale Battery Demonstration project will seek to scale up this technology to approximately 2MW/2MWh.

"Micro -SMES Applications"
Jay Raggio, *Pacific Gas & Electric Company*

PG&E is currently researching the potential of superconducting magnetic energy storage (SMES) to solve a power voltage problem on the Bay Area Rapid Transit (BART) system. Other potential applications of SMES technology include adjustable speed drives, programmable logic controllers, computers, occasions where high-dollar losses per momentary or sag occur, and areas of high frequency of disturbances (weak feeder).

"SMES for Reliability and Power Quality Enhancement"
Paul Vinett, *Central Hudson Gas & Electric Corporation*

For the last 3 years, Central Hudson has been participating in development of a superconducting magnetic energy storage device (SSD) to improve power quality to high-tech loads. An SSD does this by sensing momentary electric power disruptions and instantly providing supplementary power. In conjunction with Superconductivity, Inc., Central Hudson successfully field tested an SSD unit at one of IBM's semiconductor test facilities. Central Hudson is continuing to support commercial testing at other locations, including an Air Force base in Florida and a Motorola facility in Texas.

Appendix C
Policy and Technology Implications
Summary of Presentations

"Distributed Energy Technology Commercialization and Deployment"
Joseph Galdo, *Office of Utility Technologies, U. S. Department of Energy*

Mr. Galdo presented the Office of Utility Technologies program area funding for the fiscal years 1992 through the 1995 budget request. In addition, energy cost curve projections for photovoltaics, wind power, biomass, and binary geothermal energy sources were provided as well as provisions of the proposed Climate Change Action Plan. The renewable energy commercialization incentives in the National Energy Policy Act (EPAct) include:

- Renewable energy production incentive payments for publicly owned facilities
- Production tax credits for biomass and wind power
- Business energy investment tax credits for solar and geothermal property
- Demonstration and commercialization projects for renewable energy technologies.

"Overview of Legal and Institutional Issues Shaping the Distributed Utility"
John Nimmons, J.D., *John Nimmons & Associates*

Like other aspects of distributed utility (DU) research, legal and institutional inquiries will involve a broad and complex array of issues. Many will need to be better defined through close coordination with planning, modeling, and engineering work currently underway. The preliminary work done to this point, however, reveals that legal and institutional considerations will have a direct and significant impact on key questions such as the following:

- Will potential DU benefits be realized in practice?
- How will DU costs, benefits, risks, and rewards be allocated among utilities and other stakeholders?
- What incentives and disincentives will utilities have to adopt DU strategies?
- What roles will utilities and others play in DU activities?

Dr. Nimmons discussed several of the key issues facing utilities, potential utility competitors, and regulatory agencies. He covered issues such as ownership and control, valuation, antitrust, information access, allocation of costs and benefits among stakeholders, and incentives and disincentives for utilities.

(NOTE: A report on the proceedings from the Institutional Issues Workshop, November 1993, sponsored by the Distributed Utility Valuation Project, is available from the National Renewable Energy Laboratory.)

"EEI Utility Distributed Resources Task Force"
Kip Sikes, *Idaho Power Company*

Mr. Sikes described the Edison Electric Institute's (EEI) sponsored task force on DU, the Utility Distributed Resources Task Force (UDR). The mission of the EEI UDR is to

- Identify substantive issues and concerns
- Analyze pertinent industry, legislative, regulatory, and technical developments
- Formulate options for utilities to manage the implications of distributed resources.

"Distributed Utility Technology Cost and Performance Characteristics"
Yih-huei Wan, *National Renewable Energy Laboratory*

This presentation summarized an ongoing NREL study that identifies the cost, performance, and siting characteristics of modular generation and storage systems and demand-side management measures applicable to DU settings. The purpose of the study is to provide a consistent set of technical and cost information needed in the evaluation and planning of DU. Actual siting of facilities will require data and information specific to the site. Performance characteristics, technical attributes, and cost projections of each technology were presented, along with environmental considerations and siting constraints of the DU technologies. Actual utility siting experience of three modular generation technologies were documented and analyzed to demonstrate the process and highlight the special attributes of distributed technologies.

"Impacts of the Distributed Utility on Transmission Stability"
Jeff Dagle, Matt Donnelly (presenter), Graham Rogers, and Dan Trudnowski, *Pacific Northwest Laboratory*

This study provides a preliminary assessment of potential DU impacts on the stability of electric power bulk transmission systems. The presentation identified initial results for transient and small-signal stability cases. The goals of the research are to provide system planners with

- A listing of the potential impacts of the DU concept on the bulk transmission system
- An assessment of the stability impacts of DU on the bulk transmission system. This includes transient (first swing), small-signal (oscillatory), and voltage-stability phenomena
- Guidelines on the severity of stability impacts for a given level of DU penetration
- Knowledge of useful tools for stability analysis in a DU environment.

Future directions for the research include:

- More accurate representation of DU installations in the distribution system using network reduction techniques
- Sensitivity studies on the level of DU penetration
- Voltage stability studies

- Stability studies with generation and storage DU components.

"Dispersed Energy Impacts on the Distribution System"
Dr. David Richardson, *Electric Power Research Institute*

This presentation discussed key technical issues, impacts, and EPRI plans for assisting utilities in dealing with the impacts of dispersed energy on the distribution system. Potential impacts are:

- Different relay packages may be needed.
- Islanding detection problems.
- Reclosing practices may need modification.
- Resonant conditions may cause arrester failures.
- Harmonics may interact with system capacitors.
- Fluctuating generation will not work well with regulators.

To assist utilities in dealing with these issues, EPRI is developing tools for utility planners and engineers to incorporate dispersed energy into their distribution systems. In response to these needs EPRI has developed the following program:

- Phase 1 — Dispersed Energy Applications Handbooks
- Phase 2 — Software Tool Development
- Future — Development of a Technology Assessment Guide and Applications.