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CITY OF CHICAGO

URBAN CONSORTIUM ENERGY TASK FORCE (UCETF) OF PUBLIC TECHNOLOGY, INCORPORATED

YEAR 21 FINAL REPORT
GRANT NO. DE-FG02-99EE27577
MUNICIPAL ENERGY MANAGEMENT PROGRAM (MEMP)

Prepared by the City of Chicago
Department of Environment

DOE Patent Clearance Granted
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URBAN CONSORTIUM

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DISCLAIMER

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and

U.S. Department of Energy
For financial support, which enabled to UCETF to competitively select and co-fund nearly 400 energy projects to address locally-defined energy priorities in jurisdictions all across the United States

Eric W. Thomas, Sr.
Office of Building Technology Assistance
U.S. Department of Energy
Washington, D.C.
For invaluable program support

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MUNICIPAL ENERGY MANAGEMENT PROGRAM (MEMP) OVERVIEW

The Urban Consortium Energy Task Force (UCETF), comprised of representatives of large cities and counties in the United States, is a subgroup of the Urban Consortium, an organization of the nation's largest cities and counties joined together to identify, develop and deploy innovative approaches and technological solutions to pressing urban issues. The Urban Consortium parent organizations are: National League of Cities, National Association of County Administrators and the International County Management Association.

With funding provided by the United States Department of Energy, Municipal Energy Management Program, the UCETF annually conducted a program of applied energy technology research and development, application and replication projects that addressed locally-defined energy needs. Projects were competitively selected for funding based on merit. Projects were conducted by local government staff, in furtherance of the fundamental UCETF objective of improving the energy management capabilities of local governments. All programs had to demonstrate strong partnerships, which in many cases included cost-sharing, from the private sector and other government agencies, in order to maximize the application of successful project results. Through these emphases, the UCETF enhanced the ability of local governments to improve energy management and respond to Federal energy programmatic and policy directions.

Some UCETF-funded projects had a technology focus, some addressed longer term and institutional issues, and some were policy oriented. The UCETF program was successful because it was able to address all of these areas. A variety of technology transfer and solution deployment activities were designed to widely disseminate the knowledge gained through the performance of local government energy projects to jurisdictions throughout the United States.

The strengths of the UCETF included a diverse membership reflecting the population of urban areas; a focus on application of new technologies/techniques and management practices to deliver local services more efficiently, improve the local revenue base, and create sustainable urban areas; our commitment to development of the capabilities of local government staffs to identify and address energy issues; and the commitment and capabilities to transfer technology among similarly situated urban areas. The mission was to serve as the premier catalyst for energy efficiency at the local government level, both acting as an "urban laboratory" and technology transfer agent. The vision was for sustainable energy systems to be in place in cities and counties in the 21st century. The objectives included developing measurable outcomes and evaluation techniques; deploying solutions; broadening technology transfer; and continued focus on local government innovation and technical leadership.

TOTAL PROJECTS FUNDED/DOLLARS AWARDED

The United States Department of Energy's Municipal Energy Management Program (MEMP) demonstrated innovative and realistic technologies; strategies and methods that helped local governments become more energy efficient and environmentally responsible. The program began in 1979 and focused on the application of new technologies/techniques and management practices to deliver local energy services more efficiently, improve the local revenue base, and create sustainable communities. Approximately 400 applied research and development grants for cities and counties were granted through the MEMP. Examples of these projects are:

- Energy efficiency in public buildings
- Residential energy management
- Industrial and commercial energy management
- Vehicles and transportation
- Solid waste management
- District heating/cooling and cogeneration
- Energy utilities and local governments
- Energy planning, management and budgeting

Energy solutions developed with the help of MEMP have already saved millions of dollars, measurably cut energy consumption across the country and made breathing easier for millions of Americans.

The following is a chart of the funding levels for MEMP over the last fourteen (14) years:

MEMP funding and Number of Grants Awarded, 1987-2000

Year	Grant Cycle: Program Year No.	Number of Grants Awarded	Total Program Budget
1987	Year 8	31	$1,960,000
1988	Year 9	22	$1,960,000
1989	Year 10	31	$2,040,000
1990	Year 11	30	$1,960,000
1991	Year 12	39	$1,849,000
1992	Year 13	31	$1,982,389
1993	Year 14	13	$ 987,573
1994	Year 15	14	$1,041,000
1995	Year 16	23	$2,441,700
1996	Year 17	19	$1,823,900
1997	Year 18	18	$1,678,000
1998	Year 19	18	$1,611,384
1999	Year 20	15	$1,443,000
2000	Year 21	17	$1,700,000

Applied Research Projects
Year 21 Projects-Abstracts
1999-00 UCETF Program

Proposals to meet the specific objectives of the UCETF annual R&D program are solicited from urban jurisdictions. Projects based on these proposals are then selected by the UCETF for direct conduct and management by staff of city and county governments. Projects selected for each year are organized in thematic units to assure effective management and ongoing peer-to-peer experience exchange, with results documented at the end of each program year. Final project reports were prepared and sent to the United States Department of Energy in Washington, D.C. The following are Year 21 task force units and a summary of their projects.

TASK FORCE UNITS

COMMUNITY BASED PROJECTS

Seattle, WA- Sustainable Demand Project
Grant Award: $74,872
Dollars Leveraged: $82,257
Estimated Energy Saved: Once the strategies of the Regional Plan are implemented, they will result in an increase in sustainable designed and constructed building projects. In turn this will result in energy and water savings.
Project Partners: Rocky Mountain Institute and Seattle Chamber of Commerce's Business and Industry Recycling Venture

The goals of the project were to produce a plan for the region that is developed and supported by the major stakeholders in the region, including government, business, and environmental organizations; clearly identifies the benefits of sustainable building to the stakeholders; includes recommended action items that will promote sustainable building practices in the region; includes recommended action items that are realistic and achievable within a 2-3 year time period; and can be replicated by other jurisdictions, both in terms of process and product. The project succeeded in bring together a diverse and large group of people to work toward a common goal. The final product was a Northwest Regional Sustainable Action Plan.

Chisago, MN-County Energy Management Planning Model
Grant Award: $74,300
Dollars Leveraged: $29,000
Estimated Energy Saved: 10%
Project Partners: Chisago County Board of Commissioners; the Minnesota Environmental Quality Board Citizens Advisory Task Force; and the consulting firm MSB Energy Associates from Middleton, Wisconsin

Provide local governments with a more sustainable energy planning model that explicitly considers the impact of restructuring on planning decisions, improve energy efficiency in municipally owned and operated facilities and encourage more energy efficient structures in the private sector; identify, audit and evaluate the energy use in county facilities in terms of cost and actual fuel and electricity consumption to establish a baseline for this project. The baseline will help identify energy savings opportunities in the facilities, and to provide a reference point with which to measure the results of energy efficiency improvement measures.

Portland, OR-Developing Community-Based Energy Efficiency Programs
Grant Award: $75,000
Dollars Leveraged: $195,000
Project Partners: Battelle PNW Laboratory; Lawrence Berkeley Laboratory; Northwest Power Planning Council, USDOE Seattle Regional Office; Oregon Office of Energy; Eugene Water and Electric Board; Multi-Family Housing Council of Oregon; and Oregon Office of Energy

The City of Portland initiated draft legislative for local control of System Benefit Charge funds for local public purposes, and for local operation of these programs; proposed legislative provisions that create the opportunity for the City (rather than the incumbent utility) to serve as the "portfolio manager" under the portfolio alternative; promoted a Community Power Buying Group aggregation plan if the power system moves to full deregulation for small consumers; begun a study of the physical distribution system and loads of different distribution system and loads of different customer classes within the City in order to determine the feasibility of pursuing municipalization of the system; and educated the City Council on deregulation issues and garnered their support for an active City role on these issues.

Hennepin County, MN- Twin Cities E85 Market Support
Grant Award: $74,000
Dollars Leveraged:
Estimated Energy Saved: Use of E85 achieves a per-travel-distance reduction of greenhouse gases of between 16% and 28%.
Project Partners: American Lung Association of Minnesota; Minnesota Corn Grower Association; Minnesota Department of Agriculture; Minnesota Department of Public Service; Minnesota Ethanol Producers; National Ethanol Vehicle Coalition; U.S. Department of Energy; and Ford Motor Company

The project addressed the problem of lack of educational, marketing and public outreach support for existing and planner E85 fueling sites within the Twin Cities E85 Test Market. The Twin Cities market represented a significant opportunity for advancing use of a renewable energy source. Successful implementation of this work increased public awareness of renewable, cleaner-burning E85, increased sales of E85 to FFV owners and fleets, participation of Hennepin County-ALAM partnership in the International Clean Air Corridor (DOE Clean Cities), and expanded markets for Minnesota's agriculture and ethanol industries.

SOLAR

San Francisco, CA-Implementation Tools for Municipal Energy Retrofits
Grant Award: $75,000
Dollars Leveraged: $89,800
Estimated Energy Saved (over 15 years) $21.6 million
Project Partners: California Energy Commission; Energy Efficiency Services Division; Lawrence Berkeley National Laboratory; Montgomery County, Maryland, Division of Facilities and Services, Energy Analysis Program; and Portland Energy Conservation, Inc.

The City and County of San Francisco identified opportunities to reduce project costs and increase savings in energy retrofit projects in municipal facilities. Maximizing these opportunities required the development of new or modified auditing, commissioning, and other implementation tools in order to deliver the needed services at the minimum cost. San Francisco developed implementation tools appropriate to municipal energy retrofits by adapting existing materials, e.g. monitoring and verification protocols, and in some cases, developing new ones, such as tailored commissioning procedures for retrofits. Each tool will be test in energy retrofit projects. The tools will also help other municipalities achieve better returns from their energy retrofit projects.

Yavapai Apache Nation-Analysis of Power Quality and Reliability Issues in a Rural Tribal Community
Grant Award: $75,000
Dollars Leveraged: $12,500
Estimated Energy Saved: 30% (Appx. $100,000/year)
Project Partner: Direct Global Power

The Yavapai-Apache Power Reliability Study proposed to study power quality and reliability issues on the Reservation and to quantify the cost of poor quality and unreliable power to the Nation. Power quality data was collected during the study and a one kilowatt solar photovoltaic (PV) uninterruptable power supply (UPS) was installed as a demonstration and educational site to enhance tribal leader and community member understanding and awareness of electrical power issues.

Albuquerque, NM-Municipal Applications for Solar Powered LED Lighting
Grant Award: $75,000
Dollars Leveraged: $23,000
Estimated Energy Saved: 70%
Project Partner: Sandia National Labs

The marriage of PV and LED technologies has many potentially attractive features. PV systems produce low voltage direct current power and store this in rechargeable batteries. This power can be used directly by LED systems without the need for inverter systems, which would be required by other lighting sources. Inverters and other electronic controls reduce efficiency and add cost and weight to a lighting fixture. The project identified applications where municipalities can use these technologies that include both indoor and outdoor possibilities.

Santa Barbara, CA-Achieving a Solar Community
Grant Award: $35,000
Dollars Leveraged: $16,984
Estimated Energy Saved: Broad application of solar energy systems can reduce pollutants created from electrical power as a means of demand-side management
Project Partners: City of Santa Maria and The Sustainability project

The County of Santa Barbara created and employed a highly visible and effective, and extremely user-friendly educational strategy for marketing solar power in the Santa Barbara County area. The strategy entailed preparing a video and guidebook to serve as a vehicle to market information about solar energy systems; showcasing a solar development to demonstrate its savings in a residential development and the architectural features of solar applications; and conducting a public outreach campaign to include County presentations to a wide variety of local environmental community groups.

San Jose, CA-San Jose...Prepared with Solar
Grant Award: $25,000
Dollars Leveraged: $26,000
Estimated Energy Saved:
Project Partners: General Services Department; Environmental Services Department; FEMA; Red Cross; NASA/AMES Disaster Response Team; and Florida Solar Energy Center

The City of San Jose developed a Sustainable Energy Emergency Action Plan, which identifies the priority disaster, emergency; community and/or security applications that can be better served by solar Photovoltaic (PV) power. They identified and prioritized renewal energy applications, installed and evaluated PV systems, developed a plan to identify and install additional PV applications, and transferred the knowledge gained from the project to area, regional and state-wide emergency and disaster organizations, in addition to providing a template for other local governments and their emergency managers.

DEREGULATION/DISTRIBUTIVE GENERATION

Lincoln County, ME-Electricity Purchase Aggregation Feasibility
Grant Award: $35,345
Dollars Leveraged: $33,100
Estimated Energy Saved: Save Lincoln County residents, businesses and institutions up to $1.4 million annually
Project Partners: Central Maine Power Company; Maine Yankee Atomic Power Company; Rebuild America Program; and Bigelow Laboratory for Ocean Sciences; and Coastal Enterprises Incorporated

The State of Maine was one of the first states to implement electric utility restructuring and consumer choice. Maine's market opened to full competition in March, 2000. The project proposed to analyze what mix of energy and energy services, including "Green Power" and conservation services, best fits the needs of small, rural jurisdictions, and what subset of customers could most cost-effectively be aggregated into an energy purchasing pool; and to develop a model energy purchase agreement that addressed the outcome of the above analysis and can be executed and administered within the staff constraints and level of technical expertise common to small, rural jurisdictions. Maine developed a model solicitation/request for proposals to solicit energy and/or energy services from providers. A final list of potential providers were recommended to the County Commissioners.

Washington, D.C.-The Janus Project: Lifeline/City Government Aggregation
Grant Award: $25,000
Dollars Leveraged: $42,275
Estimated Energy Saved: $124,811 (3,350 therms)
Project Partner: Washington Gas

Forming a Lifeline Group for low-income customers during this gas pilot allowed the DC Energy Office to attack the restructuring problems facing low-income customers. Bidding out the combined Lifeline Group and District Government gas demand gains low-income customers the advantage of buying economies otherwise not at all available to them. A direct benefit to Lifeline Group will be the consumer education gained from taking part in the gas Lifeline Group against the advent of a similar Lifeline Group for electricity. Lifeline customers who participated for one or more months totaled 1,188 or 21% of 5,627 who either were sent letters (5,587) or enrolled in the lifeline program after hearing about Janus (40). They have greater understanding of alternative savings offers and, presumably, will be more responsive to future aggregation efforts by DCEO as restructuring of the utility industry leads to greater competition for retail customers.

Memphis, TN-Residential Fuel Cell System Demonstration
Grant Award: $75,000
Dollars Leveraged: $185,000
Estimated Energy Saved: A 3 kW system designed with supplemental batteries for a peak power delivery up to 10 kW.
Project Partners: EPRI; ORNL; Energy Management Section; Tennessee Valley Authority; Memphis Area Home Builders Association; and TN Energy Efficiency Network

The objectives of the project included: assessing the fuel cell technology regarding commercialization; identifying the economic barriers to overcome for competing in the market; field verification of technical specifications required for residential fuel cell systems; and business plans/market strategies for commercialization of residential fuel cell systems.

Phoenix, AZ-Distributed Electric Generation-Microturbine Generator Installation
Grant Award: $71,000
Dollars Leveraged: 33,000
Estimated Energy Saved: Cost of electric generation from the microturbine generator: appx. 7/8 cents per kWh
Project Partners: New Energy Ventures; Salt River Project; Southwest Gas Company; and Distributed Energy Association of Arizona

By utilizing an emerging small-scale Distributed Generation (DG) technology with a 75-kilowatt natural gas-powered microturbine generator, the project will provide electric power to a city facility in parallel with the power currently served by the local utility. It is intended to demonstrate the cost-effectiveness of small-scale DG; evaluate the process for installation, especially any barriers related to local codes and/or utility issues; and monitor the long-term performance of the installed unit.

Barnstable County, MA-Cape Light Distributed Generation Project
Grant Award: $25,000
Dollars Leveraged: $17,000
Estimated Energy Saved: 525 gigawatt hours of energy savings, which would yield avoided cost savings of $16,125,000 per year (if the avoided cost of electricity is assumed at 3 cents/kilowatt hour
Project Partners:Cape Light Compact and member towns; Cape and Islands Self Reliance, Inc.; Ridley and Associates; and USEPA

Provide local governments with perspective and information for inclusion of energy efficiency provisions in restructuring laws or regulatory orders; offer local governments perspective and information for inclusion of regulatory rules and standards for energy efficiency programs; share experience, information and perspective on both technical and public process elements for development of local energy efficiency plans; and generally provide a model and benchmarks that may be used to expand and advance energy efficiency in a competitive environment.

TECHNOLOGY TRANSFER

Cheshire, CT-Strategies for Reducing Municipal Outdoor Lighting costs in a Competitive Electric Marketplace
Grant Award: $25,000
Dollars Leveraged: $66,000
Estimated Energy Saved: 15% annual savings on outdoor lighting costs (Appx. $2 million)
Project Partners: Connecticut Conference of Municipalities

The project entailed identifying the major technical and legal issues facing municipalities that wish to save money on outdoor lighting costs by changing the ownership/financing structure for the lighting fixtures, changing operations and management responsibilities, performing efficiency upgrades, or shopping for electricity suppliers. The project team successfully assisted one municipality with the purchase of its street lighting system, while 24 additional municipalities are actively engaged in the acquisition process. Nineteen other municipalities have begun to explore the acquisition process. In total, 44 of Connecticut's 169 municipalities (roughly 26%) have begun the process of acquiring their streetlights - 780% more than when the project began.

Tucson, AZ-Creating Cool Communities
Grant Award: $10,000
Dollars Leveraged: $24,700
Estimated Energy Saved: Shade trees were planted and lighter colored rooftops, paving materials and buildings were used to mitigate the effects of urban heat islands.
Project Partners: The Trees for Tucson

The purpose of the Cool Communities model was to mitigate the effects of "urban heat islands" and other indicators of global warming such as air pollution and greenhouse gases by reducing the amount of heat absorption found in the built environment.

Anaheim, CA-Electric Vehicle Car-Sharing Tool Kit
Grant Award: $25,000
Dollars Leveraged: $438,000
Estimated Energy Saved: The demand for Evs and charging stations will increase as a result of California's Low Emission Vehicle/Clean Fuel mandate, which requires 10 percent of vehicles offered for sale by major manufacturers to be zero-emitting beginning 2003.
Project Partners: Anaheim Transportation Network; Edison; EV Rental Cars; and The Planning Center.

This project was implemented to fulfill a number of important local and regional goals: improve air quality; support advanced transportation technologies; increase accessibility of Electric Vehicles (EVs) to the general public; foster economic growth; enhance environmental image; and maintain leading edge. The City of Anaheim's Car Sharing Program recognized the need to make Evs available to the general public. Anaheim developed a Car Sharing Tool Kit, which included a guidebook, CD-ROM-an electronic version of the Guidebook that allows the reader to search by keyword for important information, and a video-includes footage of the program's kickoff event, as well as "the day of a commuter". The video also includes testimony from drivers, employers and hotel managers presenting their perspective on the benefits of the program.

Note: Estimated Energy Saved: It is difficult to estimate energy saved for Research and Development and Technology Transfer, which impacts over time.

PEER TO PEER TECHNICAL EXCHANGE

In addition to the specific technology transfer projects, the UCETF program featured peer to peer exchange and dialogue on a variety of issues, and concentrated in particular on effectively documenting products available for transfer from prior year programs. Specific efforts were directed to several areas to conduct direct transfer activities to widely share the benefits of Federally-supported energy technology development and application programs. The following reports document the UCETF's efforts:

International Energy Technical Peer-to-Peer Exchange: The Ukraine Experience

The UCETF presented several abstracts and information and energy efficiency for schools and municipal energy management to the Czech Republic and Lviv (Ukraine). The services provided would make available the accumulated experience of those U.S. cities and counties that have been most active over the past years in developing and implementing local energy policies and practices.

Mohawk Community Housing

After observing the energy provisions and practices of Mohawk Community Housing (MCH), the UCETF developed technical and strategic recommendations that can be considered by MCH and the Haudenosaunee people.

50 Cities Survey

Public Technology, Incorporated (PTI), in conjunction with its Energy Task Force (ETF), Environmental Task Force (ENTF) and Telecommunication and Information (TIF) members processed an on-line assessment in order to ascertain the importance of energy efficiency purchasing efforts of local governments. The municipalities selected for the survey represent the 50 largest (by population) U.S. cities and counties.

Distributed Generation (DG) Handbook

The Distributed Generation Handbook is a primer for local government officials. Three DG workshops for code officials were conducted.

Boston, Massachusetts

The City of Boston, Massachusetts, a PTI member, requested technical assistance, due to energy supply, costs and reliability issues for the city. Mayor Thomas Merino has implemented a 10% reduction of energy usage by 2005, as a reliable power supply is essential to continued economic development.

Santa Rosa, California

The City of Santa Rosa has demonstrated a commitment to energy conservation, and toward identifying and implementing proven, as well as innovative, methods to achieve the goal of resolving energy supply and reliability issues within the entire state of California.

Keeping the Lights On II

The second in an ongoing series of publications to help local governments understand and prepare for the vast changes taking place within the electric utility industry.

INTERNATIONAL ENERGY TECHNICAL PEER-TO-PEER EXCHANGE:

THE UKRAINE EXPERIENCE

INTERNATIONAL ENERGY TECHNICAL PEER-TO-PEER EXCHANGE

FINAL REPORT

Presented to:

Linda Davis, City of Chicago
And The U.S. Department of Energy

Presented by:

Public Technology, Inc.

March 2003

BACKGROUND

In late 2000, Public Technology Inc.'s (PTI) Urban Consortium Energy Task Force (UCETF) requested approximately $30,000 in funding from the Department of Energy's Municipal Energy Management Program (MEMP) to fund an international peer-to-peer technical exchange. The proposed technical exchange included representatives of PTI's UCETF and PTI staff that would travel to the Ukraine in Europe to deliver much needed technical assistance and advice within the municipal energy sector.

PTI's technical peer-to-peer exchange for energy technology application is a communication and assistance initiative for sharing the practical, tested knowledge and experience of United States practitioners with their Central and Eastern European, South and Central American, and Newly Independent States colleagues who operate, manage, and plan improvements for energy production or energy consuming facilities in municipalities, utilities, power authorities, district heating systems, other regional and local governmental institutions, universities, national environmental and energy associations, and engineering and technical societies. Plant and facilities operators and managers from member municipalities and organizations of PTI will share or teach operating and training practices; management practices; capital improvements planning; techniques of monitoring and evaluating existing and newly-installed equipment and systems; analysis and selection of replacement and upgrade equipment; analysis of national energy management and pollution control policies and regulations and developing operating, management, and capital improvement plans to achieve facility compliance. The results of this effort will be the enhanced ability of target area practitioners to comply with newly adopted energy management and pollution control programs and to ensure that facilities, systems, equipment will be optimally utilized and operated following installation of improvements to maintain compliance throughout their intended useful life.

In both North America and in the target areas, practitioners are daily confronted with the needs of existing facilities, the infeasibility of abandoning installed infrastructure and abandonment of the existing investment and the incremental improvement strategies which must be adopted to accomplish energy management and pollution control objectives. Their intimate familiarity with these realities and their success in meeting their improvement objectives in spite of challenges they face, gives North American practitioners an experience base and insight that could be invaluable to their counterparts abroad.

PTI draws on its extensive information base and the practitioners in its member cities to answer this need, providing practical knowledge and experience that practitioners in target area municipalities, power authorities, district heating systems, universities, professional societies, etc., can utilize to develop and implement their programs. These PTI practitioners are thoroughly familiar with the daily operational needs, capital improvement strategies and plans, available U.S. technologies and equipment, and equipment performance characteristics, that can assist target area counterparts in effectively and quickly responding to the energy management and pollution control challenges they face.

THE UKRAINE EXPERIENCE

The Ukraine was selected as the venue and host of this technical exchange because of their extreme need, their interest in hosting such an exchange, and the support received by the local office of The Alliance to Save Energy in the city of Lviv. PTI's UCETF was the perfect selection to conduct this technical exchange because for more than 25 years, the UCETF has been the nation's most extensive cooperative program for improving energy management and technology applications for local governments. As stated above, the UCETF is a leader in developing local strategies responsive to the national energy situation and critical environmental concerns.

Upon receipt of the funding to embark on this peer-to-peer technical exchange, the work began to develop a worthy agenda, and to select the UCETF members who could travel to the Ukraine. Mr. Henry Manczyk, representing Monroe County, NY, Mr. Paul Tseng, representing Montgomery County, MD, Mr. Kent Miller, representing the City of Philadelphia, PA, and Sharron Brown, of PTI, were all selected to participate in the Ukraine peer-to-peer technical exchange. The following list of issues was developed for discussion/presentation during the technical exchange. These topics were developed via letter exchanges with engineers and facility managers within the Ukraine.

- Introduction of Energy Conservation Concepts
- Energy Consumption Breakdown
- Energy Accounting Audit
- Energy Opportunities Checklist
- Energy Audit (Walk Through)
- Examples of Energy Conservation Measures
- Life Cycle Costing and Economic Analysis
- Energy Program Implementation
- HVAC Equipment Inventory
- Computerized Energy Management
- Demand-Side Management (Electric)
- Energy Monitoring and Metering Systems
- Energy Approach in New Construction
- Indoor Air Quality
- Energy Conservation

- Process Management Program
- Preventive and Predictive Maintenance of HVAC Equipment
- Fuel Utilization Strategy
- General Summary of District Heating in the U.S.A.

After preparing their individual presentations the team traveled to Lviv, Ukraine on October 14, 2001. They gave two intensive days of talks and training to over 30 engineers and facility managers from the six largest cities in Ukraine. There were two simultaneous translators who worked with the group from the United States so that every question posed could be addressed by the PTI team. The presentations ranged from very technical lighting applications to very practical measures like "how to conduct an energy audit." After each formal presentation by the UCETF members there was a break so that the presenter and the audience could discuss what was presented, and so the audience members could ask questions and delve deeper into the subject matter.

Based on the level of and multitude of questions the presenters felt that they accomplished the goal of the technical exchange – to impart their unique experiences and lessons learned to their counterparts in the Ukraine.

Several documents were sent to the Ukraine upon the return of the technical exchange team. One of the most important documents that was sent was PTI's "Sustainable Building Technical Manual" which was reprinted in Russian for this particular audience.

CONCLUSION

PTI wishes to thank the Department of Energy and the MEMP program for the opportunity to take our best practices and lessons learned to a region of the world where our experiences could really make a difference. We hope to have the opportunity to embark on future international technical exchanges with our membership.

PTI also thanks the local government practitioners who took their own time to travel to a far region of the world to impart and to share their unique experiences and knowledge with others. We also thank the members of the local governments of Ukraine who took time out of their very busy days to participate, to listen, and to learn. They brought open minds, a willingness to learn, and to ask excellent questions. We hope that their experience was as fulfilling as ours.

50 CITIES SURVEY

INTRODUCTION:

Energy production and consumption fuels the U.S. economy. In the United States, $697 billion was spent on energy purchases in 2000, approximately seven percent of the Gross Domestic Product (GDP), or approximately $2500 per capita. $119 billion of this was spent on oil imports[1]. Given the projected increases in energy demand under current practices, energy expenditures are expected to increase, to $887 billion by 2020. With a mere two percent of known world oil reserves, the U.S. reliance on costly energy imports cannot be expected to decrease without a significant shift in energy planning.

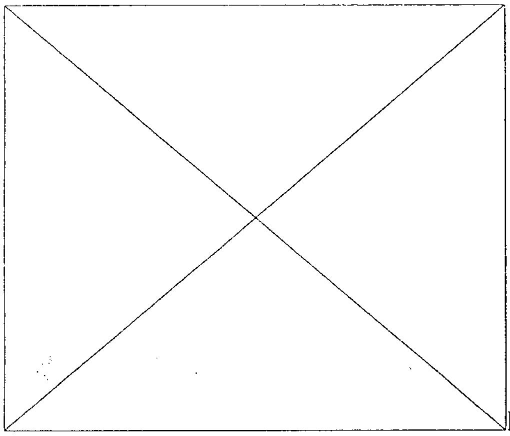
The general operating fund for most cities and counties costs average between 50 million to 1-3 billions of dollars. The average city or county pays in the millions for labor costs and the second largest expenditure is utility costs. State and local governments together represent $12 billion in annual energy expenditures.

In the United States, $697 billion was spent on energy purchases in 2000, approximately seven percent of the Gross Domestic Product (GDP), or approximately $2500 per capita. $119 billion of this was spent on oil imports[2]. Given the projected increases in energy demand under current practices, energy expenditures are expected to increase, to $887 billion by 2020 With a mere two percent of known world oil reserves, the U.S. reliance on costly energy imports cannot be expected to decrease without a significant shift in energy planning.

A study released in 2001 by the Electric Power Research Institute (EPRI) stated that power outages and other power quality disturbances are currently costing the U.S. economy more than $119 billion a year, or approximately 1.2 percent of the Gross National Product.[3,4] The study also found that California has the highest costs for outages and power quality disturbances – between $13.2 and $20.4 billion – followed by Texas ($8.3 to $13.2 billion) and New York ($8.0 to $12.6 billion).

Overview:

Energy-efficient technologies can provide substantial economic and environmental benefits to local jurisdictions. Understanding the existing practices, policies, regulations and barriers that exist to purchase energy-efficient technologies will lead to a worthwhile education and outreach effort to transform the market towards energy efficiency at the local level. Efforts to improve air-quality by reducing greenhouse gas emissions can be addressed through the increased use of energy-efficient technologies in the public sector as well.



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The general operating fund for most cities and counties costs average between 50 million to 1-3 billions of dollars. The average city or county pays in the millions for labor costs and the second largest expenditure is utility costs. State and local governments together represent $12 billion in annual energy expenditures.

In the United States, $697 billion was spent on energy purchases in 2000, approximately seven percent of the Gross Domestic Product (GDP), or approximately $2500 per capita. $119 billion of this was spent on oil imports[6]. Given the projected increases in energy demand under current practices, energy expenditures are expected to increase, to $887 billion by 2020 With a mere two percent of known world oil reserves, the U.S. reliance on costly energy imports cannot be expected to decrease without a significant shift in energy planning.

A study released in 2001 by the Electric Power Research Institute (EPRI) stated that power outages and other power quality disturbances are currently costing the U.S. economy more than $119 billion a year, or approximately 1.2 percent of the Gross National Product.[7,8] The study also found that California has the highest costs for outages and power quality disturbances – between $13.2 and $20.4 billion – followed by Texas ($8.3 to $13.2 billion) and New York ($8.0 to $12.6 billion).

Background:

Public Technology, Inc. (PTI) is a non-for-profit organization founded in 1971. It is the technology, research, development and commercialization arm of the National League of Cities (NLC), the National Association of Counties (NACo), and the International

City/County Management Association (ICMA). Public Technology, Inc. mission is to bring the benefits of technology to local government.

The Urban Consortium (UC) is PTI membership group and represents America's largest and most progressive cities and counties. The UC is a one-of-a-kind network of large local governments created to find practical economic solutions to urban problems. It also serves as a catalyst for research and development of emerging technologies that provides solutions to the problems facing local governments. Membership is composed of local government officials from America's largest cities and counties. The five task forces of the UC are Energy, Environment Telecommunications and Information, Public Safety and Transportation.

For two decades, the Energy Task Force (ETF) has identified proven technologies and developed innovative ways to improve energy efficiency, promote the use of renewable energy resources, reduce local government utility expenditures and maximize opportunities for local economic growth through energy initiatives. The ETF has been a leader in developing and testing energy solutions, and sharing the knowledge with local governments nationwide.

The membership of the National League of Cities consists of state associations of local government (State Municipal Leagues) and directs member cities. In order for a local government to be eligible for membership in NLC, they must first belong to their state association. Through the state leagues and direct membership, NLC represents approximately 18,000 cities and town through the nation.

The National Association of Counties, (NaCo) was created in 1935 when county officials wanted to have a strong voice in the nation's capital. More than six decades later, NACo continues to ensure that the nation's 3066 counties are heard and understood in the White House and the halls of Congress. NaCo's membership totals more than 2,000 counties, representing over 80 percent of the nation's population.

Selection Process:

A list was developed from information from the 2000 census reports to identify the most populous cities and counties in the United States. Frequently, a county and a city within the county both would be among the top 25 on the respective city or county list. An example is Los Angeles, with both the City of Los Angeles and Los Angeles County included on the lists. Similarly, New York City made the list, as did the five counties making up New York. Chicago/Cook County, IL, Phoenix/Maricopa County, AZ, San Diego/San Diego County, CA, Houston/Harris County, TX, Dallas/Dallas County, TX, Detroit/Wayne County, MI, Seattle/King County, WA, San Jose/Santa Clara County, CA and San Antonio/Bexar County, TX all made the initial list, however, the duplication of jurisdictions are unrepresentative from population and geographic perspectives.

In order to have a realistic approach, the largest city in a given county from the overall county population was subtracted. Then, the list was re-compiled of the top 25 counties and cities. This eliminated most of the duplication, but also some key jurisdictions, such as Seattle, Chicago/Cook County, IL, Los Angeles/Los Angeles County, CA and San Diego/San Diego County, CA were still on the list.

The next refinement of the list was accomplished by simply dropping the counties within a duplicated pair of jurisdictions. For example, in the case of Los Angeles/Los Angeles County, CA, the county was dropped, even though it has a huge population, however, Orange, Riverside, and San Bernardino Counties, CA are still represented as suburbs and unincorporated areas of the LA Basin.

There were also counties that did not function as "general purpose" counties, such as Westchester, NY or any Connecticut county. In addition, Hennepin County, MN, and two county-city combinations were added to the county list from the city list (Honolulu/Oahu and Miami/Dade). This allowed Denver and Seattle on to the twenty five (25) -city lists. Note that Denver and Philadelphia function as city-county combinations, but the city and county are co-extensive, so these are technically cities, unlike Oahu, HI and Dade, FL. (Attachment A is a copy of the 2000 Census Report).

The following is a breakdown of the cities and counties for the selection of this project:

- There are 24 states and the District of Columbia represented on the list.

- The 25 counties represent 27,033,870 populations, not counting the largest jurisdiction in the county. The 25 cities represent 33,777,478 populations. The total is 60,811,348, or about 21.6% of the U.S. population. If the largest city is added back in, and the total population of the county where the city is located is used, the survey will represent about 80,770,384, or 28.7% of the total us population of 281,421,906. Multiple county metropolitan areas will push the total represented in the survey to over 30% of the U.S. population.

- Only 6 of the 25 counties are PTI members, although PTI member Ft. Worth is the dominant city in Tarrant County and of the cities, 12 of 25 are members (13 if New York is counted). This is roughly proportional to the PTI membership of the top 50 cities (23 are members, 24 with New York) and top 50 counties (11 are members).

- Energy Task Force Members are compiled, all PTI members represent 4 of the 25 counties. There are 12 of 25 cities represented on the ETF, with 9 also being PTI members (10 if New York is included).

- ETF members on the list represent only about 38.6% of the Big 50 population; while 47.5% of the Big 50 population is represented by PTI and the ETF. It is interesting to note that if New York is taken out of the population represented by PTI, the total population of the jurisdictions represented by PTI comprises only

28.7 % of the Big 50 total population, and the ETF represents a much greater percentage than PTI's entire membership.

- This demonstrates that the ETF members must make certain to get the survey completed in their home jurisdictions, since they represent one-third of the Big 50 List in total jurisdictions, and nearly 40 % of the total population.

- Second, there are two additional counties on the list that are PTI members, not on the ETF, and three additional cities on the list which are PTI members, but not ETF members. We should concentrate on getting responses from these jurisdictions as well, because that pushes the total population represented to 47.5 %, which would be a respectable response percentage.

- Third, 29 cities or counties on the list, account for 52.5% of the population, which are neither PTI members or members of the ETF.

Assessment-Participants:

Public Technology Inc. (PTI) in conjunction with its Energy Task Force (ETF), Environmental Task Force (ENTF) and Telecommunication and Information (TIF) members processed an on-line assessment in order to ascertain the importance of energy efficiency purchasing efforts of local governments. The assessment was designed as an on-line user-friendly survey. (Attachment B is a copy of the assessment).

The municipalities selected for this survey represent the 50 largest (by population) U.S. cities and counties. These jurisdictions represent nearly 61 million people, comprising 21.6 percent of the population of the United States. This group of cities and counties provided invaluable information on the municipal energy efficiency purchasing policies and programs of local governments representing a large portion of the population.

The list was compiled from the 2000 United States census data. Frequently, a county and a city are within a county both that would be among the top 25 on the respective city or county list. An example is Los Angeles, which is both the City of Los Angeles and Los Angeles County. Similarly, New York City made the list, in addition to the five counties within New York. Chicago/Cook County, Phoenix/Maricopa County, San Diego/San Diego County, Houston/Harris County, Dallas/Dallas County, Detroit/Wayne County, Seattle/King County, San Jose/Santa Clara County and San Antonio/Bexar County are also examples of counties that were part of the initial list.

The next refinement to the list was accomplished by simply dropping the counties within a duplicated pair of jurisdictions. For example, in the case of Los Angeles/Los Angeles

County, the county was dropped, even though it has a huge population. Also, the counties of Orange, Riverside, and San Bernardino represent the suburbs and unincorporated areas of the LA Basin. (Attachment C is the list of jurisdictions).

A summary of the selection processed is as follows:

- There are 24 states and the District of Columbia represented on the list.
- The 25 counties represent 27,033,870 populations, not counting the largest jurisdiction in the county.
- The 25 cities represent 33,777,478 populations.
- The total is 60,811,348, or about 21.6% of the U.S. population.
- The total populations of the county where the city are combined represent about 80,770,384, or 28.7% of the total US population approximately 281,421,906.
- Multiple county metropolitans represent over 30% of the U.S. population.

Urban Consortium Energy and Environmental Task Forces:

The Urban Consortium Energy and Environmental task forces represents 6 of the 25 counties although PTI membership is Ft. Worth, TX the dominant city in Tarrant County. The cities represent 13 of 25 members and the PTI membership overall represent the top 50 cities (24 are members) and top 50 counties (11 are members). If ETF members are compiled, all PTI members represent 4 of the 25 counties. There are 12 of 25 cities represented on the ETF, with 9 also being PTI members (10 if New York is included). ETF members on the list represent 38.6% of the Big 50 population, while 47.5% of the Big 50 population is represented by PTI and the UCETF. It is interesting to note that if New York is taken out of the population represented by PTI, the total population of the jurisdictions represented by PTI comprises only 28.7 % of the Big 50 total population, and the ETF represents a much greater percentage than PTI.

The following is the contact list for completion of the survey:

Joe Miller, Jacksonville, FL
Matt Muniz, Alameda County, CA
Sam Mendoza, Contra Costa County, CA
William Warren, San Bernardino County, CA
Godwin Aimua, Riverside County, CA
Lisa Taylor, Detroit, MI
Joe Hylla, Oakland County, MI
George Winfield, Baltimore, MD

Steve Holmes, Honolulu, HI
*Ben Taube, Atlanta, GA
Energy Management Office, Jefferson County, KY
Anthony Rosa, Broward County, FL
Maureen Perrault, Palm Beach County, FL
Jaime Aguirre, El Paso, TX
Joe Jacobsen, Milwaukee, WI
Linda Page, Columbus, OH (also John Doutt)
Tom Wendorf, San Antonio, TX
Jarod Klaas, Indianapolis, IN
*Doug Yoder, Miami-Dade County, FL
*James Gorby, Fairfax County, VA
Will Davis, Pinellas County, FL
*Deyanira Flores, Clark County, NV
*Marla Jurosek, San Francisco, CA
*Chuck Clinton, Washington, DC
*Maura Zlody, Boston, MA
*Larry Blackstad, Hennepin County, MN
*Steve Walter, Chicago, IL
*Steve Park, Dallas, TX
*Mark Leonard, Phoenix, AZ
*Richard Miller, New York City, NY
*Kent Miller, Philadelphia, PA
*Marya Castillano, Seattle, WA
*Robert Epler, San Diego, CA
*Mary Tucker, San Jose, CA
*Steve Foute, Denver, CO
*Roger Duncan, Austin, TX
*Robert Lawler, Kansas City, MO
*Gerald Spivey, Norfolk, VA
Chuck Norville, Memphis, TN
Jacob Gorelik, St. Louis County, MO

Note: Denote (*) are PTI Task Force members.

Energy Task Force (ETF):

First, the ETF members completed the survey within their own jurisdictions, and represent one-third of the Big 50 List in total jurisdictions, and 40 % of the total population. Second, there are two additional counties and three additional cities on the list, which are PTI members, but are not on the ETF and ENVT members. Finally, the total number of responses represents the total population of 47.5% from 29 cities and counties which are either PTI members or members of the ETF.

A summary of the participation of the Energy Task Force Members were represented as follows:

- Only 6 of the 25 counties are PTI members, although PTI member Ft. Worth is the dominant city in Tarrant County.
- Cities, 13 of 25 are members this is roughly proportional to the PTI membership of the top 50 cities (24 are members) and top 50 counties (11 are members).
- The ETF members represent 4 of the 25 counties and 13 of 25 cities.

Results of the assessment:

The most populous cities (population range from 8 to 2.8 million) consists of New York, NY, and Chicago, IL responded to the survey as follows:

- Both had an organizational unit dedicated to managing energy usage;
- A full dedicated energy management program was not politically supported, lacked resources and lacked interest by one jurisdiction;
- Both had utility energy expenditures, excluding schools, of over 30 million dollars;
- All purchased Energy Star office equipment, fax machines, copiers, printers, scanners and computers;
- Both participated in Rebuild America and Energy Star Programs;
- Both had a procurement procedure for purchasing energy efficiency products and;
- Both used Energy Star as the energy efficiency standard and these standards were used to purchase office, lighting and mechanical equipment.

The second most populous group (population range from 1. 5 million to 725, 000) consists of Houston, TX, Philadelphia, PA, Phoenix, AZ, San Diego, CA, San Jose, CA, San Francisco, CA, and Jacksonville, FL:

- Two cities had an organizational units dedicated to managing energy usage;
- One jurisdiction had a fully dedicated energy management program, however; it was not politically supported, lacked resources and lacked public interest as well.
- Three had an existing local environmental and energy legislation or policies.
- All had utility energy expenditures, excluding schools, of over 30 million dollars.
- All purchased Energy Star office equipment, fax machines, copiers, printers, and

computers.

- Two participated in Rebuild America and Energy Star Programs.
- Two had a procurement procedure and one did not for purchasing energy efficiency products.
- One jurisdiction that did not have an energy purchasing ability was due to costs.
- Two used Energy Star and one used the local government standards, as the energy efficiency standard and these standards were used to purchase office, lighting and mechanical equipment. One had an energy efficiency standard for the purchase of a chiller.

The third most populous group (population range from 711,470 to 478,000) consists of Columbus, OH, Austin, TX, Boston, MA, Washington, DC, El Paso, TX, Seattle, WA, Denver, CO and Portland, OR, and Tucson, AZ.

- One city has an organizational units dedicated to managing energy usage;
- One jurisdiction had a fully dedicated energy management program, however; it was not politically supported, lacked resources and lacked public interest as well.
- Three had an existing local environmental and energy legislation or policies.
- All had utility energy expenditures, excluding schools, of over 30 million dollars.
- All purchased Energy Star office equipment, fax machines, copiers, printers, and computers.
- Two participated in Rebuild America and Energy Star Programs.
- Two had a procurement procedure and one did not for purchasing energy efficiency products.
- One jurisdiction that did not have an energy purchasing ability was due to costs.
- Two used Energy Star and one used the local government standards, as the energy efficiency standard and these standards were used to purchase office, lighting and mechanical equipment. One had an energy efficiency standard for the purchase of a chiller.

The *fifth most* populous group (population range from 441, 545 to 234,403) consists of Kansas City, MO, Atlanta, GA, Honolulu, HI, Cincinnati, OH and Norfolk, VA.

- One city has an organizational unit dedicated to managing energy usage;
- One jurisdiction had a fully dedicated energy strategy for their city;
- Three had an existing local environmental and energy legislation or policies;
- Two had utility energy expenditures, excluding schools, of over 30 million dollars, one had 5 –10 million and the other had 10-15 million.
- All purchased Energy Star office equipment, fax machines, copiers, printers, and computers.
- One participated in the Energy Star Programs;
- One had a procurement procedure and one did not for purchasing energy efficiency products.
- One jurisdiction that did not have an energy purchasing ability was due to costs.
- Two used Energy Star as its local government standards and energy efficiency standard and these standards were used to purchase office, lighting and mechanical equipment. One had an energy efficiency standard for the purchase of Heating, Ventilation and Air-Conditioning (HVAC) equipment.

The (ix) **sixth and final group consisted of Arlington, VA, Centreville, IA, Valparaiso, IN, Palo Alto, CA, Cuyahoya Falls, OH, and the states of Minnesota and Missouri. This group expressed an interest in participating in the survey and is interested in some assistance in energy efficiency programs and purchasing of this equipment. The following are the results of this group:**

- One city has an organizational unit dedicated to managing energy usage;
- Two cities have energy management plans for their jurisdictions;
- Three had utility energy expenditures, excluding schools, have over 30 million dollars including the states of MN and MO, Two had 1 –5 million and the other two had 5-20 million dollars.
- All purchased Energy Star office equipment, fax machines, copiers, printers, and computers.
- Four participated in the Energy Star Programs and five participated in the Rebuild America Program;

- Three had a procurement procedure and three did not for purchasing energy efficiency products.

- Two jurisdictions do not have an energy purchasing ability due to lowest bid process and costs.

- Four used Energy Star as its state and local government standards and energy efficiency standard and these standards were used to purchase office, lighting and mechanical equipment. One had an energy efficiency standard for the purchase of Heating, Ventilation and Air-Conditioning (HVAC) equipment.

SUMMARY OF ASSESSMENT:

The calculation process and the assessment of cities and counties for the purpose of this project had various amounts of difficulties including:

- Identifying the appropriate cities and counties;
- Provide a user-friendly mechanism either on-line, by direct mail and by telephone;
- Identifying the appropriate person within the jurisdiction to complete the assessment;
- Finally, obtaining the assessments in a timely and correct manner.

Once the assessment were completed the highlights were as follows:

- The Energy Star labeled was recognizable as the standard for all levels of energy efficiency purchasing for the majority of these municipalities.
- The Energy Star standard when a energy efficiency procurement purchase agreement was upheld in the jurisdiction was used;
- The Energy Star and Rebuild America programs had community partnerships with one-third of the jurisdictions.

CONCLUSION:

The barriers from this project are the universal dilemma in the energy efficiency field; lack of awareness of energy expenditures whatsoever either by government officials or consumers, and the plan or strategy to reduce these energy costs. In addition, an assessment was thought of as a method to solicit for business and or a mailing list for purchase from PTI. Both of these barriers were a false.

The "lessons learned" from this project was that a core group of localities that have continued the energy efficiency planning process after the 1970's oil embargo are aware of the economic and environmental aspects of reducing energy costs but the majority of those jurisdictions did not have a stand-alone energy office. These jurisdictions answered the asseeement without any type of apprehension.

The highlight was that the majority of all participants recognize Energy Star label for energy efficiency equipment. This is a remarkable achievement for this project and is noteworthy compliment to the Energy Star Program.

Local governments spend billions of dollars in energy expenditures. Energy Star is penetrating at the local government level and additional support on changing the energy efficiency procurement and purchasing barriers will provide the market penetration to implement these products for the reduction if energy expenditures and emissions.

ATTACHMENT C:

Cities:

Population from 8.1 million to 2.8 million:

- New York, NY*
- Los Angeles, CA
- Chicago, IL*

Population from 1.9 million to 1.1 million:

- Houston, TX*
- Philadelphia, PA*
- Phoenix, AZ*
- San Diego, CA*
- Dallas, TX
- San Antonio, CA

Population from 951,000 million to 554,000:

- Detroit, MI
- San Jose, CA*
- Indianapolis, IN*
- San Francisco, CA*
- Jacksonville, FL*
- Columbus, OH*
- Austin, TX*
- Baltimore, MD
- Washington, DC*
- Nashville, TN
- El Paso, TX
- Seattle, WA
- Denver, CO

Population from 540,000 million to 407,000:

- Charlotte, NC
- Fort Worth, TX*
- Portland, OR*
- Oklahoma, OK
- Tucson, AZ*
- New Orleans, LA
- Las Vegas, NV*

- Cleveland, OH
- Long Beach, CA
- Albuquerque, NM
- Kansas City, MO*
- Fresno, CA
- Virginia Beach, CA
- San Juan, PR
- Atlanta, GA
- Sacramento, CA*

<u>Counties</u>:

Population from 9.1 million to 5 million:

- Los Angeles, CA
- New York, NY
- Cook County, IL

Population from 2.6 million to 1.4 million:

- Harris, TX
- San Diego, CA
- Orange, CA
- Maricopa, AZ
- Miami-Dade, FL*
- Wayne, MI
- Dallas, TX
- King, WA
- Santa Clara, CA
- San Bernardino, CA
- Philadelphia, PA
- Broward, FL
- Riverside, CA
- Cuyahoga, OH

Population from 1.3 million to 1.1million:

- Suffolk, NY
- Alameda, CA
- Bexar, TX
- Tarrant, TX
- Nassau, NY
- Allegheny, PA
- Oakland, MI

- Sacramento, CA

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[1] US Energy expenditures from EIA oil imports number from EIA via "Energy Security - Solutions to Protect America's Power Supply and Reduce Oil Dependence", Union of Concerned Scientists, January 2002.
[2] US Energy expenditures from EIA (check with Chris); oil imports number from EIA (check date, publication) via "Energy Security - Solutions to Protect America's Power Supply and Reduce Oil Dependence", Union of Concerned Scientists, January 2002.
[3] "The Cost of Power Disturbances to Industrial & Digital Economy Companies," report by Primen, sponsored by EPRI, June 2001.
[4] U.S. Department of Commerce Bureau of Economic Analysis, 2001.

[5] US Energy expenditures from EIA oil imports number from EIA via "Energy Security - Solutions to Protect America's Power Supply and Reduce Oil Dependence", Union of Concerned Scientists, January 2002.
[6] US Energy expenditures from EIA (check with Chris); oil imports number from EIA (check date, publication) via "Energy Security - Solutions to Protect America's Power Supply and Reduce Oil Dependence", Union of Concerned Scientists, January 2002.
[7] "The Cost of Power Disturbances to Industrial & Digital Economy Companies," report by Primen, sponsored by EPRI, June 2001.
[8] U.S. Department of Commerce Bureau of Economic Analysis, 2001.

ix Fourth, in order to have at least 1% of 37,000 local governments represented in this survey, PTI solicited participation (represented in the final group of this report) from two states, four cities and one county.

DISTRIBUTED GENERATION (DG) HANDBOOK

Chapter 1
Overview

OVERVIEW

Introduction

The term "distributed generation" has no formal definition, but many interpretations. For the purposes of this handbook, distributed generation is defined as small-scale generation located near the source of the electric load it serves. Examples of distributed generation, or DG, may include stand-alone photovoltaic systems or wind turbines on farms or serving residences located off the grid of electricity transmission lines serving most of the United States. It includes back-up power systems such as generators used to provide power to hospitals and airports during power outages. Distributed generation also refers to independent generation of power by businesses such as data banks, continuously running industries such as food processors, or other businesses where power outages or poor power quality would result in serious financial and physical losses.

In this chapter, we will briefly discuss the history of DG and the current trend toward decentralized power. The current state of DG will briefly be discussed, along with emerging technologies. An introduction to economic, fuel and utility issues is also included in Chapter 1, along with a brief discussion of local government issues affecting, and affected by, DG.

Chapter 2 will discuss the purposes of DG in more depth, including issues of reliability, security of energy infrastructure, costs, and pollution issues. In Chapter 3, we consider the range of DG technologies, how each operates, their applications, advantages, and disadvantages, economics, and the current and future state of the technology. Chapter 4 provides an in-depth discussion of the issues facing local governments when it comes to DG installation and utilization.

In 2001, distributed generation took on a new importance in the U.S. because of a series of devastating events. The California energy crisis resulted in power outages for millions of residents and businesses because of inadequate transmission capabilities. Prices for electricity soared all along the West Coast, and the resulting combination of power outages and increased utility costs wreaked havoc causing severe financial and physical distress for residents, businesses, and municipalities. Distributed generation technology has been brought to the forefront as a means to alleviate some of these problems and prevent them from reoccurring. By placing the generating capability close to the source of demand, the difficulties with transmission are eliminated. This solution is being avidly explored in other regions of the country, as well.

Then, on September 11, 2001, the nation was rocked by a series of terrorist attacks on New York and Washington, DC. The attacks killed over 3,000 people and, in the case of New York, damaged critical infrastructure necessary to maintain essential and non-essential services in Lower Manhatten. Power was knocked out to over 12,000 customers in lower Manhatten, including City Hall, for over a week. Communications were in a shambles as a result. The stock exchanges were shut down not from physical damage, but because they had no power. The attacks demonstrated the need to protect critical infrastructure, and energy infrastructure in particular. Distributed generation is capable of restoring power to areas cut off from the grid, or insulating municipalities from strikes on the nationwide energy infrastructure.

And these strikes needn't come from terrorists. Far more damage has been done by natural disasters and mechanical failure of the grid than terrorist attacks. In 2000 alone, power outages cost the United States economy $119 billion in lost revenue and affected tens of millions of people. Distributed generation provides the back-up and/or energy independence municipalities require to protect their critical infrastructure from anthropomorphic or natural disasters.

Distributed generation has profound environmental advantages, as well. Most distributed generation technologies are cleaner than conventional generation, some even qualifying as "green" power with no emissions.

In this handbook, we provide a primer for local government officials on the differences between centralized (conventional) power generation and distributed generation. We will discuss the purposes and advantages, and disadvantages, of distributed generation technology. There is a section describing each of the available and emerging technologies, and comparisons of their costs, applications, advantages, and drawbacks. Regulatory issues and utility interconnection issues are of concern to local governments, and these are also discussed. We hope you will find this handbook of significant value as the progression and acceptance of distributed generation technology accelerates not just in the United States, but around the world.

Centralized Vs. Distributed Generation

Centralized power generation was not the vision of Thomas Edison. Edison imagined the shortcomings of having power generated in a central location and distributed via transmission lines. This method is vulnerable to numerous disturbances, including weather, geomagnetic storms, equipment failures and, most recently, terrorists. Instead, Edison envisioned local generation of electricity, reducing the need for transmission lines and power grids.

Centralized power generation has other drawbacks besides possible power disruptions. Transmission and distribution (T&D) of electricity involves losses of power due to inefficiencies in T&D itself, lowering overall efficiencies. While centralized power plants themselves may be more efficient than some of the distributed generation technologies, the loss of power during transmission must also be considered when comparing overall efficiencies. Taking transmission losses into account makes the two generation types much more comparable, and considering other factors, DG may actually be less expensive than centralized power generation.

Distributed generation also eliminates much of the need for transmission lines, which are not only unsightly but have been linked to health risks. Transmission lines require continual maintenance, which the use of DG technology may allow to be deferred or eliminated. In an application called ***Transmission and Distribution Deferral***, DG equipment may be installed in strategic locations on a temporary basis to delay the purchase of new transmission and distribution equipment such as transmission lines. By reducing the need for T&D systems and their upkeep, the utility and its customers may save money.[1]

Utilities also may use DG for *Peaking Power* applications to supplement the grid during periods of high demand. Peaking power applications of DG also may be used by utility customers to lower their electricity costs during peak demand periods, when utilities often charge a premium price for power.[2]

Unlike centralized power generation, distributed generation produces a very high quality and reliable power. Because of this, distributed generation is finding increasing use in the high-tech, banking, and credit industries, all of which require high quality, or *Premium Power*, and reliability of power. This is not available from the grid without installation of special conditioning equipment. In a true premium power installation, DG provides either a permanent source of power for the company or a high quality back-up to a power conditioned, grid-reliant client. Other premium power applications include *Emergency Power*, which provides back-up power in the event of an outage within a specified amount of time, and *Standby Power* that replaces the normal system and allows continuous operation of facilities such as airports and hospitals. *Continuous Power*, where the DG equipment is operated at least 6,000 hour annually is another application. Industries such as grocery stores, continuous manufacturing, and hospitals have found distributed generation essential to their operations. Using *Green Power*, electricity from environmentally benign sources, may help a facility reduce its emissions to meet local regulations.[3]

Distributed generation also is gaining increasing acceptance among local governments. These governments were greatly impacted by the energy shortages and skyrocketing prices of the past few years. Distributed generation enables entire communities to remove themselves from the grid, or to at least provide a source of reliable power for essential services in the event of a power outage. Distributed generation also provides municipalities with the means to generate additional power during periods of high demand without having to invest in additional transmission capability.

Distributed generation offers many advantages to customers and utilities alike compared to centralized power generation. In the case of local governments, DG not only offers

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[1] Resource Dynamics Corp., Assessment of Distributed Generation Technology Applications, prepared for Maine Public Utilities Commission, February, 2000, p. 7
[2] *Ibid.*, p.5-6.
[3] *Ibid.*,, p. 5-7

more flexibility in the energy resources, but more control of energy prices. Distributed generation is often less polluting, requiring fewer environmental permits. Many DG technologies are "green" technologies, producing little, if any, pollution, particularly of greenhouse gases linked to global warming. In states allowing net metering, DG may actually produce a revenue stream for local government as they sell power back into the system.

Distributed Generation Today

Distributed generation is experiencing rapid change as new technologies are brought to the market and are undergoing development. While some of these technologies have high up-front costs, many are comparable in cost to centralized power generation. Others have virtually no emissions, making them environmentally friendly, an issue of growing concern to local governments.

Even some of the older and more established DG technologies have been undergoing rapid changes. Reciprocating engines have become orders of magnitude cleaner from an emissions perspective in just the past few years, while having achieved greatly reduced noise levels. Unfortunately, these DG technologies still run on fossil fuels such as diesel, gasoline, and natural gas. Photovoltaic panels have been developed that can be used to replace shingles or be incorporated into other building materials, while at the same time possessing greatly increased efficiencies and lower upfront costs. Wind power, which has been used for centuries, has become the fastest growing energy segment worldwide and is now comparable in cost to conventional fossil fuel-fired generation. The price of wind generated electricity is expected to continue to fall. Geothermal power is the second-largest provider of renewable energy in the United States, and has tremendous potential for further development, particularly for direct use applications. Small-scale geothermal projects are becoming economically viable, as are small-scale hydroelectric plants.

Other renewable energy technologies are receiving more attention, as well. In particular, biomass, which may be produced from landfills, trees, or grains, is being used to fire power plants generating an increasing amount of power in the United States. Conventional power plants are being modified to run on biomass, which greatly reduces emissions of greenhouse gases both from power generation and venting from landfills. The U.S. Department of the Interior has announced initiatives to greatly increase the generation of power on federal lands from wind, geothermal, and solar sources. Private and military development of renewable energy also is increasing.

Development of new DG technologies is moving at a rapid pace. Exciting new technologies include fuel cells and microturbines, both of which can have overall efficiencies of nearly 85 percent. Fuel cells have no moving parts and produce only air and water as emissions, and several different technologies are under development, with two types of fuel cell already commercially available. They run on hydrogen, which is considered the fuel of the future, although current economics of hydrogen force fuel cells to run on hydrogen produced from natural gas, a fossil fuel. Major oil companies such as

Chevron Texaco and BP Amoco have made commitments to developing renewable energy technologies, fuel cells, and microturbines. Microturbines, which are essentially small jet engines used to generate electricity are able to run on fuels produced from biomass-produced fuels as well as fossil fuels. Further advances in all DG technologies should be expected. In addition, as each technology is developed, costs should fall, further increasing the attractiveness and viability of distributed generation.

As the viability of distributed generation has increased, so has the acceptance of the technology by utilities and state and local governments. Utility deregulation has increased interest in DG, and most states now allow net metering, which produces a potential revenue stream for consumers, including local governments as they sell excess power generated by DG back to the utility.

Perhaps the biggest drawback to the increased use of DG is the lack of a national set of codes and standards. This, coupled with the unfamiliarity of some of these emerging and existing technologies, has caused numerous problems with local inspectors and code officials in a number of municipalities. The U.S. Department of Energy has made development of model codes and standards a high priority and their completion is expected in the not so distant future.

Another major problem for DG lies in the interconnection issue. Many utility companies are reluctant to allow DG units to interconnect with their systems. Again, this is usually due to a lack of familiarity with the technologies involved. Also, DG is perceived, incorrectly, as a threat by many companies to their economic base should customer generated power become widespread. Another problem lies in net metering, in which power is sold back from the DG operator to the utility. The future should see utility companies not only work with DG operators, but actually embrace the technology as it lowers maintenance costs by alleviating congestion on power lines, decreasing the maintenance of the transmission and delivery network itself, and reducing or delaying the need for construction of new, and costly, generating facilities.

Local Government Issues

There are many issues of concern to local governments regarding DG. While these are discussed at length elsewhere in this handbook, a brief summary is presented here.

Probably the greatest concern to local governments is the security of power supply. This involves both generation and transmission. The urgency of the situation was illustrated during the energy crisis in California over the past two years, but it has been demonstrated before in massive power outages due to equipment failures, natural disasters, and even geomagnetic events. With the tragic events of September 11, security of energy infrastructure has become an issue not just of local importance, but national security. Many parts of the energy infrastructure in the United States are particularly vulnerable to disruption due to terrorist attacks, equipment failures, and natural events. The transmission and distribution system is most vulnerable, and failure of this element of the system can have far-reaching effects. Distributed generation eliminates the dependence on the transmission network or grid by providing a local, independent, source of power.

Local governments are also concerned with reliability of power supply. Modern society is heavily dependent on electricity, and it is the responsibility of local government to provide its citizens with reliable power. While this includes ensuring the security of the energy infrastructure, it also involves ensuring a reliable source of power even if the transmission and distribution grid is not disrupted. The energy infrastructure in the United States is aging and overloaded. Very little generating capacity has been added in the past decade. Many utility companies have, in fact, divested themselves of their generating capacity, retaining only transmission and delivery grids. This has resulted in power outages, including rolling blackouts, and restrictions on the use of electricity not from disruption of the energy infrastructure, but because generating capacity was curtailed by a distant provider of power. Local government need not accept this disruption of electricity because of decisions made in a far-off board room or for purely economic factors facing the power provider. Distributed generation provides one alternative to reliance on an unreliable source of power. Some communities are even developing their own, independent, DG-based utility system. Another solution installation of DG as a backup, particularly for critical services, should the grid fail to provide reliable power.

Reliability of power is more than a convenience issue. Not only do critical services rely on electricity, so do many modern businesses. The digital economy, continuously operating manufacturing businesses, and essential services all demand high reliability of power supply. The cost for unreliable power and poor power quality to these sectors is staggering. In 2000, of the $119 billion in losses due to power outages and poor power quality in the U.S., $45.7 billion was just in those three sectors. Reliability of power is an economic issue for local governments. In fact, a secure and reliable supply of power may be seen as an incentive for attracting new businesses to the community. Distributed generation, either as a primary source of power or as a back-up to the utility grid, provides that secure and reliable source of electricity.

Cost is always of concern to local governments. With DG technologies, there is more than the cost of the equipment to consider. The installed equipment costs for DG are usually quoted in terms of cost per kilowatt (kW) of capacity. For example, at $1000 per kW of capacity, a 50 kW generating unit would cost $50,000. There is often a wide range of costs for installed DG technology due to site specific factors such as siting difficulties, variations in labor rates for installation, interconnection issues, permitting costs, and ease of installation. The type of application will have an effect on the installed cost due to its impact on the type of equipment selected. For example, in a premium power application, the requirements of the application demand a quick startup, low installed cost, and low maintenance costs.[4] This limits the selection of technologies.

[4] *Ibid.*, p.7

Distributed generation technologies generally require a high upfront capital cost, limiting their appeal. However, there may be incentives available from state and federal agencies, such as tax rebates and subsidies. In addition, as the technologies gain more widespread acceptance and production rates increase, the upfront costs should fall. Many states now allow net metering, or the sale of unneeded power to the utility by a self-generating customer. In addition to incentives, DG may increase efficiencies due to elimination of losses which occur during transmission. Local governments also must consider the operation and maintenance costs of DG versus the rates the utility charges for an equivalent amount of electricity.

Local governments must weigh how much air pollution is generated when determining if DG is an acceptable form of electrical generation. In many cases, DG technology is cleaner than conventional centralized generation and may help in cleaning up the air in the community. For example, several DG technologies, such as photovoltaics and wind, rely on renewable resources and produce no emissions. Other technologies, such as fuel cells, produce only water vapor as an emission product. On the other hand, some DG technologies, in particular reciprocating engines, produce considerable amounts of NO_x and CO, rendering them unsuitable in many metropolitan areas.

Another environmental issue facing local governments concerns fuel. Some DG technologies, such as diesel reciprocating engines, require on-site storage of large volumes of fuel. This is also a safety issue. A fire or leak could produce severe consequences with which local governments may have to deal.

There is another issue of concern to local governments with respect to fuel. Many DG technologies (certain reciprocating engines, fuel cells, microturbines) require a supply of natural gas. This may be stored on-site, creating the concerns discussed in the previous paragraph, or supplied via pipelines. If the pipeline option is exercised, there are several significant problems to be considered. First, the community will still be dependent on outside supplier to provide their electrical generation. In this case the outside supplier would be the gas company, often one and the same as the electricity supplier. Further, the municipality is dependent on the fuel price charged by the supplier, which in the case of natural gas has fluctuated wildly in recent years. A large increase in fuel price could render the DG installation economically unviable. If the DG installation is to provide critical infrastructure protection, any event that might disrupt fuel delivery pipelines, including terrorist attacks or earthquakes, would halt the flow of fuel to the DG installation. Since pipelines rely on electricity for pumping, unless the power for the pipeline is DG, a disruption of the power grid would shut down the pipeline, as well.

Finally, local governments must be concerned with regulatory issues. Perhaps the biggest drawback to the increased use of DG is the lack of national codes and standards. The U.S. Department of Energy has made development of these codes and standards a high priority and these should be developed in the not so distant future. The development of local and state codes and standards for DG installation is also an issue. Frequently, such codes and standards do not exist, and even if they do, a lack of familiarity with DG technologies will lead code inspectors to reject an application out of hand or require extensive, and expensive, revisions prior to approval. These permitting problems may cause a project to become economically infeasible. A further regulatory issue is whether local and state codes allow net metering, and what requirements the utility has for interconnection. DG technologies may even be impacted by local ordinances that do not even apply to them, such as solar access restrictions. The site of installation may be impacted by air quality considerations, as well as local residents' concerns over noise and visual impacts.

Private sector installation of DG is also a matter of concern to local governments. The same regulatory issues apply, but the local government also is tasked with the responsibility of inspection and permitting private installations. This requires that the municipality be able to conduct the required inspections or deny the use of DG to its residents and businesses, which may be unpopular politically. The municipality has an obligation to its residents to be familiar with DG technologies, which will require training. In addition, the local government should be in the position to advise its constituents of incentive programs that may be available to the private citizen for DG installation.

Conclusion

Distributed generation technology offers many advantages to local governments in terms of security of energy supply and independence from the grid. Modern and emerging DG technologies offer clean, reliable, high quality power in demand by consumers. It is the responsibility of local governments to ensure their constituents are provided with the power needed for residential and commercial use, support of essential services and economic development. Economic and regulatory issues must be considered in determining whether DG is right for a given municipality. Because of the uncertainty of energy supply in the United States at present, which has become a matter of national security, it is essential for local governments to become familiar with the applications of DG, the advantages and disadvantages of the different DG technologies, and the economic, environmental, and regulatory issues they entail.

This handbook is intended to provide the basis for local government officials to become familiar with all of the aspects of DG, and that it will provide the incentives to further investigate these technologies for use in their communities.

Chapter 2
Purposes of Distributed Generation

PURPOSES OF DISTRIBUTED GENERATION

RELIABILITY

Overview

The term "reliability" in the electric utility industry refers to adequate generation, transmission, and distribution to the ultimate end-user. In actuality, it has three dimensions[5] -- adequacy, security, and quality. *Adequacy* means that there is adequate generation to meet customer demand requirements in a geographic region and means that there must be enough generation in place to deal with both planned (e.g., periodic maintenance) and unplanned (e.g., fallen distribution lines) outages. Uncertain levels and timing of customer demand, lead times for bringing new generation facilities on line, the state of the economy, inadequate generation for local demand (i.e., "load pocket"), and the extent customers can reduce their electricity loads (or sell excess amounts of distributed energy generated on-site back into the electricity grid serving a specific geographical region), all affect the adequacy of electric service.

Security constitutes the second element of reliability. Because electricity service requires constant real-time balancing of available supply and load demand, a systems operator requires that spare capacity in power lines and ready generation be instantly available and capable of being synchronized. It also requires that significant generating and transmission capacity in excess of peak demand needs also be available in addition to the physical protection of key generation and transmission facilities from wanton sabotage. The third element of reliability, *quality*, entails the degree and consistency that the voltage waveform oscillates between a positive and negative value in the alternating current (AC) transmission and distribution lines. The most severe power quality problem is a large voltage surge caused by a lightening strike. Other power quality problems include:[6]

[5] Sedano, Richard P., Dimensions of Reliability: A Paper on Electric System Reliability for Elected Officials, The Electric Industry Restructuring Series, The Regulatory Assistance Project for the National Council on Competition and the Electric Industry, October 2001, pp. 3-6.

[6] U. S. Department of Energy, "Power Quality and Reliability Issues", on Distributed Energy Resources, Office of Energy Efficiency and Renewal Energy, Energy Efficiency and Renewable Energy Network website, www.eren.doe.gov/der/quality_reliability.html.

- *Voltage sags and swells* — the amplitude of the wave gets momentarily smaller or larger — due to large electrical loads such as motors switching on and off. Voltage sags are the most commonly experienced power quality problem among electronic and computer equipment users.

- *Impulse events* — also called glitches, spikes, or transients — in which the voltage deviates from the curve for a millisecond or two (much shorter than the time for the wave to complete a cycle). Impulse events can be isolated or can occur repeatedly, and may or may not have a pattern to them.

- *Decaying oscillatory voltages* — the voltage deviation gradually dampens, like a ringing bell — caused by banks of capacitors being switched in by the utility.

- *Commutation notches* appear as notches taken out of the voltage wave. They are caused by momentary short circuits in the circuitry that generates the wave.

- *Harmonic voltage* waveform distortions occur when voltage waves of a different frequency — some multiple of the standard frequency of 60 cycles per second — are present to such an extent that it distorts the shape of the voltage waveform.

- *Harmonic voltages* can also be present *at very high frequencies* to the extent that they will cause equipment to overheat and will interfere with the performance of sensitive electronic equipment.

- *Brownouts* are a persistent lowering of system voltage caused by too many electrical loads on the transmission line.

- *Blackouts* are, of course, a complete loss of power. Unanticipated blackouts are caused by equipment failures, such as a downed power line, a blown transformer, or a failed relay circuit. Although normally limited by design to a small geographic area, blackouts have been known to affect wide regions of the United States.

- *"Rolling" blackouts* are intentionally imposed by the system operator upon a transmission grid when the loads exceed its generation capabilities. By blacking out a small sector of the grid for a short time, some of the load on the grid is removed, allowing the grid to continue serving the rest of the customers. To spread the burden among customers, the sector that is blacked out is changed every 15 minutes or so — and hence the blackouts "roll" through the grid's service area.

The "reliability problem" is not a single problem but arises at the intersection of at least

[7] Cowart, Richard, *et. al.*, Distributed Resources and Electric System Reliability, The Regulatory Assistance

three trends:[7]

- Power Quality Demands of the Digital Economy. A continuous power supply and improved power quality are critical underpinnings of the nation's rapidly growing digital economy.
- Effects of Persistent Load Growth. Load growth, particularly peak load growth, has been increasing so rapidly that it has put great strains on the entire power system infrastructure.
- Abandonment of Integrated Resource Planning. With the unbundling of functions that formerly were managed within franchise operations due to industry restructuring, electricity transactions are increasingly occurring in the regional wholesale market, placing greater demands on transmission grids, and integrated resource planning has essentially been abandoned.

A common standard for system reliability is delivery of 99.9% (three 9s) of energy demanded by consumers. Customers with "high" reliability needs may look for 99.9999% (six 9s) or even higher. With the policy nationally to promote competitive wholesale electricity markets throughout the U.S., it has been presumed that the existing transmission system could handle the additional transactions. In locations where the number of transactions has increased significantly, "transmission congestion" has resulted. This means that it is not possible to complete all the proposed transactions to move power from one location to another on the grid due to thermal, voltage, or stability limits on transmission lines or other facilities. Often, such congestion is not even related to the physical limits of the lines, but due to security concerns in reserving a margin of safety in capacity to respond to contingent outages. However, in places where such outages are a frequent occurrence, the resulting bottleneck could well be due to the physical limits of the transmission line.

Eight of the most significant power quality events during the summer of 1999 were examined by the U.S. Department of Energy's Power Outage Study Team (POST), which concluded that the transition to more competitive wholesale markets and to retail competition in many states had undermined the industry's traditional reliability mechanisms.[8] The report states:[9]

> *The power outages and disturbances studied by POST serve as a wake-up call, reminding us that reliable electric service is critical for our health, comfort, and the economy. While the new industry structure should improve reliability...the transition to that new structure presents a risk...[T]he reliability events of the summer of 1999 demonstrated that the necessary operating practices, regulatory policies, and technological tools for assuring an acceptable level of reliability were not yet in place.*

Project, Gardiner, Maine, September 2001, pp. 3-5.

[8] *Ibid.*, p.5-6.

[9] U.S. Department of Energy, Report of the U.S. Department of Energy's Power Outage Study Team – Final Report, March 2000, S-2.

Reliability problems include: regional transmission failure, generation inadequacy, inadequate local transmission serving a "load pocket" (i.e., inadequate local generation served by limited-capacity transmission lines), local distribution failures (e.g., aging distribution facilities, feeder cable separation), and power quality disruptions. In most cases, the high system loads required at the time of failure could have been mitigated by distributed generation resources that either moderated the high demands or served the system loads that caused the reliability problem.[10]

Urban Grid Issues[11]

The purpose of the electricity grid is to bring power from the generating plant to end-users. The conventional model has been for electric power to be generated at a large, power plant located on the fringes of major load centers and delivered to customers via a complex system of long-distance transmission and local distribution lines. Besides transmission distances (and the inevitable electricity losses), power plant siting includes a host of other considerations that influence its ultimate location such as ready access or ease of transport of fuel resources, the need for a cooling water source, and environmental considerations.

It is important to emphasis that there is no "national power grid" in the United States. In fact, the continental United States is divided into three main power grids: (1) the Eastern Interconnected System, or the Eastern Interconnect; (2) the Western Interconnected System, or the Western Interconnect; and (3) the Texas Interconnected System, or the Texas Interconnect.

The Eastern and Western Interconnects have limited interconnections to each other, and the Texas Interconnect is only linked to the others via direct current lines. Both the Western and Texas Interconnects are linked with Mexico, and the Eastern and Western Interconnects are strongly interconnected with Canada. All electric utilities in the mainland United States are connected to at least one other utility via these power grids. Alaska has an interconnected grid system, but it connects only Anchorage, Fairbanks, and the Kenai Peninsula. Much of the rest of the state depends on small diesel generators, although there are a few minigrids in the state as well. Hawaii also depends on minigrids to serve each island's inhabitants.

The main interconnections of the U.S. electric power grid and the ten North American Electric Reliability Council (NERC) regions are listed below:

ECAR - East Central Area Reliability Coordination Agreement
ERCOT - Electric Reliability Council of Texas

[10] *op. cit.*, Cowart, pp. 6-7.
[11] U. S. Department of Energy, "How the Electricity Grid Works", on Distributed Energy Resources, Office of Energy Efficiency and Renewal Energy, Energy Efficiency and Renewable Energy Network website, www.eren.doe.gov/der/grid_works.html.

FRCC - Florida Reliability Coordinating Council
MAAC - Mid-Atlantic Area Council
MAIN - Mid-America Interconnected Network
MAPP - Mid-Continent Area Power Pool
NPCC - Northeast Power Coordinating Council
SERC - Southeastern Electric Reliability Council
SPP - Southwest Power Pool
WSCC - Western Systems Coordinating Council.

Electricity is generated as it is used; unlike fuels such as natural gas or coal, there is very little ability to store electricity. Because of this instantaneous nature, the electric power system must constantly be adjusted to ensure that the generation of power matches the consumption of power. On the continental U.S. power grids, roughly 150 Control Area Operators serve this function, using computerized control centers to dispatch generators as needed. To help the Control Area Operators, electrical generators are divided into three main categories:

<u>Baseload power plants</u>, which are essentially run all the time to meet minimum power needs;

<u>Peaking power plants</u>, which are only run to meet the power needs at maximum load (known as "peak loads"); and

<u>Intermediate power plants</u>, which fall between the two and are used to meet intermediate power loads.

Nuclear plants, for instance, are nearly always operated as baseload plants, because the systems are the most stable at full power. Intermediate plants are well suited in adjusting to changing power loads (called "load following"); gas turbines can be used as intermediate plants. Peaking plants are generally the most expensive plants on the system to operate; in many cases these are small, older coal- or oil-fired plants, although gas turbines also can be used, as well.

While Control Area Operators run the grid within their control areas, on a larger scale the responsibility for electric grids has traditionally rested with electric utilities. Utilities would have responsibility for the operation of the electrical grid within their service area (coordinating the efforts of the Control Area Operators in their service area), as well as investment in new lines, maintenance, and control of access to the grid.

However, with competition in wholesale power markets, and increasing competition in retail power markets, utility control of the grid has often been viewed as a conflict of interest. Some states have moved to pass the control of the grids to Independent System Operators, or ISOs. For example, the California ISO controls the transmission grid for all of California. ISOs also exist in Texas and New England. Ownership of the transmission and distribution systems may be retained by the utilities, or may be passed off to independent transmission companies ("TransCos"), in which case the utility effectively becomes a distribution company ("DisCo").

As previously noted, the grid actually consists of two separate infrastructures: the high-voltage transmission systems — carrying electricity from the power plants and transmitting it, if needed, hundreds of miles away — and the lower-voltage distribution systems, which draw electricity from the transmission lines and distribute it to individual customers. High voltage is used for transmission lines to minimize electrical losses; however, high voltage is impractical for use in distribution lines. The interface between the two is the electrical substation, which features transformers that "step down" the voltage from the transmission voltages — ranging from 138 kV to 765 kV — to lower voltages for the distribution systems. Transformers located along the distribution lines further step down the voltage to 120 V or 240 V for household and commercial use. Substations include electrical switchgear and circuit breakers to protect the transformers and the transmission system from electrical failures on the distribution lines. Circuit breakers are also located along the distribution lines to locally isolate electrical problems (such as short circuits caused by downed power lines).

The transmission system is the central trunk of the electricity grid with thousands of distribution systems branching off and diverging into tens of thousands of feeder lines reaching into homes, businesses, and industries. The power flow to the distribution systems is largely determined by the power flow through the transmission systems; and in fact, when most people talk of the power "grid," they're often referring to the transmission system. The transmission system truly is a grid; transmission lines run not only from power plants to load centers, but also run from transmission line to transmission line, providing a redundant system that helps to assure the smooth flow of power. If a transmission line is taken out of service in one part of the power grid, the power can usually be rerouted through other power lines to continue delivering the power to the customer. In essence, the power from many power plants is "pooled" in the transmission system, and each distribution system draws from this pool. The resulting system network helps achieve a high level of power reliability, since any one power plant shut down will only constitute a fraction of the power being delivered by the grid.

One result of this pooling of power is that the electricity drawn off the grid always comes from a diversity of power sources that may include coal, nuclear, natural gas, oil, or renewable energy sources such as hydropower, biomass, wind, or solar power. This is often referred to as "system power" because it is the standard power mixture that supplies the transmission system. There are financial and contractual means of tying an individual generating source, such as a wind farm, with an individual user in a meaningful way, but the fact is that the electricity one draws from the grid is always system power.

<u>There are several problems with the existing grid system</u>. *First*, there is not always enough power generation available to meet peak demand. *Second*, existing transmission lines cannot carry all of the electricity needed by consumers. Since 1989, electricity sales to consumers have increased by 2.1% annually, while transmission capacity has increased

by only 0.8% a year.[12] *Third*, electric industry restructuring has caused many utilities to delay needed upgrades and extension of their transmission and distribution lines. *Fourth*, new line capacity is not coming on-line fast enough to meet growing demand.

Distributed generation offers a solution to these problems. Rather than waiting years for the permitting and construction of large, central power plants, many power users have brought smaller generators on line in as little as a month from the time they are ordered. Some electricity customers, frustrated with power quality and reliability problems, are installing on-site generators to meet all or part of their electricity needs. Installing distributed generation units at or near the customer's load can avoid the utility's having to upgrade transmission and distribution lines to handle the extra power requirements. Moreover, by using the cogeneration capabilities of some distributed power systems located at the energy consumer's site, the overall energy conversion efficiency of such generators approaches 80%, considerably higher than the roughly 30% efficiency of traditional, steam-based central power plants (once line losses are taken into account).

Transmission and distribution networks also are inherently expensive to build and maintain. Overall, one utility company estimates that it spends $1.50 to deliver power for every $1.00 it spends producing it. Power transmission also incurs some electricity losses; the Energy Information Administration (EIA) estimates that approximately 9% of the power produced at a central generating plant is lost in delivery. Power companies can avoid or defer some of these costs by investing in distributed power systems.

The threat of litigation also can be an incentive for power providers to embrace distributed generation for its potential to improve electric power reliability. Following the rolling blackouts on the East Coast in July 1999, New York City filed a lawsuit against the local utility company claiming that it endangered the welfare of more than 200,000 people and caused millions of dollars in property damage and economic loss. New York's mayor said that the utility should have upgraded old feeder cables in its distribution network long before they failed under the pressure of increased demand for electricity during that month's heat wave. In August the same year, the mayor of Chicago threatened similar action following a series of power failures that included a 17-hour outage that led to an estimated $100 million in losses to the local community.

Means for Overcoming Urban Grid Problems

Minigrids

One growing application of distributed energy is in minigrids — a set of generators and load-reduction technologies that supply the entire electricity demand to a localized group of customers. By avoiding the cost of transmitting electricity from a distant central-station power plant, or transporting fuel from a distant supply source, a minigrid (sometimes called a "microgrid") can significantly improve the economics of meeting

[12] National Energy Policy Development Group, Reliable, Affordable, and Environmentally Sound Energy for America's Future, Office of the Vice President, Washington, DC, May 2001, p. 1-5.

energy needs using distributed energy resources. Minigrids typically use the same technologies employed by electric utilities in distributed power applications, but are not always connected to the central grid. In some cases, the generators and other distributed resources are installed to relieve utility constraints on the existing grid, with a view to possibly disconnecting these generators and their load from the grid at a later date. In other cases, an electrically isolated minigrid is created; this minigrid may then be integrated with the central grid if that option becomes attractive. The key point is that the generators in a minigrid are capable of serving their load independently.

Distributed generation involves adding modular electricity generators close to the point of consumption on a power grid. Using a mix of generating and demand-side-management technologies gives the power supplier the flexibility to meet a wider range of loads. For example, a cost-effective application might use a combination of energy efficiency measures, cogeneration of electricity and hot water using fuels cells, and power generation using wind, PV, and backup diesel generators for emergencies.

DC Microgrids

A concept for future power grids is to set up neighborhoods that run entirely on direct current (DC). A high-voltage DC line would interface with the rest of the grid through high-tech DC-to-AC converters. DC systems are less vulnerable to power quality issues, and digital devices run on DC current. DC systems also allow distributed generation equipment to be connected directly to the microgrid without using DC-to-AC converters at the power source. According to the Electric Power Research Institute (EPRI), the converter technology needed to interface these DC microgrids with the AC power grid should become cost-effective by 2005. Another future possibility is to use a loop of high-temperature superconducting wire to carry the DC current. This power loop would isolate customers from electrical system disturbances and provide superior power quality.

Flexible Alternating Current (AC) Transmission Systems, or FACTS

These future systems would incorporate high-current and high-voltage power electronic devices to increase the carrying capacity of individual transmission lines and improve overall system reliability by reacting very quickly to grid disturbances. Using such responsive electronics, the electric power industry envisions converting the electric power grid to more of a networked system, responding in real time to a broader dispersion of electric generators, higher and less predictable line loadings, and a vast increase in transactions. The data and control system needed to achieve such a system will likely be a dispersed network, much like the Internet. One technical problem in achieving this system is figuring out how to decentralize the control of the system while still maintaining the essential balance between electrical loads and electrical generation.

Utility Power Plant Issues

Between 1993 and 1997, noncoincident summer peak load in the U.S. rose from roughly

581,000 MW to 638,000 MW – an increase of over 56,000 MW in four years.[13] This is the equivalent of adding a new six-state New England to the nation's electrical demand every 18 months.[14] Between 1997 and 2000, the rate of increase was even more rapid. Nationwide, electricity consumption grew 31% in the decade between 1988 and 1998.[15] Consumption grew 278,000 GWH (or about 9.7%) between 1993 and 1997 alone.[16]

The Vice President's National Energy Policy Development Group reports that electricity demand is projected to rise by 1.8% a year over the next 20 years.[17] This is equivalent to adding 393,000 MW of generation capacity. Satisfying the need for this much demand, i.e. simply increasing the supply side of the equation, would, according to the Vice President's report, result in a need to build between 1,300 and 1,900 new power plants. That averages out to be more than 60-90 plants a year, or over one new power plant a week.[18] Since it is unlikely, either that this many plants will be built within this time period or that energy efficiency, conservation, and renewable energy sources can make up the entire difference in increased demand, it would appear that shortages will occur in most, if not all, of the 10 regional reliability council regions of the country over the next two decades.

Given these expectations, it is possible to identify the weak links in the chain that ties generation, systems operation, transmission, and distribution to customer load and seek to remedy these. Once the necessary upgrades are made, however, the next weakest link will emerge in an endless "game of catch up". Therefore, a narrow focus on fixing today's weakest links in the supply/delivery chain will ultimately be less resilient and more expensive than a strategy that identifies reliability-enhancing distributed generation investments as well.[19]

Load reduction measures are the least expensive way to avoid adding new generating capacity to a utility's service area. But if demand continues to grow beyond the capacity of existing generation in a particular locale, it can sometimes be less expensive and easier to meet this demand by adding new generators close to the load than by adding transmission and distribution capacity. Small, modular power plants can be approved and sited close to a new load, sometimes in a matter of months versus several years for transmission line upgrades. Reasons that efforts should focus major resources on distributed generation and demand-side solutions include: (1) the untapped reservoir of distributed generation, energy efficiency, and load management options are both large and dispersed, making them less "lumpy" and, in a statistical sense, more likely to be available when needed than many supply side resources; (2) demand-side resources, even

[13] Energy Information Administration, Noncoincidental Peak Load Actual and Projected...: 1993 through 1997, U. S. Department of Energy, Washington, DC, undated,Table 35.
[14] *op. cit.*, Cowart, p. 4.
[15] *New York Times*, September 13, 1999, cited in *op. cit.*, Cowart, p. 4.
[16] Energy Information Administration, U.S. Electric Utility Sales to Ultimate Consumers: 1993 through 1997, U. S. Department of Energy, Washington, DC, Table 2.
[17] *Op. cit.*, National Energy Policy Development Group, p. 1-4.
[18] *Op. cit.*, National Energy Policy Development Group, p. 5-10.
[19] *Op. cit.*, Cowart, pp. 8-9.

if not necessarily corresponding with peak demand, will provide an offset against load demand that would otherwise have to be served; and (3) cost-effective distributed generation solutions are often less expensive than the central station and transmission-dependent solutions most frequently put forward to address reliability problems. Moreover, distributed generation that lightens the load at the end of the supply/delivery process simultaneously enhances the reliability of each link in the entire chain, from the local distribution all the way through to generation adequacy.[20]

Distributed generation can be tapped to address reliability challenges in several ways: (1) improving power quality and ensuring uninterrupted power to individual customers; (2) relieving distribution overloads and transmission congestion; (3) meeting generation adequacy requirements; and (4) providing ancillary services to the system.[21] Regarding the provision of ancillary services, the Federal Energy Regulatory Commission (FERC) began to encourage this option by requiring the separation of six ancillary (i.e., reliability) services from transmission in its Order 888 and further expanded that process with its Order 2000 on regional transmission organizations (RTOs).[22] Ancillary services that distributed generation resources might want to sell are shown in Figure 1. These

Ancillary Service	Definition	Appropriate Application
Reactive Supply and Voltage Control from Generation	Injection and absorption of reactive power from generators to control transmission voltages	Not as appropriate
Regulation	Maintenance of minute-to-minute generation/load balance to meet FERC's Performance Standard 1 and 2	Not as appropriate
Load Following	Maintenance of the hour-to-hour generation/load balance	Distributed generators, interruptible customers, and storage devices
Frequency Responsive Spinning Reserve	Immediate (10-second) response to contingencies and frequency deviations	Distributed generators, interruptible customers, and storage devices
Supplemental Reserve	Response to restore generation/load balance within 10 minutes of a generation or transmission contingency	Not as appropriate

[20] *Op. cit.*, Cowart, pp. 9.
[21] *Op. cit.*, Cowart, p.10.
[22] *Op. cit.*, Cowart, p.23.

Backup Supply	Customer plan to restore system contingency reserves within 30 minutes if the customer's primary supply is disabled	Distributed generators
Network Stability	Use of fast-response equipment to maintain a secure transmission system	Distributed generators and storage devices connected to the grid
System Blackstart	Capability to start generation and restore all or a major portion of the power system to service without support from outside after a total system collapse	Distributed generators of sufficient size to re-start other generators

Figure 1: Key Ancillary Services and Their Definitions[23]

services are required to maintain bulk power system reliability and are being opened to competitive markets in regions where RTOs operate.

Generators used to provide contingency reserves must have capacity available to respond to the contingency when it occurs and cannot be operating at full load. It can provide the reserve power either by increasing output or by temporarily curtailing load. Faster power activation service generally command higher prices, although at times it may be faster to temporarily curtail load than to start generation and restore service as additional generation is brought on line. Also, it is generally easier to incorporate energy storage on the load side in the form of thermal storage than it is on the power-supply side. If load management resources can fully participate in ancillary markets, they benefit because they can receive revenue from the sale of ancillary services as well as from energy production.[24] It also will improve overall generation/transmission grid efficiency and lower electricity prices.

Electrical Load as a Reliability Resource

Allowing customers to manage their loads (or have their loads managed for them) in response to system conditions can be thought of as a power reliability resource, as it would enable a closer match between demand and supply on a continuous basis, thereby reducing the need for power outages. Not only would this increase the stability of the electricity grid, it would also reduce the kind of extreme price spikes experienced in California during recent periods of excess demand.

For electricity markets to function in a truly competitive and efficient manner, it is not

[23] Based on analysis in *Op. cit.*, Cowart, p.24.
[24] *Op. cit.*, Cowart, p.25.

enough to focus solely on improving the supply of power. Customers must also be able to respond to changing supply conditions by modifying their demand for electricity. To the extent that this demand is flexible for an individual customer, he or she will buy less electricity when it is more expensive, shifting demand to periods when electricity is less expensive. A number of utilities have initiated programs to purchase curtailments and customer-owned generation at periods of peak demand and high prices. Many customers would willingly reduce at least some of their consumption during high-priced power periods in return for market-based savings, which might well exceed the savings obtained under the historic utility tariffs.[25]

There are two types of electrical load that are also resources:

Price-responsive load — requires real-time pricing, in which the customer sees the fluctuating price of energy during the day and chooses whether he would like to buy at that price. When generation is in short supply and prices rise, more and more customers with accurate pricing information are likely to turn off loads. At some point, load will match generation without resorting to voltage reductions or rolling blackouts.

Emergency-responsive load — this can be thought of as an ancillary service like spinning or supplemental reserves. In this case, the customer can bid his load into the operational reserve market for that day and, if called upon, turn the load off within ten minutes if his load was specified as a *spinning reserve*, and within a half hour if his load was specified as a *supplemental reserve*. The customer is paid for the reserve capacity whether or not it is called upon. This type of load is commonly thought of as a reliability resource.

To implement price-responsive load as a resource, the customer must be provided with price signals and a means to respond to these signals, preferably automatically. For emergency-responsive load, some form of load aggregation might be needed, and a means of certifying that the load was available to turn off, and that it indeed was turned off when requested. Some loads, such as water heating, can respond immediately to act as spinning reserve, while other loads might not be able to respond as quickly, but still qualify as supplemental reserves that can be dropped within a half hour.

For either price- or emergency-responsive loads, markets must be designed to give the customer the correct signal for participation in competitive energy and/or ancillary services markets in an efficient manner. This concept is thus quite complicated to implement, as it requires a variety of technological and procedural innovations, including:

- Real-time pricing — When the supply of electricity is insufficient to meet overall demand, the price of wholesale power from electricity generators goes up. Today, such variations in price are hidden from most electricity customers, who typically pay their utilities a fixed rate for each unit of electricity consumed, regardless of the time when it was used. Real-time pricing means

[25] *Op. cit.*, Cowart, pp. 19.

passing fluctuations in the true cost of generating electricity on to customers, so they have the pricing information they need to adjust their consumption of electricity.

- New communication and control technologies — Electricity system operators require more precise information about the myriad fluctuations in demand. Operational control systems need to be developed that can respond to load reductions on par with power generation.

- New end-use technologies — Some electrical equipment, such as induction motors and various power electronics devices, create challenges for reliable grid operation. Such equipment needs to be redesigned and/or operated in a way that will reduce these impacts on the grid.

These improvements in utility pricing structures, power grid control technologies, and electrical equipment are naturally complementary to some of the other new power grid concepts.

High Tech Requirements

Our economy is increasingly based upon the continuous real-time flow of information, and increasingly dependent on machines controlled by computer chips.[26] For many high-tech businesses, power outages are unacceptably expensive.[27] For many electric applications, from home computers connected to the Internet, to commercial banking networks, to multi-million dollar industrial machines controlled by computer chips, even very small variations in power quality can cause troubling and expensive disruptions. The U.S. Department of Energy now estimates that power outages and other fluctuations in power delivery cost a least $30 billion a year in lost productivity.[28] The demand for power is growing. For example, before personal computers arrived 15 years ago, industry pundits could see little prospect for growth in electricity demand. Today, the growing use of computers, business machines, and other electronic equipment is creating a resurgent demand for electricity — high-quality electricity.

Power Parks

Traditionally, electric utilities have sought to ensure reliable service to what is called

[26] *Op. cit.*, Cowart, pp. 3-4.
[27] For example, according to Larry Owens of Silicon Valley Power, a blackout costs Sun Microsystems "up to $1 million per minute." Mike Wallach of Oracle states, "The impact of momentary interruptions of power is extremely costly in terms of lost productivity and potentially damage equipment at Oracle...Whether the electricity was free or costs three times as much would have absolutely no effect on the cost of our product." Quoted in Stahlkopf, Karl, Consortium for Electric Infrastructure to Support a Digital Society (CEIDS), Electric Power Research Institute, Fort Worth, Texas, November 2000.
[28] *Op. cit.*, Cowart, p. 4.

"four nines," that is, power will be available 99.99% of the time. But high-tech industries, like Internet server farms and computerized banking systems, demand much higher reliability, in the range of "nine nines" (available 99.9999999% of the time). Creating this level of reliability potentially can be achieved using traditional grid technologies — for example, by supplying multiple power feeders to the system and providing a backup line from a hydropower station — but the cost is high, and the reliability is generally guaranteed at the expense of service to other customers.

Power parks (also called "premium power parks") are an alternative to the traditional approach. They may include uninterruptible power supplies, such as battery banks, ultracapacitors, or flywheels [see Uninterruptible Power Supply section for more a more detailed discussion]. They typically include an on-site power source to increase reliability. One of the earliest power parks, built in 1998, is the PEI Power Park in Archibald, Pennsylvania, where a combined heat and power plant is providing both steam and electricity to occupants of the park. In August 1999, American Electric Power and Siemens Power Transmission & Distribution were selected by EPRI to develop a premium power park at the Delaware Industrial Park in Delaware, Ohio. The site was chosen because of its varied customer base and load, the customer's power quality concerns, and the site's broad spectrum of power quality needs.

In May 2000, the University Research Park adjacent to the University of California Irvine campus was designated by DOE as a power park and will develop a number of distributed energy resources to meet the park's power needs, including fuel cells, gas turbine engines, microturbine generators and photovoltaics. Another power park is being built by Hunt Power in McAllen and Mission, Texas. The park will feature options for reliable on-site power generation, as well as redundant telecommunications feeds.

Interconnectivity, Islanding and Net Energy Metering

As more distributed generation is connected with the utility grid, there is an increased sense of urgency for state and even national grid *interconnection standards*. A working group of the Institute of Electrical and Electronic Engineers developed a set of common practices (IEEE P1547) in 1999 that is emerging as the universal U.S. standard. Several public and private entities are currently conducting laboratory validations of these practices in order to gain experience, validate applicability, identify key issues, and address any problem areas (e.g., National Electric Safety Code) so that the development of performance criteria, specifications, and eventual certification of distributed generation equipment can be done to ensure a compatible, reliable interconnection with the electric power grid and other load equipment. Every installation is unique, and without some common interconnectivity standards, every installation could be time-consuming and costly, further delaying the widespread application of distributed generation options. Ensuring a compatible interconnection involves knowing about many distributed energy resource designs, installation, and performance characteristics and how these will interact with the electric power system. "Certified" and labeled equipment will provide the economic sector with a simple method to compare equipment ratings, performance testing, and interconnection service capabilities that will facilitate capture of the full value of distributed generation systems. On the other hand, interconnectivity standards that are overly restrictive may drastically curtail the connection of distributed generation facilities to the grid and perpetuate monopoly control of the grid by established utilities.

Another source of concern in connecting distributed generation resources to the grid is that they might become isolated from the rest of the power system and inadvertently continue to serve loads separate from the utility system. This situation is known as "*unintentional islanding*." Unintentional islanding is a serious concern for utility engineers if distributed generators do not properly disconnect from the grid when expected, and the distributed generator becomes isolated with other loads that the utility has the responsibility for serving. Serious accidents and death can result, as well as damage to customer and utility equipment, by uncontrolled or inadvertent voltage and frequency excursions of the lines by the distributed generation facilities. Almost all specifications for utility interconnection call for some type of islanding prevention and disconnection.

The recently approved IEEE Standard 929-2000 for interconnection of photovoltaic systems is an excellent reference for the prevention of islanding. As mentioned earlier, efforts are well underway to develop a new IEEE interconnection standard (IEEE Standard P1547) that will address all types of distributed resources. However, these voluntary standards do not ensure that interconnected distributed generation systems will operate as expected and without unforeseen compatibility problems. EPRI, DOE, and others already have done a great deal of research related to islanding, but many important issues still need to be addressed before distributed generation becomes more widespread. For example, fault clearing, reclosure, and distributed generation islanding are fundamentally incompatible. If distributed generation is left connected during the fault-clearing process, there is a high risk of the fault not clearing properly. If left connected at the time of reclosing, damage to the distributed generation system is likely. Therefore, there is nearly a universal requirement in utility-interface standards for the distributed generation to separate at the first sign of a fault and remain disconnected until the utility voltage is back within the normal range for a few minutes. In the ideal case, protective relaying would detect the existence of the fault on the utility system and separate from the utility so that the utility fault-clearing process can proceed. Many utilities use what is frequently called "instantaneous reclose." A serious concern with short reclose intervals is the possibility that the disturbed generation equipment will still be connected when the reclose operation occurs.

Finally, interconnectivity enables distributed generation facilities, under state public utility commission rules, to sell excess electricity into the grid. *Net metering* measures the difference between the electricity generated on site by the customer's distributed generation equipment and the electricity it buys from its utility. Depending upon the terms of the states electricity restructuring laws, this electricity may or may not be purchased by the utility and/or done so under various rates and load management arrangements with the customer. Thus, distributed generation can not only be a source of more reliable electricity, but it can also constitute a lucrative source of income that can offset some or all of the costs of installing and maintaining the distributed generation equipment.

ENERGY INFRASTRUCTURE SECURITY

Security of energy infrastructure is one of the most pressing concerns in the United States, particularly in light of recent terrorist attacks. DG provides and alternative source of power for municipalities, greatly reducing the vulnerability to natural or anthropomorphic disruptions in power supply.

The World Trade Center disaster in September 2001, demonstrated the importance of protecting the energy infrastructure. Over 12,000 customers, including City Hall, were without power for up to a week and longer due to the collapse of the buildings[29]. The stock markets were disabled, not because of physical damage in their buildings, but because of lack of power. Poorly planned contingency sources of electricity were to blame for literally billions of dollars in losses to the national economy because of a single event. Distributed generation supplied by reciprocating engines, photovoltaics, microturbines, or fuel cells could have alleviated many of the hardships faced by the public in Lower Manhattan, and also would have saved the nation from much of the economic loss that followed the disaster.

Energy issues were also at the center of the loss of communication that plagued the New York City area during the incident. In addition to the lack of power to transmission facilities, the disaster clearly demonstrated the need not only for distributed generation resources, but also distributed communication facilities. The collapse of the World Trade Center resulted in the loss of television and cellular telephone service to much of the metropolitan area.

If this had been an incident of a larger scale, affecting water and environmental resources, power would have played an even greater role. Virtually all aspects of water delivery depend on electricity. Without water, firefighting efforts are compromised, and a basic resource is unavailable to the citizens.

Vulnerability

How vulnerable is the energy infrastructure in the United States? Consider that the U.S. electric system includes some 500,000 miles of transmission lines, 6,000 generating units, and hundreds of thousands of substations and transformers. Any of these serve as a potential target for a terrorist attack. Generally, the power plants are well-protected, particularly nuclear power plants. This leaves the transmission and distribution network as the most vulnerable portion of the energy infrastructure for a terrorist to strike. Even

[29] Electric Infrastructure Security: Urgent Issues for States, Edison Electric Institute, http://www.eei.org/issues/news/Security_State.PDF

more likely, the transmission and distribution network serve as a likely point of origin for a natural disruption of the power supply, such as be a geomagnetic event or a storm, or are simply possible points of equipment failure. Perhaps the biggest problem facing America's energy infrastructure, however, is the aging equipment, lack of new generating capacity to meet demand, congested transmission lines, and chokepoints in transmission. These provide opportunities for massive disruption of power from even relatively benign events. Distributed generation does not require the lengthy transmission capabilities of centralized distribution since it already is located at or near to the load it serves. Introduction of DG also provides the new additional generating capacity needed to maintain energy infrastructure security.

As previously discussed, electricity in the U.S. is distributed over three interconnected networks, or grids. A failure in one part of the grid can have a ripple effect throughout a much wider area. An example of this occurred on July 2, 1996, when two minor faults occurred on a large capacity transmission line linking Oregon and California. This failure triggered a domino effect causing the shutdown of power plants throughout the western United States and the loss of the intertie between Oregon and California. In the end, 13 states and tens of millions of people were affected. Studies have shown that the entire situation could have been prevented by taking 0.4 percent of the load off the grid for just 30 minutes![30]

Even natural events can create massive outages. On March 13, 1989, a geomagnetic storm shut down the entire Hydro-Quebec network in Canada, which serves 6 million customers.[31] Geomagnetic storms occur on regular cycles, so similar events will occur again and can create over 100 amps in grounding connections in transformers, many times the number of amps needed to disrupt transformer operation. Hurricanes are common along the East Coast of the United States, and also are capable of causing massive disruptions of power.

Of course, natural events and equipment failures will always occur. And as the demand for electricity grows, and aging power infrastructure is to not replaced, equipment failures and shortages of electricity will continue to occur. However, a terrorist attack could easily create a similar disruption. Power facilities such as transformers, substations, and transmission lines are often isolated and rarely guarded, making them easy targets.

Distributed generation technologies can mitigate much of the impact of massive power outages, no matter what the cause. In fact, DG technologies should correctly be seen as a matter of homeland security. Many municipalities have recognized this and have developed DG facilities for use in emergencies. An example of this is a photovoltaic powered emergency center in San Jose, California. In the event of an earthquake or other disaster, the center will provide a means to recharge cellular phones, maintaining

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[30]Electricity Infrastructure Vulnerabilities
http://www.ee.washington.edu/energy/apt/nsfepri/s4/v_overview.pdf
[31] Power Failure in Canada During 1989. IPS Radio and Space Services.
http://www.ips.gov.au/papers/richard/power_1989.html

communications, and will also provide power for essential emergency services.

Infrastructure Security Costs

Protecting the energy infrastructure comes at a cost. It is simply impossible to protect the hundreds of thousands of miles of transmission lines and tens of thousands of related facilities. Therefore, protection must come in the form of an alternative local source of power should the grid be disrupted by a terrorist attack, natural event, or equipment failure. The National Renewable Energy Laboratory has recognized this and is implementing a plan to use DG as well as renewable resources to help assure infrastructure security.[32]

Distributed generation is the best alternative for local generation of electricity. The cost involved depends on the generating capacity required. It is one matter to supply power for critical services, such as fire, police, hospitals, water treatment and wastewater treatment. Often, these services already have their own source of back-up power. It is a completely different scenario to provide power to an entire community. For a city of 100,000 people, about 80 MW of generating capacity will be required, and the cost will depend on the technology employed. Some communities have already made the decision to remove themselves from the grid and become dependent on DG technologies as their primary source of electricity. An example is Vallejo, California, which will generate its own power using a combination of landfill gas, photovoltaics, and wind. This is anticipated to cost the city about $50 million, although funding is being provided through private sources.[33]

More important, however, is the cost associated with not protecting the power supply. The modern digital economy runs on computers and data banks that require a source of reliable and high quality power. Other sectors that rely on dependable high quality power include continuous process manufacturing and fabrication and essential services (such as water delivery). All three sectors combined annually lose $45.7 billion due to power outages, and another $6.7 billion annually due to power quality problems. Overall, power outages and quality problems cost the U.S. economy over $119 billion each year[34]. This amount of money is sufficient to install between 12 and 600 gigawatts of distributed generating capacity depending on the technology selected. For illustrative purposes, 12 gigawatts provides enough power for between 18 and 24 million people, or the equivalent of the population of Texas or New York. The importance of high quality power, which DG provides, is reflected in the cost of the Technology Center for the Americas in Miami. Of the $565 per square foot

[32] New Energy Systems Enhance National Security, NREL press release, March 14, 2002 http://www.nrel.gov/hot-stuff/press/0902_security.html

[33] City Government Plans Energy Self-Sufficiency, DER Weekly, v.2, n31, August 3, 2001 http://www.eren.doe.gov/der/pdfs/summaries/aug3der.pdf

[34] EPRI Study Shows Electricity System Improvements Needed To Prevent Economic Losses in 21st Century Digital Economy . Electric Power Research Institute, Press Release, July 16, 2001

construction cost, $300 per square foot was allocated for power conditioning.[35]

A terrorist action or other disaster could easily cost the nation's economy tens of billions of dollars if the energy infrastructure is not protected. Millions of people would be without heat, lights, and water, and thousands would likely perish. DG as a back-up source of power can mitigate the effects of these disasters, and as a primary source can prevent disruption of service entirely.

COST

Overview

Determining the cost of a DG technology is more complex than simply purchasing a piece of hardware. In addition to the equipment cost, there are labor and other costs associated with its installation. The estimated cost of electricity produced by the DG technology once it becomes operational needs to be compared to the current retail price of electricity purchased from the local utility or estimated costs of electricity for another distributed generation technology. For the most accurate results, the cost of electricity needs to be calculated for a specific manufacturer's DG system, as well as for the specific location and application of the system.

Equipment costs for DG technologies often are quoted in terms of their cost per kilowatt of electricity produced, or $/kW. For example, a 50 kW microturbine may cost $1000/kW, or $50,000. High capital costs are presently the norm for many distributed generation technologies and serve as a deterrent to their widespread acceptance. These are eased to some degree by various subsidies and tax incentives offered for various technologies by the federal government and some states.[36] However, as production levels and sales increase, economies of scale should result in decreased equipment costs.

When a electricity customer is considering the adoption of a DG technology, there are a number of questions that need to be asked to determine which technology is most suited to their specific energy needs and that makes sense in terms of costs. The following DG technologies are currently available commercially: microturbines, combustion turbines, reciprocating engines, fuel cells, energy storage/uninterrupted power source (UPS) systems, photovoltaic systems, and wind systems. Other technologies, such as the Stirling engine and hybrid systems, are still considered as emerging technologies.

Factors Determining DG Cost-Effectiveness[37]

The basic formula for determining the total estimated cost of electricity (COE) to be

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[35] *Ibid.*

[36] North Carolina Solar Center, "Database for State Incentives for Renewable Energy (DSIRE), www.dsire.org.

[37] This section based on the State of California's Distributed Energy Resources Guide contained on the website of the California Energy Commission <wysiwyg://12/http:38.144.192.166/distgen/economics/economics.html>.

produced by a distributed generation technology has three components. The total cost of electricity from a distributed generation device is the sum of these three components, expressed in dollars (or cents) per kilowatt-hour:

COE ($/kWh) = Capital & Installation costs (C&I) + Operation & Maintenance expenses (O&M) + Fuel costs

The breakdown of the three components will vary with the size and type of equipment, with the fuel component typically the largest portion of the cost of electricity in a system that uses fuel. The cost of electricity decreases as the amortization period for the DG equipment increases, i.e., is spread over a greater number of years. Also, DG systems with high capacity factors, e.g., baseload units, have a lower cost of electricity because they can spread the cost over a greater number of hours of operation compared to a peak power unit. Mature technologies, like internal combustion engines, tend to have lower O&M expenses due to standard product designs and more established networks for parts and maintenance. Each of these components is explained in greater detail below.

Capital Costs

Capital and installation costs include the cost to purchase and install a DG technology at a specified site. Capital costs refer to the total equipment cost of a power generation system and can vary significantly even within the same technology, depending on size, power output, performance, fuel type, etc. Figure 2 illustrates the cost ranges for selected distributed technologies and factors currently affecting their costs.

Figure 2: Capital Costs of Selected Distributed Generation Equipment

DG Technology	Capital Cost ($/kW)	Cost Factors
Microturbine	$700-1000	Costs represent early commercial production and will likely decrease as level increase.
Combustion Turbine	$300-1000	This is a mature technology with high production levels. Larger turbines generally cost less per kW than smaller turbines.
Internal Combustion Engine	$300-800	Reciprocating engines are a mature technology with high production volume and costs that are relatively low. Larger reciprocating engines cost more per kW than smaller engines because they are still manufactured in small quantities.
Stirling Engine	$2,000-50,000	Manufacturers target lower costs (<$2,000) if higher production volumes are achieved. The higher costs are for low production, prototype engines.
Fuel Cell	$3,500-10,000	These are in various stages of development and production, thus resulting in a wide range of capital costs..
Photovoltaic	$4,500-6,000	This is a relatively mature technology with costs that vary by system type and size.

Wind Turbine	$800-3,500	These vary with the size of the project, with lower costs associated with utility scale wind farms and residential turbines at the higher end of the cost scale.

Installation Costs

Figure 3 illustrates installed costs for specific kinds of DG installations.

Figure 3: Installed Costs of Available Distributed Generation Equipment

DG Technology	Capital Cost ($/kW)	Capital Cost
Microturbine (30 kW)	$1,000	$30,000
Natural Gas Combustion Turbine (45kW)	$750	$33,750
Diesel Internal Combustion Engine (500 kW)	$500	$250,000
Natural Gas Internal Combustion Engine (500 kW)	$1,000	$500,000
Phosphoric Acid Fuel Cell (PAFC) (200 kW)	$5,500	$1,100,000
Proton Exchange Membrane (PEM) Fuel Cell (250 kW)	$8,000	$2,000,000
Photovoltaic Panel (0.1 kW)	$9,000	$900
Wind Turbine (10 kW)	$3,000	$30,000

Operation and Maintenance Expenses

Operation and maintenance (O&M) expenses of distributed technologies have both fixed and variable components. *Fixed costs* consist primarily of plant operating labor which, in turn, is highly dependent on the operating cycle and staffing arrangements of the plant. *Variable costs* represent variable maintenance and take into account the DG unit's expected capacity, periodic inspection, replacement, and repair of system components (e.g., filters, desulfurizer, etc.) as well as consumables (e.g., water, limestone, etc.). Figure 4 lists a sample maintenance intervals and costs for selected distributed generation technologies.

Figure 4: O&M Expenses of Selected Distributed Generation Equipment

DG Technology	Time Until Maintenance Required (hours of operation)	Average Maintenance Expenses (cents/kW)
Microturbine	5,000-8,000	0.5-1.6 (estimate)
Combustion Turbine	4,000-8,000	0.4-0.5

Internal Combustion Engine	750-1,000: change oil and filter 8,000: rebuild engine head 16,000: rebuild engine block	0.7-1.5 (natural gas) 0.5-1.0 (diesel)
Fuel Cell	Yearly: fuel supply system check Yearly: reformer system check 40,000: replace cell stack	0.5-1.0 (estimate)
Photovoltaic	Biannual maintenance check	1% of initial investment annually
Wind Turbine	Biannual maintenance check	1.5-2.0% of initial investment annually

Fuel Costs

Fuel costs are simply the cost of the fuel required to generate electricity with the distributed generation system. Fuel costs will vary with the efficiency (or heat rate) of the equipment and with the cost of the fuel. Therefore, a specific DG technology may have a lower cost of electricity in some geographic locations than in others due to fluctuations in the cost of natural gas, propane, or diesel fuels. Of course, some DG equipment, such as photovoltaic systems and wind turbines, do not have a fuel cost because not fuel is required.

Since the use of less-environmentally friendly fuels (e.g., diesel) is not encouraged by government air quality agencies, particularly in urban air quality nonattainment areas, the fuel of choice for most new DG technology applications has become natural gas. Also, because distributed generation technology displaces grid power, the price of natural gas versus that of grid power is a critical factor in determining the economic feasibility of a fuel-requiring DG system for a particular application.

The economics of cogeneration, in particular, depend very heavily on prevailing retail gas and electric rates that can differ significantly by geographic region and utility. Cogeneration plants displace electric utility load with gas utility load. Therefore, gas utilities see cogeneration as beneficial and may offer lower rates for gas used for this purpose. Low cogeneration gas rates not only make it cheaper to generate electricity, but they also make it less expensive to generate thermal energy. However, publicly available information on natural gas spot market contract prices and futures contracts, as well as wholesale electricity prices, are often difficult to find for the small end user, frequently requiring them to contact several utilities, independent power producers, or brokers to get an episodic "feel for the market".

Decision Analysis

A wide variety of criteria play a part in the economics of distributed generation technologies. Figure 5 lists some of the questions that need to be asked in the decision-making process for implementing DG systems:

Figure 5: Some Decision Analysis Issues

Decision Analysis Questions	Cost of Electricity Variables
Application	
Residential, commercial, or industrial?	
Baseload, backup, or peak shaving?	Capacity factor
Grid independent or grid parallel?	
Technology	
Which type of DG technology?	
Average electricity load?	
Ideal power rating of the DG system?	Fixed charge rate
Heat rate of the DG system?	Total installed cost
Reliability of the DG system?	
Capital cost of the DG system?	Operations & maintenance expense (O&M)
Installation cost of the DG system?	
O&M expense of the DG system?	Average annual net plant heat rate
Method of payment for the DG system?	
DG system life?	
Fuel	
Natural gas, propane, or diesel?	Natural gas price Diesel oil price Propane price

The cost of electricity calculated based on the above criteria may be affected by additional economic and non-economic factors that cannot be taken into account in an monetary formulas as shown in Figure 6:

Figure 6: Economic and Non-Economic Considerations

Economic	Non-Economic
Utility back-up tariffs (i.e., supplemental and stand-by charges)	Prestige/status of early adopters
Utility competitive transition (i.e., stranded cost) charges	Global warming considerations
Net metering requirements	Emissions concerns
Incentives or rebates for DG technologies	Strong feelings for or against the existing utility
Energy efficiency credits for DG technologies	Green/renewable power advocacy
High first costs	Desire to have independence from the grid
Availability of fuel (e.g., hydrogen)	Safety concerns
Uncertain maintenance costs	Mitigation of fuel price instability/volatility
	Special siting and permitting requirements

	Electricity reliability and quality
	Limited personal DG experience
	Lack of uniform interconnection standards
	Lack of understanding of the technology by local code and permitting officials
	Lack of understanding of the technology by the utility

Example: Determining the Cost of Electricity

The following is an example of a simplistic method for determining the cost of electricity for a small convenience store. The store uses a significant amount of electricity during peak daytime hours. The installation of a DG system is being considered as a baseload configuration that may be a money-saving alternative for the business owner. For this example, the following assumptions are made:

Assumptions

- A natural gas-fueled, 30 kW microturbine is the DG technology chosen.
- The price of natural gas is $6/MMBtu.
- The microturbine will operate 19.2 hours per day, 365 days per year.
- The microturbine has a five-year life.
- The electrical efficiency of the microturbine (based on the lower heating value of the fuel) is 27%.
- The total installed cost of the microturbine system is $1,000 per kW or $30,000. The interest rate is considered 0%.
- The total fixed and variable operation and maintenance expense of the microturbine system is 0.5 cents per kWh.
- The price of electricity purchased from the utility is 12 cents per kWh.
- The waste heat will not be utilized for cogeneration.
- The state offers an incentive program that provides a credit of $1.00 per watt, up to 30% of the project cost. [In this case, the maximum credit is $9,000 (30% of $30,000), reducing the total installed cost (TIC) to $700 per kW or $21,000.]

Based on this information, the total cost of electricity generated by the microturbine can be determined using the following steps:

1. The capacity factor (CF) is equal to the number of hours per year that the microturbine operates divided by the total number of hours per year (8,760).

$$CF = \frac{19.2 \text{ hours per day} \times 365 \text{ days per year}}{8{,}760 \text{ hours per year}} = 0.80$$

2. The fixed charge rate (FCR) is equal to the annual amortized installed cost ($/yr) divided by the total installed cost ($). In this example, the cost of money was not included. Therefore, the amortized installed cost is simply one-fifth of the total installed cost.

$$\text{FCR} = \frac{\$700 \text{ per kW} \times 30 \text{ kW divided by 5 years}}{\$700 \text{ per kW} \times 30 \text{ kW}} = 0.20$$

3. The heat rate (HR) of the microturbine is based on the higher heating value of the fuel. It is assumed that the lower heating value is equal to 0.904 times the higher heating value.

$$\text{HR} = \frac{3{,}413 \text{ Btu/kWh divided by } 27\%}{0.904} = 13{,}983 \text{ Btu/kWh}$$

4. The total cost of electricity (COE) is equal to the sum of the components for capital and installation (C&I), operation and maintenance (O&M), and fuel (F).

$$\text{C\&I (\$/kWh)} = \frac{\text{TIC per kW} \times \text{FCR}}{\text{CF} \times 8{,}760 \text{ hours per year}} = \frac{\$700 \times 0.20}{0.80 \times 8{,}760} = \$0.020$$

5. O&M ($/kWh) = $0.005

6. $$\text{F (\$/kWh)} = \frac{\text{FP}}{1{,}000{,}000 \text{ Btu per MMBtu}} \times \text{HR} = \frac{\$6.00 \times 13{,}983}{1{,}000{,}000} = \$0.084$$

7. COE ($/kWh) = C&I + O&M + F = $0.020 + $0.005 + $0.084 = $0.109

At a price of 10.9 cents per kilowatt-hour, the electricity generated from the microturbine in this example is less expensive than the 12 cents per kilowatt-hour from the grid. Therefore, in this case, the installed microturbine would be cost-effective for the business owner.

Incentives and Funding

The federal government provides several tax incentives, as well as some limited direct funding support, for installing DG systems, particularly those that employ renewable energy. Many states do as well. And while there is not yet a national website that contains all the types of financial assistance available for DG systems, there are two sites that are fairly comprehensive for renewable energy systems. The first is a website managed by the North Carolina Solar Energy Center that tracks information on state, utility, and local incentives promoting renewable energy technologies.[38] It expects to add

[38] *Op. cit.*, North Carolina Solar Center, "Database for State Incentives for Renewable Energy (DSIRE), www.dsire.org.

federal incentives during 2002. The second is the national informational website maintained by the U.S. Department of Energy and discussed below.

State, Local, and Utility Incentives

The website for the state, local, and utility incentives developed and administered by the Interstate Renewable Energy Council and North Carolina Solar Center can be found at **<www.dsireusa.org>**. Available incentives are organized into the following categories:

- *Financial Incentives*: tax incentives, grants, loans, rebates, industrial recruitment, solar energy equipment leasing, and sales by utilities.
- *Investment & Awareness Programs*: utility green pricing programs, green power purchasers/aggregators, education & assistance programs, demonstration projects, and outreach centers.
- *Rules, Regulations, & Policies*: public benefit funds, renewable energy portfolio standards, extension analysis, generation disclosure, contactor licensing, equipment certification, solar and wind access laws, and construction and design standards.

The list of state incentives contains a link to individual program summaries containing the following details:

- Incentive type (rebate, net metering, green pricing, etc.)
- Implementing sector (state, utility, or local government)
- End use sector (residential, commercial, governmental, etc.)
- Eligible technologies (photovoltaics, wind energy, biomass, etc.)
- Links to authorizing statutes, regulations, or policies
- Program summary
- Contact information.

Searches can be initiated based on state, community, incentive type, renewable energy technology, implementing sector (state, utility, or local government), and eligible sector (residential, commercial, governmental, etc.). One of the most comprehensive DG grant/rebate programs is offered by the California Energy Commission. It's two websites discussing incentives.[39]

Federal Incentives

The U.S. Department of Energy maintains an "Energy Efficiency and Renewable Energy Network (EREN) that provides information on a host of issues pertaining to energy efficiency and renewable energy. One of its website pages contains information

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[39] www.consumerenergycenter.org/buydown/index.html and www.energy.ca.gov/distgen/incentives/incentives.html.
[40] www.eren.doe.gov/consumerinfo/rebriefs/la7.html.

specifically on financial incentives for business investments in renewable energy.[40] This site contains brief descriptions of: (1) the Internal Revenue Service electric utility rebate program (i.e., only 35% of the value of the utility rebate is subject to being taxed); (2) the 10% tax credit for qualifying solar or geothermal projects; (3) accelerated depreciation deductions of five years for qualifying solar, wind, and geothermal property; (4) exemption of energy grants and subsidized energy financing received by businesses from a government entity; (5) DOE research, demonstration, and development competitive cost-shared grants; (6) the recently expired (December 31, 2001) Renewable Electricity Production Credit of 1.7 cents/kWh for qualifying wind and biomass projects; (7) and incentive payments made to eligible electric production facilities owned by state and local governments and nonprofit electric cooperatives for qualified solar, wind, geothermal, or biomass technologies.

The site briefly explains other incentives, such as net metering, for end-users to install renewable energy equipment as well as incentives for utilities and independent power producers to encourage renewable energy power project development (e.g., transmission line access, "green power" programs, SO_2 and NO_x credit trading programs, and renewable portfolio standards). It also provides contact information to other sources of information, such as federal agencies and renewable energy trade associations, and a list of useful publications for further reading.

Other Net Electricity Cost Considerations

Peak Load Use Reduction

In most cases the economics of a DG system are the most favorable when the availability of the energy produced by that system corresponds with the energy requirements by the end-user. For example, a photovoltaic system can create electricity to power air-conditioning systems during the peak cooling periods during the day. Since electric utilities charge customers a higher price for electricity consumed during peak periods, reducing the amount of electricity purchased during these periods when DG-produced energy would be economically advantageous, obviating the customer's need to buy expensively priced electricity during peak hours.

If excess electricity produced during peak or off-peak hours can be effectively stored to later serve peak hour needs, the effect is the same – reducing expensive purchase of peak hour electricity at retail prices from the utility. Obviously, the capital cost, installation, and O&M costs of the storage equipment (e.g., battery, flywheel) must be netted against the savings in peak hour electricity purchase savings to determine whether there is a net cost savings. One caveat, though, is that the security of having battery storage back-up for a building's operations may be justification in itself by either enabling a transitional shut-down of operational equipment or allowing the facility to continue operations without incurring costly downtime. Under these circumstances, the peak load use reduction savings from the batteries may be merely an add-on benefit.

Other Net Cost Saving Factors

Other benefits further reducing net electricity costs include: (1) reduced energy costs for the facility's thermal energy load (steam, hot water, and cooling) where a combined heat and power (CHP) system produces steam or hot water that can be used in manufacturing processes or for space heating and cooling requirements; (2) increased revenue from a new source enabling the customer to sell excess power or ancillary services back into the grid through net metering; (3) reduced need for paying standby charges to the utility; and (4) reduced or eliminated competitive transition charges and exit fees.

AIR POLLUTION

Overview

For purposes of this section, "air pollution" is any material that is introduced into the air in such quantities that it creates a significant local, regional, or global health, welfare, or ecological impact.[41] In the U.S. air pollution traditionally has been divided into four categories: criteria pollutants[42], toxic compounds[43], ozone depleting compounds[44], and global warming compounds[45]. Distributed generation can be a source for all these forms of air pollution except ozone depleting compounds. Generally, the sized equipment used in residential or small commercial settings are not covered under existing state or federal regulations. Therefore, this section focuses only on regulating emissions of DG facilities.

Distributed Generation Air Quality Regulation in the U.S.

The U.S. Environmental Protection Agency (EPA) is authorized under the federal Clean Air Act to set limits on the amount of pollutants emitted, particularly from large generators, such as central power plants or large industrial sources. Permits for such facilities, however, are generally issued by state and local air quality agencies and include information on which pollutants are being emitted, allowable emission rates, and ongoing air quality monitoring and reporting requirements of the permit holder. The permitting process and the impacts of permits issued are part of an overall State Implementation Plan (SIP) to improve the state's air quality. While large power plant siting permits generally involve both the state and local air quality agencies, permitting of smaller units (e.g.,

[41] Lents, Ph.D., Jim and Allison, Ph.D., Juliann Emmons, Can We Have Our Cake and Eat It Too? Creating Distributed Generation Technology to Improve Air Quality, prepared for The Energy Foundation, San Francisco, California, December 1, 2000, p.3.

[42] *Ibid.*, p.3. These include carbon monoxide, nitrogen oxides, sulfur oxides, ozone, volatile organic compounds, and lead.

[43] *Ibid.*, p.4. These encompass a wide range of compounds which have acute toxic properties or can cause cancer and include mercury, benzene, 1,3 Butadiene, chromium, formaldehyde, mercury, and many others.

[44] *Ibid.*, p.4. These include the family of chlorofluorocarbons, some of which are now banned.

[45] *Ibid.*, p.4. The key anthropogenic compounds in this class are carbon dioxide, methane, and nitrous oxide.

under 50 MW in California) are the responsibility of the local air quality agencies. Similarly, among states the responsibility for handling the permitting process differ depending upon whether the applicant is a stationary or portable source.

This diversity of regulatory approaches among and within states underlines the importance for establishing a minimum set of DG standards for maintaining and improving air quality standards regardless of how states handle their enforcement. Most large American cities continue to violate one or more of the EPA air quality standards and are designated as in non-attainment of specific pollutants (e.g., atmospheric ozone). The 1977 Clean Air Act Amendments enacted tighter air quality standards than those in the initial 1970 Clean Air Act and, although the EPA regulations implementing them are presently under judicial review, they are likely to become effective in a more stringent form in the future. This will entail even greater air pollution control efforts in metropolitan areas, and it is these urban settings where the highest concentrations of distributed generation facilities are apt to be located.

Unfortunately, small-scale DG technologies are not likely to be regulated much in the short term due to their relatively low emissions and small numbers. And, although federal agencies, such as the Department of Energy and Environmental Protection Agency, and some of the larger state and local air pollution control agencies are aware of their increasing significance, many local "first-line" agencies responsible for air pollution control, building, zoning, and safety permits are not necessarily aware nor prepared to process new applications for such technologies. Some larger states, such as California and Texas, and the New England-based Regulatory Assistance Project are taking the lead in developing DG air emission standards. California, for example, has required its state air resources board (Senate Bill 1298) to issue guidance to its regional air quality districts on the adoption by January 2003 of a DG certification program and uniform emissions standards for electrical generation that is currently exempt from district permitting requirements. A similar effort was launched nationally in late 2001 by The Regulatory Assistance Project with funding from DOE's National Renewable Energy Laboratory (NREL). The purpose of this working group of over 30 state utility regulators, state air pollution regulators, representatives of the distributed resources industry, environmental advocates, and federal officials is to produce model state air emission regulations for small-scale electric generation resources for states to incorporate into their laws by as early as January 1, 2003.

Air Emissions of Existing Central Plant and DG Facilities

For over a century, the generation and distribution of electricity has been accomplished principally by large central generating plants near an available fuel source, e.g., coal or waterways that allow the transport of coal, and connected to long-distance transmissions lines that are part of an interconnected regional grid system that supplies power to a local distribution system that services individual customers. Enabling federal legislation passed in the late 1970s giving independent power producers access to utility-owned transmission lines for sale of their electricity to retail customers, and technological advances in DG systems have permanently altered this scenario. With DG units capable of locating on either the utility side or the customer side of the meter, the environmental effects of these new generators need to be evaluated not only from a cost standpoint but also for their positive and negative environmental impacts, particularly on the type and quantity of air pollution emitted. And, since almost all new central power plant facilities are combined cycle natural gas units, their emissions become the base case against which the pollutants generated by the newer DG systems must be compared.

Traditionally, the predominant technology for both stationary and portable generators has (and still is) the internal combustion engine (ICE). Also, called "reciprocating engines", ICEs can use a variety of fuels, including diesel, gasoline, natural gas, and propane. Diesel is the most common fuel for ICEs used in distributed generation and is also the most polluting.[46] The popularity of diesel generators can be attributed to the fact that it is generally the most cost-effective solution for consumers, largely because neither the generator nor the fuel incorporates the public health and environmental costs of burning diesel fuel into its price to the user. Because they are the most polluting form of distributed generation, the more hours they are in operation, the more pollutants are emitted, accounting in California, for instance, for 7% of the diesel particulate matter pollution and an appreciable amount of toxic pollutants. Continuing the California example, of the approximately 65,000 diesel generators statewide, over 26,000 are believed to be used for distributed generation – 11,000 as emergency stand-by generators used 100-200 hours per year, 1,000 as prime generators supplementing grid-provided electricity, and 14,000 as portable generators.[47] And, even though relatively few in number, prime generators operating anywhere from 100 to several thousand hours per year can be a larger potential source of diesel pollution if there are used for peak-shaving or baseload operations in violation of their permits.

Model DG Air Emission Regulations[48]

Objectives

In November 2001, a Working Group of The Regulatory Assistance Project's Distributed Resources Emissions Collaborative issued for public review a draft model rule and performance standards for regulating the air pollutant emissions of smaller-scale electric system generating resources, or DG equipment. When finalized, the rules and standards are expected to be adapted by states to address the potential air quality impacts of new and existing DG resources that are not covered by current state air regulations, policies, or permits. Their purpose is to help reduce institutional and infrastructure barriers to cost-effective deployment of DG systems by facilitating the development, siting, and efficient

[46] California Public Interest Research Group Charitable Trust and the Coalition for Clean Air, The Good, the Bad, and the Other: Public Health and the Future of Distributed Generation, undated, p.17.
[47] *Ibid.*, p. 17-18.
[48] This section is largely based on this draft report produced by a Working Group of The Regulatory Assistance Project's Distributed Resources Emissions Collaborative Model Regulations for the Output of Specified Air Emissions from Smaller-Scale Electric Generation Resources, *Op. cit.*, Footnote 6.

use of DG in ways that improve, or at least do not degrade, air quality. The proposed rules also are intended to regulate emissions output in a technology- and fuel-neutral manner and encourage, or at least not discourage, deployment of non-emitting distributed resources. In this sense, they may be considered technology forcing.

Unfortunately, most currently available DG technologies produce air pollutants at a greater rate (on an output basis) than a state-of-the-art natural gas-fired, combined-cycle central generating station employing the best available control technologies (BACT) installed. On the other hand, come DG technologies produce emissions at a lower rate than certain other fossil-fuel burning technologies (both existing and new). A comparison of emission with existing fossil-fuel plants, however, is not meaningful, since almost all new central station power generation plants are using combined cycle natural gas systems and it is with these that emission comparisons need to be made. It was noted by the Working Group that the existing air pollution regulation regime in the U.S. typically is not based on the concept of emissions displaced by new technology, but rather on the basis of achievable limits. Also, to state the obvious, site-specific evaluations of a DG application must take into account factors other than emissions, such as the overall environmental impact, consumer choice, integrated energy and land use planning, economic efficiency of electricity markets, availability of electricity supplies, and competitiveness of the business sector.

Applicability

Historically, distributed resources have accounted for a very small percentage of installed capacity and even less of its energy but, as technology and industry deregulation have advanced, the potential for these applications to proliferate has increased. Therefore, it has become necessary to close the "gap" in states' existing air regulations. The proposed regulations apply to all non-mobile generators that are not subject to major source review under the federal Clean Air Act installed after the effective date of their implementation. regulations in a particular state. The new rule would be triggered by specifications relating to the size of a resource and its potential to emit pollution.

Exemptions to the emission standards would include DG applications that are less than 37 kilowatts in capacity and operate fewer than 100 hours per year and those that are subject to EPA's existing Non-Road Engine Program.[49] The first exemption applies primarily to the small portable gasoline-fired generators that are marketed to homes and small businesses and are typically used during blackouts and at remote locations. The second exemption appliers to mobile off-road generators already covered under EPA regulations. Either separately or combined, these exemptions to not constitute a significant air quality threat and their exclusion reduces the administrative burden on state air regulators.

The proposed rule would apply strictly to <u>new</u> installations, since existing installations

[49] U.S. Federal Code of Regulations, 40 CFR, parts 89, 90, and 92.

generally are intended for emergency purposes only and are, in most states, already covered under the terms of previously approved permits. States could choose, however, to phase-in model rule standards or to require compliance with the provisions in instances when the owner alters a generator's conditions of operation under a previous permit.

Emissions Covered

The overall approach of the model rule is to (1) regulate DG emissions in a "technology-neutral and fuel-neutral" manner, (2) facilitate development, siting, and efficient use of DG systems in ways that improve, or at least do not degrade air quality, and (3) encourage technological improvements that reduce emissions. The desire to express the standards in a consistent set of units and to credit efficiency gains led the Working Group to adopt an electrical output-based measurement approach, i.e., pounds of emissions per megawatt-hour.

Emissions covered by the rules include nitrogen oxides (since they contribute to ground level ozone and acid rain), particulate matter down to the 10 micron per million (PM-10), carbon monoxide (because of its direct health impacts), and carbon dioxide as the primary contributor to global climate change. Two points should be noted. First, a change in combustion temperature or combustion characteristics may increase or decrease the amount of nitrogen oxide that an engine or turbine produces, and this may have the opposite effect with respect to carbon monoxide. Second, since carbon dioxide production is a function of how much fuel is used to produce a given amount of power; any action that affects an engine's efficiency directly affects its output of carbon dioxide.

The Working Group decided to recommend a phase-in of the standards in order to provide a reasonable amount of time to accommodate manufacturers' R&D cycles. Thus, the first phase runs from the date of a state's adoption of the model rules to the end of 2005, with the second phase covering the three years beginning January 1, 2006, and ending December 31, 2008, and the third phase starting January 1, 2009 and continuing indefinitely thereafter. The standard is the one in effect on the date the DG unit is installed. In addition, there is a provision for a technology review one year before the final standards take effect in order to adjust them as necessary. Finally, the rule calls for five-year technology reviews beginning in 2014 and every five years thereafter.

Because DG technologies vary so widely, as do their applications, efficiencies, and emission characteristics, the Working Group decided that one set of emissions standards to cover all potential application would not be feasible. It felt that too strict standards might restrict some worthwhile DG applications while inhibiting others until further technological breakthroughs occurred. Likewise, setting standards too loosely might result in negative environmental effects. Therefore, it settled on three categories of generation as the basis for its model rule – emergency, peaking, and baseload – defined by the circumstances and annual hours of operation of the DG facility rather than by technology. Emergency generation, while not currently limited in its annual hours of operation (although 300 hours is being considered), is constrained to 26 hours of annual maintenance operations. It is very important, however, to carefully define what constitutes "emergency" service to avoid creating a significant enforcement loophole. The proposed emission standards for emergency generators are shown in Figure 7. *Peaking* generation would possibly be limited to 700 hours per year, and a *baseload* operation would be any unit operating over 700 hours annually. Proposed emission standards for peaking and baseload generators are contained in Figures 8 and 9.

Figure 7: Proposed Emergency Generator Emission Standards

Distributed Generation Pollutant Emitted	**Phase I January 1, 2003 to December 31, 2005**	**Phase II January 1, 2006 to December 31, 2008**	**Phase III January 1, 2009 And Thereafter**
NO_x	21.00 lbs/MWh	17.00 lbs/MWh	14.00 lbs/MWh
PM-10	0.80 lbs/MWh	0.80 lbs/MWh	0.80 lbs/MWh
CO	6.00 lbs/MWh	6.00 lbs/MWh	6.00 lbs/MWh
CO_2	1450.00 lbs/MWh	1450.00 lbs/MWh	1450.00 lbs/MWh

Figure 8: Proposed Peaking Generator Emission Standards

Distributed Generation Pollutant Emitted	**Phase I January 1, 2003 to December 31, 2005**	**Phase II January 1, 2006 to December 31, 2008**	**Phase III January 1, 2009 And Thereafter**
NO_x	1.00 lbs/MWh	0.60 lbs/MWh	0.40 – 0.30 lbs/MWh
PM-10	0.08 lbs/MWh	0.05 lbs/MWh	0.02 lbs/MWh
CO	5.00 lbs/MWh	3.00 lbs/MWh	0.80 lbs/MWh
CO_2	1500.00 lbs/MWh	1500.00 lbs/MWh	1500.00 lbs/MWh

Figure 9: Proposed Baseload Generator Emission Standards

Distributed Generation Pollutant Emitted	**Phase I January 1, 2003 to December 31, 2005**	**Phase II January 1, 2006 to December 31, 2008**	**Phase III January 1, 2009 And Thereafter**
NO_x	0.5 – 0.47 lbs/MWh	0.3 – 0.27 lbs/MWh	0.15 – 0.07 lbs/MWh
PM-10	0.08 lbs/MWh	0.05 lbs/MWh	0.02 lbs/MWh
CO	0.60 lbs/MWh	0.30 lbs/MWh	0.10 lbs/MWh

CO_2	1400.00 lbs/MWh	1400.00 lbs/MWh	1400.00 lbs/MWh

The premise for these limitations are that (1) the more a generator operates, the less emissions it will release on a cost per ton of reduction basis, (2) the compliance costs for sources that run very few hours will tend to exceed the thresholds, and (3) when the compliance cost is spread out over a greater number of hours of operation, the requirement can be more stringent. Overall, the Working Group did not consider the potential pollution from emergency generation to be a significant problem.

The first phase standards for *emergency* generators reflect the current state of uncontrolled diesel reciprocating engine technology. The second and third phase standards differ only with respect to NO_x and reflect expected technological changes in diesels over the next decade, although no significant improvements in efficiency were predicted. Furthermore, the economics of grid-connected DG applications are such that peaking needs have generally been met by resources with low capital and carrying costs, but whose operating costs are relatively high. These are the DG facilities that the draft standards for peaking generators are designed to address.

The first phase standards for *peaking* generators approximate the emissions output of today's gas-fired reciprocating engines and small gas turbines. The second phase standards anticipate improvements in those technologies, while the third phase standards correspond to the output of simple-cycle turbines that also are expected to achieve significant technological improvements. Phase I standards for *baseload* generators roughly match the emissions output of today's cleanest natural gas engines and gas-fired technologies. However, efficiency gains, critical to reducing CO_2 as a byproduct of combustion, are not expected to be that significant over the next decade. Also, the Working Group felt that the DG technologies that are likely to compete for peaking services inevitably produce more CO_2 than do those used in emergency applications and the rule recognized this.

Proposed Standards

Output-based standards were chosen because they encourage efficient facility operations, in contrast to input-based standards (i.e., calculated on the basis of the amount of pollutant per unit of fuel input) that do not reward increases in efficiency and are typically differentiated by fuel type – often discouraging substitution of less polluting fuels. Also, as stated earlier, the rules reflect a preference for standards expressed in terms of pound of emissions per unit (kWh or MWh) of output.

The emission rates for six emissions from various distributed generation technologies as compared to a large gas combined cycle generator and average 1998 coal boiler, fossil plant, and power generator emissions are shown in Figure 10. The proposed standards for

NO_x, PM-10, and CO were designed to drive technology, while those for CO_2 were not, simply because this was recognized as breaking new ground. Time and financial resources precluded the development of model standards for SO_2, and unburned hydrocarbons (UHCs).

Projected DG Emissions (with and without heat recovery)

Analyses conducted at the University of California, Riverside analyzed seven major DG technologies in relation to their ozone, fine particulates (PM-2.5), and CO_2 creation compared to those incurred using gas-fired combined cycle generation.[50] Only some fuel cells were found to be competitive with the combined cycle generation system for ozone or fine particulate emissions without the use of a heat recovery system. However, in reducing CO_2 emissions, DG units are competitive with combined cycle systems if they can achieve 50% or greater heat recovery. One of the study's conclusions was that in order for a DG unit to prevent air quality degradation compared to a combined cycle generation system, the DG unit would need to have generation efficiency that was 30% or greater, an emission rate that was less than 1.30 times the combined cycle system, and achieve a waste heat recovery rate 60% or greater than a combined cycle system. In short, the study concludes that "only the lowest emitting DG with significant waste heat recovery is even marginally competitive with combined cycle power production when air pollution issues are considered. Thus, we advocate *technology-forcing* in the specific form of *manufacturer-based regulation*, which would require DG emissions to be reduced over time to ensure improved air quality."[51] (*Emphasis added*)

Certification

The RAP Working Group's draft rule seems to take the same direction as the Lents study in that it currently does not include testing and other procedures for developers to follow in order to establish that their DG installations meet emission standards. It gives DG manufacturers and suppliers the option to certify the emissions output of their products. Such an approach relies on testing procedures already developed or under development by at least the U.S. EPA and the California Air Resources Board and would reduce the administrative burdens for both developers and regulators. However, the issue of the load conditions under which the emissions testing would be conducted, e.g., a weighted emission average resulting from a combination of partial and full loads, is still an open

Technology	Efficiency % (HHV)	Btu/kWh	Typical Capacity (kW)	NOx Tons/yr	NOx lbs/MWh	SO2 Tons/yr	SO2 lbs/MWh	PM-10 Tons/yr	PM-10 lbs/MWh	CO2 Tons/yr	CO2 lbs/MWh	CO Tons/yr	CO lbs/MWh	UHC (2) Tons/yr	UHC (2) lbs/MWh
Solid Oxide Fuel Cell	42%	8,126	25	0.001	0.01	0.0005	0.005	0	0	104	950	0	?	0	?

[50] *Op.cit.*, Lents, pp. 13-18.
[51] *Op.cit*, Lents, p. 31.

Phosphoric Acid Fuel Cell	37%	9,224	200	0.03	0.03	0.0048	0.006	0	0	944	1,078	0	?	0	?
Uncontrolled Gas-Fired Lean Burn IC Engine	36%	9,481	1,000	9.5	2.2	0.02	0.006	0.14	0.03	4,853	1,108	22	5.0	72	16.5
3-Way Gas-Fired Rich Burn IC Engine	29%	11,769	1,000	2	0.5	0.031	0.007	0.14	0.03	6,025	1,376	18	4.0	2	0.4
Catalyst Uncontrolled Diesel Engine	38%	8,982	1,000	95.3	21.8	2	0.454	3.4	0.78	6,270	1,432	27	6.2	5	1.2
SCR Controlled Diesel Engine	38%	8,982	1,000	20.4	4.7	2	0.454	3.4	0.78	6,270	1,432	27	6.2	5	1.2
Micro Turbine	25%	13,652	25	0.05	0.44	0.0009	0.008	0.01	0.09	175	1,596	0	1.2	0	0.42
Small Gas Turbine	27%	12,780	4,600	23.2	1.15	0.15	0.008	1.7	0.08	30,097	1,494	14	0.7	22	1.10
Medium Gas Turbine	30%	11,353	12,900	34.6	0.61	0.38	0.007	4.2	0.07	74,976	1,327	35	0.6	55	0.98
Large Gas Combined Cycle (1)	51%	6,640	500,000	131	0.06	8.7	0.004	96	0.04	1,699,645	776	191	0.1	100	0.05
Large Gas Turbine	31%	10,964	70,140	182	0.59	2	0.007	22.2	0.07	393,691	1,281	185	0.6	290	0.95
ATS Simple Cycle Gas Turbine	35%	9,870	4,200	5.9	0.32	0.11	0.006	1.2	0.07	21,223	1,154	10	0.5	16	0.85
Average Coal Boiler (1998)	33%	10,322	300,000	7,353	5.60	17,610	13.40	396.9	0.30	2,779,425	2,115	0	0	0	0
Average Fossil Plant (1998)	33%	10,382	300,000	6,652	5.06	15,288	11.60	356.4	0.27	2,668,587	2,031	0	0	0	0
Average Power Generator (1998)	47%	7,197	300,000	4,505	3.43	10,354	7.90	247.1	0.19	1,850,017	1,408	0	0	0	0

(1) Selected Catalytic Reduction (SCR)
(2) Unburned hydrocarbons (UHC)

Figure 10: Emission rates for some DG and conventional generation technologies (Appendix B, "Model Regulations for the output of Specified Air Emissions from Smaller-scale Electric Generator Resources", The Regulatory Assistance Project,November, 2001)

question. The draft model rule makes certification mandatory for smaller units, so that additional permitting is not required but leaves the option open for alternative approaches to certification, e.g., case-by-case permitting may be appropriate for larger units. Some form of periodic testing of permitted units in use also would likely be necessary in order to measure compliance.

Performance Incentives for Concurrent Emission Reductions

The proposed rules also sets forth circumstances under which a DG application can be credited for displacing emission that would have otherwise occurred. The Working Group specifically cited generation that is fired by gases that otherwise would have been burned off or emitted directly into the atmosphere as able to claim an offset to its own emissions of those emissions avoided. Prime candidates include methane currently being flared at landfills or wastewater treatment facilities. A similar credit also would be given to combined heat and power (CHP) applications, where the waste heat from generation is put to productive mechanical or thermal use, thereby avoiding the incremental emissions that a separately fired process would have produced. For flared gases, the developer would have an option of demonstrating actual emission offsets or using default values listed in the model rule. Calculation of the CHP offsets would employ a formula spelled out in the rules. Other credit offsets being considered by the Working Group include those for (1) grid-electricity emission savings achieved by a non-emitting DG site using renewables, and (2) end-use efficiency measures installed simultaneously with the generation.

Chapter 3
Technologies

TECHNOLOGIES

Overview

This chapter discusses the range of DG technologies available, their most common applications, advantages, drawbacks, and costs. DG technologies may be divided into those which require fuel and those that do not, or fuel-fired and renewable technologies. There are any number of applications for which one technology may be equally as useful as another, so economic, efficiency, and environmental considerations must also be considered. Figure 11 provides a summary of the current state of DG technologies, whether the technology is established, emerging, or both. Figure 12 provides a summary of each DG technology, including capacity range, efficiencies, emissions, operating costs, and suitability for various applications. The reader should note that hybrid DG installation, for example photovoltaics with wind turbines, may enhance the range of applications, as well as the economics and efficiencies of each technology compared to a stand-alone installation for either technology. The estimates of installed and operating costs of each technology also show a wide range due to interconnection costs, labor, ease of installation and other site-specific factors.

A list of manufacturers for each technology is provided in Appendix A.

Figure 11: Current state of DG technologies

DER Technologies	Commercially Available	Emerging Technology
Reciprocating Engines	√	
Microturbines	√	√
Fuel Cells	√	√
Uninterrupted Power Supply-Batteries	√	
Uninterrupted Power Supply-Flywheels		√
Solar Photovoltaics	√	
Solar Thermal	√	√
Wind Turbines	√	
Biomass-Landfill methane	√	
Biomass-Wastewater Methane	√	√
Geothermal	√	
Small-scale hydroelectric	√	

Figure 12: Summary of DG technologies and efficiencies, emissions, costs, and size ranges. (modified from http://www.distributed-generation.com/technologies.htm,)

DG Technology	Size Range (kW)	Efficnieny (Electric) (%)	Efficieny Overall	Emissions (g/kWh unless otherwise noted)	Packaged Cost ($kW)	Installa-tiion Cost ($/kW)	Electric Only Cost to Generate (cents per kWh	Cogeneration Costs to Generate Cents epr kWh
Recipproca ting Engine								
Spark Ignition	30-5,000	31-42	80-89	NO_x:0.7-42; CO:0.8-27	300-800	150-600	7.6-13.0	6.1-10.7
Diesel	30-5,000	26-43	85-90	NO_x:6-22; CO:1-8	200-800	150-600	7.1-14.2	5.6-10.8
Dual Fuel	100-5,000	37-42	80-85	NO_x:2-12; CO:2-7	250-550	150-450	7.4-10.7	6.0-9.1
Micro-turbines								
Non-recup	30-200	14-20	75-85	NO_x:9-125 ppm CO:9-125 ppm	700-1000	250-600	14.9-22.5	10.1-15.9
Recup	30-200	20-30	60-75	NO_x:9-125 ppm CO:9-125 ppm	900-1300	250-600	11.9-18.9	10.0-16.8
Fuel Cells								
PEM	5-10	36-50	50-75	NO_x:0.007 CO:0.01	3500-10000	400-1000	21.9-33.3	20.7-33.3
Phosphoric Acid	200	40	84	NO_x: 0.007 CO: 0.01	3000-4000	360	18.6-22.8	17.0-21.2
Renewable								
PV	5-5000	-	-	-	5000-10000	150-300	18.0-36.3	N/A
Wind	5-1000	-	-	-	800-3600	500-4000	6.2-28.5	
Geothermal	0->1000	25-45	85-90	-	750-1300	1150-3000	1.5-30	N/A
Hydro-electric	0-5000				Approx 1285			

FOSSIL FUEL-FIRED TECHNOLOGIES

Reciprocating Engines

Reciprocating engines, also known as internal combustion engines, were developed over a century ago. These engines fall into three categories, rotary, spark ignition and compression ignition. For the purposes of DG, only *spark ignition* and *compression ignition* engines are utilized. In both types of engines, pistons and cylinders are utilized to create combustion, igniting hot gases that drive a piston down a cylinder, which in turn drives a crankshaft. In a compression ignition, or diesel, system, a diesel fuel-air mixture is compressed by the piston within the cylinder. Usually, the compression alone is sufficient to ignite the mixture. In spark ignition units, the compressed fuel-air mixture is ignited by a spark in the combustion cylinder. Spark-ignition units are more common, and generally use natural gas as a fuel. Dual-fuel systems, use a small amount of diesel to provide the spark for the natural gas. The engine can generate electricity directly or may be paired with a generator to produce electricity. Reciprocating engines may be configured for combined heat and power through the exhaust or heat recovery jackets.[52] An illustration of a typical reciprocating engine generator set is presented in Figure 13.

The most common and, hence, familiar reciprocating engine generators are the small generators often used in camping or other recreational activities. However, reciprocating generating units range in capacity up to 60 MW, the larger capacities being suitable for baseload power applications. However. reciprocating engine generator systems are most commonly used for standby power generation, as well as combined heat and power and peaking power applications.

Reciprocating engine generating systems have several advantages. They are generally inexpensive relative to other distributed generation systems and are readily available from a variety of manufacturers. The installed cost of a typical diesel generator set is between $350 and $1300 per kilowatt, while for a spark ignition system it is between $450 and $1300 per kilowatt. Dual fuel systems have an installed per kilowatt cost of

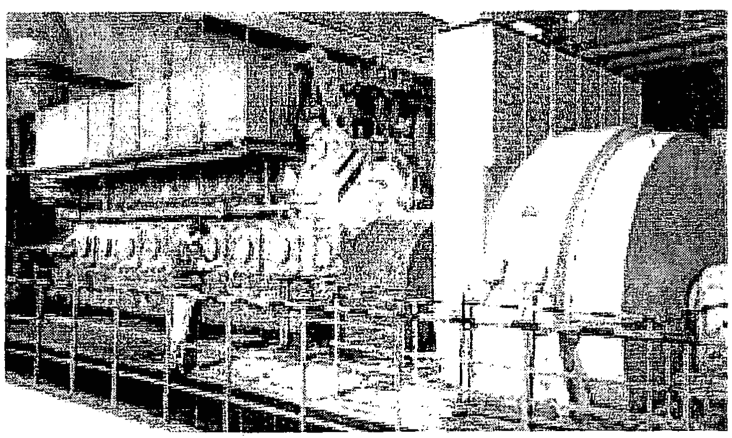

Figure 13: Photo of a typical diesel fueled generator set. (California Energy Commission, http://www.energy.ca.gov/distgen/equipment/reciprocating_engines /reciprocating_engines.html)

[52] Resource Dynamic Corp., Assessment of Distributed Generation Technology Applications, prepared for Maine Public Utilities Commission, February, 2001, pp..9-12

$400 to $1000 . Operating costs are for 7.1 cents per kWh to 14.2 cents per kWh for a diesel system, with spark ignition and dual fuel falling between these numbers. Adding cogeneration, the costs fall to 5.6 cents per kWh to 10.8 cents per kWh. The technology is simple and well understood, and efficiencies are good. The units are reliable with proper maintenance, and have good load following and heat recovery characteristics

Reciprocating engines do have some serious drawbacks, however. Diesel units have high emission levels of NO_x CO, and particulates, making them unsuitable in many applications. Emission levels have been significantly reduced in recent years, but are still higher than other DG technologies, with NO_x emissions ranging 0.7 to 42 g/kWh, and CO ranging from 0.8 to 27 g/kWh for spark ignition units. The wide range in these figures is due to the variety of fuels the units use. Natural gas fueled units have much lower emission rates. Diesel and dual fuel units fall within the emissions range for spark-ignition units. Emission controls may be added to almost all reciprocating engine generating units, and are now being incorporated into their manufacturing process. Ho.vever, in areas with high ozone levels, such as Denver, Washington D.C., and many other major metropolitan areas, the emission levels are still too high and the units may not be allowed. In addition, maintenance requirements are high.

Microturbines

Microturbines, like fuel cells (described in the next section), are new and emerging DG technologies. A *microturbine* may be thought of as a jet engine used to generate electricity (Figure 14). In fact, the technology is derived from aircraft auxiliary power systems, which are used to power the aircraft on the ground when the main engines are shut down, and the turbochargers found in some cars and trucks.[53] Unlike conventional generators, which rely on a rotating shaft, magnets, and wire coils to generate electricity, with the shaft turned by an engine or wind, an external engine or steam pressure, a microturbine uses exhaust gas pressure from burning fuel, usually natural gas, to turn the shaft directly. As with a jet engine, air is compressed and mixed with fuel, and fed into a combustion chamber where the mixture is ignited. This creates heat and high pressure gases, which then turn the turbine blades and the shaft with the magnets.[54] Microturbines are an inherently inefficient means of generating electricity compared with large centralized generating facilities fueled by fossil fuels. However, the heat of the microturbine may be used to generate steam, thus operating a second set of turbines and enhancing the overall efficiency to levels that can approach 85 percent.

Because of their lower electric efficiencies, roughly in the 14 to 20 percent range for *non-recuperator* equipped units, microturbines are generally more expensive to operate than other DG technologies. Installed costs range from $950 to $1,900 per kilowatt of generating capacity. Operating costs range from 11.9 cents per 22.5 cents per kWh,

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[53] DG Technologies Summary, http://www.distributed -generation.com/technologies.htm

[54] Resource Dynamic Corp., Assessment of Distributed Generation Technology Applications, prepared for Maine Public Utilities Commission, February, 2001, p. 12-14

although with cogeneration this rate drops to 10 cents to 16.8 cents per kWh. *Recuperator*-equipped units, which use heat exchangers to preheat combustor inlet air, have higher efficiencies of 20 to 30 percent. A new technology combines fuel cells with microturbines. The hot gases generated by the fuel cell are fed into the microturbine, generating additional electricity. These hybrid units may have electric efficiencies of greater than 60 percent. Efficiencies also are affected by the pressure of the natural gas

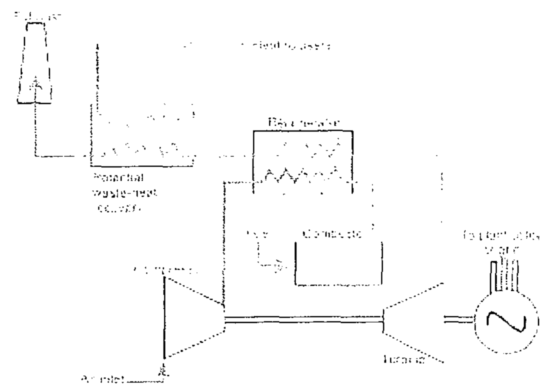

Figure 14: Illustration of the fundamentals of a microturbine. In this example, the microturbine is equipped with a recuperator, enhancing efficiency. Air is fed into the compressor and sent to the recuperator, where it is heated. The heated air is mixed with fuel and ignited in the combustor. The exhaust gases turn the turbine, generating electricity. The exhaust gases are then sent to the recuperator, where heat is exchanged, prior to being expelled from the system as exhaust.
(U.S. Department of Energy, http://www.eren.doe.gov/der/microturbines.html)

fuel. High pressure natural gas is more efficient because it reduces the compressor requirements. Microturbines also are capable of operating on *landfill gas*, *digestor gas*, and *biomass*.

Most microturbines are designed for continuous operation. By using an *inverter,* the units generate 60 Hz AC power. In single shaft units, the inverter is not required. Capacities range from 30 kW to 500 kW. Microturbines are exempt from many emissions regulations because their small size limits emissions. The units do produce NO_x and CO, but the emission levels are much lower than those of reciprocating units.

One of the drawbacks to microturbines is noise, which limits where the units may be placed and the types of enclosures needed. Also, because of their high shaft rotation speed, bearings must be of exceptional quality. Finally, microturbines take longer than reciprocating units to start, which limits their usefulness in back-up power applications.

Fuel Cells[55]

Fuel cells are another emerging DG technology. The actual concept of the fuel cell was developed in 1839, but never gained widespread acceptance until NASA incorporated fuel cells into spacecraft to generate electricity. More recently, the technology has been applied in hybrid vehicles and demonstration projects in mass transit.

Fuel cells come in a variety of types, differing primarily in the electrolyte used, which include proton exchange membrane (PEM), molten carbonate, solid oxide, phosphoric acid, alkaline, and others. At present, only phosphoric acid fuel cells and PEM fuel cells (Figure 15) are available, but the other electrolyte types are under development and should be available in the near future. All fuel cells rely on the same basic principle of utilizing electrochemical processes to generate electricity rather than combustion. Two electrodes, and an anode and a cathode are separated by an electrolyte. Hydrogen is fed into the anode, and air is introduced through the cathode. Utilizing a catalyst, the hydrogen atoms are split into a proton and electron. Protons pass through the electrolyte to the cathode, while electrons are sent through a circuit to generate a DC current. Once they reach the cathode, the electrons combine with the protons (hydrogen ions) and air to produce heat and water.

Fuel cells operate at different temperatures, depending on the electrolyte. For example, PEM fuel cells operate at lower temperatures (about 200°F) than other fuel cells. PEM fuel cells utilize a membrane of polyperfluorosulfonic acid, a polymer that allows hydrogen ions to pass through. Because the polymer is a solid, rather than a molten acid or base as in other fuel cells, PEM fuel cells have advantages in siting requirements over other fuel cells. These units are generally small, and are used mostly in residences, offices, and transportation. Electric efficiencies range from 36 to 50 percent, and overall efficiencies with cogeneration utilizing the heat generated can be as high as 75 percent.

Phosphoric acid fuel cells operate at much higher temperatures (350° F) than PEM fuel cells. Because of the higher operating temperatures, overall efficiencies can approach 85 percent if all of the heat is used in cogeneration, with electric efficiencies of 40 percent. Like PEM fuel cells, phosphoric acid fuel cells utilize a membrane, but in this case the matrix is composed of Teflon, silicon carbide, and phosphoric acid rather than a polymer.

One of the great advantages of fuel cells is that they produce virtually no emissions apart from air and water. Because of this, they are exempt from most environmental regulations affecting other generation technologies. Fuel cells also deliver a very high quality power.

The primary disadvantage to fuel cells are the high upfront costs, which range from $3,400 to $6,000 per kilowatt of installed capacity. Operating costs are also high, from 18.6 cents per kWh to 33.3 cents per kWh, which is roughly comparable to photovoltaics,

[55] *Ibid., p. 17-19*

making fuel cells and photovoltaics the most expensive of the DG technologies from both installation and operating perspectives. In addition, fuel cells require hydrogen for fuel, which is not practical. Hydrogen is obtained through the use of hydrogen-rich fuels, such as natural gas or propane, which are then converted to hydrogen fuel using a reformer.

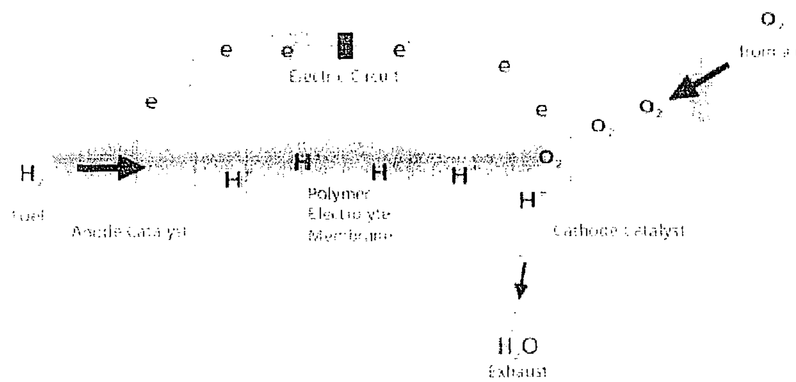

Figure 15: Diagram of a proton exchange membrane (PEM) fuel cell. Hydrogen fuel is fed to the anode ,where the electrons are stripped and sent through an external circuit as direct current. The remaining protons are able to pass through the proton exchange membrane. At the cathode, the electrons, protons and air are mixed to produce water vapor as the only emission.
(U.S. Department of Energy, http://www.eren.doe.gov/der/fuel_cells.html)

UNINTERRUPTIBLE POWER SUPPLY (UPS)

Overview

The digital economy is expanding at a rapid pace, with Internet-ready buildings (i.e., offices, manufacturers, service companies, and residences) and telecommunication operations among the fastest growing facilities in the U.S. Business customers, in particularly, require an unprecedented "six 9s" (99.9999%) of reliability for powering their growing operations. This translates into permanent protection against voltage sags, flicker, surges, momentary interruptions when utilities or customers switch loads, and power outages that can cost businesses millions of dollars every second that they are disconnected. In order to meet the growing energy demand and requirements for increased power quality and reliability, consumers, as well as utilities, are turning to distributed energy resource (DER) systems that include DG technologies. In addition to the commercial DG technologies available, to assure uninterrupted service at least until normal power is restored, the use of uninterrupted power supplies (UPS) is becoming nearly universal. As such, UPS systems are considered a distributed energy resource.

Most managers consider UPS systems (basically energy storage) a necessary evil – constituting yet another computer-related cost, a nuisance to install, an additional operating expense, and one that takes up valuable commercial space. For renewable energy systems not connected to the power grid, backup power is a necessity. Energy storage technologies produce no net energy but can (1) provide electric power over short periods of time when grid-connected power deteriorates or becomes unavailable, and (2) facilitate load management and peak shaving strategies of end-users. There are five major UPS systems available: battery storage, flywheels, superconducting magnetic energy storage, supercapacitors, and compressed air energy storage. Small-scale pumped hydro from small stream dams also serve as energy storage systems, but these are limited to near-stream applications and are not a major factor in energy storage solutions today. For reasons of cost and commercial availability for normal commercial operations, this guide focuses only on battery storage and flywheels.[56]

UPS system benefits to end users include: (1) improved power quality and reliability, (2) energy/demand cost savings from load leveling, (3) reduced sizing of DG systems, and (4) potential sale of excess power to the electric-grid with net metering. Some weaknesses of energy storage systems are: (1) the high cost for long duration storage systems, (2) parasitic power losses to keep the UPS system charged, and (3) high maintenance time and costs (e.g., frequent system testing, charge assessment for batteries).

Battery Storage

Battery energy storage can be integrated with renewable energy systems in either grid-connected or stand-alone applications. For the stand-alone systems, batteries are essential to store electricity for use when the sun is not shining or when the wind is not blowing. For grid-connected systems, batteries not only improve reliability but also add value to intermittent renewable resources by facilitating a better match between the demand and supply. For instance, a 30 kWh battery storage system operating with a 30 kW PV array employed for peak-shaving purposes is a system sized for a commercial or small industrial application. In this case, the batteries can be charged either by the PV array when PV output exceeds on-site requirements, or by the grid during off-peak hours for use during peak periods when the electricity rates are higher.[57]

Most batteries employed in renewable energy systems use the same electro-chemical reactions as the lead-acid battery in cars. But, unlike a car battery, they are specifically designed for "deep- cycle" electric vehicles where the recharge is carefully controlled and

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[56] California Energy Commission, *"Energy Storage/UPS Systems"*, Distributed Energy Resources, www.ca.gov/distgen/equipment/energy_storage/energy_storage.html, page s 1-2.
[57] U.S. Department of Energy, "Energy Storage", Aurora, http://aurora.crest.org/related/storage/index.htm, page A-8.

complete for every cycle. A car battery should not be used as a UPS system. Most

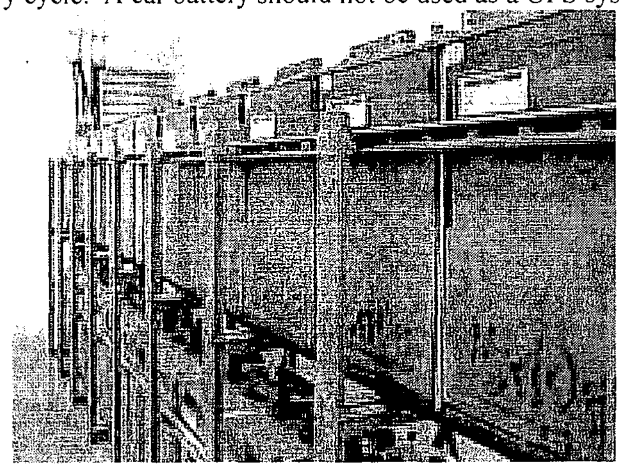

Figure 16: Photo of battery storage system. Provided by UP Networks to the California Energy Commission.
(http://www.energy.ca.gov/distgen/equipment/energy_storage/energy_storage.html)

renewable energy systems have batteries which store between 10 and 100s of times more energy than a car battery.[58] A lead battery's chemical reaction is reversible, allowing the battery to be reused with proper maintenance. There also are some advanced sodium/sulfur, zinc/bromine, and lithium/air batteries that are nearing commercial readiness that will be more light weight and capable of holding a charge for a longer period of time.

Like PV cells and other electricity generators, batteries are direct-current (DC) devices and are compatible with DC loads. As noted earlier, they can enhance the quality of power and they can be discharged as required in order to supply a variable electrical load. An insufficient battery recharge due to insufficient renewable energy output or poor charge control results in long periods of low state-of-charge that can be detrimental to some batteries. Every renewable energy power system will have a power conditioning system (PCS) that processes electricity from the DC renewable energy source and battery to make it suitable for alternating-current (AC) loads that is the common mode for most office and residential electrical equipment and appliances. The conversion from DC to AC power in the PCS is achieved by an inverter. The PCS also maintains the DC voltage within the DG system and protects the batteries from excessive overcharge and discharge, either of which can cause permanent damage.

Battery performance is a function of many variables, including rate and depth of charge

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[58] Home Power Magazine, "Battery Storage", www.homepower.com/battgo.htm, page 1.
[59] Linden, D., Handbook of Batteries and Fuel Cells, 2nd Edition, McGraw-Hill, New York, NY, 1995.

and discharge, temperature, and previous operating history.[59] The basic building block of the battery is the electrochemical cell which can be packaged together into modules that are connected in a matrix of parallel-series combinations to form a string. Lead-acid batteries consist of two-volt cells that are connected in a series and parallel arrays as needed to match the desired electrical characteristics of the application. Extremely high discharges (thousands of amperes – or amps) are possible, and batteries can be switched very rapidly between open circuit, charge, and discharge.

Battery capacity is rated in amp-hours, with one amp-hour the equivalent of drawing one amp steadily for one hour. A typical 12-volt system may have 800 amp-hours of battery capacity. This battery can draw 100 amps for eight hours if fully discharged and starting from a fully charged state. This is the equivalent of 1,200 watts for eight hours (watts = amps x volts). Completely discharging a battery decreases its longevity, with 30-50% being the maximum a battery should routinely be discharged. Deep discharges (above 70-80%) reduce the life of lead-acid batteries as do long periods of storage without use. Batteries typically are encased in plastic and need to be wired together by the installer, although some larger batteries are pre-wired and encased in steel containers.

Deep-cycle batteries cost from about $65 up to $3,000, depending on the type, capacity (ampere-hours), the climate conditions in which it will operate, how frequently it will receive maintenance, and the types of chemicals it uses to store and release electricity. A stand-alone PV system, for example, has to be sized to store a sufficient amount of power to meet power demand during several days of cloudy weather. According the U.S. Department of Energy, the cost for various sized lead-acid batteries (in 1997 dollars) were $750-$1,000/kW (20-40 MW with 2 hour storage capacity), $500-$600/kW (20-40 MW with 0.5 hours storage), and $400-$600/kW (2 MW with 10-20 second storage).[60]

Most types of batteries contain toxic materials that may pose serious health and safety problems. It is recommended that lead-acid and wet cell batteries, which give off explosive hydrogen gas when recharging, be located in a well-ventilated space isolated from other electrical components of the system and away from people-occupied building space. Batteries also must be routinely topped off with distilled water, and they need to be "equalized" with an occasional controlled overcharge to keep the individual cells at equal states of periodic "as-needed" battery replacement can help reduce purchase costs and keep the system functioning at a high level.

Environmentally, there are no emissions, solid wastes, or effluent produced during the operation of a battery system.[61] Flooded lead-acid batteries are closed, and Valve-Regulated, lead-acid Lead Acid (VRLA) and advanced batteries are essentially sealed. Electrolyte leakage from batteries is a rare occurrence because each lead-acid cell is surrounded by a double container. The volume of the self-contained leakage is typically

[59] Linden, D., Handbook of Batteries and Fuel Cells, 2nd Edition, McGraw-Hill, New York, NY, 1995.
[60] U.S. Department of Energy, "Overview of Energy Storage Technologies", http://www.eren.doe.gov/power/pdfs/append_overview.pdf , undated, Table 4, p. A-4.
[61] *Ibid.*, Aurora, page A-12.

small as each cell contains little liquid and there is a very low likelihood that a large number of cells would break open simultaneously. When the battery systems are replaced, essentially all battery materials (e.g. lead, acid, plastic casing) are captured and recycled (95% of scrapped batteries were recycled in the 1990-1995 period).[62]

The economic life of a battery system can be as much as 30 years, assuming battery component replacements are made at appropriate intervals – essentially every three years for a lead-acid battery and five years for a VRLA battery. Battery energy storage systems operate at an AC-to-AC efficiency of 75%, meaning they consume some electricity with 90% availability, and usually can be installed in a day or less. The cost of an energy system is affected primarily *by* four drivers: (1) the initial cost of the storage subsystem, (2) the cost of the power converter, (3) the cost of the balance of system, and (4) the need to design, engineer, procure, and construct a one-of-a-kind system.[63] Assuming, for example, a 30 kW distributed generation system with a 31 kW lead-acid battery system with one-hour storage capacity would have a turnkey cost $65,800 (1997 dollars) with the battery costing $10,850 ($350/kW) or about 16% of the battery storage system cost. Annual O&M expenses for the battery system, exclusive of battery replacement every 3-5 years, is estimated at $4,600.[64]

Flywheel

A flywheel is an electromechancial device that couples a motor generator with a rotating mass to store energy for short durations. Conventional flywheels are "charged" and "discharged" via an integral motor/generator that draws power provided by the grid to spin the rotor of the flywheel. During a power outage, voltage sag, or other disturbance the motor/generator provides the backup power. Kinetic energy stored in the rotor is transformed almost instantaneously to DC electric energy by the generator, and the energy is delivered at a constant frequency and voltage through an inverter and control system.[65]

Traditional flywheel rotors are usually constructed of steel and limited to a spin rate of a few thousand revolutions per minute (RPM). Advanced flywheels can spin for extended periods with high efficiency at speeds up to 40,000-60,000 RPM because they are constructed from carbon fiber materials and magnetic bearings spinning in a vacuum that virtually eliminates friction and drag. Their energy efficiency can reach 98%. The flywheel provides power during the period between the loss of utility-supplied power and the return of utility power or the start of a sufficient back-up power system. Flywheels up to 120 kW provide 1-30 second of "ride-through" time, and back-up generators are typically online within 5-20 seconds. Other commercially available flywheel units with capacities of 160 kW (flywheel/battery combination), 700 kW, and 5-1,000 kilovolt-

[62] Smith, Buckin & Associates, Inc., National Recycling Rate Study, for Battery Council International, December 1996.
[63] *Ibid.*, U.S. Department of Energy, page A-17.
[64] *Ibid.*, U.S. Department of Energy, page A-14-A-19.
[65] *Op. cit.*, California Energy Commission, www.ca.gov/distgen/equipment/energy_storage/energy_storage.html, pages 1-2.

amperes (flywheel/battery combination) have capacities of 15-20 minutes, 10 minutes, and 5-60 minutes, respectively. Figure 17 provides a diagram of a flywheel.

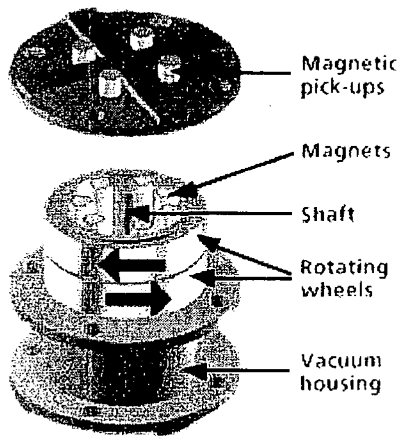

Figure 17: Diagram of a flywheel energy storage system.
(http://aurora.crest.org/related/storage/index.htm)

Under normal operation, a charging current supplied by the electric utility is used to drive the flywheel to operating speed. With friction all but eliminated, only a small amount of power is needed to maintain the unit's rated speed. In the event of a utility outage, the flywheel transitions into a generator. The rotating flywheel produces an AC current that drives the generator. This kind of instantaneous switchover in cases of unreliable power or power outages is most popular in environments that have critical equipment, such as medical, telecommunications, and data processing.

As an alternative backup power storage system flywheels offer a number of advantages, including:[66]

Low maintenance – There is not mechanical contact with the flywheel operating system making the unit virtually maintenance free.

Long lifespan – Some units have a 20-year life expectancy and are impervious to extreme weather conditions and wide wings in temperature. A longer lifespan also enables the end user a longer time to realize the cost savings (and possible revenues) from the

[66] Beacon Power Corporation, "The Next Step in Energy Storage Systems: Flywheels Explained", wwww.beaconpower.com/products/products/.htm, 2000, page 1.

flywheel, thus increasing their return on investment and, in at least one case, achieving a 2-5 year payback period.

Real-Time monitoring – Some flywheels are designed to be monitored continuously from off-site.

High reliability – With only one moving component, longer lifespan, heightened predictability, and real-time monitoring, flywheels can increase the end user's confidence in expanding their operations.

Environmentally friendly – There are no corrosive or toxic materials in flywheels, as there are with batteries, so there are no disposal charges, no regulatory compliance costs, and no threat of toxic air emissions or spills.

Safety built-in – The redundant overspeed detection and shutdown system of some flywheels makes it virtually impossible for them to reach an overspeed condition. In the unlikely event of such a failure, their composite rim is designed to delaminate in a safe and controllable manner.

According the U.S. Department of Energy, the costs for various sized advanced flywheel systems (in 1997 dollars) were $6,000/kW (approximately 1 kW) and $3,000/kW (approximately 20 kW) , and $500/kW (1 MW with 15 second storage) for steel flywheels.[67] All of these systems, however, represent the cost of prototype units and these costs are expected to fall significantly once the units become widely available commercially.

RENEWABLE ENERGY TECHNOLOGIES

Renewable energy is energy produced without the consumption of finite resources such as fossil fuels (coal, oil, gas) or uranium. Renewable energy also may be utilized in passive ways to reduce energy consumption. There are several different technologies that harness renewable resources for energy generation and conservation. These include photovoltaics, solar thermal systems, passive solar, wind, biomass, geothermal power, direct use geothermal, geothermal heat pumps, and hydropower. In this section, each of these renewable technologies will be discussed with regard to its advantages, disadvantages, economics, and applications.

Solar Photovoltaics

Photovoltaic (PV) cells utilize the sun's photons or light to create electricity. PV technologies rely on the photoelectric effect first described by French physicist Edmund

[67] U.S. Department of Energy, "Overview of Energy Storage Technologies", http://www.eren.doe.gov/power/pdfs/append_overview.pdf , undated, Table 4, p. A-4.

Becquerel in 1839. PV cells are made of semiconducting materials similar to those used in computer chips. When these materials absorb sunlight, the solar energy knocks electrons loose from their atoms, allowing the electrons to flow through the material to produce electricity. This process of converting light (photons) to electricity (voltage) is called the *photovoltaic effect*.[68] This electronic flow is gathered in the form of direct current (DC). This DC can then be inverted into alternating current (AC), which is the electrical power that is most commonly used in residences and commercial buildings.

PV *cells* are typically combined into modules that hold about 40 cells. These, in turn can be mounted into groups of ten called *PV arrays* that can measure several feet on a side. These *flat-plate* PV arrays can be mounted at a fixed angle facing south, or they can be mounted on a tracking device that follows the sun, allowing them to capture the most sunlight over the course of a day. About 10-20 PV arrays can provide enough power for a household or small business if it does not have an inordinate electricity demand.[69] See Figure 18 for a typical PV system configuration.[70]

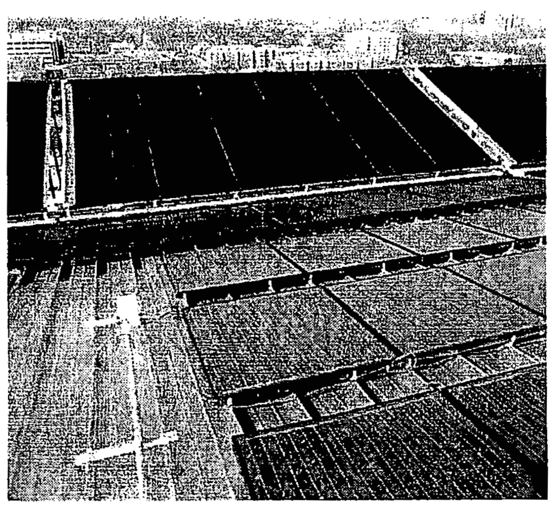

Figure 18: This swimming and diving facility uses photovoltaics (front) to produce electricity and a solar-thermal system (back) to heat pool water. The photovoltaic modules will provide 340kW of peak electrical power and will be the largest photovoltaic building installation in the world. Both systems will reduce demand on the local utility and result in significant annual energy and cost savings.(U.S. Dept. of Energy)

[68] National Renewable Energy Laboratory, "Clean Energy Basics: Introduction to Photovoltaic (solar cell) Systems", www.nrel.gov/clean_energy/photovoltaic.html, p.1.
[69] *Ibid.*, p. 1.
[70] *Ibid.*, p. 1.

(http://www.nrel.gov/data/pix/searchpix.cgi?display_type=verbose&max_display=1&skip_hf=1&query=^02105)

The performance of a PV cell is measured in terms of its efficiency at turning sunlight into electricity. Only sunlight of certain energies will work efficiently to create electricity, and much of it is reflected or absorbed by the material that makes up the cell. Because of this, a typical commercial PV cell has an efficiency of 15% -- about one-sixth of the sunlight striking the cell actually generates electricity.[71] Low efficiencies mean that larger arrays are needed, and that means higher costs. The first cells built in the 1950s had efficiencies of less than 4%.

PV modules are manufactured with varying electrical outputs ranging from a few watts to more than 100 watts of DC electricity and combined as explained above into PV arrays. Two primary types of PV technologies available commercially are crystalline silicon and thin film. In *crystalline-silicon technologies*, individual PV cells are cut from large single crystals or from ingots of crystalline silicon. In *thin-film technologies*, the PV material is deposited on glass or thin metal that mechanically supports the cell or module. Thin-film-based modules are produced in sheets that are sized for specified electrical outputs.

In addition to PV modules, the components needed to complete a PV system must be included. Called *balance-of-system (BOS) equipment*, this includes battery charge controllers (to regulate the flow of electricity from the PV modules to the battery and the load), batteries (for use at night or for meeting loads during the day when there is insufficient sunlight), inverters (for changing the DC electricity produced by PV modules and stored in batteries into AC electricity), wires, conduit, a grounding circuit, fuses, safety disconnects, outlets, metal structures for supporting the PV modules, installation, building permits fees, insurance, and data acquisition system and sensors. Inverters, in particular, are required for highest-quality electricity, such as that used by computers and other electronic equipment. For some PV systems, the BOS equipment can exceed the cost of the PV modules.

PV systems are best suited for remote sites and off-grid applications greater than a quarter of a mile from existing distribution lines where the cost to string additional lines is prohibitive. Cost-effective applications include water pumping (irrigation, stock watering, residential uses), lighting (residential, security, streets and parking lots), communications (remote relay stations), refrigeration (medical and recreational), and household appliances.

Commercially available PV modules range from 5-15% efficiency at converting sunlight into energy and a complete system can cost between $6,000-$10,000 per kW installed, with the cost depending on its size, equipment, options, and labor costs.[72] Small systems

[71] *Ibid.*, p. 1.
[72] California Energy Commission Distributed Energy Resource Program, "Distributed Energy Resource Guide: Photovoltaic Systems -- Cost", www.energy.ca.gov/distgen/equipment/photovoltaics/cost/html.

funded through some state solar incentive programs are averaging $7.00/watt after rebates. The average factory price of PV modules in 1999 was $3.62/watt,[73] excluding the BOS costs that can increase the factory costs by 30-100%. Distributed generation-sized PV systems are available in the form of small rooftop residential systems (less than 10kW) to medium-sized systems in the range of 10-100kW.[74]

The advantages of PV systems are that they work well in remote locations and some on-grid sites tied to the grid with sufficient utility or government incentives and net metering, require very little maintenance, produce no emissions or hazardous wastes (except for the possibility of lead discharge from improperly disposed batteries or a rare battery accident), and have no noise associated with them.[75] Their principal weakness is their high upfront cost, and the fact that local weather patterns and sun conditions can reduce their effectiveness considerably.

Solar Thermal

Solar thermal systems convert sunlight into heat. "Flat-plate" solar thermal collectors produce heat at relatively low temperatures (80-140 degrees Fahrenheit) and are generally used to heat air or a liquid for space and water heating or drying agricultural products.[76] Concentrating solar collectors produce higher temperatures and permit the generation of electricity. Steam turbines or heat engines drive the generators of solar thermal electricity systems in the same way as conventional electricity generation. Solar thermal systems, however, are powered by concentrating the sun's rays rather than by combustion of fossil fuels or nuclear heat. Solar systems use special focusing (rather than flat) reflectors to achieve the temperatures required to operate such systems. The three main types of solar thermal generating systems all require direct sunlight and become more suitable to regions the closer they are to the equator, particularly arid and semi-arid regions. Acceptable production costs of solar thermal electricity typically occur where radiation level exceed 1700kWh/square meter-year.[77] There are three solar thermal systems of principal interest:

Solar farms use parabolic trough reflectors that focus solar radiation onto a line receiver containing a heat transfer medium in pipes. The medium, often thermal oil, is collected and passed through a heat exchanger where steam for the turbines is produced.

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[73] Energy Information Administration, "Annual Solar Thermal and Photovoltaic Manufacturing Activities Tables, 1999", http://www.eia.doe.gov/eneaf/solar.renewables/page/solar, U.S. Department of Energy of Energy

[74] *Op. cit.*, California Energy Commission, ", www.energy.ca.gov/distgen/equipment/photovoltaics/applications.html.

[75] *Op. cit.*, California Energy Commission, ", www.energy.ca.gov/distgen/equipment/photovoltaics/strengths&weaknesses.html

[76] Energy Efficiency and Renewable Energy Network (EREN), EREC Consumer Information Briefs, "Concentrating Solar Thermal Heating Systems", U.S. Department of Energy, www.eren.doe.gov/consumerinfo/rebriefs/ac5.html, p. 1.

[77] European Union, "Solar Electricity Overview – The Future", http://eu.int/comm/energy_transport/atlas/htmlu/steotech.html, p. 1.

Temperatures produced vary between 662-752 degrees Fahrenheit and system sizes are typically 30-80 MW. To increase operating temperatures to as high as 1022-1076 degrees Fahrenheit and to improve overall heat efficiency, steam from the solar system may be heated in final stage by conventional fuels. This technology is amassing long-term operational experience at nine California Solar Electric Generating Systems (SEGS) plants, sized between 14 and 80 MW, and located in the Mojave Desert totaling 354 MW (peak) – enough electricity to power about 360,000 homes.[78] See Figure 19.

Solar power towers use one central receiver mounted on top of a tower that is surrounded by a field of heliostats (concentrated mirrors which follow the sun). Reflected light is focused onto the receiver and absorbed by the heat transfer medium, which could be sodium, water, molten salt, or air. Temperatures of 932-1832 degrees Fahrenheit can be achieved. Solar towers have been developed at sizes up to 10 MW and some researchers believe system sizes can attain 200 MW. The 10 MW Solar Two plant in Barstow, California (Figure 20) using molten salt as a heat transfer and storage medium is amassing substantial experience with this technology since it became operational in 1996. 10 megawatts is enough electricity to power 10,000 homes. Compared to solar farms, solar power towers are expected to be more economically advantageous at capacities of 100 MW and greater. Today, however, despite the success of the Solar Two plants, the Department of Energy does not see the technology taking off in the United States because

[78] California Energy Commission, "Solar Thermal Electricity", www.consumerenergycenter.org/renewable/basic/solarthermal/thermal.html, pp. 1-2.

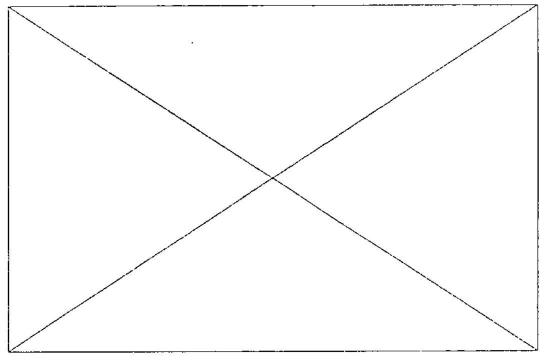

Figure 19: Solar trough water heating installation in at the LUZ SEGS plant, California. (California Energy Commission; http://www.consumerenergycenter.org/renewable/basics/solarthermal/thermal.html)

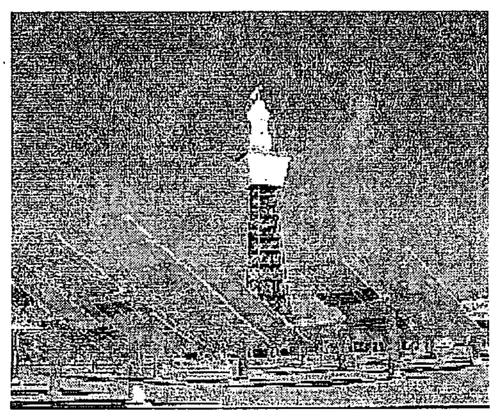

Figure 20: Solar power tower at the Solar Two power plant near Barstow, California. (U.S. Dept. of Energy, Sandia National Laboratory, http://www.energylan.sandia.gov/sunlab/snapshot/powertower.htm)

it is cost prohibitive when compared with coal and natural gas systems.[79] Its immediate applicability domestically is in the Southwest where there is a strong correlation between peak electric power demand from air conditioning loads in the region, expensive

[79] Environmental News Network, "Solar Thermal Technology Deemed a Success", http://www.enn.com/enn-news-archive/1999/08/083199/solpwr_5358.asp

electricity, and the high level of annual direct sunlight.

Parabolic dish systems (Figure 21) use parabolic concave mirrors that have a receiver mounted at the focus. These systems achieve the highest temperatures, 1112-2192 degrees Fahrenheit, but are small – 10-50 kW – and their main application is decentralized electricity generation. At present, parabolic systems usually operate with Stirling motors, based on
a principle of direct conversion of heat to kinetic (motion-generating) energy. Alternatively, small gas turbines can be used. High optical efficiency and low startup losses of the motors make parabolic dish systems the most efficient (29.4% solar to electricity conversion) of all solar technologies. These systems are not yet economically viable if grid connected, but they might offer an alternative for stand-alone applications in competition with diesel generators.

The dependence of solar thermal technology on direct sunlight for efficient operation usually limits electricity load factors to 25%.[80] Ways of improving the load factor include designing plant to incorporate energy storage (e.g., passing the heated fluid through a storage medium such as molten salts) or by combining the solar thermal

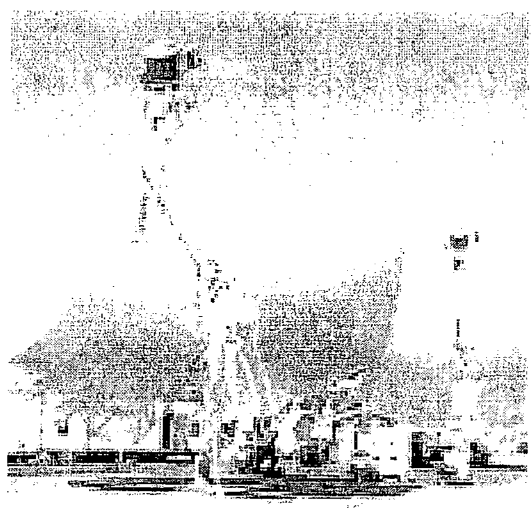

Figure 21: Parabolic dish system paired with Stirling engine. (U.S. Department of Energy, Sandia National Laboratory.) (http://www.energylan.sandia.gov/sunlab/overview.htm#dish)

[80] European Union, "Solar Electricity Overview – The Future", http://eu.int/comm/energy_transport/atlas/htmlu/steotech.html, p. 1.

electric unit with conventional combined cycle fossil fuel generation in a *hybrid system*. This would allow two stages of heating, which raises steam temperatures, operational efficiency, and extends the operating hours of the facility.

Solar thermal electricity generation is still largely in the development stage, with only the solar farm system (parabolic troughs) commercially available today.[81] Power towers, with low cost and efficient thermal storage, promise to offer dispatchable, high capacity utility sized power production in the future. The modular nature of dishes eventually will allow them to be used in smaller, high-value applications. The main barrier for all three remains financial. Several analyses consider the integrated operation of solar thermal technology with conventional power generation as having the highest cost reduction potential, and this is likely to be the first type of large-scale (e.g., 200 MW) deployment approach. It is important to note that pure solar thermal systems operate without any air emissions, although this would not apply if a facility were to operate as solar thermal/fossil fuel hybrid.

Some solar thermal trough facilities register efficiencies of approximately 22%, while Stirling solar dishes have been measured at efficiencies as high as 30%. The cost of building, operating, and maintaining solar thermal electric systems has decreased dramatically – in some cases by a factor of ten – during the 1980s and 1990s and is expected to continue dropping. By 2010, some solar thermal electric technologies could be producing electricity at $0.06-$0.07 per kilowatt hour (kWh).[82]

Wind

Wind generation of electricity is the world's fastest growing source of energy. Harnessing the power of the wind is an ancient concept, with the earliest windmills, used to grind grain and pump water, dating back to at least 200 B.C. Today, wind generation provides the benefits of other renewable energy sources, but is generally less expensive to install and operate. In fact, wind generated electricity is competitive on a cost basis even with conventional generation, and often cheaper. The cost of wind generation has fallen by 80 percent over the past several years, and it is now the cheapest form of energy generation after initial installation costs. The cost of wind power generation is expected to drop another 35 to 40 percent by 2010.[83]

Total installed electrical generation capacity from wind worldwide at the end of 2000 was 17,000 MW, most of which was in Europe. About 3,500 MW was added in 2000, and an additional 5,000 MW were expected to be installed in 2001. Germany has by far the most electrical generating capacity by wind turbines, over 6,000MW. In the U.S., the capacity

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[81] Sandia National Laboratories, Concentrated Solar Power (CSP) Program, "Overview of Solar Thermal Technologies", U.S. Department of Energy http://www.eren.doe.gov/csp/pdfs/solar_overview.pdf, undated, p. 5.5.
[82] California Energy Commission, "Solar Thermal Electricity", www.consumerenergycenter.org/renewable/basic/solarthermal/thermal.html, p. 2.
[83] International: Alternative EnergiesOxford Analytica Brief, May 8, 2001, 3, 4 p.

was 2,554MW, but is increasing rapidly. The U.S. Department of Energy's Wind Powering America Program has a goal of producing 5 percent of the nation's electricity from wind by 2020. By the end of 2002, the goal is to lower the cost of wind generation to 2.5 cents per kWh from the current range of less than 3 cents per kWh to more than 5 cents per kWh.[84]

Generation of electricity by wind is a simple technology. Turbines capture the kinetic energy of the wind and convert it into electricity. The wind turbines are installed as complete units including the rotor, generator, turbine blades, and a drive device, or gearbox, connecting the turbine with the generator. The most recent research has been with direct-drive designs, in which the generator operates at the rotational speed of the rotor, eliminating the need for gearboxes and reducing cost and maintenance requirements. The turbines are installed on towers to take advantage of the stronger and less turbulent winds at higher elevations above the Earth's surface. As with most renewable energy technology, an inverter is required to convert the electricity produced from DC to AC. Batteries are used to store electricity when the wind is not of sufficient velocity to generate electricity. The generating capacity of wind turbines ranges from 50 watts to 1.65 MW. Turbines are usually installed in groups known as "farms" by utilities, but stand-alone turbine installation is also common (Figure 22). Installation of wind turbines in combination with other renewable energy technologies, such as photovoltaic cells or biomass, is also possible, and enhances the efficiency of both technologies. This is an area that demands further research, with a vast and largely untapped market.[85]

Wind turbines produce no emissions, and have negligible environmental impact. Wind technology is generally cheaper to install than other renewable technologies, about $1 per watt, and offers some additional advantages. For example, the surface area of the land occupied by a farm of wind turbines is generally about 5 percent of the available land, unlike solar that requires all of the available land. The generating capacity of a wind farm is easily increased to meet growing demand. In addition, in areas close to the grid, installation of a wind farm requires no new transmission lines.

[84] *Ibid.*, pp.1-4..

[85] Resource Dynamics Corp., Assessment of Distributed Generation Technology Applications, prepared for Maine Public Utilities Commission, February 2001, p. 22-24.

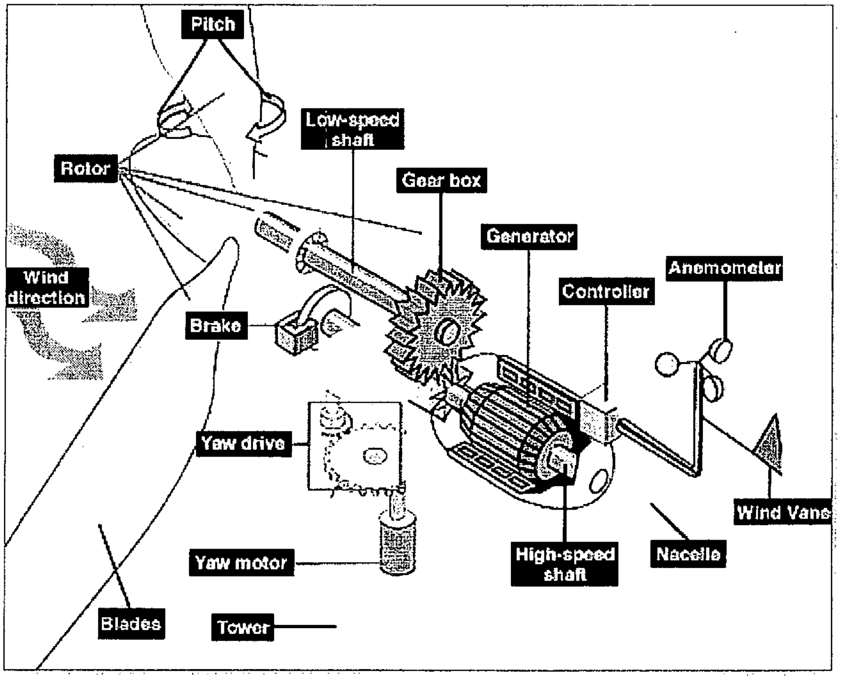

Figure 22: Diagram of a wind turbine. Wind turns the rotor, which may either be directly connected to the turbine or connected through a series of gears, as illustrated. The turbine generates the electricity, which may be stored in batteries when wind speed is insufficient to generate electricity.
(U.S. Department of Energy, http://www.eren.doe.gov/wind/feature.html)

Virtually all regions in the United States have areas suitable for development of wind generation. North Dakota alone has the wind potential to generate over one-third of the U.S. demand for electricity. Texas could provide roughly the same. In fact, the 20 states with the best wind potential could provide about three times the nation's current electricity demand. Harnessing only 10 percent of the wind potential in the 10 windiest states would produce enough power to reduce U.S. CO_2 emissions by nearly one-third[86]. The future looks bright for this plentiful renewable resource.

Wind generation does have disadvantages, not the least of which is visual impact. Towers should be at least 30 feet taller than the nearest obstacle to the wind within a 300 foot radius. Of course, winds of a minimum speed are required to generate electricity, and winds are, of course, variable. For a utility size operation, wind speeds of 16 to 60 milers per hour are needed, and 9 miles per hour for smaller applications. There have also been problems with bird deaths in the past, although these have been mostly

[86] International: Alternative Energies; Oxford Analytica Brief, May 8, 2001, 3, p. 1

resolved. Bird deaths from transmission lines greatly outnumber those from wind turbines. Also, many of the areas with the best potential for wind generation are in remote locations, increasing transmission costs. Noise pollution from the turbine and rotor can be a problem, although this has been dramatically reduced in recent years by the introduction of new turbine technology, changing the orientation of the rotors blades, and new rotor design.[87]

As with solar power, wind power requires a high upfront investment, making financing of wind turbine installation more difficult than conventional generation despite lower long-term operating costs. The installed cost of wind turbines in the United States averages about $1,000 per kilowatt. In addition, the cost of generating electricity is highly dependent on wind velocity. Energy generated from wind is a cubic function of wind velocity, resulting in considerable variations in energy production between installations, and therefore costs. In addition, there are economies of scale involved with wind production of energy. For example, a three MW wind farm may generate electricity at a cost of 5.9 cents per kWh, while a 51 MW installation in the same location would generate electricity at a rate of 3.6 cents per kWh.[88]

Biomass/Methane

Biomass

To generate electricity from biomass, two systems need to work together. The first, its supply system, collects and delivers the fuel, and the second, a power facility, generates and sells the electricity. The primary energy resource for making electricity from biomass encompasses a variety of feedstocks with wide ranging properties. Four categories of fuel resources can be used: forestry residues, agricultural residues, agro-processing residues, and energy crops. Biomass can be converted into electricity by one of several processes: conventional steam cycle, gasification, and co-firing with fossil fuel. The two primary types of technologies used in biomass combustion are grate firing and fluidized bed boiler. Each of these aspects of biomass electricity generation is discussed below.

Biomass fuel resources

Biomass fuels are derived from four sources: forestry residues, as a by-product of timber and pulp production; agricultural residues, e.g., straw from cereal production; and agricultural crop processing residues, e.g., sugar cane and alcohol distillery residue; and energy crops grown specifically for use as a fuel. Coppiced wood species, e.g., willow and poplar, are the most widely used energy crops. Grasses, urban yard trimmings, and used shipping pallets also may be used. The yield of dry matter from a hectare has increased by 50% over the past decade and practices for the establishment and management of energy crops are making commercialization possible.

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[87] Resource Dynamics Corp., Assessment of Distributed Genration Technology Applications, prepared for Maine Public Utilities Commission, February 2001, p. 22-24.
[88] International: Oxford Analytica Brief, May 8, 2001, 3, p. 3

Biomass combustion technologies

Grate firing – In grate firing, the fuel burns in a layer on a grid. Air for combustion is blown both through the grid and over the top of the fuel layer. Various types of grids or grates can move the fuel through the boiler using vibration, forward motion, or reciprocating action to ensure maximum burning of the biomass material, eventually removing the ash. This technology, while reliable and relatively inexpensive, is also somewhat inflexible and is usually designed to cope with a limited range of feedstocks.

Fluidized bed boiler – This technology burns in a bed of sand or other mineral that is violently agitated by the combustion air. The fuel is fed at a controlled rate to keep the temperature of the bed at 1472-1652 degrees Fahrenheit. Steam tubes in the walls of the boiler remove the heat. This method is very fuel flexible, for instance, being capable of using fire wood chip, coal, peat, oil and wastes both together and separately. New facilities for the co-firing of biomass and fossil fuels are likely to employ the fluidized bed technology.

Power generation technologies

Conventional steam cycle plant -- In this technology, biomass is burned in an excess of air to produce heat that is, in turn, used to raise high pressure steam in a boiler. The energy stored in the steam is converted into electricity by expanding it through a turbine that drives an electric generator.

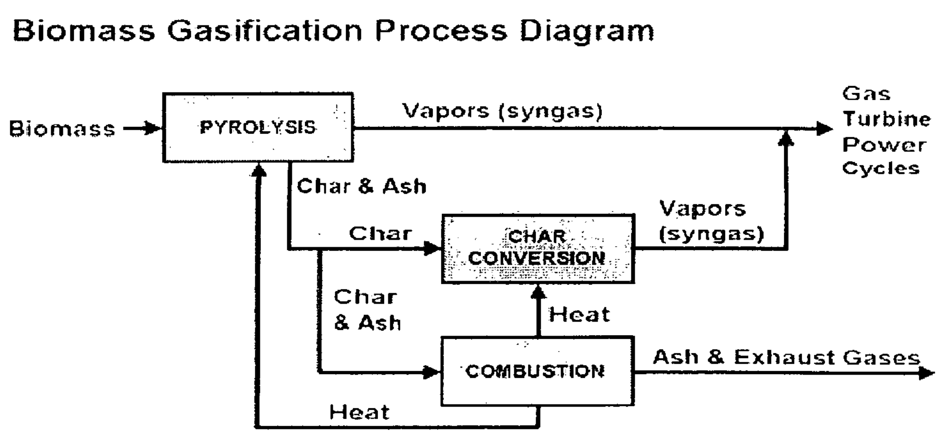

Figure 23: Diagram of a direct-fired gasification plant. (U.S. Department of Energy, http://www.eren.doe.gov/biopower/bplib/library/li_gasification.htm)

Gasification – Gasification (Figure 23) produces electricity with higher efficiencies than combustion-based steam cycles. These are achieved by converting the solid biomass to liquid or gaseous fuels and then burning these in engines or gas turbines. The heat is thus converted to power at a higher temperature than in the steam cycle, making gasification processes thermodynamically more efficient. The maximum size of a gasification power facility is likely to be about 30 MW, reaching perhaps 70 MW in heavily wooded areas. Plants using conventional steam cycles at these small scales would have a low conversion efficiency of approximately 25%. Gasification and pyrolysis have the potential to raise this to over 36-45%.

Co-firing – This technology fires a proportion of biomass with a fossil fuel in an existing power plant. Depending upon its percentage of the fuel mixture, biomass can be mixed with the coal (2-5%), shredded finely and fired through dedicated burners (5-25%), or gasified and fired through a gas burner (above 25%). Co-utilization with fossil fuels in an existing boiler is likely the lowest cost option (Figure 24).

Today, the majority of biomass electricity is generated using a steam cycle. Because its basic equipment, fuel preparation, and handling equipment are well proven, co-firing of biomass with fossil fuels is likely the most economical near-term option for introducing new biomass power generation while lowering the air emissions from coal-fired plants. Use of biomass, rather than coal or oil, for electricity generation generally will result in lower levels of NO_x, SO_2, CO_2 and volatile organic compounds (VOCs) as long as state-of-the-art air emissions technology is used. Besides energy crops providing greater diversity for wildlife habitats, reducing soil erosion, and other environmental and recreational benefits, collection of fuel from forests and agriculture and the use of energy crops can be done in a sustainable way that does not deplete future resource.

Figure 24: Photo of the Tennessee Valley Authority's Colbert Co-fired Plant which burns biomass and coal to produce electricity. (U.S. Dept. of Energy) (http://www.eren.doe.gov/biopower/technologies/index.htm)

Biomass power systems range in size from a few kW (enough to power an average U.S. home) up to 80 MW power plants. Each megawatt of bio-power generates enough electricity in a year to power about 1000 average U.S. homes. The principal barrier to the widespread adoption of biomass electricity is the delivered cost of electricity that can be up to three times the cost of fossil fuel generated power. The cost to generate electricity from biomass depends on the type of technology used, the size of the power plant, and the cost of the biomass fuel supply. For instance, dedicated feedstocks, such as wood and herbaceous crops, cost almost three times more than residue per unit of energy output.

Co-firing systems can result in payback periods as low as two years. In today's direct-fired biomass power plants, generation costs are about 9 cents/kWh which, with advanced technologies such as gasification-based systems, is expected to generate power for as little as 5 cents/kWh within a few years. When low-cost biomass fuels are used in co-firing with coal, modifications to the coal plant can have payback periods of 2-3 years. In 1998, the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) and Sandia National Laboratories placed 10 contracts with private sector companies to develop small, modular biomass power systems. These contracts were the first of a three-phase project to determine the feasibility of systems that are fuel-flexible, efficient, simple to operate, and that have minimum negative environmental impacts. The intended power range for these systems is from 5 kW to 5 MW. Since they are modular with standardized manufacture and transport and have simple connections that require minimal field engineering at customer sites, DOE believes that these sized units should enjoy cost advantages that will enable them to compete in niche markets.[89]

Methane

Methane for electricity generation can arise mainly from two sources: *naturally* when collected in landfill collection systems and in specially designed tanks called *anaerobic digesters* at wastewater treatment facilities. In both instances, methane may be flared as a fire and safety precaution or captured and used to generate electricity. In addition, capturing methane and converting it to electricity or heat can control odor, decrease air greenhouse gas emissions, reduce smog, supplant fossil fuel in the generation of an equivalent amount of electricity, use an indigenous local resource, provide local jobs, and assist the local economy in becoming more self-reliant.

As a greenhouse gas, methane is 21 times more potent than carbon dioxide.[90] If methane is used to make electricity, EPA estimates that <u>for every MW generated</u>, the greenhouse gas benefit (preventing the escape of methane and CO_2 into the atmosphere) is equivalent to taking 8,800 cars off the road, planting 12,000 acres of forest, or preventing the use of 93,000 barrels of imported oil.[91] Alternatively, <u>every million tons of waste in place</u> typically generates 300 cubic foot per minute (CFM) of landfill gas that could generate 7 million kWh/year which is enough to power 700 homes for a year and is the equivalent of removing 6,100 cars from the road in one year or the same greenhouse gas impact as

[89] See www.eren.doe.gov/biopower/projects/ia_tech_sm_exec.htm for a summary of the demonstration project results.

[90] U.S. Environmental Protection Agency, Landfill Methane Outreach Program (430-F-96-051), September 1996.

[91] U.S. Environmental Protection Agency, Landfill Methane Outreach Program, www.epa.gov/lmop.

planting 8,300 acres of trees.

Landfill Methane

Landfill gas (LFG) is generated by the natural degradation of municipal solid waste by anaerobic (without oxygen) microorganisms. Once the gas is produced, it is gathered by a collection system usually consisting of a series of wells drilled into the landfill and connected by an underground plastic piping system. The gas as collected is saturated with water that must be removed if the gas is to be efficiently burned. The typical dry composition of the gas is 57% methane, 42% carbon dioxide, 0.5% nitrogen, 0.2% hydrogen, and 0.2% oxygen.[92] In addition to these gases, LFG contains trace amounts of hydrogen, oxygen, nitrogen, and non-methane organic compounds (NMOCs) that include volatile organic compounds (VOCs), hazardous air pollutants (HAPs), sulfur dioxide, and other odorous compounds. LFG is continuous produced by landfills, with the rate at which it is produced depending upon the temperature, moisture, and type of wastes contained in the landfill. In a 1999 study, EPA estimated that 37% of U.S. methane emissions were from landfills.[93]

After dewatering, the LFG can be used directly in reciprocating engines. It also can be further processed into higher-Btu gas suitable for use in boilers for manufacturing processes, as well as for electricity generation via gas turbines. The most important part of the scrubbing process is the removal of sulfur dioxide from the gas, since it results in corrosion within the combustion equipment. Further processing into a high-BTU gas requires the removal of CO_2 as well as all remaining trace components, resulting in a gas of high enough quality to be blended with existing natural gas systems. Figure 25 presents a schematic of a landfill gas system.

[92] California Energy Commission website, www.energy.ca.gov/development/biomass/landfill_gas.html, page 1.

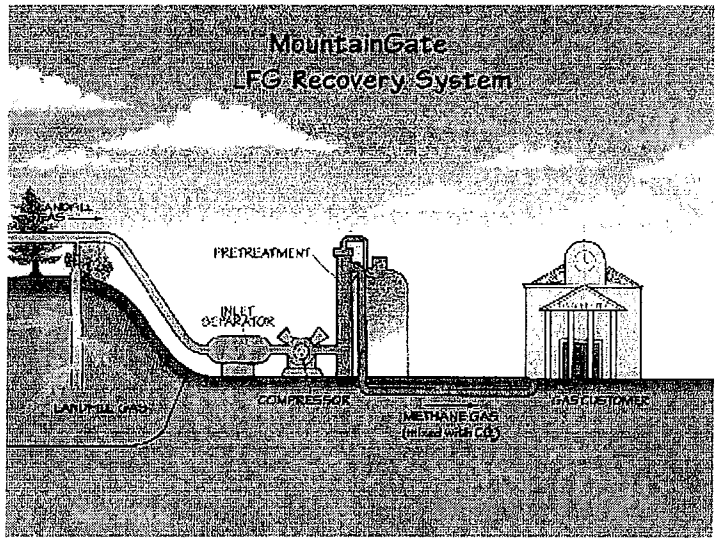

Figure 25: Diagram of the landfill gas recovery system at the Mountaingate Landfill in West Los Angeles, California. For generation of electricity, the gas customer as diagramed would be fuel cells, microturbines, or reciprocating engines fueled by the methane generated from the landfill. (http://www.nstengineers.com/Landfill_Gas.htm)

In 1996, the U.S. EPA promulgated the New Source Performance Standards (NPS) and issued Emission Guidelines for Municipal Solid Waste (MSW) landfills. The regulation requires LFG to be collected at landfills that: (1) have a potential capacity greater than 2.5 million metric tons and (2) have the potential to emit more than 50 metric tons/year of NMOCs. [Note: A landfill with 12.5 million tons of waste has an electric generating potential of 10 MW.] The process of reducing NMOCs (which contribute to smog production) also simultaneously reduces methane emissions. This regulation affects between 600-700 landfills nationwide, which represents only about 18% of the total number of landfills in the U.S.

LFG-to-Energy (LFGTE) Technologies

Landfill methane projects can involve a variety of power generation technologies in a wide range of sizes. The size and type of generation technology depends upon the amount of methane captured. Landfills with low capture rates can use internal combustion engines (250 kW and up), ones with medium capture rates can use gas turbines (3 MW and up), ones with high capture rates can use Rankine Cycle steam turbines (8 MW and up), and ones with very high capture rates can utilize combined cycle engines (20 MW and up).[94] Landfill methane project economics are promising—electricity costs for

[94] Singh, Virinder, Biomass: Landfill Methane Explained, REPP-CREST, Washington, D.C.,

different commercially available landfill methane options all fall within the range of costs for new combined cycle natural gas plants.

At least seven technologies in the 1,000-3,000 kW range are currently being used or could potentially be used for converting LFG to energy. They systems and their efficiencies are:[95]

- ***Internal Combustion Systems***
  Otto Cycle* – internal combustion reciprocating engine (33%)
  Brayton Cycle* – gas turbine (28%)
- ***External Combustion Systems***
  Stirling Cycle – external combustion engine (38.5%)
  Organic Rankine cycle (ORC) – vapor turbogenerator system (18%)
- ***Microturbine Systems****
  Only available in 30 kW size but these can be stacked (27%)
- ***Fuel Cell Systems*** *(require LFG pretreatment systems)*
  Phosphoric Acid Fuel Cell (PAFC) (36%)
  Molten Carbonate Fuel Cell (MCFC) (50%)

* Commercially available

Older landfills and small landfills (less than 500,000 metric tons) are usually neither economically feasible for LFGTE systems nor capable of supporting LFGTE system technology. System developers usually prefer a landfill with at least 2 million tons of waste in place.[96] Depending on the size of the landfill and the technology used, LFG systems are economically feasible for 10-20 years. Costs for electricity purchased from LFG collection systems range depending on the technology used, the size of the system, and the amount of power purchased. Before using any available federal or state tax credits, commercially available LFG systems range from 5.7-6.1 cents/kWh, with those still in the developmental stage ranging from 5.6-12.8 cents/kWh. Using available tax credits, these costs can be reduced to 3.5-5.5 cents/kWh.[97] Another source estimates that the cost of power generated from landfill gas can range from 3.5-7.9 cents/kWh, depending on the size of the landfill, financing available, distance from the grid, or readily available local applications.[98] The most significant barrier to the adoption of methane recovery technology is the initial capital cost. Once in place, however, operating

www.crest.org/articles/1/988047061_6.html, page 1.

95 Green Power Market Development Group (The), "Landfill Methane Technology", August 2000, www.thegreenpowergroup.org/lfg.html, pages 2-3.

96 *Ibid.*, page 3.

97 *Ibid.*, page 3.

98 Renewable Energy Policy Project (REPP), "Bioenergy – Frequently Asked Questions", Center for Renewable Energy and Sustainable Technology (CREST), http://www.crest.org/bioenergy/index..html, page 3.

and maintenance expenses can be kept at a minimum if proper methane recovery and processing equipment is used.

Many medium-to-large landfills (5,000-15,000 metric tons) affected by the 1996 EPA regulation may find it economically attractive to convert the LFG to energy rather than collecting the gas as a waste product and flaring it. Under the Public Utility Regulatory Policies Act (PURPA), a local utility is required to buy power generated at a landfill (which is a "Qualified Facility under the Act) if the power can be sold at a price typically offered by the utility. However, in a deregulated market environment, prices for power generated from the LFG will need to be competitive with conventional electricity generators. The average capacity of the approximately 325 LFGTE projects in operation in May 2001 was 4.1 MW.[99]

Air Emission Reductions

EPA has given guidance on expected emission from various sources in the form of emission factors collectively named AP (Air Pollution)-42. The emissions from flare, an internal combustion engine (IC), and a gas turbine using landfill gas according to AP-42 are shown in Figure 26, below.

It should be noted that energy recovery emissions from a gas turbine are considerably less than those from an IC engine. Excess air is used in the combustion chamber of the gas turbine, and as a result the residence time is shorter and lower NO_x emissions are attained. Flaring the gas in an open atmosphere also leads to lower NO_x emissions as compared with the IC engine due to excess air present with the gas turbine or possibly because of incomplete combustion.

Emission	Flare lbs/mmBtu	IC Engine lbs/mmBtu	Turbine lbs/mmBtu
Nitrogen Oxides (NO_x)	0.04	0.25	0.087
Carbon Monoxide (CO)	0.75	0.47	0.230
Particulate Matter (PM)	0.02	0.05	0.022
Sulfur Dioxide (SO_2)	0.02	0.02	0.020

Reference: AP-42, Volume 1, 5th Edition

Figure 26: EPA Air Pollution Factors

Wastewater Facility Methane

Characteristics

[99] *Ibid.*, page 4.

The water we use every day in our homes, offices, and factories becomes wastewater. A maze of underground pipes carries the wastewater to a wastewater treatment facility. Wastewater is drawn through a series of mechanical, chemical and biological processes before being returned to the river generally safe for aquatic life and communities that take their water downstream. Sludge - solid waste rich in organic material - is removed from wastewater and sent to anaerobic (without oxygen) digester tanks. Within these heated tanks, microscopic bacteria digest (or decompose) the sludge and break it down into stable organic matter called "biosolids" that are beneficially re-used through agricultural land application or as a component in topsoil for landfill cover material, fertilizer, or soil conditioner, either applied directly onto soils or composted and used for landscaping and gardening. This "stabilization process" reduces odors and destroys most of the potentially harmful pathogens contained in the solids. As the microbes consume the start up sludge, they release "anaerobic digester gas". ADG is comprised of methane and carbon dioxide, and has about 60 percent of the energy value of natural gas. Like natural gas, digester gas is highly flammable. Figure 26 presents the flow pattern of a typical wastewater treatment plant.

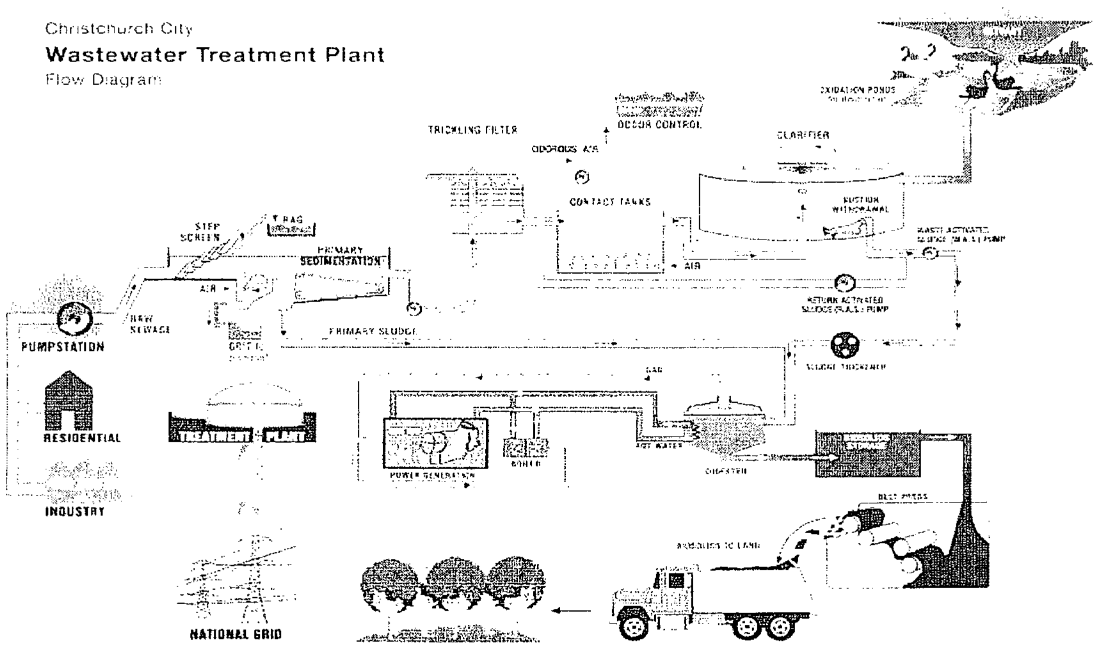

Figure 26: Flow chart of the Christchurch, New Zealand, wastewater treatment plant. (http://www.ccc.govt.nz/WasteWater/TreatmentPlant/FlowDiagram.asp)

Cogeneration

Today, most municipalities simply flare the digester gas and released it into the environment to reduce the risk of explosions. Some burn it in boilers that produce heated water used to heat the buildings in the plant and or use it as process heat to accelerate the bacterial stabilization process. Still others are using it to power absorption chillers, reciprocating electric generators, or even as fuel for a gas turbine. During low heat demand periods the heated water is discharged to the sewer and the beneficial use of this energy source is wasted. Over the past two decades, however, more municipalities have begun to use this "waste" heat in ways that wring more beneficial energy use from this resource. Cogeneration has been one solution.

Simply put, cogeneration is a process through which electricity and heat are produced from burning fuel (e.g., methane gas created by the wastewater treatment process). A cogeneration facility associated with a wastewater treatment facility converts available energy in the digester gas to electrical energy (electricity) and thermal energy (heat). This electrical power and heat can then be used to operate the wastewater treatment facility.

Such a cogeneration plant cuts fuel costs, improves efficiencies and reduces emissions of harmful greenhouse gases, like methane and CO_2. In Ottawa, Canada, the city's facility, which became operational in 1998, was built at a cost of $4.5 million. This investment saves Ottawa taxpayers $650,000 annually on the purchase of electricity and should enable it to fully recoup its investment by 2004 based on its processing 116 million gallons of wastewater annually. In San Diego, a similar cogeneration electric system operated by the Metropolitan Wastewater Department has a 4.5 MW capacity, saving the city $3.0 million in energy costs to run the facility in 2000 and, in addition, the city was able to sell $1.4 million of its excess power (1.2 MW) to the energy grid.[100]

Digester gas from the anaerobic digesters is piped and burned by continually running combustion engines located in the cogeneration facility, with the digester gas serving as fuel for the engines that drive the generators that produce the electricity. To continue the example, in Ottawa each of three engines drive a 810 kW generator, producing a total output of 2.4 MW of electrical energy - enough to supply electricity to 2,000 homes. Ottawa also uses this energy to power the aeration blowers and centrifuges used in the wastewater treatment process. The cogeneration facility uses as much digester gas as possible, up to 960,000 ft^3/day, to maximize electricity production.

Heat generated from the engines is captured in two ways. First, a circulating coolant runs through cavities in each engine body. As the digester gas combusts, excess heat raises the coolant temperature to approximately 248°F. Hot coolant is channeled to a heat exchanger where the heat is transferred to the plant heating system. Second, exhaust gas that leaves the engine at temperatures of up to 842°F, runs through a heat exchanger where it is cooled to about 302°F. The heat recovered in this process is also transferred to the plant heating system. The exhaust gas is vented into the atmosphere through mufflers

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[100] City of San Diego, California, Metropolitan Wastewater Department Energy Efficiency Program, Energy Efficiency Series, www.sannet.gov/mwwd/community/energy.shtml, pages 1-2.

located at the top of the cogeneration facility. The hot water goes into the plant heating system at between 185 and 203°F.

Together, these two procedures capture 2.9 MW of thermal energy -- enough to heat 400 homes. That's more than enough energy to fulfill the wastewater treatment plant's summer heating needs, which include warming the anaerobic tank contents to help speed up natural decay. During cold weather seasons, the energy is used to heat a significant portion of the building space at the facility. Many municipalities may continue to maintain a flare system as an emergency backup to the cogeneration and boiler systems. The flare burns off excess digester gas and ensures that, should the systems shut down for any reason, all digester gas produced by the plant will be combusted safely.

Fuel Cells and Biomass

Fuel cells, until recently a novelty largely confined to the space program, generate electricity through a chemical reaction, rather than combustion. The basic fuel is generally natural gas, which is processed to form hydrogen. The hydrogen combines with oxygen in the air to produce electricity, heat, and water. A logical next step is using as fuel the anaerobic digester gas (ADG) that is a renewable byproduct of the wastewater treatment process.

In May 1998, the New York Power Authority began operating the Western Hemisphere's first fuel cell power plant. It is a 200 kW PC25 phosphoric acid fuel cell at the Yonkers Wastewater Treatment Plant in Westchester County. With the methane content of the ADG varying from 40-65%, the operators of the plant increased the volume of gas that the fuel cell consumes to a maximum flow rate of 200 cubic feet per minute (cfm) to the fuel cell, which is the equivalent of about 50% methane content. At full capacity, the unit can produce about 1.7 million kWh annually, with the average being about 1.0 million kWh. A second challenge the facility faced was removing the impurities in the ADG, which was resolved by pretreatment filtration.

Assuming that the fuel cell generates about 1.0 million kWh per year, it will consume about 8,050 million Btus of ADG annually. Together, reduced flaring and lower demand for power from the grid avoid the emission of some 910 tons of CO_2 a year, as well as nearly four tons of SO_2, and just over two tons of NO_x.[101] For just CO_2, this is equivalent to reducing oil consumption by 1,660 barrels or taking nearly 130 cars off the road. EPA analysis indicates that the facility's emissions were below the measuring equipment's detection limits of 0.5 parts per million (ppm) for CO and VOCs and 1 ppm for SO_2. NO_x emissions were measured at 0.4 ppm.[102] A key to the project was the use of a

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[101] Sliker, Guy, Cost Solutions for Global Warming: Capitalizing on the Waste from Waste Treatment, The New York Power Authority, no date, www.nypa.gov, pages 1-2.

[102] Warner, Brian, Press release entitled Pioneering NYPA Fuel Cell Earns High Grades in Initial Test, The New York Power Authority, November 5, 1998.

prototype gas-processing unit that removes sulfur and moisture from the ADG before the gas enters the fuel cell. This was the first application worldwide of this processing unit. Minor CO_2 passes through the unit and is emitted to the air, but its contribution to the greenhouse effect is substantially less than that of methane. These results are in addition to reducing demand on the regional electricity grid.

The fuel cell is generating power at just below 8 cents/kWh, and while the original estimated operation and maintenance expenses were 1.5 cents/kWh, actual results have been running below that figure.[103] The success of this project led the U.S. Department of Energy to award grants to similar projects in California, Massachusetts, and Oregon.

Geothermal Power

Geothermal generation of electricity is not generally thought of as a distributed generation technology primarily because, as with wind and solar, it is very site specific. Most locations in the United States are not favorable for the development of geothermal power generation. However, a significant portion of the U.S. population lives in close enough proximity to areas favorable for geothermal development to warrant a closer inspection. In addition, recent studies have demonstrated that small scale geothermal development is often economically feasible, bringing the possibility of independent power generation to hundreds of communities.[104]

Generation of electricity by geothermal power plants is the second-largest source of renewable electricity in the United States, exceeding solar and wind combined. A single geothermal plant, the Geysers near Santa Rosa, California, produces enough electricity to theoretically power San Francisco and Oakland together. In fact, if the output of all the geothermal plants in California were combined, the electricity generated would be sufficient for about 2 million homes, or 8 million people. An innovative program, which will generate an additional 85 MW of power from the Geysers, involves injection of treated wastewater from Santa Rosa and surrounding communities into inactive parts of the geothermal field. If fully developed, geothermal power generation has the potential to supply the equivalent of the energy needs of the world for the foreseeable future.

Geothermal generation of electricity relies on the heat from either deeply buried hot rocks or near surface hot water to produce steam to turn turbines. Three basic types of power plants are the most common. *Binary Cycle Power Plants* (Figure 27) inject cool brine or water into the geothermal zone of superheated rocks. Hot brine is then extracted from a production well and run through a heat exchanger where the heat is transferred to Iso-Butane, converting the Iso-Butane into a vapor that then turns a turbine. The turbine

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[103] U.S. Fuel Cell Council, "Fuel Cells Could Energize Treatment Plants" in Environmental Science & Engineering, March 2001, page 1, www.esemag.com.

[104] Vimmerman, Laura, 1999, Opportunities for small geothermal power projects, GHC Bulletin, June 1999, p. 27-29.

turns a generator, producing electricity . The cooled brine is recycled to the injection well. The Iso-Butane is then run through a condenser, where it is cooled by water. The heated water is run through a cooling tower, where air and water vapor are given off as emissions. For *Flash Steam Power Plant* (Figure 28), the cool water is also injected into the geothermal zone and the resulting brine is extracted from a production well. However, the superheated brine is placed in a vessel where the steam is drawn off to turn the turbine. No heat exchanger is involved. The turbine then powers the generator, producing electricity. The steam is then mixed with water to cool it, and the water is then sent to a cooling tower. Air and water vapor are the only emissions. The waste brine may be used for direct heat purposes, or mixed with water from the cooling tower and recycled into the injection well. In a *Dry Steam Power Plant* (Figure 29), the oldest form of geothermal plant, steam from the hydrothermal fluid is used directly to turn the turbine. The Geysers Geothermal Plant is a dry steam plant. All of these plant types have reliability rates of 90-97 percent, as opposed to 60-65 percent for conventional power plants.

The cost of geothermal electricity is competitive already with conventional generation, and is in use in several locations in the United States. The U.S. Navy is a large proponent of geothermal energy, and meets 20 percent of its electricity needs from geothermal and other renewable sources. Calpine, a Fortune 500 energy company based in California, draws a significant portion of its production from geothermal power.

Small-scale (250 kW to 1 MW) geothermal plants are a different matter. These plants have many advantages, including a long history of performance in the western U.S. Modularization allows plant upfront costs to be reduced, and the plants can be

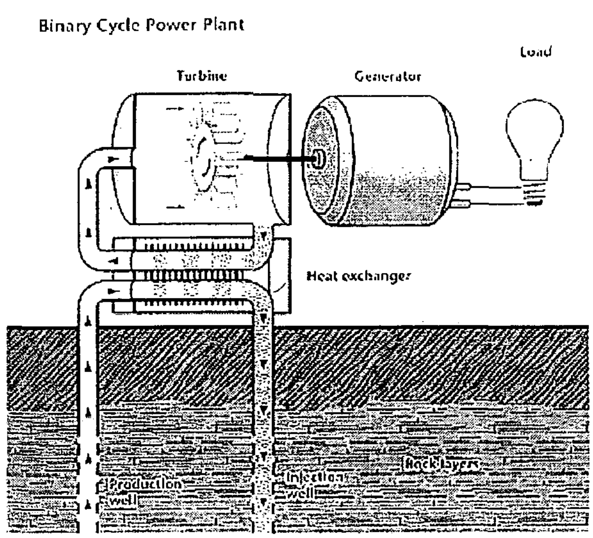

Figure 27: Illustration of a Binary Cycle Geothermal Plant. Fluids are injected through an injection well, heated by subsurface rocks, and recovered via the production well. The brine is then run through a heat exchanger where the hot brine convertss Iso-butane to steam. The steam drives the turbine which drives the generator. Steam is then returned to the heat exchanger, where it is condensed and the process starts again. The brine is reinjected.
(U.S. Dept. of Energy, http://www.eren.doe.gov/geothermal/geopowerplants.html)

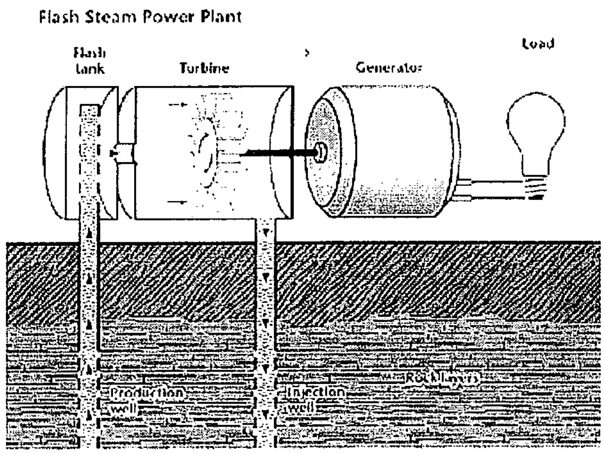

Figure 28: Diagram of a Flash Steam Power Plant. In this type of plant, brine is injected through the injection well, heated in the subsurface, and recovered through the production well. The brine is pumped into the flash tank, where the steam is drawn off to turn the turbine, which drives the generator. The remaining brine is reinjected.
(U.S. Dept. of Energy, http://www.eren.doe.gov/geothermal/geopowerplants.html)

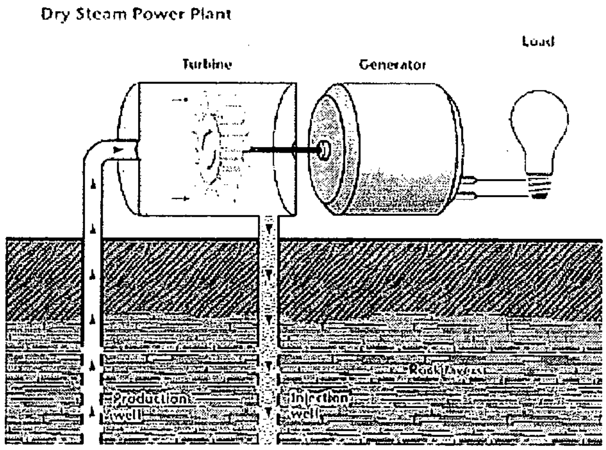

Figure 29: Diagram of a Dry Steam Power Plant. Brine is injected to hot rocks beneath the surface, where it is heated to steam. The steam is recovered through the production well and drives the turbine, which turns the generator.
(U.S. Dept. of Energy, http://www.eren.doe.gov/geothermal/geopowerplants.html)

automated, eliminating the need for an operator. The production of power produces virtually no emissions, and the reliability is high compared to conventional generation. The economic viability of these plants depends on cost-sharing of exploration and construction. Because of exploration and development, total upfront costs can still be high, but with an 80 percent cost-share, the cost of electricity from small-scale geothermal power plans can be less than 5 cents per kWh. Combining geothermal production of electricity with a direct-use application, such as a greenhouse or district heating, greatly improves the economic viability of an installation.

In the 10 western states, not including Alaska, there are 271 sites already identified with potential for either small-scale geothermal power development and/or direct use geothermal applications. These sites could conceivably serve a population of 7.4 million people

The disadvantages to geothermal power lie mainly in the limited geographical area suitable for the application of this technology. Most of the United States does not possess the high heat flow required for the generation of geothermal energy. Some geothermal plants produce some noxious gases, mainly SO_2, which has generated limited opposition from environmental groups. Similarly, some environmental groups object to the development of geothermal power on lands held by the public. In addition, geothermal power plants have high upfront costs because of the need for exploration and drilling in addition to construction. These costs can make geothermal power less attractive to investors because of the longer rate of return relative to fossil-fuel powered plants. Nonetheless, geothermal power has become an accepted and proven technology that may be of use in some areas.

Small-scale Hydroelectric Power

Small-scale hydroelectric power is considered a renewable resource. In general, small-scale hydroelectric power refers to plants producing less than 30 MW of electricity. As with larger plants, which are not considered renewable resources, these smaller plants convert the energy of flowing water into electricity. Unlike larger installations, which currently provide about 10 percent of the electricity consumed in the U.S., small-scale hydroelectric plants are not considered to be high impact, i.e., they do not change natural river flows, degrade water quality, or block fish migration. Small-scale hydroelectric generation has become increasingly popular over the past 20 years, and new installations as well as small-scale hydroelectric plant additions to existing dams and irrigation facilities are being built. As a distributed energy resource, small-scale hydro has been employed in municipal water systems. An example is the City of Boulder, Colorado, where 5 small scale hydroelectric plants produce sufficient electricity to support 7 percent of 'he city's energy needs. Installation of two additional units will triple this capacity.[105]

The feasibility of installing a small-scale hydroelectric plant rests on many factors. First there must be adequate power available from the stream. The amount of power is dependent on flow volume and head. The "gross head" is the actual vertical drop of the water from the top of the penstock to where it exits the turbine. The "net head" is the gross head minus the head losses due to friction and turbulence within the penstock. A greater head, or "high head" system, is preferable because more power may be produced from a smaller volume of water, allowing less costly, smaller, and more efficient turbines to be used. A "low head" system requires a larger volume of water and the use of more expensive turbines. Flow volumes on most streams may be obtained from the U.S. Geological Survey, the U.S. Army Corps of Engineers, the U.S. Department of Agriculture, state and local officials, or calculated using set formulas from a site survey. Once the flow and head have been determined, an estimate of the power may be made by using a formula.

Small-scale hydroelectric power also may be restricted by federal, state, and local regulations. For example, the amount of water that may be utilized by a hydroelectric installation may vary depending on the time of year because of agricultural or wildlife requirements. In much of the country, particularly the western states, water usage is heavily regulated and water rights treated as a precious resource. At the federal level, the regulation of small-scale hydroelectric facilities falls under two agencies, the Federal Energy Regulatory Commission (FERC) and the U.S. Army Corps of Engineers. Projects that fall under the jurisdiction of FERC are primarily those that will use federal land or water rights, affect interstate commerce, or are located on a navigable waterway. The Corps of Engineers is primarily concerned with preservation of wetlands. Other

[105] "Small Scale Hydro Within a Municipal Water System", Caddett Center for Renewable Energy Technical Brochure No. 130, 4 p., http://www.caddet-re.org/assets/no130.pdf

federal agencies may be involved if the project affects the resources they administer, such as the Fish and Wildlife Agency or the Forest Service.

Economic factors play the key role in determining the viability of a project. These factors include availability and cost of equipment, the cost of permitting the system, and the cost of installation and operation. Once these factors are determined, the cost per kWh is determined. Another important economic consideration is the rate the local utility will pay for excess power if connection to the grid is envisioned, along with the cost of that interconnection.

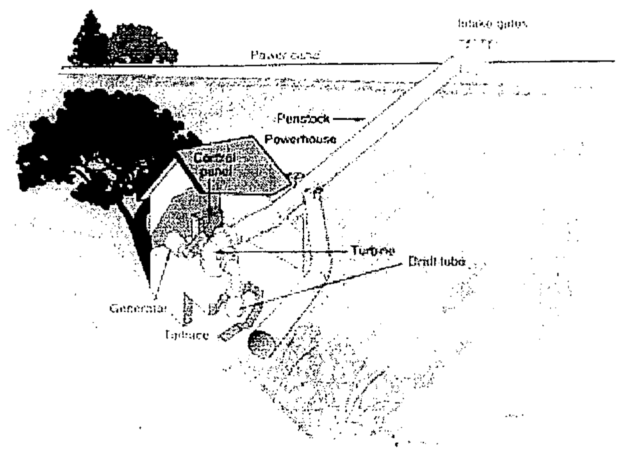

Figure 28: Illustration of a micro-hydroelectric plant. (U.S. Dept. of Energy). http://hydropower.inel.gov/facts/types.htm

Chapter 4
Local Government Issues

LOCAL GOVERNMENT ISSUES

Overview

As the electric utility monopolies granted by states during the early part of the last century are being split up by industry deregulation, many state public utility commissions continue to apply the same principles, rules, regulations, and precedents designed for a centralized generation and distribution era. In those states that have not achieved meaningful deregulation, this regulatory system is still the only one being applied. In these circumstances, it is not surprising that DG technologies continue to confront a significant number of technical and institutional barriers to their widespread adoption. Creating a "fair playing field" that removes the barriers to DG technologies in an evolving mixed centralize/decentralized electric generation and distribution system will need to occur before DG applications become more widespread.

A local government can become involved in fostering DG applications from a couple of perspectives – as a regulator of DG installations and as a DG technology owner and operator itself. It is in a position to overcome barriers to DG implementation in both of these roles. The kinds of barriers that DG technologies face can be divided into at least eight major categories: electricity reliability, facility siting, costs, pollution, hazardous materials, utility interconnectivity and net metering, private sector installations, and government-as-consumer issues. Many of these issues need to be addressed at all three levels of government -- federal, state, and local. And, certainly, the form and timing of deregulation in a particular state will have a major impact on DG technology selection and system economics, and overall in how DG evolves in that state. However, local governments, in particular, have a crucial role to play in determining policies and procedures that can enable or constrain widespread DG deployment. This section focuses on these areas and the ways local governments can effectively address them.

Reliability

With modern society so dependent on electricity both from a personal and business standpoint, every local government has an obligation to ensure that the community has reliable electric service at competitive prices. Reliability encompasses both the adequacy and security of the generation, transmission, and distribution system. These same criteria obviously are involved in the kind of power the local government purchases for its needs as well. To accomplish this objective, the municipality needs to make sure it is considering all options available in this increasingly competitive industry. It can no longer assume that its local investor-owned utility will be generating sufficient electricity to meet the community's needs at competitive prices. In fact, many utilities have chosen to withdraw from the generation portion of their formerly vertically integrated operations in favor of a "wires only" distribution company business mode. Under pressure of increased power demand, increased power supply competition, corporate mergers and acquisitions, and diversification of the their revenue sources, grid system reliability has sometimes taken a backseat. These developments do not mean, however, that local governments must accept this situation as one over which they have no control.

With more and more states phasing in a retailing pricing system for electricity, local governments, as well as business and residential customers, are becoming free to select an alternative electricity provider. Some municipalities are seriously exploring the possibility of creating their own municipal utility. Even the threat of switching energy suppliers or forming their own utility at or near the end of the investor-owned utility's franchise period frequently has led the incumbent utility to make improvements in its distribution system's reliability and service. At the same time, increased use of DG technologies by the local government and private sector customers can help alleviate the stress on the local distribution lines and buy time for the electric utility to make the necessary upgrades to improve grid reliability.

A local government can work with its utility and a group of localized customers to form a mini-grid composed of one or more DG technologies capable of meeting some or all of their electricity needs. The local government can help the utility appreciate that this and other decentralized DG applications can actually assistance the utility financially by allowing it to postpone or eliminate the need for costly distribution line extensions or upgrades. Such DG systems can enable the utility to avoid costly construction of new generating facilities that are no longer factored into the utility's rate base as well as enabling it to avoid expensive spot market purchases by actually returning electricity back to the grid during peak use periods.

Finally, by contributing to the enhancement of the grid's overall reliability while helping keep the cost of electricity down for the community, DG technologies can make the community more appealing to modern businesses of all sizes that rely heavily on electricity, thereby making the community more attractive from an economic development standpoint and eventually increasing overall electricity sales for the local utility. Viewing the local portion of the grid as part of the community's integrated electricity generation and distribution system enables a mix of grid and DG solutions that can have a synergistic effect in addressing the overall reliability issue and enable economic development to continue unaffected by reliability concerns.

Facility Siting

The debate on DG facility siting and permitting requirements is mainly focused on opportunities to reduce the time and costs and still protect, and even strengthen, the environment, public health and safety, and other social priorities. While many DG facilities are too small to trigger most states' power generation facility siting requirements which were intended for central power plants, they may well be required to comply with local, state, and regional air quality permitting requirements, as well as local zoning, building and fire codes. Current time requirements (which can range from as little as one month up to18 months), codes, and emission standards are usually not standardized, but rather are frequently developed on a project-by-project basis. As a result, even though a DG project may be able to satisfy regulatory requirements, the time-consuming and expensive processes needed to demonstrate compliance sometimes can render a project economically infeasible.[106] Issues affecting DG facility siting typically fall into three major categories – environmental, energy, and social.[107] *Environmental* issues include regulated media, plan and permit approval, and compliance. Although each site is unique, the primary environment issues are air quality, land use/zoning, hazardous material/waste, aesthetics/visual impact, and noise pollution. *Energy* issues generally revolve around technical engineering concerns. The primary issue here is interconnectivity to the existing power grid. *Social* issues include community and economic considerations, such as environmental justice/equity, "NIMBYism" (not in my backyard), and solar or wind access restrictions.

More specifically, siting may be an issue if the proposed DG system creates noise, emissions, or has a negative visual impact.[108] Photovoltaic systems can usually avoid siting issues, particularly if they are integrated into the roof of a building, but they may face resistance in some communities with strict rules on building appearance, such as historical districts. Small wind turbines generally are not recommended for urban locations due to their visual and potential noise impacts, but are usually easy to site in rural areas. Small-scale hydroelectric systems have special requirements, particularly if they involve the construction of a dam, since that generates potential safety issues downstream as well as navigational restrictions. Because of their effects on streams, they also may require environmental assessments and approval from the Federal Energy Regulatory Commission (FERC) and the U.S. Army Corps of Engineers.

Fuel cell systems generally are easy to site because of their low emissions and silent

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[106] Indiana Utility Regulatory Commission staff, "Distributed Generation White Paper", January 25, 2002, www.in.gov/iurc/energy/distribute/whitepaper_012502.pdf. Pages 6-7.

[107] Rivera, Shirley F., "Distributed Generation Challenges: Air Quality, Siting, and Permitting", http://www.oit.doe.gov/bestpractices/energymatters/emextra/pdfs/63-79_rivera.pdf, pages 64-65.

[108] Office of Distributed Energy Resources, " Buying and Installing a DER System", U.S. Department of Energy, www.eren.doe.gov/der/buy_install_system/html, page 1.

operation, but other proposed DG systems are likely to fall under state, local, and federal restrictions on air emissions. If the system generates noise that can be heard offsite, local opposition to the installation may arise. And, of course, if a structure is needed to house the facility, applicable local building codes and permits also will apply. In states that have enacted solar and wind access laws or prohibited neighborhood covenants from restricting certain types of DG systems (e.g., solar panels), these laws can ease siting concerns considerably. It is important, however, that these laws be rigorously enforced. Some states allow for the creation of easements under the premise that a wind or solar easement is a privilege to have access to wind or sunlight even though another person's property may be affected. Such laws state that a property owner cannot restrict any other property owner's access to wind or sunlight.[109] Other states have laws that prohibit neighborhood covenants from explicitly restricting the installation or use of solar equipment. While solar and wind access is not considered an automatic right, the laws are meant to prohibit unreasonable infringement on access. In at least one state, the law allows subdivisions to include solar easements that apply to all properties with the subdivision.

Costs

Local governments are interested in the cost of DG technologies from two perspectives – their own interest in installing such systems and the community's. For each proposed application the costs of installing, maintaining, and fueling (when appropriate) the systems must be weighed against use of existing grid-connected power if available. The local government also must balance these cost considerations with its leadership and market development responsibilities and promoting more environmentally generating facilities. A municipality can assist in bringing down the costs of DG technologies by helping create greater demand for their installation through an ongoing public awareness campaign, its own purchases, the inclusion of DG performance standards in its local building and fire codes as well as subdivision ordinances, facilitating aggregate community purchases of DG technologies, and expediting the processing time for its approval of DG facilities.

Public information services by the local government providing cost comparisons of various DG technologies, providing a clearinghouse of certified contractors and equipment, sponsorship of training programs for local architects and builders, and making financial assistance available or providing information about federal and state funding programs. All of these efforts can help to bring down the high upfront installation costs of most DG systems. While most of the increased demand necessary for factory mass production that can bring down the manufacturing cost of the units to more competitive levels will need to come from the demand generated in larger urban communities, local governments serving rural areas can play a key role as well in stimulating demand for DG technologies under appropriate circumstances. They have an obligation to ensure that isolated rural citizens have access to the kinds of information that will enable them to

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[109] *Op. cit.*, National Renewable Energy Laboratory, "Solar and Wind Access Regulations," page 1.

make a cost-benefit assessment of their uniqueapplications.

For instance, utilities have sometimes charged customers for the cost of upgrading distribution lines and transformers to handle the increased current that potentially could be introduced by a DG system, despite the fact the additional power could reduce peak period stress on the grid. Local governments can take measures to ensure citizens seeking service in areas within its jurisdictional boundaries, but who are not served by grid power, have the information they need to make informed decisions on the cost and reliability of a DG system compared to grid extension power. Besides the cost of the actual power line being strung, service extension should, in most cases, only include the cost of a transformer upgrade. In remote rural locations, however, it is possible that the distribution system may be designed for a level of current below what the new DG system will produce. If so, the utility may charge the DG applicant for line upgrades, which can be a significant expense. Therefore, it is important that the local government, both for any remote DG system it or its citizens might be considering, should be aware of what fees the utility is authorized to charge. Particularly for customers in rural areas, electricity from DG technologies can offer a viable economic option, obviating their need to pay for extending power lines to the rural property. State "power line extension policies" require that, in cases where a utility requires a customer to pay a contribution toward the construction of extending utility power lines to a remote location, the utility must provide information about on-site renewable technology options.[110]

Pollution

DG technologies range from technologies that are significantly more polluting than a central station combined cycle natural gas facility (i.e., internal combustion engines and small gas turbines) to zero-emission, non-polluting technologies (i.e., solar thermal, wind, geothermal, and small-scale hydro-electric). Since most distributed generation today is powered by polluting diesel fuel, it is critical that, before DG policies lead to further proliferation of this type of technology, there be a consistent set of air and noise standards accepted across the nation. This is necessary for three reasons. Uniformity of standards will provide the incentive for DG equipment manufacturers to develop and test units in large quantities to meet these certification requirements. Such uniformity will lead to standardization of units that can be mass produced. It also will allow a new generation of installers, facility managers, maintenance personnel, architects, builders, municipal planners, and local code enforcement officials to be trained and become experienced in the performance and acceptability of various DG technologies. These developments, in turn, will contribute to the lowering of their manufacturing and sales costs that result in lower prices, faster state approval for new DG equipment, and speedier local code and permitting approvals.

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[110] National Renewable Energy Laboratory, "Line Extension Policies", at Energy Efficiency and Renewable Energy Network (EREN) website, " U.S. Department of Energy, www.eren.doe.gov/state_energy/policy_content.cfm?policyid=20, page 1.

Air pollution standards, in particular, must be somewhat "technology forcing" through a phased-in approach that allows DG equipment manufacturers to ratchet up their refinements to achieve more and more effective results. The phasing in of the standards also must make allowances for the intended use of the unit – peaking or baseload. Depending on its intended purpose, it is possible that a generator with slightly higher air emissions that is only used during power emergencies could justifiably have somewhat higher air emissions than a unit that operates as a primary power source. Obviously, this would be a local decision and points up the need for comprehensive training of local zoning, fire, code, and subdivision permitting staffs to completely understand, not only the technical attributes and performance capabilities of the various DG technologies, but also to be able to apply this knowledge in the context of their local situation. In some circumstances (e.g., a densely populated, heavily polluted urban area), it may make sense for local government officials to partner with the state in offering financial incentives to the private sector to install DG equipment that exceeds the minimum state air or noise pollution standards.

Hazardous Materials

Compared to conventional fossil fuel and nuclear power plants, DG technologies produce a minimal amount of hazardous materials during their manufacture, installation, and operation. Specifically, the production and operation of solar thermal, wind, geothermal, small-scale hydroelectric, and microturbines systems produce little or no hazardous materials. Those DG systems for which some care needs to be taken include:

- *Reciprocal engines* – fuel source can be diesel, gasoline, natural gas, or propane, with diesel being the most common; diesel and gasoline spills into surface water or leakage into underground water are a concern, as is potential for fire or explosion of equipment or storage containers for each of the four fuels.
- *Photovoltaic* -- manufacturing involves generation of small quantities of hazardous materials for which appropriate handling must occur to reduce risks of exposure to humans and to the environment.
- *Biomass/methane* – generally minimal for gasification and co-firing with fossil fuels unless there is contamination of the fuel source; landfill gas may have trace amounts of non-methane organic compounds (NMOCs) and sulfur dioxide, while methane co-generation with fuel cells has yielded some SO2residue; fire and explosion possibilities always exist with methane.
- *Solar fuel cells* – only trace elements of hazardous material involved in their manufacture.
- *Interruptible power supply (batteries only)* – minimal leakage due to encasement of the battery inside a double container and the fact that the amount of hazardous material in any one battery is quite small.

Local government need to ensure the use of certified DG equipment, adequate storage space in the facility's design, installation by trained contractors, adherence to local fire and safety codes, and periodic inspection and maintenance of the units to preclude a hazardous materials problem from developing.

Utility Interconnection and Net Metering

Interconnection

Most states require DG technologies to meet national standards established by the Underwriters Laboratory (UL), the Institute of Electrical and Electronics Engineers (IEEE), and the national Electrical Code (NFPA 70). Some states also require conformity to the National Electrical Safety Code. In particular, the Underwriters Laboratory guidance, UL1741, addresses safety concerns related to grid-connected distributed generation.

The local electric utility may place restrictions on grid-connected systems that could affect the economics of the installation. Many utilities require manual disconnects, special meters, isolation transformers, redundant circuit breakers and other devices to ensure both the safety and reliability of the power grid. Many states, however, have set limits on what your utility can require for grid interconnection, so it is important for the applicant, be it the local government or a citizen, to be aware of the laws and decisions by the public utility commission affecting interconnectivity.[111] If there appears to be a lack of information on this matter, a local government may want to initiate measures, e.g., a website that makes the information available to the public.

Utility safety concerns generally focus on "islanding," which is the ability of DG to keep distribution lines energized during a power outage potentially threatening the safety of workers who are trying to restore power. However, systems that meet UL1741 contain anti-islanding features that satisfy this concern. Despite these standards, some utilities also are requiring expensive liability insurance for DG systems, often with high limits that would meet a worst-case situation of personal and property damage due to energized lines.[112] Again, making factual information available to the public and the utilities should mitigate this problem.

Net Metering

Net metering allows consumers to offset the cost of electricity they buy from a utility by selling renewable electric power generated at their homes or businesses. In essence, the customer's electric meter runs both forward and backward during the same metering period, with the customer charged just for the net amount of power used. Metering is usually done monthly, although occasionally the period extends for a full year, with any amount owed the customer credited to their account. Approximately 23 states have adopted net metering laws, with four of them restricting the program only to residential

[111] *Ibid.*, page 1.

[112] *Ibid.*, page 1.

customers.[113] Some states specify that only certain types of renewable systems are eligible. However, most states that offer net metering limit it to a certain generating capacity – typically in the range of 10 kW to 100 kW, but in some cases as large as 1000 kW. If an end user wishes to install a generation system larger than the maximum size that qualifies in their state, they may need to pursue a power purchase agreement with the local utility for which there may already be established a standard rate for such power purchases in its electric rate tariff.[114]

Private Sector Installations

A local government has an obligation to its citizens and taxpayers to encourage the community to take advantage of the many viable DG technologies commercially available today. It needs to do this for several reasons: (1) use of these advanced DG technologies can help the community become more secure economically by reducing its dependency on distant fuel and power suppliers, whether domestic or foreign; (2) they enable the community to have more reliable power attractive to modern businesses while still holding down its electricity costs, thereby making it more competitive both in a business sense as well as from a quality of life standpoint; and (3) a greater use of more decentralized power sources enables smaller businesses to more easily flourish, resulting in a more diversified local economy that reduces its vulnerability during economic downturns.

To achieve these objectives, a local government needs to ensure its residents and businesses that there is a sufficiently competent pool of local tradesmen and contractors to perform the installation and repairs that will be required. It can do so by requiring state-of-the art DG performance standards in its building, fire, and subdivision codes, accelerating the approval of certified equipment installations, educating its staff, private architects, builders, and trade unions on the performance of DG systems and accelerating the process of governmental building code and subdivision applications using these technologies. To accomplish all this, the local government needs to be aware of the state's requirement for contractor licensing and require that its approved installations be performed by experienced and competent professionals. Designed to ensure a minimum level of contractor experience and knowledge, each state has its own combination of requirements for training, experience, exams, fees, and types of licenses available. For instance, contractor licensing may be for specific DG technologies, such as solar water heat, active and passive solar space heat, solar industrial process heat, solar thermal electricity, and photovoltaics. The extent of training can vary from 1-2 days to an associate's degree in energy technology programs. For example, most states with certification laws do require a minimum amount of experience (either in years or number

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[113] *Op. cit.*, National Renewable Energy Laboratory, "Net Metering Rules," page 1.

[114] Office of Distributed Energy Resources, " Evaluating State and Local Factors", U.S. Department of Energy, www.eren.doe.gov/der/evaluating_slfactors.html, page 1.

of installations) to obtain a solar contractors' license.[115]

Local governments also need to be aware of what kinds of federal and state financial incentives are available for private sector installations of DG technologies and make information available to the public so they can apply for such assistance to reduce their high front-end capital and installation costs. States that offer financial incentives to promote the use of DG technologies need an objective rationale for determining which systems will qualify for state assistance. As noted earlier, most states require DG technologies to meet national standards established by the Underwriters Laboratory (UL), the Institute of Electrical and Electronics Engineers (IEEE), and the national Electrical Code (NFPA 70). Some states also require conformity to the National Electrical Safety Code. The certification process usually requires the equipment to meet some set of performance criteria and for the manufacturer to apply to the appropriate state office for certification. The application process for equipment certification varies by state with some states requiring that the equipment meet the standards set by a recognized certification agency (e.g., the Solar Rating and Certification Corporation),

End users seeking grants or loans to finance their DG installation or claiming a tax credit will likely be required to provide proof of the system's certification, purchase and installation. Other states may require detailed engineering drawings of the system or permits for installation after system certification requirements have been met. Many states require that the equipment carry minimum warranties on materials and installation. Some states even require that all equipment must be certified before it is sold.[116] And, of course, a number of national DG technology associations offer recommended equipment performance guidelines.

Government-as-Consumer

Green Buildings

A "green building" can be defined as any building that is sited, designed, constructed, operated, and maintained for the health and well-being of the occupants, while minimizing impact on the environment. There are different degrees of "greenness." Often, it is necessary to strike a balance between many different, sometimes conflicting, green options based on the particular conditions of a given project. For example, proper strategy for a sustainable retrofit project may differ from that of new construction design.[117]

Green building practices offer an opportunity to create environmentally sound and resource-efficient buildings by using an integrated approach to design. Green buildings

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[115] *Op. cit.*, National Renewable Energy Laboratory, "Contractor Licensing Rules," page 1.

[116] *Op. cit.*, National Renewable Energy Laboratory, "Equipment Certification Rules," page 1.

[117] Green Building Program, City of San Jose, California, www.ci.san-jose.ca.us/esd/gb-home.htm.

promote resource conservation by including design features that encourage energy efficiency, use of renewable energy, and water conservation. By promoting resource conservation, green building design creates healthy and comfortable environments, reduces operation and maintenance costs, considers environmental impacts of building construction and retrofit, and concentrates on waste minimization. Green building design also addresses such issues as historical preservation and access to public transportation and other community infrastructure systems. The entire life cycle of the building and its components is considered, as well as the building's economic and environmental impact and performance.

Green design actually can decrease construction costs by saving infrastructure expenses and by using passive heating and cooling techniques that make costly mechanical equipment unnecessary.[118] And since Americans spend 90% of their time in buildings, they use 33% of our total energy, and 66% of our electricity,[119] it is worthwhile for a local government to "lead by example" by ensuring all the buildings that it builds or leases make maximum use of energy efficient and DG technologies. It can do so be specifying in its bid documents and lease contracts, as well as its renovation, equipment, and operational purchases, that these technologies are to be used wherever their life-cycle costs can justify them.

This involves a high level of design integration among a number of professions and contractors from the very beginning of the design effort. Each member of the design/construction team must understand how its efforts relate to and impact the other building components. For instance, maximizing the energy efficiency of all aspects of the building will enable the selected DG technology to be sized at a smaller level than would otherwise be required. To encourage this multi-disciplinary effort, the mechanical trades and contractors performing the work need to be skilled in their craft in order to avoid repetition of the consumer experiences of the 1970s when, for example, solar contractors and businesses had little experience and often improperly installed the systems. As a result, many states have enacted laws that require contractors to be licensed, particularly for installation, repair, and maintenance on solar and photovoltaic systems. A local government needs to be knowledgeable about its state's licensing and contractor requirements for those skills necessary to install, repair, and maintain its DG systems and insist that only qualified persons and contractors receive contracts to perform this work.

As previously noted, most states require DG technologies to meet national standards established by the Underwriters Laboratory (UL), the Institute of Electrical and Electronics Engineers (IEEE), and the national Electrical Code (NFPA 70). Some states also require conformity to the National Electrical Safety Code. Again, a local government needs to make sure these nationally recognized standards are contained in

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[118] Hawken, Paul, Lovins, Amory, and Lovins. L. Hunter, Natural Capitalism, Little, Brown and Company, 1999, page 87.

[119] *Ibid.*, Page 85.

any construction or lease contract that it enters into and to verify that the appropriate equipment has been installed or repaired correctly through a comprehensive building commissioning process. Finally, a local government building can serve as a prototype test site for advancing state-of-the-art DG equipment developed by the U.S. Department of Energy's national laboratories as well as competent private manufacturers.

APPENDICES

Appendix A

Vendors of Distributed Generation Equipment

The California Energy Commission (www.energy.ca.gov) has compiled a comprehensive list of vendors of distributed generation equipment. Excerpts from this list are presented below.

From http://www.energy.ca.gov/distgen/equipment/equipment.html

Reciprocating Engines

> Caterpillar, headquartered in Peoria, Illinois, manufactures reciprocating engines and generator sets for a variety of fuels and with power output ranging from 40 kW to 10 MW.

Cummins, based in Columbus, Indiana, is a manufacturer of engines and power generators for many applications. Cummins products operate on a wide variety of fuels and have power outputs of 2 kW to 2 MW.

Generac Power Systems, located in Waukesha, Wisconsin, manufactures diesel- and gaseous-fueled engine generator systems with power output of 3 kW to 2 MW for residential, commercial, industrial, mobile, recreational vehicle, and communications applications.

Honda Power Equipment of Alpharetta, Georgia is a manufacturer of engines and generators that operate on various fuels for DER applications with power output up to 20 kW.

Kohler, based in Kohler, Wisconsin, manufactures 6 kW to 20 kW engines and 8.5 kW to 2 MW on-site power generators.

Waukesha Engine of Waukesha, Wisconsin is a manufacturer of gaseous- and liquid-fueled reciprocating engines up to multi-megawatt power outputs.

Microturbines

Bowman Power Systems is a U.K. company that develops 80-kW microturbine power generation systems for DER and mobile power applications.

Capstone Turbine Corporation, based in Chatsworth, California, is a leader in the commercialization of low-emission, high-reliability microturbine power generators. The company offers 30-kW and 60-kW systems for DER applications.

Elliott Energy Systems, located in Stuart, Florida, develops and manufactures 80-kW microturbines now with plans for larger units later.

Ingersoll Rand Energy Systems of Portsmouth, New Hampshire develops the PowerWorks™ line of microturbine generators with output of 70-kW now with plans for larger units later.

Turbec AB is a Swedish company jointly owned by ABB and Volvo Aero. The company offers a 100-kW microturbine power generator for commercial DER applications

Fuel Cells

Molten Carbonate

Fuel Cell Energy of Danbury, Connecticut is regarded as the leading developer of MCFC technology. The company plans to offer its Direct

Fuel Cell™ power plants with power outputs ranging from 250 kW to 3 MW.

The Power & Industrial Systems R&D Division of Hitachi, Ltd. and the Hitachi Works Fuel Cell Development Center, both located in Japan, develop and design MCFC structures and stacks.

Ansaldo Ricerche Srl of Genova, Italy plans to manufacture and commercialize the "Series 500" MCFC power plant, which has an output of 500 kW and is based entirely on European technology

Phosphoric Acid

The Fuel Cell Business Department of Japan's Fuji Electric Company, Ltd. manufactures and sells the FP-100, a 100-kW PAFC power plant.

UTC Fuel Cells, formerly ONSI, located in South Windsor, Connecticut, offers the world's only commercially available fuel cell system: the 200-kW PC25™ PAFC power plant.

Mitsubishi Electric Corporation plans to commercialize 200-kW PAFC systems. The company conducts PAFC work at the Advanced Technology R&D Center in Japan.

Proton Exchange Membrane

Avista Labs of Spokane, Washington, has patented a modular "hot-swap" PEM fuel cell cartridge and plans to commercialize PEM fuel cell systems for residential and small commercial applications.

Ballard Generation Systems, based in Burnaby, British Columbia, is a leading developer of 1-kW and 250-kW PEM fuel cell systems for stationary power applications.

Dais-Analytic Corporation, with offices in Odessa, Florida, plans to commercialize a 3-kW residential fuel cell system based on PEM technology.

H Power, located in Belleville, New Jersey, is a developer of 3- to 4.5-kW residential cogeneration units based on PEM fuel cell technology.

IdaTech of Bend, Oregon intends to offer a 3-kW PEM fuel cell system for residential DER applications.

UTC Fuel Cells, headquartered in South Windsor, Connecticut, plans to release a 7.5-kW residential PEM fuel cell system.

Nuvera Fuel Cells, based in Cambridge, Massachusetts, develops stationary PEM fuel cell systems for applications in the 1-kW to 50-kW range.

Plug Power of Latham, New York manufactures a 7-kW residential fuel cell system. General Electric is the master distributor of this system throughout the world, except for in Michigan, Indiana, Ohio, and Illinois where DTE Energy has distribution rights.

Proton Energy Systems, with offices in Rocky Hill, Connecticut, develops regenerative fuel cells, utilizing PEM technology and electrolyzers.

Batteries/UPS

Energizer, headquartered in St. Louis, Missouri, offers a full line of battery products, including alkaline, carbon zinc, miniatures and rechargeable batteries.

Evonyx, Inc., located in Hawthorne, New York, develops zinc-air (Zn-Air) batteries and fuel cells.

Ovonic Battery Company (Energy Conversion Devices) of Troy, Michigan is a leading developer of nickel metal hydride (NiMH) batteries.

Panasonic Industrial Company, based in Secaucus, New Jersey, manufactures numerous types of batteries, including lead-acid, carbon-zinc, lithium, lithium-ion, nickel-cadmium and nickel metal hydride.

Sony Corporation, with American headquarters in New York, New York, is a developer of alkaline and lithium-ion (Li-ion) batteries.

Ultralife Batteries, Inc. of Newark, New Jersey is a developer of lithium and polymer rechargeable battery technology.

Flywheels

Active Power, located in Austin, Texas, has developed two flywheel power systems that can handle DC loads up to 250 kW and 500 kW, respectively, for short periods of time. In additon, the company has teamed with Caterpillar in the development of battery-free UPS systems.

AFS Trinity, with manufacturing facilities in Livermore, California, produces flywheel power systems for stationary and mobile applications.

Beacon Power of Wilmington, Massachusetts has developed a flywheel power system that stores 2 kWh of usable energy for communications applications.

Pentadyne, based in Sun Valley, California, has developed a flywheel that supplies up to 120 kW of electricity for up to 20 seconds, or any other combination of 2400 kW-seconds.

Precise Power Systems, headquartered in Palmetto, Florida, is a developer of flywheel power systems for power protection applications.

Photvoltaics

AstroPower of Newark, Delaware produces a complete line of photovoltaic solar cells, solar modules, and complete packages for residential, commercial, and industrial DER applications.

Baekert ECD Solar Systems LLC and United Solar Systems Corp., based in Troy, Michigan, develop and produce the UNI-SOLAR® photovoltaic products for a wide variety of applications.

BP Solar, headquartered in Linthicum, Maryland, designs integrated photovoltaic systems and sells system components for a variety of DER applications.

DayStar Technologies, Inc. of Denver, Colorado is developing 10-50 kW photovoltaic systems based on proprietary packaging and thin-film processing.

Solec International, Inc., based in Carson, California, is a group of Sanyo Electric Co., Ltd. that produces photovoltaic systems with advanced crystalline silicon materials.

Xantrex Technology, Inc., headquartered in Vancouver, British Columbia, offers commercially available solar systems up to 20 kW for both on- and off-grid applications.

Wind

Atlantic Orient Corporation of Norwich, Vermont manufactures wind turbines with rated power outputs of 12 kW and 50 kW.

Bergey WindPower Company, Inc., located in Norman, Oklahoma, is a manufacturer of wind energy systems with ratings up to 15 kW.

Enron Wind, based in Tehachapi, California, manufactures wind turbine systems ranging in size from 600 kW to 1.5 MW.

Northern Power Systems of Waitsfield, Vermont manufactures a 100-kW, cold-weather wind turbine for utility-scale applications and a 3-kW wind turbine for small wireless applications (i.e., telecommunications).

Southwest Windpower Inc., headquartered in Flagstaff, Arizona, produces small, battery-charging wind turbines with rated outputs of 300 W to 1 kW.

Vestas-American Wind Technology, Inc. of North Palm Springs, California manufactures wind turbines with rated outputs ranging from 660 kW to 2 MW and provides turnkey installation services. Its parent company is Vestas Wind Systems A/S of Denmark.

Appendix B

Glossary

The California Energy Commission (http:www.energy.ca.gov) has produced an excellent comprehensive glossary of energy terms. Those excerpted below pertain specifically to this guide book. The complete glossary may be accessed at:

http://www.energy.ca.gov/glossary/glossary-x.html#x

ACCESS CHARGE -- A charge paid by all market participants withdrawing energy from the ISO controlled grid. The access charge will recover the portion of a utility's transmission revenue requirement not recovered through the variable usage charge.

ACTIVE SOLAR ENERGY -- Solar radiation used by special equipment to provide space heating, hot water or electricity.

ACTIVE SOLAR ENERGY SYSTEM -- A system designed to convert solar radiation into usable energy for space, water heating, or other uses. It requires a mechanical device, usually a pump or fan, to collect the sun's energy.

AFTERMARKET - broad term that applies to any change after the original purchase, such as adding equipment not a part of the original purchase. As applied to alternative fuel vehicles, it refers to conversion devices or kits for conventional fuel vehicles.

AGGREGATOR -- An entity responsible for planning, scheduling, accounting, billing, and settlement for energy deliveries from the aggregator's portfolio of sellers and/or buyers. Aggregators seek to bring together customers or generators so they can buy or sell power in bulk, making a profit on the transaction.

AIR POLLUTION -- Unwanted particles, mist or gases put into the atmosphere as a result of motor vehicle exhaust, the operation of industrial facilities or other human activity.

ALTERNATING CURRENT -- (AC) Flow of electricity that constantly changes direction between positive and negative sides. Almost all power produced by electric utilities in the United States moves in current that shifts direction at a rate of 60 times per second.

ALTERNATIVE (transportation) FUELS -- as defined by the National Energy Policy Act (EPAct) the fuels are: methanol, denatured ethanol and other alcohols, separately or in mixtures of 85 percent by volume or more (or other percentage not less than 70 percent as determined by U.S. Department of Energy rule) with gasoline or other fuels; CNG; LNG; LPG; hydrogen; "coal-derived liquid fuels;" fuels "other than alcohols" derived from "biological materials;" electricity, or any other fuel determined to be "substantially not petroleum" and yielding "substantial energy security benefits and substantial environmental benefits."

ANSI -- American National Standards Institute is the national organization that coordinates development and maintenance of consensus standards and sets rules for fairness in their development. ANSI also represents the USA in developing international standards.

ANCILLARY SERVICES -- The services other than scheduled energy that are required to maintain system reliability and meet WSCC/NERC operating criteria. Such services include spinning, non-spinning, and replacement reserves, voltage control, and black start capability.

AMPERE (Amp) -- The unit of measure that tells how much electricity flows through a conductor. It is like using cubic feet per second to measure the flow of water. For example, a 1,200 watt, 120-volt hair dryer pulls 10 amperes of electric current (watts divided by volts).

ANCILLARY SERVICES -- Services that the Independent System Operator may develop, in cooperation with market participants, to ensure reliability and to support the transmission of energy from generation sites to customer loads. Such services may include: regulation, spinning reserve, non-spinning reserve, replacement reserve, voltage support, and black start.

AREA LOAD -- The total amount of electricity being used at a given point in time by all consumers in a utility's service territory.

ASHRAE -- Acronym for American Society of Heating, Refrigerating and Air-Conditioning Engineers.

AUXILIARY EQUIPMENT -- Extra machinery needed to support the operation of a power plant or other large facility.

AVERAGE COST -- The revenue requirement of a utility divided by the utility's sales. Average cost typically includes the costs of existing power plants, transmission, and distribution lines, and other facilities used by a utility to serve its customers. It also included operating and maintenance, tax, and fuel expenses.

AVERAGE DEMAND -- The energy demand in a given geographical area over a period of time. For example, the number of kilowatt-hours used in a 24-hour period, divided by 24, tells the average demand for that period.

AVOIDED COST -- (Regulatory) The amount of money that an electric utility would need to spend for the next increment of electric generation to produce or purchase elsewhere the power that it instead buys from a cogenerator or small-power producer. Federal law establishes broad guidelines for determining how much a qualifying facility (QF) gets paid for power sold to the utility.

AVOIDED COST -- The cost the utility would incur but for the existence of an independent generator or other energy service option. Avoided cost rates have been used as the power purchase price utilities offer independent suppliers (see Qualifying Facilities).

BASE LOAD -- The lowest level of power production needs during a season or year.

BASE LOAD UNIT -- A power generating facility that is intended to run constantly at near capacity levels, as much of the time as possible.

BASELINE FORECAST -- A prediction of future energy needs which does not take into account the likely effects of new conservation programs that have not yet been started.

BASE RATE -- That portion of the total electric or gas rate covering the general costs of doing business unrelated to fuel expenses.

BATTERY -- A device that stores energy and produces electric current by chemical action.

BIOMASS -- Energy resources derived from organic matter. These include wood, agricultural waste and other living-cell material that can be burned to produce heat energy. They also include algae, sewage and other organic substances that may be used to make energy through chemical processes.

BLACKOUT -- A power loss affecting many electricity consumers over a large geographical area for a significant period of time.

BOILER -- A closed vessel in which water is converted to pressurized steam.

BROWNOUT -- A controlled power reduction in which the utility decreases the voltage on the power lines, so customers receive weaker electric current. Brownouts can be used if total power demand exceeds the maximum available supply. The typical household does not notice the difference.

CAPTIVE CUSTOMER -- A customer who does not have realistic alternatives to buying power from the local utility, even if that customer had the legal right to buy from competitors.

CAPACITY (Electric utility) -- The maximum amount of electricity that a generating unit, power plant or utility can produce under specified conditions. Capacity is measured in megawatts and is also referred to as the NAMEPLATE RATING.

CARBON DIOXIDE -- A colorless, odorless, non-poisonous gas that is a normal part of the air. Carbon dioxide, also called CO2, is exhaled by humans and animals and is absorbed by green growing things and by the sea.

CARBON MONOXIDE (CO) -- A colorless, odorless, highly poisonous gas made up of carbon and oxygen molecules formed by the incomplete combustion of carbon or carbonaceous material, including gasoline. It is a major air pollutant on the basis of weight.

CFCs (CHLOROFLUOROCARBONS or CHLORINATED FLUOROCARBONS) -- A family of artificially produced chemicals receiving much attention for their role in stratospheric ozone depletion. On a per molecule basis, these chemicals are several thousand times more effective as greenhouse gases than carbon dioxide. Since they were introduced in the mid-1930s, CFCs have been used as refrigerants, solvents and in the production of foam material. The 1987 Montreal protocol on CFCs seeks to reduce their production by one-half by the year 1998.

COGENERATOR -- Cogenerators use the waste heat created by one process, for example during manufacturing, to produce steam which is used, in turn, to spin a turbine and generate electricity. Cogenerators may also be QFs.

COGENERATION -- Cogeneration means the sequential use of energy for the production of electrical and useful thermal energy. The sequence can be thermal use followed by power production or the reverse, subject to the following standards:

(a) At least 5 percent of the cogeneration project's total annual energy output shall be in the form of useful thermal energy.

(b) Where useful thermal energy follows power production, the useful annual power output plus one-half the useful annual thermal energy output equals not less than 42.5 percent of any natural gas and oil energy input.

COMBINED CYCLE PLANT -- An electric generating station that uses waste heat from its gas turbines to produce steam for conventional steam turbines.

COMBUSTION Burning -- Rapid oxidation, with the release of energy in the form of heat and light.

CONGESTION -- A condition that occurs when insufficient transfer capacity is available to implement all of the preferred schedules simultaneously.

DEMAND -- The rate at which energy is delivered to loads and scheduling points by generation, transmission or distribution facilities.

DEMAND (Utility) The level at which electricity or natural gas is delivered to users at a given point in time. Electric demand is expressed in kilowatts.

(U.S.) DEPARTMENT OF ENERGY (US DOE) -- The federal department established by the Department of Energy Organization Act to consolidate the major federal energy functions into one cabinet-level department that would formulate a comprehensive, balanced national energy policy. DOE's main headquarters are in Washington, D.C.

DIRECT ACCESS -- The ability of a retail customer to purchase commodity electricity directly from the wholesale market rather than through a local distribution utility. (See also Retail Competition)

DIRECT CURRENT (DC) -- Electricity that flows continuously in the same direction.

DISAGGREGATION -- The functional separation of the vertically integrated utility into smaller, individually owned business units (i.e., generation, dispatch/control, transmission, distribution). The terms "deintegration," "disintegration" and "delamination" are sometimes used to mean the same thing. (See also "Divestiture.")

DISTRIBUTED GENERATION -- A distributed generation system involves small amounts of generation located on a utility's distribution system for the purpose of meeting local (substation level) peak loads and/or displacing the need to build additional (or upgrade) local distribution lines.

DISTRIBUTION SYSTEM (Electric utility) -- The substations, transformers and lines that convey electricity from high-power transmission lines to ultimate consumers. See GRID.

DRY STEAM -- The conventional type of geothermal energy used for electricity production in California. Dry steam captured at the earth's surface is used to run electric turbines. The principal dry steam resource area is the Geysers in Northern California; one of only two known areas in the world for dry steam -- the other being Larderello, Italy.

ECONOMIC EFFICIENCY -- A term that refers to the optimal production and consumption of goods and services. This generally occurs when prices of products and services reflect their marginal costs. Economic efficiency gains can be achieved through cost reduction, but it is better to think of the concept as actions that promote an increase in overall net value (which includes, but is not limited to, cost reductions).

ECONOMIES OF SCALE -- Economies of scale exist where the industry exhibits decreasing average long-run costs with size.

EDISON, THOMAS ALVA -- The "father" of the American energy industry, Thomas Edison was an American inventor who was born in 1847 and died in 1931. He patented a total of 1,093 inventions -- more than any other person in American history. Among the most important were the incandescent electric light bulb (1879), the phonograph (1877) and the movie projector (1893).

EEI -- Edison Electric Institute. An association of electric companies formed in 1933 "to exchange information on industry developments and to act as an advocate for utilities on subjects of national interest."

ELECTRIC UTILITY -- Any person or state agency with a monopoly franchise (including any municipality), which sells electric energy to end-use customers; this term includes the Tennessee valley Authority, but does not include other Federal power marketing agency (from EPAct).

ENERGY EFFICIENCY -- Using less energy/electricity to perform the same function. Programs designed to use electricity more efficiently -- doing the same with less. For the purpose of this paper, energy efficiency is distinguished from DSM programs in that the latter are utility-sponsored and -financed, while the former is a broader term not limited to any particular sponsor or funding source. "Energy conservation" is a term which has also been used but it has the connotation of doing without in order to save energy rather than using less energy to do the some thing and so is not used as much today. Many people use these terms interchangeably.

EPA -- The Environmental Protection Agency. A federal agency charged with protecting the environment.

EFFICIENCY -- The ratio of the useful energy delivered by a dynamic system (such as a machine, engine, or motor) to the energy supplied to it over the same period or cycle of operation. The ratio is usually determined under specific test conditions.

ELECTRICITY -- A property of the basic particles of matter. A form of energy having magnetic, radiant and chemical effects. Electric current is created by a flow of charged particles (electrons).

ELECTROLYSIS -- Breaking a chemical compound down into its elements by passing a direct current through it. Electrolysis of water, for example, produces hydrogen and oxygen.

EMISSION STANDARD -- The maximum amount of a pollutant legally permitted to be discharged from a single source.

ENERGY -- The capacity for doing work. Forms of energy include: thermal, mechanical, electrical and chemical. Energy may be transformed from one form into another.

ENERGY CHARGE -- The amount of money owed by an electric customer for kilowatt-hours consumed.

ENERGY CONSUMPTION -- The amount of energy consumed in the form in which it is acquired by the user. The term excludes electrical generation and distribution losses.

EXHAUST -- Air removed deliberately from a space, by a fan or other means, usually to remove contaminants from a location near their source.

FEDERAL ENERGY REGULATORY COMMISSION (FERC)- An independent regulatory commission within the U.S. Department of Energy that has jurisdiction over energy producers that sell or transport fuels for resale in interstate commerce; the authority to set oil and gas pipeline transportation rates and to set the value of oil and gas pipelines for ratemaking purposes; and regulates wholesale electric rates and hydroelectric plant licenses.

FLUIDIZED BED COMBUSTION -- A process for burning powdered coal that is poured in a liquid-like stream with air or gases. The process reduces sulfur dioxide emissions from coal combustion.

FOSSIL FUEL -- Oil, coal, natural gas or their by-products. Fuel that was formed in the earth in prehistoric times from remains of living-cell organisms.

FUEL CELL -- A device or an electrochemical engine with no moving parts that converts the chemical energy of a fuel, such as hydrogen, and an oxidant, such as oxygen, directly into electricity. The principal components of a fuel cell are catalytically activated electrodes for the fuel (anode) and the oxidant (cathode) and an electrolyte to conduct ions between the two electrodes, thus producing electricity.

GENERATING STATION -- A power plant.

GEOTHERMAL GRADIENT -- The change in the earth's temperature with depth. As one goes deeper, the earth becomes hotter.

GEOTHERMAL STEAM -- Steam drawn from deep within the earth.

GIGAWATT (GW) -- One thousand megawatts (1,000 MW) or, one million kilowatts (1,000,000 kW) or one billion watts (1,000,000,000 watts) of electricity. One gigawatt is enough to supply the electric demand of about one million average California homes.

GIGAWATT-HOUR (GWH) -- One million kilowatt-hours of electric power. California's electric utilities generated a total of about 270,000 gigawatt-hours in 1988.

GLOBAL CLIMATE CHANGE -- Gradual changing of global climates due to buildup of carbon dioxide and other greenhouse gases in the earth's atmosphere. Carbon dioxide produced by burning fossil fuels has reached levels greater than what can be absorbed by green plants and the seas.

GREENHOUSE EFFECT -- The presence of trace atmospheric gases make the earth warmer than would direct sunlight alone. These gases (carbon dioxide [CO2], methane [CH4], nitrous oxide [N2O], tropospheric ozone [O3], and water vapor [H2O]) allow visible light and ultraviolet light (shortwave radiation) to pass through the atmosphere and heat the earth's surface. This heat is re-radiated from the earth in form of infrared energy (longwave radiation). The greenhouse gases absorb part of that energy before it escapes into space. This process of trapping the longwave radiation is known as the greenhouse effect. Scientists estimate that without the greenhouse effect, the earth's surface would be roughly 54 degrees Fahrenheit colder than it is today -- too cold to support life as we know it. See GLOBAL CLIMATE CHANGE.

GREENHOUSE EFFECT (relating to buildings) -- The characteristic tendency of some transparent materials (such as glass) to transmit radiation with relatively short wavelengths (such as sunlight) and block radiation of longer wavelengths (such as heat): This tendency leads to a heat build-up within the space enclosed by such a material.

GRID -- A system of interconnected power lines and generators that is managed so that the generators are dispatched as needed to meet the requirements of the customers connected to the grid at various points. Gridco is sometimes used to identify an independent company responsible for the operation of the grid.

GRID -- The electric utility companies' transmission and distribution system that links power plants to customers through high power transmission line service (110 kilovolt [kv] to 765 kv); high voltage primary service for industrial applications and street rail and bus systems (23 kv-138 kv); medium voltage primary service for commercial and industrial applications (4 kv to 35 kv); and secondary service for commercial and residential customers (120 v to 480 v). Grid can also refer to the layout of a gas distribution system of a city or town in which pipes are laid in both directions in the streets and connected at intersections.

HELIOTHERMAL -- A process that uses the sun's rays to produce heat.

HYDROELECTRIC POWER -- Electricity produced by falling water that turns a turbine generator. Also referred to as HYDRO.

HYDROTHERMAL SYSTEMS -- Underground reservoirs that produce either dry steam or a mixture of steam and water.

INTERCHANGE (Electric utility) -- The agreement among interconnected utilities under which they buy, sell and exchange power among themselves. This can, for example, provide for economy energy and emergency power supplies.

INTERCONNECTION (Electric utility) -- The linkage of transmission lines between two utilities, enabling power to be moved in either direction. Interconnections allow the utilities to help contain costs while enhancing system reliability.

INTERNAL COMBUSTION ENGINE -- An engine in which fuel is burned inside the engine. A car's gasoline engine or rotary engine is an example of a internal combustion engine. It differs from engines having an external furnace, such as a steam engine.

INTERRUPTIBLE SERVICE (Electric utility) -- Electricity supplied under agreements that allow the supplier to curtail or stop service at times.

INTERTIE -- A transmission line that links two or more regional electric power systems.

INVESTOR-OWNED UTILITIES -- A private company that provides a utility, such as water, natural gas or electricity, to a specific service area.

KILOWATT (kW) -- One thousand (1,000) watts. A unit of measure of the amount of electricity needed to operate given equipment. On a hot summer afternoon a typical home, with central air conditioning and other equipment in use, might have a demand of four kW each hour.

KILOWATT-HOUR (kWh) -- The most commonly-used unit of measure telling the amount of electricity consumed over time. It means one kilowatt of electricity supplied for one hour. In 1989, a typical California household consumes 534 kWh in an average month.

LANDFILL GAS -- Gas generated by the natural degrading and decomposition of municipal solid waste by anaerobic microorganisms in sanitary landfills. The gases produced, carbon dioxide and methane, can be collected by a series of low-level pressure wells and can be processed into a medium Btu gas that can be burned to generate steam or electricity.

LOAD -- The amount of electric power supplied to meet one or more end user's needs.

LOAD -- An end-use device or an end-use customer that consumes power. Load should not be confused with demand, which is the measure of power that a load receives or requires.

LOSSES (Electric utility) -- Electric energy or capacity that is wasted in the normal operation of a power system. Some kilowatt-hours are lost in the form of waste heat in electrical apparatus such as substation conductors. LINE LOSSES are kilowatts or kilowatt-hours lost in transmission and distribution lines under certain conditions.

MEGAWATT (MW) -- One thousand kilowatts (1,000 kW) or one million (1,000,000) watts. One megawatt is enough energy to power 1,000 average California homes.

MEGAWATT HOUR (MWh) -- One thousand kilowatt-hours, or an amount of electricity that would supply the monthly power needs of a typical home having an electric hot water system.

METER -- A device for measuring levels and volumes of a customer¼s gas and electricity use.

METHANE (CH4) -- the simplest of hydrocarbons and the principal constituent of natural gas. Pure methane has a heating value of 1,1012 Btu per standard cubic foot.

MUNICIPAL ELECTRIC UTILITY -- A power utility system owned and operated by a local jurisdiction.

MUNICIPAL SOLID WASTE -- Locally collected garbage, which can be processed and burned to produce energy.

MUNICIPALIZATION -- The process by which a municipal entity assumes responsibility for supplying utility service to its constituents. In supplying electricity, the municipality may generate and distribute the power or purchase wholesale power from other generators and distribute it.

MUNICIPAL UTILITY -- A provider of utility services owned and operated by a municipal government.

NATURAL GAS -- Hydrocarbon gas found in the earth, composed of methane, ethane, butane, propane and other gases.

NOx -- Oxides of nitrogen that are a chief component of air pollution that can be produced by the burning of fossil fuels. Also called nitrogen oxides.

OUTAGE (Electric utility) -- An interruption of electric service that is temporary (minutes or hours) and affects a relatively small area (buildings or city blocks). See BLACKOUT.

OZONE - A kind of oxygen that has three atoms per molecule instead of the usual two. Ozone is a poisonous gas, but the ozone layer in the upper atmosphere shields life on earth from deadly ultraviolet radiation from space. The molecule contains three oxygen atoms (O3).

PARALLEL PATH FLOW -- As defined by NERC, this refers to the flow of electric power on an electric system's transmission facilities resulting from scheduled electric power transfers between two other electric systems. (Electric power flows on all interconnected parallel paths in amounts inversely proportional to each path's resistance.)

PARTIAL LOAD -- An electrical demand that uses only part of the electrical power available. [See California Code of Regulations, Title 24, Section 2-5342(e) 2]

PARTICULATE MATTER (PM) -- Unburned fuel particles that form smoke or soot and stick to lung tissue when inhaled. A chief component of exhaust emissions from heavy-duty diesel engines.

PASSIVE SOLAR ENERGY -- Use of the sun to help meet a building°s energy needs by means of architectural design (such as arrangement of windows) and materials (such as floors that store heat, or other thermal mass).

PASSIVE SOLAR SYSTEM -- A solar heating or cooling system that uses no external mechanical power to move the collected solar heat.

PEAK LOAD OR PEAK DEMAND -- The electric load that corresponds to a maximum level of electric demand in a specified time period. Peak periods during the day usually occur in the morning hours from 6 to 9 a.m. and during the afternoons from 4 to about 8 or 9 p.m. The afternoon peak demand periods are usually higher, and they are highest during summer months when air-conditioning use is the highest.

PEAK LOAD -- The highest electrical demand within a particular period of time. Daily electric peaks on weekdays occur in late afternoon and early evening. Annual peaks occur on hot summer days.

PEAK LOAD POWER PLANT-- A power generating station that is normally used to produce extra electricity during peak load times.

PEAKING UNIT -- A power generator used by a utility to produce extra electricity during peak load times.

PHOTOVOLTAIC CELL -- A semiconductor that converts light directly into electricity.

PIPELINE -- A line of pipe with pumping machinery and apparatus (including valves, compressor units, metering stations, regulator stations, etc.) for conveying a liquid or gas.

POWER -- Electricity for use as energy.

POWER PLANT (Note: Two separate words, not one word.) -- A central station generating facility that produces energy.

PURPA -- The Public Utility Regulatory Policy Act of 1978. Among other things, this federal legislation requires utilities to buy electric power from private "qualifying facilities," at an avoided cost rate. This avoided cost rate is equivalent to what it would have otherwise cost the utility to generate or purchase that power themselves. Utilities must further provide customers who choose to self-generate a reasonably priced back-up supply of electricity.

RECOVERED ENERGY -- Reused heat or energy that otherwise would be lost. For example, a combined cycle power plant recaptures some of its own waste heat and reuses it to make extra electric power.

RELIABILITY -- Electric system reliability has two components-- adequacy and security. Adequacy is the ability of the electric system to supply the aggregate electrical demand and energy requirements of the customers at all times, taking into account scheduled and unscheduled outages of system facilities. Security is the ability of the electric system to withstand sudden disturbances such as electric short circuits or unanticipated loss of system facilities.

RENEWABLE ENERGY -- Resources that constantly renew themselves or that are regarded as practically inexhaustible. These include solar, wind, geothermal, hydro and wood. Although particular geothermal formations can be depleted, the natural heat in the earth is a virtually inexhaustible reserve of potential energy. Renewable resources also include some experimental or less-developed sources such as tidal power, sea currents and ocean thermal gradients.

RENEWABLE RESOURCES -- Renewable energy resources are naturally replenishable, but flow-limited. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Some (such as geothermal and biomass) may be stock-limited in that stocks are depleted by use, but on a time scale of decades, or perhaps centuries, they can probably be replenished. Renewable energy resources include: biomass, hydro, geothermal, solar and wind. In the future they could also include the use of ocean thermal, wave, and tidal action technologies. Utility renewable resource applications include bulk electricity generation, on-site electricity generation, distributed electricity generation, non-grid-connected generation, and demand-reduction (energy efficiency) technologies.

REREGULATION -- The design and implementation of regulatory practices to be applied to the remaining regulated entities after restructuring of the vertically-integrated electric utility. The remaining regulated entities would be those that continue to exhibit characteristics of a natural monopoly, where imperfections in the market prevent the realization of more competitive results,and where, in light of other policy considerations, competitive results are unsatisfactory in one or more respects. Reregulation could employ the same or different regulatory practices as those used before restructuring.

RESERVE -- The extra generating capability that an electric utility needs, above and beyond the highest demand level it is required to supply to meet its users° needs.

RESERVE GENERATING CAPACITY -- The amount of power that can be produced at a given point in time by generating units that are kept available in case of special need. This capacity may be used when unusually high power demand occurs, or when other generating units are off-line for maintenance, repair or refueling.

RESERVE MARGIN -- The differences between the dependable capacity of a utility's system and the anticipated peak load for a specified period.

RESISTANCE (ELECTRICAL) -- The ability of all conductors of electricity to resist the flow of current, turning some of it into heat. Resistance depends on the cross section of the conductor (the smaller the cross section, the greater the resistance) and its temperature (the hotter the cross section, the greater its resistance).

SELF-GENERATION -- A generation facility dedicated to serving a particular retail customer,usually located on the customer's premises. The facility may either be owned directly by the retail customer or owned by a third party with a contractual arrangement to provide electricity to meet some or all of the customer's load.

SELF-SERVICE WHEELING -- Primarily an accounting policy comparable to net-billing or running the meter backwards. An entity owns generation that produces excess electricity at one site, that is used at another site(s) owned by the same entity. It is given billing credit for the excess electricity (displacing retail electricity costs minus wheeling charges) on the bills for its other sites.

SOLAR COLLECTOR -- A component of an active or passive solar system that absorbs solar radiation to heat a transfer medium which, in turn, supplies heat energy to the space or water heating system.

SOLAR CELL -- A photovoltaic cell that can convert light directly into electricity. A typical solar cell uses semiconductors made from silicon.

SOLAR COLLECTOR -- A surface or device that absorbs solar heat and transfers it to a fluid. The heated fluid then is used to move the heat energy to where it will be useful, such as in water or space heating equipment.

SOLAR ENERGY -- Heat and light radiated from the sun.

SOLAR POWER -- Electricity generated from solar radiation

STIRLING ENGINE -- An external combustion engine that converts heat into useable mechanical energy (shaftwork) by the heating (expanding) and cooling (contracting) of a captive gas such as helium or hydrogen

SUBSTATION -- A facility that steps up or steps down the voltage in utility power lines. Voltage is stepped up where power is sent through long-distance transmission lines. it is stepped down where the power is to enter local distribution lines.

SUPPLY-SIDE -- Activities conducted on the utility's side of the customer meter. Activities designed to supply electric power to customers, rather than meeting load though energy efficiency measures or on-site generation on the customer side of the meter.

SURPLUS -- (Electric utility) Excess firm energy available from a utility or region for which there is no market at the established rates.

SYSTEM -- A combination of equipment and/or controls, accessories, interconnecting means and terminal elements by which energy is transformed to perform a specific function, such as climate control, service water heating, or lighting.

TAX CREDITS -- Credits established by the federal and state government to assist the development of the alternative energy industry

TARIFF -- A document, approved by the responsible regulatory agency,listing the terms and conditions, including a schedule of prices, under which utility services will be provided.

TRANSFORMER -- A device, which through electromagnetic induction but without the use of moving parts, transforms alternating or intermittent electric energy in one circuit into energy of similar type in another circuit, commonly with altered values of voltage and current.

TRANSMISSION -- Transporting bulk power over long distances

TURBINE GENERATOR -- A device that uses steam, heated gases, water flow or wind to cause spinning motion that activates electromagnetic forces and generates electricity.

ULTRAHIGH VOLTAGE TRANSMISSION -- Transporting electricity over bulk-power lines at voltages greater than 800 kilovolts.

UTILITY -- A regulated entity which exhibits the characteristics of a natural monopoly. For the purposes of electric industry restructuring, "utility" refers to the regulated, vertically-integrated electric company. "Transmission utility" refers to the regulated owner/operator of the transmission system only. "Distribution utility" refers to the regulated owner/operator of the distribution system which serves retail customers

VOLT -- A unit of electromotive force. It is the amount of force required to drive a steady current of one ampere through a resistance of one ohm. Electrical systems of most homes and office have 120 volts.

WATT -- A unit of measure of electric power at a point in time, as capacity or demand.

WATT -- A unit of measure of electric power at a point in time, as capacity or demand. One watt of power maintained over time is equal to one joule per second. Some Christmas tree lights use one watt. The Watt is named after Scottish inventor James Watt and is capitalized when shortened to w and used with other abbreviations, as in kWh.

WATT-HOUR -- One watt of power expended for one hour. One thousandth of a kilowatt-hour.

WHEELING -- Using a utility's lines to transport power from one neighboring system to another.

BOSTON, MASSACHUSETTS

PUBLIC TECHNOLOGY INC.

RECOMMENDATIONS AND REPORT OF PEER-TO-PEER EXCHANGE

FOR BOSTON, MASSACHUSETTS

SUBMITTED BY: SHARRON BROWN, DIRECTOR

Public Technology Inc. (PTI) is the research and technology organization for the National League of Cities, the National Association of Counties, and the International City/County Management Association. PTI's mission is to bring the benefits of technology to local governments.

BACKGROUND:

Public Technology Inc. (PTI) is the research and technology organization for the National League of Cities, the National Association of Counties, and the International City/County Management Association. PTI's mission is to bring the benefits of technology to local governments.

The Urban Consortium, representing America's largest and most progressive cities and counties, serves as a catalyst for research and development of emerging technologies that can solve problems facing all local governments.

The Energy Task Force (ETF) of PTI identifies proven technologies and develops innovative ways to improve energy efficiency, promote the use of renewable energy resources, reduce local government utility expenditures and maximize opportunities for local economic growth through energy initiatives.

One of the most effective methods of providing sustainable solution information to a local jurisdiction is through a peer-to-peer technology exchange. During a peer-to-peer technology exchange meeting, ETF members will travel to a local jurisdiction to assess the current energy management practices and provide recommendations for better energy management practices for the jurisdiction. These recommendations include short term and long term strategic and energy efficiency planning. PTI and the ETF have worked in conjunction on these meetings for more than 25 years.

INTRODUCTION:

The City of Boston, Massachusetts, a PTI member, requested assistance from PTI for technical assistance, due to energy supply, costs and reliability issues for the city. Mayor Thomas Merino has implemented a 10% reduction of energy usage by 2005, as a reliable power supply is essential to continue economic development.

Public Technology, Inc. (PTI), and members of its Energy Task Force (ETF) conducted a peer-to-peer exchange workshop in Boston on June 24-25, 2002. The meeting was held as part of PTI's SWAT program, that was funded by the United States Department of Energy's (DOE) Municipal Energy Management Program (MEMP).

Mayor Thomas Merino from the City of Boston has committed to the reduction of energy consumption by 10% and toward identifying and implementing proven and innovative methods to achieve this goal. The findings and recommendations of these SWAT meetings will provide a foundation upon which to build.

Participants from Boston included: Maura Zlody, Nancy Grilik, Andrea d'Amato, Toni Pollack and Sarah Zephinis (can not understand your writing fill-in).

ETF members participating in the meetings included Margaret Downey (Barnstable County, Massachusetts), Kevin Larry Blackstad, Hennepin County, MN Kent Miller from Philadelphia, PA, and Steve Walter from Chicago, IL and John Deakin, former Director of Energy from San Francisco, CA related his experiences with an energy plan/policy via conference call.

Sharron Brown, Director of Energy Programs from PTI, coordinated, provided information and will summarize this meeting as well.

This report summarizes the findings and recommendations resulting from the meetings and site visits.

INITIAL INITIATIVES:

Boston has an energy champion necessary to begin the planning and implementing a comprehensive program and plan. The energy champion is Mayor Thomas Merino who has formulated an energy task force with the objective of reducing the city's energy consumption by 10% by the year 2005.

The Building Division has also performed an energy audit on several of their buildings. The findings of these audits can begin the retrofit process as well.

DISCUSSION TOPICS AND SITE VISITS:

Other city officials and agencies within the city, i.e. public housing and the school administrators, made not only by the UCETF members, but the findings of the SWAT meetings also.

Other findings from the meetings included that Con Edison the utility serving the city's not particularly receptive to distributed generation technologies, probably due to a lack of familiarity with the technologies and net metering.

All participants noted that Boston has made progress toward greater energy efficiency, and that there seems to be support for further efforts toward energy efficiency and, perhaps, toward the city becoming a net energy supplier.

Findings of the field visit to city facilities and energy audit were also presented. These included City Hall, were the majority of city agencies including the Mayor and City Council offices have public offices. There were no energy efficiency lighting, occupancy sensors and even at night the majority of lights remained lit. Also, the HVAC was inefficient and a residential air conditioner unit was placed to assist with their cooling

Another multi-purpose building had note able code violations including exposed asbestos at the furnace room. In addition, the entire HVAC equipment and energy efficiency lighting is the some of the first recommendations for this building. The Public Safety Building, with its pitched roof, could use PV for outdoor lighting purposes.

Vending machines are currently in operation 24 hours daily every day of the week. Installation of vending misers or simple timers would drastically reduce energy consumption.

Finally, the meetings noted that Boston's public schools is a partner in the Rebuild America program, however, the city is not a community partner for this program.

SHORT TERM PLANNING RECOMMENDATIONS:

The findings of the participants resulted in the following Short Term- Strategic and Technological Recommendations:

- The city should officially join as a community partner in the DOE's Rebuild America Program.
- An energy audit;
- The city should implement simple energy conservation measures including LED exit signs within the buildings, occupancy sensors in all bathrooms for lights, water sensors for sinks and toilets; turn off lights in unoccupied government buildings; turn the lights off at City Hall at night.
- It is strongly recommended that a billing analysis and target a department that will monitor these bills.
- The city government and departments should form an interdepartmental cooperative team to review the utility costs and devise methods within each department to reduce the consumption.
- The city should develop an Office of Energy Efficiency a public education and outreach program encouraging private use of photovoltaic and energy efficiency
- Distributed Energy and current financing opportunities currently provided from the Massachusetts State Energy Office.

SHORT TERM PLANNING:

Rebuild America:

The US Department of Energy's Rebuild America program began in 1994, which focuses "on energy-savings solutions as community solutions". Its "mission to accelerate energy-efficiency improvements in existing commercial, institutional and multifamily residential buildings through private-public partnerships created at the community level".

As a Rebuild America partner, Boston will realize many benefits. They will receive on-site technical assistance and training either within the community or at regularly scheduled national, regional, and state workshops. Rebuild America partnerships allow access to experts in the field of energy efficiency, renewable energy, and financing of energy efficiency and renewable energy projects. As a Rebuild America partner, various other levels of technical assistance and tools are available to the community partners as well. All of these resources are available to develop new energy efficiency initiatives within the community.

Recommendation:

The ETF members recommend that the city become a partner in the Rebuild America program that will provide the city with numerous benefits and opportunities in energy management.

Implementation:

During the meeting Eileen McHugh from the Massachusetts State Energy Office and Greg Davoren from the US DOE regional office were present for one day during the meeting. They both applauded PTI's efforts and committed to assisting Boston with technical advice and some financial assistance.

Energy Audit:

Information about an energy audit is another service available through the Rebuild America program. An energy audit will provide an inventory of the energy usage for the city's municipal buildings. It will also identify areas in which energy efficiency measures can provide reduction of energy consumption and energy savings. The results from the energy audit can be used to develop a comprehensive energy management plan that reflects the city's priorities.

Recommendation:

The ETF members recommend that an energy audit be performed by either a third party Energy Service Company (ESCO) or as part of the city's participation as a Rebuild America partner.

Implementation:

As a Rebuild America partner, the energy audit may be provided at no cost to the city. Alternatively, the city may request referrals of experts from PTI, the ETF, the Green Building Council, or the Rocky Mountain Institute. Finally, Rebuild America program team can perform this audit as part of a peer-to-peer exchange. The results from the energy audit (for buildings that were not part of the initial audit) will then be used to develop a comprehensive energy management plan for the city.

Recommendation:

The ETF members recommend the City of Boston investigate simple, inexpensive ways to reduce energy consumption.

Implementation:

Simple Energy Conservation Measures:

The majority of Boston's municipal buildings do not make extensive use of fluorescent lighting, including, T-8, lighting, window film and the HVAC equipment and energy efficient motors for 25 buildings are centrally controlled. Once these buildings are retrofitted (installation of energy efficiency lighting) it is estimated that the city can reduce its electricity budget for buildings from $600,000 to $450,000, a 25 percent reduction.

Another example of a potential simple energy conservation measure is within the Public Works Department, that has the responsibility for streetlights and traffic signals. This department can aggressively reduce energy consumption. The city can purchase high-pressure sodium streetlights and green and red LED traffic signals. The combined energy bill for streetlights and traffic signals is $850,000, $250,000 of which is for traffic signals. Energy use in traffic signals can be reduced by 50 percent.

Public transportation is the single biggest consumer of energy in the city, but also has the highest percentage of vehicles fueled by alternative fuels among the city's overall fleet of 1000 vehicles. Fuel cells can be examined by the transportation department future use in public transportation including buses and the city's fleet.

Also, for park's recreational facilities, the city is investigating the use of motion detectors rather than timers for lighting. These facilities also can benefit from a commercial timer called a Vending Miser. This timer cut the vending machine's energy costs by 30% and the timer paid for itself within less then a 30-day period. For example, the City of Albuquerque has 300 soft drink machines. These machines consume about 15 kWh of electricity per day, or about $45.00 per month, yet for over two-thirds of the time, there is no one around to use the machines. By installing Vending misers, a commercial timer, they can reduce the energy by 30%.

The Rebuild America program will provide numerous examples of simple and effective ways to reduce energy consumption. In addition, as a member of PTI and the ETF, the City of Boston may avail itself of the many resources, case studies, examples, meetings, and peer exchanges where energy conservation and management are discussed. The city has already made great strides in this area, and clearly the commitment and resolve to further these efforts is present.

Discussion:

This report presents several recommendations stemming from the discussions and field trips during the SWAT meetings. While it is unlikely that all recommendations will be accepted or are practical, adoption of any of the recommendations will enhance the City of Boston's commitment for energy reduction and continue their efforts in energy conservation, energy management, and energy awareness.

There are many resources available to the city, starting with the city's membership in PTI and the ETF. This allows the city access to all members of the ETF and their combined expertise, as well as access to MEMP publications compiled over the 21 years of the program.

Throughout this report, reference is made to the Rebuild America program. By becoming a Rebuild America partner, substantial additional resources will be made available to the city. This partnership will expedite the implementation of most of the recommendations made by during the SWAT meetings.

Interdepartmental Cooperation:

Discussion:

It was the recommendation of the SWAT team, that a group of the departments, responsible for energy expenditure, including the Mayor's energy task force, be formulated. This group will identify energy conservation opportunities, aggregation of electricity usage and opportunities for renewable energy applications. A unified city program of energy conservation and alternative energy sources demonstrates the viability of these programs to the public, encouraging private sector conservation and support for alternative energy sources.

Recommendation:

Based on experiences in their home jurisdictions, the ETF members stress the importance of interdepartmental cooperation in energy management programs.

Implementation:

The City of Boston has contemplated energy efficiency and conservation programs within individual departments. To facilitate more inter-departmental cooperation between the departments with regard to energy issues, the city can improve communication and coordination through a centralized office, such as an Office of Energy Efficiency.

Office of Energy Efficiency:

Discussion:

An established Office of Energy Efficiency would be responsible for will be responsible for monitoring energy consumption and billings, design and implement an outreach program to educate the public and city officials on the methods, technologies, and benefits of energy conservation measures. Representatives from all relevant agencies within the government infrastructure, the general public and elected officials should provide input and feedback to this office. In addition, the Office of Energy Efficiency will implement programs that will generate savings from the initial energy reduction/costs projects that will fund future energy conservation programs from within this office.

For example, simply by monitoring utility bills, the City of Albuquerque's Energy Management Office has saved over $300,000 annually due to errors in their utility bill charges. The office has also been instrumental in passing a solar access ordinance, promoting the use of passive and active solar, reducing CO2 emissions from wood burning stoves, and cutting utility costs through simple yet effective measures.

Recommendation:

The ETF members recommend that the city establish an Office of Energy Efficiency to administer the city's programs in energy management.

Implementation:

A centralized, Office of Energy Efficiency consisting of one to two staff people is essential to implementation of a comprehensive energy program. The ETF SWAT members that have established similar offices will provide a template i.e. *Tools for the Job from San Francisco, CA* and options for establishment of this office.

Distributed Energy Resources:

Discussion:

"Distributed energy (DE) refers to a variety of small, modular power-generating technologies that can be combined with energy management and storage systems and used to improve the operation of the electricity delivery system, whether or not those technologies are connected to an electricity grid.

Other Distributed Energy Technology

Distributed energy technology such as micro turbines, combustion gas turbines, and fuel cells should be investigated for use by the City of Boston. These may be fueled with biogas or natural gas, and will provide uninterrupted, high-quality and highly reliable power.

Description of recommended DE applications:

Gas-fired Micro turbines: have been developed from aircraft power systems and turbochargers. They are available in sizes ranging from 30 to 400 kW generating capacity. Micro turbines are designed for continuous operation.

Combustion gas turbines: are also developed from aerospace technology. They are multiple stage units with larger capacity, which distinguishes them from smaller micro turbines. The units have relatively low installation costs, low emissions, and low maintenance requirements. The units have a low electric efficiency, which has limited their use to peaking and combined heat and power (CHP) use.

Fuel cells: contain no moving parts and provide a highly reliable and high quality source o power. The technology was first developed in 1839, but was put to practical use in the 1960's in the American space program. Fuel cells range in size from 5 to over 1000 kW. Several types of fuel cells are available, but they all share the same basic principle to generate electricity. The fuel cell consists of two electrodes separated by an electrolyte. A hydrogen rich fuel, such as propane or natural gas, is fed through a reformer, producing hydrogen, which is then fed into the fuel cell through the anode. Oxygen (as air) is fed into the cathode. A catalyst splits the hydrogen atom into a proton and electron. The positively charged proton passes through the electrolyte, while the electrons are routed through an external circuit, creating a direct current. At the cathode, the electrons combine with the protons (H+) and oxygen to produce water and heat. With water vapor as the only product, fuel cells are extremely desirable from an environmental perspective, and they are very efficient. A new type of fuel cell, utilizing proton exchange membrane technology is in development. Fuel cell manufacturers expect to be able to compete with more conventional technologies within two years. Fuel cells have been demonstrated for use on buses and in commercial and domestic applications.

Micro turbines, combustion gas turbines, and fuel cells generate heat that may be used in CHP applications, greatly enhancing the efficiency of the units. Table 1 provides a comparison of the different technologies.

Technology	Recip Engine: Diesel	Recip Engine: NG	Microturbine	Combustion Gas Turbine	Fuel Cell
Size	30kW - 6+MW	30kW - 6+MW	30-400kW	0.5 - 30+MW	100-3000kW
Installed Cost ($/kW)[1]	600-1,000	700-1,200	1,200-1,700	400-900	3,000-4,000
Elec. Efficiency (LHV)	30-43%	30-42%	14-30%	21-40%	36-50%
Overall Efficiency[2]	~80-85%	~80-85%	~80-85%	~80-90%	~80-85%
Variable O&M ($/kWh)	0.005 - 0.015	0.007-0.020	0.004-0.01	0.003-0.008	0.0019-0.0153
Footprint (sqft/kW)	.22-.31	.28-.37	.15-.35	.02-.61	.9
Emissions (gm / bhp-hr unless otherwise noted)	NO_x: 7-9 CO: 0.3-0.7	NO_x: 0.7-13 CO: 1-2	NO_x: 9-50ppm CO: 9-50ppm	NO_x: <9-50ppm CO:<15-50ppm	NO_x: <0.02 CO: <0.01

[1] Cost varies significantly based on siting and interconnection requirements, as well as unit size and configuration.
[2]Assuming CHP.
Table 1: Comparison of distributed generation technologies. From Distributed-Generation.com , Resource Dynamics Corp.

The economics of distributed generation technologies are dependent on the price of natural gas (the most common fuel), the price of conventionally generated electricity, and the desired payback period. In the ideal situation for micro turbines, combustion gas turbines and fuel cells, gas prices should be low, and electricity prices high. This was the case recently in California.

Recommendation and Implementation:

Implementation:

First, city inspectors and code officials must familiarize themselves with distributed generation technology through numerous courses and other sources. The Rebuild America program provides speakers and consultants with expertise in this area. Applicable codes and standards are being summarized in a set of volumes on distributed generation that should be available in the near future. These volumes are a joint publication of PTI and DOE.

For distributed generation systems, the following technologies are eligible for program funding, provided that they meet certain efficiency and environmental specifications:

- Microcogeneration
- Gas Turbines
- Fuel Cells
- Reciprocating Internal Combustion Engines
- Electricity Storage (other than for eligible solar energy systems)

LONG TERM STRATEGIC AND TECHNOLOGICAL RECOMMENDATIONS

LONG TERM PLANNING:

The findings of the participants resulted in numerous recommendations for long term planning the City of Boston.

- The city should develop a public education and outreach program encouraging private use of photovoltaic and energy efficiency measures.
- The city should develop a renewable energy application criteria in conjunction with the Massachusetts ' Renewable Energy Portfolio
- Critical Energy Infrastructure
- Secure funds from Public Benefits Funds from the State as well.

Education and Outreach:

Discussion:

The city should also develop an education and outreach campaign, including the local media, brochures, and videos, to explain the advantages, costs and applications of photovoltaic, passive solar, and distributed generation for residential use. Seattle has also used a media campaign to promote energy awareness and conservation with excellent results.

The city's use of these technologies will also demonstrate to residential users the viability of these technologies.

Recommendation:

The ETF members emphasize the importance of education and outreach programs as key elements of any energy conservation, energy management, and energy awareness program.

Implementation:

The City of Boston already has education and outreach programs within the public schools. These programs may be expanded to include energy the entire public sector. PTI will supply technical reports from other local governments that have established this type of program.

Renewable Energy Portfolio:

- The state of Massachusetts has a statewide renewable energy portfolio. It is available on the state's website.

Recommendation:

The ETF members recommend that the city investigate the use of photovoltaic with the ultimate goal of becoming a net supplier of electricity.

Implementation:

In addition, we recommend referring to the Database of State Incentives for Renewable Energy (DSIRE) at http://www.dsireusa.org/ for federal and state rebate and incentive programs for the installation of photovoltaic technology.

Wind:

Wind generation of electricity is another form of distributed generation that the city should consider. As with photovoltaic, the upfront cost of wind power is high, so the payback period must be considered.

During the meetings, it was apparent wind power was not a high priority for the city. However, the use of wind power in an integrated renewable energy program should be considered. In fact, a combination of solar and wind power is recognized as one of the most consistent and inexpensive methods for generating electricity from renewable resources.

Wind should not be discounted as an energy source. There is over 17,000 MW of wind generation capacity installed, with some 3,500 MW installed in 2000. Germany alone has over 6,000 MW of wind generation capacity, and the United

States has nearly 2,600 MW. In Denmark, wind turbines are projected to produce just fewer than 50 percent of its electricity needs from wind by 2030. The U.S. DOE's Wind Powering America Initiative has set a goal of producing 5 percent of the nation's electricity from wind by 2020.

The potential for wind generation of electricity is virtually unlimited. Worldwide electricity consumption totals roughly 12,500 megawatt-hours (TWh) per annum. Wind energy potential is 50,000 TWh per annum, although a technically realistic estimate is about 20,000 TWh annually. Neither of the wind potential figures includes offshore potential.

The costs of wind generation are less than $0.05 per kilowatt (KW), and the DOE is working to reduce the cost to $0.025 per KW in 2002. This would bring the cost of wind-generated electricity in line with conventional power plants. Wind turbines are available in a number of sizes, from 250 watts to 1.65 MW, and may be combines and expanded as needed within a given wind farm.

Wind is a clean, unlimited resource for electrical generation, and is particularly effective when teamed with solar technology.

Recommendation:

The members of the ETF recommend that the city investigate the use of wind turbines to generate electricity, particularly in combination with other renewable resources such as solar.

Implementation:

Photovoltaic and wind power are mutually beneficial, and dual implementation of these energy sources is considerably more efficient and reliable than either technology alone.

Critical Energy Infrastructure:

Discussion:

Distributed generation provides a significant benefit to local government by providing alternative generating capacity in the event of a natural or anthropomorphic disaster.

The City of San Jose, recognizing the potential problems caused by earthquakes in the San Francisco Bay area, has developed a solar-powered emergency power station, allowing for cellular telephones to be charged and providing power for emergency services. The same station also will serve as a point for dispensing drinking water and other necessities.

Distributed generation should be considered as more than a potential energy conservation measure and revenue generator for the City of Boston. With recent events, distributed generation has become an important part of any disaster mitigation plan as the need for critical infrastructure security has become a paramount concern.

Recommendation:

The ETF members recommend that the City of Boston consider the use distributed generation technology as primary and/or secondary sources of electrical power. The ETF members particularly recommend that the city investigate the role of distributed generation in critical infrastructure security.

Implementation:

The Department of Energy's Emergency Operations Office is involved with Infrastructure Protection. During the last few months Emergency Operations staff have contacted each State Energy Office (SEO) about the services they offer including; maps of energy grids, draft vulnerability assessment checklist for each state, review of each state's energy emergency plans and they are preparing several CDs and a training video for each state about recovery after a disaster (the CD and videos are promised within the next ten days).

Site Visits:

City Hall:

An expedient lighting retrofit implementation project should be initiated as soon as possible. As a Rebuild America partner can request assistance from Lawrence Berkley Laboratory and a lighting business partner to assist with this venture. In addition, an education program for government employees to turn it off. A report on Office Plug Load from San Francisco is available from PTI. If computer equipment, printers and other office equipment are completely turned off recorded savings are $40,000 per month.

The HVAC equipment is in need of replacement, an air-conditioning unit that has to be cooled by a residential air-conditioning unit is not cost or energy efficient. Again Rebuild America can assist with information about the new equipment that us available and a leasing agreement or a municipal bond can pay for these retrofits. Also, a performance based energy efficiency retrofits by an energy savings companies (ESCO) should be explored. Again the National Association of Energy Savings Companies as a Rebuild America Strategic Partner can assist with this process. Attachment A is a description of a performance contract).

Employee Assistance Center (Maura change the name):

This aged building needs a total renovation of its electrical, mechanical systems and HVAC equipment that was a health hazard due to the asbestos. This building and one that were built in the same time period are perfect candidates for a performance contracting. The retrofits should include:

- Lighting
- Entire mechanical equipment replacement
- Entire HVAC equipment
- Refurbish of all office

SUMMARY: The City of Boston like most major cities in the US did not continue with energy conservations programs that began in the 1970s. As our country is in a nationwide deficit the second largest expenditure to its budget are utility costs. The recommendations of this report are the basis for beginning an energy conservation strategy and mutual participation by all its agencies is imperative.

ATTACHMENT A

PERFORMANCE CONTRACTING

Performance Contracting is a termed used in the energy and construction industry. It is a method of financing building and facility retrofit projects. Usually, it is considered a last-resort type of financing. In most cases a jurisdiction enters into a performance contract because a building retrofit is desperately needed; however, no funding is available. By entering into a Performance Contract, the contractor who will be performing the retrofit either finances the project or finds a lending institution to finance the project. How will the contractor or lending institution recover its investment? Typically when a government agency enters into a Performance Contract, the savings generated by the retrofit will be used to offset the cost of the investment. Reviewing the building's energy consumption and comparing the amount to a pre-established baseline calculate savings. Once the savings is determined, the jurisdiction will cut a check to the contractor on a monthly, quarterly, or annual basis until the debt is paid off.

Staff contacted several jurisdictions that have entered into performance contracts to solicit their input.

(Jurisdiction names have been removed.)

<u>Conclusion:</u>

Based on staff's research, there are a number of benefits and advantages to entering into a performance contract:

- If funding options have been reviewed and it has been determined that the jurisdiction cannot fund the project internally either through capital improvements or bonds, the only option is outside financing. By using the contractor or another lending institution to finance the project, the jurisdiction will not jeopardize its budget or its bond rating. In addition, the outside funding is less visible than bonds (which may or may not be a good idea).
- If the payback period is reasonable, then the retrofit could be seen as worthy investment. However, it is very important that the payback period is less then the warranty / life of the product(s) and building / facility.
- If the contract includes a combination of lighting and mechanical retrofits, the savings generated from the lighting retrofits will basically front the cost for the more costly mechanical retrofits that have longer payback periods.
- If, the jurisdiction is interested in standardizing lighting systems, mechanical systems, or building control systems across various buildings; using a performance contract to accomplish this is generally believed to be a good idea because:
  - The jurisdiction hires an expert
  - The partnership last for several years

    - The jurisdiction ends up upgrading all buildings at the same time
    - Maintenance is reduced dramatically for the first 2 to 3 years.
- The savings formula should be based on energy consumption, with an annual review that includes: an annual audit, annual reconciliation and a new baseline, then a jurisdiction may experience fewer problems during the savings reconciliation process.
- When the complete project is outsourced to a contractor and it does not go through all the internal reviews, in many cases design, implementation, and completion time are significantly reduced. Therefore, the energy savings are realized much sooner than if the project was completed internally.

However, there are numerous drawbacks and disadvantages to performance contracts, as discussed by all the jurisdictions. For the most part, the jurisdictions where the performance contracts have been in place for several years didn't believe performance contracts were a good idea. Sacramento County flat out stated that if the jurisdiction had any other option to obtain the funding for the project, it would not of used a performance contract. The drawbacks and disadvantages can be divided into 4 categories: financing / payback, little or no oversight of the project, monitoring / tracking savings and maintenance.

- Financing / Payback
    - The jurisdiction could acquire the financing at a much low rate than any contractor.
    - Usually the project ends up being more costly because it has a longer payback period than if financed internally or the work was performed internally.
    - One jurisdiction's philosophy is: if the contractor is making a profit, then government can certainly achieve the project for less.
    - Since the project is not completed with internal staff and resources, the jurisdiction will not see the results right away. The break-even point is farther away.
- Monitoring / Tracking Savings
    - A Performance Contract works by establishing baseline conditions. However, once the conditions change, i.e., adding a second shift, extending the building hours of operation, adding new electronic devices, etc., then this could ultimately invalidate the contract. Because every building changes constantly, the projected savings are never fully realized.
    - It's one thing to say that the jurisdiction will pay for the project with the savings. It's an entirely different story to reconcile the actual savings. It's becomes an accounting nightmare, according to several jurisdictions.
    - The jurisdiction must set up a tracking and monitoring system to properly account for energy consumption. There is <u>constant</u> monitoring. The jurisdiction must track all changes to the buildings

and report all changes to contractor. One jurisdiction was asked to install real-time meters that measure consumption on 15-minute intervals and another hired an independent third party to review the savings annually.

- The most important issue is how to address the constant changes that will be taking place in the building(s) for the term of the contract. This language must be part of the contract, and it is the most challenging to draft.
- In addition, because most staff is not familiar with the intricacies involved in tracking and monitoring the savings, the staff overseeing the Performance Contract have the added burden of constantly having to explain to other staff how the programs works.
- It appears that in the first couple of years, both the jurisdiction and the contractor are willing to try to resolve the "savings" issues. However, the longer the contract is in place, the more complicated it becomes to track and monitor savings and building changes. This becomes especially important when a building that starts as one function and is then converted into a different function altogether. For example, one building may start as a fire station in year one and may then be converted into a community center in year seven. The jurisdiction has changed the building's initial function, hours of operation, etc, and thus the building no longer has the same baseline and consequently the contract is no longer valid. Although the savings may no longer be valid, an obligation remains on the part of the jurisdiction to pay the contractor for the initial investment and the cost of financing the project.

- Control
  - Unlike projects done internally, with a performance contract, the jurisdiction has very little oversight or control over the project. The savings guarantee is for the overall performance of the building.
  - In addition, the contractor may recommend and/or install items that are not always considered "standard" building practices by the jurisdiction.
- Maintenance
  - If the jurisdiction completes retrofits for several buildings at one time, then the jurisdiction must be cognizant that the replacement equipment's life will all expire at roughly the same timeframe. For example, if a lighting retrofit was completed for 6 buildings, and the life of the lamps is 4 years, at the end of those 4 years most of the lamps will have to be replaced. The same thing can be said if all the chillers or boilers are replaced at the same time. Therefore, a jurisdiction will all be required to budget for the replacement items accordingly and well as the maintenance to replace the items.

Most jurisdictions are pleased doing the early years of the contracts, but the longer the performance contracts are in place, the more adamant the jurisdictions are that they would never enter into another performance contract.

SANTA ROSA, CALIFORNIA

PUBLIC TECHNOLOGY INC.

RECOMMENDATIONS AND REPORT OF PEER-TO-PEER EXCHANGE

FOR SANTA ROSA, CALIFORNIA

SUBMITTED BY: SHARRON BROWN, DIRECTOR

Public Technology Inc. (PTI) is the research and technology organization for the National League of Cities, the National Association of Counties, and the International City/County Management Association. PTI's mission is to bring the benefits of technology to local governments.

BACKGROUND:

Public Technology Inc. (PTI) is the research and technology organization for the National League of Cities, the National Association of Counties, and the International City/County Management Association. PTI's mission is to bring the benefits of technology to local governments.

The Urban Consortium, representing America's largest and most progressive cities and counties, serves as a catalyst for research and development of emerging technologies that can solve problems facing all local governments.

The Urban Consortium Energy Task Force of PTI identifies proven technologies and develops innovative ways to improve energy efficiency, promote the use of renewable energy resources, reduce local government utility expenditures and maximize opportunities for local economic growth through energy initiatives.

One of the most effective methods of providing sustainable solution information to a local jurisdiction is through a peer-to-peer technology exchange. During a peer-to-peer technology exchange meeting, UCETF members will travel to a local jurisdiction to assess the current energy management practices and provide recommendations for better energy management practices for the jurisdiction. These recommendations include short term and long term strategic and energy efficiency planning. PTI and the UCETF have worked in conjunction on these meetings for more than 25 years.

INTRODUCTION:

The City of Santa Rosa, California, a PTI member, requested assistance from PTI for technical assistance, due to energy supply and reliability issues within the entire state of California. In addition, in order to continue economic development a reliable power supply is essential.

Public Technology, Inc. (PTI), and members of its Urban Consortium Energy Task Force (UCETF) conducted a peer-to-peer exchange workshop in Santa Rosa, California on July 26 and July 27, 2001. The meeting was held as part of PTI's SWAT program, that was funded by the United States Department of Energy's (DOE) Municipal Energy Management Program (MEMP).

The City of Santa Rosa has demonstrated a commitment to energy conservation, and toward identifying and implementing proven as well as innovative methods to achieve this goal. The findings and recommendations of these SWAT meetings will provide a foundation upon which to build.

Participants from Santa Rosa included: Marc Richardson, Assistant City

Manager and, Ed Buonaccorsi, General Services Administrator and other local officials, elected representatives, and officials from nearby jurisdictions including Sonoma County.

UCETF members participating in the meetings included Deyanira Flores (Clark County, Nevada), Margaret Downey (Barnstable County, Massachusetts), and John Morrill (Arlington County, Virginia). UCETF member Mary Tucker (San Jose, California) and Kathy McLean-Pfeifer (Santa Barbara, California) related their experiences with photovoltaics via conference call.

Sharron Brown, Director of Energy Programs and Jeff Miller, Senior Manager, from PTI coordinated, provided information and will summarize this meeting as well.

This report summarizes the findings and recommendations resulting from the meetings and field trips. A more complete record of the meeting may be found in the "Minutes of the SWAT Meetings", attached to this report.

INITIAL INITIATIVES:

Santa Rosa has a number of success stories that should be highlighted. The majority of their municipal owned buildings have extensive use of fluorescent lighting, including, T-8, lighting, window film and the HVAC equipment and energy efficient motors for 25 buildings are centrally controlled. As a result of these measures, from 1994 to 1998, the city reduced its electricity budget for buildings from $600,000 to $450,000, a 25 percent reduction.

Another example of a success story is the Public Works Department, which includes streetlights, traffic signals, public transportation, and utilities. This department has been aggressive in reducing energy consumption. The city has purchased high-pressure sodium streetlights, with 14,000 in service currently, and 20,000 expected to be in service within the next few years. The city is also in the process of switching to green and red LED traffic signals. The combined energy bill for streetlights and traffic signals is $850,000, $250,000 of which is for traffic signals. Energy use in traffic signals has been reduced by 50 percent. The city is currently studying the use of inductive lamps for decorative streetlights. Public transportation is the single biggest consumer of energy in the city, but also has the highest percentage of vehicles fueled by alternative fuels among the city's overall fleet of 1000 vehicles. Fuel cells are being examined for future use in public transportation.

Santa Rosa has managed to reduce the energy bill for parking structures by 20 percent. This has been accomplished by reducing lighting in the structures, although this has raised some questions about public safety. For recreational facilities, the city is investigating the use of motion detectors rather than timers for lighting.

In the wastewater treatment area, Santa Rosa generates about one-third of the power required for its treatment plant from on-site cogeneration (methane generators). The facility still purchases about $1 million worth of electricity annually, so the cogeneration saves about $500,000 each year.

A new development is the pipeline to the Geysers geothermal plant. Currently under construction, the pipeline will deliver treated wastewater to recharge sections of the geothermal field, generating a conservatively estimated 85 megawatts (MW) of electricity. The pipeline will also be used to supply irrigation water to agricultural users along its route, such as vineyards. This will help to defray the cost of building and operating the pipeline. The operator of the Geysers, Calpine Corporation, is paying for about one-third of the cost of the pipeline, and all of the pumping expenses. Not only is this a potential revenue generator and, as discussed later, power source for Santa Rosa, the pipeline, more importantly, will eliminate discharge of treated wastewater to the Russian River.

These examples serve to illustrate the savings already realized by the city through relatively simple measures and without a formal energy management plan. The successes should be highlighted to generate support for further measures to reduce energy consumption and develop alternative sources of energy. Marc Richardson, Assistant City Manager, noted that by implementing further energy conservation measures, the city could possibly save energy equivalent to an additional power plant, based on what has already been saved.

DISCUSSION TOPICS AND SITE VISITS:

The findings of the SWAT meetings were made not only by the UCETF members, but also by city officials from the City of Santa Rosa. For example, Mr. Richardson noted from the outset that Santa Rosa does not have an energy management plan. Judy Lynch noted the lack of an energy efficiency policy built into the lending policy for housing and redevelopment.

Other findings from the meetings included that Pacific Gas and Electric (PG&E) is not particularly receptive to distributed generation technologies, probably due to a lack of familiarity with the technologies and net metering.

All participants noted that Santa Rosa has made progress toward greater energy efficiency, and that there seems to be support for further efforts toward energy efficiency and, perhaps, toward the city becoming a net energy supplier. The latter follows Mr. Richardson's suggestion to install photovoltaics (PV) in the downtown area, particularly on parking garages. The problem is that PG&E will need to agree to meter aggregation.

Findings of the field visit to city facilities and energy audit were also presented. These included that for City Hall, the only unobstructed flat roof is directly over the council; chambers. The Public Safety Building, with its pitched roof, could use PV for outdoor lighting purposes. The Finley Center and swimming pool could use PV and/or passive solar for water heating and for lighting. The Finley Center has awnings, helping to keep out direct sunlight, but the air conditioning is not zoned, resulting in cooling of sections of the building that are not in use. The same is true for interior lights. Exit signs in all public buildings are not LED. If these signs were LED, energy would be saved.

The use of parking structures as sites for PV installation is feasible since these structures are in sunlight during periods of peak electricity usage. The only drawback is that installation of PV would involve construction of awnings, which would increase the cost.

Vending machines are currently in operation 24 hours daily every day of the week. Installation of vending misers or simple timers would drastically reduce energy consumption.

Finally, the meetings noted that Santa Rosa is not a partner in the Rebuild America program.

SHORT TERM PLANNING RECOMMENDATIONS:

The findings of the participants resulted in the following Short Term- Strategic and Technological Recommendations:

- The city should become a partner in the DOE's Rebuild America Program.
- An energy audit
- The city should implement simple energy conservation measures.
- The city government and departments should form an interdepartmental cooperative team.
- The city should develop an Office of Energy Efficiency a public education and outreach program encouraging private use of photovoltaics and energy efficiency
- Distributed Energy Resources and current financing opportunities currently provided from the California Energy Commission.

SHORT TERM PLANNING:

Rebuild America:

The US Department of Energy's Rebuild America program began in 1994, which focuses "on energy-savings solutions as community solutions". Its "mission to accelerate energy-efficiency improvements in existing commercial, institutional and multifamily residential buildings through private-public partnerships created at the community level".

As a Rebuild America partner, Santa Rosa will realize many benefits. They will receive on-site technical assistance and training either within the community or at regularly scheduled national, regional, and state workshops. Rebuild America partnerships allow access to experts in the field of energy efficiency, renewable energy, and financing of energy efficiency and renewable energy projects. As a Rebuild America partner, various other levels of technical assistance and tools are available to the community partners as well. All of these resources are available to develop new energy efficiency initiatives within the community.

Recommendation:

The UCETF members recommend that the city become a partner in the Rebuild America program that will provide the city with numerous benefits and opportunities in energy management.

Implementation:

The City of Santa Rosa must first contact the Energy Efficiency and Renewable Energy Clearinghouse at 800-363-3732 for initial information about join the Rebuild America program. A program representative from the DOE Seattle Regional Office will provide additional information and guidance.

Energy Audit:

Information about an energy audit is another service available through the Rebuild America program. An energy audit will provide an inventory of the energy usage for the city's municipal buildings. It will also identify areas in which energy efficiency measures can provide reduction of energy consumption and energy savings. The results from the energy audit will then be used to develop a comprehensive energy management plan, which will reflect the city's priorities.

Recommendation:

The UCETF members recommend that an energy audit be performed by either a third part Energy Service Company (ESCO) or as part of the city's participation as a Rebuild America partner.

Implementation:

As a Rebuild America partner, the energy audit may be provided at no cost to the city. Alternatively, the city may request referrals of experts from PTI, the UCETF, the Green Building Council, or the Rocky Mountain Institute. Finally, PTI and its UCETF members can perform this audit as part of a peer-to-peer exchange. The results from the energy audit will then be used to develop a comprehensive energy management plan for the city.

Simple Energy Conservation Measures:

Energy may be saved through the use of some simple, yet effective, measures. For example, the City of Albuquerque has 300 soft drink machines. These machines consume about 15 kWh of electricity per day, or about $45.00 per month, yet for over two-thirds of the time, there is no one around to use the machines. By installing Vending misers, a commercial timer they cut their energy costs by 30% and the timer paid for itself within less then a 30-day period.

Recommendation:

The UCETF members recommend the City of Santa Rosa investigate simple, inexpensive ways to reduce energy consumption.

Implementation:

The Rebuild America program will provide numerous examples of simple and effective ways to reduce energy consumption. In addition, as a member of PTI and the UCETF, the City of Santa Rosa may avail itself of the many resources, case studies, examples, meetings, and peer exchanges where energy conservation and management are discussed. The city has already made great strides in this area, and clearly the commitment and resolve to further these efforts is present.

Discussion:

This report presents several recommendations stemming from the discussions and field trips during the SWAT meetings. While it is unlikely that all recommendations will be accepted or are practical, adoption of any of the recommendations will enhance the City of Santa Rosa's already commendable efforts in energy conservation, energy management, and energy awareness.

There are many resources available to the city, starting with the city's membership in PTI and the UCETF. This allows the city access to all members of the UCETF and their combined expertise, as well as access to MEMP publications compiled over the 21 years of the program.

Throughout this report, reference is made to the Rebuild America program. By becoming a Rebuild America partner, substantial additional resources will be made available to the city. This partnership will expedite the implementation of most of the recommendations made by during the SWAT meetings.

Appended to this report are the minutes from the meeting, as well as additional references available on-line. A list of vendors is also presented.

Interdepartmental Cooperation:

Discussion:

It was the recommendation of the SWAT team, that a group of the departments, who are responsible for energy expenditure, be formulated. This group will identify energy conservation opportunities, aggregation of electricity supplies and renewable energy applications. A unified city program of energy conservation and alternative energy sources demonstrates the viability of these programs to the public, encouraging private sector conservation and support for alternative energy sources.

Recommendation:

Based on their experience in their home jurisdictions, the UCETF members stress the importance of interdepartmental cooperation in energy management programs.

Implementation:

The City of Santa Rosa has already made considerable progress in energy efficiency and conservation programs within individual departments. To facilitate more inter-departmental cooperation between the departments with regard to energy issues, the city can improve communication and coordination through a centralized office, such as an Office of Energy Efficiency.

Office of Energy Efficiency:

Discussion:

The establishment of an Office of Energy Efficiency, in consultation with the city's design review board, that will be responsible for will be responsible for monitoring energy consumption and billings, designing and implementing an outreach program to educate the public and city officials on the methods, technologies, and benefits of energy conservation measures. Representatives from all relevant agencies within the government infrastructure, the general public and elected officials will provide input and feedback to this office. In addition, the Office of Energy Efficiency, based on the experiences of other jurisdictions, will implement programs that will generate savings from energy reduction that will fund the programs from within this office.

For example, simply by monitoring utility bills, the City of Albuquerque's Energy Management Office has saved over $300,000 annually due to errors in their utility bill charges. The office has also been instrumental in passing a solar access ordinance, promoting the use of passive and active solar, reducing CO emissions from wood burning stoves, and cutting utility costs through simple yet effective measures.

Recommendation:

The UCETF members recommend that the city establish an Office of Energy Efficiency to administer the city's programs in energy management.

Implementation:

A centralize, Office of Energy Efficiency which may consist of one to two staff persons initially is essential to implementation of a comprehensive energy program. The UCETF SWAT members that have established similar offices will provide a template and options for establishment of this office.

Distributed Energy Resources:

Discussion:

"Distributed energy resources (DER) refers to a variety of small, modular power-generating technologies that can be combined with energy management and storage systems and used to improve the operation of the electricity delivery system, whether or not those technologies are connected to an electricity grid. Department of Energy's Office of Power Technologies.

Other Distributed Generation Technology

Distributed generation technology such as micro turbines, combustion gas turbines, and fuel cells should be investigated for use by the City of Santa Rosa. These may be fueled with biogas or natural gas, and will provide uninterrupted, high-quality and highly reliable power.

Description of recommended DER applications:

Gas-fired Micro turbines: have been developed from aircraft power systems and turbochargers. They are available in sizes ranging from 30 to 400 kW generating capacity. Micro turbines are designed for continuous operation.

Combustion gas turbines: are also developed from aerospace technology. They are multiple stage units with larger capacity, which distinguishes them from smaller micro turbines. The units have relatively low installation costs, low emissions, and low maintenance requirements. The units have a low electric efficiency, which has limited their use to peaking and combined heat and power (CHP) use.

Fuel cells: contain no moving parts and provide a highly reliable and high quality source o power. The technology was first developed in 1839, but was put to practical use in the 1960's in the American space program. Fuel cells range in size from 5 to over 1000 kW. Several types of fuel cells are available, but they all share the same basic principle to generate electricity. The fuel cell consists of two electrodes separated by an electrolyte. A hydrogen rich fuel, such as propane or natural gas, is fed through a reformer, producing hydrogen, which is then fed into the fuel cell through the anode. Oxygen (as air) is fed into the cathode. A catalyst splits the hydrogen atom into a proton and electron. The positively charged proton passes through the electrolyte, while the electrons are routed through an external circuit, creating a direct current. At the cathode, the electrons combine with the protons (H+) and oxygen to produce water and heat. With water vapor as the only product, fuel cells are extremely desirable from an environmental perspective, and they are very efficient. A new type of fuel cell, utilizing proton exchange membrane technology is in development. Fuel cell manufacturers expect to be able to compete with more conventional technologies within two years. Fuel cells have been demonstrated for use on buses and in commercial and domestic applications.

Micro turbines, combustion gas turbines, and fuel cells generate heat that may be used in CHP applications, greatly enhancing the efficiency of the units. Table 1 provides a comparison of the different technologies.

Technology	Recip Engine: Diesel	Recip Engine: NG	Microturbine	Combustion Gas Turbine	Fuel Cell
Size	30kW - 6+MW	30kW - 6+MW	30-400kW	0.5 - 30+MW	100-3000kW
Installed Cost ($/kW)[1]	600-1,000	700-1,200	1,200-1,700	400-900	3,000-4,000
Elec. Efficiency (LHV)	30-43%	30-42%	14-30%	21-40%	36-50%
Overall Efficiency[2]	~80-85%	~80-85%	~80-85%	~80-90%	~80-85%

Variable O&M ($/kWh)	0.005 - 0.015	0.007- 0.020	0.004-0.01	0.003-0.008	0.0019- 0.0153
Footprint (sqft/kW)	.22-.31	.28-.37	.15-.35	.02-.61	.9
Emissions (gm / bhp-hr unless otherwise noted)	NO_x: 7-9 CO: 0.3-0.7	NO_x: 0.7-13 CO: 1-2	NO_x: 9-50ppm CO: 9-50ppm	NO_x: <9-50ppm CO:<15-50ppm	NO_x: <0.02 CO: <0.01

[1] Cost varies significantly based on siting and interconnection requirements, as well as unit size and configuration.
[2]Assuming CHP.
Table 1: Comparison of distributed generation technologies. From Distributed-Generation.com , Resource Dynamics Corp.

The economics of distributed generation technologies are dependent on the price of natural gas (the most common fuel), the price of conventionally generated electricity, and the desired payback period. In the ideal situation for micro turbines, combustion gas turbines and fuel cells, gas prices should be low, and electricity prices high. This was the case recently in California.

Recommendation and Implementation:

Implementation:

First, City inspectors and code officials may familiarize themselves with distributed generation technology through numerous courses and other sources. The Rebuild America program provides speakers and consultants with expertise in this area. Applicable codes and standards are being summarized in a set of volumes on distributed generation that should be available in the near future. These volumes are a joint publication of PTI and DOE.

Second, The city should act immediately in preparing the appropriate grant applications for the current financing programs available from the California Energy Commission.

These grant programs are as follows: Current California Energy Comisison Programs:

The California Energy Commission currently has the following programs

available for financing: Solar Domestic Water Heating Systems

- Solar Swimming Pool Heating Systems
- Solar Swimming Poll Heating Systems
- Battery Backup (Electricity Storage) for Photovoltaic Systems

Up to $750 is available for eligible solar energy systems except swimming pool heating applications, which are eligible for a maximum of $250 per system. Up to $2,000 or 10 percent of the total system cost, which ever is less, is available for eligible distributed generation systems. A maximum of $750 is available for battery storage systems for Emerging Renewable Buy down Program participants. Funds may be reserved for one or more eligible solar energy or distributed generation systems. Multi-unit systems serving five or more single- family dwellings or separate business units that meet the Program eligibility requirements are eligible the lesser of (a) 50 percent of the maximum amount available on a per dwelling/unit basis, or (b) 25 percent of total eligible system costs.

For distributed generation systems, the following technologies are eligible for Program funding, provided that they meet certain efficiency and environmental specifications:

- Microcogeneration
- Gas Turbines
- Fuel Cells
- Reciprocating Internal Combustion Engines
- Electricity Storage (other than for eligible solar energy systems)

In addition, all solar energy and distributed generation systems must be as follows:

- Owned or leased by a California resident and operated within the State
- Purchased and placed in service on or after January 1, 2001
- Installed and operated in compliance with the approved Program guidelines and all applicable laws;and
- Covered by a three-year warranty

A minimum of $850,000 is available to fund eligible solar energy or distributed generation systems. Funds will be awarded on a first-come, first-serve basis until the available funds are exhausted. Of this amount, no more than 20 percent of the funds may be used for solar swimming pool heating systems, and no more than 20 percent of the funds may used for battery backup or electricity storage systems.

Emerging Renewable Buy Down Program:

The California Energy Commission offers cash rebates on installations of renewable-energy electric generating systems. Eligible technologies include photovoltaic (PV), small wind turbines, fuel cells that use renewable fuels, and solar thermal electricity systems.

LONG TERM STRATEGIC AND TECHNOLOGICAL RECOMMENDATIONS

LONG TERM PLANNING:

The findings of the participants resulted in numerous recommendations for long term planning the City of Santa Rosa.

- The city should develop a public education and outreach program encouraging private use of photovoltaics and energy efficiency measures.
- The city should develop a renewable energy application criteria
- Critical Infrastructure

Education and Outreach:

Discussion:

The city should also develop an education and outreach campaign, including the local media, brochures, and videos, to explain the advantages, costs and applications of photovoltaics, passive solar, and distributed generation for residential use. Seattle has also used a media campaign to promote energy awareness and conservation with excellent results.

The city's use of these technologies will also demonstrate to residential users the viabilities of these technologies.

Recommendation:

The UCETF members emphasize the importance of education and outreach programs as key elements of any energy conservation, energy management, and energy awareness program.

Implementation:

The City of Santa Rosa already has education and outreach programs in place for topics such as water conservation. These programs may be expanded to include energy. PTI will supply technical reports from other local governments that have established this type of program.

Renewable Energy Applications:

Photovoltaic:

The UCETF members identified other opportunities for installation of photovoltaic- sunlight to electricity. These items include:

- The Public Safety building, with its canted roof,
- The roof of the City Council chambers,
- The Finley Center pool and community center complex.

The SWAT Team also recommended that the city becoming an electricity aggregator for energy supply from photovoltaic for the central business district. For example, the City of San Jose has an aggressive solar program that should be examined. Also, in Albuquerque, the city has passed an ordinance guaranteeing homeowners access to sunlight. This encourages development of photovoltaic by residential consumers and should be considered in Santa Rosa as well.

Recommendation:

The UCETF members recommend that the city investigate the use of photovoltaic with the ultimate goal of becoming a net supplier of electricity.

Implementation:

Santa Rosa should pursue the PV buy down program that was offered by the California Energy Commission. In addition, we recommend referring to the Database of State Incentives for Renewable Energy (DSIRE) at http://www.dsireusa.org/ for federal and state rebate and incentive programs for the installation of photovoltaic technology.

Wind:

Wind generation of electricity is another form of distributed generation that the city should consider. As with photovoltaic, the upfront cost of wind power is high, so the payback period must be considered. However, the City of Santa Rosa should investigate the energy program of the City of Vallejo. Under its plan, Vallejo will become energy independent utilizing a combination of solar, wind, and biogas generation of electricity.

During the meetings, it was apparent wind power was not a high priority for the city. However, the use of wind power in an integrated renewable energy program should be considered. In fact, a combination of solar and wind power is recognized as one of the most consistent and inexpensive methods for generating electricity from renewable resources.

Wind should not be discounted as an energy source. There is over 17,000 MW of wind generation capacity installed, with some 3,500 MW installed in 2000. Germany alone has over 6,000 MW of wind generation capacity, and the United States has nearly 2,600 MW. In Denmark, wind turbines are projected to produce just fewer than 50 percent of its electricity needs from wind by 2030. The U.S. DOE's Wind Powering America Initiative has set a goal of producing 5 percent of the nation's electricity from wind by 2020.

The potential for wind generation of electricity is virtually unlimited. Worldwide electricity consumption totals roughly 12,500 megawatt-hours (TWh) per annum. Wind energy potential is 50,000 TWh per annum, although a technically realistic estimate is about 20,000 TWh annually. Neither of the wind potential figures includes offshore potential. Wind generation also has an advantage over other forms because 95 percent of the land used by a wind farm is available for other uses, such as grazing and farming.

The costs of wind generation are less than $0.05 per kilowatt (KW), and the DOE is working to reduce the cost to $0.025 per KW in 2002. This would bring the cost of wind-generated electricity in line with conventional power plants. Wind turbines are available in a number of sizes, from 250 watts to 1.65 MW, and may be combines and expanded as needed within a given wind farm.

Wind is a clean, unlimited resource for electrical generation, and is particularly effective when teamed with solar technology.

Recommendation:

The members of the UCETF recommend that the city investigate the use of wind turbines to generate electricity, particularly in combination with other renewable resources such as solar.

Implementation:

Photovoltaic and wind power are mutually beneficial, and dual implementation of these energy sources is considerably more efficient and reliable than either technology alone. The City of Vallejo is relying on this pairing, along with biogas, to become energy independent. Santa Rosa should study the Vallejo example, and in consultation with outside sources (Rebuild, PTI, UCETF) determine of wind is a viable addition to a sustainable, renewable, energy program.

Critical Infrastructure Security:

Discussion:

Distributed generation provides a significant benefit to local government by providing alternative generating capacity in the event of a natural or anthropomorphic disaster.

The City of San Jose, recognizing the potential problems caused by earthquakes in the San Francisco Bay area, has developed a solar-powered emergency power station, allowing for cellular telephones to be charged and providing power for emergency services. The same station also will serve as a point for dispensing drinking water and other necessities.

Distributed generation should be considered as more than a potential energy conservation measure and revenue generator for the City of Santa Rosa. With recent events, distributed generation has become an important part of any disaster mitigation plan as the need for critical infrastructure security has become a paramount concern.

Recommendation:

The UCETF members recommend that the City of Santa Rosa consider the use distributed generation technology as primary and/or secondary sources of electrical power. The UCETF members particularly recommend that the city investigate the role of distributed generation in critical infrastructure security.

Implementation:

The Department of Energy's Emergency Operations Office is involved with Infrastructure Protection. During the last few months Emergency Operations staff have contacted each State Energy Office (SEO) about the services they offer including; maps of energy grids, draft vulnerability assessment checklist for each state, review of each state's energy emergency plans and they are preparing several CDs and a training video for each state about recovery after a disaster (the CD and videos are promised within the next ten days). Also, they will also hold distant learning 2-day training course and a 5-day training course in mid-May for each state as well. The California Energy Commission can be reached at either 1516 Ninth Street, MS-#32, Sacramento, CA 95814 or by phone-916-654-4287 or website; http: www.energy.ca.gov.

MOHOWK COMMUNITY HOUSING

PUBLIC TECHNOLOGY, INC.

Mohawk Community Housing

PTI

Introduction

"Of all the elements of creation, at this time and place in history, we human beings have the power to directly impact and affect the continuing existence of our Mother Earth and other beings. We can choose to think only in terms of human needs and wants, or we can make other choices."

— Taiaike Alfred, *Words That Come Before All Else*

This quote embodies the status of our society's relationship with our environment. We live in an age of advanced technological capability, which can help or impede preserving a world and environment that is struggling to survive. The use of different forms of energy has had a noticeable affect on our environment, particularly when posterity has not been considered. Using technology and knowledge as our tools we can choose to protect something larger than any human being or corporation: the environment and Earth.

In the winter of 1998, the Haudenosaunee people experienced a tremendous hardship. A strong winter storm destabilized transmission lines that provide electric power for the Haudenosaunee people. Among the building complexes affected by the power outage was Mohawk Community Housing (MCH) including the Senior Center, Iroquois Village, and the Mohawk Housing units. These units were without electricity and heat for nearly three weeks. Lazoure, head of Mohawk Community Housing, ex-pressed her concerns regarding the energy issues of the Haudenosaunee people and the ability to react to energy needs in a crisis. Carol Lazoure sent a proposal to Sharron Brown, Director of Energy Programs at Public Technology, Inc. (PTI), to aid in alleviating these energy concerns. A peer-to-peer technology exchange visit was determined to be the most appropriate strategy to develop specific technological recommendations.

Acknowledgement

This meeting was a coordinated effort between Lazoure, the Mohawk Community Housing Authority and the Haudenosaunee people, and PTI staff that included Brown and Daniel Feltes along with Urban Consortium Energy Task Force (UCETF) members. The members of the UCETF were; Glenn Coontz, Albuquerque, NM, Larry Blackstad, Hennepin County, MN, and John Deakin, San Francisco, CA. The UCETF provided valuable insight on the various energy issues confronting the MCH and provided technological and strategic recommendations that can be of use to the Mohawk Community Housing and the Haudeosaunee people. PTI staff and the UCETF found the generosity and hospitality of the Hadensaunee people, refreshing, particularly Lazoure, who put forth great efforts in arranging the visit.

Background

Public Technology, Inc. (PTI) is a not-for-profit organization founded in 1971. It is the technology research, development and commercialization arm of the National League of Cities (NLC), the National Association of Counties (NACo), and the International City/County Management Association (ICMA). PTI's mission is to bring the benefits of technology to local governments.

The Urban Consortium, representing America's largest and most progressive cities and counties, serves as a catalyst for research and development of emerging technologies that can solve problems facing all local governments.

The Energy Task Force is one of five task forces in the PTI Urban Consortium. Membership is composed of local government officials from America's largest urban centers. For two decades, the Urban Consortium Energy Task Force (UCETF) has been a leader in developing and testing energy solutions, sharing the knowledge with local governments across the globe. The UCETF has received funding in part from the U.S. Department of Energy's Municipal Energy Management Program (MEMP).

The UCETF identifies proven technologies and develops innovative ways to improve energy efficiency, promote the use of renewable energy resources, reduce local government utility expenditures and maximize opportunities for local economic growth through energy initiatives.

One of the most effective methods of providing sustainable solution information to a local jurisdiction is through a peer-to-peer technology exchange. During a peer-to-peer technology exchange meeting, the UCETF members will travel to a local jurisdiction to assess the current energy management practices and provide recommendations for better energy management for the jurisdiction. These recommendations may be in the form of a complete audit and/or short-term and long-term strategic planning. This specific meeting was funded through MEMP. PTI and UCETF have worked in conjunction on these meetings for more than 21 years.

After observing the energy provisions and practices of Mohawk Community Housing (MCH), the UCETF developed technical and strategic recommendations that can be considered by MCH and the Haudenosaunee people.

Strategic and Technological Recommendations:

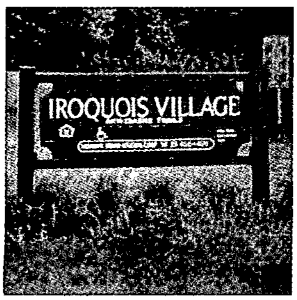
- Short-term strategic planning for MCH
- Long-term strategic planning for MCH
- Short- and long-term strategic grid
- Technical reference section
- Addressing the power needs of the Haudenosaunee Community

Short-term Strategic Planning:

- Emergency measures (back-up power generation for MCH)
- Short-term energy efficient strategies for MCH

Mohawk Community Housing Emergency Energy

The recommendation for a long-term energy solution is to transition from electric to natural gas energy. Because of time constraints, it



is unlikely that logistical arrangements for natural gas can be made by winter. Therefore, the transition to natural gas could be part of a five-year, long-term capital plan. An on-site diesel- or gas-powered generator is the most suitable for emergency measures for the upcoming winter and beyond. A helpful exercise in determining the appropriate source of generation is to take the number of days the community was out of power the last five winters and divide that number by five. If the community was out of power an average of 3-4 days then acquire diesel generation and stand. If the community was out of power near 8-10 days per year then pursue natural gas generation. The recommended short-term response is to acquire a diesel powered generator for the upcoming winter.

The most substantial advantage of having a diesel-powered generator is the on-site benefits. Energy is not delivered over a long distance and is a more consistent and cheaper source of power. On-site energy generation creates greater energy independence and flexibility, especially in cases of power outages.

The first step in this process would be to hire an engineer to do an appropriate load analysis. The UCETF roughly estimates that a 500-800 KW diesel generator would supply the appropriate levels of back-up energy generation for Mohawk Community Housing. This generator should run off approximately an 8,000-gallon diesel tank. Also, used generators are cheaper and are in abundance after the Y2K New Year. It should have a vaulted storage tank placed above ground on a cement slab and inside a shed, or with some sort of roofing. Above ground tanks subtract from maintenance costs and diminish the risk of ground-water pollution from leakage. Underground distribution lines should be connected to each unit. It is advisable to check with FEMA as a possible funding source for these emergency measure activities. The Department of Defense's surplus disposal of excess equipment and funding is another possible funding source. In addition, almost every federal agency has an Indian Affairs component that can assist in finding resources.

It is always advisable to have two different sources of heat for a building. This is advantageous in cases of emergency, and can be used to reduce energy expenditures. The 80 units in Mohawk Community Housing would use approximately one-eighth of their electricity for heating. One could reduce the load-size to 250 KW by using pellet stoves for a few days. It takes approximately 50 watts to run a pellet stove versus 5,000 watts to operate electric heat. The incorporation of pellet stoves or furnaces not only decreases heating loads, but also provides a secondary source of heating.

Anywhere from 40 to 70 pellet stoves could be used for the 80 units. Each pellet stove costs $650 to $1,500 depending on the design and the manufacture date. There will be an initial capital cost of $150 to install the standard ventilation for each stove. To heat 2,000 square-feet a pellet stove needs 25 to 30 pounds of pellets a day. A 40-pound bag of pellets will cost $2.50 to $3. Pellets can also be purchased in aggregate quantities. One ton of pellets will cost $130 to $160. Pellet stoves are not completely enclosed, and it is suggested that they not be used in the Senior Center. HUD and FHA should be able to assist Mohawk Community Housing in these matters. If pellet stoves cannot be operated in the Senior Center one could incorporate the use of pellet furnaces. A pellet furnace will cost $2,000 to $3,500 depending on the design and the manufacture date. Pellet stoves are generally more manageable than pellet furnaces, which have the tendency to over-heat an area and are less energy efficient. A pellet furnace will burn 50 to 75 pounds of pellets a day in comparison to 25 to 30 pounds of pellets by the pellet stove.

It is suggested that pellet stoves and furnaces not be used as the primary source of heating. They also require proficient operation and maintenance. Pellet stoves and furnaces must be continually fed pellets throughout their operation. Clogged and dirty augers are the main source of problems with the operation of pellet stoves and furnaces.

The UCETF recommends the use of pellet stoves and/or pellet furnaces in conjunction with a diesel-powered generator as part of MCH emergency measures strategy. The long-term solution is to transition to natural gas and/or a natural gas generator. As mentioned earlier, time constraints have affected the probability that natural gas lines and a natural gas generator will be available to MCH for the coming winter. However, it is advocated that a natural gas generator be included as part of a long-term capital budget.

The tables below illustrate the approximate prices of the various emergency and back-up power methods as well as the cost for natural gas energy generation.

Emergency Measures and Mohawk Community

Housing Energy—Short Term

Item or Service	Approx. Number	Approx. Price
New or Used Diesel Powered Generator-(500-800 KW)	1	$25,000-$50,000
Installation, Dist. Lines, and Delivery of the New or Used Generator	1	$20,000-$35,000
8,000 Gallon Vaulted Diesel Tank	1	$13,000-$15,000
Pellet Stoves and/or Pellet Furnaces	40-70	$26,000-$50,000
Installation and Standard Ventilation Of Pellet Stoves and/or Furnaces	40-70	$6,000-$10,500
Total Approximate Price		**$90,000-$160,500**

Emergency Measures and Mohawk Community Housing Energy—Long Term

500 KW Natural Gas Generator System (Including Installation, Dist. Piping, and Delivery)	$205,000-$235,000
800 KW Natural Gas Generator System (Including Installation, Dist. Piping, and Delivery)	$270,000-$300,000

The following links give more detailed information on the functions, acquisition, and operation of gas generators and pellet stoves and furnaces.

Special note: PTI and the UCETF do not specifically endorse any of the following companies.

Diesel and Natural Gas Generators:

- US-Generator – www.us-generator.com
- A/C Energy Systems – www.acenergy.com
- Lister-Petter Inc. – www.lister-petter.com
- Independent Power Systems – www.independentpower.com

Pellet Stoves and Pellet Furnaces:

- Sustainable Agricultural Network – www.sare.org
- Dell-Point Technologies Inc. – www.pellet-stove.com
- Hearth Products – www.hearth.com
- American Energy Systems – www.magnumfireplace.com

Short-Term Energy Efficiency Strategies for Mohawk Community Housing

During the UCETF's visit to MCH, the UCETF actively analyzed the facilities in the context of energy efficiency building materials, practices, and strategies. The UCETF made several on-site observations and identified areas of opportunity for greater energy efficiency for MCH. Here are some immediate strategies that MCH can use to produce greater energy efficiency.

Landscaping – The landscaping surrounding a building can greatly enhance a building's energy efficiency by protecting it from cold winds in the winter, and properly shading it in the summer. These factors reduce the burden on air conditioning and heating systems and therefore increase their thermal performance and energy efficiency and lower energy costs. It is the UCETF's understanding that winter winds come from the west in the Akwasasnee area. Therefore, thick evergreen trees can be planted on the west side of buildings to protect against the cold winter winds. Deciduous trees that lose their leaves in winter could be planted sparingly on the sides of buildings that receive a great deal of sunlight. These trees will shade buildings from the hot summer sun and lose their leaves in winter and allow the sun to help warm buildings. Many of the buildings in the Mohawk Community Housing, including the Senior Center, could be improved through the incorporation of this strategy. It has also come to the attention of the UCETF that there is an annual youth tree-planting program in the Haudenosaunee Community. This program could be optimized in aiding in the energy efficiency and beauty surrounding MCH.

Lighting in Commons Area of the Senior Center: The Senior Center common area is over-illuminated. An adjustable 35-watt fluorescent circular lampiere would be a cost-effective, short-term solution for greater energy efficiency in the lighting of the common area. For more technical information on lighting go to the Technical Reference Section.

Possible Earthquake Damage: Recent earthquakes affecting the Akwasasnee area may have damaged the roof framing of the Senior Center. The UCETF observed a couple of roof beams that appear to be off-line. There have been noted troubles with the roof and framing of the Senior Center. The UCETF recommends the roof be inspected.

Other Senior Center Roofing Concerns: The UCETF observed that the building design included a fan that runs the ventilation through soffits and a charcoal filter. All of the above should be thoroughly examined and investigated because the roofing appears to lack adequate ventilation. These conditions contribute to ice build-up on the roofing during the winter. The UCETF also observed stains on the roof that may be of concern and inspected for possible water and/or other damages. It is imperative that the soffit on the Senior Center gets fixed.

Ventilation Shutters: The ventilation shutters in the ceilings of the Senior Center were observed to be dirty and impaired. Clogged ventilation or ventilation shutters result in an increased burden on heating and air conditioning units, therefore drastically lower energy efficiency. A solution to this problem is the simple cleaning of each shutter.

Windows: The windows of the housing units in MCH and the Iroquois Village were observed to have substantial water vapor. A window without an adequate moisture barrier is an indicator of a window's inefficiently. Most window manufacturers provide for a 15- to 20-year warranty on their windows (i.e. Pella Windows). The windows at MCH do not protect against water vapor and therefore could be replaced immediately if under warranty. The new windows could be vinyl edged for greater energy performance. For more technical information on windows go to the Technical Reference Section.

Refrigerators: It was brought to the attention of the UCETF that MCH plans to purchase refrigerators in the near future. The Environmental Protection Agency (EPA) EnergyStar-labeled refrigerators can save a consumer 30 percent or more on the energy operation costs in comparison with a non-EnergyStar refrigerator. This also holds true for EnergyStar-labeled office equipment, washers, dryers and other appliances. MCH could attempt to get involved NARO with aggregate purchasing contracts. The New York State Housing finance corporation may also be able to help with aggregate purchasing contracts in this, and many other areas. For more technical information on EnergyStar-labeled appliances go to the Technical Reference Section.

- Transition to natural gas energy and strategic recommendation for the 10 new units
- Long-term planning for retrofit on existing buildings in MCH

Long-Term Strategic Planning for MCH:

Transition to Natural Gas Energy and 10 New Housing Units

As mentioned earlier, an excellent long-term goal for MCH is acquire energy through natural gas. A new natural gas generator and system will have an initial capital cost of $205,000 to $300,000, variable upon size. Sources of natural gas and distribution networks could also be explored (i.e. line under bridge). An expected result of natural gas energy is greater energy efficiency and therefore a more sustainable local environment.

The UCETF recommends that MCH consider organizing, budgeting, and planning a five-year capital plan to address many of the energy concerns expressed to and observed by the UCETF.

The area of greatest opportunity for energy efficiency lies in the initial capital development of new buildings. Retrofitting new and advanced energy efficient technologies and strategies to existing buildings is quite expensive, but the incorporation of these strategies and technologies in the initial capital development of a new building pays huge dividends. The development of 10 new housing units for MCH provides for an excellent and exciting opportunity for an energy efficient and environmentally sustainable building design. Listed below are a few recommendations developed by the UCETF to be considered by MCH in developing the 10 new housing units.

Duplex design: The shared wall design of duplex housing results in greater energy efficiency and thermal performance. MCH could possibly develop five duplexes to meet their housing needs.

Geothermal or ground-source heat pumps: The weather conditions in the Haudenosaunee area are typically cold and wet, optimal for effective incorporation of ground-source technology. Geothermal technology can save buildings more than 50 percent of energy costs on heating and cooling. Geothermal technology is very expensive, even when incorporated in the initial design. However, the initial capital costs for ground source technology is recouped in energy savings. For more detailed information on geothermal technology go to the Technical Reference Section.

Lighting and Daylighting Strategies: Daylighting strategies maximize the power of the sun and limit daytime electrical lighting and energy use. Skylights would probably be the most appropriate strategy to incorporate in the design of the new housing units. When using electric lighting, T-8 fluorescent lights with electronic ballasts are the most energy-efficient lighting in the market today. For more detailed information on lighting go to the Technical Reference Section.

Windows: Inert gas-filled windows that have low-conductivity window frames made of "vinyl" with thermal breaks are among the most energy-efficient window designs in the market. While competitively priced, these windows provide for optimal thermal performance and energy efficiency. For more detailed information on window technology go to the Technical Reference Section.

Siding and Insulation: Vinyl siding is the most cost-effective, suitable, and energy-efficient siding for the climate of the Haudenosaunee area. It is the understanding of the UCETF that neighborhood games may damage vinyl siding. The selection of siding, building materials and insulation should meet the optimal R-values (insulation values) for the given cold and wet environment. TyVek vapor seals with 6 inches of fiberglass insulation may be appropriate. To get more information on insulation and siding go to the Technical Reference Section.

Long-Term Planning for Retrofit on Existing Buildings in Mohawk Community Housing

Extra phone jacks: It may be a good idea to install extra phone jacks in the new housing units to accommodate possible Internet use.

Long-term strategies should be implemented as part of a five-year capital plan. The following recommendations were drawn from on-site observations made by the UCETF on the condition of the Iroquois Village housing units, Mohawk Housing units, the Senior Center, and the MCH office. It is important to think in the context of all resources with the inclusion of offices and housing when considering capital energy improvements. The following recommendations are financially low-tech, and in a five-year capital plan of retrofitted technology, very feasible.

Heat tape: Running a heat tape in the back of the Senior Center across the roof could alleviate some of the ice and snow buildup problems the Senior Center has experienced. A heat tape can adequately warm a roof so that ice and snow buildups on roofs and in gutters become virtually non-existent. This strategy prevents downspouts from becoming clogged intensifying the problem. Serious structural damage may result when melting snow penetrates under the roof surface. A heat tape draws approximately 300 watts.

Replace Senior Center Roof: The replacement of the entire roof may be considered as part of a five-year capital budget by MCH. The new roof should be 4-10, which is a good pitch for the geographical location. MCH can also put a heat tape in the drain areas to keep the drains unclogged.

Replace Siding on Senior Center: The cladding of the Senior Center is virtually deteriorated. It is advisable that MCH switches from T-111 fiber cladding, which deteriorated quickly, to vinyl siding to improve the building's thermal performance and the durability of the cladding.

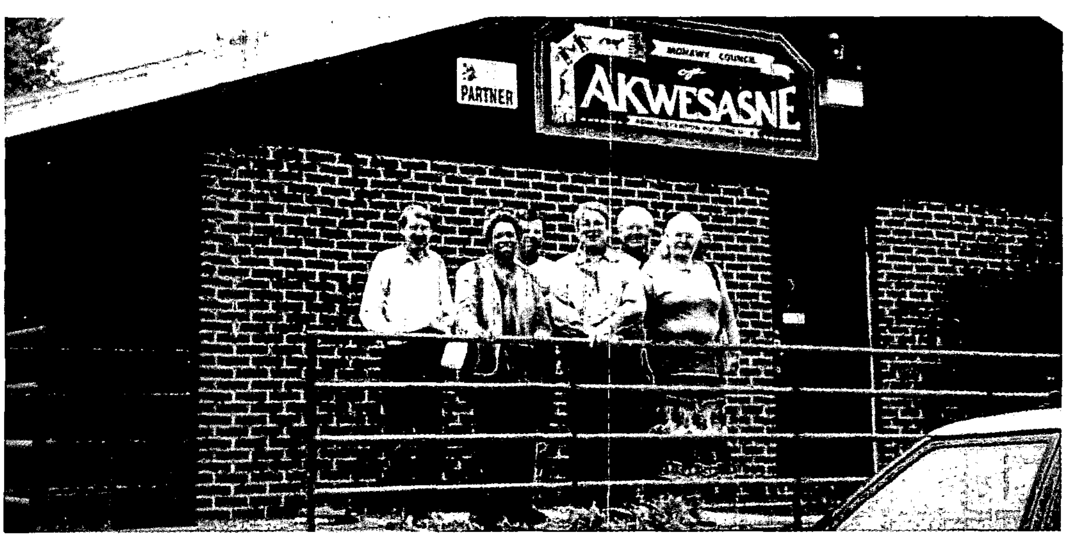
Reflective Barrier: A reflective barrier could also be retrofitted to the Senior Center to improve its thermal performance.

Insulation: The UCETF recommends the incorporation of 6 inches of fiberglass insulation to improve the buildings R-values. Vinyl with a TyVek vapor seal would increase the walls' R value to R=26. An R value of 26 through the methods proposed above is a relatively high insulation value at a relatively low strategic price. For more information about insulation go to the Technical Reference Section.

Air Conditioning: Air conditioning can drastically improve the comfort of a building, especially for the elderly. The UCETF recommends installing AC sleeves in each unit. Each sleeve can be engineered to reduce leakage, and increase the efficiency of the air conditioning system.

Comprehensive Switch to T-8 Electronic Ballast Lighting: A comprehensive replacement of all the lighting in the offices and housing units of MCH to T-8 electronic ballast lighting will cut total energy costs by up to 22 percent. The Department of Energy may provide funding for the aggregate purchasing of T-8 electronic ballast lighting. For more information about lighting technologies go to the Technical Reference Section.

Solarium Development: The development of a solarium in the front of the Senior Center is an excellent idea for several reasons. First, the glass from the windows that will be replaced in the Iroquois Village and Mohawk Housing units could be recycled in the production and formation of the solarium. Secondly, natural daylighting within the solarium eliminates the requirement of electrical lighting and further electrical burdens. Finally, a solarium strategically placed in the front of the Senior Center will draw the residents to that space to congregate, and therefore reduce the electrical lighting burdens in other areas (i.e. common area).



Short- and Long-Term Strategic Grid

Short-Term Strategies	Long-Term Strategies
Diesel Generator for Back-up Power	Natural Gas Generator
Pellet Stoves and/or Pellet Furnaces	Natural Gas and Independent Energy Exploration
Strategic Landscaping	Energy-Efficient Duplex Design and Insulation in New Housing Units
35 Watt Fluorescent Circular Lampiere to be place in Commons Area Electronic Ballasts	Comprehensive Replacement of Lighting to T-8 Fluorescent
Fix Roofing Soffit on Senior Center	Replacement of the Roof on the Senior Center
Heat Tapes on Roof and in Drains	Heat Tapes on Roof and in Drains
Clean Ventilation Shutters in Housing units and especially Senior Center	Reflective Barrier in the Senior Center
EnergyStar Refrigerator Purchasing Cladding of the Senior Center	Replacement of Insulation and
Replacement of Windows in Iroquois and Mohawk Housing Units (Warranty?)	Energy-Efficient Windows in New Housing Units – Skylights
	Solarium in front of the Senior Center
	Explore Use of Geothermal for New Housing Units

Technical Reference Section

Each of the technical categories below contains brief bulleted descriptions of the given technologies described in this report, along with informative Website links and manufacture links. *Special Note: PTI or the UCETF does not specifically endorse any of the following companies*

1. Energy-Efficient Window Technologies
2. Energy-Efficient Lighting Technologies
3. Insulation Technologies
4. Pump Systems (including Geothermal Heat Pumps)
5. Energy-Efficient Office Equipment
6. Directory of Energy-Efficient Building Technology Links

1. Energy-Efficient Window Technologies:

- **Warm-Edge Windows:**
  - Low-conductivity material (typically an aluminum edge-spacer) is used around the perimeter to the separate the slides of glass and to prevent heat transfer of air and moisture in and out on the inter-glass cavity
  - Reduces wintertime heat-loss, reduces condensation at the bottom of glazing units, and reduces summertime solar heat gain, increasing the energy efficiency of a building and reducing operational costs of heating, ventilating, and cooling
  - Warm-edge spacers reduce the thermal stress on the glazing and therefore increase the durability and life of the window
  - Applicable to any building
  - New technology; higher initial cost
- **Inert Gas-Filled Windows:**
  - Most windows have a sealed glazing unit which consists of two or more slides of glass
  - The gas which fills the inter-glazing cavity is influential in affecting heat loss
  - The use of inert gas (argon or krypton) can significantly reduce window heat transfer
  - Reduction in wintertime heat loss and in summertime conduction heat gain
  - Applicable to any building; increases the energy efficiency of heating, ventilating, and cooling systems
- **Low-Conductivity Window Frames (made from vinyl):**
  - Window frames account for half of a window's heat and energy loss
  - In metal window frames there is a thermal break that is usually 3mm to 12mm wide and improved low-conductivity frames have thermal breaks anywhere between 15mm and 70mm and are made of vinyl – instead of liquid urethane or nylon
  - Use of fiberglass in the overall window frame
  - Reduces wintertime heat loss, summertime solar heat gain, and interior condensation
  - Higher initial cost, and may not comply with certain fire codes in certain areas

Manufacturer Links:

Accurate Dorwin	www.accuratedorwin.com
Thermotech Windows Ltd	www.thermotechwindows.com
Kawneer	www.kawneer.com
Visionwall	www.visionwall.com

Information Links:

Energy Efficient Windows Collaborative	www.energyefficientwindows.org
Enermodal Engineering Ltd.	www.enermodal.com
Energy-Efficient Residential and Commercial Window Reference Guide	www.canelect.ca
Tips for Daylighting with Windows	eetd.lbl.gov/BTP/pub/deignguide
Field Assessment of Daylighting Systems and Design Tools	www.nrcan.gc.ca
Advanced Green Building Technologies	www.advancedbuildings.org
Green Building	www.buildinggreen.com

2. Energy-Efficient Lighting Technologies:

- As noted earlier, the most energy efficient lighting is T-8 fluorescent lamps
- Compact fluorescent lamps use 75 percent less energy than standard incandescent bulbs and last 10 to 20 times longer
- T-5 fluorescents currently in development could prove to be even more energy efficient
- High intensity discharge (HID) lamps have an extremely long life and emit more lumens per fixture than do fluorescent; considered by many as the best source for energy-efficient adjustable and directional lighting
- Electronic ballasts are the most energy-efficient ballasts; these ballasts provide an energy savings over magnetic ballasts of up to 20 percent
- Electronic ballasts are easily interchangeable and can be incorporated into daylight control sensor systems
- Electronic ballasts are more energy-efficient because they operate at cooler temperatures (less waste); electronic ballasts also give off lower amounts of heat, thus decreasing cooling loads

Manufacturer Links:

Venture Lighting	www.venturelighting.com
Philips Electronics Ltd	www.Philips.com
Sylvania	www.Sylvania.com

Information Links:

Advanced Green Building Technologies	www.advancedbuildings.com
Greenlights Program	www.epa.gov/greenlights.html
United States Energy Information Administration	www.eia.doe.gov
Internet Community for Lighting Professionals	www.lighting.com
Illuminating Engineering Society Lighting Handbook	www.iesna.org
Lighting Search	www.lighting-link.com

3. Insulation Technologies (Structural and Exterior):

The following insulation technologies can, if applied properly, increase the energy efficiency of a building and its thermal comfort. Fiberglass is a common, low-tech and cheap, but fairly high-performing, insulator. The following technologies listed below are other insulating options in for building construction.

- **Insulating Concrete Forms (ICFs):**
  - May be used for above or below grade concrete walls
  - Consists of rigid plastic (expanded or extruded polystyrene) foam forms that hold concrete in place while it cures – lightweight, and results in durable energy-efficient construction
  - Drastically improves the R values of a concrete wall – (concrete is a horrible insulator)
  - Concrete and block foundations can be built to reach R values equivalent to ICFs, but will have overall additional cost and design difficulties
  - ICF walls provide higher R values, and lower air infiltration rates than typical wood frame construction
  - A good example of an air-tight wall system

Informational Links:

National Association of Home Builders Research Council	www.nahbrc.org
Insulating Concrete Forms Association	www.forms.org
Portland Cement Association	www.concretehomes.org

- **Structural Insulating Panels (SIPs):**
  - Same idea as ICFs, although applied to wood wall structures
  - The rigid foam cores are composed of expanded polyisocycanurate
  - Applicable to walls, floors, and roofs to generate energy efficiency and increase airtight levels
  - Excellent thermal performance and soundproofing, just like their counterparts—the ICFs

Informational Links:

National Association of Home Builders Research Council	www.nahbrc.org
Structural Insulated Panel Association	www.sips.org
R Values of Materials; Source:	www.nahbrc.org

Material, thickness	R-value per inch of material
EPS (ICF type) Foam, 4 inches	3.8-4.2
XPS (ICF type) Foam, 4 inches	5.0
Polyisocyanurate foam used in (SIPs), 4 inches	7.0
Fiberglass insulation, 3.5 inches	3.71
Concrete, 8 inches	0.0625

- **Exterior Insulation:**
  - EIFS (exterior insulation and finishing systems) are building claddings that offer improved thermal and moisture performance – thus greater energy efficiency
  - Applicable to any building type, increases insulation levels, reduces thermal bridging, reduces air leakage
  - Polystyrene exterior insulation sprays can only be used for buildings of four stories or lower due to fire codes; mineral-wool based EIFS (new technology) produces greater energy efficiency and can be applied to a building of any height

- The cost of mineral-based EIFS is competitive with steel stud and brick veneer claddings and creates drastically greater energy-efficient results

Manufacturer Link:

STO Corporation	www.stocorp.com

Informational Links:

Advanced Green Building Technologies	www.advancedbuildings.org
Exterior Insulation Finish Systems Industry Members Association	www.eifsfacts.com

4. *Benefits of Various Pump Systems* (Including Geothermal):

- Regular furnace and central air conditioning are used most frequently in the United States
- Boilers are the most common source of building heating
- Electric air-source heat pumps use the temperature difference between indoor and outdoor air to heat and cool inside air; EnergyStar-labeled electric air-source heat pumps will save approximately 15 percent to 20 percent on heating and cooling costs, according to the EPA
- Gas-fired heat pumps use natural gas as their primary source of fuel, but have considerably less pollution associated with their installation and can save a building 20 percent to 40 percent on heating and cooling loads if they contain the EnergyStar label, according to the EPA
- Geothermal, or ground-source, heat pumps take advantage of stable temperature conditions in the ground, and limitless supply of renewable heating and cooling energy that is stored to power HVAC systems; EnergyStar labeled geothermal heat pumps can save a building 30 percent to 40 percent on heating and cooling bills, according to the EPA

Geothermal Heat Pump Technology:

- Ground-source heat pumps replace the need for a boiler in the winter by utilizing heat stored in the ground; this heat is then upgraded by a vapor-compressor refrigeration cycle
- In hot conditions heat is rejected from the building and sent back into the ground
- Particularly applicable to buildings which require significant space or water heating
- Geothermal heat pumps require less mechanical room space, have quiet operation, emit no pollutants and use renewable energy, and substantially reduce the HVAC operating cost of a building
- Can save a building more than 50 percent of its heating energy costs in a colder climate
- Higher initial cost for the system and a higher design cost
- Geothermal heat pump technology could save a building up to 20 percent of its entire operating costs

EnergyStar-Labeled Geothermal Heat Pump Manufacturer Links:

Addison Products	www.Addison-HVAC.com
ECONAR Energy Systems Corp.	www.econar.com
ECR Technologies	www.ecrtech.com
Hydro-Temp Corporation	www.hydro-temp.com
Mammoth, Inc.	www.mammoth-inc.com
TETCO Geothermal	www.geoproducts.com/index.html
Trane Company	www.trane.com/res/res.html
WaterFurnace International	www.waterfurnace.com

Informational Links:

ASHRAE Commercial/Institutional Ground-Source Heat Pump Engineering	www.ashrae.org/book/bookshop.htm
Canadian Earth Energy Association	www.earthenergy.org
Geothermal Heat Pump Consortium	www.geoexchange.org
International Ground Source Heat Pump Association (IGSHPA)	www.igshpa.okstate.edu
Advanced Green Building Technologies	www.advancedbuildings.org
EPA Geothermal EnergyStar	www.epa.gov/appstar/hvac/geothermal
Residential Environmental Design	www.reddawn.com

5. Energy-Efficient Office Equipment:

- The use of energy efficient office equipment can save 50 percent on these operating costs, according to a variety of sources including the EPA
- Fax machines, photocopiers, printers, computers, and refrigerators are all areas of opportunity for energy savings
- New technology enables these machines to power down to less than 15 percent of normal energy usage when the machines are not being operated
- Best application is the EnergyStar-labeled equipment and appliances; EPA lists EnergyStar manufacturer partners on its Website as a comprehensive buyers guide and regional search engine

Informational Links:

EPA's EnergyStar Program	www.energystar.org
ACEEE Publications on Office Equipment	www.aceee.org
Advanced Green Building Technologies	www.advancedbuildings.org

6. Directory of Possible Green Building and Energy-Efficient Design Websites:

- www.energystar.gov – EPA's EnergyStar link and search application of technology that meets the EnergyStar energy efficiency qualifications
- www.advancedbuildings.org – Supported by not-for-profit research organizations, this Website provides information and application thereof, of more than 90 advanced green building technologies
- www.oikos.com – By far the most comprehensive search engine of manufacturers and distributors specifically designed for green building technologies
- www.sbicouncil.org – Sustainable Buildings Industry Council
- www.eren.doe.gov/buildings – Office of Building Technology with the Department of Energy; includes building loads analysis and system thermodynamics (BLAST) in the tools link, a directory of more than 190 energy-related software tools for buildings with an emphasis on using renewable energy and energy efficiency and sustainability in buildings
- www.wbdg.org/sustainability/energy.html – Whole Building Development Guide
- www.sustainable.doe.gov – Center of Excellence for Sustainable Development
- www.rmi.org – Rocky Mountain Institute
- www.usgbc.org – U.S. Green Building Council
- www.sustainable.org – Sustainable Communities Network

Conclusion: Addressing the Energy Situation of the Haudenosaunee Community

Public Technology, Inc. and the Urban Consortium Energy Task Force appreciates and empathizes with the unique social and political circumstances surrounding the Haudenosaunee community energy supply. This unique and complex situation is of profound concern to PTI and the UCETF. Federal deregulation of publicly owned utilities further compounds this predicament. PTI is a not-for-profit arbitrary organization that does not intervene in local political and social circumstances, but instead seeks to bring the benefits of technology and strategic information to local jurisdictions to empower jurisdictions and help provide information for decision-making processes. Other Native American communities have also gone through similar situations with their energy supply and energy prices. It may be helpful for the Haudenosaunee community leaders to converse with other Native American leaders who have faced similar challenges and barriers. This information exchange could aid the Haudenosaunee community leaders in their decision-making processes.

PTI and the UCETF would be delighted if Mohawk Community Housing and the Haudenosaunee community take the aforementioned technical recommendations and informative strategies under consideration. Hopefully these recommendations will lay the groundwork for constructive discussion and assist the Haudenosaunee people in being proactive toward their energy needs. It is not always easy to make the right decisions, but together we can strive to make a difference, and protect our Earth.

The UCETF would once again like to thank the Haudonesaunee people for their gracious and generous hospitality during our visit to the Akwasasnee community. A special thanks to Carol Lazoure for organizing a constructive and insightful visit.

If anyone has any questions, concerns, or clarifications regarding any of the information presented, please do not hesitate to contact Sharron Brown, Director of Energy Programs at Public Technology, Inc., at 202/626-2428 or via e-mail at sbrown@pti.org.

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KEEPING THE LIGHTS ON II

KEEPING THE LIGHTS ON II

GET READY FOR POWER MARKETING

Whether your local government is an electric consumer or an electric supplier, tune in to this debate. Seize short-term opportunities and protect your community's long-term interest.

A Primer for Local Governments on Utility Industry Restructuring and Competition

PUBLIC TECHNOLOGY, INC.

KEEPING THE LIGHTS ON II:

GET READY FOR POWER MARKETING

A Primer for Local Governments on Utility Industry Restructuring and Competition

PUBLIC TECHNOLOGY, INC.

Acknowledgments

Keeping the Lights On, Vol. II: Get Ready for Power Marketing is the second in an ongoing series of publications to help local governments understand and prepare for the vast changes taking place within the electric utility industry. The first publication, *Keeping the Lights On: A Primer for Local Governments on Utility Industry Restructuring and Competition,* introduces municipalities to the issues and options relating to these changes. A companion Resource Guide provides more in depth information and reprints of legislation and articles from five perspectives: federal government, state government, local government, private industry and public power, for those interested in more detailed information.

This volume explains the latest information concerning how electricity will be traded, bought, and sold and ways in which local governments can expect to function in this new market reality. It describes the fundamentals of load research and why it is important to understand your load profile in order to benefit from the competitive environment now unfolding. This information will enable readers to examine their own electricity usage patterns, and consider making changes to maximize their potential energy cost savings. Sections dealing with you, the Customer, the Producers and the Energy Traffic Controllers help explain the emerging structure that is taking the place of the former monopolistic, single-provider landscape.

PTI wishes to acknowledge the assistance of the following individuals and organizations who have contributed to this publication:

- Roger Duncan, Assistant Director, Environment and Conservation Services, City of Austin, Texas, and Vice Chair, Urban Consortium Energy Task Force;
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Urban Consortium Energy Task Force

Contents

Designed by AURAS Design.

Introduction

Electricity is a $200 billion market–and growing–in the United States. From the electric alarm clock that wakes us, through the hairdryer and coffee maker, to the home security system as we lock our door, we are consumers. From the traffic signals that guide us to work, the business transactions we conduct, the long work day and late hours, and finally, to the 11 o'clock newscast before we bed down under a toasty electric blanket, we depend on electricity.

As dependence on electricity increases at home, work and in our communities, the market for electro-technologies continues to grow. Although energy-efficient technologies lessen consumption for traditional uses such as lighting, heating and cooling, dependence on electricity increases for computers, robotics and telecommunications. Electricity permeates every facet of our lives.

This new volume in PTI's *Keeping the Lights On* series on Electric Utility Industry Restructuring and Competition discusses electric rate-making and how local governments can obtain the most attractive rates from competing suppliers. It describes the latest information on that competitive market, and defines "power marketers" and their role in the electricity marketplace.

Keeping the Lights On: Get Ready for Power Marketing, offers three perspectives: (1) you, the consumer, (2) suppliers and power marketers, and (3) the energy traffic controllers.

I. The Consumer

WHAT IS A CUSTOMER?

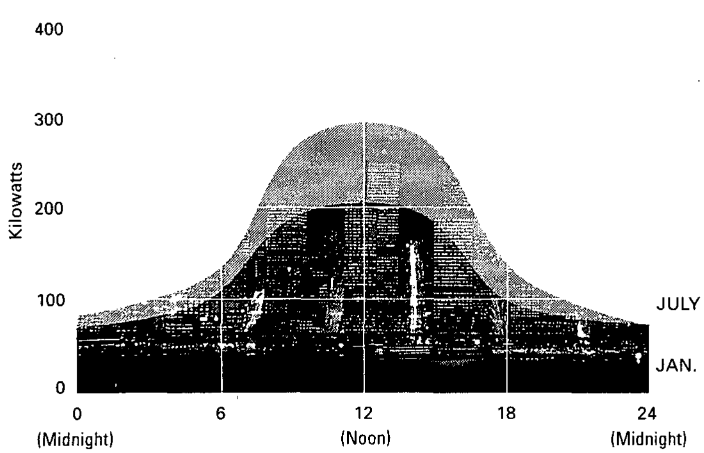
To an electric company, the term can mean many things. To a utility, as with most retail operations, a customer is characterized by a bill, and one is typically generated for each metered facility.

The customer is also the person–or department–that pays the bill for the electric use.

Who pays the utility bill for a local government? For an entire city or county, accounts most often are broken out and paid by different departments, such as the library or human services, which operate in different buildings. Rarely does a municipality have one bill for all its meters. Yet, consolidating all bills into one is what some local governments are attempting in order to gain a clearer view of how much electricity they consume. Determining how much electricity your municipality consumes, and at what rates and circumstances, will reveal a range of opportunities for cost savings, regardless of new options that will become available through utility restructuring. Ultimately, the entire city or county government could be considered "the customer," with services and pricing related to the needs of the entire jurisdiction and its many functions.

FIGURE 1

LOAD PROFILE



COMPONENTS OF ELECTRIC USAGE– THE BASIS FOR ELECTRIC RATES

Electricity usage varies throughout the day, week and season, depending on the type of building. For residences, electricity use is highest in the morning and evening when more people are at home. For offices, electricity use peaks in the mornings during the heating season and in the late afternoons during summer when air conditioning for a typical home and office building is used. This pattern of use, when plotted on a graph, is called a load profile (see Figure 1). It reflects the amount of electricity being used over each hour of the day. This load profile is aggregated over each segment of the market (e.g. residential, commercial, industrial and municipal) so suppliers can see how electricity is consumed by each sector over the day, week and season. A typical set of sector load shapes is shown in Figure 2.

Electric suppliers incur costs for providing electricity based upon which sources (e.g. power plants, purchase contracts) are used to produce electricity. The least expensive power plants are used first when demand is low, but increasingly expensive power must be added as demand increases. Power plants typically dispatch electricity over 24 hours to meet the demand for electricity using the cheapest sources of power first. Thus, nuclear plants run all the time, and more expensive gas combined cycle plants, for example, are run only at peak hours (see Figure 3). The cost is composed of the recovery of investment in the power plant and the cost of fuel, such as coal, oil, nuclear or natural gas. That mix of capital and fuel costs is the basis for the supply component of rates charged to customer segments. A typical electric bill for any customer also consists of charges for transporting the power (transmission and distribution) and customer charges (metering and administration).

There is a direct relationship between when and how much electricity is demanded and the costs to the electricity supplier. While consumers do not pay different rates during the day for different uses (called real-time pricing), they pay average rates driven by the usage pattern of their customer class or group. However, in some regions of the country, some consumers pay higher summertime rates during the summer to reflect higher costs due to increased air conditioning loads and corresponding higher overall demand.

For more than a decade, state public utility commissions (PUCs) have set the rates that electric suppliers charge customers, with most segments paying an average fixed rate by season. Large customers in some areas have been offered a time-of-use rate, that charges more for electricity during daily peak periods, when it is more expensive to produce, and less when the demand is lower and production less expensive. (For example, time-of-use rates typically are employed at beach communities where air conditioning use is high on summer days. Rates are lower at night.) However, despite the costs incurred by the electrical supplier, most consumers pay average rates mandated by state PUCs, allowing suppliers to recoup their costs for providing the power.

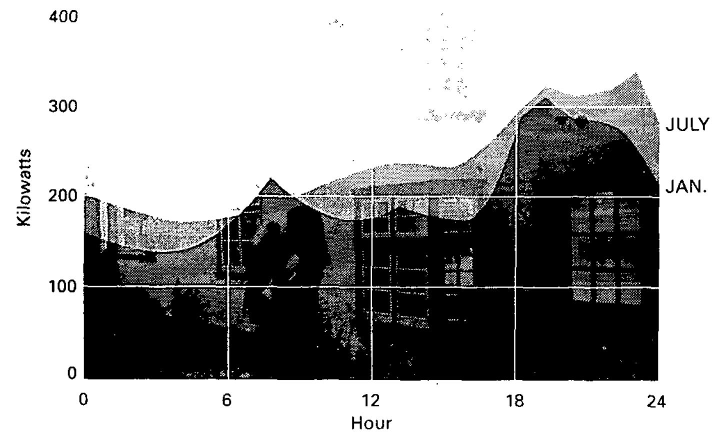
YOUR LOAD PROFILE–WHY IT MATTERS

Knowing your ***load profile*** is important to benefiting from the restructuring and competition in the electric utility industry. Soon (1998 for New Hampshire, California and Massachusetts), municipal customers will be allowed to choose their electric supplier. But how much will electricity cost? What rates will competing suppliers be charging? How can you get the lowest rates possible?

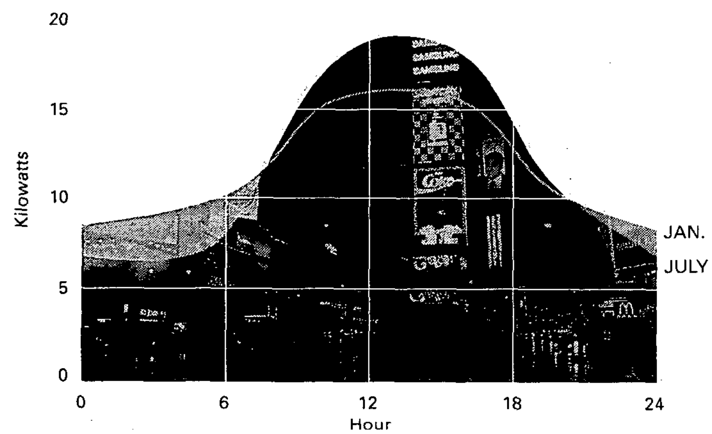
The answers will depend largely on your load profile.

FIGURE 2

RESIDENTIAL LIGHTING LOAD PROFILE



COMMERCIAL LIGHTING LOAD PROFILE



INDUSTRIAL LIGHTING LOAD PROFILE

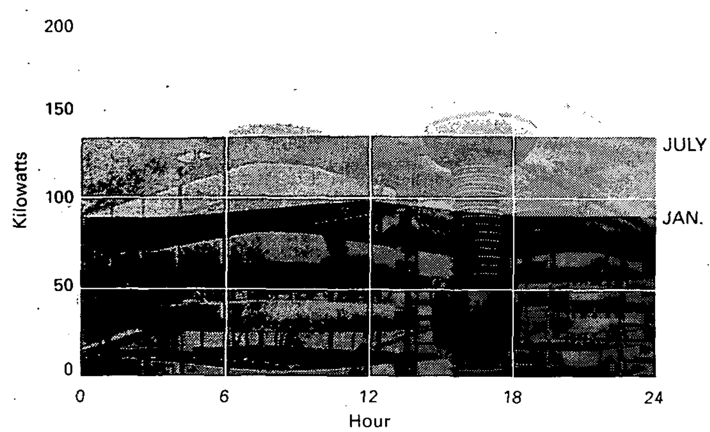
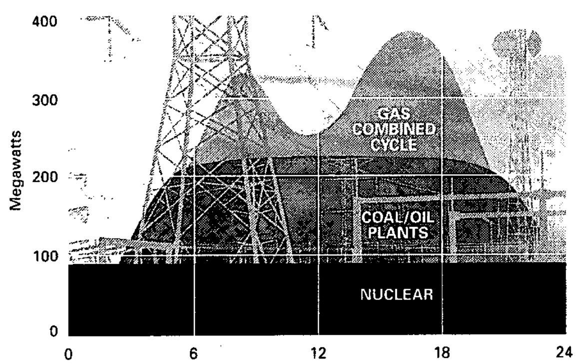


FIGURE 3

HOW POWER PLANTS DISPATCH ELECTRICTY TO MEET THE LOADS



From the point of view of the electric supplier–whether an investor-owned electric utility company (IOU) or a municipality's electric department–it is more economic to provide power to a customer that has a fairly even load shape–meaning a customer who consumes a consistent level of electricity over 24 hours. This costs the utility less than serving a customer with a large discrepancy between daytime peak usage and evening or weekend off-peak usage.

It is even more important how a group consumes electricity, since those customers represent a large block of demand to the electric supplier. Residential customers tend to consume electricity homogeneously, or in a similar pattern, at morning and evening mealtimes but virtually nothing at night. Commercial customers, or businesses, are less homogeneous than residential or industrial customers. Most businesses consume more electricity in the morning and peak in the afternoon before closing time, but heating and cooling are usually constant throughout the day. Businesses have a large variety of customer types and sizes but can be categorized to produce more homogeneous groupings. Industrial customers also vary considerably and do not display a consistent load shape as a group. Some use intensive electric processes as part of their operations, while others do not. Some have a night shift, others do not. Most have flat load shapes during their operations, making for more cost effective electric customers. Similarities in types of industry, such as paper mills, allow for a group load shape that characterizes specific segments.

Municipal operations, like commercial customers, vary greatly. Most municipal buildings operate like the commercial sector. Office buildings with regular hours of operation and consistent uses tend to consume the most. Schools have a similar but separate load shape, with usage highest between 7 a.m. and 4 p.m., but often have reduced summer operations. New uses of school buildings for after-school programs or adult education in the evenings are changing that load shape, but generally schools' usage patterns are predictable and stable. Other municipal operations, like jails, demonstrate a load shape more typical of a residential facility.

Two of the biggest electricity-consuming operations of local government are water facilities (water pumping and wastewater treatment facilities) and street lighting. Water facilities operate continuously and require considerable amounts of electricity to power the technologies used for processing drinking water and wastewater. Street lighting is one of the most attractive loads to utility companies as it uses cheaper-to-produce off-peak power, and offers consistent and typically large usage patterns. Under the monopoly system, this source of revenue has often been abused through excessive charges by utilities. In fact, many utilities charge a variety of often expensive fees associated with street lighting that are ripe for renegotiating in a contract review between a municipality and a utility. These include pole charges, light bulb stock, maintenance fees and other associated charges that can add up to considerable expense for the local government.

After the load profile, the second important factor determining what electricity will cost is your ***total usage,*** comprised of consumption in kilowatt hours (kWh), and demand, or the highest amount of electricity consumed within a period, such as a month, measured in kilowatts (kW). If you are a large consumer of electricity in consumption or demand, you represent an attractive source of revenue to an electric supplier. However, a higher ratio of average to peak consumption (a.k.a. load factor) is better for an electric supplier, since it will cost the utility more to supply power if more is consumed (relatively) at the peak periods of high demand.

Electric suppliers have been allowed to charge large customers—those with high consumption and demand—two rate components: a kWh rate for all customers in that class, and a demand charge to compensate for the higher cost of providing power during peak times.

To demonstrate the variability in current electric prices, Table 1 lists average rates by state for small commercial customers. States where rates are higher are moving more rapidly toward deregulation.

DEMAND-SIDE MANAGEMENT

Under the regulated monopoly system that has been in place, the only way customers have been able to control their electricity costs is by controlling their use—called ***demand-side management*** or DSM, because it refers to managing the demand for electricity rather than altering supply. Costs can be controlled by reducing the amount of electricity used or by changing when it is used. Consumption can be drastically reduced by energy conservation measures—installing high-efficiency lighting, energy-efficient motors or high-efficiency appliances. Weatherization measures—such as weather stripping and window treatments that help reduce air infiltration—also have helped to reduce use of heating and cooling.

Demand can be controlled by reducing or shifting use. Using equipment that consumes less power at peak times, or eliminating a high-consumption activity, are two ways. Demand also can be controlled by shifting some uses of electricity to another time of the day or month when it is less costly for the electric supplier to produce. For example, some industrial and commercial operations have reduced their peak demand by adding work shifts to their operations to spread or shift activities to other times of day. Hotels that do laundry at night reduce peak consumption and costs. Some businesses install controls to shut off operations that reach high levels of demand. (Residential customers have taken advantage of time-of-use rates by doing these things as well—shifting non-essential activities to later in the evening or to weekends, or by using time controls on appliances, such as preventing a dryer from operating during certain times of the day.) By reducing the activities using electricity at the same time, large customers (those that incur a demand charge) can significantly reduce their total demand for electricity and their demand charge.

The relationship between total demand and consumption is called your ***load factor,*** defined as the ratio of average hourly consumption to the highest hour's consumption (i.e. demand). Having a low load factor is undesirable because it means that a higher proportion of consumption is used during the higher cost time periods. If a consumer uses three times more electricity during its peak hour than the average for all other times, the load factor would be 33 percent (calculated as the average demand divided by the peak demand).

A high load factor means the hour of highest usage is fairly similar to an average hour of use. (Manufacturing or industrial customers often reach load factors of 80 percent to 90 percent.) For a high-load-factor customer an electric supplier uses lower-cost power plants to provide a higher proportion of the electricity, and can then pass those lower costs on to its customer.

TABLE 1

SMALL CUSTOMER RATES FOR COMMERCIAL AND INDUSTRIAL RATE CATEGORIES

STATE	RATE (cents/kWh)	STATE	RATE (cents/kWh)
AK	8.22	MS	7.24
AL	6.46	MT	6.13
AR	6.51	NC	5.96
AZ	7.27	ND	5.73
CA	9.03	NE	5.10
CO	5.57	NH	10.87
CT	9.89	NJ	10.15
DC	6.00	NM	7.98
DE	6.79	NV	6.56
FL	6.86	NY	11.77
GA	7.53	OH	7.38
HI	13.75	OK	4.69
IA	5.90	OR	5.05
ID	4.39	PA	8.35
IL	7.19	RI	10.78
IN	5.98	SC	5.80
KS	6.09	SD	6.62
KY	5.05	TN	5.90
LA	7.70	TX	7.05
MA	9.83	UT	5.60
MD	6.06	VA	5.72
ME	11.92	VT	12.71
MI	7.79	WA	5.56
MN	6.12	WI	5.67
MO	5.15	WV	5.52
		WY	4.93

Average rates by state

Source: Energy Buyers' Advisory June & Aug. issues, data for Februrary 1997.

Under competition, these same price components will remain the basis of your rates. It will benefit you to have a high load factor, with fairly even usage over each day and, more importantly, over billing periods (typically monthly). The more attractive your load profile, the more attractive you will be as a customer to electricity suppliers, and the better rate you will get.

AGGREGATION

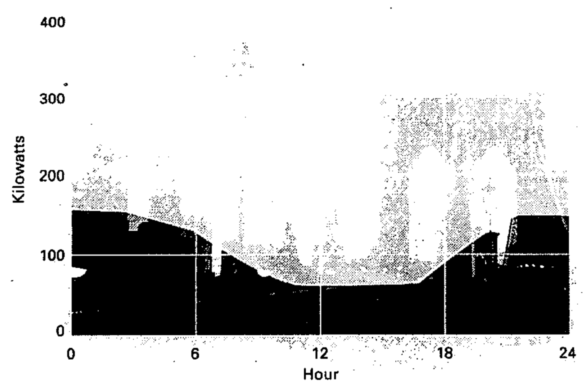
If your local government already has implemented energy conservation and optimized peak demand, what other avenues can improve your load factor? This is where ***aggregation*** comes in.

By grouping your various electric accounts–metered accounts for schools, offices, water pumping and streetlights–to present a more attractive load profile, your jurisdiction can position itself in the competitive marketplace. A local government can form a group with other customers to create a purchasing block that, in the aggregate, has a more attractive load profile. By aggregating your loads for billing as one customer, you also are creating a larger block of consumption, better able to realize economies of scale and to present a more attractive target for potential electricity suppliers.

While those are some benefits of aggregation, there are costs, too. To be an aggregator in today's emerging market, there are several additional functions, the most important being distribution and billing. To consider these functions, and whether to perform them yourself or to outsource them, it is necessary to consider the role of suppliers in the power marketing game.

FIGURE 4

STREETLIGHTS



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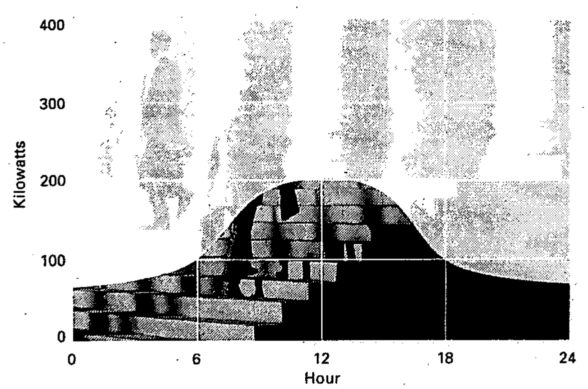
COUNTY COURTHOUSE (OFFICES)



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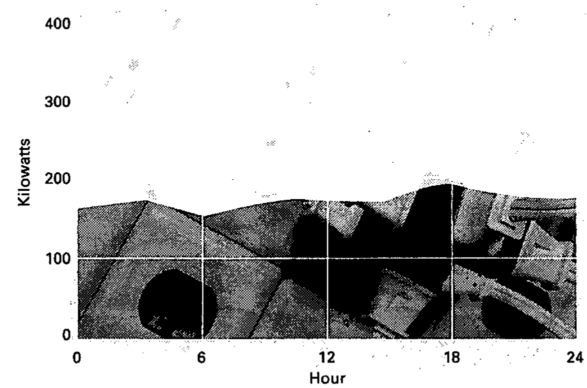
COMBINED LOADS



II. The Suppliers

THE WAY IT HAS BEEN WORKING

Under the regulated monopoly system in place for decades, retail consumers have been limited to one retail electric supplier. This supplier may generate electricity from power plants it owns, or it may purchase power from other generators, either other investor-owned utilities (IOUs) or independent power providers. State PUCs determine rates charged by investor-owned electric retail companies to customers–residential, commercial, industrial and municipal–typically grouped into smaller groups (rate classes) defined by size, based upon costs of providing services to those customer groups. Public power entities, such as municipal electric departments, set their rates in a similar fashion by local governing bodies (city councils, municipal boards, etc.). Customers have been able to influence rates only through rate cases, state PUC hearings or elected governing bodies that set rates. In many states, a consumer counsel intervenes in rate cases and represents residential and small-business customers. Industrial and large commercial customers have influenced rates through litigation or through organizations representing a group of large customers, such as an association of car manufacturers, who intervene in rate cases to espouse their point of view.

DID YOU KNOW?

Whatever entity currently **delivers** your electricity will most likely still deliver your power after competition unfolds. Thus, if you are served by a municipal utility system, a co-op, or an investor-owned utility (IOU), that entity will still own the wires and meters that bring you your electricity. You will be able to buy the electricity from a variety of suppliers. However, there will be a charge on your bill from the *supplier* of the electricity as well as a charge for bringing it to you by the *distribution entity.*

THE WAY IT'S EXPECTED TO WORK

Talk of electric industry competition and how customers will be able to choose suppliers abounds. But what does it mean? Who will sell power? From whom will we receive the electric bill?

There are two ways in which retail suppliers will market electricity: directly from individual electricity suppliers or through independent power brokers. However, these two types of power marketers will be hard to distinguish because:

- Many electric companies that have served a geographic territory have changed their names to erase their regional image.
- Several electric companies have formed unregulated subsidiary companies that will buy and sell electricity to consumers, including the electricity generated by parent companies' plants.
- Some independent power brokers will not answer to any one utility company, but will purchase power from electric wholesalers. (A wholesale electric company owns a power plant that sells electricity to another entity for resale.)

All power marketers are required to register with the Federal Energy Regulatory Commission (FERC) that controls interstate energy commerce. To date, 82 companies have registered with FERC as power marketers and indicated power sales in 1996, many more have registered their names but have had no sales. About half represent holding companies that include former investor-owned electric utility companies, or IOUs. Some power marketers take title to the electricity and resell it, while other do not and are more akin to brokers. While some power marketers are linked to an IOU, many are not. Each power marketer has to report quarterly purchases and sales of power to the FERC. Currently, there are no restrictions or prerequisites for registering as a power marketer.

Table 3 presents the largest 10 power marketers registered with the FERC at the end of 1996, and their sales and purchases. These 10 firms represent more than 70 percent of electric sales in the 1996 market, with Enron dominating the pack with 25 percent of market share.

TABLE 2

1996 RESULTS OF ELECTRIC POWER MARKETING ACTIVITY

Rank	Company Name	Sales (MWh)	Purchases (MWh)	Market Share
1	Enron Power Marketing	58,663,426	57,251,322	24.98%
2	Duke Louis Dreyfus	28,302,934	28,247,453	12.05%
3	LG&E Power Marketing, Inc.	17,075,223	14,229,716	7.27%
4	Electric Clearinghouse, Inc.	14,627,510	14,901,973	6.23%
5	Citizens Lehman	11,891,543	13,680,696	5.06%
6	Vitol Gas & Electric	10,005,452	10,150,413	4.26%
7	Koch Power Services	9,952,684	9,973,751	4.24%
8	Aquila Power (UtiliCorp)	6,726,504	6,611,416	2.86%
9	DuPont Power Marketing	5,286,158	5,357,516	2.25%
10	CNG Power Services	4,880,561	4,465,264	2.08%
	TOTAL MARKET SHARE			**71.28%**

The information in this table is public information available through the Federal Energy Regulatory Commission (FERC).

AN ILLUSTRATION OF A TRANSACTION

To offer a more specific example of how power marketing works for large customers, and may ultimately work for all customers, here's an illustration:

> State Electric Co. has provided electric service to all types of customers within State X for several years. It operates a nuclear unit that generates relatively low cost electricity all the time and a peaking unit fueled by natural gas that is more expensive to run and is operated only during periods of high demand. Anticipating deregulation and competition, State Electric Co. forms a power marketing subsidiary called Power Marketing Inc. This company sets up a trading operation much like stock exchanges equipped with computers for making transactions between suppliers and customers.

The power marketers employed by the company contact attractive customers both within and outside of State Electric Co.'s service territory to determine customers' electricity needs. If a prospective customer's load profile is attractive, the power marketer offers a package of electricity to be delivered in a specified quantity and time.

To do this, he or she examines the range of wholesale rates for electricity in the marketplace by various companies, including electricity generated by State Electric Co. Since it behooves the marketers to sell their own electricity in order to generate profits for the parent company, they will strive to fit it into the mix of power being sold.

However, the availability of electricity depends on demand from existing customers of State Electric Co., so they may not have enough to offer on the wholesale market. Also, to reach a competitive price, the power marketer may have to add cheaper power from another supplier; to meet demand and fill the order, they may have to supplement more expensive power from another supplier. This system works like trading of other commodities, such as corn.

If the price, partially made up of the package of blocks of electricity from a variety of suppliers, is agreeable to the consumer, a sale is contracted between purchaser and Power Marketing Inc.

The sale price is composed of more than the price of electricity. Transportation costs or "wheeling charges" are levied by electric companies that own transmission lines between power plants and consumer's meters. Some power marketers sell to end users, such as a big industrial customer, and others sell to retail companies who will distribute it to end users (for example, a local municipal electric department). Presumably, the farther away the power, the higher the transmission fee to the purchaser. This suggests that regional markets will develop for power sales.

Therefore, it will be more economical to purchase power from a distance only if the delivered price is lower than local suppliers charge. Given existing geographic distribution of electricity prices, a significant quantity of electric sales can be anticipated from the less expensive regions of the Midwest (primarily coal based plants), to consumption centers such as the Northeast, where electricity is more expensive (due to higher cost oil plants). Similarly, one can anticipate consumers in Florida making long-distance purchases from cooler regions of the country during hot summer months when local electric demand is high.

If the purchaser is an end user of the electricity, that customer will receive a bill directly from Power Marketing Inc. If the purchaser plans to resell the electricity to other customers, it will bill them and collect the money to cover its payment to Power Marketing Inc. An example of this model is a municipal electric department making the purchase and distributing the electricity to its citizens. Another example is an aggregator of customers, which assembles a group of customers and a more attractive load profile. In this case, the aggregator is responsible for billing the customers and recouping the costs of the purchase from Power Marketing Inc. If a group of school boards banded together to form an aggregation block, the aggregator would be responsible for distributing the electricity and billing the customers. (Of course,

OPEN ACCESS SAME-TIME INFORMATION SYSTEM (OASIS)

OASIS represents the first fully electronic trading platform for a major commodity in cyberspace.

Information about electric suppliers and their prices is available on the Internet through FERC. Open Access Same-Time Information System, or OASIS, was set up under FERC Order 888. (See the *Keeping the Lights On Resource Guide* for a detailed summary of the order.) This legislation guaranteed wholesale open access—the system whereby all electricity wholesalers have access to transmission lines to market power to whomever they want.

POWER MARKETERS AND AGGREGATORS– CAN THEY BE PARTNERS?

Yes, recognizing these marketplace realities:

- Driving for national scale/market share growth, with limited resources
- Seeking low-cost, effective sales channels to reach small accounts
- Place premium on "value-added" services based on knowing customer needs
- High cost of selling/administering small retail and residential customers
- Interest in long-term, stable sales and distribution relationships
- Successful aggregators will grow to resemble "wholesale" customers

SELECTING A POWER MARKETER AS AN AGGREGATION PARTNER WHAT TO LOOK FOR:

- Financial strength/reputation for integrity
- Access to generation and/or portfolio of system power
- Comprehensive set of transmission agreements
- Knowledgeable trader and risk manager
- Nationwide coverage and affiliation with major power pools
- 24-hour dispatch and scheduling capabilities
- Innovative and prudent management

Source: LG&E Power Marketers

the aggregation group could elect to contract out these functions and/or pay a distributor for use of the system.)

In California, this aggregation is already happening. Legislation is in place for "aggregators" to form and take title to the electricity purchased. Similar or different systems may emerge in other states. It is unclear at this point who will be responsible for distribution and billing for aggregators, and power marketers are gearing up to provide different levels of service. Some local governments, such as Columbus, Ohio, are considering developing competitive rates for leasing their distribution systems to other suppliers. As other examples, Enron will bill directly to end users, while LG&E Power Marketing Inc. prefers to sell to aggregators and will provide no direct customer billing.

WHAT DOES THIS MEAN FOR MUNICIPALIZATION?

The changes taking place in the marketing of electricity demand a re-examination of the term "municipal utility." Traditionally, a municipal utility is a local government that sells electricity to end users, electricity that it generates or purchases on behalf of those customers. The utility is owned by its citizens, and is managed ultimately by elected and appointed officials drawn from the citizenry. To that aim, all municipal utilities are aggregators.

Several municipal utilities welcome deregulation and competition, since they feel well-positioned with traditionally lower rates and, in many cases, higher ratings in terms of customer service. Customers know that municipal utilities will be there for the long run as an integral part of the community, unlike the rapid rate of merger and name-changing activity taking place in the private market. Some aggressive municipal utilities are considering expanding their service territories and offering cheap power to adjacent and distant communities. The negative concerns relating to municipal utilities are revenue reductions from changes in taxation and franchising powers; lower rates of competitors if stranded investments are allowed to be recouped or written off; and competing with more than just the local IOU. For the most part, public power hopes to hold its own as competition unfolds.

But what if a local government that is not a municipal utility wants to aggregate customers from among its citizens or businesses? Should it form a municipal utility to do so?

Falls Church, Virginia, didn't think so. Falls Church attempted to aggregate its citizens by purchasing the meters and distribution lines from its former monopoly service provider, Virginia Power. This would have allowed the city to distribute electricity it purchased from power marketers and bill customers according to usage. They called their experiment "Muni-Lite," as their plan did not go the full extent of municipalization as interpreted by FERC. Predictably, Virginia Power took exception and successfully barred Falls Church from acting. After deregulation is complete, IOUs like Virginia Power may not be able to dodge such a request. They may be obligated to serve all wholesale customers in the future.

To be an aggregator, you must have the authority to distribute power and bill customers. You don't have to own the facilities, you may contract out the work, and it is increasingly likely that suppliers will be required to serve you.

III. Electricity Traffic Control

WHO RUNS THE SYSTEM?

Six regional "power pools" have existed nationwide for many years to facilitate the exchange of electricity among and within regions. Electric companies that own generating facilities (power plants) belong to these ***power pools***. The PJM Power Pool (the Pennsylvania-New Jersey-Maryland power pool), coordinates the operation of all power plants in those three states.

Determining which power plants to operate is a complex optimization process to ensure that providers' supply meets demand in the most economical manner. This process considers which power plants are available, operating, or out of service (experiencing an outage). It also considers operating costs of each plant, and the comparative costs of electricity produced outside the region if adequate electricity is not available within the pool. The regional power pools operate with their member utilities and are obligated to sell electricity produced within a member pool first. If there is excess power, individual electric companies can sell the power, provided that a required reserve margin is maintained at all times. If the pool is short on power, the individual companies whose customers need the power must purchase from outside the pool. However, the dispatching of the power from inside and outside sources is conducted by the power pool operators.

The power pools operate out of one regional facility outfitted with complex computers that provide real-time data on plant operations–generally how much is produced by each plant and its associated cost estimate. Using this data, a facility operator can decide which plants to bring on line to fill the immediate need. The standard protocol is to use cheapest power plants first, leaving the most expensive generators for peak-period operation only. (The exception is nuclear units, which cannot economically or technically be shut on and off, or dispatched quickly.) Except for scheduled maintenance outages, they operate constantly.) Predicting demand is an educated guessing game that requires forecasting several hours in advance. Weather, time of day, day of week, month (where load profiles are aggregated for each utility into a System Load Profile), and other factors determine how much electricity will be needed by the region.

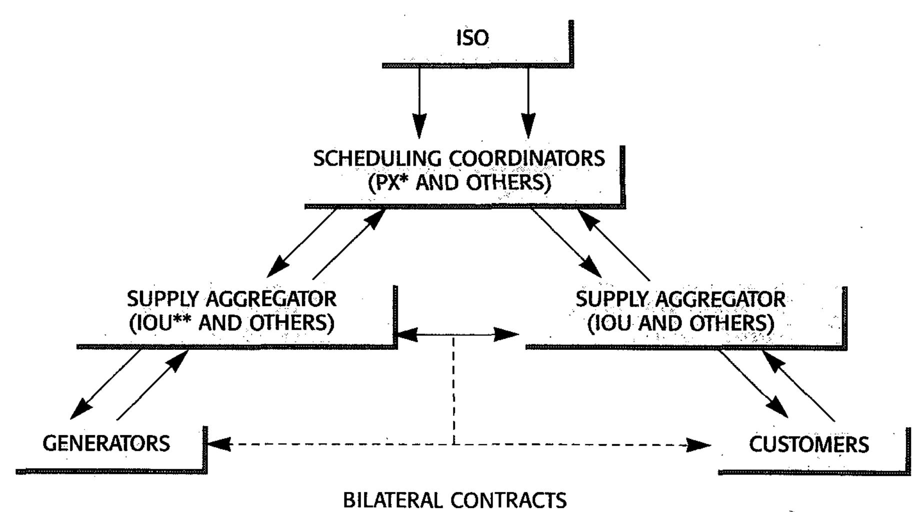
INDEPENDENT SYSTEM OPERATORS: THE NEW TRAFFIC COPS

In a competitive market, with power marketers purchasing and selling electricity across the country, regional power pools will not be able to maintain control over all transactions. The federal government is considering forming new regional entities called independent system operators, or ISOs, to perform this task (See Figure 4). California has an ISO, and other states may follow suit. The ISOs will be independent of electric companies in power pools, and therefore have no vested interest in scheduling those plants before selling outside power. The ISOs will have the critical function of scheduling electricity transmissions and ensuring adequate supply to customers from their own local suppliers and through power marketers.

Power marketers will have to schedule sales through an ISO in order to conduct transactions between suppliers and customers. ISOs follow a protocol of priorities to ensure timely scheduling, transmission availability, proper pricing, and that no traffic jams occur on transmission lines. Because priority is given to customers within an electric company's territory, a power marketer's sale from a supplier to a customer may be "bumped" if transmission lines are jammed. It will be the power marketer's responsibility to purchase electricity from the spot market and get it to the customer as promised. In this case, the power marketer incurs the added cost of the more expensive spot power, but mechanisms exist to recoup some of the costs from the parties involved in the traffic jam.

FIGURE 4

RESTRUCTURED POWER MARKETS



*Power Exchange **Investor-owned Utilities

Source: LG&E Power Marketers

IV. Conclusion and Technology Implications

The best analogy for deregulation and competition in the electric industry is the existing stock market, where commodities such as corn are traded on short- and long-term contracts in bulk amounts at fluctuating prices. The difference is that shipping corn can be easily measured and can occur over a longer time; shipping and measuring electricity occurs in real time, and its highway is not designed for long-distance transactions. There are significant implications for technology in several areas:

- **Metering technology**–Electric companies may not be the only owners of metering technology in the future as aggregators begin to form and transact power sales, and as customers need more knowledge regarding their usage.
- **Strategic planning software**–As municipalities collect information on their usage patterns in order to consider their options–including aggregation with other departments or groups–analytical software is needed to quickly condense and sift through the data on building load profiles. In the industry, this is commonly called load profiling software. PTI is currently customizing industry software for municipal government use, with plans for product introduction in the Fall of 1997.
- **Transmission wire technology**–Keep an eye out for innovations of cheaper methods of transmitting electricity (i.e., whatever happened to superconductivity?).
- **Expansion of transmission grid**–Bottlenecks may emerge between low and high cost regions that will require investments in new bigger transmission lines to handle the traffic, but…who will be making these investments?
- **Storage technology**–Electricity cannot be produced in significant quantities for later use because no storage mechanism exists except for battery technology. Expect significant advances in battery technology and other ways to store electricity.
- **Internet**–OASIS (see sidebar, p. 9) is the first full use of the Internet for commodity trading, and its advent will have spin-off product implications related to power exchange.
- **International transactions**–As many U.S. companies are investing in overseas power, it won't be long before international transactions enter the fray. We already buy significant amounts of electricity in the Northeast from cheap sources in Canada; expect to see mechanisms to expand that flow.
- **Distributed power options**–fuel cells, photovoltaic panels (supplemented by batteries) and other new technologies will provide additional power options for local governments interested in ensuring a portion of their supply through self-generation using renewable resources.

PTI will continue to keep you informed on these issues as they relate to local government through its *Keeping the Lights On* series.

ACRONYMS

APPA	American Public Power Association
ESCOs	Energy service companies
DISCOs	Distribution companies
DSM	Demand-side management
EPACT	Energy Policy Act of 1992
FERC	Federal Energy Regulatory Commission
GENCOs	Generating companies
GRIDCOs/ TRANSCOs	Transmission grid companies
IOUs	Investor-owned utilities
IPPs	Independent power producers
ISOs	Independent systems operators
NARUC	National Association of Regulatory Utility Commissioners
NCSL	National Council of State Legislatures
NUGs	Non-utility generators
PME	Power market exchanges
PTI	Public Technology, Inc.
PUCs	Public Utility Commissions
PURPA	Public Utility Regulatory Policies Act of 1978
UCETF	The Urban Consortium Energy Task Force of Public Technology, Inc.

Appendix A: Five Steps to Get Ready For Power Marketing

1. IDENTIFY LOAD/ENERGY REQUIREMENTS

- ▶ Review historical load/energy data
- ▶ Recreate historical data using best information available and data for comparable loads
- ▶ Project load/energy requirements
- ▶ Develop building load profiles

2. DEVELOP RFP DOCUMENTS

- ▶ KISS–Keep It Simple Stupid
- ▶ Background information on requester
- ▶ Historical/projected load data
- ▶ Power supply arrangements
- ▶ Deadline for submittal
- ▶ Designate a contact person for questions

3. DISTRIBUTE RFP TO POTENTIAL SUPPLIERS

- ▶ Indentify potential power suppliers (IOUs, marketers, generation and transmission coops, munis, IPP's, etc.)
- ▶ Pre-verify interest in receiving RFP
- ▶ Pre-notice RFP thru trade press
- ▶ Distribute to interested parties
- ▶ Post notice thru trade press

4. REVIEW/ANALYZE RESPONSES TO RFP

- ▶ Summary of responses
- ▶ Economic analysis/price vomparison
  - Apply rates to load/energy requirements
  - Adjust to common delivery point
- ▶ Subjective analysis of proposal
  - Firmness, term, delivery arrangements, etc.
- ▶ Evaluation of respondent
  - Track record, credit worthiness, etc.

5. SELECT SHORT-LIST AND NEGOTIATE DEAL

- ▶ Select best proposals (3-5)
- ▶ Notify non-selected respondents
- ▶ Meet with short-listed respondents
- ▶ Reduce list further (if possible)
- ▶ Negotiate the deal

Source: Courtney & Associates, John T. Courtney.

Appendix B: Template for Power Supply RFP

Source: Baarnstable County, MA Community Franchise Study, PTI Order #97/96-318

1. OVERVIEW

1.1 *Electric Industry Restructuring in [State]*

In [date of action] the [state] Public Service Commission issued its order on electric industry restructuring (P.S.C. XX-XX). The order set forth principles for a restructured industry and steps for a transition. Included in the order was the option for use of a mechanism to aggregate consumers under a municipality, or group of municipalities. As part of the restructuring process, the PSC has also indicated its support for pilot projects to develop experience and test market options.

The [town or city if individual effort] or [A group of towns interested in municipal aggregation have organized as [name of joint body or compact] The [town or joint body] is interested in formation of a full community aggregation franchise, or should the retail market fail to open on the PSC's proposed date of XXXX, 1998, formation of an interim pilot project.

1.2 *Profile of [the town, or city or joint body]*

[Town, city, or joint body] is made up of XXXX in the geographic region of XXXXXX. Electric rates in the region are lstate current competitive condition of electric rates] The [state local authorizing body or bodies] have authorized the [state department or joint body] to seek out competitive market prices for electricity supply. The combined XX,XXX metered customers in the [town, city joint body area] purchased an estimated XXX,XXX MWh in 1996.

1.3 *The Request for Proposals*

The purpose of the Request for Proposals is twofold: 1) to gather and evaluate market data for fixed-price, all-requirements, firm power on behalf of the [town, city, number of multiple municipalities]; 2) to select a short list of qualified electricity suppliers for further negotiation over provision of electricity and ancillary services to the consumers aggregated under the [town, city, joint body]. The proposed power supply contract is included in Appendix A.

1.4 *The [town, city, joint body] Pilot Project*

Should the retail market for electric supply fail to open on the projected date of XXXX, 1998, the community franchise pilot project is planned as a two-year program conducted to test potential economic and non-economic benefits of customer aggregation. The pilot will commence [same date as above], 1998 and extend through [two year period], 2000. Should retail competition be implemented during this period, the pilot may be phased into a permanent program, provided proper approvals and agreements are obtained. Should retail competition be delayed, the period of the pilot may be extended, provided proper approvals and agreements are obtained. Additional information on the pilot project is included in Appendix B.

2. GENERAL PROVISIONS

2.1 *Inquiries*

Inquiries concerning the RFP should be addressed to:

********** *********** ****
****
****

2.2 *Proposal Submission Date*

Proposals must be received at the address set forth in paragraph 2:1 by 12:00 p.m. on Friday, XXXX, 1997. Any proposal not submitted and complete at that place and time, in the format specified in this RFP, will not be considered. [Deadline will be four to six weeks after issuance.]

2.3 *Pre-Bid Conference*

A voluntary pre-bid conference is scheduled for [date soon after issuance of RFP] at 10:00 a.m. It will be held at (location). Attendance by all interested suppliers is encouraged. Additional information may be presented at this conference and it will be the responsibility of Bidders to be aware of this information. Please contact the [contact at town, city, joint body] at the telephone number provided in paragraph 2.1 if you plan to attend.

2.4 *Form of Proposal and Number of Copies*

Proposals must be delivered in hard copy form. Proposals may not be submitted by facsimilie. Each Bidder must submit five (5) copies of their proposal, along with five (5) copies of supporting documentation. Bidder must also complete and submit five (5) copies of the forms attached as Appendix C.

2.5 *Terms of Submission*

This invitation to submit a proposal does not commit the [town, city, joint body, or any of the towns participating in the joint body], to make an award. The [town, city, joint body authority] at their sole discretion, reserve the right to issue additional instructions or requests for additional information, or to extend the submission deadline.

All proposals shall be considered an offer to provide electric power supply and ancillary services to the consumers aggregated by [town, city, joint body]. Offers will be deemed valid until [market date], 1998, or through the end of the supplier selection process, whichever is later. The [town, city, joint body authority] reserve the right to reject any and all bids on any basis.

2.6 *General Description of the Request for Proposals*

[Town, city, joint body authority] are requesting proposals for fixed-price, all-requirements, firm power supply for up to XXX,XXX MWh per year commencing XXX, 1998 and ending XXX, 2000. Suppliers will arrange for the delivery of power at points specified in Appendix D. A separate agreement, consistent with state policy and statutes, will be negotiated by the [town, city, joint body] with [existing utility company] for billing, metering, and distribution services. Suppliers must demonstrate load following capability to maintain system reliability and any additional services necessary to meet [specify power pool or control area authority] requirements. The contract provided in Appendix A should be consulted for details.

2.7 *Proposal Format*

Bidders must complete the forms provided in Appendix C. All description of services, or supporting documents should be attached as necessary.

2.8 *Evaluation*

Evaluation of proposals will be based on both economic and non-economic criteria. Criteria will include: 1) Qualifications, reputation, and experience of supplier; 2) Bid price expressed as retail rate price cut for all specified classes of customers; including capacity and services necessary to guarantee delivery of all-requirements, firm power supply to specified delivery points; 3) Portfolio profile of power supply offered including environmental and renewable energy components as specified in the contract at Attachment A; 4) Proof of firmness and reliability of transmission; proof of firmness and reliability of generation capacity and availability to guarantee all-requirements service to aggregated consumers and to evaluate priority related to supply; 5) Non-price factors including priority of supply, range of services offered, nature of guarantees, and other issues concerning participation in local research and development of renewable energy sources; participation in local conservation and DSM programs; participation in local economic development or other programs; bundling of services; other non-price elements that may be proposed.

2.9 *Selection of Supplier*

The selection process shall take place in two stages. In the first stage a "short list" of prospective suppliers will be chosen by the [town, city, joint body authority]. Negotiation with suppliers on this "short list" will take place in a second stage of selection. Final determination of a supplier, or suppliers, for contract award shall be made by the towns choosing to participate in the pilot project, based upon the recommendations of the [joint body if multiple-municipal group]. [Town, city, or towns or cities participating in joint body] shall have no obligations with respect to any Bidder until a bid has been formally accepted through the execution of a written contract.

2.10 *Customer's Selection*

Consistent state policy and law in [state compliance with state policy on aggregation and local franchise powers and form of franchise and consumer options]. [If consumer selection state process of selection]. The relationship of the contracted supplier, or suppliers, with the customers remaining aggregated under the [town, city or joint body] will be direct with the customer. Billing will be carried out as an administrative function of the distribution, metering, and billing contractor [existing utility].

2.11 *Contract and Pilot Project Administration*

General administration of the RFP and contract process, and oversight for the pilot project, shall be carried out by [town, city, joint body], or a designee of the [town, city, or the towns participating in the joint body].

3. SPECIFIC REQUIREMENTS OF PROPOSAL

3.1 *Qualifications and Status of Bidder*

3.1.1 Contact(s): Name and business address of the principal officer responsible for submission of the RFP and (if different) name and principal officer responsible for administration of contract.

3.1.2 Business information: Legal trade name; date of incorporation or organization; state of incorporation or organization; list of officers and directors; list of affiliates, if any; a copy of 1994 and 1995 Annual Reports to Stockholders, or other audited annual report; copies of final year-end FERC Form 1 filings for 1994 and 1995; current bond rating(s) by Moody's Investor Services, or other rating agencies, if applicable; latest audited financial statement(s) with confirmation of no material or adverse changes since the date of statement(s).

3.1.3 Business qualifications: [power pool] membership, or agreement with [power pool] member; Certification of all regulatory approvals necessary to provide all-requirements, firm power included in offer; Certificate of Good Standing from the [state] Department of Revenue, or similar certification that all state taxes have been paid in state of incorporation or organization; evidence of qualification to do business in [state].

3.1.4 Business status: Statement as to whether or not business or affiliate has commenced, or been forced into, any solvency proceeding within the last five years; Statement as to whether business or affiliate has been subject to any investigation by a state or federal agency within the last five years; Statements as to the number, if any, of any consumer complaints filed with a state, federal, or local agency, against the business or affiliate (in any state) within the last five years.

3.2 *Price*

3.2.1 [In the typical bid the price is fixed for energy and capacity. This RFP solicits a price addressing reduction over current prices and specified to existing customer classes.] The bid must be expressed as fixed across the board reduction of current price for energy and capacity provided by [existing utility]. Transmission is to be included in the price but indicated separately. Delivery of all-requirements, firm power supply is for the specified two-year period commencing [XXX], 1998 and ending [XXXX] 1, 2000 for up to XXX,XXX MWh per year. All prices and charges should be specified separately for each customer class. In addition, similar fixed-price offers are also sought for varied terms extending beyond the two year period.

3.2.2 The price component is broken into energy blocks to examine any impact of price on quantity of purchase. Price offers are desired for 750,000 MWh per year, 500,000 MWh per year, 250,000 MWh per year, and 100,000 MWh per year. All price bids should be expressed consistently , indicating the price reduction noted above for each customer class.

3.2.3 In order to consider changes in the duration of the pilot, or transition of the pilot into a permanent program, due to altered regulatory conditions, the pricing component also seeks prices for all energy blocks indicated above for: one year, two years (as stated), three years, five years, seven years, and ten years.

3.2.4 Bidders must clearly state any terms they desire in their rate schedules that would permit or require changes in the rates based on inflation indexes, fuel cost adjustment or similar factors. Preference will be given to fixed-price bids over adjustable bids. Any index must be clearly identified.

3.3 *Portfolio Profile*

3.3.1 The portfolio profile seeks to assess experience, total power supply capabilities and the supply being offered. Data is requested on: total supply capabilities; amount of power bidder provided to [power pool] and/or other power pools during 1994, during 1995, during 1996, and the first six months of 1997.

3.3.2 Name and location of facilities to be used to provide power supply under this proposal, including: fuel type, capacity, year originally placed in service, and current availability status. Bidders are also asked to provide the fuel source and location of capacity

3.3.3 Percent renewable energy in power supply under this proposal.

3.3.4 Specification of any emission credits related to power supply included in proposal.

3.4 ***Transmission and Reliability***

3.4.1 Bidders are requested to provide Information on transmission and reliability to evaluate factors affecting reliability of the proposed supply including: priority of supply in "tight capacity" situations; range of ancillary services related to reserves; contracts and agreements for transmission; options for new or expanded load; nature of any other guarantees.

3.5 *Non-Price Factors*

3.5.1 Bidders are asked to state their willingness to provide additional services; including willingness to participate in Research and Development of local projects for renewable energy supplies; participation in demand side management and conservation programs, participation in local economic development, and other services that might be proposed by the supplier.

3.5.2 Bidders must certify their willingness to abide by the billing. Collection and termination regulations of the Public Service Commission in effect as of this date, and any additional protections set forth in the contract contained in Appendix A.

Bidders must also certify their willingness to serve all aggregated customers, regardless of income, without requesting a deposit, guarantee, or other security beyond that permitted by the Public Service Commission and the contract contained in Appendix A.

4.0 **NOTICE OF AWARD**

4.1 The contract shall be deemed as having been awarded when formal notice of acceptance of the proposal has been duly served upon the successful Bidder.

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LESSONS LEARNED

A. Many energy issues are unique to local governments, e.g. Distributed Generation Pemitting and traffic lights.

B. The requirement to leverage funds with private sectors and/or other governmental entities was very effective.

C. Local governments can effectively be an "urban laboratory" for the testing of new energy products.

D. Research and Development (R&D) and technology transfer proved to be the most effective application of funds.

PROGRAM BARRIERS TO BE AVOIDED

A. Funds should not be used for just expanding already proven technologies, e.g. buying more alternative-fueled vehicles.

B. Limit availability of consultant fees to ensure local government involvement.

CONCLUSION

Through the Municipal Energy Management program, local governments were a component of the national effort to maintain the United States as the world's leader in developing, applying and exporting sustainable, environmentally benign and economically competitive energy technologies.

The UCETF program enhanced the ability of local governments to identify, design and implement energy policies that supported local economic objectives, including jobs growth and retention. The program offered the nation a proven successful method to identify ways that energy technologies can be applied to ain in addressing community issues; to share information among local governments, and to prepare local officials to respond to the energy and energy-related environmental issues in their own communities.