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UPVG Phase 2 Report

August 1995

Utility PhotoVoltaic Group

Washington, DC

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UPVG PHASE 2 REPORT

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Washington, DC 20036**

August 1995

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DEPARTMENT OF ENERGY**

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August 1995

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Key Acronyms and Terms

A&M – Applications and Markets, previously one of the UPVG Work Groups, since renamed
 AC – Alternating Current
 AFB – Air Force Base
 BLM – Bureau of Land Management
 BOS – Balance-of-System
 CO₂ – Carbon Dioxide, a gas believed to contribute to global warming
 CS&M – Commercialization Strategies and Markets, one of the UPVG Work Groups
 DC – Direct Current
 DOD – U.S. Department of Defense
 DOE – U.S. Department of Energy
 E&S – Engineering and Specifications, one of the UPVG Work Groups
 ECIP – Energy Conservation Investment Program
 EPA – U.S. Environmental Protection Agency
 EPRI – Electric Power Research Institute
 FHA – Federal Highway Administration
 ft³/min – cubic feet per minute
 GCA – Grid-Connected Applications
 gpm – gallons per minute
 hp – horsepower
 kW – Kilowatt, a unit of electrical power; 1 kW equals 1,000 Watts
 MCAGCC – Marine Corps Air-Ground Combat Center
 MW – Megawatt, a common unit of power used by electric utilities; 1 MW equals 1,000 kW
 NARUC – National Association of Regulatory Utility Commissioners
 NASUCA – National Association of State Consumer Advocates
 NAWS – Naval Air Weapons Station
 O₂ – Oxygen
 O&M – Operation and Maintenance
 P&E – Planning and Evaluation, one of the UPVG Work Groups
 psi – pounds per square inch
 PVC – Polyvinyl chloride
 PVC3 – PV-COMPACT Coordinating Council
 PV-COMPACT – PhotoVoltaic COLlaborative Market Project to Accelerate Commercial Technology, a collaborative effort involving a broad spectrum of organizations interested in PV
 PVMaT – A DOE initiative to improve PV manufacturing techniques and processes
 PVRC – DOD's Photovoltaic Review Committee
 PVUSA – PV for Utility-Scale Applications, a national cooperative research project
 REWS – Range Electronic Warfare System
 RFP – Request For Proposals
 SERDP – Strategic Environmental Research Development Program
 SMUD – Sacramento (California) Municipal Utility District
 SSA – Small-Scale Applications (grid-independent)
 TT&MD – Technology Transfer and Member Development, one of the UPVG Work Groups
 TAB – Traffic Auto Bureau
 TEAM-UP – The UPVG program to build Technology Experience to Accelerate Markets in Utility Photovoltaics
 UPVG – Utility PhotoVoltaic Group
 W – Watt, a unit of electrical power equal to the rate of work represented by a current of one ampere under a pressure of one volt
 WAPA – Western Area Power Administration
 Work Group – Technical committee of the UPVG

1. Background & Introduction

A. The UPVG & its *TEAM-UP* Program

The Utility PhotoVoltaic Group (UPVG), supported by member dues and a grant from the U.S. Department of Energy, has as its mission the acceleration of the use of cost-effective small-scale and emerging large-scale applications of photovoltaics for the benefit of electric utilities and their customers. Formed in October, 1992, with the support of the American Public Power Association, Edison Electric Institute, and the National Rural Electric Cooperative Association, the UPVG currently has 90 members from all sectors of the electric utility industry.

The UPVG's efforts as conceived were divided into four phases:

- Phase 0: Program Plan,
- Phase 1: Organization and Strategy Development,
- Phase 2: Creating Market Assurance, and
- Phase 3: Higher Volume Purchases.

The Phase 0 effort developed the program plan and was completed early in 1993. The Phase 1 goal was to develop the necessary background information and analysis to lead to a decision as to which strategies could be undertaken by utilities to promote greater understanding of PV markets and achieve increased volumes of PV purchases. (A six-part report on the UPVG's Phase 1 efforts was published in June, 1994.) This report provides the details of the UPVG's Phase 2 efforts to initiate *TEAM-UP*, its multiyear, 50-MW hardware initiative.

TEAM-UP stands for building Technology Experience to Accelerate Markets in Utility Photovoltaics. During its Phase 2 efforts, the UPVG significantly shifted the direction of the organization toward outreach to educate utility and other audiences and toward building the foundation for full *TEAM-UP* utility PV purchase commitments. This shift was appropriate given the important "story" which emerged from the UPVG's Phase 1 program, which identified significant opportunities and benefits for electric utilities to become more actively committed to early photovoltaic commercialization.

The UPVG is managed and led by the utility industry itself. It is governed by a 15-member Board of Directors comprised of representatives from member utilities and their trade associations. Support to the organization is provided by a Washington, D.C.-based staff. The UPVG's activities are carried out through four technical Work Groups, each chaired by a utility member. Those Work Groups are:

- Commercialization Strategies & Markets,
- Engineering & Specifications,
- Planning & Evaluation, and
- Technology Transfer & Member Development.

The chairpeople from each of these Work Groups form a Steering Committee which meets before each UPVG Board meeting, approximately three times a year. The Steering Committee helps coordinate the UPVG's technical efforts and provides interim recommendations to the UPVG Board for issues and new directions as they arise.

B. The Changing Utility Industry

The electric utility industry is undergoing dramatic change. Both the industry as a whole and the individual utilities themselves are changing. The U.S. Energy Policy Act of 1992 made some key changes at the federal level and urged review at the state level to allow increased competition for wholesale supplies of power. Large industrial and wholesale utility customers are or soon will be able to shop around for suppliers of electric service to meet their needs; small commercial and residential customers may be able to do the same within a few years.

In April of 1994, the California Public Utilities Commission issued a draft plan that called for the major restructuring of the regulated utilities in that state. And in March of 1995, the Federal Energy Regulatory Commission issued proposed rule changes that deal with open access to utility transmission facilities for all power providers. These actions are forcing utilities into a more competitive position and the utilities are responding by seeking ways to lower their costs, to lower their rates to these large customers, and to respond to customer needs more effectively.

As discussed in the UPVG Phase 1 reports, individual utilities are continuing to restructure, downsize, and re-engineer their organizations through early retirements, terminations, and employee buy-outs. The overall result is a continuing loss of experienced utility personnel to the industry. Although a few of those personnel subsequently work for their former utilities as consultants and outside contractors, there is still a continuing net reduction in personnel in the electric utility industry. This action is occurring in all sectors of

the industry: investor-owned, public, cooperatives, government utilities, and federal power marketing agencies. In some cases, this is the first time and, with other utilities, it is the second and even third restructuring in the past few years. The experienced people leaving the industry are numbered in the thousands.

Investor-owned utilities are continuing to restructure to become more flexible and competitive, with fewer levels of management in the new operating environment. Many are forming a corporate organization with a number of separate operating units under it. Such reorganization may separate the central generating part of the company into a regulated and an unregulated unit and the traditional transmission, distribution, and customer service segments into a separate regulated unit. Other unregulated units are being formed to take advantage of customer service opportunities.

In this increasingly competitive atmosphere, utility personnel are working more closely with their customers to identify a wide range of service opportunities which the utility might perform more cost-effectively or efficiently than the customer. Fuels purchasing, energy efficiency support, and central payroll services are but a few of the many possible services that utilities can and are beginning to perform for their customers.

Although the growth in use of electricity in this country is still going up at a rate near two percent per year, there is still excess capacity in many areas of the country. In other areas, where new capacity might be needed in the future, utilities are reluctant to start large new generating facilities. To help meet growing load, utilities are working with customers to evaluate already installed, customer-owned generation for which

the utilities might provide operating and maintenance service and which also could be operated during peak load periods by the utility to help meet customer needs.

These programs, along with utility interest in the concept of distributed resources, are being pursued by utilities to help them meet their peak loads, increase the utilization of existing facilities, reduce the cost-of-service to their customers, and even to help them recover more quickly from natural disasters. In light of the utility industry's continued reduction in personnel, this last issue is beginning to be raised by the insurance industry and public organizations that deal with disaster recovery. They are asking questions as to the future capability of utilities to recover in a timely manner from natural disasters—such as forest fires, tornados, hurricanes, ice storms, etc.—with reduced staffs.

2. Task Activities for Phase 2

A. Commercialization Strategies & Markets

In Phase 1 of the UPVG effort, the Applications & Markets (A&M) Work Group evaluated and assessed the market for PV in grid-connected, grid-independent, and international village electrification applications based upon then-available information. In Phase 1, the A&M Work Group reported that, due to a paucity of data regarding grid-independent applications, analysis and quantification of only a few grid-independent applications was possible. However, because PV-powered, grid-independent applications can usually be traded-off against the higher cost of line extensions, it was felt that many additional cost-effective opportunities exist in the grid-independent arena.

Many of these applications are cost-effective now and, therefore, would play a major role in the early commercialization efforts for PV and, consequently, help to lower prices. The A&M Work Group then recommended that further searching for source data to support analyses in several grid-independent areas be performed.

During Phase 2, the Commercialization Strategies and Applications & Markets Work Groups were combined to form one Work Group with the title and focus of Commercialization Strategies & Markets (CS&M).

The overall goal of the CS&M Work Group is to develop strategies for the successful commercialization of PV while investigating the potential market in utility applications. The goals for the

Commercialization Strategies & Markets Work Group are to:

- Identify and evaluate markets and application niches for PV of benefit to electric utilities and their customers that have good prospects for early market adoption;
- Understand and compile information relevant to customer, utility, or stakeholder factors that may either act to promote or hinder early adoption by those markets;
- Recommend strategies and policies that accelerate the use of PV systems by utilities by: (1) reviewing and evaluating governmental, private industry, and voluntary policies; (2) comprehensively identifying and comparing various acceleration strategies; and (3) formulating preferred utility strategies that promise the lowest risks and highest benefits; and
- Make recommendations to shape UPVG decisions and state and federal policies to support those preferred strategies.

To achieve these goals, the CS&M Work Group recommended the following Phase 2 tasks:

- Conduct a markets and strategies workshop,
- Prepare analysis of financing and ownership options,
- Further evaluate customer acceptance factors, and
- Continue grid-independent market analysis.

Due to budget constraints during the Phase, the following tasks were omitted from the original program plan:

- Study of market leverage opportunities;
- Development of targeted policy papers;
- Market analysis from commercial DSM, residential, and distributed generation areas.

The CS&M Work Group conducted one workshop on commercialization strategies on April 13, 1995. Invited guests included utility representatives, PV suppliers, distributors and other product manufacturers, and UPVG staff. Some key points of the meeting are included in Appendix A.

The CS&M Work Group continued the work of the Applications & Markets Work Group in Phase 1 by investigating additional small-scale applications of PV for use by utilities. The results indicated an extraordinary market for six applications with new installation potential of up to 500 MW. Including Phase 1 investigations into remote residential service, water pumping for livestock applications, and cathodic protection, the total potential market for small-scale applications is almost 800 MW. Table 1 lists all of the applications investigated by the UPVG in both Phases 1 and 2. Those from Phase 1 have an asterisk.

The CS&M Work Group also sponsored sessions on financing and ownership options and customer acceptance during the UPVG 1995 Annual Meeting. The results of these sessions are included in the report of the annual meeting in Appendix A.

i. New SSA Market Study Results

The Small-Scale Applications (SSA) markets investigated in Phase 2 were those that appeared to have the greatest

promise based upon prior reports and studies, accessibility, and expected size:

- Remote Military
- Railroad Crossing Safety Lighting
- Pond & Lake Aeration
- Remote Irrigation
- Rural Billboard Lighting
- Park Lighting & Remote Uses
- Highway Sign Lighting
- Bus Shelter Lighting

Not all of these markets were planned to be included in these Phase 2 analyses. In particular, Railroad Crossing Safety Lighting and Remote Military applications were further investigated because of the discovery of information during the course of the Phase 2 analyses which suggested that these markets were, in fact, much larger than what prior market estimates have indicated. They were subsequently included in this report because of the very significant magnitude of their market sizes.

In a few cases, the results of some of these analyses indicate that the markets are smaller than had been professed by prior studies and general

Table 1. Total Potential Market for Small-Scale PV Applications

Application	Domestic Market Potential
Bus Shelter Lights	Minimal
Highway Sign Lights	Minimal
National Park Lighting	2 to 3 MW
Rural Billboard Lighting	3.5 to 4 MW
Cathodic Protection*	5 to 6 MW
Pond and Lake Aeration	30 to 35 MW
Livestock Water Pumping*	30 to 40 MW
Railroad Crossing Signs	45 to 55 MW
Remote Residential Service*	200 to 240 MW
Remote Military Installations	200 to 400 MW

**From Phase 1.*

expectations. Others, however, appear to be larger than expected. One conclusion is that markets are dynamic and always in a state of flux. The mere availability of a new technology at an affordable price will shape peoples' thinking and can significantly affect opportunity and the market size itself.

These are not small markets. Preliminary information indicates that the total 1994 world output of PV was only slightly in excess of 70 MW. Compare that to the remote military market at 200 MW to 400 MW. And remote markets can usually justify higher prices by virtue of the high cost of line extension required from utility power sources or the high costs of engine-driven generators and their fuel consumption and fuel transportation requirements. These market sizes are very significant.

a. PV in Military Applications

Military use of PV has been fairly limited. PV has been used for powering such applications as satellites, but terrestrial, unclassified uses generally have focused on small remote systems. Now, the military is beginning to commit larger resources to the intermedi-

ately sized remote market. This market for PV is for bulk power generation on military installations. The current focus and funding is on installations in this country, but the expectation is that it will, in time, be expanded to include all military installations where PV makes sense.

Under the Energy Conservation Investment Program (ECIP) and the Strategic Environmental Research Development Program (SERDP), the U.S. Department of Defense (DOD) started to purchase and install 1.4 MW of PV in 1994. ECIP program funds must be used only for projects that are cost-effective today. SERDP funds can be used for projects that may not be currently cost-effective because they are designed for experimental projects that test new technologies and generally fall under the category of research and development. These programs are being performed under the aegis of the DOD Photovoltaic Review Committee (PVRC) which is composed of representatives of the Army, Navy, Marines, and Air Force. The installation, size, type, and other information regarding current projects slated to begin in 1994 are shown in Table 2.

Table 2. PV Programs for Military Installations Begun in 1994

Military Installation	Size	Branch	Funds	Type
Junction Ranch/NAWS China Lake, CA	150 kW	Navy	ECIP	PV/Diesel Hybrid
Wild Horse Mesa/NAWS China Lake, CA	200 kW	Navy	ECIP	PV/Diesel Hybrid
Superior Valley/NAWS China Lake, CA	300 kW	Navy	SERDP	PV/Diesel Hybrid
REWS/San Clemente Island, CA	150 kW	Navy	ECIP	PV/Diesel Hybrid
Range 500/MCAGCC 29 Palms, CA	100 kW	Marines	ECIP	PV/Diesel Hybrid
Yuma Proving Grounds/Yuma, AZ	450 kW	Army	Both*	Utility Grid Support
Multiple Water Pumping/Ft Carson, CO	~30 kW	Army	ECIP	Stand-Alone PV
Grasmere Range/Mtn Home AFB, ID	80 kW	Air Force	ECIP	PV/Diesel Hybrid
TOTAL	1,460 kW			

*PV systems under ECIP. Load leveling equipment under SERDP.

Although some of these installations may be on large military bases, the installations themselves usually range from approximately 20 to more than 40 miles from grid power. Typical installations include power for the computers and electronics that monitor bombing ranges, missile ranges, ECM ranges, etc. One of the systems will be grid-connected and approaches the size of the 500-kW PVUSA Kerman installation in California. Another is for multiple small water pumping applications.

The most significant aspect of the remaining projects is that they are for large, grid-independent systems. Each one will include batteries for storage and inverters for conversion to alternating current to serve AC loads. These systems will be the largest stand-alone PV systems installed to date in the U.S. They will work in cooperation with diesel generators which are the present source of power for these installations. PV is being used to reduce both diesel fuel costs and its associated transportation and O&M costs.

These installations also will be very valuable in demonstrating capability to serve large PV-powered, grid-independent enclaves more akin to village electrification in third-world countries than the highly developed grid system here in the U.S. Up to this point, communities in the U.S. have almost always formed in areas that are serviceable only by the existing grid or, at least, in locations that required only modest extensions. Truly rural and uninhabited areas have been available only to those individuals willing to forego many of the conveniences and creature comforts normally associated with the availability of electric power or with the financial wherewithal to fund long and expensive grid extensions.

Remote stand-alone PV systems of the size to be installed in these military installations may provide an alternative to providing electric service by costly grid extension. This could allow communities to form and grow in locations far from the existing grid. Utilities will be able to service a new market by being able to supply and install PV systems to power these communities without distribution or subtransmission line extensions. As a result, and as mentioned in the Phase 1 reports, some electric utilities may expand from being only a power supplier and add the services of being a system financier, supplier, installer, and/or source of maintenance.

This will be different from the remote home/vacation cabin market in that, because there will be multiple homes on one system, the total system size will not have to be as large as the aggregate amount of the systems needed to power the same number of individual remote homes. This is because the peak power usage is not expected to be coincident among all homes.

Grid-independent systems of this size have not yet been tested nor evaluated in pilot-plant settings. One utility is already working with the military on one of these projects and others are interested. Working together in the acquisition, installation, operation, and maintenance of these PV systems will provide utilities with an opportunity to pilot-test and evaluate systems for the grid-independent, community market. In addition, for those utilities that wish to investigate and play a role in the international village electrification market, the lessons learned will be directly transferable.

Currently, \$10 million to \$12 million has been approved for PV research in the 1995 federal budget. It is expected that at least the same amount will be

appropriated and approved each year for PV-related projects over the next several years, particularly as the cost-effectiveness continues to increase through lower and lower PV prices and the cost savings of very low maintenance become more and more evident.

The future market for PV potential in military applications is significantly larger. In 1986, an unpublished Navy survey was conducted for each military branch to assess the potential for PV-powered, remote applications. Subsequent study and field surveys have refined the results, which identified 51,000 installations. Estimation efforts by the PVRC based on the survey results have concluded that there exists approximately 200 MW to 400 MW of potential for PV systems.

Another survey, by the Tri-Service Renewable Energy Committee (which determines the renewable energy potential for DOD), is currently underway to update the data base and to confirm the prior analysis with the accumulation of additional "hard data." Preliminary results appear to bear out the original estimates that PV independent potential is in the hundreds of megawatts. Confirmation will have to await the completion of the new survey, analysis, and quantification efforts.

Because of the larger sizes of PV systems involved, these types of applications will become significant in commercialization efforts. Because many of these applications are already cost-effective—which will continue to increase as the cost of PV comes down—the general feeling of the military (according to the PVRC) is that, at the very least, most of these applications should be implemented and, within the constraints of approved funding, will be. [The military is required by the Energy Policy Act to replace generation with re-

newable energy sources if the payback is less than 10 years.] The speed of implementation is and will continue to be a function of both the price of PV systems and the amount of funding made available for this purpose.

b. Railroad Crossing Safety Lighting

Safety lighting at railroad crossings presents significant opportunities for PV. According to sign and lighting personnel at the Federal Highway Administration (FHA), car versus train accidents at passive railroad crossings¹ are becoming more frequent. Because the car invariably loses and a high percentage include fatalities, interest in lighting some of these passive crossings has seriously increased.

FHA personnel attribute many of the accidents to the fact that the cars drive directly into the side of a moving train because they cannot see the train with their headlights alone. Train colors are not usually bright and the trains themselves have very few highly reflective surfaces. The FHA has lighting recommendations for overhead luminaries that should prevent many of these accidents if some electricity source can be found to power the luminaries.

There are 168,000 public railroad crossings in the country.² Of these, 111,000 are passive crossings. FHA personnel feel that adding luminaries to approximately 20% to 50% of these could benefit public safety immensely. The recommended installation provides

¹Passive crossings refer to those that have just signs and no lights (luminaries or crossing signals).

²Public railroad crossings are those that cross public streets and highways.

for two 250-Watt luminaries on each approach or four luminaries per crossing. Using the average of the 20% to 50% range (35%), this results in 38,850 crossings using 1,000 watts of light each, for a total of 39 MW.

There are also 108,000 private railroad crossings. Of these, only 24,000 have signs. The remainder have no signs, signals, or safety lighting. Private railroad crossings occur on private (not residential) property. These crossings refer to tracks crossing the entrances or private roads for factories, manufacturing plants, warehouses, etc., that have long access roads. Electric power, though obviously provided to the factory or plant, comes into the property from some other direction and is not usually available along these access roads and crossings. Often, these are rear and side entrances or access roads.

Of these crossings, FHA personnel felt that at least 10% also should have safety significantly enhanced by the addition of luminaries at the busier crossings, and would push for their installation if a low-cost, remote power supply were to become available. This would add another 10,800 crossings or approximately 11 MW, for a total of 50 MW of remote, PV-powered lighting opportunity.

c. Pond & Lake Aeration

Ponds and lakes have undergone significant changes since the Industrial Revolution began in the late 1800s. As urbanization and rapid industrialization have occurred, large amounts of sewage, erosion from stream banks, excess fertilizers, and other wastes have been released into waterways, reservoirs, ponds, and lakes. The result has been that an excessive amount of nutrients have accumulated and caused algal blooms in the uppermost water layers,

with a commensurate depletion of available oxygen. Besides using up the available oxygen in the upper layers, these algae screen out sunlight and therefore limit or severely reduce the production of oxygen through photosynthesis at lower levels.

To exacerbate the situation still further, dead algae cells drop into the deeper waters and bacteria and fungi use up the remaining oxygen in an effort to decompose the dead algae cells. At this point, not only is the dissolved oxygen level very low, the extensive decay continues to use it up faster than it can be replenished. These extreme levels of oxygen depletion can cause massive fish kills, which subsequently release still more nutrients into the water, furthering more overgrowth of algae and other plants.

Bodies of water in this condition are known as *eutrophic*, which literally means "good nutrition." On large lakes, wind action across the surface will cause water movement and splashing, which generally provides sufficient gas exchange (carbon dioxide out, oxygen in) to maintain the delicate balance.

On smaller bodies that are less affected by wind action, this balance is much harder to achieve. Eutrophication is a natural process that normally proceeds very slowly. However, the effects of human intervention are almost always one of acceleration caused by the release of massive amounts of nutrients into the water. Once this occurs, additional oxygenation help using an external means becomes necessary.

The usual way to restore such a water body is through artificial oxygenation of the water by pumping large amounts of air down to the bottom. Air pumped to the bottom rises and results in not only gas exchange at the surface,

but also causes the pond or lake to "turnover." The rising bubbles draw up water with them as they rise and surface water drops down to take the place of the water drawn up. The final result is one of bringing freshly oxygenated waters down deep and stale, oxygen-deprived waters up from the bottom for surface oxygenation. This pond or lake turnover stops the tendency toward further eutrophication and begins the process back toward a lower nutrient—more oxygen—rich environment (oligotrophy).

This application can take advantage of some of PV's unique properties. For example, PV can reach ponds and lakes that lack grid-supplied electric power. Also, for smaller installations, DC motors can be used and obviate the need for inverters and their associated losses.

The Clean Water Act of 1972 requires that all the states in the nation assess their water quality for attainment of the fishable and swimmable goals of the act and report the results to the Environmental Protection Agency (EPA) every two years. In actuality, most of the states do not assess all of their bodies of water during each two-year cycle. Thus, the assessed waters reported in each biennial period are a subset of the nation's total waters.

In 1992, the total estimated surface acreage of lakes, ponds, and reservoirs was 39,920,000 acres, excluding the Great Lakes. Of that, 18,300,000 acres, or roughly 46%, were assessed.³ More than 43%, or 7,958,064 acres of lakes, ponds, and reservoirs that were assessed, were determined to be impaired by pollutants. Though pollutants by metals was the largest category at 47% of the polluted bodies, the effect of metals was concentrated in one state: Minnesota. The second largest pollutant was by nutrients, affecting 40% or 3,183,225 surface acres, and was widely

reported by 41 states. This is the source of eutrophication.

Experts that monitor and study ponds and lakes across the U.S. estimated that even more—at least 75% to 80%—of the ponds and lakes in the country were eutrophic or mesotrophic.⁴ However, not all of them can be considered for PV-powered aeration. Any of the bodies of water that have access to grid power will obviously use that power. Most of the larger lakes in the country are near populated areas and, therefore, near the power grid.

Of the smaller lakes and ponds that are in rural areas away from grid-supplied power, only those used for fishing, boating, swimming, etc., will experience a demand for aeration. More rural bodies of water will have insufficient aeration advocates willing to shoulder the costs involved. According to limnologists⁵ and other individuals in the aeration field, only about 10% of the water in the ponds and lakes of the country are candidates for PV-powered aeration applications and that these generally have less than 1,000 surface acres.

If the acreage of lakes, ponds, and reservoirs that have been assessed as impaired by excessive nutrients—3,183,225 surface acres—is considered and 10% are selected so as to conservatively limit the assessment to only those bodies of water with less than 1,000 surface acres and that are both remotely located from grid power yet close

³*Environmental Protection Agency, National Water Quality Inventory: 1992 Report to Congress.*

⁴*Intermediately eutrophic and on their way down the path.*

⁵*Those who study freshwater bodies like lakes and ponds.*

enough to populated areas to support demand for aeration, the result is 318,322 acres.⁶ A pond or small lake between 500 and 700 surface acres requires, on average, about two 40-horsepower motor compressors.⁷ Each compressor pumps approximately 120 to 160 cubic feet per minute (ft³/min) of air at 50 to 70 pounds per square inch (psi) to an average depth of 20 to 50 feet deep. Each 40 hp motor will require 29,840 Watts [40 x 746] without consideration for losses [746 Watts = 1 hp]. Therefore, using the average of 500 and 700, each 600-acre pond will require approximately 60 kW for aeration. By using simple proportion [(318,322 ÷ 600) x 60], there exists 31.2 MW of opportunity for PV-powered pond and lake aeration.

Although 31.2 MW is a significant opportunity for PV, the opportunity is actually much larger. This estimate is overly conservative for the following reasons:

- Less than half (46%) of the nation's bodies of water were assessed and,

⁶This is most likely a significant understatement of the opportunity. Experts have identified 10% of the total bodies of water as being candidates for PV-powered aeration. We are taking 10% of those which are eutrophic, which are 40% of those polluted, which are 43% of those assessed, which are 46% of the total. Essentially, we are using 0.79%, less than 1% of the total. Also, in all likelihood, the eutrophic lakes are more likely to be a larger percentage of these smaller water bodies (less than 1,000 surface acres) which have the least volume to dilute nutrients and, because of less surface area, also have the least natural aeration through wind action.

⁷See the section Large Motors in PV Applications later in this report.

therefore, considered in these calculations.

- No compensation was made for losses in the motors and pumps, which are known to have efficiencies of less than 100%.
- Analysis does not consider bodies of water greater than 1,000 surface acres.
- Some of these bodies, both assessed and not assessed, are in still worse shape, being so eutrophic as to be unsurvivable by many freshwater species of fish (hypereutrophic). These bodies of water will require more aeration per acre to reverse eutrophication.
- As PV allows individuals to live in what were previously rural, uninhabited areas, demand to aerate local, eutrophic bodies of water will increase due to public demand.

For these reasons, some larger market potential—perhaps exceeding 50 MW to 100 MW or more—is probably more realistic. However, a 30 MW to 35 MW range is being used in an attempt to remain conservative and because it is fully supportable by the existing data. It is clear that pond and lake aeration is a large application that can make good use of PV's special characteristics. And, as large grid-independent PV systems are installed and tested, such as those currently planned for military installations and described earlier in this report, engineers will become more comfortable in using them in large power applications such as pond and lake aeration. Currently, most people, even in the PV industry, think of small systems when thinking of grid-independence. This is about to change.

d. Remote Rural Irrigation

Rural irrigation is the mainstay of farming throughout the central and western United States. Without irrigation, much of this farmland—such as the central high plains—would revert primarily to dry grassland, unable to support agriculture as we know it. Wells and ditches are dug and, where practical, the route is selected to use gravity to maintain flow as much as possible. Almost always, however, pumps are necessary to bring water up from the wells and for at least several portions of the irrigation route.

The motors used are typically very large at 40 or 50 horsepower (hp). Even 100 hp is not uncommon and, in some applications, the motors used exceed 500 hp.⁸ The load, therefore, is very significant. The horsepower required for any particular well is a function of the volume of water needed and the depth from which the motor must pump. The more water needed or the deeper the well, the larger the horsepower motor that is required for an installation.

Where a grid connection is unavailable or too costly to extend, the alternative has been to bring in a propane-, gas-, or diesel engine-powered pump. As the cost of PV continues its drop in price, PV will become another alternative to combustion engines in the powering of remote irrigation pumps.

PV has opportunity in water pumping, at least in the smaller installations initially and scaling up from there. It is reasonable to expect that, as the cost of PV drops, PV will become a candidate

for powering larger and larger installations. For example, PV could provide the electricity that would enable the use of submersible pumps in remote applications without the energy conversion losses associated with motor-generators. The use of these pumps would radically reduce the cost, time, and difficulty associated with pump installation.

Besides cost savings from installation, time, and servicing, operational costs and flexibility also improve, which further offsets the higher initial capital costs of PV. Not all irrigation pumps need run 24 hours per day. Running at night is common for certain crops, such as rice, and in some locations, such as northern Florida, where it is used to provide frost protection. However, in other circumstances, depending upon the location and crop, running at night can cause problems, such as the promotion of fungal growths. Therefore, it is not always necessary to have water storage or battery storage for pumping. With at least minimal battery power, primarily for control circuitry, pumping systems could run automatically and unattended for start-up and shutdown. They also could be controlled remotely. Current diesel-powered line-shaft pumps require operator attendance for starting and stopping each day.

On the economics side, the savings would be still greater. PV modules are expected to last at least 20 to 30 years and are solid-state, with no moving parts. There are no fuel costs, plus there are no costs for handling and transporting fuel and no risk of fuel spillage.

As the price comes down and PV systems finally begin to compete with grid power, even grid-connected pumping installations may become potential candidates for conversion to PV-powered systems, particularly when considering

⁸See the section, *Large Motors in PV Applications*, later in this report.

that some of these farmers currently are paying as much as \$50,000 to \$100,000 per year for electricity.

As yet, there is insufficient data to assess and report market size. More work needs to be done before market size results will be available.

e. Large Motors in PV Applications

In two of the applications considered, pond/lake aeration and remote irrigation, mention was made of the large motors that are typically used in these applications—at least up to 40 or 50 hp for aeration and perhaps up to more than 100 hp for irrigation. Motors of these sizes are not considered small loads by any measure. Indeed, these customers usually represent large utility loads. PV currently finds limited, if any, application in powering motors of this size. In addition, these motors use three-phase alternating current and, therefore, an inverter is not only necessary but must provide three-phase output.

A 40 hp motor requires more than 29,840 Watts [40×746] not including losses, power factor considerations, etc. [746 Watts = 1 hp]. More realistically, a 40- or 50-kW system would be used to power a motor of this size. The PV system size is not a source of concern as systems can be assembled in essentially unlimited size configurations just by the addition of more modules. Inverters of this size and capability currently are manufactured for grid-connected applications starting from about 50 kW.

The general rule of thumb with today's PV efficiencies is to expect to use approximately 100 square feet of PV panels to generate 1,000 Watts of electricity, assuming about 9% conversion efficiency (solar to electric). As stated

above, a 40 hp pump, for example, will require in excess of 30 kW. Using 50 kW for this example (which should provide adequate capacity to address losses, some overhead clouding, etc.), means the requirement of 5,000 square feet or approximately one-ninth of an acre. Clearly, it is possible to give up an eighth of an acre alongside a 400 to 500 surface acre lake for aeration. Moreover, as efficiencies increase with future developments, the area required to generate a certain amount of power will continue to go down, further reducing PV panel space requirements.

A special consideration which will require attention in inverter/motor starter design is current requirements for motor starting. Starting currents generally range from five to 10 times the amount of current necessary for running under load. It is doubtful that it will ever be cost-effective to justify providing PV capacity based upon motor start-up requirements unless there are other ancillary loads which can use that added capacity between motor start-ups.⁹

A more practical approach will be to provide soft-start capability in the motor starter to allow a large motor to start slowly and with far lower current requirements than is generally accepted when connected to grid-power. For standardized, stand-alone packages, the entire soft-start motor starter circuitry could even be integrated into the inverters for these applications. Therefore, it appears that, although these markets require larger sizes of equipment than that presently used in typical grid-inde-

⁹*There are not usually many daily start-stop cycles of large motors in these applications. The motors are generally started in the mornings and run throughout the day. Sometimes, motors in aeration applications are left running.*

pendent applications, in general, larger PV panel and motor sizes are not major obstacles to entrée of PV in these and similar applications.

f. Rural Billboard Lighting

Billboards are common on the American landscape. As concern for environmental issues, the ecology, and esthetics has grown, billboard advertising companies and associations have become concerned and taken actions to minimize those billboard installations that have appeared to clutter the landscape or have turned into eyesores. Most of today's new installations are designed with an eye as to how they will fit into their intended surroundings. While some may feel that all billboards are a nuisance, a case can be made for the informational role that they fulfill, such as indicating restaurant and lodging locations for travelers.

In rural locations, supporting the nighttime utility of billboards has proven troublesome. In many locations, grid access to power billboard lighting is unavailable. Without lighting, billboard visibility is limited to those that can be lit with headlights. Yet, many of the boards have been moved out of locations immediately near the highway for the aforementioned reasons of esthetics and, therefore, are not well-lit by vehicular road lighting. PV, with battery storage, has an opportunity to play a role in this application.

From a cost standpoint, PV allows rural billboards to be lit without incur-

ring the high costs of a line extension. From an esthetic point of view, use of PV obviates the need to install utility poles and distribution lines through rural landscapes.

There are approximately 400,000 billboards in existence nationwide. Although the boards can be any size, the great majority fall into the three standard sizes listed in Table 3.

The data listed in the table and discussed in this methodology came from speaking with representatives at billboard trade associations, firms that provide billboard lighting, and from the Traffic Auto Bureau (TAB). TAB evaluates the exposure that billboard locations offer advertisers. This service is similar to the Nielsen ratings given to television programs. However, rather than reporting the percentage of market share that tuned-in to a particular program on television, TAB compiles and reports the average number of vehicles passing a particular billboard location on a daily basis.

The quantities for each billboard size are national numbers and do not indicate what fraction of the total are pertinent to rural areas. Of the total number of boards in the country, 20% to 40% are in rural America. And the great majority fall into the eight- or 30-sheet poster sizes.

In an effort to be conservative, only 20% each of the eight- and 30-sheet poster billboards were considered. In addition, if it is assumed that only 50%

Table 3. Advertising Billboards in the U.S.

Dimensions	Name	Quantity	Lighting Wattage
6' x 12'	8-Sheet Poster	150,000	40 Watts Each
12' x 25'	Standard or 30-Sheet Poster	200,000	160 Watts Each
14' x 48'	Painted Bulletin	50,000	240 Watts Each

of the owners of these billboards are willing or able to pay to light them at night, this amounts to 15,000 and 20,000 boards respectively. Using 40 Watts of lighting for each eight-sheet poster and 160 watts of lighting for each 30-sheet poster results in 3.8 MW of opportunity for PV in this application.

g. Park Lighting & Remote Uses

Parks, often viewed as respites from civilization or bastions of unspoiled nature, seem to be a natural partner with PV. People like parks to be free of utility poles and wires. Yet, they expect lighting at the flip of a switch in a park rest room; they expect parking lots and walkways to be lit; and park rangers desire the convenience of electric lights and appliances at remote stations or buildings. PV, in addition to being a renewable resource, fits this bill handily. It doesn't clutter the park skyline with poles and wires. It doesn't require accepting the costs of fuel and its transportation and risk of spilling fuels. It doesn't emit any effluents to pollute the environment. It doesn't even emit loud sounds to spoil the mood.

Parks are divided into three primary categories: national parks, state parks, and city/county parks. The National Park system is the only one to undertake a survey of present PV usage and the opportunity for new systems. The state and city/county parks are not integrated: a state park in one state has little communication with or relation to state parks in another, or with city/county parks in its own state or anywhere else. Although there are exceptions and some parks obviously will form working relationships, there is no data base of existing PV applications of all state parks or all city/county parks. Calls to associations such as the National Association of County Park Officials and the National Association of

State Park Directors have confirmed that the associations serve primarily to foster communications among park leaders across the country and the sharing of knowledge and ideas in resolving similar problems. Programs implemented in each of the parks are not controlled by any central agency, as the national parks are, but rather are the domain of state, county, and city governments. Therefore, this section has been limited to the National Park system, which has recently undertaken a PV application survey with Sandia National Laboratories and plans installation of new PV systems in the near future.

The National Park system consists of 368 parks over the country. An effort was begun in the first quarter of 1994 to compile a data base on existing PV applications in the park system and evaluate their acceptance of PV. They also attempted to identify new applications that were a good match with PV. Although the responses and raw data are still being reduced, they were able to share some of their conclusions. There are currently 455 identified, existing PV systems being used in the national park system. A breakdown of functions is shown in Table 4.

Since the survey has been completed, field trips taken by Sandia personnel have uncovered many small, unreported, existing systems, such as navigation aids on park-administered lakes. Therefore, there is a significant likelihood that many other small PV systems also were not reported accurately. The general feeling is that there are actually more current installations than the 455 identified, at least more than 600. These were in addition to the larger systems identified on the survey responses. The respondents expressed great satisfaction with the performance of the existing PV systems. The satisfaction level was 97%.

The survey also sought to identify barriers that get in the way of implementing new PV systems. It is hoped that identification of and information about these barriers will help those in the PV industry to address solutions which might speed PV implementation and their accompanying advantages. The barriers identified thus far, and some solutions identified by Sandia and the Park Service, are:

- **High initial cost.** The National Park Service will attempt to form partnerships with other agencies/groups.
- **Lack of familiarity with PV by operating personnel.** Presentations should be prepared and performed for park personnel.
- **Uncertainty about performance record of PV systems.** Presentations should be prepared and performed for park personnel.
- **Visual quality concerns.** Sophisticated design technologies such as computer visual simulation should be employed to evaluate the visual impact of alternatives prior to construction.
- **Conflicts with historical resource context.** Again, computer visual simulation could be used. Also, PV will allow systems to be placed close to the loads away from sensitive areas to reduce untoward visual impact.
- **Lack of familiarity with PV by designers.** Better education and cooperative working relationships between park designers and PV specialists offer awareness of present technology and resource of expertise.

- **Adverse climate.** Better designs with today's technology offer promise of more robust systems.

In addition, some field personnel are haunted by the legacy of prior failures with solar thermal technology that was installed in the late 1970s and early 1980s for domestic hot water heating. These systems did not live up to expectations, were disconnected, and the rooftop panels have remained as a constant reminder of the frustrations experienced. Coupled with the fact that many people view all panel technology as "solar" and do not understand the differences, it is easy to see why some individuals will be very skeptical of the value of PV until convinced by a series of successful installations.

Finally, there was an attempt to identify future projects. As of this writing, 666 new installations have been identified. Of those, 643 currently are being planned for implementation in 125 national parks. They range from 10 Watts to 100 kW in size and are spread over 125 national parks. They are broken down by function in Figure 1.

In total, this results in another 2 MW to 3 MW of new grid-independent applications for the National Park system.

Table 4. Breakdown of Existing PV Installations in the National Park System

<u>Function</u>	<u>Quantity</u>
Resource Monitoring	141 (31%)
Communications	123 (27%)
Water Pumping	45 (10%)
Facility Power	64 (14%)
Lighting	4 (1%)
Ventilation	32 (7%)
Other	46 (10%)

Figure 1. Pie Chart of Planned PV Installations in the National Park System

The implementation of these projects is expected to occur over five to seven years. A summation of the expected costs for all 643 projects—as provided by National Parks personnel—is approximately \$22 million. Initial field analysis suggests that the total cost is more in the \$40 million to \$50 million range. However, if the money were available now, all these projects could and would be built today. Therefore, the implementation will be prioritized. The highest priority applications are those that can replace existing generator sets. These are fossil-fueled and therefore have the attendant costs and risks associated with fuel hauling and spillage. Cleanup costs at parks of some fuel spills have been in the hundreds of thousands of dollars. Finally, noise resulting from engine generator operation can be eliminated.

It must be noted that, although these projects will be implemented in the future, they still address existing needs. These future projects do not include any future needs that will arise. Therefore, the actual number of PV applications that will be desired will con-

tinue to increase as needs grow and more experience is gained. Also, 335 survey forms were sent out. Some of the park management teams administer more than one park. Responses totaled 201 and were primarily from the largest, most remote parks and not the small parks in urban areas. The full report from the National Park Service and Sandia National Laboratories, *Renew the Parks*, was published in February, 1995.

As the national parks install more PV systems and some systems actually are designed with park applications in mind, administrators of state and city/county parks will become more aware of PV technology and its advantages. Also, the cost of PV hardware will keep coming down and this will promote the use of PV systems in these other parks as well.

Some also will have applications not ordinarily associated with parks. For example, some city parks have marinas. PV already has been used successfully by the U.S. Coast Guard to power more than 12,000 channel buoys and other

aids to navigation. As these parks' personnel become more aware of PV, they will move toward selecting it as a solution to power these remote loads. Because of the desire to keep parks as pristine and close to nature as possible, PV will become a common solution and alternative to current energy options in the park systems.

Sandia also conducted a survey with the National Forest Service. There are 156 National Forests in the U.S. and this assessment will most likely identify many more cost-effective applications for PV. A report is expected to be completed by June, 1995.

Finally, Sandia began working with the Bureau of Land Management (BLM) late in 1994 to assess current and future PV applications on land that they administer. This is extremely important because of the sheer size of the area involved. The BLM currently administers 752 million acres of land, or 31% of all the land in the contiguous United States and Alaska combined. This assessment is expected to be completed by the end of 1995. The National Forest Service and the BLM will augment the cost-cutting impact of the use of PV by further increasing the volume of PV systems chosen for similar applications. The UPVG will continue to update projections for these markets as additional information becomes available.

h. Highway Sign Lighting

Highway sign lighting has been identified in prior PV market studies as a significant application opportunity for PV. Like billboards, highway signs can be very large, requiring large light sources; are used across the country; and are often placed in locations where grid power is unavailable. UPVG analysis indicates that, while some opportu-

nities do exist in this application, they are not currently significant.

According to sign and lighting personnel at the Federal Highway Administration (FHA), there are 45,500 miles of interstate highways in the U.S. Of this, 33,000 miles of highway are rural, while 12,500 miles are urban. Also, there are 94,000 additional miles of principle arterial highways. In all cases, when a decision is made to use electrically lit signs, availability of power already has been confirmed. In the remaining cases, where electric power is not available, the signs are made of retroreflective materials and placed on the right-hand shoulder of the road where they can be seen with either high or low headlight beams.

According to the FHA, lack of grid-supplied electric power to light urban signs has not been a problem. The few exceptions have been situations where power is nearby yet not close enough for connection. In these instances, it may be necessary to dig up concrete and asphalt to run the power cable across a bridge or freeway. These are the few applications where PV is selected to light urban highway signs, but not many of these applications exist.

Overhead signs, however, are not well-illuminated by headlights and require supplemental lighting. Oncoming traffic often necessitates the use of low beams, which almost guarantees poor sign visibility. Fortunately, there is usually ample space for retroreflective signs on the shoulder of the road, except in urban situations where underpasses, for example, limit or preclude shoulder space and force the use of overhead signs.

In a slightly different and new twist, FHA personnel have indicated that the

state of California has elected to turn off the lighting to many of the overhead signs over highways across the state due to high electricity costs. This has resulted in difficult- or impossible-to-read guide signs in many locations.

Normally, PV is cost-effective for grid-independent applications, even at today's prices, because it can be traded-off against the high costs of line extensions. In this case, line extension cost trade-offs are not an issue as power is already available. Therefore, PV will only become an option if it is truly the lowest-cost alternative available on an energy comparison basis. This is not currently the case and is not expected to be so in the near future.¹⁰ Based upon the foregoing, the opportunity for PV-powered highway sign lighting is currently minimal.

i. Bus Shelter Lighting

Bus shelter lighting is another application that is often touted as having significant opportunity for PV-powered safety lighting applications. In fact, however, UPVG research indicates otherwise.

Just from a conceptual aspect, it is obvious that most bus shelters will be located where most buses stop to pickup and drop-off passengers: *in metropolitan areas*. It is also obvious that grid-supplied electric power usually will be readily available in metropolitan areas. As in highway sign lighting, the few exceptions that occur are in situations where power is nearby yet not close enough for connection. Again, in these instances, it may be necessary to dig up concrete and asphalt to run the power cable to the bus shelter. Another instance might be where power must be

run across a bridge, freeway, etc., to feed power to a bus shelter on a nearby road or intersection.

In speaking with vendors and manufacturers of this type of lighting, they have confirmed that these applications do in fact exist, but also that they make up a very small market. Their experience corroborates UPVG expectations that the preponderance of bus shelters are in cities and towns where grid power is usually readily available and that, when it is not, it is usually close but some structure like a bridge abutment or the high cost of construction in metropolitan areas makes a PV-powered light the more cost-effective option.

The UPVG's initial inquiries have failed to find any national or regional compilations of information about bus shelters and their proximity to electric power. This information, if it exists, is compiled only on a city, town, or county level. Based on the dearth of nationwide information and the aforementioned facts, it appears that further pursuit in attempting to research the bus shelter lighting market is neither warranted nor cost-justified.

j. Grid-Independent PV Market Analyses—A Summary

Most grid-independent PV-powered applications are currently cost-effective. Many of those that are not will be so prior to general cost-effectiveness of unsubsidized, grid-connected applications. Of those, the applications that produce savings through deferral of transmission and distribution upgrades and eligibility for renewables savings or subsidies will come next. Finally, those applications which must compete on an energy basis alone will be the last to become cost-effective and, therefore, the last to be exploited.

¹⁰Approximately five years.

Some of the most important lessons learned as a result of these market analyses have been from the feedback solar advocates have provided, along with the information necessary for these analyses. These individuals generally have been at the forefront in pursuing alternative generation to supply energy needs in remote locations. They have identified several important actions that must occur for the commercialization of PV technology to succeed:

- Systems must be properly sized and designed or, if a standard off-the-shelf system will be considered, it must be properly sized to meet the requirements for each application. The sizing of the system, the amount of battery backup, charge controllers, etc., vary with application and location. If oversized, the system may not be cost-effective and not compete well with alternative energy sources. If undersized, the system may fail to meet the demands of the application and undermine the entire PV energy effort. For larger systems, site-specific assessments should be performed.

- Systems must be properly installed. Incorrectly installed systems are, at best, unreliable and, at worst, a total failure, through no fault of the system itself.

Figure 2. Market Sizes for Grid-Independent Applications Analyzed in Phases 1 & 2

- There must be adequate training for all maintenance personnel. The systems must be correctly inspected and cleaned on an occasional basis. If a tracking system is used, additional maintenance must be performed to maintain moving parts in a clean and lubricated condition.

These points exemplify the value of exploiting grid-independent PV applications today as the most cost-effective way to initiate PV system usage by utilities. Within the *TEAM-UP* program, the grid-independent applications which have been identified and quantified provide perhaps the best opportunity for PV to become pervasive in utility applications on a cost-effective basis.

To that end, Figure 2 shows all the grid-independent markets evaluated under UPVG efforts to date. (The remote home/vacation cabins, livestock watering, and cathodic protection markets have been included from the UPVG's Phase 1 analyses so as to compare all the grid-independent markets evaluated by the UPVG to this point.)

ii. New PV Installations in the U.S.

U.S. electric utilities have been installing PV-powered systems—both grid-connected and grid-independent—around the country in increasing numbers. Some of these have been in various stages of development for some time (see UPVG Phase 1 report Part 2: *The Utility Experience Base With PV Systems*, Table 5). Others have been the result of more information becoming available about the technology and increased support provided by the federal government through its Sandia National Laboratories and the National Renewable Energy Laboratory; state organizations, such as the PV4U groups in 14 states; the utility industry itself through the Electric Power Research Institute; and now the Utility PhotoVoltaic Group.

The potential domestic markets for both grid-connected and grid-independent applications have been better defined as a result of the UPVG's Phase 1 efforts. The documentation of this market assessment has provided PV manufacturing and supply organizations with better information and a number of PV equipment manufacturers are looking more closely at the utility market segment and are directing marketing and sales resources to this area.

a. Grid-Connected Installations

Some of the recently installed, grid-connected PV systems are listed below. There is definite increased interest in PV systems installed on residential, commercial, and industrial buildings to help serve customer loads right at the customer's facility. In addition, a number of grid-support systems also are being installed. There are many more systems being installed today by utilities than those listed; these, however,

are expected to provide significant information or demonstrate important technology advances.

1. Sacramento Municipal Utility District. The PV Pioneer residential program is continuing. Thus far, this program has installed 108 4-kW systems in 1993 and 134 3.5-kW systems in 1994-95, for a total installed capacity of 901 kW at 242 residences.

In its commercial building program, SMUD installed a 40-kW line-focus concentrator system supplied by SEA Corporation in 1994; eight 18-kW systems on commercial buildings are being installed over the 1994-95 period. SMUD's total installed capacity on commercial buildings is 184 kW.

Under its distribution system support program, SMUD installed four PV systems: one 200-kW system in 1993 and three 100-kW systems in the 1994-1995 period, for a nominal installed capacity of 517 kW.

2. Central & South West Services. More than 300 kW of various types of systems have been installed at C&SW's Fort Davis, Texas, test facility. This includes 100 kW of flat-plate (one-axis tracking), 100 kW of Entech line-focus concentrator systems, and an additional 100 kW of flat-plate systems. C&SW also has installed a number of residential units on homes in the area surrounding Fort Davis.

3. TU Electric. A PV test facility has been built near the Dallas-Fort Worth airport. Thus far, a 100-kW flat-plate system and a 100-kW Entech line-focus concentrator system have been installed.

4. Arizona Public Service Company. Working with a system developer and the Electric Power Research Insti-

tute (EPRI), APS has installed a 20-kW high-concentration system at its STAR facility in Tempe, Arizona. This pre-commercial, Amonix Corporation unit has demonstrated 18 percent efficiency and is the latest step in the development effort to bring high concentration systems to the commercial market.

5. Utility/EPA/EPRI Nationwide PV-DSM Demonstration. Twelve electric utilities and EPRI are participating in an EPA-led project to install 18-kW PV systems on commercial and industrial buildings around the U.S. and to measure the potential reduction in utility power plant emissions as a result of the PV system output. This project is being used to help determine if a nationwide strategy of installing PV systems on buildings would be effective in reducing power plant emissions during the peak load periods of the day. A second outcome of this project is the effort to have all major components listed by Underwriters Laboratories—modules, inverters, and associated hardware. This important UL-listing effort has been supported by Sandia National Laboratories' PV Design Assistance Center. The utilities participating in this project are listed below:

- Arizona Electric Power Cooperative
- Atlantic City Electric Company (N.J.)
- Boston Edison Company (Mass.)
- Consolidated Edison Company (N.Y.)
- Duke Power Company (N.C.)
- Florida Power Corporation
- Idaho Power Company
- Los Angeles Department of Water & Power (Cal.)
- Nevada Power Company
- New York State Electric & Gas Company
- Public Service Company of Colorado
- Public Service Company of Oklahoma

6. PacificCorp. The utility has installed three 5-kW systems on commercial buildings—one each in its operating areas in Oregon, Utah, and Wyoming. These installations include 5-kW Abacus inverters.

7. PVUSA. This 500-kW array provides utility distribution system support for Pacific Gas & Electric. Located near Kerman, California, the grid-support project uses Siemens modules and Omnion inverters and has one-axis tracking. Purchased by PVUSA in 1992, the turnkey Kerman project had a cost of \$8.90/W and includes a 12-kV step-up transformer. "Utility transaction costs" were an additional \$3.30/W. PVUSA stands for Photovoltaics for Utility-Scale Applications.

b. Grid-Independent Systems

A number of utilities recently have become interested in utilizing PV-powered systems to meet customer loads that are located uneconomical distances from existing utility distribution facilities. Up to this time, utilities have had to turn away customers that were located too far away from an existing distribution feeder to justify the cost of the line extension. Now, 10 utilities have formal programs that have been approved and have pilot or demonstration systems installed at remote customer sites to meet their electric service needs. A list of the utilities with operating systems is given in Table 5.

A number of other utilities are evaluating the business opportunities, benefits, costs, etc., of expanding their customer service base by offering electric service with PV-based systems to off-grid customers. For investor-owned utilities, this probably will involve obtaining approval of a new tariff, for municipalities, approval by a city council,

and for cooperatives, approval by their board of directors.

B. Engineering & Specifications

As originally formed, the UPVG realized a need to have utility members become actively involved in engineering, design, and demonstration activities for PV systems. The UPVG created the Engineering & Demonstrations Work Group to handle these activities during Phase 1.

In Phase 2, this Work Group recognized the shift in its focus to specification requirements for grid-connected and small-scale applications of PV. It was during Phase 2 that the E&D Work Group recommended a change in its title to Engineering & Specifications; this was approved by the Board of Directors.

The E&S Work Group was charged with the task of developing the technical specifications, design criteria, acceptance tests, and data monitoring sections that would be included in the *TEAM-UP* grid-connected Request for

Proposals (RFP). The process included UPVG staff collecting specifications and criteria from previous RFPs used in other utility grid-connected PV projects and then, based on this information, developing a draft document that would be reviewed by the many stakeholders in the *TEAM-UP* program.

i. New Specifications for Grid-Connected Applications

Specifications, codes, acceptance criteria, and data collection methodologies were obtained from the procurement documents used by PVUSA, Sacramento Municipal Utility District, the City of Austin Electric Utility, Niagara Mohawk Power Corporation, TU Electric, and other relevant PV projects. A draft set of grid-connected specifications were developed based on the best practice from the respective projects.

The resulting specifications and design criteria were intended to lead to safe, reliable operations and also lead to standardized, packaged, and lowest-cost PV systems that could be used by many utilities and other power producers for the future procurement of PV systems.

Table 5. Utilities with Operating Grid-Independent PV Systems*

Utility	State	Application
Idaho Power Co.	Idaho	Residential, Water Pumping
La Plata Electric Association	Colorado	Residential, Communications
Nevada Power Co.	Nevada	Residential, Water Pumping
New York Power Authority	New York	Residential
New York State Elec. & Gas Co.	New York	Residential
Northwest Rural Pub. Pwr. Dist.	Nebraska	Water Pumping
Pacific Gas & Electric Co.	California	Residential
Plumas-Sierra Rural Electric Coop.	California	Residential
Sierra Pacific Power Co.	Nevada	Residential, Water Pumping
Southern California Edison Co.	California	Residential

*Not comprehensive

The draft RFP also included definitions of the PV system rating criteria, detailed PV system start-up and acceptance tests, operations checkout, and data monitoring requirements.

The first draft of the grid-connected RFP was reviewed by the *TEAM-UP* Advisory Committee in early August, 1994, where several concerns were raised about the need to specify many of the items in the specifications and the required level of detail for the specifications. A second review occurred at a special Engineering & Specifications Work Group meeting on August 17, 1994. This meeting was attended by E&S Work Group members and utility, PV equipment manufacturer, national lab, and experienced PV system representatives; the participants reviewed the level of detail and the need to include many of the specifications and criteria in the RFP.

Based on the industry input at this meeting, a modified set of specifications and acceptance tests were produced. Each individual item in the technical specification, codes and standards, data monitoring, and acceptance testing areas was discussed in considerable detail during the meeting and the experiences of each meeting participant were considered. The resulting document maintained most of the original input, but was fine-tuned to guide the PV industry and the utility users in the direction that provided safe, reliable, and somewhat "standardized" PV systems with the vision of future utility PV commercialization.

The meeting also identified those criteria and specifications that the E&S Work Group felt should be left out of the first RFP but which should be included in the second or third grid-connected RFP as the PV industry and the utility users matured. It was suggested that

these "future" items be included in the first RFP as "information only" to indicate to bidders in which direction the *TEAM-UP* program was heading in the commercialization of grid-connected PV.

A third and final review was accomplished through a Public Review Meeting held on September 14, 1994. Draft copies of the RFP had been distributed to a wide PV community audience prior to this public meeting. Valuable comments were received on the technical specification and acceptance sections during this meeting.

ii. Changes Needed After the First GCA RFP Results

Specifications were included in the first grid-connected RFP under the *TEAM-UP* program. This RFP was released on December 23, 1994, with all responses due in the UPVG offices by February 23, 1995. The UPVG received 26 proposals representing almost 8.6 MW of new PV capacity and more than \$13.6 million of requested cost-sharing. (See Appendix B for more information.)

C. Planning & Evaluation

The Planning & Evaluation Work Group was formed to assist utility members in determining where and how PV systems fit into utility planning. The P&E Work Group wanted to emphasize traditional as well as nontraditional benefits of PV.

During Phase 1, the P&E Work Group, in conjunction with Niagara Mohawk Power Corporation, developed the software program called PVSCREEN to assist members in this task. During Phase 2, the P&E Work

Group had goals of:

- Validating the PVSCREEN tool using case studies, revising the program, and implementing utility applications with PVSCREEN; and
- Assisting the National Renewable Energy Laboratory in development of capacity-based resource maps.

The P&E Work Group met twice during the Phase to work on these goals. The P&E Work Group met on March 31, 1994, following the 1994 Annual Meeting of the UPVG in Phoenix, Arizona, and again on April 13, 1995.

i. Update on the State of PVSCREEN

It was during Phase 2 that the P&E Work Group built a case for the use of photovoltaics by electric utilities. This software package compares the non-traditional benefits of PV to other energy sources. The P&E Work Group members conducted case studies using the program and determined that PV can be economical when nontraditional benefits are considered.

To encourage UPVG members to use the program, the P&E Work Group published a professionally prepared users' manual during the Phase and distributed the manual with the program to all member representatives. Also during the Phase, the P&E Work Group held two training sessions for the program. The first training session was held in Washington, D.C., on September 22, 1994. This workshop was facilitated by the Work Group chairman and the developer of the program, Bob Putnam, manager of IRP programs at Electrotek Concepts, Inc.

The training session was attended by eight (8) individuals from the electric utility industry as well as one (1) representative from the consumer advocate community. The training session was well-received. The UPVG has received requests for public release of the program in response to the training session. The Board of Directors of the UPVG had previously determined that the program would be made available following sufficient member use and validation of the program.

The second workshop was a half-day meeting where attendees were introduced to the concepts of the program and, using the manual, were shown how to work with the software using data from their own utility systems. This was held April 13, 1995, in San Antonio, Texas, in conjunction with the UPVG 1995 Annual Meeting. Again, Bob Putnam was the moderator.

ii. Capacity Resource Maps

The National Renewable Energy Laboratory has been working with Richard Perez of the State University of New York to complete capacity-based resource maps. Similar to PV insolation maps, these will plot out the solar capacity in the U.S.

Many UPVG member utilities have provided 1993 load information for the project. A sample capacity resource map, showing the distribution of effective load carrying capability (ELCC) for photovoltaics, is shown in Figure 3.

The map illustrates the geographical distribution of PV capacity and how different it is to standard solar energy resource distribution maps.

Figure 3. Sample Effective Load Carrying Capability (ELCC) for Grid-Connected Photovoltaic Power in the United States

ELCC Map courtesy of Richard Perez, ASRC, SUNY, Albany, N.Y.

D. Technology Transfer & Member Development

As the Utility PhotoVoltaic Group has built its foundation for the commercialization of photovoltaics, it has concentrated on outreach and communication efforts to member and nonmember electric utilities, state regulators, energy offices, and governments, and the other groups interested in solar energy for electric utilities.

This foundation has included activities that bring the Tech Transfer Work Group closer to its goals of:

- Packaging and disseminating the UPVG's Phase 1 "story";
- Promoting the use of PV systems to electric utility representatives at multiple points within the utility, including top management, engineering, marketing, and customer service;
- Promoting membership in the UPVG;

- Providing liaison with other PV groups as appropriate; and
- Identifying topics, preparing proposals, awarding contracts, and reviewing progress for appropriate outside contracts.

i. Disseminating the UPVG's Phase 1 Story

The UPVG laid the groundwork for disseminating the Phase 1 results with the sponsorship of four (4) Phase 1 briefings which were open to all who wanted to attend. The workshops were held throughout the United States in the following cities: Washington, D.C.; Kansas City, Missouri; Dallas, Texas; and Los Angeles, California. The meetings were attended by utilities, regulators, state energy officials, journalists, and others. A primary product of the preparations for the meeting were two packages of slides and hard copies used as hand-outs. These slides presented the results of the UPVG's 18 months of Phase 1 investigations. A total of 124 people attended the one-day meetings.

The UPVG also disseminates information regularly to its members via the 16-page *PV Vision* newsletter. This newsletter is published three times per year and includes new technical information developed by the UPVG and others; updates on federal, state, and local programs; and more.

To assist in getting the UPVG's story out to the general public, the Tech Transfer Work Group participated in the Edison Electric Institute's Climate Challenge Action Plan signing and Earth Day event in Washington, D.C., in April of 1994. This event was attended by utility CEOs, marketing representatives, administrators, and others, as well as by the general public and federal government representatives.

ii. Publications Mentioning UPVG

The UPVG also worked with various utility and energy publications to get the word out. Articles on the UPVG story were published in *Sun World Magazine* (June 1994); the American Public Power Association's *DEED Digest* (Summer 1994); *San Francisco Chronicle*, December 28, 1994 (Page C1); *Solar Today Magazine*, January/February 1995; *The Electricity Journal*; and various solar publications such as *The Solar Letter*, *PV News*, and others. In addition, the UPVG program was included in a 1994 book published by the WorldWatch Institute called *Power Surge*.

The UPVG also was able to spread the word through direct communication with utilities, the PV community, and others. Personal communication via letters and meetings was initiated between the UPVG and the utility member CEOs, representatives from the Solar Energy Industries Association, staff of PV manufacturers, and others.

iii. New Exhibit Capability

The UPVG also developed the capability for exhibits for Phase 3. The UPVG now has available an exhibit wall and professionally prepared graphics are planned for Phase 3. The UPVG will use the wall to participate in trade shows and exhibits where utility representatives are to be in attendance.

iv. PV Education Kit

The UPVG assembled information on photovoltaics into a kit to be used for educating the staff at UPVG member utilities. The kit includes one set of slides covering basic solar resource in-

formation as well as PV applications and benefits. The slides also provide details on the UPVG program.

Other kit accessories include flyers on how PV works, on the UPVG program, and on publications available to benefit utilities and getting information to members' employees.

Perhaps the most important aspect of the kit is the full-size demonstration panel. These panels, donated by various PV manufacturers, provide an actual example of a PV module and shows what this will look like in the field.

The kit will be finalized in Phase 3 and available for loan to UPVG members.

v. Newsletters & Press Releases

Three issues of *PV Vision*, the UPVG's 16-page newsletter, were published in 1994. The spring issue's cover story dealt with resorts using PV and other renewable energy technologies as a hook to lure "ecotourists"; the summer issue focused on key findings from the UPVG's Phase 1 efforts. The fall issue covered the expansion plans of numerous PV manufacturers, but reported that most of these PV cells and modules are destined for export from the U.S. *PV Vision* is sent to more than 200 individuals at 90 UPVG member utilities, as well as to 30 subscribers to the newsletter. Some issues are used as a marketing tool and sent to more than 2,000 individual utilities.

Press Releases were distributed on the following topics:

■ 'EON' Released for TEAM-UP Solar PV Projects, May 13, 1994

- *Over 70 Utilities to Vie for \$66 Million in TEAM-UP PV Project Awards, July 22, 1994*
- *PV for Remote Homes and Livestock Water Pumping, October 24, 1994*
- *RFP Represents \$15 Million in New PV Projects, January 9, 1995*
- *Proposals Usher in New Era of Utility Business Opportunities with Solar PV Installations, March 3, 1995*
- *20 Utilities Plan New Solar PV Installations [under the TEAM-UP program], April 12, 1995*

Copies of each press release plus one issue of *PV Vision* can be seen in Appendix C.

vi. Report on the 1995 Annual Meeting

The UPVG's primary vehicle for technology transfer was its 1995 Annual Meeting held April 11 and 12 in San Antonio, Texas. This meeting was held in conjunction with the Solar Energy Industries Association annual meeting called SOLTECH95. This co-location allowed the utility market and the supplier community to interact during more than two days of meetings and exhibits.

The agenda of the meeting, plus highlights and technical synopses, are included in Appendix A.

3. Technology & Application Events

A. Grid-Connected Applications

The UPVG conducted a competitive *TEAM-UP* solicitation for large-scale, electric grid-connected applications of PV systems. Twenty-six proposals were submitted and eight cost-sharing awards were recommended.

This first *TEAM-UP* Request For Proposals (RFP) for grid-connected photovoltaic systems was issued on December 23, 1994. Projects were solicited that would increase utility experience with PV technology and help develop sustainable market opportunities for utility grid-connected PV applications through collective market actions or pre-commercial PV installations. *TEAM-UP* is an acronym for building Technology Experience to Accelerate Markets in Utility Photovoltaics.

The proposals were due on February 23, 1995; 26 organizations and teams submitted proposals. The UPVG issued *Notices of Intent to Award* to successful proposers on April 7, 1995. Proposed schedules for the projects indicate that some of the installations could be in operation beginning in the last quarter of 1995.

The Evaluation Committee was formed by the UPVG and consisted of an independent panel of eight members representing diverse sectors both external and internal to the PV community (see Appendix B). UPVG solicited volunteers and nominations for this Committee through a nationwide search. The Evaluation Committee was established in February, 1995; members re-

ceived the 26 proposals for review and evaluation on February 27, 1995. After individual review of each proposal, the Evaluation Committee met near Washington, D.C., for four days—March 13 to 16, 1995. (For an agenda or information on the evaluation process, see Appendix B.)

The Evaluation Committee selected 10 proposals (amounting to eight awards) out of the 26 responses which, based on the evaluation criteria, best fit the commercialization objectives of the *TEAM-UP* program and also provided valuable application, technology, geographic, and team participant diversity. This array of recommended projects provides additional and needed experience for utilities, broadens the use of PV systems in several applications, and has the potential to help develop sustainable markets that will lead to reduced costs for grid-connected photovoltaic systems.

The eight recommended team projects request more than \$13.6 million from the *TEAM-UP* program. Current DOE funding for *TEAM-UP*, however—expected to be \$5 million—is insufficient to fund them fully as proposed. The Evaluation Committee spent significant time developing strategies to reduce budgets and suggested new cost-share ratios which may allow these proposals to proceed. It is understood that these recommendations could impact contract negotiations and cause changes in

Table 6. Highlights of the Eight TEAM-UP Recommended Awards

- 8 Different PV Technologies/Suppliers
- 4 Different Power Conditioner Suppliers
- 355 Individual PV Installations
- 8,572 kW of PV Installed
- 12 States with PV Installations

scope, schedule delays, or proposals to be withdrawn by the proposer.

Table 7 lists the eight recommended awards in alphabetical order by lead organization. The Evaluation Committee advocates funding the entire list of eight recommended awards, but at levels lower than certain proposals requested. Again, the proposals are listed in alphabetical order, *not by priority*.

i. Impact of Recommended Awards

The RFP Evaluation Committee's selections for award were complemented by two additional recommendations. The first was the recommendation that the UPVG request additional funding.

The second, and most significant, recommendation was to maintain the array of projects even if the *TEAM-UP* budget is reduced. The Evaluation Committee's recommendations include a mix of applications, utilities, and system suppliers which are vital to healthy

industry growth; such diversity should be maintained.

The Evaluation Committee realized that it had left the UPVG with unexpected complexity in contract negotiations. One of the strengths of the *TEAM-UP* program is that individual utilities and suppliers are responsible for implementing their own PV programs. However, the Committee provided guidance for some of the proposals which may allow the recommended awards to proceed and still maintain, albeit at a lower level, significant value towards the commercialization goals of *TEAM-UP*. The Evaluation Committee also made suggestions as to the range of funding for proposals that will be used during the negotiations to ensure that projects funded by *TEAM-UP* provide the value required.

The Evaluation Committee also noted that negotiations with proposers could cause significant schedule delays, may cause the proposals to be withdrawn by the proposer, or, more impor-

Table 7. Evaluation Committee Recommended Awards for TEAM-UP Request For Proposals 94.8

Lead Organization	Project Budget					Exceptions to Standard Contract
	TEAM-UP \$/kW	TEAM-UP \$ Requested	Total Project \$	TEAM-UP Share (%)	Project \$/W	
Amoco/Enron Solar Development	\$875	\$4,375,000	\$8,750,000	50%	\$1.75	Yes
Arizona Public Service Company	\$3,689	\$1,309,620	\$5,392,712	24%	\$15.19	Yes
Ascension Technology, Inc.	\$3,998	\$1,295,592	\$2,977,806	44%	\$9.19	No
Collaborative Utility PV/SMUD	\$2,325	\$3,841,000	\$13,496,000	28%	\$8.17	Yes
Empire Electric Association	\$4,000	\$504,000	\$1,915,000	26%	\$15.20	No
Hawaii Electric Light Company	\$4,000	\$60,000	\$216,200	28%	\$14.41	No
Niagara Mohawk Power Corporation	\$4,000	\$400,000	\$3,394,000	12%	\$33.94	Yes
New World Power Corporation	\$1,860	\$1,860,000	\$8,590,000	22%	\$8.59	No
TOTAL/AVERAGE	\$3,093	\$13,645,212	\$44,731,718	30%	\$5.22/W	average*

Note: Project \$/W is not an indication of PV system costs since other costs may be included.

*Weighted average based on total project dollars (\$44,731,718) divided by total project kilowatts (8,572 kW).

tantly, might reduce the value to the *TEAM-UP* program and, therefore, may cause the modified proposal to be rejected by the UPVG. The Committee provided UPVG staff with recommendations and limitations for portions of each proposal which must be maintained in order to provide value to the *TEAM-UP* program.

These proposals include the necessary elements of aggregated purchases, pre-commercial PV system installations, and widespread PV system installations in potentially high-value applications. Participants include a significant number of utilities, independent power producers, system integrators, suppliers, and customers. The recommended awards have the potential to help develop a sustained market for grid-connected photovoltaic systems.

These awards, if successfully negotiated, will provide a necessary step forward in helping accelerate the commercialization of grid-connected PV systems. The recommended awards include a significant amount of supplier-utility-state teaming; have application, geographic, and technology diversity; and include many of the elements identified as necessary for accelerating a commercial market for utility photovoltaics.

All selections for potential awards under the *TEAM-UP* program are contingent upon the successful negotiation and ultimate execution of a Cooperative Agreement between the U.S. Department of Energy and the UPVG and the continued availability of appropriated funds designated for this program.

For further details, see Appendix B.

B. Small-Scale Applications

The *TEAM-UP* proposal submitted to the U.S. Department of Energy on September 27, 1993, briefly described the Small-Scale Application part of the *TEAM-UP* program. The overall objective is to significantly increase the number of utilities with PV technology experience by supporting the installation nationwide of off-grid systems in six to eight application areas. By using market forces and aggregating purchases of specific PV applications, an increased number of utilities can participate and larger sales volumes are produced. By working with and developing the PV system supply and service infrastructure, PV application designs become better integrated, better packaged, and more standardized.

Today, more than 80 specific PV applications have been shown to be cost-effective in a wide range of utility installations throughout the U.S. In the Phase 1 market assessment work by the Applications & Markets Work Group, a number of applications, both grid-connected and grid-independent, were evaluated. Also, in May of 1994 the UPVG issued an Early Opportunity Notice and the responses indicated high utility interest in a number of off-grid applications. The UPVG published a report, "Responses to the *TEAM-UP* Early Opportunity Notice," in July, 1994, which summarizes the 62 responses received.

Based upon the Phase 1 market assessments, the Early Opportunity Notice responses, and a valuation of the state-of-development for the candidate applications, the UPVG staff recommended to the Board of Directors that the initial applications for the SSA program area be remote livestock water

pumping and remote electric service for residential applications. The Board supported the staff recommendations and work on the SSA Opportunity Notice was initiated.

During early 1995, it became clear that the proposed six-year *TEAM-UP* program effort may not be viable, based upon significant DOE funding, given the dramatic change in the political climate (e.g., the Republican sweep of Congress) and subsequent call for reduction in—and even elimination of—the budgets of a number of federal departments. It was therefore judged to be wise to get as many of the buyers/market development groups underway as possible. Thus, the SSA Opportunity Notice was developed which will be open to all applications, not only remote water pumping for livestock and remote electric service for residential applications but also any other of the numerous applications in which a buyers or market development group might be interested.

The intent of the SSA Opportunity Notice is to provide a mechanism whereby UPVG could begin discussions and, subsequently, negotiations with utilities, groups of utilities, and other groups interested in putting together buyers groups or market development groups to pursue the large-scale utilization of specific PV-powered applications. The SSA Opportunity Notice was developed and reviewed by utility and PV industry personnel and was issued on May 8, 1995. It seeks responses from utilities and organizations interested in PV applications in three areas: livestock water pumping, remote residential service, and an open category where groups are urged to propose a specific application of interest. A brief discussion of these three areas is given below. Responses to the SSA Opportunity Notice are requested on June 19, 1995.

i. Livestock Water Pumping—Photovoltaic Services Network

Water pumping systems powered by a PV power supply for domestic and livestock needs began appearing in the late 1970s in the U.S. It is estimated that today there are a few thousand systems in operation, owned by ranchers, farmers, and homeowners. Since the late 1980s, Western Area Power Administration (WAPA), Sandia National Laboratories, and the Electric Power Research Institute (EPRI) have been working with utilities and their customers in the Western U.S. to gain experience with and understanding of the benefits and capabilities of PV-powered water pumping systems. The Florida Solar Energy Center has had similar efforts underway in that state, beginning in the early 1990s. The UPVG Phase 1 market assessment identified a potential market of from 30 MW to 40 MW in the U.S. for PV-powered livestock water pumping systems.

In mid-1994, a group of utilities in the Western U.S., WAPA, and a coordination contractor, NEOS Corp., initiated action to form a buyers group, the Photovoltaic Services Network (PSN), which would: (a) provide training and technical support for utilities and their customers, (b) work with local hardware suppliers to develop systems that meet specific requirements, and (c) procure systems in a coordinated manner for member utilities and their customers. In response to the *TEAM-UP* Early Opportunity Notice, the PSN submitted a program plan for that organization along with identified opportunities where the UPVG could provide critical support for the PSN and its members. Discussions were opened and the UPVG is today providing support on an initial task to the PSN on a cost-sharing basis.

ii. Remote Residential Service

PV systems installed at remote residential sites to provide electricity for some or all of remote customers' electrical needs began appearing in the mid-1970s. Today, these systems number in the thousands in the U.S. and range in size from about 100 Watts to more than 10 kW in capacity. They are used on homes occupied year-round, on hunting and fishing cabins, and on second homes.

These systems have been provided by the growing infrastructure organizations (wholesale distributors, retail businesses, installers and contractors, and mail-order organizations) that exist today. This market sector buys a few megawatts per year of PV components and systems. The UPVG Phase 1 market assessment identified a potential market between 200 MW and 240 MW in the U.S. for remote PV-powered residential systems.

iii. Other Applications

As noted above, more than 80 different PV-powered applications have been identified that are cost-effective in a wide variety of utility and utility-customer installations. However, market assessments have not been conducted on each of these applications. Again, in Phase 1, the UPVG conducted assessments on three of these applications and, as discussed above in Section 2.A., seven additional application assessments were completed in Phase 2. The total list of the small-scale applications for which UPVG market assessments have been made is shown in Table 1 (page 5), along with the domestic market potential for each application.

The SSA effort within the *TEAM-UP* program is open to working with and supporting, on a cost-shared basis, groups interested in developing buyers/market development groups for any of these or other applications, such as communications systems, etc. The SSA Opportunity Notice stressed that potential support is open to any utility, group of utilities, or group of utilities led by a coordinating contractor which would like to create a buyers' group or market development group for any application.

The total Small-Scale Applications effort within the *TEAM-UP* program is expected to account for about 17 MW of new installations over the lifetime of the *TEAM-UP* program. With the potential opportunity to support six to eight application areas, the *TEAM-UP* program, on average, is looking for market development/buyers groups that would result in 3 MW nationwide and lesser amounts of installed PV systems for regional efforts. The length of time for *TEAM-UP* involvement with individual market development/buyers groups is anticipated to be two to three years.

4. Management & Administration

A. Financial Status

The Utility PhotoVoltaic Group's Phase 2 program was supported by the U.S. Department of Energy with a grant agreement effective from April 1, 1994, through March 31, 1995. This grant was extended through May, 1995 (DOE did not apply additional funding to the program).

Additional funding for UPVG activities was received from membership dues, from the sale of publications and subscriptions, and from meeting fees. Non-DOE revenue for the period was sufficient to cover the cost of all management and administrative tasks. This allowed the DOE funding to be applied to product-related tasks throughout the period. The total budget for the program was \$1.2 million, with \$1 million committed from DOE.

Actual expenditures for the Phase totalled \$1,088,804, with actual revenues totalling \$1,129,177. The UPVG completed activities through April with \$63,330 available for May expenditures.

B. Structure of the UPVG

The UPVG is structured around four (4) technical Work Groups and its governing Board of Directors. Members of the Work Groups and the Board are representatives from the 90 UPVG member utilities and organizations. (See Table 9 for a complete organizational chart for the UPVG.) The Work Groups are responsible, with the assistance of UPVG staff, for the completion of the tasks and meeting the goals of the Work Groups.

The Work Groups are Commercialization Strategies & Markets, Engineering & Specifications, Planning & Evaluation, and Technology Transfer & Member Development. The Work Groups' activities for the Phase were discussed in previous sections.

The 15-member Board of Directors is responsible for the oversight of the Utility PhotoVoltaic Group. The Board meets approximately three times per year in different locations throughout the United States. The Board ensures that the Work Groups and the staff are achieving their goals and working together toward the mission of the UPVG.

The UPVG is a participant in the PV-COMPACT Coordinating Council or PVC3. The PVC3 members are comprised of members representing key organizations that are encouraging utility use of PV. Such organizations include the National Association of Regulatory Utility Commissioners, Interstate Renewable Energy Council, and the National Association of State Utility Consumer Advocates.

From among the members of the PVC3, the UPVG has requested assistance from a smaller group of representatives. This group, the *TEAM-UP* Advisory Committee, provides guidance to the UPVG Board of Directors in establishing direction for the *TEAM-UP* program and provides assistance in the development of program initiatives such as the grid-connected Request for Proposals. Members of the UPVG *TEAM-UP* Advisory Committee are listed in Appendix D.

C. UPVG Staffing

During Phase 2, the UPVG was able to expand the program from the original Phase 1, \$800,000 budget to the Phase 2

Figure 4. UPVG Organizational Chart

program plan, which included initiation of the *TEAM-UP* program. Phase 2 served as the foundation and support for the activities to be completed during Phase 3 and the implementation of *TEAM-UP*.

To accommodate the increasing technical needs of the members, the UPVG secured a Technical Director for the program, John Bigger. Mr. Bigger is an employee on loan from the Electric Power Research Institute (EPRI).

At EPRI, Mr. Bigger was Manager of Photovoltaic Systems Applications for its solar program. Mr. Bigger had been with EPRI for 19 years and managed programs and projects in the solar thermal, geothermal, hydro, and photovoltaic areas; he also was responsible for demonstration and integration of PV projects for the more than 700 utility members of EPRI. Previously, Mr. Bigger was employed for 10 years by the

Los Angeles (California) Department of Water and Power.

Mr. Bigger holds Bachelor and Master of Science degrees in Electrical Engineering and has completed additional studies in business and engineering economics.

During the Phase, the UPVG also secured the assistance of Steve Hester as primary staff liaison for the Engineering and Specifications Work Group. The UPVG also negotiated with Mr. Hester for his permanent employment as the Grid-Connected Applications Manager. Mr. Hester previously was employed with the Pacific Gas and Electric Company and has extensive experience in managing large-scale, grid-connected PV installations, including management of the PVUSA project. Mr. Hester holds a Bachelor's of Science in Electrical Engineering from the University of Colorado and is

a Registered Electrical Engineer in California.

Meanwhile, the UPVG lost the assistance of two staff liaisons. Mike Bergman and Jerry Tardif, who helped during Phase 1 and for the initial activities, resigned from the UPVG. The staff liaison positions for their activities have been taken up temporarily by John Bigger, with assistance from Steve Hester and Bethany Wills, the UPVG's Project Coordinator. Brief biographies for the staff are included in Appendix D.

A list of Work Group members, the Board of Directors, and the staff is included in Appendix D.

5. Status of Phase 3 Grant Negotiations

As discussed in the chapter on Commercialization Strategies, the UPVG has been building a program that will accelerate commercialization of PV for use of electric utilities and their customers. This program will be continued during Phase 3 which is planned for June, 1995, through May, 1996. As currently structured, the Phase 3 program will focus on market conditioning for commercialization and technology transfer activities, while increasing the utility experience base through installations of PV in small-scale, grid-independent and large-scale, grid-connected applications.

As of June 1, 1995, the UPVG was in negotiations with the U.S. Department of Energy for the implementation of the Phase 3 program, including funding for the grid-connected projects and small-scale applications market buyer teams. As originally requested, this phase of the program would be the first step in the *TEAM-UP* program and, thus, \$18 million in cost-sharing was requested from the Department of Energy. The UPVG has been notified by the DOE that \$8.9 million will be available for the program.

Of this \$8.9 million, the UPVG will apply a minimum of \$6.8 million to the installation of grid-connected hardware. Approximately \$800,000 will be available to support the installation of small-scale projects, though no funding will be applied to hardware. Funding in this area will be available for the development of the buyers' teams, including development of marketing and business plans, promotional activities, etc. (See Small-Scale Applications, section 3.B.)

The remaining available funds will be used for the market conditioning and technology transfer activities mentioned above and operating the UPVG and managing the contracted projects. A list of the tasks are included in Appendix E.

Appendix A. Results & New Ideas from the UPVG 1995 Annual Meeting

The UPVG held its third annual meeting April 10-13, 1995 in San Antonio, Texas. The theme was "Building Toward Commercialization." More than 200 attendees (including representatives from UPVG members, manufacturers, system integrators, state organizations, and various service and support organizations) enjoyed the warm Texas weather. The SOLTECH95 solar conference was located about a half mile away and this provided an opportunity for attendees at both meetings to interact over the week.

The plenary session at the UPVG meeting opened with a welcome from **Jamie Axtell, Assistant General Manager of the San Antonio Public Service Board**, a municipally owned utility. The San Antonio Public Service Board is one of the newer public utility members of UPVG.

An overview of the U.S. photovoltaic manufacturing industry was provided by **Robert Johnson, Vice President of Strategies Unlimited**. The U.S. industry is enjoying a continued increase (expected in the range of 15% to 20% for 1995) in market demand for cells and modules, both domestic and international. With more than 60 MWp produced worldwide in 1994 and over 20 MWp in the U.S., most of the manufacturers are producing at high capacity and the largest ones are enjoying a backlog of orders. Recent support of large photovoltaic projects by the international funding agencies (e.g., World Bank) along with recently announced large national programs are resulting in large buys of PV components and systems around the world; Brazil, China, Germany, Italy, Japan, and Mexico are the reasons the upward trend continues.

The electric utility industry is changing rapidly and the plans and actions being taken by one utility to remain a viable, competitive business were described by **J. David McCann of the Atlantic City Electric Co.** Their AE2000 Bridge Plan was described as that company's transition road map from today to the future. It does involve some leaning down of the core business to get costs in line and the price of their product down to a more competitive level.

Mr. McCann sees his company finding out about customer needs and developing valuable products and services for each customer sector. He also foresees his company getting more involved in enhancing the economy regionally. Less construction of new transmission and distribution facilities is also foreseen. Making better use of their existing facilities by using new technologies for distributed generation and demand-side management approaches is the approach planned. Using their customers' on-site generation in a partnership arrangement and expanding grid monitoring with distribution automation and SCADA system are also in the plans.

Jeff Serfass, Executive Director, and Steve Hester, Acting Grid-Connected Manager for the UPVG, announced the awardees of the *TEAM-UP* Request-for-Proposals for grid-connected projects. The total amount available for funding was about \$5 million. Eight projects were awarded *TEAM-UP* support funding. For further details, see Appendix B.

1. Introduction To PV Applications

A number of utilities around the U.S. have been interested in the strategy of "green pricing" to raise funds for PV and other renewable projects. **Chris Henrichs of the Public Service Company of Colorado** outlined their program. In 1992, PSCO initiated market research to determine if a "green pricing" approach was realistic for their area. This research included customer interviews and focus groups; they learned a considerable amount about customer attitudes and about the characteristics of those customers that would support such a program. After receiving management approval, the program was initiated in 1994; print and TV coverage, six mail inserts, and a number of newspaper articles helped get the information about the program out to the customers. Today there are more than 4,300 contributors that give an average of \$1.73/month to the program; this provides about \$100,000 annually for the program. A Customer Advisory Panel helps PSCO select the projects to be funded. The first project was a PV-powered irrigation project for a tree-planting program by a city in the Denver area.

PSCO learned that the research conducted was good, but that talk is cheap. They have had a difficult time increasing the awareness of their customers about renewables in general and about the program specifically. PSCO spent \$270,000 in 1994 in marketing the program. Despite the slow initial response to the program, PSCO is committed to continue with the effort.

More and more states are becoming active in the effort to utilize PV and other renewable systems in daily operations at state organizations and in pri-

vate industry. **Jane Weissman of PV4U and Chris Cook of the Maryland People's Counsel** presented an overview of state activities around the U.S. A total of 14 state working groups have formed and are now active under the PV4U banner.

Under PV4U, a "gap analysis" has been undertaken to identify and assess the needs of state organizations for tools, methodologies, and procedures to determine the value of PV systems installed by utilities around the U.S. The analysis is being conducted by the North Carolina Solar Center; the accelerating rate of change in the utility industry is making the analysis difficult. More effort needs to be directed toward understanding and determining the strategic value of PV in the new competitive utility environment, and then actions taken to support these strategic advantages.

As a result of the issuance of the *TEAM-UP* Request for Proposals and announcement of the awards (see below), the National Association of State Utility Consumer Advocates (NASUCA) issued a contract to JBS Energy, of Sacramento, California, to review a number of the winning proposals and identify issues that need to be addressed in the near future to ease the administrative and regulatory burdens of future PV projects. One significant issue already identified relates to the ownership of PV-system hardware mounted on customer-owned property. The first draft of the JBS report will be available in June, 1995.

Commissioner Renz Jennings, chairman of the NARUC Renewables Subcommittee, mailed to all state commissioners and senior staff the second PV resolution passed by NARUC. The second NARUC/DOE Renewable

Energy conference was held in Madison, Wisconsin during the week of May 8th.

Over the past three years, there has been increased interest by utilities in PV systems that are installed on, integrated into, or just connected with buildings—residential, commercial, and industrial. **Lisa Frantzis of Arthur D. Little, Inc.**, presented information from a recently completed study on the technical and economic status of these building-integrated systems; the study was funded by DOE's Office of Building Technology.

The study involved reviewing results of past market assessments and closely examining their assumptions, compiling information on installing PV systems on buildings today, and obtaining building load profiles. A PV performance model was used to determine PV system output, look at specific utility rates, and determine electricity savings, demand savings, and Integrated Resource Planning potential benefit. Also, a nationwide market potential for each specific type of installation was determined. After this material was developed, recommendations for DOE program personnel were made. The bottom's-up allowable system costs resulting from this study seemed to be a bit higher than some of the earlier studies, indicating that A. D. Little, Inc., researchers believe PV systems will take a bit longer to become economical if viewed and analyzed from the customer perspective.

2. PV Industry Speaks on Early Commercialization

The UPVG utility membership continued its dialog with representatives from the PV supply industry. At the an-

nual meeting, a forum was provided where individual perspectives could be voiced and views of the speakers and the audience exchanged. A brief summary of some of the key points are given below.

a. Edward C. Kern, Jr., President, Ascension Technology, Inc.

- Ascension Technology, with support of Sandia National Laboratories, has been working with two inverter manufacturers to assist in getting two inverters UL-listed. The aim of this effort is to work toward a complete UL-listed PV system. Currently, Ascension has nine systems where all the components are UL-listed. An additional three are nearing completion.
- Over the past three years, Ascension Technology engineers have worked to refine the design and squeeze all the costs possible out of the "ballasted pan" design for flat-roofed buildings. They have been fairly successful, but see that this approach may not get them "all the way down the cost curve."
- They have initiated work on an AC-Module with initial funding obtained from New England Electric and Sandia National Laboratory. Future funding will come from DOE's PVMaT program. Ascension staff believe that the AC-Module has the potential to significantly move the cost of PV systems installed on buildings further down the cost curve.

b. Daniel Shugar, Vice President of Marketing, Advanced Photovoltaic Systems, Inc.

■ Advanced Photovoltaic Systems, Inc. (APS) has been looking closely at the measured results from the PVUSA/PG&E 500-kW Kerman project recently released. The original PG&E study estimated that strategically placing PV systems out in the utility distribution system would increase its value up to a factor of three over central station installations. The results of the analysis of measured data from the Kerman project indicate that the unconventional values to the utility can be measured and that they increase overall value of the facility by a factor of two instead of three. The costs of the PV system are still too high.

■ Work by Howard Wenger of the Pacific Energy Group indicates there are some real benefits to customer-side generation, both for the customer and for the utility.

■ APS has been looking very hard at third-party financing. When traditional utility economic parameters are used, the break-even costs are in the \$3/W range. However, when third-party financing parameters are used, the break-even costs are in the range of \$5/W.

c. Rolland Skinner, Chairman, Photovoltaic Services Network Board of Directors

■ The Photovoltaic Services Network (PSN) was formed to work with the PV manufacturing and supply sectors to develop well-integrated and well-packaged PV applications that

meet utility and customer cost, performance, and reliability objectives.

■ The utility members of PSN know their customers and want PV systems that meet their specific needs.

■ PSN members can help develop specific PV application markets and support development of the PV supply infrastructure to provide products and services for the growing market.

3. Concurrent Sessions

Three concurrent breakout sessions were conducted to provide attendees an opportunity to interact with people involved directly in specific areas of PV commercialization efforts.

a. T&D Support Applications

Session moderator was Steve Hester, Consultant to the UPVG.

1. Howard Wenger, Pacific Energy Group

A presentation by Pacific Energy Group described a simple screening methodology they have developed that quickly analyzes the cost-effectiveness of grid-support benefits for specific sites in a utility distribution system. Although still under development, the methodology uses easy-to-obtain, nontechnical data, requires no modeling, and gives results to screen projects and screen "helps" to qualify markets. The model has been checked against several detailed and extensive grid-support studies and results compare within 10%. The method is called *Quick Screen*.

With *Quick Screen* one person can complete an evaluation in 30 minutes using easily obtained utility system data (i.e., the cost of distribution and subtransmission, the cost per kilowatt of bulk transmission and generation, the marginal cost of energy and environment, load growth projections, discount rates, and standard times of peak). The model was developed by Wenger and Tom Hoff using parameters that only require knowing the location of the site; the capacity and load match factors have been modeled into the methodology.

A comparison of the Arizona Public Service grid-support study and the results obtained using *Quick Screen* revealed results within 10% of each other. The APS study required many months of data collection and evaluation and several months to complete; *Quick Screen* results were available within 30 minutes.

Quick Screen is being funded by Sandia National Laboratories' PV Design Assistance Center; a model and user handbook should be completed late in the summer of 1995.

**2. Art Peterson, Niagara Mohawk Power Corp.
Jim Healy, AWS Scientific
Phil Barker, Power Technologies, Inc.**

This presentation described the process used by Niagara Mohawk Power Corporation (NMPC) to identify a high-

value grid-support site within its service area for a PV/battery system. NMPC staff and consultants presented their process to find the best site for a planned 100-kW PV/battery storage system. (Coincidentally, this particular project was one of the successful selections for a *TEAM-UP* award.)

The objectives were: (a) to find a satisfactory site that provided the highest value for the 100-kW demonstration, (b) build upon the recently completed 15-kW PV/battery system that NMPC had fielded, (c) utilize a larger PV and battery system, (d) have the hybrid system located at the distribution level, and (e) deploy it on a transmission right-of-way.

First, some 2,100 feeders and 750 transformer banks in the Niagara Mohawk service territory were examined. The feeders and banks were screened for equipment that was at, near, or over capacity in summer, but not in the winter. This process identified 140+ feeders and 28 transformer banks. Then, actual hourly feeder data was analyzed for areas that had the best solar resource. This step identified seven candidate sites located in the Albany, New York, area.

The benefits assessment considered energy, losses, reliability, voltage support, equipment deferrals, both transmission and generation capacity, and externalities. The produced energy even has some value: sunlight conditions in the Albany area meant the

system was expected to have a conservative capacity factor of 14% and, at the NMPC marginal value, the energy is worth 3.2¢/kWh. This equated to about \$4,000 per year for a 100-kW system.

Table 8. NMPC Values Versus Industry Range

Benefit	NMPC Value	Industry Range
Transmission Capacity	\$45/kW	\$0 to \$120/kW
Generation Capacity	32¢/kW	\$12 to \$141/kW
Externalities	1.18¢/kWh	0¢ to 1.5¢/kWh

The next benefits considered were voltage support, feeder losses, and transformer loss. This analysis identified the best feeder for the system; however, it is not necessarily the one with the best load match. Another benefit was the increased reliability that the PV and battery system afforded. The system could allow a section of the feeder to remain operational. PV can either help shave the peak or can help load level, if the feeder peaks at night, by filling in the valley.

The data in Table 9 was presented for a comparison of NMPC values to a normal industry range.

Some of these values were extremely low compared to industry ranges. For example, the generation benefits are low due to a large amount of Independent Power Producers in the area and the fact that NMPC has extra generation capacity.

The following key points indicate what power factor control the system required to assist operations support:

- PV prices need to fall below \$3,000 per kW (installed).
- Power quality benefits combined with the T&D support may justify the added cost of storage.

Based on these results, NMPC's resulting project strategy is to deploy a technology that offers promise for driving PV prices down and, at the same time, attempt to develop a standardized Balance Of System (BOS) with both PV and power quality benefits.

b. Working With Local Suppliers and Regulators

Session moderator was J.E. Bigger, Technical Director of the UPVG.

The objective of this session was to continue open discussions in the areas of utility programs and the necessary involvement of regulators and infrastructure organizations. Two very active states in the PV demonstration and commercialization arenas are California and Texas. Representatives from these two states were invited to give their perspectives; an open discussion followed.

1. Mike DeAngelis, California Energy Commission

The California PV4U group was formed in 1993 with the goal to "commercialize PV" within the state so its citizens and taxpayers would obtain the benefits of the technology. Working with representatives from all the major stakeholders in the state, an early accomplishment was the development of a "commercialization plan" for the state. In this effort, we learned about the problems and benefits of the collaborative approach.

The next major effort undertaken by the PV4U Group was to address Southern California Edison Company's off-grid PV program. This effort involved not only the Group's regular stakeholders but also brought in PV infrastructure organizations presently doing business in the state. These distributors, retailers, installers, and related service organizations have been serving the slowly growing off-grid PV market and are concerned about the entrance of the state's major investor-owned utilities into this market. The benefits of having these large utilities involved were recognized, especially in the fi-

nancing of the PV systems by the utilities and the marketing of the systems by the utilities to their customers. However, the concern was raised that these large businesses would overwhelm the present PV suppliers. It has taken over two years to work through most of the issues. The one remaining issue to be agreed upon is the "ownership" of a PV system where it is installed on the customer's property.

This question, along with the monitoring of the TEAM-UP projects installed in California will keep the PV4U Group busy during 1995 period.

2. Douglas Whyte, Southern California Edison Company

Southern California Edison Company has been working for 27 months to implement an off-grid PV program for customers in its service area. Using the collaborative process with the California PV4U group has had its ups and downs. But, when looking back, staff at Edison feel that the program is better than envisioned at the beginning. The collaborative process is valuable if everyone's perspectives and goals are understood. Financing and market development are two areas where most of the local suppliers want the utility involved. Other areas—such as utility ownership of the systems—are still under discussion; the ownership issue may require utility commission action to settle.

The collaborative process started out with a lot of misunderstanding and not a lot of trust in every sector. Independent facilitators helped at some of the earlier meetings; today, Edison staff run the meetings themselves. Edison's off-grid program is underway and a number of organizations have come up with suggestions about how to make it even better.

3. Kevin Conlin, Photocomm, Inc.

In today's market, the utilities look at price too much; the industry is evolving standards but the utility industry doesn't take advantage of these. In most nonutility PV applications, reliability is paramount and price is secondary.

Utilities purchasing PV systems should demand validation of reliability, not just promises. Many PV suppliers really understand the environmental conditions under which these systems will operate and can make recommendations on how system reliability can be enhanced. The utility industry is very cost-sensitive, but when one shops for price only, one gets an inferior product. Utilities also should consider the cost of a system failure.

There was much interaction between the audience and the panelists regarding cost versus quality of systems and how the infrastructure organizations got the latest information on failing components from customers, Sandia, utilities, etc. There was some discussion about training the infrastructure organizations so they understood the utility requirements and the utility market. Also, some discussion centered around warranties, both component and system.

4. Commercialization Strategies Work Group Session

In light of the major changes that the electric utility industry is undergoing, the change in direction that Congress is taking as a result of the November, 1994, elections, and the increasing international market for PV systems, the Commercialization Strate-

gies & Markets Work Group was concerned about the direction of the UPVG. Under its chairman J.B. Hedrick of TU Electric, the Work Group held a work session April 13, 1995, at the UPVG 1995 Annual Meeting to discuss the present direction of the UPVG and the *TEAM-UP* program and potential new directions. Representatives from the PV manufacturing, supply and service infrastructure, and UPVG member utilities were present. The session was facilitated by Andy Vesey for the utilities and Rick Sellers for the PV industry. The following is a summary of a number of key points that were made during the Work Session.

- The UPVG Phase 1 reports showed all the stakeholders that there is a very big market in the U.S. However, the U.S. has concentrated on the grid-connected market sector, whereas the major international markets are for off-grid applications. The only "real market" here in the U.S. is also the off-grid market. The grid-connected market is there, but it will develop later.

- The original *TEAM-UP* program could have made a significant difference if funded as it was originally conceived. As it is actually developing—with very limited DOE funding and, now, concern about its lifetime—it is too small to be a true commercialization plan.

- The basic premises upon which the UPVG and *TEAM-UP* were founded need to be reexamined. Utilities and the UPVG must focus on customer needs; utilities are beginning to do this and so must the UPVG. Industry, the utilities, and the UPVG need to come together and review the technical, economic, market, and political premises upon which the

UPVG was founded and, in light of the changing environment, redirect or restructure as needed to meet today's needs. No federally funded program will stay out in front of the federal program for more than two or three years.

- The next round of the *TEAM-UP* program, the SSA Opportunity Notice, is critical to the overall program. It is the effort that will get the larger numbers of utilities involved as well as work with and develop the infrastructure organizations. It also gets utilities and customers buying useful, cost-effective systems today.

- There needs to be an UPVG effort to show every utility the strategic advantages and benefits of photovoltaic systems and how to develop a "solar plan" for each utility. Utilities need help in this area as they are not ready yet for a major marketing push with this technology. This also will get more utilities active.

- Next year's *TEAM-UP* RFP should emphasize the development of PV businesses rather than the hardware-in-the-ground emphasis this year. This also goes for the SSA area. One single RFP that emphasizes business development by teams, groups of utilities, buyers groups, market development groups, etc., should be issued.

- UPVG staff must think creatively on a wide variety of opportunities that might become possible.

- ◆ The UPVG should encourage domestic utilities to team up with foreign utilities to develop and expand the market both internationally and domestically.

- ◆ The UPVG might be able to match foreign utilities up with domestic utilities to bring everyone "up to speed" together.
- ◆ The UPVG should continue to coordinate and support the grid-connected and bulk power market, even though it is a later market.
- A compelling vision of the future of PV needs to be developed; this is critical. A story on PV possibilities that is so compelling that one cannot say no to it is required. This is a classic emerging industry; there are no rules so the UPVG and its members can help set up the rules.

lection effort involved with the *TEAM-UP* program data. The desire to have data from all the various installations available and safely stored in one place was felt important and could assist many other's efforts. The ability to have a consistent and accurate data base of PV performance, solar and weather patterns, and, where collected, utility load characteristics available was identified as very important to assist utility PV commercialization.

5. Engineering & Specifications Work Group Session

At a meeting held April 13, 1995, the data collection and reporting requirements of the current *TEAM-UP* RFP were reviewed by the Engineering & Specifications Work Group. The E&S Work Group agreed that the desire to collect a minimum set of data from the *TEAM-UP* installations was the correct focus and agreed that the level of data monitoring stipulated in the RFP was probably the smallest set of data that should be collected at this point of utility PV development. The need to collect this data daily was agreed to and the need to have a "sanity check" available in the data collection software was verified. The reporting requirements were approved as appropriate to keep both the utility staff's involved and informed, and give UPVG staff sufficient information to assist the successful installation and operation of the PV systems.

The E&S Work Group verified the importance of having a central data col-

Agenda **UPVG 1995 Annual Meeting** **San Antonio, Texas**

Monday, April 10

2:00pm - 5:00pm
UPVG Board of Directors Meeting
 (open to UPVG Board only)

4:00pm - 7:00pm
Early Bird Registration and Reception

7:00pm - 9:00pm
Utility Marketing Study Workshop
 (Open Meeting)

9:35am - 10:00am
The Utility of the Future
J. David McCann, Vice President,
 Strategic Customer Support, Atlantic
 Electric

10:00am - 10:25am
BREAK

10:25am - 11:00am
State of the Utility PhotoVoltaic Group
Jeffrey A. Serfass, Executive Director

■ **New Products Report**
Bethany N. Wills, Senior Project
 Coordinator

■ **Grid-Connected Program Report**
Stephen L. Hester, Consultant

■ **Small-Scale Program Report**
John E. Bigger, Technical Director

Tuesday, April 11

7:30a - 9:00a
Registration and Continental Breakfast

BUILDING TOWARD COMMERCIALIZATION I

8:30am - 8:45am
Introduction and Welcome
Andrew M. Vesey, Chairman of the
 Board, Utility PhotoVoltaic Group and
 Vice President, Power Delivery,
 Niagara Mohawk Power Corporation

8:45am - 9:10am
Welcome to Texas Introduction
Jamie E. Axtell, Assistant General
 Manager, Planning and Development,
 San Antonio, Texas, Public Service
 Board

9:10am - 9:35am
PV Industry and Pricing Directions Visited
Robert Johnson, Vice President,
 Strategies Unlimited

11:00am - Noon
**Grid-Connected Awards Report,
 Panel of Selected Proposals**
 Moderator: *Jeff Serfass*

Noon - 1:30pm
LUNCH

1:30pm - 1:45pm
**INTRODUCTION TO PV
 APPLICATIONS**
 Moderator: *Andrew Vesey*

1:45pm - 2:10pm
Renewable Energy Alternative Program
Chris Henrichs, Commercial and
 Residential Sales Team Leader, Public
 Service Company of Colorado

2:10pm - 2:35pm

What You Need to Know: State Programs

Christopher Cook, Maryland People's Counsel, National Association of State Utility Consumer Advocates and
Jane Weissman, Photovoltaics for Utilities

2:35pm - 3:00pm

Building Integrated Photovoltaic Projects

Lisa Frantzis, Senior Consultant, Arthur D. Little Consulting

3:00pm - 3:30pm

BREAK

3:40pm - 4:45pm

CONCURRENT SESSIONS

T&D Support Applications

Moderator: *Steve Hester*, UPVG Consultant

Howard Wenger, Pacific Energy Group
Art J. Peterson, Niagara Mohawk Power Corporation
Jim Healey, AWS Scientific

Financing and Ownership Options

Moderator: *J.B. Headrick*, TU Electric Company
Jeff DeLaune, Wisconsin Public Service Corporation
Wayne Gould, Southern California Edison Company

Working with Local Suppliers and Regulators

Moderator: *John Bigger*, UPVG
Kevin Conlin, PhotoComm, Inc.
Michael DeAngelis, California Energy Commission
Douglas Whyte, Southern California Edison Company

4:45pm - 5:30pm

UPVG 1995 ANNUAL MEMBERSHIP MEETING
(Open to UPVG members only)

Moderator: *Andrew Vesey*

Board of Directors Elections

Treasurers Report

Chuck Linderman, Treasurer, UPVG and Director, Fossil Fuels & Renewables Programs, Edison Electric Institute

Program Update and Alternate Commercialization Strategies

6:00pm - 8:00pm

UPVG TEXAS-STYLE RECEPTION

8:30pm - 9:30pm

What Have You Done With All of the Money? (PV-COMPACT Program Status)

Moderator: *Karl R. Rabago*, Director, Utility Technologies, Energy Efficiency and Renewable Energy, U.S. Department of Energy

■ **National Renewable Energy Laboratory**

Tony Catalano

■ **Photovoltaic Education Project**

Christopher Cook, NASUCA

■ **Renewable Energy Technology Analysis**

Jerrold Oppenheim

■ **Sandia National Laboratories**

Roger Hill

■ **Solar Energy Industries Association**

Rick Sellers

■ **State Working Group Alliance**

Jane Weissman, PV4U

■ **TEAM-UP**

Andrew Vesey, UPVG

Wednesday, April 12

7:00am - 7:45am

Continental Breakfast and Barge Trips to Convention Center at Hyatt Regency

HOW TO TAKE SOLAR ENERGY ALONG THE PATH TO SUCCESS
(Joint Session with SOLTECH '95)

Moderators: *Jeff Serfass*, Utility PhotoVoltaic Group, and *Scott Sklar*, Solar Energy Industries Association

8:00am - 8:20am

Welcome and Introduction
The Honorable Joe L. Barton (R-TX), United States House of Representatives

8:20am - 8:40am

Solar Energy is a Wise Investment of Public Funds
William White, Deputy Secretary, U.S. Department of Energy

8:40am - 9:00am

Investment Resources in Technologies that will Help Mitigate Risk of Global Climate Change
Dr. Philip Ludvigsen, Vice President, AM-RE Services, Inc.

9:00am - 9:20am

An Investor's Perspective on the Promise of International Markets for Solar in Small-Scale Power Systems
John Kuhns, Chairman and Chief Executive Officer, New World Power Corporation

9:20am - 9:40am

New Technologies Provide Opportunity for Independent Power Developers
Robert Kelly, President, AMOCO/ENRON Solar Development Corporation

9:40am - 10:00am

BREAK

Opportunities in a Sea of Change
(Joint Session with SOLTECH '95)

10:00am - 10:15am

Moderator: *Karl R. Rábago*

10:15am - 10:35am

New Directions and New Business Opportunities for Utilities to Invest in Solar
Pam Bass, Vice President of Energy Solutions, Southern California Edison Company

10:35am - 10:55am

Renewables as a Business Partnership with Austin's Electric Customers
Laura Doll, Chief Administrative Officer, City of Austin Electric Utility

10:55am - 11:15pm

New Strategic Planning and Decision-Making Tools for Electric Utilities
Steve Chapel, Manager, Energy Storage Economics, Electric Power Research Institute

11:15am - 11:35am

The Electrotechnology and Renewable Energy Fund
Dennis Costello, Advent International

11:35am - Noon

The Solar Enterprise Zone

Rose McKinney-James, Director, Nevada Department of Business and Industry, and *Tim Carlson*, Executive Director, Nevada Commission on Economic Development

Noon - 2:00pm

LUNCH & EXHIBITS

**BUILDING TOWARDS
COMMERCIALIZATION II**

2:00pm - 2:45pm

The PV Industry Speaks on Early Commercialization

Moderator: *Richard Sellers*, Deputy Director, Solar Energy Industries Association

Dan Shugar, Advanced Photovoltaic Systems

Edward Kern, Ascension Technology

Jim Trotter, Solar Electric Specialties, Inc.

2:45pm - 3:15pm

The Next in Line for Small-Scale Applications

John E. Bigger

3:15pm - 3:30pm

BREAK

3:30pm - 5:00pm

**CONCURRENT SESSIONS:
IN-DEPTH DISCUSSIONS ON
SMALL-SCALE APPLICATIONS**

Livestock Water Pumping

Moderator: *Peggy Plate*, Western Area Power Administration

Remote Residential Service

Moderator: *Ralph Nigro*, Delmarva Power & Light Company

Strategic Alliances and Business Opportunities for New Teams

Moderator: *John Bigger*

5:00pm - 6:00pm

UPVG Board of Directors Meeting
(Open to UPVG Board Only)

6:00pm - 8:00pm

Joint UPVG/SOLTECH Reception & Exhibits

8:00pm

SOLTECH '95 Annual Awards Banquet

Thursday, April 13

8:30am - Noon

CONCURRENT WORK GROUP MEETINGS

(Open to UPVG Members Only)

Engineering and Specifications

Chair: *John Hoffner*, City of Austin Electric Utility

Planning and Evaluation

Chair: *William Ferguson*, Delmarva Power and Light Company
Vice-Chair: *Larry Eng*, Niagara Mohawk Power Corporation

Noon - 1:00pm

LUNCH (On Your Own)

1:00pm - 5:00pm

PV-SCREEN Training Session

Facilitator: *Robert Putnam*, Electrotek Concepts

Appendix B. *TEAM-UP* RFP Evaluation

1. The UPVG *TEAM-UP* Evaluation Committee Members

Robert Allan, Senior Engineer, Florida Power and Light Company
Irvin Barash, President, Vencon Management, Inc.
Michael Eckhart, President, United Power Systems
Keith Durand, Solar Energy Industries Association
John Goldsmith, Former Vice-President, Solarex Corporation
Christy Herig, Senior Utility Engineer, National Renewable Energy Laboratory
James Welch, Electric Board, City of Fort Collins Light and Power Utility; President, Remote Power, Inc.
Howard Wenger, Principal, Pacific Energy Group

2. Evaluation Committee Meeting Agenda

Monday, March 13, 1995

Morning: *TEAM-UP* Program Perspectives

- Jim Rannels, U.S. Department of Energy
- Jane Weismann, PV-COMPACT
- Rick Sellers, SEIA
- Jeff Serfass, UPVG

Evaluation Committee Introductions

Afternoon: Evaluation Criteria Overview
Evaluation Process
Issues, Concerns, and Comments

Tuesday, March 14, 1995

Morning & Afternoon: Review of each of the 26 proposals, including in-depth discussions related to each proposal's strengths and weaknesses

Evening: Review proposal scoring (each member individually) based on the discussions during the day

Wednesday, March 15, 1995

Morning: Establish a new group average ranking for the proposals based on the adjustments and establish an initial rank order for the proposals

Afternoon and Evening: In-depth discussions on the array of top ranking proposals, taking commercialization objectives, diversity factors, and funding constraints into consideration

Thursday, March 16, 1995

Morning: Review findings, suggest modifications, develop Committee recommendations and strategies for potential project downsizing to fit funding constraints, brief UPVG Executive Director on selected awards

Afternoon: Review evaluation process; provide recommendations for the next RFP, proposal development, and evaluation process; and make general recommendations and strategies for UPVG and *TEAM-UP*

3. Evaluation Process

Monday morning (March 13, 1995) consisted of "perspective" presentations by representatives from the U.S. Department of Energy (DOE), PV-COM-PACT (Photovoltaic Collaborative Market Project to Accelerate Commercial Technology), the Solar Energy Industries Association (SEIA), and the UPVG. These presentations helped bring complementary views of program goals to the evaluation process.

John Bigger and Steve Hester, UPVG staff at the meeting, were asked to join the discussions and to add information when necessary. Neither was involved in any voting or ranking of proposals.

a. Preliminary Proposal Ranking

The Evaluation Committee established a ranked listing of the individual Committee members' evaluation scores for each of the 26 proposals and the initial ranking—top to bottom—using a numerical average as outlined in the RFP. There was surprising agreement in individual Committee members scores (and with the group average) both at the upper end and at the lower end, although there were some exceptions to this general agreement.

b. Detailed Review and Discussion of Each Proposal

Each Evaluation Committee member randomly selected three proposals for which to prepare a review Monday evening after that day's meeting adjourned. The next morning the members presented an overview of the strengths and weaknesses of each proposal. Due to the complexity of the two

larger "teaming" proposals, Mr. Bigger and Mr. Hester were asked to provide an overview of the Ascension and the CUPV/SMUD proposals during these "pros and cons" discussions. The time allocated to each individual presentation was about 15 minutes for each of the 26 proposals, with about 20 minutes of group discussions on the strength and weakness of each proposal. The Committee then adjourned to individually adjust their rankings of the 26 proposals based on the day's discussions.

To prevent any potential conflict of interest, two members abstained from voting (one each for two separate proposals) due to their past participation with that proposer. These members' rankings were not included for these two proposals and the group average excluded these members for that proposal ranking.

The results of this step in the process was an initial, prioritized rank ordered listing of the 26 proposals. This list identified 10 proposals that, although none had a significantly high score based on the total of 100 points, were tightly clustered with a point spread of approximately 12 points. This array of high-ranking proposals was utilized for the next step of the process.

c. Consideration of Commercialization Objectives, Funding Constraints, and Diversity Factors

This group of high-ranking proposals then was used in a process that considered commercialization interests first, diversity factors second, and funding constraints last. This process was used to establish any modifications to the array of proposals.

In developing its additional conclusions and recommendations, beyond the ranking of the proposals, the Evaluation Committee considered the language in the U.S. House of Representatives Energy and Water Development Appropriations Bill for 1995 that pertains to diversity of projects and funding sponsors:

DOE and its funding entities are encouraged to recognize geographical and technological diversity and to fund cost-effective, reproducible projects sponsored by but not limited to: utilities, PV manufacturers, independent power producers, or developers.

The diversity factors considered at this point in the selection process included:

- **Application Diversity**—Roof-top residential, commercial, substation, or T&D system, support, etc.
- **Geographic Diversity**—Considering broad geographic regions, or National Electricity Reliability Council regions, for example.
- **Technology Diversity**—Crystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, flat plate versus concentrator, tracking versus nontracking, etc.
- **Team Participation Diversity**—Sponsorship as used in the Appropriations Committee report is interpreted to mean the team members, not just the leader of the proposal team. This was considered in the quantitative Evaluation Criteria and was considered again at the conclusion of the selection process.

d. Projects Recommended for Award

The results of the entire evaluation process, including all considerations, are shown in Table 7. This table shows the recommended funding of the 10 top-ranking proposals (amounting to eight cost-sharing awards); it is *sorted by alphabetical order only*. This list of top-ranking proposals is the recommended package for award through the *TEAM-UP* program.

The Evaluation Committee selected the eight awards shown in Table 7 and believes that these projects best fit the commercialization objectives of the *TEAM-UP* program. The Committee felt that these proposals provide valuable application, technology, geographic, and team participant diversity while having the potential of meeting the budget constraints. The recommended projects were selected to provide additional and needed experience for utilities, broaden the use of PV systems in several applications, and help develop sustainable grid-connected photovoltaic systems markets.

The proposed DOE *TEAM-UP* funding is insufficient to fully fund the recommended projects at the requested levels. The eight recommended awards request more than \$13.6 million from the *TEAM-UP* program. The funding expectation for this grid-connected portion of the *TEAM-UP* program is \$5 million.

e. Recommended Awards, in Depth

The following profiles give brief descriptions of the projects contained in the proposals selected by the Evaluation Committee for award.

1. Advanced Photovoltaic Systems, Inc./New World Power Corporation

This independent power producer proposal describes a project to finance, design, build, and possibly operate up to 1 MW of thin-film, amorphous silicon PV systems (Advanced Photovoltaic Systems) in the City of Austin, Texas. The applications will include building-integrated roofing systems (0.5 MW), curtain wall/skylight glazing (0.2 MW), and ground-mounted polar-axis tracking system (0.3 MW). These PV systems will be installed at sites identified as having high value by the utility. A number of ownership and financial alternatives are being discussed with the City of Austin's Electric Utility. One or more of the installations may use Kenetech inverters. The project schedule has all systems operating 16 months after receipt of the Notice of Intent. This proposal was selected because of the many applications (building integrated, curtain wall, and innovative tracking flat-plate) deployed in high-value T&D locations. The project can result in volume purchases by establishing a market model for customer and third-party ownership using several PV-specific financing methods. The ability to offer several financing options along with other pricing strategies to the utility or the customer could assist the commercialization efforts. The project team has requested \$1,860/kW of *TEAM-UP* funding and proposed a 22:78 cost-share ratio. No contract exceptions.

Total Project Cost: \$8,590,000

Total *TEAM-UP* Request: \$1,860,000

Total kW(ac): 1,000

2. Amoco/Enron Solar Power Development

This independent power producer proposal describes a project to design, build, and operate a 5 MW thin-film,

amorphous silicon PV power plant located in the Imperial Valley of California. It is associated with a new 10 MW thin-film module production plant, to be built by Amoco/Enron Solar; more than \$25 million has been committed for the manufacturing facility. The PV power plant design is underway and Requests for Qualifications (RFQs) have been released on the balance-of-system (BOS) equipment. The electric power generated will be sold to San Diego Gas & Electric Company under a Uniform Standard Offer #1; early discussions with SDG&E have taken place. This proposal was selected due to the aggressive pricing and volume deployment of a new PV technology. The combination of a very low-cost PV module production facility with high-volume purchases of BOS components and a very large installation gives this project good commercialization potential. The project will take many months to deploy due to its very large scale and will involve the installation of a new 10-MW production facility. The large scale is expected to stimulate the use of standardized system designs and equipment. The project team requested \$875/kW of *TEAM-UP* funding and proposed a 50:50 cost-share ratio. The one major contract exception involves the project schedule: module delivery starts September, 1996, and operation starts December, 1997.

Total Project Cost: \$8,750,000

Total *TEAM-UP* Request: \$4,375,000

Total kW (ac): 5,000

3. Arizona Public Service Company

This award anticipates funding up to 355 kW of PV systems in three areas, including PV integrated into covered parking structures, T&D support, and high concentration photovoltaic systems. The applications will use different PV technologies with the following team

members: United Solar Systems Corporation, Advanced Photovoltaic Systems, Inc., and Amonix Corporation. Nevada Power Company and Central and South West Corporation are also team members. The award is being made for several reasons, including the high commercialization potential for the covered parking structures, which have a potential market of 6,000 to 7,000 MW. In addition, the high concentration system is viewed to be a potentially low-cost PV system with a large commercialization potential in the Southwest region. The T&D support applications are planned as phased installations which will allow the use of the least-expensive PV system to be deployed in the grid-support location, giving a potential match with the cost and the value derived from this type of application. The project team requested \$3,689/kW of *TEAM-UP* funding and proposed a 24:76 cost-share ratio. One contract exception was identified.

Total Project Cost: \$5,392,712

Total *TEAM-UP* Request: \$1,309,620

Total kW (ac): 355

4. Ascension Technology, Inc.

This proposal describes a project to install 324 kW of PV systems on 100 residential and commercial buildings at nine utilities around the U.S. Ascension is the project integrator and the utilities involved are: Arizona Public Service, City of Austin Electric Utility, Boston Edison, Central and South West Corporation, Detroit Edison, New York State Electric & Gas, Northern States Power, Portland General Electric, and Wisconsin Public Service. The objective of this project is to validate the results developed in "PV-Friendly" market research studies already completed at three utilities and underway at four other participating utilities. The hardware procurement process will combine the

requirements of all the utilities and be competitively bid, with one or more suppliers selected to provide the major components. All installations are scheduled to be installed and operating within 15 months of a receipt of a Notice of Intent. This proposal was selected because it has high commercialization potential. The projects involve volume purchases of PV components by an experienced integrator, using the "PV-Friendly" utility/customer concept, installed in nine utility service territories. The link to commercialization is the combination of aggregated purchases, standardized and UL-approved mechanical and electrical components installed in residential and commercial rooftop applications that have a very large market potential. This project includes a substantial number of utilities and proposes to provide case studies to estimate the dimension of the PV-Friendly market. Their plans include having the complete PV system be UL-listed, including the Ascension balance-of-system (BOS) wiring and connection junction boxes. The proposal indicates case studies will be completed for each of the nine utility partners to estimate the dimension of this market and establish local practices for pricing PV systems and services for their customers. The project team requested \$3,998/kW of *TEAM-UP* funding and proposed a 44:56 cost-share ratio. No contract exceptions.

Total Project Cost: \$2,977,806

Total *TEAM-UP* Request: \$1,295,592

Total kW (ac): 324

5. 1995 Collaborative Utility PV/ Sacramento Municipal Utility District

This proposal describes a project to install 1,652 kW of PV systems at 232 sites in six utility service areas around the U.S. The applications include residential, commercial, and industrial

building-rooftop and building-integrated installations and T&D grid-support systems. This project supports continuation of SMUD's PV Pioneers program; its team members include experienced utilities (SMUD, Southern California Edison, City of Austin Electric Utility, and New York Power Authority) and new utilities (three municipal members of Northern California Power Agency, the City of Anaheim, and Citizens Utilities Company). Hardware procurement (competitive solicitations) will be done by each individual utility for their systems; the City of Anaheim has selected the suppliers for their projects (Advanced Photovoltaic Systems and PowerLight Corp.). Coordination and technical support will be provided by the experienced utilities for the new-to-PV utilities. Although this proposal may or may not involve volume purchases (SMUD already has requested bids for its portion and other partners may join the procurement), the "aggregation" of purchase documents (RFPs, specifications, performance measurements, acceptance testing) and benefit assessment procedures and processes were seen as having high potential for commercialization. The "coaching" by experienced utilities for the new-to-PV utilities could have the potential to help lead to sustained markets. The project team has requested \$2,320/kW of *TEAM-UP* funding and proposed a 28:72 cost-share ratio. One exception to the Standard Contract was listed.

Total Project Cost: \$13,496,000
Total *TEAM-UP* Request: \$3,841,000
Total kW (ac): 1,652

6. Empire Electric Association

This proposal describes a project to install a single 126-kW PV system near the end of a six-mile radial distribution feeder owned by a rural cooperative in Colorado. The objectives of the project

are to: (1) defer immediate reconstruction of the 60 year old line, (2) increase the reliability of electric service to customers served by this line, and (3) demonstrate the value of this type of application for cooperatives and other utilities. The project team also includes NEOS Corporation, Cornice Engineering, Southwest Technology Development Institute, and Solarex Corporation. This project demonstrates an application identified by UPVG as having a significant potential market (3,000+ MW). The proposed project will provide significant opportunity to promote volume purchases for utilities that serve rural areas with radially constructed distribution lines. The ability to defer the upgrade on this "long-skinny-feeder" is viewed to have high commercialization potential. The modules will be polycrystalline silicon provided by Solarex; the inverter supplier has not been selected. The PV system is scheduled to be operational in December, 1995. The project team has requested \$4,000/kW of *TEAM-UP* funding and proposed a 26:74 cost-share ratio. No contract exceptions.

Total Project Cost: \$1,915,000

Total *TEAM-UP* Request: \$504,000

Total kW (ac): 126

7. Hawaii Electric Light Company

This proposal describes a project to install a single 15-kW PV system on a commercial building owned by the county government located in Kailua-Kona, Hawaii; HELCo will own and operate the PV system. Amorphous silicon modules will be supplied by Advanced Photovoltaic Systems, Inc., and the inverters by Omnion Power Engineering Corporation. The project team also includes Bell Products and the County of Hawaii. The installation is scheduled to be operating nine months after Notice of

Intent. This project is part of a HELCo PV program to provide both on-grid and off-grid systems for utility customers. This proposal was selected as it will be the first grid-connected PV system on the island of Hawaii and the initial effort in the utility's integrated resource planning (IRP) program. The information gained from this installation is expected to transfer to many high-value applications to solve peak-loading concerns. This project's link to commercialization is the potential to lead to future volume purchases by creating market assurances, responding to existing peak-overloading conditions, and demonstrating the beneficial characteristics of roof-mounted PV on the island. In addition, they plan to conduct market studies and monitor the benefits to the local distribution feeder. Data from a recent distributed generation study, along with substation monitoring, are expected to identify many locations for the use of PV systems for load reduction. The proposal identifies a large market for load reduction within HELCo's service territory. The project team requested \$4,000/kW of *TEAM-UP* funding and proposed a 28:72 cost-share ratio. No contract exceptions.

Total Project Cost: \$216,200

Total *TEAM-UP* Request: \$60,000

Total kW (ac): 15

8. Niagara Mohawk Power Corporation

This proposal describes a project to develop and deploy pre-commercially a 100-kW "Power Enhancement & Delivery System" (PEDS) which uses thin-film, polycrystalline silicon modules supplied by AstroPower integrated with a battery and inverter to supply ac power. PEDS is a power control, storage, and conversion unit intended to become a commercial product, deployable in utility power quality and power flow ap-

plications, with or without a PV supply. The major part of this project is the development of the PEDS; the remainder will provide support for module development at AstroPower. The project team includes New York State Energy Research and Development Authority (NYSERDA), AstroPower, Power Technologies, Inc., Omnion Power Engineering Corporation, AC Battery, AWS Scientific, and ECG Consulting. Operation of the first PEDS unit is scheduled for May, 1996. The proposal was selected as it has good commercialization potential and includes market studies for this type of application. The project involves the development of a low-cost module and involves a PV array integrated with a high-value utility power quality/battery storage system. Significant BOS cost reductions are expected from the dual use of the power conditioning components and interconnection equipment. The project team has requested \$4,000/kW of *TEAM-UP* funding and proposed a 12:88 cost-share ratio. A large number of contract exceptions were made; some may be material exceptions to the Standard Contract.

Total Project Cost: \$3,394,000

Total *TEAM-UP* Request: \$400,000

Total kW (ac): 100

f. Conclusions for Future Years

During its deliberations, the Evaluation Committee drew conclusions about the evaluation process that should be considered in future years of *TEAM-UP*. These are outlined below.

Comments on the overall RFP/bid process revealed the need for a longer proposal evaluation period (the significant delay in the release of the RFP had compressed the Committee's evaluation period), the need to have sufficient time for the Evaluation Committee to request

clarifications and questions from proposers, and the possibility of having the proposers "present" their proposals in front of the Committee (this may be prohibitively expensive for many of the smaller funding requests). Additionally, it was suggested that the legal/administrative review be done prior to the Evaluation Committee's deliberation. Several of the proposals may have material exceptions to the standard *TEAM-UP* contract that could prevent awards.

Some Evaluation Committee members mentioned that there seemed to be several proposals that indicated a difference in "good proposals" and "good projects." This round of responses revealed examples of both, but not necessarily in the same proposal. Some responses were missing sufficiently detailed budgets and schedules to properly identify satisfactory management oversight. Another general comment was that the grading system didn't bring the "best" proposals to the top.

g. Evaluation Committee Comments Related to the RFP Evaluation Criteria Sections

1. Plan for Commercial Activity (50 points)

Many of the Evaluation Committee members felt guidance beyond that stated in the RFP for the "Commercialization and Business Plans" area of the Criteria would have been helpful. The definition of the term "commercialization" was not articulated well enough in the RFP. Committee members thought that most proposers had provided insufficient descriptions of their commercialization plans. It also was evident that many of the supporting letters did not have a link to any serious commitment. Evaluation Committee members recom-

mended several supplemental criteria that could be considered for the next RFP.

2. Project Cost Sharing (30 points)

In the "Project Cost Sharing" area, the Evaluation Committee expressed disappointment that the intended division of the "Lowest \$/kW Requested" from *TEAM-UP* and the "Highest \$/kW" from the participants did not give the credit where needed. Instead, it tended to favor large, potentially overburdened projects. The "Energy Adjusted \$/kW" criteria seemed to level the playing field for tracking and concentrator systems, but did not alter any rankings. It was recommended that this area of the evaluation criteria be carefully reviewed and evaluation points be reallocated for the next RFP.

3. Project and Management Plans (20 points)

The "Project and Management" area was felt to be more reasonable, although additional breakdown of this criteria was suggested in order to better judge future proposals. In particular, this area was felt to be sufficiently important that it could be considered as an immediate "pass-fail" criteria for future RFPs.

Appendix C. Press Releases & *PV Vision*

Six press releases were released during Phase 2. A copy of each is attached. (A list of UPVG member utilities was part of each release; it is not included here.) The press releases covered the following topics and were issued on the noted dates:

- 'Early Opportunity Notice' Released for *TEAM-UP* Solar Photovoltaic Projects (May 13, 1994) C-2
- Over 70 Utilities to Vie for \$66 Million in *TEAM-UP* PV Project Awards (July 22, 1994)..... C-4
- PV for Remote Homes and Livestock Water Pumping (October 24, 1994) .
..... C-6
- RFP Represents \$15 Million in New Photovoltaic Projects (January 9, 1995) C-8
- Proposals Usher in New Era of Utility Business Opportunities with Solar Photovoltaic Installations (March 3, 1995) C-10
- 20 Utilities Plan New Solar PV Installations (April 12, 1995)..... C-12

Also attached is a copy of the fall, 1994, issue of the *PV Vision* newsletter, beginning on page C-19.

**Utility
PhotoVoltaic
Group**

PRESS RELEASE

FOR IMMEDIATE RELEASE

Contacts: Jeff Serfass or Bethany Wills
(UPVG) 202/857-0898

'EARLY OPPORTUNITY NOTICE' RELEASED FOR *TEAM-UP* SOLAR PHOTOVOLTAIC PROJECTS

WASHINGTON, D.C., May 13, 1994—A first-of-its-kind "Early Opportunity Notice" was released today to announce the Utility PhotoVoltaic Group's *TEAM-UP* initiative, a component of a U.S. Department of Energy program proposed by the UPVG to receive approximately \$18 million in federal funding assistance in 1995. The responses to the notice will help shape the first *TEAM-UP* request-for-proposals, anticipated in October of this year.

Solar photovoltaic project ideas submitted in response to the notice should be under serious consideration for start-up in the next 18 months. Respondents may include any electric utility but eventual proposers for *TEAM-UP* funding must include at least one UPVG utility member on their project team. Multiple-utility responses for commercialization-oriented project ideas best implemented through collective market actions also are strongly encouraged.

TEAM-UP stands for building Technology Experience to Accelerate Markets in Utility Photovoltaics. Presented last September to the U.S. Department of Energy by the UPVG on behalf of its then-67 electric utility industry members, *TEAM-UP* is proposed as a \$509 million, market-led program to be managed by the UPVG over a six-year period to broaden the base of utility hardware experience with photovoltaics. *TEAM-UP* will dramatically expand the practical application of electricity from the sun using photovoltaics (PV) for the benefit of the nation's electricity consumers. Electric utilities and other groups committed to PV view the results of the *TEAM-UP* program as an essential foundation for sustainable commercialization of the technology.

The goal of the *TEAM-UP* program is to assist electric utilities to competitively procure, install, and demonstrate 50 MW of PV systems. Funding of \$157 million over six years is being sought from the federal government, with the remainder coming from utilities and other participants. In January, *Time* magazine named solar photovoltaics and *TEAM-UP* as the number one environmental happening of 1993.

"It's in the best interest of electric utilities to gain experience with solar photovoltaics as soon as possible," said Andrew M. Vesey, Chairman of the UPVG Board of Directors and Vice President, Operations Support at Niagara Mohawk Power Corporation. "New business opportunities, demands for clean energy sources, and our constant desire to better serve our customers suggest we move rapidly to obtain this experience."

Respondents to the notice are asked to limit their responses to projects they are considering starting within the next 18 months. The deadline for responding to the notice is June 13, 1994; formal release of the RFP is scheduled for October, with 60 days provided for response. Subsequent annual procurements are planned for projects farther down the planning horizon.

The Utility PhotoVoltaic Group was formed in 1992 to accelerate the use of small-scale, "cost-effective" and larger-scale applications of PV for the benefit of electric utilities and their customers. The group currently has 82 members from all sectors of the electric utility industry. Together, the membership represents approximately 40% of total U.S. electricity sales.

A list of UPVG utility members is attached. For a copy of the complete Early Opportunity Notice, contact the UPVG by phone at 202/857-0898, by fax at 202/223-5537, or via eMail at "upvg@ttc.mhs.compuserve.com."

#

**Utility
PhotoVoltaic
Group**

PRESS RELEASE

FOR IMMEDIATE RELEASE

Contacts: Jeff Serfass or Bethany Wills

202/857-0898

OVER 70 UTILITIES TO VIE FOR \$66 MILLION IN TEAM-UP PV PROJECT AWARDS

Washington, DC, July 22, 1994—In answer to its Early Opportunity Notice, the Utility PhotoVoltaic Group (UPVG) and the U.S. Department of Energy (DOE) announced today receipt of 62 responses involving more than 70 electric utilities and other organizations. In this first round of utility project support activities, the responses identified more than 8.5 MW of solar photovoltaic (PV) systems that may be installed over the next 18 months. These 62 responses identify up to \$66 million in new photovoltaic installations.

The projects, presented in response to an Early Opportunity Notice issued by the UPVG, are considered an indication of the potential success of the Group's six-year, 50 MW *TEAM-UP* hardware initiative, scheduled to receive approximately \$10 million in federal funding assistance in 1995.

The Notice was issued with goals of soliciting expressions of interest in utility industry support for PV and guiding the UPVG in establishing the actual Request-for-Proposals to be issued under the *TEAM-UP* program in October of 1994. Responses will guide this innovative utility industry/government/private industry partnership to ensure the proper place of PV in the energy future of electric utilities and their customers.

"This technology is on its way to being a market success and the electric utility industry recognizes the advantages of accelerating the process," said Andrew M. Vesey, Chairman of the UPVG and Vice President of Operations Support at Niagara Mohawk Power Corporation in New York. "Our customers want it, the suppliers want it and now we are confirming that utilities also want it."

"We are extremely excited about the prospect of PV commercialization which now appears to be just around the corner," stated Bud Annan, Director of the Office of Solar Energy Conversion for the U.S. Department of Energy. He added, "We are confident that the Department's support of this program will be a benefit to industry and our environment."

Responses received were catalogued and included in a summary report now being published by the UPVG. The Notice is part of the UPVG's Phase 2 activities which also include documenting Phase 1 findings in such important issues as planning tools for PV applications, the state of PV manufacturing, and the utility markets for PV that exist today.

Phase 2 highlights will include the initiation of a small-scale application aggregated purchase program and the development of the *TEAM-UP* RFP. Phase 2 is considered a transition to the full *TEAM-UP* program, which stands for Building Technology Experience to Accelerate Markets in Utility Photovoltaics. *TEAM-UP* is the \$509 million, market-led program to be managed by the UPVG over a six-year period to broaden the base of utility hardware experience with photovoltaics. Electric utilities and other groups committed to PV technology view the results of the *TEAM-UP* program as an essential foundation for sustainable commercialization of the technology.

The Utility PhotoVoltaic Group was formed in 1992 to accelerate the use of small-scale "cost-effective" and larger-scale applications of PV for the benefit of electric utilities and their customers. The group currently has 85 members from all sectors of the electric utility industry representing approximately 40 percent of total U.S. electricity sales. Along with UPVG utility members and other organizations, the Department of Energy has pledged its support to the UPVG with cofunding of the UPVG's Phase 1 and Phase 2, as well as the upcoming *TEAM-UP* activities.

A list of UPVG utility members is attached. Copies of the Early Opportunity Notice Response Report and the UPVG's Phase 1 reports may be purchased from the UPVG. For information, contact the UPVG by phone at 202/857-0898, by fax at 202/223-5537, or via eMail at "upvg@ttc.mhs.compuserve.com."

**Utility
PhotoVoltaic
Group**

PRESS RELEASE

FOR IMMEDIATE RELEASE

Contacts: Jeff Serfass or Bethany Wills

(UPVG) 202/857-0898

PV for Remote Homes and Livestock Water Pumping

Washington, DC, October 24, 1994 — The Utility PhotoVoltaic Group (UPVG) Board of Directors announced today the implementation of two new initiatives to promote small-scale utility applications of solar photovoltaics in grid-independent installations. These two—remote homes and livestock water pumping—are the first of approximately six applications to be promoted nationwide by the UPVG for collective utility purchases. Each is intended to result in installation of two to three megawatts of new PV systems in the next 18 to 36 months.

The UPVG will identify Market Application Teams for each application. These teams will set design, performance, and procurement standards as well as competitively evaluate suppliers and recruit purchasers for the selected applications.

In the case of the livestock water pumping application, the UPVG is beginning negotiations to work with a team led by the Photovoltaic Services Network (Denver, CO) to implement a program to develop PV water pumping. The team—initiated by Western Area Power Administration (Loveland, CO) and NEOS Corporation (Lakewood, CO)—is in place and includes more than 30 utilities in 10 states. PV-powered water pumping is currently available; however, the technology requires use of specialty pumps to accommodate the use of photovoltaics. This group will work to develop a package that utilizes conventional pumps with PV, resulting in a reliable, low-cost livestock water pumping option.

"This is the beginning of a new era in cooperative utility purchases of photovoltaics," stated J. M. Shafer, administrator of Western Area Power Administration. "Many livestock watering installations are far from electric service and more costly to serve with conventional means. Western's partnership with the UPVG to collectively purchase PV water pumping systems offers a powerful way for rural utilities to provide a new consumer service."

The second application is aggregate purchases of PV for use at residential homes far from the utility grid. This application represents a potential market of 250 MW or so nationwide. These homeowners may now be without power due to the high cost of extending electric distribution lines to their property. Bringing reliable, photovoltaic-supplied electricity to these homeowners will be the focus of an opportunity notice to be issued by the UPVG early in 1995. The opportunity notice will recruit the Market Application Team(s) necessary to coalesce the bulk PV

system purchases for this application. Planning of regulatory, supplier, local service, and financial elements of the program is now beginning.

"We are enthusiastic about offering this clean, renewable source of electricity from the sun to better serve our customers in remote areas," said John E. Bryson, chairman and chief executive officer of Southern California Edison Company in Rosemead, CA. "Customers get power they need and pay for it as part of the utility bill, just like power from any other source."

The Small-Scale Applications initiative of *TEAM-UP* will develop market aggregation programs for small-scale, grid-independent PV applications, with no direct support for hardware purchases *per se*. About \$5 million in *TEAM-UP* funds will be spent on this component of the six-year *TEAM-UP* program. Total utility purchases through this component are expected to exceed \$200 million.

TEAM-UP, which stands for building Technology Experience to Accelerate Markets in Utility Photovoltaics, is a six-year, 50-MW PV hardware program designed to build a sustainable utility market for PV. The *TEAM-UP* program is supported by the U.S. Department of Energy. The program is expected to generate 17 MW of small-scale purchases, with the remaining 33 MW to be obtained through a complementary initiative in grid-connected applications. [The first of at least four Request for Proposals will be issued separately by the UPVG in conjunction with the U.S. Department of Energy for \$8.3 million in new, *grid-connected* applications of PV under *TEAM-UP*'s Grid-Connected Applications initiative.]

TEAM-UP was developed in 1993 by the UPVG as the next phase in its multiyear program. The UPVG was created with a mission of increasing electric utility use of small- and large-scale photovoltaics for the benefit of the utilities and their customers. Formed in 1992 with 17 charter members, the UPVG now has 86 members representing more than 40% of the kilowatt hour sales of electricity in the United States (list attached).

The UPVG spent 18 months investigating the market opportunities, engineering requirements, and planning tools necessary for utilities to develop commercialization strategies for PV. The results of these Phase 1 investigations are available to the public through the UPVG in a six-volume set of reports. The UPVG is currently in Phase 2, which involves continued work on the market opportunities and standardized specification packages for utility PV installations.

The UPVG and the *TEAM-UP* program are coordinated with the larger PV-COMPACT program which incorporates the views of the PV supplier community, utility regulators, consumer advocates, and others into successfully bringing photovoltaics to electric utilities.

To receive a copy of the Grid-Connected Applications Request for Proposals, to order the Phase 1 reports and other UPVG publications, or for questions on the *TEAM-UP* and UPVG programs, please write Bethany Wills, the UPVG's Project Coordinator at 1800 M Street NW, Suite 300, Washington, DC 20036-5802. The UPVG may be reached by telephone at 202/857-0898 or by fax at 202/223-5537.

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**Utility
PhotoVoltaic
Group****PRESS RELEASE**

FOR IMMEDIATE RELEASE

Contacts: Jeff Serfass or Bethany Wills
(UPVG) 202/857-0898**RFP Represents \$15 Million
in New Photovoltaic Projects**

Washington, DC, January 9, 1995 — A Request for Proposals (RFP) for cost-sharing of approximately \$15 million in new solar photovoltaic projects was issued on December 23, 1994, by the Utility PhotoVoltaic Group in conjunction with the U.S. Department of Energy. This is the first in a series of annual RFPs to be issued by the Utility PhotoVoltaic Group (UPVG) under its 50-MW hardware initiative, *TEAM-UP*. The result of this year's RFP is expected to be \$7.4 million in DOE cost-sharing support, totalling up to three megawatts of utility grid-connected PV.

The UPVG is implementing the *TEAM-UP* program in an effort to increase the electric utility industry's experience with solar photovoltaic (PV) systems. *TEAM-UP*, which stands for building Technology Experience to Accelerate Markets in Utility Photovoltaics, is a six-year program designed to build toward a sustainable utility market for PV. Proposals may be submitted by teams that include utilities, independent power producers, PV suppliers, consultants, state agencies, consumer and public interest groups, and others interested in solar energy for electric utilities; however, winning proposals are expected to provide value to the electric utility systems and utility customers.

The RFP is for grid-connected applications of photovoltaics, with the sizes of individual projects determined by the proposers. Projects that lead to near-term, sustainable, high volume commercialization results or firm business commitments will be given preference in proposal evaluation. Responses to the RFP are due in the UPVG office on **February 23, 1995**. Proposals will be evaluated by an independent committee, with recommendations on selected proposals completed in March, 1995. Selected proposers will be notified by April, 1995.

"*TEAM-UP* is reinventing the way government and private industry work together to achieve common goals," stated Andrew M. Vesey, Chairman of the UPVG and Vice President of Power Delivery at Niagara Mohawk Power Corporation. "Never before has such a diverse group united to provide significant support of a clean, renewable energy technology. The sure success of this effort will provide new direction for the utility industry."

"The UPVG, utility regulators, consumers, and environmental advocates have worked hard to develop this program in a truly collaborative effort. In the last 18 months, we have carefully analyzed the market and technology, identifying public interest in some 9,000 MW of potential domestic PV installations in ten applications. This is a significant service opportunity in an increasingly competitive industry," added Vesey.

"*TEAM-UP* is about utilities using market forces and government and industry partnerships to build industry, jobs, and new competitive business options from a foundation of world-class research and development," said Karl R. Rábago, Deputy Assistant Secretary for Utility Technologies at the U.S. Department of Energy. "DOE is proud of this innovative, industry-driven effort. Our role is government at its best—listening to and working with U.S. business in support of new economic competitiveness. The high tech PV market at home and abroad is an ideal and growing field for U.S. industry leadership."

TEAM-UP was developed in 1993 by the UPVG as the next phase in its multiyear program. The UPVG was created with a mission of increasing and accelerating electric utility use of small- and large-scale photovoltaics for the benefit of the utilities and their customers. Formed in 1992 with 17 charter members, the UPVG now has 89 members representing more than 40% of the kilowatt-hour sales of electricity in the United States (list attached).

The UPVG spent 18 months investigating the market opportunities, engineering requirements, and planning tools necessary for utilities to develop a commercialization strategy for PV. The results of these Phase 1 investigations are available to the public through the UPVG in a six-volume set of reports. The UPVG is currently in Phase 2, which involves continued work on the market opportunities and standardized specification packages for utility PV installations.

The UPVG's *TEAM-UP* program is part of the larger PV-COMPACT program which includes the PV supplier community, utility regulators, consumer advocates, and others in successfully bringing photovoltaics to electric utilities.

To receive a copy of the Request for Proposals, to order the Phase 1 reports and other UPVG publications, or for questions on the *TEAM-UP* and UPVG programs, please write Bethany Wills, the UPVG's Program Coordinator at 1800 M Street NW, Suite 300, Washington, DC 20036-5802. The UPVG may be reached by telephone at 202/857-0898 or by fax at 202/223-5537.

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**Utility
PhotoVoltaic
Group**

PRESS RELEASE

FOR IMMEDIATE RELEASE

Contacts: Jeff Serfass or Bethany Wills
(UPVG) 202/857-0898

Proposals Usher in New Era of Utility Business Opportunities with Solar Photovoltaic Installations

Washington, DC, March 3, 1995—The Utility PhotoVoltaic Group announced reaching another major milestone in its efforts to create new opportunities for utility and industry investments in solar energy. The UPVG's *TEAM-UP* program, designed to increase the options utilities have to serve their customers, has resulted in proposals for almost 10 megawatts of new grid-connected photovoltaic installations. The result of this new "market-pull" program will be to accelerate the commercialization of photovoltaic systems and significant cost reductions by as much as five years. In response to its first *TEAM-UP* Request for Proposals (RFP), the Utility PhotoVoltaic Group received 26 proposals from teams of organizations ready to develop grid-connected projects. These projects would almost double the amount of grid-connected photovoltaic installations in the United States within two years.

The electric utility industry currently has more than 400 grid-connected PV systems, totaling about 10 megawatts of installed capacity. These systems range in size from five watts to two megawatts. The responses to the RFP include projects from one to 5,000 kilowatts, for a total of 9,754 kilowatts of new proposed PV capacity. The projects would be installed throughout the United States.

The Request for Proposals for grid-connected solar photovoltaic projects was issued on December 23, 1994, by the Utility PhotoVoltaic Group with support from the U.S. Department of Energy (DOE). This was the first in a series of annual RFPs to be issued by the UPVG under its utility- and DOE-sponsored *TEAM-UP* program. The total value of the projects proposed in this first year is more than \$56 million; the requests for *TEAM-UP* funds total \$18 million.

UPVG Executive Director Jeff Serfass hailed the success of this first year's effort, noting that "the results validate DOE's vision that helped create the UPVG. With their leadership, we have been able to deliver a strong array of projects that will greatly expand the necessary experience-base in utility, grid-connected applications."

The UPVG is implementing the *TEAM-UP* program in an effort to increase the electric utility industry's experience with solar photovoltaic (PV) systems. *TEAM-UP*, which stands for building Technology Experience to Accelerate Markets in Utility Photovoltaics, is a six-year

program designed to build toward a sustainable utility market for PV. Proposals were submitted by teams that include utilities, independent power producers, PV suppliers, consultants, and others interested in solar energy for electric utilities; winning proposals are expected to provide value to the electric utility systems and utility customers.

The initial RFP was for grid-connected applications of photovoltaics. Projects that lead to near-term, sustainable, high-volume commercialization results or firm business commitments will be given preference in proposal evaluation. Proposals will be evaluated by an independent committee, with recommendations on selected proposals completed in March, 1995. Selected proposers will be notified by April, 1995.

"Photovoltaic markets—both here and abroad—present important, growing business opportunities for U.S. industry," said Karl R. Rábago, Deputy Assistant Secretary for Utility Technologies at the U.S. Department of Energy. "We are proud to be supporting this collaborative effort led by the UPVG. They have consistently delivered on their plans. The *TEAM-UP* effort is good business, reflecting a different commercialization approach—targeted government support with broad industry cost-sharing, built on industry's own project-specific commercialization goals. The partnerships formed under *TEAM-UP* will result in new industry, new jobs, and new competitive business options."

TEAM-UP was developed in 1993 by the UPVG as the next phase in its multiyear program. The UPVG was created with a mission of increasing and accelerating electric utility use of small- and large-scale photovoltaics for the benefit of the utilities and their customers. Formed in 1992 with 17 charter members, the UPVG now has 91 members representing more than 45% of the kilowatt-hour sales of electricity in the United States (list attached).

The UPVG spent 18 months investigating the market opportunities, engineering requirements, and planning tools necessary for utilities to develop a commercialization strategy for PV. The results of these Phase 1 investigations are available to the public through the UPVG in a six-volume set of reports. The UPVG is currently in Phase 2, which involves continued work on the market opportunities and standardized specification packages for utility PV installations.

The UPVG's *TEAM-UP* program is part of the larger PV-COMPACT program which includes the PV supplier community, utility regulators, consumer advocates, and other public interest groups, and is directed toward successfully bringing photovoltaics to electric utility applications.

To order the Phase 1 reports and other UPVG publications or for answers to questions regarding the *TEAM-UP* and UPVG programs, please write: Bethany Wills, Program Coordinator, UPVG, 1800 M Street N.W., Suite 300, Washington, DC 20036-5802. The UPVG may be reached by telephone at 202/857-0898 or by fax at 202/223-5537.

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**Utility
PhotoVoltaic
Group**

PRESS RELEASE

FOR IMMEDIATE RELEASE
Contacts: Jeff Serfass or Bethany Wills
(UPVG) 202/857-0898

20 Utilities Plan New Solar PV Installations

Washington, DC, April 12, 1995 — The Utility PhotoVoltaic Group (UPVG) announced today its intent to make awards to eight teams proposing to install \$44 million in new photovoltaic installations. Included in the projects proposed are more than 350 individual PV systems totalling more than 8.5 megawatts, all connected to electric utility systems. The average price for the PV systems selected is \$5.22 per Watt, with the lowest potential cost reaching \$1.75 per Watt. (For comparison, the current average PV system price is about \$7 per Watt.)

This announcement marks the continuing success of the Utility PhotoVoltaic Group and the U.S. Department of Energy (DOE) in their efforts to create new opportunities for U.S. utility and industry investments in solar energy. These awards, which will result in new PV installations in up to 12 states throughout the U.S., are the first effort under the UPVG's *TEAM-UP* program, which is designed to increase the options U.S. electric utilities have to serve their customers. The eight teams requested \$13.6 million from the UPVG under the program.

The UPVG anticipates awarding \$5 million to the eight teams, although not all team projects will be funded as proposed. Actual awards are contingent upon the successful negotiation and ultimate execution of a cooperative agreement between DOE and the UPVG and the continued availability of appropriated funds designated for this program.

The utilities involved will use PV to provide electric service to customers in a wide array of applications, including residential and commercial rooftop, building-integrated designs, grid support, and distributed generation. The projects support eight different photovoltaic technologies and four inverter suppliers. A summary of each project is attached.

The UPVG's spokesperson, Jeff Serfass, was enthusiastic about the wide range of proposals received, exclaiming that "these new PV installations will accelerate the deployment of PV with aggregated PV system purchases in diverse areas of applications and technologies. The systems to be installed will provide high-value applications and experience to the teams and to the entire industry."

The Request for Proposals for grid-connected solar photovoltaic projects was issued on December 23, 1994, by the Utility PhotoVoltaic Group with support from the U.S. Department of Energy. This was the first in a series of annual RFPs to be issued by the

Types of PV Applications Selected

Residential & Commercial Rooftop
Building-Integrated
Grid-Support & Distributed Generation
Small, Intermediate, and Large Sizes

UPVG under its utility- and DOE-sponsored *TEAM-UP* program. The total value of the projects proposed in this first year is more than \$56 million; the requests for *TEAM-UP* funds total \$18 million.

The UPVG is implementing the *TEAM-UP* program in an effort to increase the electric utility industry's experience with solar photovoltaic (PV) systems. *TEAM-UP*, which stands for building Technology Experience to Accelerate Markets in Utility Photovoltaics, is a six-year program designed to build toward a sustainable utility market for PV. Proposals were submitted by teams that include utilities, independent power producers, PV suppliers and integrators, consultants, and others interested in solar energy for electric utilities; winning proposals are expected to provide value to the electric utility systems and utility customers.

The RFP was for grid-connected applications of photovoltaics. Projects that lead to near-term, sustainable, high-volume commercialization results or firm business commitments were given preference in proposal evaluation. Proposals were evaluated by an independent committee, with recommendations on selected proposals completed in March, 1995. Selected proposers were notified on April 7, 1995.

TEAM-UP was developed in 1993 by the UPVG as the next phase in its multiyear program. The UPVG was created with a mission of increasing and accelerating electric utility use of small- and large-scale photovoltaics for the benefit of the utilities and their customers. Formed in 1992 with 17 charter members, the UPVG now has 90 members representing more than 45% of the kilowatt-hour sales of electricity in the United States (list attached).

The UPVG's *TEAM-UP* program is part of the larger PV-COMPACT program which includes the PV supplier community, utility regulators, consumer advocates, and other public interest groups, and is directed toward successfully bringing photovoltaics to electric utility applications.

For answers to questions regarding the *TEAM-UP* and UPVG programs, please write to: Bethany Wills, Program Coordinator, UPVG, 1800 M Street NW, Suite 300, Washington, DC 20036-5802. The UPVG may be reached by telephone at 202/857-0898, by fax at 202/223-5537, or by e-mail at: upvg@ttc.mhs.compuserve.com.

Selected *TEAM-UP* Proposals

- **Eight Potential Technologies/Suppliers**
 - Crystal Silicon
 - Polycrystalline Silicon
 - Polycrystalline Film Silicon
 - Amorphous Silicon (3 Suppliers)
 - Low & High Concentration Systems
- **Four Inverter Suppliers**
 - Two Existing
 - Two New Manufacturers

Summary of *TEAM-UP* Awards

Lead Organization

Advanced Photovoltaic Systems/New World Power Corp.
 Amoco/Enron Solar Power Development
 Arizona Public Service Company
 Ascension Technology, Inc. (9 Utilities)
 CUPV/Sacramento Municipal Utility District (7 Utilities)
 Empire Electric Association
 Hawaii Electric Light Company
 Niagara Mohawk Power Corporation

Application

Various
 Distributed Generation
 Various
 Residential/Commercial
 Various
 T&D Support
 Commercial
 T&D Support

Details of the **TEAM-UP** Award Recommendations

(Listed in Alphabetical Order by Lead Organization)

Advanced Photovoltaic Systems, Inc./New World Power Corporation

This independent power producer proposal describes a project to finance, design, build, and operate up to 1 MW of thin-film, amorphous silicon PV systems in and about the City of Austin, Texas. PV systems will be provided by Advanced Photovoltaic Systems, Inc. (APS), with project development and financing provided by New World Power Corporation. The applications will include building-integrated roofing systems (0.5 MW), curtain wall/skylight glazing (0.2 MW), and ground-mounted polar-axis tracking system (0.3 MW). These PV systems will be installed at sites identified as having high value by the utility. A number of ownership and financial alternatives are being discussed with the City of Austin's Electric Utility. The project schedule has all systems operating 16 months after receipt of the Notice of Intent. This proposal was selected because of the many applications (building integrated, curtain wall, and innovative tracking flat-plate) deployed in high-value T&D locations. The project can result in volume purchases by establishing a market model for customer and third-party ownership using several PV-specific financing methods. The ability to offer several financing options along with other pricing strategies to the utility or the customer could assist the commercialization efforts. The project team has requested \$1,860/kW of **TEAM-UP** funding and proposed a 22:78 cost-share ratio.

Total Project Cost: \$8,590,000

Total TEAM-UP Request: \$1,860,000

Total kW (ac): 1,000

Amoco/Enron Solar Power Development

This independent power producer proposal describes a project to design, build, and operate a 5-MW, thin-film, amorphous silicon PV power plant located in the Imperial Valley of California. It is associated with a new 10-MW thin-film module production plant to be built by Amoco/Enron Solar; more than \$25 million has been committed for the manufacturing facility. The PV power plant design is underway and Requests for Qualifications (RFQs) have been released on the balance-of-system (BOS) equipment. The electric power generated will be sold to San Diego Gas & Electric Company under a Uniform Standard Offer #1; early discussions with SDG&E have taken place. This proposal was selected due to the aggressive pricing and volume deployment of a new PV technology. The combination of a very low-cost PV module production facility with high-volume purchases of BOS components and a very large installation gives this project good commercialization potential. The large scale is expected to stimulate the use of standardized system designs and equipment. The project team requested \$875/kW of **TEAM-UP** funding and proposed a 50:50 cost-share ratio.

Total Project Cost: \$8,750,000

Total TEAM-UP Request: \$4,375,000

Total kW (ac): 5,000

Arizona Public Service Company

This award anticipates funding up to 355 kW of PV systems in three areas, including PV integrated into covered parking structures, distributed generation plants, and a new, low-cost, high concentration photovoltaic system. The applications will use a variety of PV technologies from team members including United Solar Systems Corporation, Amonix Corporation, and several other PV suppliers. Nevada Power Company and Central and South West Services are also

team members. The award is being made for several reasons, including the high commercialization potential for the covered parking structures, which have a very large potential market. In addition, the high concentration system can become competitive for large peaking plants in regions with sunny climates. The distributed generation applications are planned as phased, competitive installations which will allow the use of the least-expensive PV systems in locations where they have the greatest value. The project team requested \$3,689/kW of *TEAM-UP* funding and proposed a 24:76 cost-share ratio.

Total Project Cost: \$5,392,712

Total *TEAM-UP* Request: \$1,309,620

Total kW (ac): 355

Ascension Technology, Inc.

This proposal describes a project to install 324 kW of PV systems on 100 residential and commercial buildings at nine utilities around the U.S. Ascension is the project integrator and the utilities involved are: Arizona Public Service, City of Austin Electric Utility, Boston Edison, Central and South West Corporation, Detroit Edison, New York State Electric & Gas, Northern States Power, Portland General Electric, and Wisconsin Public Service. The objective of this project is to validate the results developed in "PV-Friendly" market research studies already completed at three utilities and underway at four other participating utilities. The hardware procurement process will combine the requirements of all the utilities and will involve one or more PV module suppliers. All installations are scheduled to be installed and operating within 15 months of a receipt of a Notice of Intent. This proposal was selected because it has high commercialization potential. The projects involve volume purchases of PV components by an experienced integrator, using the "PV-Friendly" utility/customer concept, installed in nine utility service territories. The "PV-Friendly" pricing refers to the preference of some consumers to purchase electricity produced by environmentally attractive methods, such as PV, even if the price is somewhat higher. The link to commercialization is the combination of aggregated purchases, standardized and UL-approved mechanical and electrical components installed in residential and commercial rooftop applications that have a very large market potential. This project includes a substantial number of utilities and proposes to provide case-studies to estimate the dimension of the PV-Friendly market. Their plans include having the complete PV system be UL-listed, including the Ascension balance-of-system equipment. The proposal indicates case studies will be completed for each of the nine utility partners to estimate the dimension of this market and establish local practices for pricing PV systems and services for their customers. The project team requested \$3,998/kW of *TEAM-UP* funding and proposed a 44:56 cost-share ratio.

Total Project Cost: \$2,977,806

Total *TEAM-UP* Request: \$1,295,592

Total kW (ac): 324

1995 Collaborative Utility PV/Sacramento Municipal Utility District

This proposal describes a project to install 1,652 kW of PV systems at 232 sites in six utility service areas around the U.S. The applications include residential, commercial, and industrial building-rooftop and building-integrated installations and T&D grid-support systems. Its team members include experienced utilities (SMUD, Southern California Edison, City of Austin Electric Utility, and New York Power Authority) and new utilities (three municipal members of Northern California Power Agency, the City of Anaheim, and Citizens Utilities Company). Hardware procurement (competitive solicitations) will be done by each individual utility for their system. Coordination and technical support will be provided by the experienced utilities for the new-to-PV utilities. This proposal involves volume purchases, the "aggregation" of purchases, and benefit assessment procedures and processes, which were seen as having high potential for

commercialization. The "coaching" by experienced utilities for the new-to-PV utilities could have the potential to help lead to sustained markets. The project team has requested \$2,320/kW of *TEAM-UP* funding and proposed a 28:72 cost-share ratio.

Total Project Cost: \$13,496,000

Total *TEAM-UP* Request: \$3,841,000

Total kW (ac): 1,652

Empire Electric Association

This proposal describes a project to install a single 126-kW PV system near the end of a six-mile radial distribution feeder owned by a rural cooperative in Colorado. The objectives of the project are to: (1) defer immediate reconstruction of the 60 year old line that serves a portion of Mesa Verde National Park, (2) increase the reliability of electric service to customers served by this line, and (3) demonstrate the value of this type of application for cooperatives and other utilities. The project team also includes Western Area Power Administration, NEOS Corporation, Cornice Engineering, Southwest Technology Development Institute, and Solarex Corporation. This project demonstrates an application identified by the UPVG as having a significant potential market (3,000+ MW). The proposed project will provide significant opportunity to promote volume purchases for utilities that serve rural areas with radially constructed distribution lines. The ability to defer the upgrade on this "long-skinny-feeder" is viewed to have high commercialization potential. The PV system is scheduled to be operational in December, 1995. The project team has requested \$4,000/kW of *TEAM-UP* funding and proposed a 26:74 cost-share ratio.

Total Project Cost: \$1,915,000

Total *TEAM-UP* Request: \$504,000

Total kW (ac): 126

Hawaii Electric Light Company

This proposal describes a project to install a single 15-kW PV system on a commercial building owned by the county government located in Kailua-Kona, Hawaii; HELCO will own and operate the PV system. Amorphous silicon modules will be supplied by Advanced Photovoltaic Systems, Inc., and the inverters by Omnion Power Engineering Corporation. The project team also includes Bell Products, the County of Hawaii, and Renewable Energy Systems. The installation is scheduled to be operating nine months after receipt of Notice of Intent. This project is part of a HELCO PV program to provide both on-grid and off-grid systems for utility customers. This proposal was selected as it will be the first grid-connected PV system on the island of Hawaii and supported by the utility's initial efforts in integrated resource planning (IRP). The information gained from this installation is expected to transfer to many high-value applications involving commercial building to peak-loading reductions. This project's link to commercialization is the potential to lead to future volume purchases by creating market assurances, responding to existing utility system peak-loading conditions, and demonstrating the beneficial characteristics of roof-mounted PV on the island. In addition, they plan to conduct market studies and monitor the benefits to the local distribution feeder. Data from a recent distributed generation study, along with substation monitoring, are expected to identify many locations for the use of PV systems for load reduction and T&D support. The proposal identifies a large market for load reduction within HELCO's service territory. The project team requested \$4,000/kW of *TEAM-UP* funding and proposed a 28:72 cost-share ratio.

Total Project Cost: \$216,200

Total *TEAM-UP* Request: \$60,000

Total kW (ac): 15

Niagara Mohawk Power Corporation

This proposal describes a project to develop and deploy pre-commercially a 100-kW "Power Enhancement & Delivery System" (PEDS) which uses thin-film, polycrystalline silicon modules supplied by AstroPower, integrated with a battery and inverter to supply ac power. PEDS is a power control, storage, and conversion unit intended to become a commercial product, deployable in utility power quality and power flow applications, with or without a PV supply. The major part of this project is the development of the PEDS; the remainder will provide support for module development at AstroPower. The project team includes New York State Energy Research and Development Authority (NYSERDA), AstroPower, Power Technologies, Inc., Omnion Power Engineering Corporation, AC Battery, AWS Scientific, and ECG Consulting. Operation of the first PEDS unit is scheduled for May, 1996. The proposal was selected as it has good commercialization potential and includes market studies for this type of application. The project involves the development of a low-cost module and involves a PV array integrated with a high-value utility power quality/battery storage system. Significant BOS cost reductions are expected from the dual use of the power conditioning components and interconnection equipment. The project team has requested \$4,000/kW of *TEAM-UP* funding and proposed a 12:88 cost-share ratio.

Total Project Cost: \$3,394,000

Total *TEAM-UP* Request: \$400,000

Total kW (ac): 100

PV Vision

Volume 2 Number 3

The Newsletter of the Utility PhotoVoltaic Group

Fall 1994

UPVG Phase 2 Report

PV Manufacturers Expand Production, But For Export

The solar photovoltaic industry is expanding in a new era of success. U.S. commercial, utility, and world commitments to PV reflect the confidence that the technology behind solar photovoltaics is capable and is being deployed at an increasing pace. These commitments have, in turn, stimulated and given confidence to the PV manufacturers, so that they are ramping up production. Announced plans for expansion from nearly every PV manufacturing company indicate that they could *quadruple* current production by the end of the century.

The planned expansions announced by the major U.S. PV manufacturing companies can't help but increase the number of factory jobs, and also will develop positions for those in sales, distributing, transportation, advertising, etc. Independent

contractors and construction workers, too, may benefit. The greatest increases may occur in the number of companies and employees involved in retail and wholesale distribution, installation, and manufacture of noncollector system components.

Despite the worldwide growth of PV shipments, actual deployment of PV *in the U.S.* has not changed much over the past 10 years or so. The most explosive growth has been in *export* of PV cells and modules. And it is estimated that two-thirds of PV produced in the U.S. is exported to other countries. Although this trend supports PV businesses getting established and growing in the U.S., expanding use of PV within the country needs to include the leadership of the electric utility industry for bulk purchases.

The Numbers Tell the Story...

Based on Energy Information Administration (EIA) survey data, shipments of PV cells and modules totalled 21 MW in 1993, which is 34% higher than the total for 1992. This marks the ninth consecutive yearly increase in PV shipments.

Since 1988, shipments of PV cells and modules have increased at an average annual rate of 17%. The value of PV shipments increased to \$110 million in 1993, up 26% from \$87 million the previous year. (With the expansions planned by manufacturers, these numbers may well double by 1995.)

Announcements by many players in the U.S. photovoltaic manu-

facturing industry in 1994 all seem to have the same theme: they plan to double or even triple current production in the next year or so.

■ Amoco and Enron Corporations formed a new partnership (see box);

■ Canon/Energy Conversion Devices will be building a new manufacturing facility to accommodate 10 megawatts in Newport News, Virginia;

■ Solarex Corporation will increase production at its crystalline facility from six to 20 megawatts;

■ ASE-America (formerly Mobil Solar) is now owned by Daimler Benz and RWE (a strong German consortium) and stands ready to expand by several additional megawatts in Massachusetts;

■ New World Power purchased majority shares of stock in both Photocomm, Inc. (Ariz.), and Solartec, S.A., of Argentina.

Additional expansion plans are expected from Siemens Solar Industries and BP Solar.

(continued on page 2)

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Amoco/Enron Joint PV Venture is Announced

Amoco and Enron Corporations have agreed—effective January 1, 1995—to form a new general partnership to manufacture PV modules and develop solar-powered generation facilities. The joint venture, Amoco/Enron Solar, will fund a new thin-film PV module manufacturing facility producing 10 MW+ annually of large-area, multijunction a-Si modules.

Solar PV Mfrs. Expand

(continued from page 1)
...Sometimes

Although the basic calculations for the domestic market of PV cells and modules show an increase of 80% between 1985 and 1993, they do not tell the entire story. Although the EIA indicates 7.9 MW of PV

were sold in the U.S. in 1993 (up from 4.3 MW in 1985), further investigation by SEIA, the UPVG, and others shows that 40% to 70% of these shipments are subsequently resold outside the U.S.

Not counting these domestic resales outside the country, the export market for PV expanded from 1.6 MW to 14.8 MW during the same

time period, an increase of 825%.

An example of world commitments to PV is the new focus on renewables held by the World Bank. It provided \$145 million in 1993 to help with renewable energy power programs throughout the world. This included \$55 million dedicated exclusively to the installation of PV in India, which has an official policy of seeking to electrify 100,000 villages with renewable energy.

The planned expansion of PV manufacturing may prove an ideal opportunity for U.S. electric utilities to increase their use of PV at an economical level, but with foreign markets paying \$1/W to \$3/W more than U.S. markets, manufacturers may concentrate less on increasing their domestic sales. If the price of PV drops, solar photovoltaics surely will take on a serious role in the energy mix of the future. ■

Despite the phenomenal growth of PV shipments, actual deployment of PV in the U.S. has not changed much over the past 10 years or so. The most explosive growth has been in export of PV cells and modules. And it is estimated that two-thirds of PV purchased in the U.S. is resold to other countries. Source: EIA, UPVG.

UPVG's Phase 3 Program Prepared

As the release date approaches for the first grid-connected application request for proposals under *TEAM-UP* (see page 16), the UPVG also is preparing the program plan for Phase 3 activities. These Phase 3 activities support the objective of focusing the *TEAM-UP* initiative to achieve early, sustained PV commercialization by the conclusion of the program. These efforts are to be formed by the results of the early *TEAM-UP* projects and the findings from the UPVG's Phase 1 efforts.

A number of premises underlies the approach proposed herein:

- Sustained PV commercialization for domestic grid-connected applications may require on the order of 250 MW to 350 MW of PV purchases involving "subsidies" (over conventional value) of up to \$500 million;
- *TEAM-UP*, as initially proposed, may not be fully funded. However, significant federal support is nonetheless anticipated for the program promised with the aim of achieving

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PV Vision is the newsletter of the Utility PhotoVoltaic Group, a consortium of potential utility buyers of photovoltaic systems which has banded together to develop and implement market assurance strategies that will enable PV manufacturers to invest in the next critical round of cost reductions, while rewarding those utilities that have made the future happen through their early involvement. UPVG members receive this newsletter as a benefit of membership. Subscriptions are available for \$300 per year.

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Highlights of Recent Balance-of-System Research and Evaluation

[The following was excerpted from a paper by Michael G. Thomas and John W. Stevens of Sandia National Laboratories (Albuquerque, N.M.) presented at the Photovoltaic Performance and Reliability Workshop held September 21-23, 1994, and sponsored by the National Renewable Energy Laboratory.]

The current market for photovoltaic systems is for remote stand-alone and PV-engine hybrid power systems. These systems are dominated both in terms of performance and costs by the energy storage subsystem, controls, and power conditioning, items considered part of the balance-of-system (BOS). Investment in BOS can benefit PV system cost and performance. Currently, emphasis on developments for PV-powered systems continues to be focused on the need for new collectors. Unfortunately, lower-cost collectors have a limited potential for reducing system costs within the current cost-effective market place, and are principally needed for the grid-tied systems of the future, systems whose costs are dominated by the collectors.

Example 1. Battery Charging Voltage Key to BOS

In August of 1992, a wind-PV hybrid system was installed in the village of Xcalak, Quintana Roo, Mexico. The Xcalak hybrid system has received a large amount of exposure in the U.S. because of the fact that it is principally a village wind system; roughly 80% of the power is produced from wind generators over the year, with about 20% coming from the PV array.

Although originally designed to

use a backup diesel generator, a 125-kW SELMAC, the system is essentially a battery bank charged by six Bergy 10-kW wind turbines and an 11.2-kW PV array because the Gen Set is not used. The system also includes 1,740 ampere-hours (Ah) of GNB 6-7C23 deep-cycle flooded lead acid batteries and an AES 40 kVA sine wave inverter. When the system approaches the lower operational voltage, the loads are manually disconnected. Currently this allows load availability around 18 hours a day.

The voltage window for the batteries should be 195 to 260 volts, but because the inverter will shut down at 240 volts, the PV and wind charge controller set points have been lowered to below 240 volts. This voltage window results in the battery being cycled from somewhere above 30%

SOC [state of charge] to probably around 80% on a daily basis. Two analyses have been performed to determine the effect of this non-optimum operation.

The amount of ampere-hours removed from the battery can be estimated by looking at low and high bus voltages. First, a look at the cumulative charge on the battery bank taken from 1993 and 1994 operation shows a decline in the amount of energy. One can estimate the capacity of the battery by looking at the amount of usable energy available between high and low voltages. To do this, one must choose a period of time where there is a significant number of days where the charge exceeds the load. For example, prior to today 186, there was a period of two weeks where the voltage was relatively constant, near 240 volts. Between days 186 and 195, 1,030 Ah were removed, or close to 60% of the rated capacity. (On day 195, the lower limit on voltage (LVD) was approached.) However, between days 87 and 100, 1994, only 818 Ah were available. This puts

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UPVG Phase 3 Program Focuses on TEAM-UP

(continued from page 2)

sustained, domestic PV commercialization by the year 2000 or so;

- The critical component in deriving sustainable commercialization strategies will be to identify the self-interest of other parties besides the government (PV vendors, utilities, consumers, or other parties) to shoulder the remaining "subsidy" after accounting for the federal government's support;

- An eventual aim of sustainable PV commercialization strategies should be the complete weaning of the need for federal funding support; and

- Perhaps two to three years of TEAM-UP projects funded under the program's current approach may

be necessary to answer fundamental questions regarding markets, prices, partnering, and strategies before more directed strategies can be implemented. However, given the likely limits to open-ended federal support, as soon as such strategies emerge the TEAM-UP program should be focused toward these ends.

These premises suggest a transition from TEAM-UP's current grass roots, "bottom-up" approach, to one in the program's later years that can be targeted most cost-effectively to commercialization strategies that have the highest likelihood of success. The Phase 3 efforts are geared to begin laying the groundwork for this eventual (and desired) transition in the program. ■

Highlights of Recent BOS Research

(continued from page 3)

the available capacity at about 45% to 50% of rated capacity.

The second analysis was the direct determination of battery capacity of some of the batteries by the manufacturer. Because of concerns related to these low bus bar voltages, the batteries were replaced in June, 1994, and some of the original batteries were sent back to the manufacturer for capacity tests. The first two cycling tests performed by GNB of Kansas City indicated that the batteries had only 45% and 50% capacity as received, consistent with the earlier observations. This voltage limit on the batteries is resulting in incomplete charging and would reduce the battery life. Based on this analysis, the voltage limit on the charge controllers was increased by 20 volts (in August of 1994) and are now closer to the manufacturer's

recommended set points.

As an historical reference, the PV hybrid at Natural Bridges National Monument operated between 1979 and 1989 before reaching end-of-life of similar batteries. Here, however, the system routinely reaches a full 260 volts and the batteries were equalized every two weeks by an on-site engine generator. These data are also consistent with the results of the last three years of laboratory testing at Sandia and the Florida Solar Energy Center. Full cycle life has been observed with periodic equalizations of even smaller deep-cycle flooded batteries with only periodic equalization—every two to three months.

Example 2. BOS Designs and Insolation

Insolation affects the total system design, and there is some question about just how to use the

information. The combination of insolation, loads, and desired system availability establishes the battery size. However, many of the short-hand design procedures underestimate the battery size required. This leads to unexpectedly low system availability, shortened battery life, and customer dissatisfaction. A review of representative data from a mix of weather patterns shows that just knowing the average daily insolation or predicted array output is not enough information. Figure 1 shows voltage and current from a system in Atlanta, Georgia. (The voltage curves associated with the first seven days are indicative of good weather. The next six days show poor weather.) If this system is designed using the typical procedures which only look at TMY [typical meteorological year] averages, some problems develop.

For example, the system can operate for several bad days. However, one can see by the data that there can be nine out of 10 days with low charging current. Using averaged data, the assumption is that the good days and bad days will be relatively evenly distributed over the month. It can be seen, however, that 10 of the last 12 days of the month were poor while the entire first quarter of the month had good weather. First, in a typical system, the battery would reach LVD after three to four days of bad weather, and then the load would have limited run time for the next five or six days until good weather returns. If these days are then followed by 10 great days in a row, we begin to throw out energy by regulating after a few days—during the design month in which we should be using every available electron. The problem is that Atlanta is a site where we have extended periods of both very good days and very poor days, with relatively few "average" days. The battery bank for Atlanta will

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Figure 1. Voltage and Current Measurements from PV System in Atlanta, Georgia, February, 1994. The voltage curves associated with the first seven days are indicative of good weather; the next six days show poor weather. Atlanta is a site with extended periods of both very good and very poor days and few "average" days; the battery bank will have to be larger than would have been predicted to obtain the design system availability and cycle life.

Highlights of BOS Research

(continued from page 4)

have to be bigger than we would predict to obtain the design system availability and cycle life. In contrast, most southwestern U.S. sites will have a better distribution of good and bad days, resulting in more "average" insolation. This difference in weather pattern distribution among sites with the same load and same design month insolation results in a battery size modification as well as a possible variation in the size of the array.

Example 3. BOS and System Costs

System costs are usually divided into collectors, balance of system, and indirects. Today, modules in U.S. procurements are selling between \$4/W and \$5/W. Historically, the collectors have represented the cost drivers in many of the published studies. Most of these studies have, in fact, been performed on grid-tied systems. These systems and the results are, in fact, based on a number of very important considerations, for example: land values are insignificant and BOS costs are limited of the array structure and the electrical subsystem. As the collectors became a smaller percent of system cost, BOS becomes a more significant part of the system cost, and demands greater attention, both in cost and performance improvements.

Recent data on the costs for a dozen grid-tied systems installed in 1993 through the EPA PV-DSM Project are consistent with these previous analyses.

By contrast, for present PV systems, where much of the current market is, the collectors represent only 20% to 25% of the overall cost. These system costs also include loads, an area where improvements are reflected in lower cost, higher reliability PV systems. An example of collector cost impact can be seen

in a small, 35-W area lighting system designed for a Southwestern city. It will use approximately 100 W of modules at roughly \$500, while the overall system will cost at least \$2,000. If the load could be reduced, for example, by using a higher-efficiency ballast, it will reduce the overall system cost. This same collector cost impact can be seen in larger systems. A review of recent bids for hybrid communications systems and facilities puts a typical hybrid PV-Gen Set system at \$20/W; i.e., PV is about 25% of the entire project cost. Improvements in BOS component performance and design concepts will clearly have a greater impact on these systems than on grid-tied systems.

Example 4. BOS and Energy Value

A judicious selection of BOS components can enhance energy value. An interesting example of energy value and an increased investment in BOS is the AC battery. An example can be built around the John F. Long Solar One systems in Phoenix, Arizona. From 1985 to 1990, John F. Long Properties owned this 192-kW PV system that was designed to be self-sufficient in terms of net electrical use/generation. In 1990, the system ownership transferred to the Homeowners Association, along with the responsibilities to operate and maintain it. The system has been producing between 250,000 and 300,000 kWh/yr even though there has been some degradation. There are costs associated with this generation which include taxes, insurance, and maintenance (primarily BOS issues) which are estimated at about \$5,000/yr.

In this system, there is a problem of mismatch between PV generation and homeowner loads. The residential usage is typical with peaks early and late in the day, but generation is during the middle of the day. The problem is that the energy generated during the middle of the day is sold to the utility at a

wholesale rate, whereas the energy required early and late in the day is purchased at retail rates. The best economics result when no energy is sold back to the utility (or when the utility is willing to buy at retail rates, such as with net billing). This is because all of the energy generated is then valued at the retail rate. This can be accomplished with on-site energy storage.

Let's construct a straw man where all of the energy is worth \$0.20/kWh, its retail value. The 250,000 kWh/yr that the PV array generates has a value of about \$50,000. With a rate structure where the retail-to-wholesale cost ratio is five and one-third of the energy is sold back to the utility, the value is reduced from \$50,000 to less than \$34,000. By adding an AC battery with 200 kWh of usable energy, the value of the system could increase by the difference of these two values, or by \$16,000/yr. Because the wholesale cost of the batteries alone is \$23,000, with a projected lifetime of two to three years, the economics are "break-even" for this hypothetical case. The economics will improve when the differential between rates is greater or when energy storage becomes cheaper.

Conclusions

The cost and performance of the BOS is extremely important for today's photovoltaic systems and the current market for remote power. The BOS is the largest component of capital and maintenance costs in currently economical systems. This situation is unlikely to change in the near future. Even the development of a grid-tied market may not change this situation because distributed, grid-tied PV systems may require energy storage to fully utilize the value of energy generated by PV. Improvements in BOS cost, performance, and reliability will result in lower cost, better performing PV systems. ■

PV on Parade

What's Going On in Photovoltaics Around the World

■ **Up to 4,000 households in South Africa** will receive electricity from solar and other renewable resources through an agreement between Renewable Energy for African Development (REFAD) and the Dept. of Mineral and Energy Affairs of the government of South Africa. REFAD—founded as a partnership between government, the development community, and the renewable energy industry—emphasizes commercial, educational, and economical sustainability. It is focusing its activities in southern Africa, developing rural programs in Botswana, Lesotho, Malawi, and Namibia. The multimillion dollar first phase in South Africa will include the establishment of a credit facility to allow up to 4,000 consumers in rural areas to purchase PV home power systems. More than one million rural households are not served by the utility grid in that country. Call James Porter, 202/383-2550.

■ **Solar tax credits in the State of North Carolina** have increased substantially and now include PV systems. The State's General Assembly passed the solar tax credit bill unanimously during its 1994 Short Session. The bill adds PV to the existing state income tax credits for solar technologies and raises the personal tax credit for all solar equipment from 25% to 40%, with the maximum raised from \$1,000 to \$1,500 for each installation. For commercial and industrial applications, the bill raises the corporate tax credit from 25% to 35%, with a limit of \$25,000. The bill also raises the tax credit from 20% to 25% for a PV manufacturing plant.

■ **The use of PV-generated electricity to support disaster relief** efforts will be studied by the State of Florida's Dept. of Energy under a grant from the U.S. Dept. of Energy. It often takes weeks to restore normal power in areas struck by floods, storms, or earthquakes, but, with advance planning, solar power could be used in such areas on a temporary basis. The Florida State Energy Office already has con-

ducted several tests of PV's feasibility; after Hurricane Andrew in August, 1992, PV cells were used to power communications devices, refrigerators for cooling vaccines, security lights, and other systems. The results will be compiled in a "how-to" manual targeted at government agencies, emergency management organizations, and relief workers. Call Fred Singleton, 404/347-3482.

■ **The U.S. Army Corps of Engineers** is seeking construction and related design of a 450-kW (peak) PV power station for the main administrative area at Yuma Proving Ground in Arizona. The array will include power conditioning and control equipment, transformer and about ¼-mile of distribution line for grid connection to a 12-kV line, and a security fence to enclose the array and control equipment. Estimated cost is between five and ten million dollars. For details on solicitation No. DACA05-95-R-0007, contact USAED Sacramento, Attn: Plan Room, 1325 J St., Sacramento, CA 95814-2922. Deadline is January 3, 1995.

■ **Custom-made, translucent laminates** were installed this summer on the entire south-oriented façade of a cable car top-station in the Swiss Alps. The grid-connected PV system at the peak of the Parpaner-Rothorn used 39 m² of the laminates; the actual active cell area is 27 m² and produces 4.1 kW peak power. The cells are 8mm apart, allowing light to come through the laminate to illuminate the upper part of the cable car arriving at the station. Because of wind speeds up to 150 km/h, all laminates are installed in a massive metallic grid structure. The laminates were manufactured by Gebaude Solar Systeme GmbH; Siemens monocrystalline cells were used.

■ **A large, decorative fountain** that is powered by solar energy and floats atop ponds and reservoirs has been developed and is being marketed by Hitachi, a Japanese firm known for its electronic appliances, reports *Public Innovation Abroad*. The new

device is being marketed to local government jurisdictions and public utilities. It does not require any construction work; it is simply floated on the surface of the body of water and works entirely on solar energy. The solar fountain consists of a pump, a ventilator, and 36 battery-equipped solar panels placed crosswise on a raft.

■ **New regulations in Japan** require that utilities buy surplus power from residential customers, reports *Popular Science*. The government also will subsidize up to half the cost of buying and installing a residential solar power system (quite a deal where a 3-kW system—enough to cover the energy needs of the typical four-person Japanese household—costs about \$50,000, including installation). Companies such as Sanyo Electric and Sharp offer complete systems that include solar panels, mounting frames, wiring, an inverter, and the junction box and meters needed to tie into the utility grid. The utility pays the same rate it charges, about 24¢/kWh in the Tokyo area. Exceptionally hot and sunny weather this past summer allowed Japanese householders with PV systems to sell back substantial amounts of electricity to local utilities; there were twice as many sunny hours in July and August as there were last year.

■ **The Naval Air Warfare Center** in China Lake, Calif., soon will include a 290-kW solar power system. Photocomm is the prime contractor, supplying 352 of ASE Americas' large (4'x6') double-glass modules. Each module will contain 216 crystalline solar cells and be connected to the others by self-locking quick connects. The system is scheduled for completion in late 1995.

■ **The largest roof-mounted PV installation in Europe** will be installed atop new buildings at the Science Park Gelsenkirchen near the city of Essen, Germany, reports *PV News*. Flachglass Solartechnik GmbH of Germany will supply 300 kW of PV modules, which will cover 2,130 m² of roof.

Electricity from the \$4.5 million project will be fed into the grid. Call Mrs. Renate Piesker-Spahn, (+49)221/257-3811.

■ **Police in New Britain, Conn.,** now use a three-wheeled, solar-powered, electric motorcycle to patrol for parking violations. The trike, dubbed Envirocycle II, was modified by the Central Connecticut State University Solar/Electric Research team by removing the gasoline-powered engine and substituting a direct-current electric motor and a bank of six 12-V lead-acid batteries. A solar array on the back provides a trickle charge to the batteries.

■ **The U.S. Coast Guard** has called for bids to supply PV-powered navigational beacons. The beacons must be solar-powered and visible for 26 nautical miles, the motor must not exceed 8 W, and the lamp must not surpass 250 MWe. A New Zealand firm, Vega Industries, is expected to be awarded the \$910,000 contract. Three years ago Vega designed a landfall beacon for the USCG with similar specifications for use inside a lighthouse, and currently is supplying 60 medium-range PV landfall beacons visible for 22 nautical miles.

■ **PV-powered lanterns, power plants, and irrigation apparatus** appear on the list of equipment to be exempted from sales tax in the State of Haryana in Northwest India. Several other "nonconventional" energy instruments and equipment get the sales tax waiver, too, as part of the government's new energy-saving program: solar water heating systems, solar cookers, biogas stoves, and industrial units engaged in the production of equipment for generating power based on wind energy.

■ **A PV-powered carport** for recharging electric vehicles used for commuting was unveiled at Pennsylvania State University at Harrisburg this fall. The Penn. Energy Office provided nearly \$38,000 in grant funds to design, build, and test a campus-based, grid-connected charging station. The 15 m² array uses thirty 55-W Siemens panels to produce 1.5 kW. Call Darlene Crawford, 717/783-9981.

■ **The government of the State of Rajasthan** in Western India is proposing setting up a hydrogen village, reports *Asian Energy News*. The \$48 million project would use hydrogen generated by 500 MW of solar power produced at plants near the Jaisalmer and Barmer districts of the Thar Desert. The project would use PV cells to convert sunlight into electricity, which would be used to electrolyze water, generating hydrogen. The fuel would be stored as a metal hydride, allowing safe transport.

■ **The most powerful solar telescope** ever flown is the two-ton Flare Genesis observatory, states *Popular Science*. Powered by the sun via photovoltaics, the device will be lifted 125,000 feet by a helium balloon this December, where it will hover above the South Pole, mapping magnetic fields on the sun's surface. The maps may help scientists learn what causes solar flares, violent bursts of energy that can disrupt communications and transmission of electricity.

■ **The first telephone switch in North America** to get 100% of its power from PV was installed in San Bernardino, Calif., by Siemens for GTE, reports *Electric Light & Power*. The PV power supply for the digital loop carrier system provides telephone service to a remote community of 20 homes located near the switch, which is miles from the nearest electrical grid. Twelve Siemens M75 panels generate up to 576 W and charge a 48-V, 350 ampere-hour battery bank; the PV panels can supply 33 ampere-hours/day to the system.

■ **An 18-kW PV system** is being installed on the student center at Northeastern University's Boston, Mass., campus. Funding is coming from Boston Edison, EPA, and EPRI. The project involves 90 flat solar panels on the roof of the Eli Student Center.

■ **The U.S. Environmental Protection Agency** has requested bids for military rooftop PV applications. The contractor would provide commercially available, grid-interactive PV modular units capable of generating at

least 18 kW per site and demonstrate the use of such arrays as a demand-side power source on military buildings. Copies of solicitation D400939M1 are due December 20. Call Dale DeFilippis or Janice White, 919/541-3165.

■ **A turnkey facility with amorphous silicon solar cell performance guarantees** will be used for research and development, says *Photovoltaic Insider's Report*. The University of Arkansas ordered the multichambered PECVD (plasma enhanced chemical vapor deposition) and sputtering system from MVS Systems, Inc. (Golden, Colo.). A cluster tool design allows for retrofits of up to seven PECVD/sputtering process chambers stationed around a central, circular, evacuated isolation and transfer zone. A robotic arm, situated within the zone, automatically injects and extracts the substrates from the process chambers. Call 303/526-9016.

■ **A bank of solar cells atop Ricoh's XR-Solar 35mm SLR camera** replaces the usual three-volt NiCad, reports *Popular Science*. The cells power the camera's shutter, light meter, and optional LCD databack. Like a solar calculator, the cells provide power in adequate indoor or outdoor light. The flash must be battery-powered, however. The price is \$450. Contact Ricoh Consumer Products Group, 180 Passaic Ave., Fairfield, NJ 07004.

■ **A new method of energy training in developing countries—via satellite—**has been launched by the Florida Solar Energy Center and Savannah State College of Georgia with the support of NASA Lewis Research Center. The program will test the capabilities of NASA's Advanced Communication Technology Satellite (ACTS) for delivering economical, high quality, two-way video, audio, and data to countries in Latin America and Africa. FSEC and Savannah State will develop training materials and methods for use in distance education to educate and train indigenous personnel in developing countries in sufficient numbers and depth to aid development of their energy infrastructures. ■

AMONIX Concentrator PV Attains 20%+ Efficiency

An Integrated, High-Concentration PV (IHCPV) system built by AMONIX, Inc. (Torrance, Calif.), set a world record for commercial-scale electrical energy conversion efficiency. The IHCPV system attained a conversion efficiency of 20.3% under STC (18.5% at PVUSA operating conditions) in a 2-kW testbed array installed at the Shenandoah Environment and Education Center at Georgia Power Company near Atlanta, Georgia.

The IHCPV uses low-cost plastic, point-focusing Fresnel lenses and a reflective secondary optical element to direct sunlight onto a high concentration, back-contact PV cell. The cell is mounted on a copper conductive layer, which is mounted on an insulating layer atop an aluminum substrate.

According to AMONIX president Vahan Garboushian, the IHCPV system development is complete and only volume production—not technical breakthroughs—is needed to meet the cost goals of <\$2/W at multimewatt levels. The IHCPV technology is expected to cost \$1.50 per watt of installed capacity and produce energy at 6¢/kWh in commercial quantities.

IHCPV STARS in Arizona

A full-scale, two-axis tracking, 20-kW demonstration unit of the IHCPV system was deployed for utility evaluation in October, 1994, at Arizona Public Service Company's Solar Test and Research (STAR) facility in Tempe. Although up and running, the system will not be fully integrated into APSC's grid until the end of this year.

The high-concentration (260x) system was developed for cost-effective, utility-scale applications. High-concentration PV systems offer several advantages for low-cost

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Integrated High-Concentration Photovoltaic System (IHCPV).

The basic concept of an "integrated array" is to integrate the module housing or module structure into the tracker structure, thereby eliminating redundant structural components. Fresnel lens parquets attach directly to the top of the tracker structure and PV "panels" or "circuit boards" attach directly to the back of the structure. The concept requires that components be precisely fabricated and assembled in order to meet optical alignment requirements and that the structure have sufficient stiffness to maintain alignment under all operating conditions. The panel's substrate consists of a three-part, thermally conductive laminate, with the front surface being electrically conductive and electrically isolated from the back surface. The cells, reflective secondary optical elements, blocking diodes, and interpanel wiring terminations are all soldered directly to the top surface of the laminate, thereby eliminating individual cell packages.

Concentrator PV Attains 20% Efficiency

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power generation: (1) cost reduction through higher utilization of silicon (concentrator systems reduce the amount of costly silicon required to generate a given amount of electricity by an amount approximately equal to the concentration ratio); (2) high cell conversion efficiency at concentration versus one-sun; and (3) inherently higher capacity factor (compared to fixed-tilt, flat-plate systems) in high direct normal insolation (DNI) areas because of its built-in tracking. (The graph at right depicts actual data of output power (DC) versus DNI under variable temperature conditions for the IHCPV at Arizona Public Service.)

The integrated system concept greatly reduces the costs associated with system hardware and labor by: (1) integrating the load-bearing structure and the Fresnel lens/receiver plate elements, eliminating the need for separate modules; and (2) use of a receiver plate which makes use of "circuit-board" con-

Actual data of output power (DC) versus direct normal insolation (DNI) under variable temperature conditions shows that the IHCPV array at Arizona Public Service exceeded the design goal of 20 kW.

struction techniques.

Additional IHCPV demonstrations are planned for utility test sites in 1995; these are still under negotiation.

The IHCPV's integrated structure was designed by Scientific Engineering, Inc. (Montgomery, Ala.).

The lenses were manufactured by Fresnel Optics, Inc. (Rochester, N.Y.). The Electric Power Research Institute (Palo Alto, Calif.) is sponsoring development of the IHCPV technology. For further information, contact David Roubideaux, 310/325-8091.

9

'Century Challenge' Implemented for Current, Future UPVG Members

The Century Challenge is an opportunity for current UPVG members to promote the advantages of membership in the UPVG, with a goal of reaching 100 members (thus, the "Century" Challenge).

Membership applications for 1995 allow applying utilities to notify the UPVG if current members have encouraged them to join. Awards will be given to those current (1994) members which are identified as having influenced the greatest number of other electric utilities to join the UPVG for 1995.

The top three awards are as follows:

- The member sponsoring the most new members, with a mini-

mum of five, will be given a 100% reduction in 1996 dues.

- The member sponsoring the second highest number of new members, with a minimum of three, will be given a 50% reduction in 1996 dues.
- The member sponsoring the third highest number of new members, with a minimum of two, will be given a 30% reduction in 1996 dues.

Individuals named in the Century Challenge will receive the UPVG's PV Education Kit. The kit includes:

- A PV module with attachments to show how solar energy works;
- Slides and brochures on "what

is PV?";

- Information on UPVG programs; and
- UPVG's "Shine for a Century" tee shirt.

The PV Education Kit may be used to bring utility management "up to speed" on PV and the UPVG program. It also may be used to educate others in local communities about the benefits of solar energy.

The deadline for 1995 is February 28. Awards will be announced at the 1995 Annual Meeting. Questions about the Century Challenge should be addressed to Bethany Wills, project coordinator, 202/857-0898.

Industry Indicator

Solarex Corp. plans to triple the capacity of its polycrystalline silicon module manufacturing plant in Frederick, Md. The State of Maryland and the Maryland Energy Administration have granted loans to Solarex in the amount of \$3.7 million for the project; Solarex will invest \$4 million. The expansion—which should put annual production capacity at 20 MW per year—should be complete in 1996. The firm also is searching for a location for a new thin-film amorphous silicon plant, which will produce large-area, multi-junction, thin-film a-Si modules at an initial capacity greater than 5 MW per year. Call Sarah Howell, 301/698-4272.

New World Power Corp. (Lime Rock, Conn.) has been busy in the PV arena. During the summer it formed a business alliance with Westinghouse Electric Corp. (Pittsburgh, Pa.) to reach global renewable energy markets. (As part of the agreement, NWPC purchased Westinghouse's shares in Photocomm, increasing its share of ownership to 45%.) In October, NWPC purchased additional shares in Photocomm, Inc. (Scottsdale, Ariz.), resulting in a majority interest in the largest publicly owned manufacturer and marketer of solar electric power systems in the U.S. It also acquired 51% of the stock of Solartec, S.A., of Argentina, a PV systems fabricator and distributor of PV products in South America. The new company, New World/Solartec, promptly bid on a \$2.4 million rural electrification project for the State of Santa Fe, Argentina. Now NWPC has signed a joint venture agreement with China Chang Jiang Energy Co. Group and Metropolitan Enterprises Corp. to develop renewable energy projects in China. NWPC will own a 65% share of the new firm, Chang Jiang New World,

which will build, own, and operate various wind, hydro, and solar facilities to generate electricity. Call Al Austin, 203/435-4000, or Dwight Kuhns, 510/416-0600.

BDA Buro Dakadvies BV, a roof and façade construction engineering company in the Netherlands, has built a test facility for PV roofs, reports *PV News*. Tests of PV modules integrated into pitched roofs can be carried out on various support constructions and inclines. Tests deal with waterproofness, durability, safety, fire resistance, sound transmission, energy efficiency, and building physics. The facility is based on a report prepared by Ecofys Research and Consultancy, which is cooperating in the tests, and was ordered by the Netherlands Energy Ministry (NOVEM). Call BDA at (+31)18/306-9690.

Webel-SL Energy Systems (India) plans to set up an "export processing unit" to make PV cells using technical and financial collaboration from Helios Technology (Italy), reports *The Solar Letter*. Helios will buy back 75% of the production for three years. The \$3.3 million unit, with an annual installed capacity of 100 kW, will be located in Calcutta. The company will issue shares to partially finance the project.

Sanyo Electric of Japan plans to establish a manufacturing facility in the Philippines for the commercial production of photoelectric systems, reports *Asian Energy News*. Sanyo already has reserved a 50,000 m² lot at the Luisita Industrial Estate in the city of Tarlac for its planned projects.

Three European companies have merged to create the largest silicon wafer company on the continent. The resulting company, Bayer Solar GmbH, will build a new plant

in Freiberg, Germany, with a planned capacity of 20 MW of 10x10cm wafers, and plans to hire 160 persons.

Flachglas Solartechnik GmbH (Köln, Germany) received the first-time awarded European Solar Prize this year in the "best integrated solar façade in buildings" category. The prize was for the design and integration of the largest solar electric façade, installed at one of its factories in Wernberg, Germany. More than 11,000 PV cells in five different module types generate 10 kW; an annual minimum production of 7,000 kWh is expected. Contact Mrs. Renata Piesker-Spahn, (+49)221/257-3811 or fax (+49)221/258-1117.

A mid-range PV controller was introduced by Morningstar Corp. this summer. The ProStar uses a microprocessor to provide "intelligent" battery charging, which is claimed to substantially increase battery life. The controllers are suitable for both industrial and consumer applications, covering a power range of 12 amperes to 30 amperes at both 12 and 24 volts (DC). Call Lee S. Gordon, 215/321-8983.

Clarification: Winners of the 1994 R&D 100 Awards

In the summer issue of *PV Vision* (p. 10), an article on *R&D Magazine's* 1994 R&D 100 Competition neglected to give credit for a winning silicon PV cell to all the parties involved. Sharing the award are the Electric Power Research Institute (Palo Alto, Calif.); AMONIX, Inc. (Torrance, Calif.); SunPower Corporation (Sunnyvale, Calif.); the U.S. Department of Energy; and Sandia National Labs (Albuquerque, N.M.). The photovoltaic cell was cited as "one of the most technologically significant new products of the year."

World PV Conference Sees Higher PV Efficiencies, Greater Production

The First World Conference on Photovoltaic Energy Conversion (WCPEC) was held in Waikoloa, Hawaii, on December 5-9, 1994. This was a combination of three conferences: the U.S. IEEE PV Specialists Conference, the European PV Conference, and the Japanese PV Conference. More than 900 attendees from around the world attended.

It was clear from the meeting that the international market for PV is increasing. Applications of grid-independent systems have increased worldwide as well as several grid-connected residential opportunities in Europe. Several new module "global" partnerships are expected to start production soon.

Several papers focused on the continued performance improvement and cost reduction of crystalline silicon and its continuation as the workhorse technology. Amorphous silicon sessions discussed improved lifetimes and increased efficiencies, but few of the systems have been deployed in the field. Other thin-film materials like CIS,

CdTe, etc., are improving, with several companies planning production facilities in the near future.

A session devoted to "PV on Buildings" included papers from the U.S., Europe, and Japan and described the benefits and the economical and technical issues of the PV system/building integration concept. Presenters described how PV systems have been used as part of DSM measures and several papers identified the potential of a utility/customer partnership with PV. Several technical sessions provided overviews of the latest modeling and performance measurement processes and described the increased accuracy and level of sophistication of newer models and products.

Balance-of-system issues centered around the inverter, appropriately, as the performance (or lack of performance) has been the biggest issue for the reliability of a PV system. New protection techniques, utility interconnection, and circuit topographies were discussed.

The final values for the Kerman 500-kW system were presented by PVUSA. The analysis indicated that the value of the nontraditional benefits did, in fact, double the value of a PV system in a grid-support application, instead of tripling the value as originally predicted.

AstroPower issued a press release related to the successful performance rating of its new thin-film silicon on ceramic cell array installed at PVUSA in Davis, Calif. This is the first EMT array to exceed power expectations.

TEAM-UP Paper Presented

A paper—authored by Mike Bergman, John Bigger, Steve Hester, Jeff Serfass, and John Hoffner—entitled "Implementation

Utility PV Employee News Update

Since we last went to press, there have been a few changes in PV personnel in which you might be interested:

■ **Andrew Vesey**, chairman of the UPVG Board of Directors, has been promoted. Formerly vice president of operations support, he is now vice president of power delivery at Niagara Mohawk Power Corporation in New York.

■ **Robert Putnam**, formerly manager of supply-side planning at Niagara Mohawk Power Corporation and chairman of the UPVG Planning and Evaluation Work Group, has left. He is now manager of IRP at Electrotek Concepts, Inc.

■ **Larry Mansueti**, formerly director of technical services at the American Public Power Association and Secretary of the UPVG's Board of Directors, is now special assistant to the executive director at the Solar Energy Industries Association. He was replaced at APPA by **Bill Wemhoff**.

■ Once **TEAM-UP** has been approved by DOE (see story, page 16), the UPVG will be searching for directors for both the **TEAM-UP** and the Small-Scale Applications programs, as well as for members of the Evaluation Committee.

of the U.S. Utility Industry's **TEAM-UP** Commercialization Initiative" was presented. The paper described the **TEAM-UP** goals and objectives, the four program areas, and briefly described the grid-independent activities of the program and the first-round RFP for grid-connected systems. ■

PV-SCREEN to be Ready in January

The Utility PhotoVoltaic Group's Planning and Evaluation Work Group has contracted with Electrotek Concepts on the completion of the first version of the PV-SCREEN software program. The final package is expected to be available and delivered to UPVG member representatives during January, 1995.

The Work Group members hope that all UPVG members will utilize the program in determining the benefits of photovoltaics in utility applications. ■

Calendar

January, 1995

PVUSA Balance of Systems Workshop. January 23-24, 1995; Davis, Calif. Sponsored by the Photovoltaics for Utility-Scale Applications project. Phone: 510/866-3100.

Renewable Energy Asia Pacific '95. January 23-25, 1995; New Delhi, India. Contact Cassy Kurtzman, Advanstar Communications, Tai Yau Building, 23rd Floor, 181 Johnston Road, Hong Kong. Phone: 852-832-4998. Fax: 852-575-4611.

February

Northwest Renewable Forum: Building a Sustainable Market in a New Utility World. February 14, 1995; Portland, Ore. Sponsored by the Northwest Power Planning Council, the Renewable Northwest Project, and Bonneville Power Administration. Phone: 503/222-5161 or toll-free 1-800/222-3355. Fax: 503/795-3370.

March

12th International Seminar on Primary and Secondary Battery Technology and Application. March 6-8, 1995; Deerfield Beach, Fla. Contact S.P. Wolsky, Ansum Enterprises, Inc. (Boca Raton, Fla.), 407/391-3544. Fax: 407/750-1367.

International Solar Energy Conference. March 19-24, 1995; Maui, Hawaii. Sponsored by the American Society of Mechanical Engineers, Japanese Society of Mechanical Engineers, and the Japan Solar Energy Society. Contact Conferences, ASME, 345 E. 47th St., New York, N.Y. 10017. Phone: 212/705-7793.

1995 Affordable Comfort Conference. March 26-31, 1995; Pittsburgh, Pa. Contact Gail Ettinger, 708/864-5651. Fax: 708/864-7535.

April

SOLTECH '95. April 9-13, 1995; San Antonio, Texas. Sponsored by the Solar Energy Industries Association. Contact Michelle Birkenstock, 202/383-2620.

1995 UPVG Annual Meeting. April 10-13, 1995; San Antonio, Texas. Sponsored by the Utility PhotoVoltaic Group. Contact Angela Barbara, 202/857-0898. Fax: 202/223-5537.

PVUSA Power Quality, Data Acquisition, and Procurement Workshop. April 19-20, 1995; Davis, Calif. Sponsored by the Photovoltaics for Utility-Scale Applications project. Phone: 510/866-3100.

GLOBALCON '95. April 19-20, 1995; San Francisco, Calif. Phone: 404/447-5083, ext. 210. Fax: 404/446-3969.

Sun Day 1995. April 23, 1995. For details, contact Sun Day 1995, 315 Circle Avenue, #2, Takoma Park, MD 20912. Phone: 301/270-2258.

May

13th NREL Photovoltaics Program Review Meeting. May 16-19, 1995; Lakewood, Colo. Sponsored by the National Renewable Energy Laboratory. Contact Ms. Jeri Wagner, 303/275-4317. Fax: 303/275-4320.

1995 American Tour de Sol. May 20-27, 1995; Waterbury, Conn., to Portland, Maine. Sponsored by the

Northeast Sustainable Energy Association. Phone: 413/774-6051.

June

Midwest Renewable Energy Fair. June 23-25, 1995; Amherst, Wis. Sponsored by the Midwest Renewable Energy Association. Phone: 715/824-5166.

July

Solar '95: 10,000 Solutions: Paths to a Renewable Future. [ASES' 24th Annual Conference and 20th National Passive Solar Conference.] July 15-20, 1995; Minneapolis, Minn. Sponsored by the American Solar Energy Society, Inc. Contact Becky Campbell-Howe, 303/443-3130. Fax: 303/443-3212.

September

1995 Solar World Congress: In Search of the Sun. September 9-16, 1995; Harare, Zimbabwe. Sponsored by the International Solar Energy Society. Contact: 1995 ISES Solar World Congress, P.O. Box MP 119, Mount Pleasant, Harare, Zimbabwe.

October

13th European Photovoltaic Solar Energy Conference and Exhibition. October 23-27, 1995; Nice, France. Sponsored by the European Commission and ADEME (Agence de l'Environnement et de la Maîtrise de l'Energie, France). Contact WIP, Sylvesterstr. 2, D-81369 München, Germany. Phone: +49/89-720-1232. Fax: +49/89-720-1291.

April, 1996

Solar '96. April 13-18, 1996; Asheville, N.C. Sponsored by the American Solar Energy Society, Inc. Contact Becky Campbell-Howe, 303/443-3130. Fax: 303/443-3212.

The Current UPVG Board of Directors, FYI

This list of the UPVG's current Board of Directors is provided for your information. The UPVG currently is investigating individuals to fill the vacancy created by the departure of Larry Mansueti. Questions regarding the UPVG Board should be addressed to Bethany Wills at the UPVG, 202/857-0898.

Chairman

Andrew M. Vesey, vice president of power delivery, Niagara Mohawk Power Corporation (NY)

Vice-Chairman

James Rein, director of power services, Arizona Electric Power Cooperative

Members

Robert L. Bellenger, director, technology management, Alabama Power Company

Gary S. Brinkworth, superintendent, system planning, City of Tallahassee (FL) Electric Department

Larry A. Crowley, senior manager, strategic planning, Idaho Power Company

Thomas Foreman, manager, electric planning and regulatory, Lower Colorado River Authority (TX)

Wayne R. Gould, manager, photovoltaic applications, Southern California Edison

Albert Kirby, III, manager, ME&S, Delmarva Power & Light Company (DE)

Charles Linderman, director, fossil fuels and renewables, Edison Electric Institute (DC)

William E. Muston, manager, research and development, TU Electric (TX)

Donald E. Osborn, senior project manager, solar program, Sacramento (CA) Municipal Utility District

Victoria Ponce, assistant to

UPVG Annual Meeting in San Antonio in April

The 1995 UPVG Annual Meeting will be held in San Antonio, Texas, April 10-13, 1995. For the first time, the UPVG Annual Meeting and SOLTECH will be held in the same city at the same time; several sessions will be held jointly. UPVG sessions will be held at La Mansión del Rio Hotel; the meeting will focus on "Building Toward Commercialization."

SOLTECH '95 will be held at the Hyatt Regency San Antonio, just a short walk down the Riverwalk from the UPVG hotel; all joint UPVG-SOLTECH plenary sessions and the exhibit hall will be located at the Hyatt Regency.

UPVG sessions will cover building toward commercialization, a focus on applications and implementation, an overview of

the PV-COMPACT programs, the UPVG annual membership meeting, work group meetings, and concurrent sessions with in-depth discussions. Joint activities with SOLTECH include PV-COMPACT presentations, a plenary on how to take solar energy along the path of success, a utility general session on major changes brewing, a reception, and the exhibits.

Dress, as always, is casual. Earlybirds may be interested in river rafting on the Guadalupe River on Sunday, April 9, and the Second Annual UPVG Golf Tournament on Monday, April 10.

Airline discounts are available. For further information on the meeting, contact Angela Barbara, meeting coordinator for the UPVG, 202/857-0898.

La Mansión del Rio hotel is the site of the UPVG's 1995 Annual Meeting. Originally built in 1852 as a private school, this charming, villa-style hotel is located on San Antonio's beautiful Riverwalk and just three blocks from the Alamo.

the administrator, Western Area Power Administration (CO)

Mark D. Rogers, senior research engineer, Northern States

Power Company (MN)

Rolland Skinner, general manager, Northwest Rural Public Power District (NE)

PV Pioneer

NYPA Harnesses Sun in Northern Latitudes

The New York Power Authority is the largest nonfederal power system in the U.S., producing more than one-quarter of the electricity for its state. Two-thirds of NYPA's generation is through hydroelectricity, but its use of PV is on the rise.

In one of its first PV programs, NYPA conducted a trial installation of a 4-kW PV unit atop White Plains High School in Westchester County. This array produces 6,000 kWh/yr; it has replaced more than 6,000 kWh from conventional sources and trimmed more than \$1,000 off the school district's energy bills since it was installed in May, 1993. During the summer of 1993, the Power Authority installed a 20-kW unit on the roof of a New York City Transit Authority warehouse in Queens; this installation produced more than 18,000 kWh over the 12-month period ending in October, 1994.

NYPA began a demonstration of 1-kW PV hybrid power systems

when a prototype was installed in September, 1993, at a remote home in Crown Point, N.Y. This program, run in cooperation with the N.Y. State Office of Rural Affairs and the State Energy Office, will monitor the hybrid system over two years, refine the design, and establish servicing requirements. NYPA hopes to reduce the costs of future systems through standardization. This hybrid unit consists of a solar panel array, storage batteries, and a propane generator to provide electricity when there is insufficient sunlight.

The hybrid system's array consists of 16 crystalline silicon modules—12 rated at 75 W (peak) each and four at 35 W each. The modules are wired four in series with four parallel sets to provide a nominal 48 V and 1,000 W under full sun. The array contains 16 bypass diodes and a blocking diode for each string and is mounted on the platform using an extruded aluminum rack tilted at 45°.

This 1-kW PV hybrid system—solar panels, storage batteries, and a propane generator—was installed at a remote home in Crown Point, N.Y., last year.

This 20-kW installation on the roof of a New York City Transit Authority warehouse in Queens produces more than 18,000 kWh a year.

Reaching Valhalla

In its latest venture, NYPA joined with PV manufacturer Solarex Corp. to install a nominal 40-kW PV grid-connected array at the Laboratory and Research Building at Valhalla College in Westchester County, N.Y. (Empire State Electric Energy Research Corp. and the N.Y. State Energy and Development Authority also are participating in the project.)

In the Valhalla project, 360 Solarex MSX 120-W modules were mounted onto steel pans that were ballasted with small-grade rock and placed on the roof of the building. This prevents roof penetration yet the array is designed to withstand 80 mph winds; the design also allows for both factory subassembly and easy transportability. The system provides approximately 7% supplemental electrical power for the lab.

NYPA is planning six to eight new PV installations of 40 kW each for 1995. For further information on NYPA's PV programs, contact Mark Kapner, manager of alternative technologies, 212/468-6725.

An Update on PV-COMPACT

PV-COMPACT, the coordinating organization of the four proposals to the U.S. Department of Energy in support of utility use of PV, has continued to develop since its inception in September, 1993. The organization is comprised of individuals in the regulatory, consumer advocate, PV supplier and integrator communities; state and federal governments; and electric utility industries. The primary focus of the group is the successful implementation of the four proposals submitted to DOE during 1993. The individual groups have seen significant achievements in the last year.

A two-day meeting was held in November in Reno, Nevada, on the Value Analysis Assessment Project. This meeting reviewed value analysis needs of the different stakeholder communities, identified gaps between needs and research, and adopted a research agenda and assignments to fill gaps and support commercialization efforts.

Photovoltaics for Utilities State Working Groups

The PV4U State Working Groups foster communication among key stakeholders at state and national levels. The first edition of the PV4U *Connections* newsletter was sent out in late summer, with the second edition to follow in March of 1995. In addition, the group prepared a PV4U *Connections* "PV Clearinghouse and Bibliography Service." This report provides readers with a comprehensive bibliography of photovoltaic publications. Please contact the UPVG or PV4U (617/323-7377) for a copy.

There are now 14 state that coordinate PV4U Working Groups. In addition, Pennsylvania and Utah have recently formed collaborative forums.

Photo-Voltaic Education Project

This project, guided by the National Association of State Utility Consumer Advocates, is working to keep consumer advocates informed about the developments in electric utility use of PV. Two new committees have been formed to help them in their efforts. Joan Peterson (from Minnesota) chairs the PV-EP Steering Committee. While Joan is on maternity leave, Chris Cook (who hails from Maryland) is acting chair. In addition, Chris chairs the Technical Task Group for PV-EP.

The PV-EP Steering Committee plans to issue an RFP in the next

several months to engage expert consultation to assist in the education of consumer advocates.

Renewable Energy Technology Analysis

RETA, a project of Pace University Law School, supports utility investments in photovoltaics by providing information, education and training in the development of this safe, clean, economic, and self-sustaining energy supply. RETA determined the needs of its environmental and public interest constituents through an ongoing assessment process. It will distribute a handbook of environmental, technical, legal, regulatory, and economic information in the spring. For details, call 914/422-4141. ■

15-Year Study Shows Public Perceptions, Preferences on Renewable Energy in the U.S.

Barbara C. Farhar, a member of the Analytic Studies Division at the National Renewable Energy Laboratory, has reviewed 15 years of public opinion polls to uncover trends in the U.S. regarding energy and the environment. Her resulting paper, *Trends in U.S. Public Perceptions and Preferences on Energy and Environmental Policy*, documents that public concern about the environment has increased over the past decade in the U.S. In addition, increasing majorities of the public, in opinion polls, have selected renewable energy and energy efficiency over other energy alternatives for the past 15 years.

A good many polls asked about people's willingness to pay for environmental protection. Findings show that majority concern for environmental protection extends even to personal costs. To protect and improve the environment, majorities in most surveys indicated a willingness to pay more for taxes, gasoline, electricity, other fuels, and automobiles. One survey even found a majority (63%) "willing to accept a lower standard of living if it meant a cleaner

environment."

Majorities of 57% to 80% said they were willing to pay more for electricity produced in a cleaner way or from sources less harmful to the environment. In 1990, a national poll asked: "How much more would you personally be willing to spend each month to have your electricity come from sources that are less harmful to the environment?" A majority (76%) said they were willing to pay more: 29% said they would pay \$6 to \$10 more; 21% said \$11 to \$20 more; and 26% said more than \$20 more.

In December, 1990, bipartisan polling organizations queried a national sample about national energy policy preferences; 86% favored reestablishing solar tax credits. The polls included some specific proposals relative to electric utilities. Majorities favored the following policies: integrated resource planning, DSM programs, use of renewables to generate electricity, utility profit incentives for using and promoting energy efficiency and renewables, pollution controls on oil- and coal-burning power plants, and green pricing. ■

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TEAM-UP RFP Released December 23

The much anticipated *TEAM-UP* Request for Proposals (RFP) was released on Friday, December 23, 1994. This first in a series of RFPs for grid-connected PV projects implements the *TEAM-UP* program to install up to 50 MW of new photovoltaic projects over the next six or so years.

Ready since October 17, 1994, release of the RFP was awaiting final approval from the U.S. Department of Energy. Responses to the RFP will be due February 23, 1995, 60 days from the actual release date. The UPVG will be seeking both candidates to serve on the Evaluation Committee for the *TEAM-UP* program and project proposals. Individuals interested in serving on the Evaluation Committee are urged to contact the UPVG.

In October, the UPVG announced implementation of the grid-independent portion of its program with the first two small-scale applications initiatives. Through negotiations with the Photovoltaic Services Network (Denver, Colo.), the UPVG will be initiating a buyers

group for AC livestock water pumping systems. In addition, an opportunity notice will be distributed early in 1995 to form teams for the remote homes power service initiative.

Please contact Bethany Wills or John Bigger at the UPVG (202/857-0898) for information on *TEAM-UP*, to receive a copy of the RFP, or to volunteer for the evaluation committee. ■

IEA Survey to Measure PV Progress Worldwide

In early 1994, the UPVG conducted a survey of electric utilities to obtain information on their PV technology activities and installations. The resulting information identifies more than 400 grid-connected PV systems in operation and more than 80 utilities with grid-independent systems installed. This database is the most up-to-date that exists today about electric utility PV installations. (This database will be released to members following validation of

the information; validation is scheduled for completion in early 1995).

As part of its Photovoltaic Power System Programme, the International Energy Agency (IEA) has requested that its member nations conduct a baseline survey of photovoltaic systems installed in each member country. The initial survey—covering systems installed up to 1993—will be used as the baseline survey to measure progress in subsequent years. For the baseline survey, Mr. Charles Linderman of the Edison Electric Institute is coordinating the collection of data for the United States. The Utility PhotoVoltaic Group is responding to a request for a summary of information from the UPVG databases and other sources to help a number of organizations supplying information for the survey to obtain the national information needed for the IEA survey.

The next meeting of the IEA will be held in Sun Valley, Idaho, in September, 1995. The IEA is hoping this beautiful setting will result in a productive and informative session in the efforts toward building an international photovoltaic market. ■

Appendix D. UPGV Officer & Staff Lists

1. UPGV Board of Directors

R. L. Bellenger
Director, Technology Management
Alabama Power Company

Gary S. Brinkworth
Superintendent, System Planning
Tallahassee (Florida) Electric
Department

Larry A. Crowley
Senior Manager, Strategic Planning
Idaho Power Company

Laura Doll
Chief Administrative Officer
Austin (Texas) Electric Department

Thomas A. Foreman
Manager, Electric Planning and
Regulatory
Lower Colorado River Authority (Texas)

Tony Fung
Director of Technology
UtiliCorp United (Missouri)

Wayne R. Gould
Manager, Dispersed Energy Solutions
Southern California Edison Company

Gary Jurkin
Demand Side Programs Manager
Arizona Electric Power Cooperative, Inc.

Albert F. Kirby, III
Manager, ME&S
Delmarva Power and Light Company
(Delaware)

Charles Linderman
Director, Fossil Fuels & Renewable
Energy Program
Edison Electric Institute

William Muston
Manager, Research and Development
Texas Utilities Electric Company (TU
Electric)

Victoria L. Ponce
Assistant to the Administrator for
Conservation, Environment, and Safety
Western Area Power Administration
(Colorado)

Mark D. Rogers
Senior Research Engineer
Northern States Power Company
(Minnesota)

Rolland Skinner
General Manager
Northwest Rural Public Power District
(Nebraska)

Andrew M. Vesey
Vice President, Power Delivery
Niagara Mohawk Power Corporation
(New York)

2. TEAM-UP Advisory Committee

Brent Atkins
Atlantic Solar Products (Maryland)

Allen M. Barnett
President
AstroPower, Inc. (Delaware)

Anthony Catalano
Photovoltaics Division
National Renewable Energy Laboratory
(Colorado)

Michael DeAngelis
Assistant Deputy Director
California Energy Commission

Edgar DeMeo
Manager, Solar Power Program
Electric Power Research Institute
(EPRI)

Roger Hill
Design Assistance Center, PV System
Applications
Sandia National Laboratories

Charles Linderman
Director, Fossil Fuels & Renewable
Energy Program
Edison Electric Institute

Hans Meyer
Omnion Power Engineering Corporation
(Wisconsin)

Jerrold Oppenheim
Director
Renewable Energy Technology Analysis
(Massachusetts)

Joan G. Peterson
Special Assistant Attorney
Minnesota Attorney General's Office

Rick Sellers
Deputy Director
Solar Energy Industries Association

Jeffrey A. Serfass
Executive Director
Utility PhotoVoltaic Group

William A. Spratley
President
Photovoltaic Education Project (Ohio)

Michael Stern
Utility Power Group (California)

Andrew M. Vesey
Vice President, Power Delivery
Niagara Mohawk Power Corporation
(New York)

Jane M. Weissman
Director
Photovoltaics for Utilities [PV4U]
(Massachusetts)

3. Commercialization Strategies & Markets Work Group

Robert S. Allan
Principal Engineer
Florida Power & Light Company

Patsy Baynard
Director, Research and Development
Florida Power Corporation

Thomas J. Bradish
Manager, Research & Development
GPU Service Corporation
(Pennsylvania)

Larry A. Crowley
Senior Manager, Strategic Planning
Idaho Power Company

Jeffrey L. DeLaune
R&D Consultant, Marketing
Department
Wisconsin Public Service Corporation

David H. Devendorf
Director, Research and Development
Niagara Mohawk Power Corporation
(New York)

Chuck Foster
Potomac Electric Power Company

J. B. Headrick
Program Manager, R&D
Texas Utilities Electric Company (TU
Electric)

Byford E. Hoffman
Manager, R&D
Salt River Project (Arizona)

Peter Jansson
Manager, Strategic Customer Support
Atlantic City (New Jersey) Electric
Company

Bradley W. Johnson
Manager, Corporate Planning
Potomac Electric Power Company

Curt Kaminer
Planner
Arizona Public Service Company

Charles Linderman
Director, Fossil Fuels & Renewable
Energy Program
Edison Electric Institute

Donald E. Osborn
Senior Project Manager, Solar Program
Sacramento (California) Municipal
Utility District

Ernie Palomino
Principal Research Engineer
Salt River Project (Arizona)

Norman J. Stevens
Principal Engineer
Detroit (Michigan) Edison Company

Andrew M. Vesey
Vice President, Power Delivery
Niagara Mohawk Power Corporation
(New York)

Chuck Ward
Power Quality Engineer
Oglethorpe Power Corporation
(Georgia)

Brian Wenning
Program Manager, R&D
Texas Utilities Electric Company (TU
Electric)

4. Engineering & Specifications Work Group

Dave Collier
Sacramento (California) Municipal
Utility District

Frank Goodman, Jr.
Manager, PV Technology
Electric Power Research Institute

John E. Hoffner
Program Manager, Alternative Energy
Austin (Texas) Electric Department

Charles H. Huling
Assistant to the Executive Vice
President
Georgia Power Company

Randall Kyle
Senior Engineer
Southern Company Services, Inc.
(Alabama)

Leslie Libby
Engineer
Austin (Texas) Electric Department

Monique I. Martinez
Public Service Company of New Mexico

Brian A. Mastro
Engineer, Electric System
Potomac Electric Power Company

Gary N. Miller
Manager, Fossil Fuels & Renewable
Programs
Edison Electric Institute

Art J. Peterson, Jr.
Sr. Research Specialist
Niagara Mohawk Power Corporation
(New York)

Edan Prabhu
Manager of Projects Research
Southern California Edison Company

Ernie Palomino
Principal Research Engineer
Salt River Project (Arizona)

Clark Reed
Senior Electrical Engineer
Texas Utilities Electric Company (TU
Electric)

Waheed Sayed
New York Power Authority

John W. Stevens
Photovoltaics Division
Sandia National Laboratories

Roger Taylor
Solar Energy Research Facility
National Renewable Energy Laboratory
(Colorado)

Chuck Ward
Power Quality Engineer
Oglethorpe Power Corporation
(Georgia)

John Wennstrom
Solar Engineer
Idaho Power Company

5. Planning & Evaluation Work Group

Bud Beebe
Licensing & Regulatory Affairs
Coordinator
Sacramento (California) Municipal
Utility District

R. L. Bellenger
Director, Technology Management
Alabama Power Company

Chris Bissett
Manager, Production
Central and South West Services, Inc.
(Texas)

David Byrne
Systems Planning
Tallahassee (Florida) Electric
Department

Michael V. Carter
R&D Engineer
Duke Power Company, Inc. (North
Carolina)

Eric Dominguez
Engineer
Nevada Power Company

Larry Eng
Transmission Planning
Niagara Mohawk Power Corporation
(New York)

William D. Ferguson
Research Projects Coordinator
Delmarva Power and Light Company
(Delaware)

Dieter J. Franz
Southern California Edison Company
(California)

Greg Langan
Sacramento (California) Municipal
Utility District

Robert L. Mauro
Technical Consultant
Utility PhotoVoltaic Group

Kirk McAllister
Planning Department
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Joseph Oates
Senior Engineer, General Planning
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Kenneth Price
Resource Analysis Supervisor
Texas Utilities Electric Company (TU
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Paul Smith
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Assistant Engineer, Distribution
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6. Technology Transfer & Member Development Work Group

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Kent Johnson
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Debbie Lewis
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Bethany Wills
Project Coordinator
Utility PhotoVoltaic Group

Larry Wittrup
Principal Advanced Tech. Engineer
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7. List of UPVG Staff

Jeffrey A. Serfass
General Manager

Bethany N. Wills
Coordinator

John E. Bigger
Technical Director

Stephen L. Hester
Consultant

Christian Arellano
Program Support

Carlos Boesch-Catão
Membership & Records Assistant

Support Staff

Jacquelyn A. Cochran
Director of Publications

Tina Merkle
Finance Manager

Seth Kalish
Graphics Specialist

Angela Barbara
Meeting Planner & Exhibitions
Coordinator

Christine DeShields
Operations Assistant

8. Staff Biographies

a. John Bigger, Technical Director

Mr. Bigger joined the UPVG in July, 1994. On loan from the Electric Power Research Institute, Mr. Bigger brings added expertise to the UPVG in the areas of PV and electric utility industries. At EPRI, Mr. Bigger was Manager of Photovoltaic Systems Applications for its Solar Program.

Mr. Bigger had been with EPRI for 17 years and managed programs and projects in the solar thermal, geothermal, hydro, and photovoltaic areas; he also was responsible for demonstration and integration of PV projects for the more than 700 utility members of EPRI. Previously, Mr. Bigger was employed for 10 years by the Los Angeles (Calif.) Department of Water and Power.

Mr. Bigger holds Bachelor and Master of Science degrees in Electrical Engineering and has completed additional studies in business and engineering economics.

b. Stephen L. Hester, Consultant

Mr. Hester has 16 years experience with utility photovoltaics. He became a staff consultant to the UPVG in 1994. Prior to working with the UPVG, he was with Pacific Gas and Electric Company's R&D Department with several positions, including PV Program Manager and Project Manager for PVUSA. In addition, he was Principal Investigator for many PG&E and Electric Power Research Institute (EPRI) photovoltaic research projects and studies.

Mr. Hester provides technical and analytical support to the UPVG; he is the staff liaison for the Engineering and Demonstrations [now Engineering and Specifications] Work Group. Mr. Hester holds a Bachelor's of Science in Electrical Engineering from the University of Colorado and is a Registered Electrical Engineer in California. He is based in Martinez, California.

**c. Jeffrey A. Serfass,
General Manager**

Technology Transition Corporation (TTC) was organized in 1986 by Jeffrey A. Serfass, President. He also is the founding Executive Director of the Utility PhotoVoltaic Group. Mr. Serfass has been engaged in U.S. and international fuel cell commercialization and market development efforts since 1982 and was the executive director of the Fuel Cell Users Group of the Electric Utility Industry, Inc. He is the founding President of the National Hydrogen Association, an organization with wide-ranging industrial and university interests in hydrogen production, storage, and utilization. He is the founding Executive Director of the Fuel Cell Commercialization Group, a consortium of potential buyers of a specific manufacturer's fuel cell power plants. In addition, he is the founding Executive Director of the Utility Biomass Energy Commercialization Group.

Mr. Serfass has experience in the manufacturer, customer, and government roles in commercialization strategies, particularly as they relate to the electric utility industry. Previous accomplishments have included market research and strategic planning for Westinghouse Electric Corporation and the management of U.S. Department of Energy programs in research and state

utility regulation. He holds a Master of Electrical Engineering degree from Cornell University.

**d. Bethany N. Wills,
Coordinator**

Ms. Wills joined TTC as coordinator of the UPVG in 1992. She brings experience in project management of various recycling programs for the State of Maryland, as well as experience in database management and state legislative initiatives.

Ms. Wills obtained her B.S. from Salisbury State University, where she studied Business Management and Communication Arts. She currently is pursuing an M.S. degree in Environmental Studies at Johns Hopkins University.

**e. Christian Arellano,
Research Assistant**

Mr. Arellano joined the TTC team in June of 1994. After five years as a research assistant for the U.S. Army Corps of Engineers, Mr. Arellano worked as an aide in the Gypsy Moth program for the State of Virginia Department of Agriculture. He has a B.A. in International Studies from George Mason University. Originally from Spain, Mr. Arellano provides research and other program support to the UPVG.

**f. Carlos Boesch-Catão,
Membership & Records
Assistant**

A native of Brazil, Mr. Boesch-Catão came to TTC full-time in May, 1994. He is the UPVG's Membership and Records Assistant.

Appendix E. List of Phase 3 Tasks

This Appendix sets out those activities to be undertaken by the Utility PhotoVoltaic Group for the implementation of *TEAM-UP*, a 50-MW hardware initiative, and building commercialization strategies for photovoltaic systems in the electric utility industry. The objective of the joint effort between the U.S. Department of Energy and the UPVG, as identified by Congress, is the establishment of an accelerated market for photovoltaic system suppliers that encourages investments in manufacturing, leading to a reduction in PV unit costs through economies of scale and creating broader market potential. The UPVG's organization and program will develop credible technical and educational information for utilities, assist utility purchases through market buyer teams, encourage a greater array of potential system applications, and provide a foundation for *TEAM-UP*.

The UPVG's Phase 3 program includes five tasks defined by goals, objectives, approaches, and deliverables. Tasks are managed by individual utility-member Work Groups, the Executive Committee of the Board, and the Board of Directors. Each of the Work Groups is chaired by a utility UPVG member and the chairpeople serve as the Steering Committee to the Board. An Advisory Committee—with representatives from a broad segment of the PV community and related interest groups—provide guidance. The five tasks are: (1) technology transfer, (2) market conditioning, (3) small-scale application program implementation, (4) grid-connected application program implementation, and (5) management and administration.

TASK 1: Technology Transfer Activities

Task 1 focuses on UPVG member briefings, technology transfer, workshops, meeting presentations, and exhibits through ten subtasks.

1.1 Promote Membership in the UPVG

This subtask consists of implementation of a three-part program to promote membership in UPVG and to reach a goal of 100 members. The program includes: (1) targeted correspondence and communication via telephone and mass mailings; (2) presentations at solar events with utility representatives in attendance; and (3) exhibitions at utility-oriented trade shows. The subtask will include six (6) meeting presentations and three (3) trade show exhibits. The UPVG will develop a transportable exhibit booth and accessories to include a slide show (subtask 1.4), exhibit displays, and hands-on tools and materials.

1.2 Maintain & Update the UPVG Information Package

A goal of this subtask is to provide information about UPVG to interested individuals and organizations. The UPVG forwards information on the program upon request. The information package will consist of four (4) utility-targeted fact sheets, three (3) issues of the *PV Vision* newsletter, and various press releases and trade articles. The fact sheets may include updates to the UPVG program brochure and grid-connected and small-scale application pro-

gram projects. Press releases will focus on UPVG programs such as meeting membership goals, *TEAM-UP* program announcements, and new UPVG initiatives. Four trade articles may focus on the electric utility industry, solar energy, and other renewable energy initiatives.

1.3 1996 Annual Meeting

The subtask includes holding one meeting for the general membership which includes Board of Directors elections, Treasurer's and UPVG program updates, as well as exhibits. Participants may include utility representatives, suppliers, regulators, consumer advocates, etc., with attendance anticipated to be approximately 200.

1.4 UPVG Multimedia Materials

A slide library will be maintained to update members and interested parties on the UPVG program; an executable presentation with layered and moving slides for use at trade shows and by members and interested parties also will be developed. A contract will be awarded for the production of a video on the key points of the *TEAM-UP* program and UPVG's previous results and accomplishments. A PV Education Kit will be developed to assist UPVG members in demonstrating how PV systems operate.

1.5 Member Briefings

UPVG staff will participate in ten (10) briefings to utility executives.

1.6 Summary & Membership Reports

This subtask includes: (1) maintenance and update of UPVG's member-

ship directory; (2) technical report on the *TEAM-UP* and UPVG programs; (3) an annual financial and project report for the Utility PhotoVoltaic Group; (4) development of periodic reports on market applications and potentials from the *TEAM-UP* program; and (5) issuance of quarterly updates to UPVG members addressing program developments, meeting notices, etc.

1.7 Update & Verify Experience Data Base

This subtask will update and verify the Engineering & Specifications Work Group's Utility PV Systems Experience database by reviewing the previous published report and incorporating new information and experiences from the utility applications.

1.8 Liaison & Coordination with External Organizations

This subtask will emphasize direct communication and coordination with external organizations, including participation and travel to four (4) meetings of the PV-COMPACT Coordinating Council for the broad commercialization effort of PV-COMPACT. The subtask continues to emphasize communication and coordination to facilitate PV purchase commitments by utilities.

1.9 Policy-Making Issues

This subtask includes periodic briefings to policymakers within the U.S. Department of Energy, the U.S. Environmental Protection Agency, and other agencies regarding the UPVG and the *TEAM-UP* program.

1.10 Technology Transfer Activities for the TEAM- UP Program

A briefing will be held for teams unsuccessful during the first Request for Proposals for grid-connected projects, including information to assist in becoming successful in future RFPs. The UPVG also will provide information to proposers about other programs, departments, or grants which may be available.

TASK 2: Market Conditioning Activities

Task 2 has ten subtasks for the evaluation of alternative commercialization strategies. Task 2 will focus on nontraditional benefits of PV systems for electric utilities, engineering and specification issues of concern to utilities, and includes finalization and implementation of the PVSCREEN software. The following is a list of activities to included as part of Task 2.

2.1 Evaluation of Financial & Ownership Options

Different PV system financing and ownership options will be evaluated, considering costs of capital, risk, and possible regulatory acceptability.

2.2 Customer Acceptance & Utility Acceptance Factors & Markets

This subtask would continue to collect information from market surveys, as well as conduct quantitative refinement for both small-scale and grid-connected markets. A report that updates utility issues such as "externalities," re-

tail wheeling, reliability, and total fuel cycle costs will be generated.

2.3 Validations of Nontraditional Benefits

The UPVG will continue to evaluate the benefits of PV installed by utilities and produce a summary for emission reductions that may be used by regulatory organizations for policy-making and evaluation of emission standards.

2.4 Liaison with Third Party Activities for Market Conditioning

Liaisons will be maintained with the Electric Power Research Institute, the National Renewable Energy Laboratory, Pace University, and others that have ongoing projects aimed at valuing distributed generation, solar resource data collection, PV benefits, and completion and updating of situation matrices. As part of the subtask, participation in two (2) meetings on value analysis are planned.

2.5 Enhance PVSCREEN

This subtask includes enhancing PVSCREEN software program and increasing its availability to proposers of grid-connected projects for use in evaluating costs and benefits of proposed projects.

2.6 Utility Issues

This subtask will include action in five (5) areas: (1) standardized interconnection guidelines, (2) purchase and implementation issues, (3) assemble information for small-scale applications, (4) technical performance guidelines and requirements, and (5) finalization of engineering specifications for new applications.

"Standardized interconnection guidelines" will include identification of common UPVG guidelines for utility interconnection practices and policies for utility connection of PV systems. "Purchase and implementation issues" will be considered including financing/leasing options, customer costs, insurance, liability, and legal issues. "Assemble information for small-scale applications" will collect information on the application including price, performance, packaging, infrastructure, and markets. The UPVG will assist the small-scale teams in identifying and defining system performance; cost and reliability issues; warranty, customer interaction, and support issues; and system integration and packaging requirements. Working with the Engineering & Specifications Work Group, the UPVG will help determine the specifications and requirements which may be requested of grid-independent systems and determine any followthrough requirements in this area.

2.7 UPVG Standards Issues

Standard UPVG issues include reporting formats and guidelines and standardized contracts. Standard reporting formats and guidelines will be finalized and reviewed with selected proposers. To minimize contract negotiations and ensure common reporting and technology transfer requirements, the standard contract will be finalized for use in all grid-connected project awards.

2.8 Incorporate Phase 2 Findings into Phase 3 & the TEAM-UP Program

UPVG Work Group activities regarding market opportunities, engineering and specification issues, and commercialization strategies will be incorporated into the program.

2.9 Market Conditioning Workshops

Market conditioning workshops may include two types: (1) commercial activity and (2) markets and strategies. The UPVG will sponsor a commercial activity workshop on topics such as financial planning, internal networks, customer marketing, and PV system ownership issues. The UPVG plans three (3) joint utility/PV supplier workshops to explore alternative markets and commercialization opportunities with assistance from the Solar Energy Industries Association. The goal of these workshops is to find common ground between potential utility purchasers and PV vendors, assisted by outside experts and stakeholders, as appropriate. A summary of the workshops is planned.

2.10 Critical Evaluation of Alternative Commercialization Strategies

The subtask includes generating a report that documents and compares alternative commercialization strategies from various perspectives such as utility, PV vendor, consumer, regulatory, and governmental.

TASK 3: Small-Scale Program Implementation

This task provides for the continued implementation of two (2) small-scale application initiatives and the initiation of an additional four (4) to six (6) applications during Phase 3. The overall goal of the task will be formation of market buyer team(s) for six to eight small-scale applications and the beginning purchases of systems under the teams leading the livestock water pumping

and the remote residential applications. Attention will focus on promoting development of standardized packages that meet utility standards and assist and encourage the wide array of PV equipment and service suppliers in developing market infrastructure to facilitate utility purchases of small-scale PV.

3.1 Notice of Selection & Negotiation

The UPVG has a goal of implementing six to eight small-scale applications. This subtask includes meeting and negotiating with teams for the successful completion of the application and a project schedule.

3.2 Support of Team & Program

This subtask includes assisting team members in the promotion of the application and enlistment of additional team members. Project structuring may include data monitoring requirements, team member responsibilities, and/or development of business and marketing plans. UPVG support will be in the form of technical, managerial, and financial assistance.

3.3 Data Collection & Project Monitoring

For each application, all projects installed by team members will be documented, including location, size, manufacturing information, etc. A photograph of each installation with required information will be provided by team members and maintained by the UPVG to document projects. In addition, selected project information will be analyzed and shared with the UPVG's technical Work Groups.

TASK 4: Grid-Connected Program Implementation

The goal of Task 4 is to identify projects and competitively award cost-shared contracts to achieve a balanced cost reduction in the PV system, including modules, balance of system, packaging, and standardization for grid-connected PV systems. In addition, the UPVG will encourage development of supplier capability to provide turnkey PV systems that meet utility standards and promote partnership among suppliers, utility purchasers, state energy offices, consumers, and others. Subtasks and a brief overview of key activities follow.

4.1 Review of *TEAM-UP* Proposals

In-depth, critical reviews of the proposals under the guidance of the UPVG's technical Work Groups will be performed to refine technical specifications and assessment of commercialization approaches and markets. Refinement of the specifications for subsequent solicitations will be a part of the subtask, which may include a questionnaire and workshop to solicit comments and suggestions from parties involved in the *TEAM-UP* program. Commercialization approaches and markets proposed in the first RFP (94.8) will be documented. Expertise may be solicited to support the UPVG Work Groups in the completion of the activities.

4.2 Project Management

Management of the grid-connected program implementation includes project reviews, both technical and financial, as well as project monitoring. This will encompass the coordination

and administration of reviews for individual projects, preparing advance materials, arranging project updates, and documenting review comments. To ensure the technical success of the program and the financial stewardship of DOE funds, the UPVG will perform record keeping and reporting functions, including technical monitoring and information transfer to the DOE, as required. The UPVG shall collect and analyze information from the selected projects and installations and share results with the UPVG's technical Work Groups.

4.3 Coordination with Advisory & Evaluation Committees

Through periodic meetings, the *TEAM-UP* Advisory and Evaluation Committees will provide feedback and recommendations for the program. The UPVG shall perform coordination, liaison, and staffing requirements for both Committees, including preparation of workbooks, meeting preparations, proposal packaging, etc., in support of the grid-connected program.

4.4 Awards

This subtask includes contract negotiation and formal contract award for selected proposals under the first RFP (94.8).

4.5 Develop, Publicize, & Release 1995 Request for Proposals

Based on input from the UPVG's technical Work Groups and experience gained during the first *TEAM-UP* solicitation, the subtask includes refining and issuing the second Request for Proposals (1995).

4.6 Evaluate Proposals & Negotiate Awards for 1995 Request for Proposals

Proposals received in response to the 1995 grid-connected RFP will be evaluated by an independent Evaluation Committee with project selection recommendations provided to the *TEAM-UP* Director for selections. The UPVG Board of Directors and the U.S. Department of Energy will verify that the procedures in the selection process were just and fair and authorize the notice of intent to award. Following the notices of intent to award and contract negotiation, the selected proposers will be awarded a cost-shared contract with the UPVG.

TASK 5: Management & Administration

This task supports corporation business matters, membership records, financial administration, and duties and other activities of the Board of Directors and Officers.

5.1 Board of Directors Management

This subtask includes staff time and travel for UPVG Board meetings, documentation through meeting minutes, and preparation of Board notebooks for each meeting. UPVG business between Board meetings will be handled through Executive Committee conference calls. Executive Committee conference activities will include staff notices about teleconferences, staff participation in the meetings, and documentation of the meeting minutes.

5.2 DOE Program Administration & Program Evaluation

Monitoring of the DOE program requirements and evaluating and reporting key results from the program is covered under this subtask.

5.3 Management Activities

This UPVG management subtask includes bookkeeping, accounting, and invoicing, as required by the U.S. Department of Energy and the UPVG's Board of Directors, and provides for standard maintenance of UPVG membership records and invoicing for membership dues. Additionally, support for the development of policy papers for Board consideration which might address proprietary information, policies for membership, or procedures for public release of reports are included.