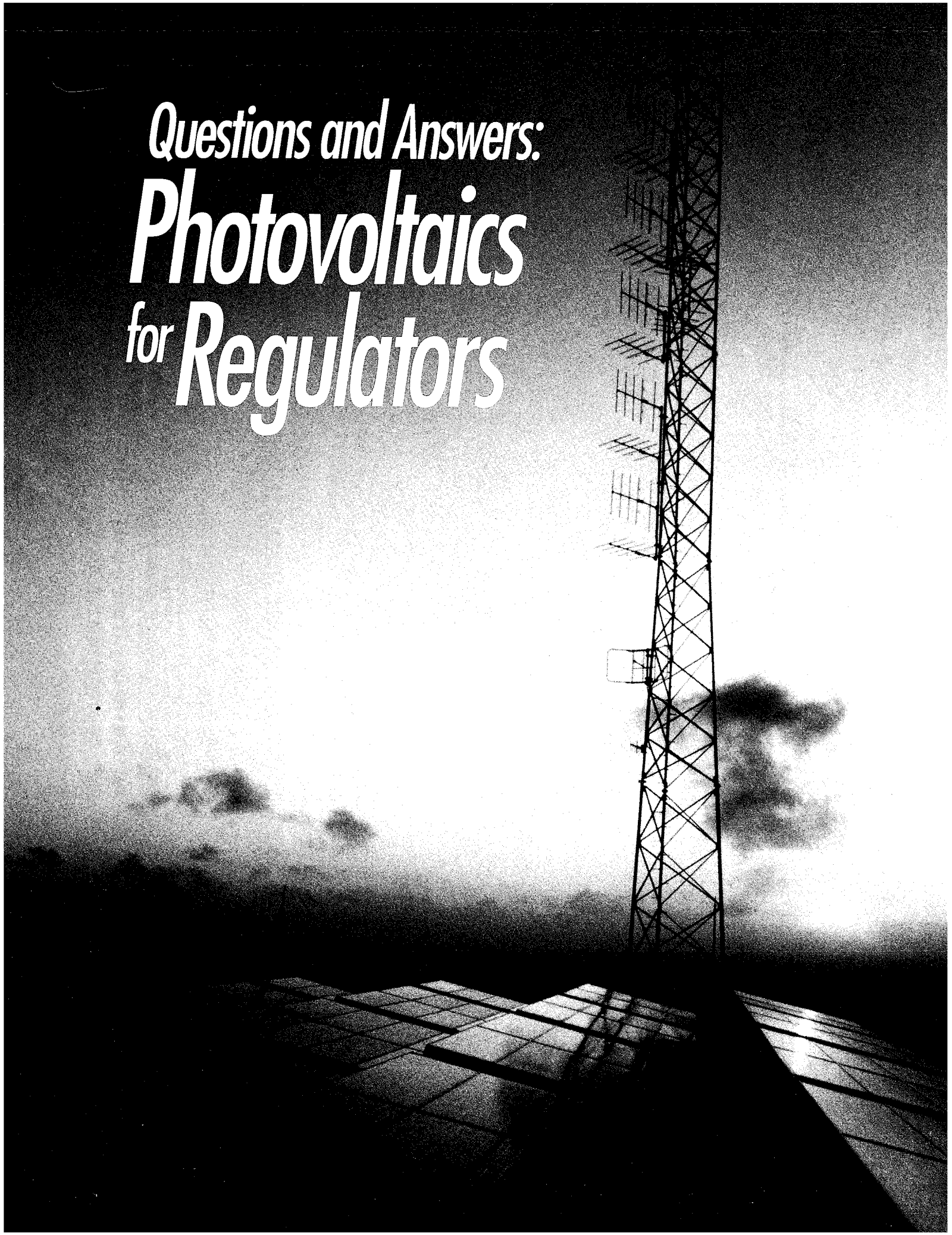
Questions and Answers: Photovoltaics for Regulators



Cover photo courtesy of Siemens Solar Industries
Located atop Tafelberg, the highest hill in eastern Curacao, is Radio Hoyer's FM transmitting tower. According to Fred Chumaceiro, technical director of Industrial Electronics, who designed and installed the station: "The site was perfect–except for the lack of electricity. From the many options available to obtain electricity, the need for high reliability sparked the decision to go with solar power." The PV array contains 128 modules that charge a 24-volt battery bank with 72-hour reserve capacity. This allows operation at night and during periods of insufficient sunshine. The two 300-watt FM transmitters and associated equipment operate directly from the 24-volt DC supply.

Questions and Answers: Photovoltaics for Regulators

Why should regulators be concerned about PV?

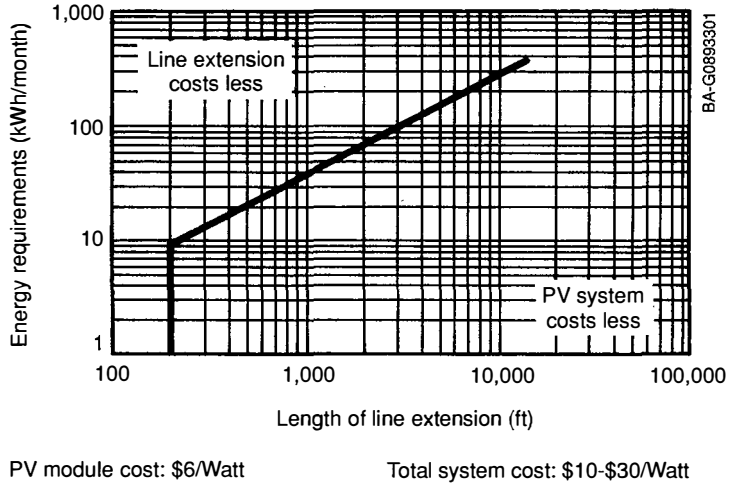
Photovoltaic (PV) energy is currently the most cost-effective energy available, in an increasing number of situations, to both utilities and their customers. PV is currently more cost effective than conventional alternatives in several dozens of applications within electric, gas, and communications utilities. If PV is not being used in these cost-effective applications, then utility costs are higher than necessary.

PV-generated power is often less expensive than new grid-supplied power in applications where facilities are remote and loads are small or difficult to serve with conventional technology. When a PV option is not included in evaluations of power supply alternatives for these remote applications, utility ratepayers may be paying too much.

As PV conversion efficiencies continue to improve and the cost of PV power continues to drop, even more PV applications will become cost effective. It is important that utility regulators understand the state of development of new technologies (including PV). As this happens, utilities will increasingly want to become involved in new technology demonstrations and install new technology systems during their early commercial stages. To achieve the understanding that will be critical to future cost-effective applications, utilities and their regulators must begin to work with PV systems now, in today's applications.

What do PV systems cost?

With currently cost-effective applications, we must focus initially on PV system costs compared to those of conventional approaches. It is very important to accurately understand the utilities' costs for conventional approaches before comparing them to PV system costs. For example, installing power poles or underground power cables can cost tens of thousands of dollars per mile.



PV module cost: $6/Watt

Total system cost: $10-$30/Watt

Work performed for the Electric Power Research Institute is providing insight into the cost effectiveness of PV versus line extensions.

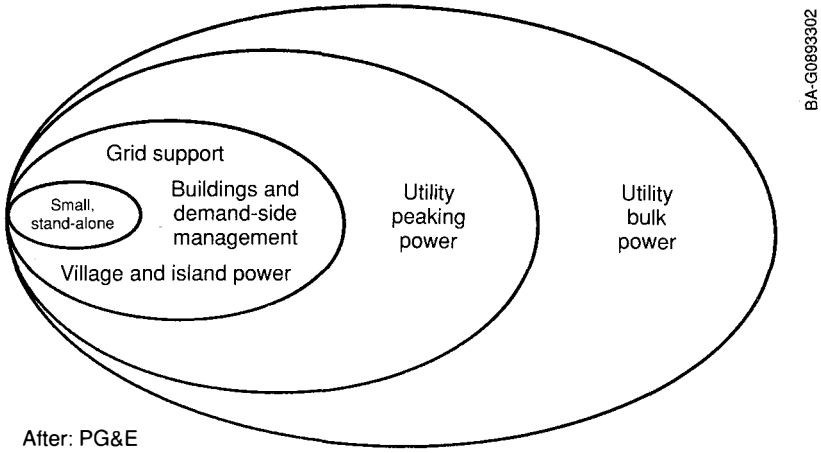
Keeping this in mind, a few hundred or even several thousands of dollars invested in a stand-alone PV system can be a cost-effective alternative, particularly where the load to be served is small. Other costs, such as those associated with cutting and repairing street surfaces and installing transformers, can also be avoided with PV systems–even in applications that are not remote from the electric grid. So, while electric power from current PV technology costs about 25-30 cents per kilowatt hour, the effective energy cost by itself is not an appropriate measure of cost effectiveness.

What is the trend in PV system costs?

PV costs are dropping. According to the U.S. Department of Energy's 1992 *Solar 2000* plan, PV module costs are now 1/100 of those in 1972, dropping from $500 per watt to about $5 per watt in 1990. PV electricity prices, measured in cents per kilowatt-hour, have dropped to 1/20 of 1972 prices. Total system installed costs for small, cost-effective systems range from $10 per watt (for PV/ battery systems serving DC loads) to $30 per watt (for PV modules mounted on trackers with battery storage and inverters to serve AC loads). However, even at these prices, there are applications where PV systems are more cost effective than conventional approaches.

Distributed, on-grid PV systems for consumer demand-side management and local distribution system support are likely to become cost effective within the next decade. And, about 2000, PV systems for centralized peaking power generation could become cost effective. By 2010, PV systems for bulk power generation are expected to begin entering the commercial utility market.

Because of the increasing market for PV modules around the world, and because new manufacturing facilities have not yet been completed, recent prices for PV modules have leveled off. Most module manufacturers are now working at or near capacity and have backlogs of orders. As a result, module prices are being market driven. Still, it is important to further increase demand to help ensure the installation of new, larger production facilities and show the PV industry that the utility market is significant.



As costs continue to decline, new markets will open up and old markets will become even more cost effective.

How reliable are PV systems?

PV power systems are composed of solid-state electronic components with no moving parts, an inherently reliable configuration. The systems were originally developed and applied to space applications (a continuing market) where reliable power is critical because repair is impossible. Today's cost-effective terrestrial systems are exhibiting lifetimes of about 20 years.

A number of organizations and industries represent specific markets that have used and reported on PV-powered system reliability over a number of years:

- The U.S. Coast Guard has more than 10,000 PV-powered navigation aids in operation throughout the United States. Many of these systems see very harsh environments and continue to operate reliably.

- The telecommunications industry has been installing PV systems for well over 10 years and continues to install and operate systems today, even in very harsh environments around the world.

- The Southwest Technology Development Institute in Las Cruces, New Mexico, has been measuring the performance of PV installations throughout the United States for a number of years. The generally positive details of these investigations are available in reports published by Sandia National Laboratories (Sandia) and the Electric Power Research Institute (EPRI).

- A few electric-utility-owned, PV-powered installations have been operating reliably for more than 10 years. A PV power supply system was installed by Public Service Co. of New Hampshire on one of its microwave relay stations in 1979. Although the old modules were recently replaced in a company upgrade, the old modules had operated satisfactorily for 12 years.

A recent EPRI publication, *Bringing Solar Electricity to Earth*, states

"The bottom line: **photovoltaics, the technology for converting sunlight directly into electricity, is here.** PV markets are expanding worldwide, and PV technologies are making steady progress toward serving electric utility bulk power needs. Some utilities have already seized the opportunity to use PV in situations where it is **more cost effective to use solar-generated electricity than it is to string a wire**." (emphasis added)

Are cost-effective PV systems viable throughout the United States?

Yes. Where cloudy weather cuts down the amount of sunlight, the economics of currently cost-effective PV systems change, but only slightly. The annual mean sunlight reaching the ground each day is about 5.3 kilowatt-hours per square meter. Cloud cover over the United States causes this daily average to vary from about 3.3 to 6.7 kilowatt-hours per square meter.

PV systems can be used cost-effectively in many applications in every state, including Alaska. A review of literature, papers, and reports from Sandia, EPRI, the National Renewable Energy Laboratory (NREL), the Institute of Electrical and Electronics Engineers (IEEE), and the Solar Energy Industries Association (SEIA) reveals that PV systems are indeed located in all 50 states. These include government-supported demonstrations as well as systems installed by utilities, the military, and consumers. Electric utilities in more than 20 states have cost-effective applications operating today. With the range of costs incurred for

serving small loads by conventional approaches (including distribution lines or step-down transformers), cost-effective PV applications will be found by utilities in every state.

What are currently cost-effective uses of PV systems?

EPRI has identified more than 60 different applications, for both utilities and their customers, that are potentially cost effective. The studies uncovered cost-effective applications in every major area of electric utility operations. The following table lists utility uses of PV according to category.

Transmission and Distribution: • Tower obstruction beacons • Sectionalizing switches • Cathodic protection	**Environmental Monitoring:** • Remote weather stations • Water quality monitors • River level gauges • Water temperature monitors • Cloud seeding • Insolation monitors	**Communications:** • Microwave repeaters • Remote metering • Emergency call boxes
Power Plants and Facilities: • Plant warning sirens • Navigation aids • Backup generators • Cathodic protection • Automatic gate openers • Lighting	**Customer Services:** • Remote residences • Water pumping and control • Lighting	**Gas Systems:** • Flow meters and computers • Valve actuators • Cathodic protection • SCADA remote terminals

A recent Pacific Gas and Electric (PG&E) report shows that gas-flow computers, water-level sensors, and automated gas meters make up 84% of PG&E's estimated 1100 PV systems at the end of 1991.

How much PV is in use within utilities?

Today, more than 35 electric utilities in 20 states have cost-effective PV systems installed and operating. Many have more than one system; the list below identifies a few of the utilities with multiple systems:

PG&E, California	1100+
Florida Power Corp.	90+
Salt River Project, Arizona	80+
Public Service of Colorado	19
Arizona Electric Power Cooperative	11
U.S. Bureau of Reclamation	10+

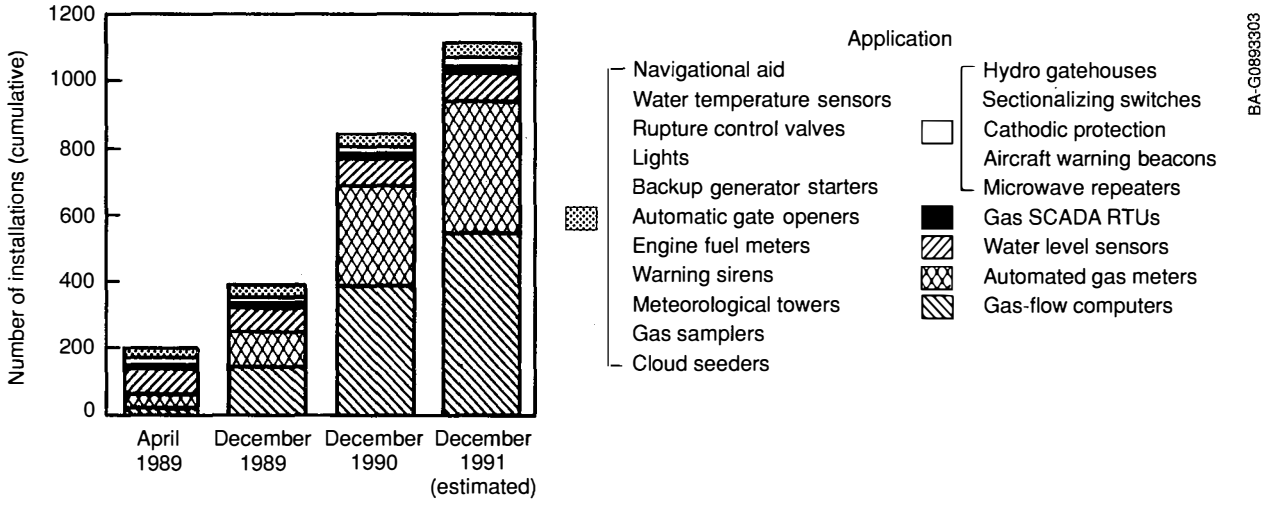
What are some consumer examples of PV systems in use?

Many consumers have opportunities to use PV systems in applications similar to those mentioned for utilities, and additional opportunities exist for some consumers.

An example exists on Colorado's eastern plains. In cooperation with the Western Area Power Administration and the NEOS Corporation, a rural electric cooperative (K.C. Electric) has successfully used a PV system for powering stock-watering pumps. Many of these loads are very expensive to serve because they are small, remote, and subject to high maintenance costs (snow and ice storms damage power distribution lines). In fact, annual maintenance costs often exceed the revenues generated. Since the successful demonstration, local

distributors of PV systems have reported that the Colorado market for PV-powered stock watering increased dramatically during the summer of 1991.

In the United States today, there are more than 500 PV-powered water pumping systems installed and operating. In a recent EPRI-funded study, NEOS Corporation surveyed the owners of more than 250 systems to obtain information on reliability, performance, and cost. These systems have been purchased and installed by ranchers, farmers, homeowners, companies, and various government agencies. The first systems were installed in the late 1970s.



Pacific Gas and Electric shows rapid growth in cost-effective PV system installations.

Many remote residential consumers now use stand-alone systems. PG&E surveyed residential PV users in California and found that about 3500 such systems existed at the end of 1989. PG&E estimates the stand-alone residential PV market to be growing at about 30% per year.

In the not-too-distant future, utilities or their commercial customers on time-of-day rates might consider PV systems as part of a demand control program to meet part of the summer peak load. This is only logical, because PV systems produce power when the sun is heating buildings and contributing to building cooling requirements. So, not only does the building owner save on utility bills, but summer peaking utilities can reduce their peak loads by considering PV as a demand-side management option.

How much of a demand would be created if all currently cost-effective utility applications actually used PV systems?

The 1991 U.S. manufacturing capacity for PV modules was about 17 megawatts. EPRI's admittedly conservative estimate suggests that utility uses alone could add at least 5 megawatts of PV demand annually. So, in addition to the benefits of starting up the learning curve on PV systems and cutting current costs in cases where PV is the technology of economic choice, the added demand for PV can help support the development of an expanding market. As consumer and utility uses of PV systems begin to proliferate, costs will continue to decline through a combination of competition and investment in new, more efficient, and larger manufacturing facilities. A 30% added demand for domestic, cost-effective utility PV systems would help U.S. manufacturers expand domestic PV markets and be more competitive internationally as well.

What are the risk-reduction and environmental benefits of PV power?

University of Massachusetts finance professor Shimon Awerbuch recently analyzed the financial benefits of PV systems. The analysis addresses discount rates used in revenue requirements calculations performed to justify utility investments in new generation. It suggests that such rates should be adjusted to reflect the risks of various sources of energy. Today, small cost-effective systems are very low risk. As the technology continues to evolve, larger systems should also prove to be very low risk. This analysis approach is adopted from modern finance theory and provides reason for utility investments in PV power generation as a means to reduce risks to stockholders and ratepayers.

PV systems have the following additional benefits.

- PV power generation is environmentally benign, with zero emissions during operation.
- PV power has no fuel cost and therefore no risk of unexpected fuel cost increases.
- PV systems integrated into buildings or covering parking lots have no land requirement.
- PV power is modular, so systems can be deployed in a wide range of sizes and can be scaled up as needed. This reduces both the technical and financial risks of its use.
- PV systems have short lead times, which reduces problems of installing under-used capacity.
- PV systems have no moving parts; they are composed of solid-state electronic components and are therefore inherently reliable.
- PV power is characterized by steady reductions in cost and advances in performance, with considerable promise for further improvements.

Who supports increased utility and regulatory attention to cost-effective PV use?

Many utilities in the United States are working with EPRI on a number of projects to support utilities in (1) identifying, installing, and developing cost-effective applications; (2) training personnel in identifying these applications, including written and video educational materials; and (3) developing tools and methodologies for utility evaluations of PV systems.

Through NREL and Sandia, DOE carries out a major PV research and development program and supports state and utility PV activities by providing people to visit commissions to brief commissioners and their staffs on the technical performance, development status, and promise of PV systems.

SEIA is the PV industry's trade organization. It stands ready to bring the expertise of both manufacturing- and distribution-oriented private-sector companies to the aid of commissions interested in a broader use of PV systems.

Additionally, the Edison Electric Institute is assisting in the development of a utility PV commercialization group.

A large number of advocacy and public-interest groups also support using more renewable energy resources.

What states have rules or decisions on using PV systems?

The Colorado Public Utilities Commission recently amended its electricity extension policy rules to require regulated utilities to offer potential customers a cost comparison between PV systems and a new line extension. The potential customers first supply the utility with an estimate of their monthly energy use. If

the ratio of monthly energy use (in kilowatt-hours) to the required extension-line distance (in miles) is 1000 or less, the utility must supply the comparison free of charge. For ratios larger than 1000, the utility must notify the customer that such a comparison is available and may charge for it.

A recent Arizona Corporation Commission resource planning order encourages the use of PV systems for remote site applications, and the Vermont Public Service Board is considering amending its extension policy to encourage PV system use. Other states are indirectly encouraging PV system use by incorporating environmental externalities in resource planning decisions or by giving some preference to renewable energy technologies in supply planning or in all-source bidding schemes. Still, more states need to move directly to take advantage of currently cost-effective PV systems.

What should commissioners be asking their utilities?

Commissioners and their staffs should ask the following questions:

- How many cost-effective PV system applications are installed and operating within your utility?
- What is the real cost of serving low-power loads today at your utility? What is the cost of distribution-line extensions and step-down transformer installations?
- Have you obtained current written information on cost-effective PV system applications? ¼
- What potential applications of PV systems are there within your utility, and how were they found?
- What analysis do you perform to justify PV system use?
- Have your personnel completed any PV training?
- Are you familiar with the local manufacturers and distributors of PV systems in your service area? In your general region?
- What regulatory, economic, or technical barriers are there to using PV systems within your utility?
- Do you have a program to finance consumer PV applications?
- Have you analyzed your system regarding the use of PV systems for distribution feeder support as an alternative to feeder or substation upgrades?
- Have you considered the use of PV as a demand-side management option?

Resolution on Currently Effective Utility and Consumer Photovoltaic Applications

WHEREAS, Photovoltaic (PV) is currently cost-effective in at least several dozen different applications within electric and gas utilities when compared with conventional utility practices; and

WHEREAS, PV is cost effective in a large number of small, expensive-to-serve or remote consumer applications, and a small and growing supply and service industry exists to serve this market sector; and

WHEREAS, The 1991 U.S. manufacturing capacity for PV was about 15-18 MW. If today's total potential of identified, currently cost-effective utility and customer PV applications were to be installed, meaningful new demand for PV equipment would be added; and

WHEREAS, Added utility and customer demand for PV will further reduce manufacturing costs by allowing new demand-induced investment in new manufacturing facilities and in research and development; and

WHEREAS, PV electric power generation has many advantages. It is environmentally benign, has no fuel cost, and is modular so that systems can be deployed in a wide range of sizes and scaled up as needed, thus reducing technical and financial risks. PV has no moving parts because it is composed of solid-state electronic components and is therefore inherently reliable. PV is characterized by steady reductions in cost and advances in performance, with bright promise for further improvements; and

WHEREAS, Experience gained by utility company personnel and regulators in the use of cost-effective PV will position them to make informed decisions regarding demonstrations of the next round of cost-effective applications, including distribution and transmission applications, demand-side management options, and evaluation of the future potential for using PV as a source of larger, grid-connected peaking and bulk power generation; and

WHEREAS, The electric utility industry, through EEI and EPRI; DOE, through its Office of Solar Energy Conversion and the national laboratories (NREL and Sandia); the PV industry, through SEIA; and many consultants and academics stand ready to support state regulators and utility companies who take up the issue of currently cost-effective PV; and

WHEREAS, The 1990 NARUC report, *Renewable Energy and Utility Regulation*, stated:

> "If NARUC takes only one action on renewable energy, it ought to aim to make available current, reliable information on the cost, availability, and performance of renewable energy resources to state regulators." and

WHEREAS, To meet the goal of providing current information to regulators about PV, the NARUC Energy Conservation Committee has adopted a handbook, developed in cooperation with DOE, NREL, Sandia, EPRI, and EEI, to help regulators understand and encourage PV in currently cost-effective utility and consumer applications; and

WHEREAS, To further assist regulators who are interested in the development and use of PV, cooperative efforts among stakeholders have resulted in a consensus process, called "PV for Utilities," in which parties will work together to overcome barriers on the path from currently cost-effective PV applications to significant use of PV by utilities in the future; now, therefore, be it

RESOLVED, That the Executive Committee of the National Association of Regulatory Utility Commissioners (NARUC), convened at its Winter Meeting in Washington, D.C., declares that utility regulators should take advantage of the many opportunities to obtain information and assistance from organizations experienced with PV technology and systems: and be it further

RESOLVED, The economic and system benefits of PV's many advantages should be fully explored by utilities and state commissions in their integrated resource planning; and be it further

RESOLVED, Regulators should support utility investment in currently cost-effective PV applications and in validations of the emerging applications that will be cost-effective as PV system prices decline; and be it further

RESOLVED, Utility regulators should focus their regulatory attention on the use of PV-powered applications by inquiring of jurisdictional utilities as to the status of their current PV use and their future plans to use cost-effective PV, and regulators should strongly encourage PV to be used when cost-effective.

Sponsored by the Committees on Electricity, and Energy Conservation
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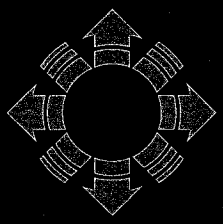

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