Program Plan for Renewable Energy Generation of Electricity

Response to Section 2111 of the Energy Policy Act of 1992

Prepared by the Office of Energy Efficiency and Renewable Energy
United States Department of Energy

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Preface

Section 2111(b) of the Energy Policy Act of 1992 (EPACT) mandates that the U.S. Department of Energy (DOE) prepare a 5-Year Program Plan to provide cost-effective options for generating electricity from renewable energy sources. In response to this mandate, the DOE Office of Energy Efficiency and Renewable Energy has prepared this plan and will be largely responsible for its implementation, chiefly through its Office of Utility Technologies.

The Program Plan provides a guiding framework for individual program annual operating and multi-year plans. The Program Plan encourages a balanced set of market-pull and technology-push approaches and thus extends beyond the classic technology research and development (R&D) setting. In particular, there is increasing reliance on strategic partnerships with industry and other sector stakeholders. The partnerships have provided effective industry access to data and information while at the same time leveraging federal dollars with those of others.

These partnerships will be further expanded and encouraged to inject more industry-driven character into the program. Such actions will also facilitate progress through specific cooperative and collaborative arrangements, covering the span from R&D to market-deployment activities.

Thus, technology-push activities now include industry collaboratives that will substantially improve renewable technology manufacturing processes. Market-pull activities include a wide range of innovative cooperative efforts such as market aggregation efforts as well as traditional financial and regulatory incentives.

We first discuss utility-sector¹ history, to set the stage for the renewable energy program mission and activities described later in the plan. With regulatory reforms leading to greater competition in the electricity generation marketplace, it is important to define a program that is responsive to the requirements of EPACT and the needs of the utility sector.

Next, we describe the current situation along with DOE's general approach to responding to that situation and relating specific technology programs to it. The situation and response are expressed in the context of overall utility-sector needs derived from the current environment, rather than just in terms of traditional bulk power generation requirements.

Subsequent sections describe the general program scope and breadth and the expected thrust of the individual renewable energy programs.

¹As used in this plan, utility sector refers to the full spectrum of utilities, customers, equipment manufacturers, and other generators and users of electricity.

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The Utility-Sector Situation

Historical Background

Electrification has been an important engine for social and economic change since the turn of the century, contributing to the nation's quality of life, economic health, and security. During the three decades from 1900 to the early 1930s, electricity emerged as a preferred form of energy, providing lighting for the majority of U.S. households and supplanting mechanical energy for most industrial uses. Electricity had such a mass appeal because of its cleanliness, efficiency of use, relatively low cost compared to other energy sources, convenience, adaptability to a broad array of functions, and increasingly widespread availability.

The electric utilities' focus on supply worked well during this period as newer facilities were built that offered greater economies of operation and thus lowered the per-unit cost of production. At the same time, inventors were boosting demand by developing new products and appliances including the refrigerator, washing machine, radio, and filament lamp.

In parallel with the electrification of the nation, renewable resources in the form of hydropower provided a large portion of the electricity supply. Beginning with small development along streams near customers in the late 1800s, hydropower grew quickly. By the 1930s hydropower provided 30% of the nation's total installed capacity and 40% of the electricity generated.

After World War II, the utilities met steadily growing demand for electricity by building large central power stations—some hydropower, but mostly thermal plants fueled by oil, coal, and nuclear—that captured economies of scale and improved efficiency. This development pattern enabled the real price of electricity to continue to decline, further stimulating demand. During the period from 1949 to

1973, demand for electricity grew at an average annual rate of 8.3%, significantly outpacing the rate of growth in the economy during the same period.

The energy price shocks of the 1970s began to change the operating environment of electric utilities. Sudden and dramatic increases in the price of fossil fuels, particularly oil and gas, caused the real price of electricity to rise substantially. The market response was an increase in energy conservation in buildings, a slump in energy-intensive industries, and a slowdown in overall economic growth. The combined impact of these actions was a dramatic reduction in the growth rate in demand for electricity. Nevertheless, electrical energy use has continued to grow faster than total energy use in recent years.

Electrical Energy Consumption as a Percent of Total Energy Consumption

As these actions took hold, the utility industry was caught up in a decades-long generation construction program focused on large coal and nuclear baseload power plants. These power plants, typically in the size range of 500 to 1000 megawatts (MW), often exceeded \$1 billion in capital costs, representing roughly a doubling or tripling of costs for capacity compared to the 1960s. Adding to the cost of constructing these plants, inflation and interest rates started to spiral upward in the 1970s, new environmental requirements emerged, and plant completion times started to increase significantly.

U.S. Generating Capacity Using Non-Hydro Renewable Resources

¹ Does not include MSW

² Existing capacity is grid-connected power only, so is largely solar thermal; most existing photovoltaic capacity is off-grid. The DOE goal for 2000 does include off-grid PV.

During this period, many state public utility commissions (PUCs) started to review the prudence of major utility construction investments. Under pressure from ratepayers to hold down the rising price of electricity, PUCs established more stringent positions on utility costs and sought to exclude billions of dollars worth of construction investment from the rate base. These actions, coupled with continuing electricity demand uncertainties, made utilities begin to question whether utility construction of new generation was in the best interest of either customers or shareholders.

With increasing awareness that pursuing traditional supply options (such as construction of large new generation facilities) was no longer the sole answer to meeting customer needs, utilities, regulators and customers began to treat electricity as a

resource to be used as efficiently and effectively as possible. The passage of the Public Utilities Regulatory Policies Act of 1978 (PURPA) specifically encouraged increased efficiency and conservation of electric energy. PURPA also encouraged innovative rate schedules such as time of day charges.

In addition, PURPA created a new class of non-utilities called Qualifying Facilities (QFs), consisting of cogenerators using fossil fuels and of small power producers using renewable energy. PURPA encouraged the growth of QFs by guaranteeing access to a market for the excess electricity they produce and exempting them from previous regulatory restrictions.² The resulting competition set in motion forces which are now a major influence on the industry; for example, 1991 was the first year that non-utility generators (NUGs)³ built more new capacity than utilities. In 1991, NUG electric generation capacity amounted to 6% of the installed generation capability and produced about 9% of the electricity generated in the United States.⁴

In the 1980s, PURPA, federal tax credits, and other factors created an environment that fostered development of emerging renewable technologies in many states. In California, a combination of good renewable resources, state tax credits, and relatively generous standard-offer purchase contracts by utilities resulted in installation of 1500 MW of wind capacity, more than 350 MW of solar thermal capacity, more than 800 MW of biomass capacity, and 2600 MW of geothermal capacity.

Other states also benefitted from substantial development of renewable resources, particularly in the Northeast and Southeast, where surplus or waste biomass was converted to useful electricity and process heat by utilities and by industrial companies.

² Qualifying Facilities are non-utility-owned facilities that meet the requirements specified by PURPA. A QF must generate electricity using a technology which either produces electric energy and another form of useful energy (e.g., thermal energy) using the same fuel source (cogeneration) or uses renewable energy as a fuel source (small power producer). In addition, QFs must meet certain efficiency, ownership, and operation criteria established by regulation by the Federal Energy Regulatory Commission.

³ NUGs include QF operators as well as other non-utility generators.

⁴ Energy Information Agency, *The Changing Structure of the Electric Power Industry, 1970-1991*, DOE/EIA-0562 (Washington, D.C., March 1993), p. vii.

Recent Evolution

This history set the stage for the current situation and DOE's programs in response to that situation. The utility industry is now in an era of significant transition and change. Continuing growth in demand for electricity and increasing limitations on traditional options are forcing utilities to examine both conventional and unconventional approaches for supplying energy efficiently and responsively to their customers.

Utility Planning Influences

In the past, utilities and their regulators dominated the resource planning and acquisition process by focusing on new supply investments. Today, integrated resource planning motivates many utilities to consider a broader range of technology resources than in the past.

Fueled by environmental concerns and regulations, by increasing capital costs and construction delays for traditional large generating plants, and by a desire to increase the efficiency and maintain the quality of energy services, utilities are evaluating a growing number of options for meeting new demand. Nontraditional options include demand-side management (DSM) and renewable energy technologies.

At the same time, utilities and PUCs are being challenged to allow customers, public interest groups, and other intervenors to play a larger role in determining resource preferences. Additionally, increased competition as a result of changes in legislation and regulation, as well as more market-oriented rules, have expanded and complicated the operation of the industry's established, traditionally regulated, monopolistic approach.

The Energy Policy Act further revised the way that utilities can respond to the nation's energy needs. The law contains far-reaching provisions with significant impact on all aspects of the utility sector, including expanded use of integrated resource planning for both electric and gas utilities.

The legislation also promotes the development and use of renewable energy resources through tax and other incentives for certain renewable energy production and investments; through research, development, and demonstration and commercialization programs for renewable energy technologies; and through expansion of programs to promote export of renewable energy technologies.

Another important accomplishment of EPACT was a major reform of the Public Utilities Holding Company Act of 1935 (PUHCA). The legislation helped increase competition in electricity generation by expanding the number of possible players to include a new category of non-utility generators called exempt wholesale generators (EWGs).

Operation of these EWGs differs from operation of PURPA QFs in several ways. For example, EWGs are not required to meet PURPA's cogeneration or renewable fuels restrictions. Also, utilities are not required to purchase the power they generate. Utilities themselves may even own and operate EWGs outside their service territory. However, from the vital standpoint of regulatory control, EWGs operate in a relaxed environment—the result of their "exempt" designation—and in this sense share some kinship with the nonregulated QFs.

David Parsons, NREL

The year 2000 goals for photovoltaic systems are to produce electricity at 12-20 cents per kilowatt-hour and to achieve 1000 MW of installed capacity in the United States.

EPACT also amended the Federal Power Act to provide increased access to the interstate electric transmission grid for all classes of non-utility generators and for utilities seeking to wheel wholesale power. The combination of these changes is likely to make EWGs the most important new approach for adding capacity in the near term.

Regulatory Trends

PURPA stimulated a major change in the generation of utility electricity, particularly among non-utility generators. Through 1991, total non-utility generation increased to approximately 50 gigawatts of installed capacity; this includes about 11 gigawatts of non-hydro renewable electric generation. Although some of this capacity was built pre-PURPA, the majority was built after 1978. Electric utilities over the same period installed 1 gigawatt of non-hydro renewables.

In the mid-to-late 1980s, changes began to occur in how utilities acquired new resources. To complement utility construction of new capacity, competitive bidding solicitations have emerged as a method for acquiring new supplies. Competitive bidding has been conducted in 25 states, and through 1992, nearly 100 bidding requests for proposals were issued in the United States, soliciting more than 25 gigawatts of resources. With the continued evolution of competitive bidding programs for new

energy resources, the utility system has been opened to competition from all resources including both supply-side technologies and demand-side management efforts by utility and non-utility entities.

In addition to the competition issues being injected into utility decision making for new supply resources, siting and licensing actions for power plants and transmission lines are becoming more difficult and contentious. Communities are no longer willing to be passive hosts to facilities that generate or deliver power. Issues such as quality of life, water usage by power plants, waste disposal, air emissions, and potential for health effects from exposure to electromagnetic fields (EMFs) are emerging as areas of public concern.

In addition, environmental regulations, such as the Clean Air Act Amendments of 1990, which mandate reductions in utility emissions of sulfur oxides and nitrogen oxides and may also restrict other emissions such as air toxics, may constrain utilities' use of traditional generating technologies. Although such trends create new barriers, they also provide opportunities for renewable energy systems because the inherent nature of renewables facilitates compliance with environmental regulations. DOE programs will be tailored, where possible and appropriate, to assist the U.S. renewables industry in capitalizing on the opportunities presented.

Warren Gretz, NREL

The year 2000 goal for geothermal electrical generation is to achieve 1000 MW of new capacity installed in the United States.

Competition

Regulatory reform, requirements to examine both supply and demand options, and the proliferation of players and technical options have led to a situation where a successful utility plan must assess numerous factors relating to electricity production, delivery, and use. None of these factors can be assumed to be static. All may have the potential for profitable investment. In the face of these influences, utilities are downsizing, cutting costs, and reorganizing to meet competitive forces.

The presumption is that the trend toward more multifaceted operations will lead to a more productive system. To remain competitive, utilities are expanding beyond their traditional reliance on utility-owned central-station generation. To develop integrated systems of options and provide the most effective and efficient energy services to their customers, utilities are considering dispersed generation, acquisition of non-utility supplies, trade-offs in use of transmission assets, and end-use strategies—all decisions requiring careful study. The emergence of a competitive environment in the utility sector will likely have a mixed effect on renewables (see sidebar at right). Initially, the negative effects may outweigh the positive. But by the turn of the century—as the cost competitiveness of renewables improves—the negative impacts could be significantly overcome.

Utility Asset Utilization—An Emerging Driver

To compete successfully in the changing business environment, utilities are reassessing the desirability of being primarily sellers of electricity in contrast to being providers of energy services upstream and downstream of the meter. In the latter case, to be successful, utilities will need to profitably employ and manage assets across the electric-energy supply

fabric of generation, transmission, distribution, and end use. To best respond to utility needs in this situation, DOE currently funds research, development, and demonstration activities on transmission and distribution technologies, energy storage systems, superconducting systems, and EMF, as well as the complete spectrum of electricity supply technologies, including renewable energy systems.

Utility-Sector Competition and Renewables

The utility industry has entered a period of transition wherein most observers anticipate significant departure from the traditional regulated monopoly framework to some form of a more competitive market. There is uncertainty and much debate with respect to both the eventual form of this competition and the timetable for changes to occur.

A more competitive market for electricity has the potential for both negative and positive effects on deployment of renewables. Negative impacts might include the following:

- It will be more difficult for utilities to select a capital-intensive, renewable technology with long-term benefits, if rate competition forces electricity pricing to become the paramount driver in most decision making.
- It will be more difficult for utilities to select any capital-intensive option, if the utility is uncertain that it will retain its customers because of retail wheeling.
- Income may not be sufficient to encourage renewables projects under PURPA, if PURPA's avoided cost payments are developed from competitive bids of (currently low-cost) natural gas projects.

In contrast, potential positive impacts might include:

- A competitive marketplace may force suppliers to absorb risks associated with fuel price changes and more stringent environmental laws, thereby enabling renewables to compete on more favorable terms.
- Utility-sector competition may promote consideration of customer choice and greater accommodation of consumer preferences for a clean environment and sustainable energy approaches, and thereby create a more receptive audience for marketers of options offering environmental quality, sustainability, and reduced risk of price volatility.
- Increased transmission access may allow more successful marketing of renewables by promoting wheeling from areas of excellent renewable resources to areas in need of increased supply.

These DOE programs promote options for regulators and utilities to consider when making resource decisions. They support R&D to help industry commercialize cost-effective and environmentally sound renewable energy technologies for applications across the entire energy delivery system. They invest in development of new technology that will enable better use of the transmission system to receive and transport power. They develop new energy storage technologies to facilitate better energy management. They explore alternative distribution options that improve the use of current assets and provide utilities with better responsiveness to and influence over end-use demand. They encourage greater use of energy efficiency and utility investment in DSM measures.

Generation

Although growth in demand for electricity has slowed, it has not stopped. The Energy Information Administration projects that the increase in demand for electric power between 1990 and 2010 will require the addition of 172 gigawatts of new capacity.⁵ This prospect has prompted a variety of federal efforts on supply R&D programs that could reduce costs and increase performance of technologies. These programs should increase the diversity of response options available to satisfy new demand and should include R&D support for both traditional and alternative advanced supply technologies.

Federal efforts in the area of supply technologies are focused both on improvements in conventional technologies and on advancements in renewable electric technologies. R&D support for renewable technologies includes efforts for base-load capacity that would be available in 100s of MWs. It also explores small, modular technologies in the kW to 1-MW range that are appropriate as dispersed resources on the distribution system or as resources for remote applications.

Federal programs also support integrated resource planning, an integrating framework that facilitates even-handed evaluation of competing supply- and demand-side technology options. By investing in these programs, the federal government seeks to enhance energy security, improve environmental quality, lower the drain on national energy resources, reduce dependence on imported oil, and engender economic growth and well-being.

Transmission

Increasing electricity demand, coupled with growing regional transfers of wholesale bulk power, will stretch the existing (high-voltage) transmission system to its limits. A growing not-in-my-backyard (NIMBY) attitude, EMF concerns, and a lack of understanding of the national transmission planning process exacerbate the situation. The potential for a general decline in reliability, power quality, and ability to support economic growth is becoming a major industry concern. However, new technology can overcome many of these deficiencies.

Federal R&D support is provided to increase the power-transfer capability and manageability of existing high-voltage alternating-current systems and to pursue lower cost high-voltage direct-current transmission systems. Programs also support the development of advanced control devices, algorithms, and software to achieve a measure of real-time control of systems. These measures could save energy and provide opportunities for the use of renewable energy systems.

Federal investments support national economic growth and economic security by ensuring continued availability of competitively priced electric supplies through intra- and inter-regional transfers and through improved management of end-use demand. They can also encourage increased adoption of renewable systems by facilitating power delivery from remote, high-resource areas.

Distribution

Traditionally, the utility distribution system was often regarded as simply a required investment for power delivery to the customer. The level of management attention was less than that accorded to bulk generation and transmission. As such, utilities have been slow to employ new technologies on distribution systems. Thus, distribution systems typically have little manageability and limited automation, while at the same time they are responsible for most customer outages and many of the power-quality problems. The situation is changing, however. Electric utilities spent more for construction for distribution in 1990 to 1992 than they did for generation.

New complications are currently being introduced as large-volume customers can invest in self-generation options and may even purchase power from outside the system (if retail wheeling becomes a reality). Such changes may make it difficult for utilities to plan effectively for future distribution needs.

As a potential counter, the rapidly evolving concept of distributed supply is providing utilities with a new range of service options. Advances in emerging modular technologies may make it possible for small generation and dispersed storage to defer investment in distribution and to improve the use of existing distribution systems.

Advances in distribution-system communications and control have already made direct control of certain customer loads possible, giving utilities the ability to control electricity consumption in much the same way they dispatch generation.

Federally funded R&D supports development of distributed utility generation and storage technologies, as well as expanded approaches for employing load management and other aspects of DSM.

End Use

The options for self-generation by large industrial and commercial customers have been expanded with the emergence of new generation and cogeneration technologies in sizes that match customers' energy requirements. PURPA has provided an incentive for cogeneration by customers by guaranteeing utility purchase of surplus power and energy. Utilities are focusing more intently on the needs of the customers because of this increased competition and also because existing customers can reduce their energy demand and thus make capacity available for new customers through DSM and energy efficiency programs. By considering energy efficiency programs where appropriate, utilities have been able to shift emphasis from simply supplying electricity to supplying energy services.

Federally supported R&D in more efficient use of electricity promotes economic growth through the development and production of more competitive products for both U.S. and international markets.

Program Scope and Breadth

DOE Strategies

DOE must pursue renewable energy program strategies that work in concert with the emerging markets. This requires recognition of the four utility elements of generation, transmission, distribution, and end use, not just generation activities. Objectives and strategies need to be designed to be effective in an environment where: competition is increasing; disparate, vertically integrated utilities are increasingly being replaced by multiple interlocking but independent parties; key traditional options are being foreclosed and new ones have a limited experience base; and investment decisions are based on criteria that are more rigorous and complex than in the past.

Recognizing these factors, this plan seeks to provide overall guidance for federal investment in developing and commercializing renewable electric generation. The approaches defined must respond to the evolving needs of the utility sector. A guiding principle in these efforts is to pursue reliable and cost-effective renewable energy system designs that can meet stringent utility standards, thereby ensuring that they

can meet less demanding off-grid needs as well. A second key element is to support the renewable energy industry in its efforts to capture a significant portion of both domestic and international markets for renewable and utility-system technologies, markets that are now becoming available and that are likely to extend well into the next century.

Our approach is based on a strong foundation of collaboration between the federal government and industry. The success in core R&D and other earlier efforts can now provide the bases for enhanced deployment and commercialization activities. The principal new thrust of this plan is its emphasis on deployment and on market-conditioning and market-pull actions that will complement continuing investment in core R&D. Success in these efforts will provide affordable and reliable electric power, promote a more robust U.S. economy by creating jobs, engender energy security, and improve the quality of life through a cleaner environment.

Throughout these efforts, the program needs to be cognizant of and responsive to constituents within the utility sector. To achieve this, DOE continues to seek input on program development and plans from all stakeholders within the electricity sector including utilities, consumers, manufacturers, developers, energy service companies, regulators, and others. Many program efforts are already being conducted in collaboration with stakeholders through a variety of cooperative agreements. These range from informal collaborative efforts to joint-venture partnerships (such as Solar Two) to formal cooperative research and development agreements (CRADAs). These efforts to work directly with industry toward mutual goals for commercializing renewable energy technology will continue as key priorities in implementing future program activities.

Warren Greitz, NREL

The year 2000 goals for wind power systems are to produce electricity at 4 cents per kilowatt-hour (for 13-mph-average wind speed sites) and to have 10,000 MW installed in the United States.

Expanded Renewables Programs

To effectively implement these general strategies and efforts, strategies for individual renewable energy programs will now include two major thrusts—a "market-pull" approach which focuses on reducing market barriers and accelerating customer acceptance (sales) of renewable energy technologies, and a complementary "technology-push" approach with initiatives that will decrease the cost and increase the performance of these technologies.

A common theme that runs through these approaches is the reliance on strategic partnerships with the private sector to achieve successful technology commercialization. These partnerships include states, national laboratories, universities, the Electric Power Research Institute, the National Rural Electric Cooperative Association, the American Public Power Association, large and small investor-owned utilities, the National Association of Regulatory Utility Commissioners, public power utilities, the federal power marketing administrations, equipment manufacturers, and industries that develop renewable energy technologies or that make renewable energy systems.

In the past, these partnerships have accelerated progress by providing effective access to data and information, by meeting specific needs of industry, and by leveraging federal dollars with those of the renewable energy industry and utility-sector players. These collaborations will be further encouraged and expanded to provide even more industry-driven character into the renewable technology programs and to facilitate the transfer of federal research progress through specific cooperative and collaborative research and market-deployment arrangements.

Commercialization of renewable energy technologies is the ultimate goal for all programs, but is primarily the role of the private sector. Strategic partnerships will be formed to enhance commercialization of renewables through market-conditioning

activities, through improved manufacturing methods, and through focused research, development, and demonstration. DOE will also support U.S. industry in its competition with overseas suppliers through continued support of the Committee on Renewable Energy Commerce and Trade, cooperative efforts with the Agency for International Development, consultation with multinational funding agencies, and selected individual program activities.

This plan provides an overarching framework for individual-program annual operating and multi-year plans. It does not duplicate these individual plans, which provide for greater detail on program activities and which, in some cases, will be revised to more fully conform to the overall guidance presented here.

This plan encourages a balanced set of technology-push and market-pull approaches extending well beyond the classic laboratory R&D setting. Technology-push efforts focus on improving performance and reducing costs of technologies to make it easier to compete economically with other options. This includes R&D, improved manufacturing technology, and advances in supporting infrastructure.

**Technology Push and Market Pull
Join to Commercialize RETs**

The Program Plan uses technology-push strategies to improve the efficiency of renewable energy technologies and reduce manufacturing cost, and uses market-pull strategies to overcome financial and institutional barriers that retard entry into the marketplace.

Market-pull approaches focus on increasing market acceptance by overcoming barriers, both technical and non-technical, that may impede the adoption of technologies. This includes analytic methods such as integrated resource planning, as well as financial incentives and technology validation through demonstration of commercial applications. The combination of technology-push and market-pull approaches can maximize the rate of deployment of renewable energy technologies. These activities are not conducted in isolation, but rely on partnerships and interaction with key stakeholders in the utility sector.

CRADAs—Putting Technology Push to Work

A relatively recent technology-push device for DOE and its national laboratories is the cooperative research and development agreement or CRADA. Authorized by the National Competitiveness Technology Transfer Act of 1989, CRADAs are a specific form of research partnership between a federal research institution and a private company or consortium, bringing together the expertise, resources, and facilities of each for commercializing new technology. The national laboratories may contribute intellectual property such as patented inventions to the projects, and industrial partners may lease those rights or acquire rights to new intellectual property developed during the project.

An example of a CRADA in the electric utility sector is the one among the National Renewable Energy Laboratory, Argonne National Laboratory, an electric utility, and two waste management companies to develop pellets of refuse-derived fuel for burning in combination with a power plant's normal coal feedstock. The technology compresses municipal solid waste (after glass and metal have been sorted out) into thumb-sized pellets bound together with lime. The lime neutralizes acid released by the burning coal. Analysis of project test runs found that sulfur dioxide emissions were substantially reduced and that economics were good enough to be attractive for power plants using certain types of coal. This CRADA could be a major step toward realizing the full potential of waste-to-energy plants. DOE believes that they could contribute six times the energy they do today.

Technology-Push Efforts

Core R&D for renewable energy provides the basis for technology improvements and advances. These activities constituted the primary program thrust throughout much of the 1980s. R&D today provides the technologies for cost-effective systems for tomorrow. By working together, DOE, universities, utilities, and the renewable industries can bring the needed talent, priority, and resources to the overall R&D effort. The renewable energy core R&D is intended to provide the long-run edge in cost and performance.

Where appropriate, DOE will pursue a broader scope of technology-push activities. Methods to improve industry manufacturing processes is one example. Recent examples from the photovoltaics program indicate that advances in manufacturing and production processes can translate to success in increased penetration into domestic and international markets. Clearly, these improvements can lead to more competitive prices and greater high-technology exports, providing value to both the United States and the purchaser of the technology.

The use of properly planned and structured partnerships between government and industry is frequently cited as a contributing reason for Japan's international success in numerous technological arenas. We believe that the United States can surpass Japan's record by employing cost-shared contracts, CRADAs, and other cooperative research mechanisms; by adopting agendas that meet the research needs of industry; and by engaging in appropriate market-pull efforts.

Market-Pull Efforts

Market-pull approaches include market assessment, application studies, technology demonstrations, field tests, prototype evaluations, product buy-downs, and similar market-entry enhancements.

Market-pull efforts for renewable energy technologies can also include supporting export initiatives to strengthen U.S. industry; developing new analysis techniques to value renewables; improving resource assessment methods; and demonstrating commercial applicability and market readiness. These efforts can be accomplished through a variety of consortia, partnerships, and other market-influencing mechanisms including financial and regulatory incentives.

Strategic alliances with regulators to enhance integrated resource planning activities can be an important part of expanded market-pull methods. The federal government can also accelerate commercial market development through its own routine operations. Executive Order 12902 takes advantage of this opportunity by directing DOE's Federal Energy Management Program to help all federal agencies improve energy efficiency and to develop plans for significantly increasing their use of renewable energy.

Lessons from the late 1970s and early 1980s indicate that federally funded demonstration or tax-credit programs, without performance requirements or critical stakeholdings by suppliers and buyers, can fail to lead to the desired industrial development objectives. Federal programs to assist commercialization should help speed market penetration and help blunt foreign competitors seeking to win early market share leadership. Future market deployment and demonstration activities will employ a partnership approach and performance-based measures to ensure a strong industry incentive to invest in commercialization following successful installation and operation of such projects.

Aggregated Purchasing—Putting Market Pull to Work

One of the most promising market-pull devices for DOE is pooled purchasing of renewable energy systems. Potential buyers of a technology aggregate an order of sufficient size to make it attractive for a manufacturer to make the necessary investment in more automated and higher volume production facilities that can ratchet product quality to the next higher level and product cost to the next lower level. Such buying groups help resolve the chicken-and-egg problem of manufacturers not wanting to build production facilities until there is an active market and users not wanting to commit to using a product until there is a reliable, efficient supplier.

An example of a buying group in the electric utility sector is the *TEAM-UP* (Technology Experience to Accelerate Markets in Utility Photovoltaics) initiative of the Utility PhotoVoltaic Group (UPVG). This group of 85 electric utilities is currently soliciting project ideas for aggregated purchases in order to develop a formal request for proposals planned for October 1994. They have already received 50 specific project ideas with a total capacity of about 8 MW. The project is proposed for six years with total funding of more than \$500 million to achieve a goal of 50 megawatts of installed PV. UPVG is asking the federal government to contribute about one-third, including \$18 million for fiscal year 1995. DOE has indicated support and has incorporated the proposal in the Climate Change Action Plan. The UPVG has projected that PV use by utilities can be commercialized on a self-sustaining basis if the installed price can be brought down to about \$3,000 per kilowatt. The *TEAM-UP* initiative could play a major role in reaching that goal.

Substantial international opportunities exist, even in current highly competitive international markets. The value of international efforts is at least two-fold. First, the purchasing party acquires and installs an environmentally sound and sustainable energy system. Secondly, the increased sales by a U.S. technology producer provide revenue and a larger base of production that can bring about reduced costs, additional domestic and export sales, and job growth.

The choices of market-pull programs and activities will likely be technology specific. For example, export promotion may benefit photovoltaics commercialization, participation in biomass co-firing tests in coal plants with individual utilities may help promote biomass power systems, and demonstrations of pilot plants with utility consortia may encourage development of solar power towers.

Specific Generating Technologies

Characteristics of Future Renewable Energy Programs

DOE programs will apply the technology-push and market-pull approaches where appropriate to each of the specific renewable energy technologies. These programs are intended to provide the nation's utility sector with an increasing array of generation and system technology options that will be cost effective, dependent on a domestic energy source, often modular, and of limited environmental impact.

Average Daily Global Solar Radiation
(On a horizontal surface, resource for flat-plate PV)

It is worth noting that "cost effective" does not necessarily translate to equal cost of energy for each renewable technology. The value of generated electricity varies, and depends on when it is produced, whether the production facility can be dispatched on demand, and other factors. For example, the average value of solar electricity, most of which is produced during the highest demand periods, is greater than the average value of wind electricity, much of which may be produced during low-demand periods. These characteristics, in turn, influence cost-of-energy goals for the federal programs (that is, wind seeks to produce electricity at 3 to 4 cents per kilowatt-hour, while the PV program goal is 6 to 7 cents per kilowatt-hour).

The programs are designed to serve the needs of the evolving electricity supply community and to provide competitive utility systems for the rapidly expanding international utility markets. Because of the merits of conducting complementary technology-push and market-pull activities, we are adjusting individual program content as needed in FY 1994 and FY 1995. The following sections highlight the future character of DOE programs for individual renewable technologies for electricity generation.

Photovoltaics Technology

Photovoltaics uses solid-state materials to convert solar radiation directly to electricity. As such, photovoltaic power systems do not require heat engines or mechanical generators that are associated with most other systems that generate electric power. This operational simplicity is one of the attractive characteristics of photovoltaics. It has contributed to the ability to develop very reliable photovoltaic power systems that require virtually no maintenance—even at the current stage of product maturity.

Photovoltaic power systems can be small enough to power a watch or large enough to power a substation. This modularity of power systems is a key characteristic of photovoltaics which has led to its expanding use in a wide variety of relatively small power applications, such as water pumping systems, independent residential or village power systems (systems not connected to a utility grid), remote telecommunications stations, and independent lighting systems. Of course, battery storage is included in those systems whose loads require service when the sun isn't shining. For many of these kinds of applications, photovoltaics is already competitive.

The sunshine-based output of a photovoltaic power system often coincides with peak demand loads experienced by utilities, and thus, the value of the energy produced is frequently higher than the system average. The value of photovoltaic power in a utility grid can be further enhanced by selectively locating the system to provide distributed voltage support and peak demand reductions on local conductors and distribution supply transformers. These distributed utility applications are likely to represent a key utility market opportunity for photovoltaic power systems over the next 10 years.

The primary challenge for photovoltaics technology is cost. The selling prices of photovoltaic modules are typically \$3 to \$4 per watt, and complete installed systems may cost \$6 to \$8 or more per watt. At this cost, current PV systems generate power at a levelized cost of about 25 cents per kWh. Although these costs are high compared to conventional and many other renewable power technologies, photovoltaics technology appears to have excellent potential for major advances that can both reduce costs and increase performance.

The goals of the photovoltaics program are to lower electricity costs from photovoltaics systems to 12–20 cents per kilowatt-hour, to have 1000 MW of photovoltaics systems installed in the United States, and to have U.S. industry install 500 MW overseas, by 2000.

The technology-push activities of the photovoltaics program place heavy emphasis on lowering costs through two approaches. First, research is aimed at increasing solar-to-electric conversion efficiencies because these directly reduce the costs of power systems. This continues to be a fertile research field, with the potential for continuing advances as the result of new research capabilities such as engineering materials at the atomic and molecular levels. At the same time, researchers are using these materials to develop reliable and durable photovoltaic modules through a collaborative program involving the National Renewable Energy Laboratory, Sandia National Laboratories, numerous universities, and the photovoltaics industry.

Second, technology-push activities have been expanded, especially the development of more advanced manufacturing technologies. The principal thrust is PVMaT, the Photovoltaic Manufacturing Technology initiative, which undertakes cost-shared projects with industry to support definition and development of more cost-effective processes for manufacturing photovoltaic modules.

The photovoltaics program has begun market-pull activities by cooperating, supporting, and investing with the industry, potential users, regulators, and other interested parties. A major current market-pull effort is the set of collaboratives and commercialization projects under the Photovoltaic Collaborative Market Project to Accelerate Commercial Technology (PV:COMPACT). PV:COMPACT is a unique collaborative involving a broad spectrum of organizations with an interest in PV development, education, and deployment. The collaborative includes the Utility Photovoltaic Group—known as UPVG, PV for Utilities—known as PV4U, National Association of Utility Consumer Advocates, Electric Power Research Institute, Edison Electric Institute, American Public Power Association, the National Rural Electric Cooperatives Association, and others.

Critical components of PV:COMPACT include significant hardware development and technological advancement to provide widespread public exposure to PV applications; education of consumers and public interest groups to develop informed positions on PV technology, and facilitation of state collaborative efforts to meet local conditions. The goal of PV:COMPACT is to create an environment where self-sustaining commercial markets for PV can emerge in response to the needs of the domestic energy sector including utilities.

Market developments have also been enhanced through the Buildings Opportunities in the U.S. for PV program (PV:BONUS). PV:BONUS involves developing new PV applications such as roof or wall panels that are integrated into a building's structure. The program also supports analysis of the value for utility systems that PV power serves in various distributed applications. Plus, the program identifies opportunities for the domestic industry to export PV power systems to international markets.

During the 5-year Program Plan period (1994 through 1998), the photovoltaic program will work aggressively to bring the technologies to the marketplace. Technology-push options include enhanced collaborative efforts to move high efficiency module technologies from the laboratory to the commercial manufacturing stage. Further expanded technology-push efforts will focus on extending module lifetime to 30 years.

Market-pull activities with utilities and other stakeholders will be enhanced and more highly leveraged as current programs increase industry involvement in PV commercialization. This will be done by expanding education and information programs, analyzing market opportunities, and coordinating bulk purchases.

Solar Thermal Electric Technology

Solar thermal technology uses concentrated solar radiation to power a heat engine that drives a generator to produce electricity. In two of the three leading design concepts, parabolic trough systems and power tower systems, the solar energy is first collected as thermal energy in a high-temperature liquid, such as an oil or molten salt, at 350°C to 800°C. With these designs the thermal energy is stored in an insulated tank before it is used to drive a steam turbine, thereby overcoming a temporary loss of sunlight. Several factors, including collector-field economies of scale and the heat exchanger and turbine-generator technologies employed, require that these systems be relatively large. Parabolic trough systems are 30–100 MW or more, and power tower systems are expected to be at least 100 MW in size.

The third solar thermal system design uses a Stirling-engine generator at the focal point of a reflective dish collector to produce electricity. These systems can be sized as small as the power output of a single Stirling engine, with 7-kW and 25-kW sizes currently being developed.

With these technology options, solar thermal systems can address applications ranging from dispatchable sources for utility peak power needs, to distributed utility applications, to kilowatt-level remote power needs.

Average Direct Normal Solar Radiation
(on a tracking surface always facing the sun, resource for solar thermal and concentrator PV)

Parabolic trough solar thermal power systems have experienced some commercial success, with about 350 MW installed in the United States. These systems incorporate thermal storage or co-firing with natural gas to enable their dispatch as peak-load capacity, thus making these systems valuable to utilities as peak power generators.

Several power tower demonstration systems have been installed and operated worldwide, the largest being the 10-MW Solar One plant in California. This system is currently being retrofitted as a molten-salt system to demonstrate the feasibility of that technology.

Dish/Stirling power systems are not yet commercial, but the first systems are currently undergoing field tests.

The goals of the solar thermal electric program are to demonstrate electricity costs of 6 cents per kilowatt-hour for power tower and dish/Stirling systems, to have 750 MW of systems installed in the United States, and to have 1250 MW of systems installed overseas by U.S. industry, by 2000.

Technology-push activities of the solar thermal program emphasize core research in optics, materials, and components, as well as increased collaboration and cost-sharing with industry. A key component in the efforts to reduce costs is the solar thermal manufacturing technology initiative, named SolMaT. This is a cost-shared program that currently focuses on heliostat manufacturing issues and developing additional program directions in consultation with industry.

The program also supports industry through the Solar Thermal Design Assistance Center and the National Solar Thermal Test Facility. These two activities, located at Sandia National Laboratories, provide technical guidance and standardized performance evaluations to solar thermal manufacturers and users.

Recently expanded technology-push activities have examined hybrid and co-firing opportunities such as advanced central receiver/combined-cycle hybrids.

The solar thermal program also pursues market-pull activities. The Electric Power Research Institute, eight utilities, and several industrial organizations are providing 50% of the funds needed to convert the Solar One power tower to a molten-salt tower system called Solar Two, and to operate it.

The industries involved with Solar Two have also formed a commercial advisory board to look at issues related to commercial use of power towers. DOE will exercise maximum effort to insure that its investments in power tower technology support this forward-looking activity.

International and remote power applications and distribution system support for dish/Stirling systems are receiving increased attention. Each of the cost-shared initiatives are expected to allow U.S. industry to commercialize solar thermal systems in the late 1990s and to maintain a preeminent ability to export power tower and dish/engine systems worldwide. DOE also continues to support parabolic trough technology by working with a consortium of industries to develop new manufacturing capability and by working with generators to reduce operation and maintenance costs.

Another recent possibility in the market-pull area is conversion of the Nevada Test Site into a National Solar Enterprise Zone. The solar resource at the Test Site is significantly above average, and government sponsorship along with existing infrastructure at the test site could lead to large amounts of solar power being developed and solar electricity being supplied at costs well below current levels.

The solar thermal program will also respond to new opportunities for collaborating in the marketplace, and for moving laboratory advances into commercial manufacturing processes through initiatives to improve manufacturing.

Wind Power Systems

Today's use of wind turbines to generate electricity is a continuation of the centuries-old practice of extracting useful energy from the wind for applications ranging from water transport to milling. The technical feasibility of producing electricity from wind was demonstrated several decades ago, and a total of 1600 MW of wind power capacity has been installed by a number of system developers in California. Worldwide, 2800 MW have been installed, and considerable international competition for wind power markets exists.

A major determinant of the economics of wind power systems is the quality of the resource. Although good resources are found in many parts of the United States, the best resources are generally in mountain ranges, coastal regions, and parts of the Great Plains. A major thrust of the wind power program is to develop wind turbines that can extract useful energy from the plentiful moderate wind resources. The output of wind power systems is intermittent, so the temporal match of utility peak load and wind output affects the value of the power produced.

The goals of the wind power program are to lower the costs of electricity from wind power systems to 5 cents per kilowatt-hour by 1995 and 4 cents per kilowatt-hour by 2000 (for sites where the wind speed averages 13 mph). The American Wind Energy Association has set a goal of 10,000 MW of installed capacity by 2000 in the United States. The European Community's goal is 4000 MW installed in the same time frame.

The wind power program is focusing its technology-push activities on increasing the efficiency and reliability of wind turbines while decreasing capital and operational costs. Ongoing areas of applied research include aerodynamics, structural dynamics, fatigue, power electronics, and resource turbulence characterization.

Average Annual Wind Power

LS-CD21-a146702

A key component is the advanced turbine development program. This program includes near-term and long-term contracts with industry to share the cost of developing advanced turbines. Near-term efforts are focused on three value-engineered turbines that represent significant incremental improvements to existing designs. Long-term efforts address the next generation of utility-scale wind turbines through advances in innovative components and subsystems. Industry support is provided through model development, which feeds into both the near- and long-term design improvements.

Researchers from industry and government can use sites at the National Wind Technology Center to test entire systems or to test and develop individual components.

Market-pull activities have focused on expanding the experience of wind turbines in different geographic settings, preparing and coordinating utility-oriented educational materials and activities, characterizing the wind resource, and performing studies on the value of wind power, market barriers, and environmental issues. The Wind Turbine Verification Program is a cooperative and cost-shared effort with EPRI and utilities that promotes installation of turbines with the goal of reducing the perceived risk of new technologies. Projects of 6 MW or more are cost-shared with utilities and turbine manufacturers.

The DOE program also provides support for the Utility Wind Interest Group and the Utility User Support Group, both of which help promote utility interest in wind power. The resource assessment program provides both broad assessments of the potential power in the wind (appropriate for assessing national and regional potential) and guidance on site-specific instrumentation and measurement needs.

A Wind Market Mobilization Collaborative composed of the Electric Power Research Institute, individual utilities, independent power producers, regulators, manufacturers, service providers, and consumer and environmental groups has been established. This collaborative will help coordinate and implement future market-pull activities. Areas of near-term focus include adding seven cost-shared projects of 6 MW or more to the Turbine Verification Program, soliciting proposals for cost-shared projects of 25 MW or more under a Climate Change Action Plan initiative, helping utilities acquire site-specific wind resource data through the Utility Resource Assessment Program, and supporting the National Avian Research Program to reduce avian mortality at wind farm sites.

During the 5-year Program Plan period, the wind program will maximize gains from incremental improvements in existing designs through near-term programs in collaborative development. Long-term efforts providing substantial improvements from innovative designs will receive increased attention in the latter part of the period. Market-pull activities for the wind program will rely increasingly on industry collaboratives through cost-sharing and leveraging of federal investments with utility and turbine manufacturers.

Known and Potential Geothermal Resources

LS-CD21-v146702

Geothermal Power Systems

A total of about 3000 MW of geothermal capacity is installed in the western United States, using dry steam or other favorable high-temperature liquid resources. These installations have demonstrated that geothermal power systems can provide dispatchable base-load or intermediate power at low cost. Recent new capacity additions have focused on development of moderate temperature, but more abundant, liquid-dominated geothermal reservoirs. Issues associated with developing liquid-dominated reservoirs include exploration and proving of the resource, characterization of resource extent and potential sustainable capacity, cost-effective extraction and reservoir recharge, and efficient conversion to power.

A major focus of DOE geothermal efforts is development of binary cycle technology which uses the geothermal water to heat a secondary, lower-boiling-point fluid in a closed-loop system. Binary cycle technology will make it possible to tap many moderate- and even low-temperature resources that could not otherwise be economically used.

The goals of the geothermal program are to achieve 1000 MW of newly installed geothermal capacity in the United States and 1000 MW of capacity installed overseas by U.S. industry, by 2000.

To meet these goals, technology-push programs are under way in all four main areas of geothermal technology: exploration, drilling, reservoir technology, and energy conversion. Several well-known, high-quality reservoirs are nearing full development. A new cost-shared initiative between government and industry for drilling is just beginning to rebuild the inventory of discovered, undeveloped fields. In parallel, a new integrated strategy for geothermal exploration will reduce costs and increase success of exploration efforts.

One focus of drilling research has been the use of slim-hole technology, which is much cheaper than full-diameter production wells. The goal is to use slim holes to provide sufficient reservoir data to determine the resource's ability to support electric generation. Other core-program drilling efforts are addressing circulation problems from loss of drilling fluid, and developing advanced drilling instruments and materials.

Efforts in reservoir technology include ongoing cost-shared programs to stabilize power production at The Geysers dry-steam field, and more general efforts at understanding, modeling, and managing geothermal reservoirs. Efforts in conversion technology are aimed at increasing power plant efficiencies. Successful completion of these conversion technology projects will result in definition of the next-generation geothermal power plant.

There are attractive opportunities for market-pull activities in the geothermal program. The market mobilization initiatives supporting the Climate Change Action Plan are intended to reduce greenhouse gas emissions through rapid deployment of geothermal technologies. An exploration initiative will apply the new technologies to pioneering development of geothermal resources in the Pacific Northwest, where significant electric needs are anticipated.

A National Advanced Drilling and Excavation Technologies initiative is designed to allow U.S. industry to regain dominance in international drilling markets. Another initiative, GT-World, will synthesize advances in exploration, drilling, reservoir, and conversion technologies into an integrated resource development package for application in foreign markets. Planned cost-shared initiatives to develop power plants on new fields and increase plant efficiency are expected to lead to 780 MW of new capacity and 300 MW of upgraded capacity at existing plants by the year 2000.

It is important to recognize that geothermal plants tend to operate at relatively high capacity factors (potentially more than 90%) and that each new megawatt of geothermal capacity added will provide a greater electric energy contribution than its solar or wind counterpart.

From 1994 through 1998, technology-push activities in the geothermal program will provide the bases for resource confirmation and access that will allow expanded development in undeveloped and newly discovered resource fields. These advances will be combined with market-pull approaches to encourage deployment of new geothermal capacity through cooperative exploration efforts with industry. Other activities will focus on reservoir management and engineering to maximize the life and operability of existing and newly developed resource fields.

Biomass Power Systems

The use of biomass fuels such as wood or agricultural residues for electricity generation is conceptually similar to the use of fossil fuels. A major difference is that, to the extent that the biomass fuels are grown on a continuing basis, biomass combustion systems contribute virtually no net increase to atmospheric carbon dioxide levels.

Like geothermal plants, biomass facilities operate at a relatively high capacity factor and their electric energy output will be greater than that from corresponding solar or wind facilities.

U.S. Biomass Resources

Current biomass power systems employ direct fuel combustion to power steam generator-turbine systems. About 6500 MW of direct combustion biomass power capacity is used for base-load and intermediate electric power needs in the United States today. Much of this is industrial generation such as wood-waste-fired power plants operated by lumber mills, paper companies, and others in the wood-processing industry. More advanced technologies that incorporate biomass gasification or pyrolysis will result in cleaner and more efficient electricity from renewable biomass energy sources.

The combustion of municipal solid wastes (MSW) represents another source of biomass energy. This renewable source of energy has the potential to provide more than 3 quadrillion BTUs (quads) of energy per year in the United States, about two-thirds of which can be realized through the combustion of MSW in waste-to-energy plants. This is a mature technology which consists of about 160 plants that convert MSW to 16,500 MW of electrical power.

A major opportunity for biomass power systems is co-firing or repowering of existing fossil-fuel-fired power plants. These steps provide utilities an option for complying with provisions of the Clean Air Act Amendments on emissions of sulfur and nitrogen compounds and for reducing carbon dioxide emissions without replacing the entire power plant.

The goals of the biomass power systems program are to demonstrate the feasibility of biomass gasification technologies, to have an additional 3700 MW of capacity installed in the United States, and to have 500–1000 MW of capacity installed overseas by U.S. industry, by 2000.

Technology-push activities focus on improving existing technology in direct-combustion systems, studying technical issues in co-firing existing fossil-fuel

plants, developing dedicated feedstock supply systems, and developing the next-generation technologies.

In direct combustion, the program helps industry with stack-gas cleanup, heat exchanger fouling (through the Sandia multifuel combustion laboratory), and fuel preparation and handling. The program also supports research on smaller, more modular plants and on evaluating high-efficiency steam cycles. A direct-fired gas turbine is being evaluated in a cost-shared demonstration.

Co-firing issues to be examined include biomass handling and combustion characteristics, and environmental effects. Next-generation technology includes both biomass gasification and pyrolysis.

Gasification issues focus on characterizing and mitigating effects of gases and particles on the combustion turbine. Future scale-up and testing of this technology will involve a cost-shared partnership with industry. Planned pyrolysis research focuses on producing enough biocrude oil to allow determination of critical combustion characteristics. Small-scale and larger tests with actual turbines are also anticipated. Infrastructure issues associated with drying, storage, and transport of biomass also need to be addressed.

Market-pull activities have focused on education and outreach, planning/regulatory/policy assistance, and collaborative commercialization. Commercialization joint ventures include biomass gasification combined-cycle efforts in Hawaii, plans for advanced technology at pulp and paper industry sites, and acceleration of commercial deployment of biocrude. Twelve private-sector consortia of project developers, utilities, and industries have been funded to develop feasibility studies and business plans for biomass facilities.

Under a program initiative to support the President's Climate Change Action Plan, the program anticipates supporting cost-shared installation of follow-on prototypes.

The year 2000 goals for solar-thermal electrical generation are to produce electricity at 6 cents per kilowatt-hour and to achieve 750 MW installed capacity in the United States.

The program also participates in two groups important to biomass market pull: the Utility Biomass Energy Commercialization Association (supporting deployment of biomass plants in the utility sector) and the National Biofuels Roundtable (examining environmental concerns and perceived barriers to development).

During the 5-year Program Plan period, technology-push activities of the biomass electric program will move increasingly toward new technology and dedicated feedstock supply systems. These efforts will provide advances in smaller, more modular, more efficient generation and will demonstrate early results with dedicated feedstocks. Market-pull activities will focus on increased collaborations with utility-sector participants and with other industry partners to enhance deployment of biomass technologies.

Hydroelectric Power Systems

Hydropower is one of the oldest and most mature technologies employed for electricity generation. About 75,000 MW of hydropower capacity (not counting pumped-storage) exists in the United States. The major issues facing this renewable electric power technology are those concerned with siting of new facilities, relicensing of existing facilities, dam safety, and environmental impacts of hydropower systems. There are also opportunities for increasing the electricity output of existing hydropower systems by upgrading the efficiency of their turbine-generators.

The goals of the hydropower program are to improve methods for analyzing environmental impacts and mitigation measures, to clarify and simplify the licensing process for hydro power systems, and to develop new turbine technologies that would reduce impacts on wildlife and fisheries.

Technology-push efforts in the hydropower program have traditionally focused on studies and methodologies that can be used by analysts addressing environmental characteristics at impoundment sites. A recently initiated focus of the program

will target cost-shared development of environmentally friendly turbines (that is, hydroelectric turbines less harmful to fish and other aquatic life).

Market-pull activities involve assisting operators at existing sites by developing better information on environmental impacts of hydropower systems and means to mitigate them. These activities facilitate use of hydropower resources by easing the regulatory, siting, and relicensing processes for hydropower operators. DOE has also begun a program to review federal water facilities and identify opportunities for economical improvement of hydroelectric generation.

Resource assessment activities are under way to examine environmental attributes associated with the resource base for high-head, low-head, and run-of-the-river facilities. This resource examination is aimed at determining a more realistic new-resource potential, given the environmental issues of hydropower siting.

From 1994 through 1998, technology-push activities of the hydropower program will continue to focus on environmentally friendly turbines. Market-pull activities will focus on improving the ability to analyze and mitigate regulatory and licensing issues and on developing more realistic estimates of new-resource potential through resource assessments.

Supporting Programs: Assessment and Incentives

In addition to technology-push and market-pull activities for specific technologies, DOE has several programs that provide general support for the full range of renewable energy technologies. Supporting programs are activities that enable the expanded use of renewable technologies. The two principal supporting programs address resource assessment and incentives for renewable energy production.⁶

Warren Greitz, NREL

The goals for hydroelectric power generation are to simplify licensing and to develop turbines that have less impact on aquatic life.

The availability of renewable resources is critical to developing and using renewable energy systems, just as the availability of fossil or nuclear fuels is essential to those technologies. Resource assessment characterizes and quantifies the renewable energy resources and is a fundamental part of evaluating and deploying renewable energy technologies. Resource assessment provides essential information for the prediction of the amount and timing of energy production from renewable energy systems. Because the economic viability of specific solar and wind power projects depends strongly on the levels and timing of solar or wind energy that

will be available, accurate resource assessment data are vital to project decision makers.

The DOE resource assessment program is focused on improving the capabilities for estimating renewable energy resources in regions and localities in the United States (and in other parts of the world, to assist export-market development) and on making information on renewable resources readily available to system developers in a user-friendly form. A key element in understanding future resource availability is the collection and analysis of historical resource data. A comprehensive data base including information on solar, wind, hydro, biomass, and geothermal resources is being developed to support the renewable energy community and to allow better analysis of renewable energy options in making supply decisions.

The Energy Policy Act established two strong financial incentives for renewables. Over the next 10 years, investor-owned utilities and independent power producers may take advantage of a 1.5-cent tax credit allowed for each kilowatt-hour of electricity generated by wind or by energy-crop-based biomass facilities. Non-utility investors in solar and geothermal systems can benefit from a 10% investment tax credit. These incentives are administered by the Internal Revenue Service without direct DOE involvement.

The Energy Policy Act also established a parallel incentive for public and cooperative power systems, which is administered by DOE. Subject to annual appropriations, this program provides a payment of 1.5 cents for every kilowatt-hour of energy produced and sold from qualifying solar, wind, geothermal, and biomass facilities for a 10-year period. The purpose of the public-power incentive payment is to promote commercialization and stimulate greater use of these technologies by public and cooperative utilities. DOE supports the intent of the program and is proceeding to implement it.

⁶ Other supporting elements of the renewable energy program include integrated resources planning, transmission and distribution, storage, and superconductivity.

Implementing The Plan

Organizational Structure

Successful implementation of this plan will lead to an expanded role for renewable energy in both grid and non-grid applications, will contribute to energy security by reducing the vulnerability to disruptions of foreign energy supplies, and will reduce the environmental impacts of energy production, distribution, and use.

Both the near-term and long-term success of this plan will be achieved by collaboration with other DOE programs in fossil, nuclear energy, and basic sciences; other economic development and environmental programs within DOE and other agencies, and at other levels of government; and by developing partnerships with the private sector, DOE laboratories, state and local organizations, and the universities, to execute the Plan's research, development, and deployment programs.

Overall management responsibility for the activities outlined in this program plan is in the Office of Energy Efficiency and Renewable Energy (EE). EE is the lead federal government organization for energy efficiency and renewable energy technology research, development, demonstration, and technology deployment activities.

Specific responsibility for the implementation and execution of the programs in this plan rests with the Office of Utility Technologies (EE-10). The Office also supports other programs related to utility needs and has the requisite background, experience, and utility relationships to make renewable power systems accepted sources of energy supply for both utility networks and off-grid applications.

Program Resources

The increasing investment trend shown below reflects DOE's commitment to research and development of promising renewable technologies that can promote the availability of environmentally sound options for sustainable domestic energy production. In executing these programs, the Office of Utility Technologies will work in partnership with industry to leverage federal dollars to the fullest extent practicable.

The individual program annual operating plans define substantial efforts to promote commercialization and accelerate the wide-scale use of renewable energy resources and technologies, and to make these domestic technologies a major contributor to our national energy needs.

Funding of Renewables for Utility Applications

Future program funding depends on many factors and cannot be forecast accurately. However, the Clinton Administration has demonstrated a strong commitment to federal action on behalf of renewable technologies, and these program areas can be expected to be given priority consideration in future budget cycles.

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Summary

The Program Plan provides an aggressive yet practical framework for federal activities that can lead to the adoption of increasing amounts of renewable electric-generating technologies. Renewables must compete in an electricity sector in the United States that is undergoing change. These changes include decreased regulation of generation supply, a continuing need for new capacity, increased competition, tougher environmental rules, and a lower public tolerance for facility intrusion of almost any type. The plan recognizes this changing environment and relies on a variety of collaborations and interactions with sector stakeholders to help achieve forward progress for renewables.

Furthermore, the plan retains a variety of renewable technology options, a diversity of technical approaches within each technology program, and the pursuit of multiple interactions with different partners in numerous collaboratives.

The Program Plan promotes positive near-term results, as well as longer term technical progress. Most importantly, the plan contemplates a combination of technology-push and market-pull actions that can promote a strong U.S. renewable energy industrial base serving both U.S. and export markets. The result is a stronger U.S. economy, increased energy security, a more environmentally sound energy infrastructure, and improved competitiveness internationally.

Warren Greitz, NREL

The year 2000 goals for biomass power electrical generation are to demonstrate the feasibility of biomass gasification technologies and to achieve 3700 MW of additional capacity installed in the United States.

Warren Greitz, NREL