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DEPARTMENT OF ENERGY

Federal Energy Regulatory Commission

18 CFR Part 292

[Dockets Nos. RM79-54 and RM79-55]

Small Power Production and Cogeneration Facilities—Environmental Findings; No Significant Impact and Notice of Intent To Prepare Environmental Impact Statement

March 31, 1980.

AGENCY: Federal Energy Regulatory Commission.

ACTION: Notice of finding of no significant impact and notice of intent to prepare environmental impact statement.

SUMMARY: The FERC has issued rules implementing Section 210 of PURPA, which provide that electric utilities must purchase electric power from and sell

electric power to qualifying cogeneration and small power production facilities. In addition they exempt qualifying facilities from State and Federal regulation of rates and financial organization of electric utilities. The rules implementing Section 201 of PURPA set forth criteria by which a cogeneration or small power production facility can qualify for these rate and exemption provisions.

The FERC has prepared an environmental assessment, in which it determined that, with the exception of new diesel cogeneration facilities, these rules will not significantly affect the environment. The FERC also gives notice that it intends to prepare an environmental impact statement (EIS) evaluating the effects of the increased use of diesel cogeneration that would result from qualification of that technology.

ADDRESS: The appendices to the environmental assessment are available at the Commission's Division of Public Information, Room 1000, 825 North Capitol St. NE., Washington, D.C. 20426.

FOR FURTHER INFORMATION CONTACT:

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Adam Wenner, Executive Assistant to the Associate General Counsel, Federal Energy Regulatory Commission, 825 North Capitol St. NE., Washington, D.C. 20426, (202) 357–9338.

SUPPLEMENTARY INFORMATION: Notice is hereby given that the Federal Energy Reguatory Commission (FERC) has prepared an environmental assessment (EA) of the rules implementing Sections 201 and 210 of the Public Utility Regulatory Policies Act of 1978 (PURPA).

The rules implementing Section 210 of PURPA provide that electric utilities must purchase electric power from and sell electric power to qualifying cogeneration and small power production facilities.[1] In addition they exempt qualifying facilities from State and Federal regulation of rates and financial organization of electric utilities. The rules implementing Section 201 of PURPA set forth criteria by which a cogeneration or small power production facility can qualify for these rate and exemption provisions.[2]

The scoping process carried out by the Commission has included the preparation of a preliminary EA which was circulated for comment on October 19, 1979. Four regional public meetings were held in which extensive comments were presented. The EA and Appendices to the EA are on file in the FERC Division of Public Information, 825 North Capitol St. NE., Washington, D.C., and are available for public review upon request. These documents are also available for public review at the following FERC locations:

Atlanta Regional Office, 730 Peachtree Building, Room 500, Atlanta, GA 30308.

Chicago Regional Office, 31st Floor, Federal Building, 230 Dearborn Street, Chicago, IL 60604.

Fort Worth Regional Office, 819 Taylor Street, Room 9A05, Fort Worth, TX 76102.

New York Regional Office, 26 Federal Plaza, Room 2207, New York, NY 10007.

San Francisco Regional Office, 333 Market Street, Sixth Floor, San Francisco, CA 94105.

Notice of Intent To Prepare an Environmental Impact Statement

The proposed rules in Docket No. RM79–54 [3] would permit all diesel cogeneration facilities to qualify. On the basis of the EA, and the comments received during the scoping process, the Commission believes that, with regard to new diesel cogeneration facilities, the rule as proposed may constitute a major Federal action significantly affecting the environment within the meaning of Section 102(2)(C) of the National Environmental Policy Act of 1969 (NEPA). Accordingly, prior to issuance of final rules on the qualification of new diesel cogeneration, the Commission will prepare and circulate an environmental impact statement evaluating the PURPA-induced environmental implications of this technology.

For further information on the environmental assessment or environmental impact statement contact:

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Upon completion of the draft EIS, notice will be given in the Federal Register, at which time comment will be solicited from Federal agencies and other interested parties.

Kenneth F. Plumb,

Secretary.

Environmental Assessment

Contents

1. Summary

Sections 201 and 210 of the Public Utility Regulatory Policies Act of 1978 (PURPA) amend the Federal Power Act to remove many of the jurisdictional provisions that act as disincentives to certain types of electric generation. The Federal Energy Regulatory Commission's (FERC) regulations implementing Section 201 (RM79–54) establish criteria for qualifying cogeneration facilities and small power producing facilities, collectively called qualifying facilities (QF).[1] The rules

[1] RM79–55, issued Feb. 19, 1980, 45 FR 12214 (Feb. 25, 1980).

[2] RM79–54, issued Mar. 13, 1980, 45 FR 17959 (Mar. 20, 1980).

[3] 44 FR 38873 (July 3, 1979).

* Available at the FERC and the regional FERC offices.

[1] A cogeneration facility produces both electricity and steam or some other useful form of energy, such as heat. A small power production facility uses biomass, waste, renewable resources (including hydropower, solar, geothermal, wind) or any combination thereof as a primary energy source;

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implementing Section 210 (RM79-55) establish rates at which power should be exchanged between QFs and electric utilities, and exemptions from certain State and federal regulations for QFs.

Issuance of rules under Section 201, acting in concert with the 210 rules, will encourage cogeneration and small power production and increase the number of such facilities in the United States. However, there are certain other incentives for such facilities even without these regulations; many cogeneration facilities have been in use for over half a century and new ones are being added, although in recent decades a considerable number have been phased out. The projected increase in facilities that will result from these regulations will provide approximately 12,000 Mw of electric capacity by 1995. This includes 5,900 Mw of industrial and commercial cogeneration, 3,500 Mw from small-scale hydropower at existing dams, 360 Mw from municipal solid waste systems, and 1,900 Mw from wind energy conversion systems.

The market projection analysis indicated that before 1995 these rules are not expected to encourage significant amounts of electrical generation using biomass, geothermal, or solar thermal and photovoltaic energy.

The Federal action requiring scrutiny under the National Environmental Policy Act of 1969 (NEPA) is a product of the rules under Section 201 of PURPA, acting together with the rules under Section 210 of PURPA. The environmental effects are not related to the total environmental impacts of the numerous technologies and facilities covered by PURPA, but only that increment of those effects that result from the incentives provided by these rules. Therefore, the environmental assessment concentrates on the PURPA-induced technologies of wind, small-scale hydropower at existing dams, municipal solid waste, and cogeneration. The results of that assessment are summarized as follows:

- Industrial and commercial cogeneration, particularly new facilities utilizing steam topping cycles, diesel engines and combustion turbines will result in slight increases in air emissions (nitrogen oxides, sulfur oxides, particulates, carbon monoxides and hydrocarbons) on a national basis. However there may be significant increases of certain pollutants (NO_x) from new diesel cogeneration on a localized basis in highly urbanized areas. Overall, QFs will have a small beneficial effect by reducing national emission levels of sulfur oxides (−0.07 percent), whereas NO_x, hydrocarbons and total suspended solids will increase slightly (0.32 percent, 0.05 percent, and 0.02 percent) respectively. On a nationwide basis, carbon monoxide emissions will remain the same.
- Wind energy systems, especially those over 5 kilowatts, may create aesthetic impacts, electromagnetic interference and conflicts in land use.
- Municipal solid waste to energy systems create localized effects due to emissions of nitrogen oxides, sulfur oxides and particulates, waste water discharges and consumptive water usage, and disposal of toxic and hazardous wastes.
- Small-scale hydropower development creates local water quality and related ecological impacts as well as potential conflicts over the use of resources. These impacts are generally not significant for existing dams (ones maintaining a constant pool), but can be significant if breached dams are rehabilitated as part of the hydropower development at a site, or if new dams are constructed.

Directly related to the energy and capacity provided by QFs are certain environmental benefits and tradeoffs that result from these rules. First, utilities will be able to defer or cancel construction of certain facilities, originally scheduled for construction between 1980-1995. These deferrals are expected to include some eleven—500 Mw coal-fired steam plants, one-1,000 Mw nuclear plant, a number of 75 Mw gas turbines, and certain large scale hydropower and combined cycle installations. All of the environmental impacts associated with the construction and operation of these facilities would be avoided.

PURPA will produce significant energy savings of non-renewable resources. An estimated 40,000 bbl/day of oil will be conserved, plus an additional 40,000 bbl/day equivalent of natural gas and 120,000 bbl/day equivalent of coal by 1995.

On the basis of the environmental assessment of PURPA-induced technologies, the Commission has made the following findings:

- The program, taken as a whole, will not have a significant impact on the quality of the human environment within the meaning of section 102 of NEPA. The Commission also has noted certain beneficial environmental impacts that may result from this program.
- Where the expected market-penetration of technologies which could qualify under this program is not expected to cause any significant environmental effects in the near term, the Commission will allow qualification of these technologies without delay.
- Where a technology is expected to cause significant environmental effects in the near term, an EIS covering the technology will be prepared and considered before the Commission acts on qualification.
- The Commission is establishing a monitoring program to alert the Commission to the likelihood or extent of market penetration by technologies which qualify under this program. This procedure is designed to produce information that may be relevant to taking appropriate action to protect the environment in the future before technologies under the program reach a stage of investment or commitment to implementation likely to determine subsequent development or restrict later alternatives.

2. Preface

Section 201 of the Public Utility Regulatory Policies Act of 1978 (PURPA) mandates that the Commission prescribe rules under which small power production facilities and cogeneration facilities can obtain "qualifying" status.[1] The proposed rules for such status in Docket No. RM79-54 were issued June 27, 1979.[2]

Section 201 of PURPA defines a "small power production facility" as a facility which:

- Produces electric energy solely by the use, as a primary energy source, of biomass, waste, renewable resources, or any combination thereof; and
- Has a power-production capacity which, together with any other facilities located at the same site (as determined by the Commission) is not greater than 80 megawatts.

A cogeneration facility is defined as a facility which produces electric energy and steam or forms of useful energy (such as heat) which are used for industrial, commercial, heating or cooling purposes.

A cogeneration or small power production facility may not be owned by a person primarily engaged in the generation or sale of electric power (other than electric power solely from cogeneration or small power production facilities).

On October 19, 1979, the Commission issued a request for further comments on its proposed rulemaking establishing requirements for determining qualifying status for cogeneration and small power production facilities. One purpose of renoticing Docket No. RM79-54 was to provide an opportunity for the public to comment on the findings of the staff's preliminary environmental assessment.[3]

While the legislation permits certain facilities to be exempt from State and Federal laws, it excludes exemptions from environmental laws. Thus, a qualifying facility may not be built or operated unless it complies with all

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and does not have a capacity of greater than 80 megawatts.

[1] Pub. L. 95-617.

[2] Small Power Production and Cogeneration Facilities—Qualifying Status, Docket No. RM79-54 (44 FR 38873, July 3, 1979).

[3] Available at the Office of Congressional and Public Affairs, Room 1000, 825 North Capitol St. NE., Washington, D.C.

applicable local, State, and Federal zoning, air, water, and other environmental quality laws, and unless it obtains all required permits.

On February 9, 1980, the Commission issued final rules implementing Section 210 of PURPA.[4] The rules provide that electric utilities must purchase electric energy and capacity made available by qualifying cogenerators and small power producers at a rate reflecting the cost that the purchasing utility can avoid as a result of obtaining energy and capacity from these sources, rather than generating an equivalent amount of energy itself or purchasing the energy from other suppliers.

The Section 210 rules also provide that electric utilities must furnish electric energy to qualifying facilities on a nondiscriminatory basis, and at a rate which is just and reasonable and in the public interest. Utilities must also provide certain types of service which may be requested by qualifying facilities to supplement or back up those facilities' own generation.

The Section 210 rules exempt all qualifying cogeneration facilities and certain qualifying small power production facilities from rate regulation under the Federal Power Act, from the provisions of the Public Utility Holding Company Act of 1935 related to electric utilities, and from State laws regulating electric utility rates and financial organization.

The implementation of the Section 210 rules is to be carried out by the State regulatory authorities and nonregulated electric utilities within 1 year of the issuance of the Commission's rules under Section 210. The implementation may be accomplished by the issuance of regulations, on a case-by-case basis, or by any other means reasonably designed to give effect to the Commission's rules.

The rules provide encouragement to the development of certain types of facilities. They do not prevent any facility which does not qualify from using cogeneration or small power production, or from using any type of fuel. The rules merely grant or deny certain benefits to certain facilities.

In this environmental assessment, the environmental effects of these rules are limited to the effects resulting from the construction and/or operation of facilities which occur as a result of the granting of these benefits, or from changes in the operating characteristics of existing facilities which results from the granting of these benefits. If a cogeneration or small power production facility would be constructed or operated without the incentives of these rules, the environmental effects resulting therefrom cannot properly be described as environmental effects of these rules. However, a technical and environmental discussion of each technology is provided whether or not its use is expected to be encouraged by these rules.

3. Introduction

3.1 Background

Numerous strategies have been adopted during the 1970's to deal with the nation's serious energy problems. These strategies have been directed toward increasing domestic energy supplies, decreasing dependence on foreign oil, expanded energy research and development, conservation, and increased efficiency of energy use.

One such strategy is a once-common industrial technology now called cogeneration—the combined production of electrical and/or mechanical energy and useful energy, such as heat or steam, through sequential use of an energy resource. An important means of conserving energy, cogeneration can increase the usable energy derived from a given amount of fuel compared to conventional generation of electricity and production of heat or steam.

Cogeneration was widely applied in the early 1900's when the majority of industrial plants generated their own electricity. In 1920, on-site industrial electrical generation accounted for about 30 percent of total U.S. electrical generation. Today, less than 4 percent of this country's electric energy is produced by industrial generation. (*1*)

Interest in cogeneration gradually waned as electricity supplied by public utilities became more available and less expensive. The cost of electricity decreased as new technologies and larger central generating stations captured increased economies of scale. For several decades electric utility rates steadily declined. The difficulties and costs of self-generation increasingly gave industrial consumers incentives to rely on public utilities.

Since 1970, however, the cost of electricity to industrial consumers has dramatically increased. Further, State and Federal government efforts to reduce institutional, regulatory and economic barriers are making cogeneration more attractive.

One barrier to cogeneration has been that, under certain circumstances, the sale of power subjected cogenerators to regulation as a public utility. This means that a cogenerator would be required to have the rates which it charged for the sale of excess power approved by a State or Federal regulatory agency. In addition to the time and expense of participating in regulatory proceedings, the cogenerator would also have to adhere to utility accounting standards and submit to the government data required of public utilities. The complications and cost of complying with these regulations in many cases could far outweigh the economic benefits to be gained by a company from cogeneration.

Many cogenerators also need to be assured that they can sell excess electricity and buy back-up power at fair and nondiscriminatory rates. In the past, some electric utilities have refused to buy or sell the cogenerated electric power or have charged high back-up rates when a cogenerator needed to buy electricity.

Section 210 of PURPA requires the FERC to establish rules to ensure fair rates for both the sale of excess power and the purchase of back-up power by cogeneration facilities. Under that Section the Commission was also given the authority to exempt qualifying cogeneration facilities from certain State and Federal regulations.

Many of the regulatory barriers that have impeded the development of cogeneration have also hindered small-scale efforts to generate electricity using renewable resources. For this reason, these sections of PURPA also apply to non-utility-owned small power production facilities that use renewable resources such as geothermal energy, wind power, solar power, municipal waste, biomass, or the hydraulic energy potential of small-scale dams to generate electricity.

3.2 Technological Aspects

(a) *Cogeneration.*—Cogeneration involves the production of both electric power and heat at a single facility through the sequential use of an energy resource. Under the PURPA definition, one of the energy streams so produced must be electricity. Steam is mentioned in the definition apparently because the cogeneration of steam and electricity is the most common industrial practice. But the production of steam is not a requirement; any form of thermal energy will suffice.

The advantages of cogeneration can be shown by considering some examples. Consider an industrial furnace used for melting glass where the glass is melted by direct combustion of a fuel, typically natural gas, and a stream of hot exhaust gases is produced; if a means could be found to harness the heat energy in the exhaust for

[4] Small Power Production and Cogeneration Facilities—Rates and Exemption, Docket No. RM79-55 (45 FR 12214, Feb. 25, 1980).

generating electricity, significant energy savings could occur.

Another example is the use of an internal combustion engine to turn an electric generator, where the hot exhaust from the engine is subsequently used. The exhaust can be directed through a heat exchanger in which water is heated to near its boiling point or boiled into steam. The hot water or steam can then be used for space heating. Again, the advantage is that energy ordinarily wasted in the exhaust is recovered and put to use. It is noted that the term "cogeneration" has only recently come into common use; previously the term "total energy system" was more common for the system just described.

The total energy system concept can be used to provide space heating, hot water, central air conditioning (through use of absorption cycle refrigeration units), and electricity for many applications. Apartment complexes, hospitals, university campuses, and shopping centers have used such systems. Although diesel engines are popular for use in total energy systems, numerous other engines have been used—for example, combustion turbines (similar to the jet engines used on aircraft) and spark-ignition engines (automobile-type engines) running on natural gas.

In the industrial sector, other forms of cogeneration provide both electricity and process steam. In a typical example, steam at a high temperature and pressure is produced in a boiler. From the boiler the steam passes through a turbine which drives an electric generator. After passing through the turbine, the steam still has sufficient energy to be used in an industrial process. Pulp and paper mills, chemical plants, and oil refineries frequently require large quantities of steam; thus cogeneration using steam turbines is sometimes practical in these industries.

Cogeneration is feasible with a variety of technologies and energy sources, including, in addition to the examples mentioned above, fuel cells, magneto-hydrodynamic (MHD) generators, solar-electric converters, geothermal energy, municipal waste, biomass and nuclear energy. The basic concept can be applied in many ways, with technical feasibility and economics being the principal selection factors.

Within the wide spectrum of possibilities, cogeneration systems can be grouped broadly into topping-cycles and bottoming-cycles. In a topping-cycle, power is generated first with the waste heat from the power cycle used to meet process heat requirements or for space heating. In a bottoming-cycle, a high temperature industrial process occurs first, and power generation is accomplished with the low temperature waste heat. Because of the low temperature of the available heat, bottoming-cycle power generation systems of practical importance are vapor systems, based upon boiling and condensing a fluid such as water (steam) or various organic fluids.

For topping-cycles, however, the power generation possibilities of practical value cover a wider range, including as a class, internal combustion engines (diesel engines, spark-ignition engines, and dual-fuel engines). Combustion turbines and steam turbine systems are another class, both back-pressure turbines and extraction turbines.

The steam topping systems have the greatest flexibility in usable energy sources. In contrast, the internal combustion engines generally require specialized fuels such as diesel fuel, distillate oil, natural gas or synthetic gas.

(b) *Small Power Production.*—The Commission rules also apply to small power production facilities. A small power production facility is defined by Section 201 of PURPA as a facility that is not greater than 80 MW and produces electric energy solely by the use, as a primary source, of biomass, waste, renewable resources, or any combination thereof.

These rules do not present an exhaustive list of specific primary energy sources. Guidance is provided in the preamble, where certain energy sources are identified as being renewable, waste, or biomass. Any form of solar or wind energy is considered renewable. Hydropower development may occur at existing dams (those currently maintaining a constant pool) or at structures built, repaired or modified after the issuance of the PURPA regulations. For the purposes of these rules, the term "biomass" means any organic material not derived from fossil fuels. A technology will fall within the biomass category if 50 percent or more of its energy content is biomass. For example, municipal solid waste conversion (MSW) may also be classified as a biomass technology as long as 50 percent of the energy input is organic material not derived from fossil fuels. Waste is defined as by-product materials other than biomass.

Small power production technologies include hydraulic turbines, wind turbines, steam turbines where energy sources can generate appropriately high temperatures, organic fluid power cycle systems for low-temperature sources such as some geothermal resources, and photovoltaic systems.

3.3 *Environmental Issues*

The environmental effects of the Commission rules for purposes of NEPA evaluation do not encompass all of the environmental impacts of the technologies encompassed by PURPA, but only the *increment* of those effects that results from the incentives provided by PURPA. As discussed in the subsequent section on methodology, this EA is concerned with these incremental environmental effects.

This environmental assessment evaluates the environmental issues raised by the Commission's rules. In promulgating the rules, the Commission used the EA to determine:

(a) the overall environmental significance of its regulatory program in implementing PURPA;

(b) the types of QFs which, as a result of the incentives under this program, will not cause significant environmental impacts, and for which the Commission prepares appropriate findings of no significant impact (FONSI);

(c) the types of QFs which, as a result of the incentives under this program, may cause significant environmental impacts. The Commission will not grant these technologies qualifying status until it completes and evaluates an environmental impact statement (EIS); and

(d) the types of QFs which, as a result of the incentives under this program, will not cause significant environmental effects in the near-term but which may have the potential to cause significant impacts in the long term. The Commission will proceed with qualification of these QFs, however, the market penetration will be monitored. If the program appears to approach a level of development likely to foreclose or restrict future alternatives, the Commission will take appropriate environmental protection action.

4. Analysis

4.1 *General Outline of Approach*

During the next 15 years (to 1995) the use of a variety of energy technologies may be stimulated by sections 201 and 210 of PURPA. The extent of PURPA stimulation effects the extent of the environmental impacts of interest here. Staff has evaluated the environmental effects of these rules in a three-step process:

(1) Identify the technologies affected by these rules;

(2) Assess the environmental effects and specific resource conflicts related to

the development of each technology; and

(3) Identify those technologies which at a predicted level of market penetration may produce significant environmental effects.

4.2 Market Penetration Analysis

The market-penetration analysis is based on the assumptions that section 210 of PURPA provides economic incentives to QFs by requiring utilities to purchase electricity from them at a price that equals the utilities avoided costs, by requiring utilities to provide fair backup rates, and by exempting QFs from certain State and Federal regulations.

The degree of growth in the various QF technologies was estimated by the following procedure:

1. Retail electric rates from utilities and utility avoided costs were projected for representative transactions between utilities and potential QFs.

2. Electricity generating costs were projected for potential QFs.

3. Technologies and regions of the U.S. were identified where prices and costs indicated an economic advantage to a potential QF.

4. Market penetration limits were established on the basis of availability of renewable resources, equipment manufacturing capacity, and technology status.

5. Net market penetration rates were estimated for those technologies and regions identified to have positive PURPA inducements.

Each of the steps in this procedure is discussed briefly below. The logic network for selecting QF technologies for evironmental analysis is shown in Figure 1.

Selling price.—The utility selling prices were based on historical data. These data present total sales and revenues by class of user. A limited trend analysis was performed with double weighting of 1977 and 1978 data because these two years were considered representative of current utility conditions. A fuel adjustment charge was added to this trend based on an estimate of oil and gas prices and their projections. Regional oil and gas prices paid by electric utilities in 1978 were adjusted to incorporate the effect of the mid-1979 OPEC crude oil price increase and the initial effects of natural gas price deregulation. These step increases were estimated as 60 percent for oil and 40 percent for natural gas. The preliminary data for 1977 regional thermal power generation by fuel type are assumed to be relatively unchanged for 1980 and were combined with the fuel price projections to obtain the 1980 incremental fuel charges. Regional variations in the use of oil and gas affect the incremental fuel charges, e.g., these charges vary from 10.8 mills/kWh in the Pacific and 7.1 mills/kWh in New England, to 0.8 and 0.9 mills/kWh in the East South Central and East North Central areas respectively. Also, the 1979 tariffs of a reference utility in each region were examined to construct a selling price for a representative large customer using the power and demand charges given in those tariffs.

Avoided costs.—Buying prices are the avoided costs. The options for avoided costs were calculated on the basis of the weighted average of oil and gas in each region, and a nominal O & M charge of 4 mills/kWh. The consumption rate of fuels was based on representative 12,000 BTU/kWh heat rate.

Generation costs for QFs.—For cogenerators the generation costs were the incremental costs associated with electricity generation. These incremental costs were determined from the capital investment for the steam generator and the turbine. The incremental capital cost was determined by subtracting from this investment the cost of a low-pressure steam generator that would be used only for meeting steam requirements of a facility that did not cogenerate, but instead purchased its electricity. The fuel charge assigned to the electricity was the net cost of fuel for that electricity. Net heat rates of 5000, 5500, and 6500 BTU/kWh were used for steam turbines, combustion turbines and diesel motor-generator sets respectively.

For small production generating facilities, generation costs were determined on the basis of the total capital investment plus any fuel charges (such as disposal costs for wastes) minus by-product credits and tipping fees (such as from scrap metal sold from solid waste plants).

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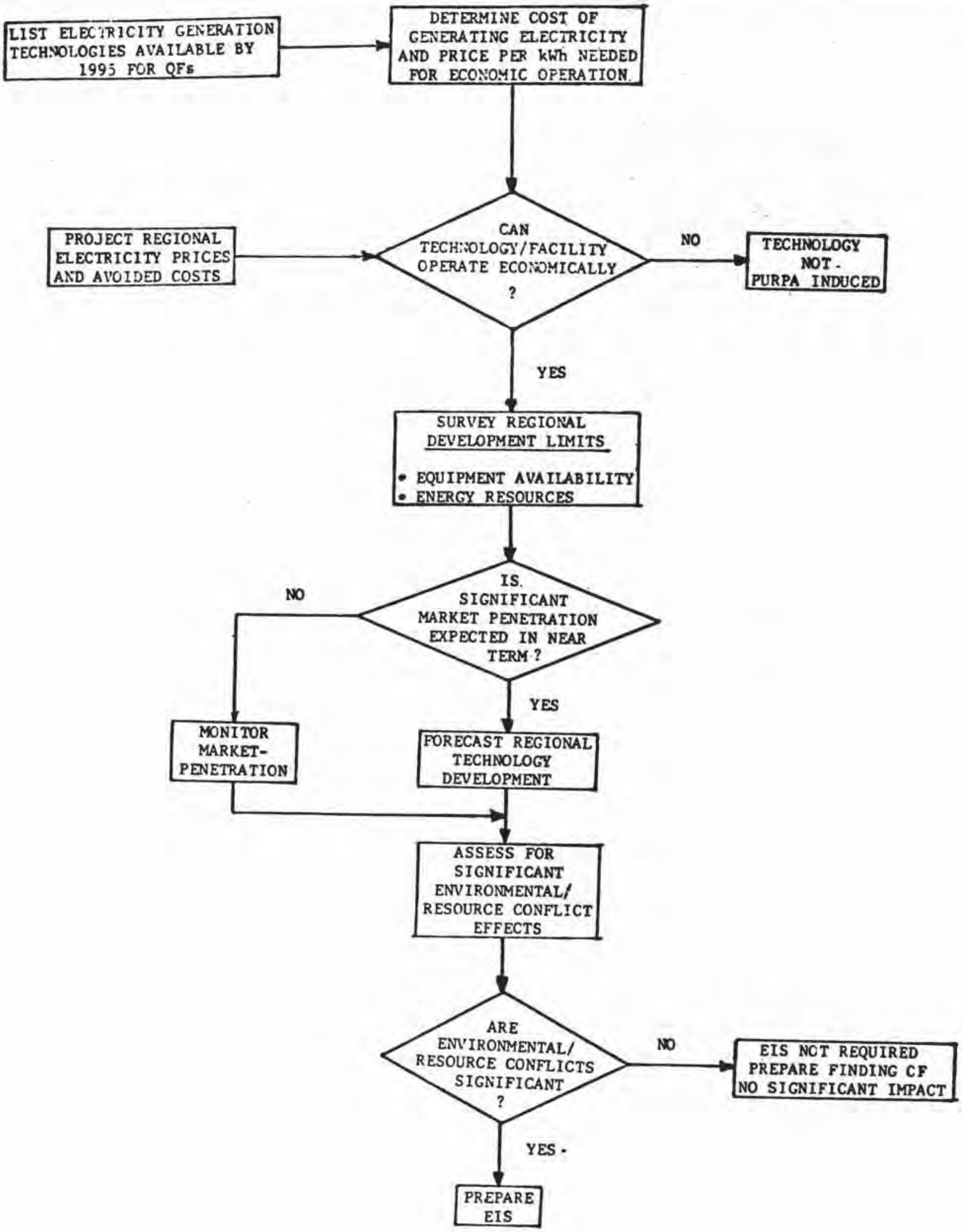

FIGURE 1

LOGIC FOR SELECTING TECHNOLOGIES TO BE INCLUDED IN AN ENVIRONMENTAL IMPACT STATEMENT

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Technologies with an economic advantage.—For cogenerators, electricity from the lowest cost technology was compared with the avoided cost in each region to determine whether or not it had an economic advantage. When such advantage appeared it was assumed that the simultaneous buy-sell privilege from PURPA would induce cogeneration. Where commercial cogeneration technologies were estimated to generate electricity at lower cost than the average commercial price obtained by utilities, it was assumed that the protection from discriminatory standby charges as offered in PURPA would act to induce commercial cogeneration, especially as it relates to diesel cogeneration. For SPPFs the costs of available technologies were compared with avoided costs; when there was an economic advantage the growth rate was attributed to PURPA.

Market penetration limits.—It was assumed that the incremental fuel for cogeneration would be oil or natural gas. For biomass the incremental fuel could be wood wastes or municipal solid wastes. For wind power and hydropower the limitation is not on fuel but on wind or water availability. For these technologies estimates of regional wind conditions and the number of existing dam sites were used. In addition there are current production capability limits on the number of large windmills and on the number of appropriate size diesel motor-generator sets that can be manufactured in the near-term. Thus wind power and commercial cogeneration growth is limited by equipment availability. For geothermal facilities, the availability of hot water hydrothermal convection resources was used, because dry steam resources are already fully exploited by utilities.

Capacity Installation.—in order to estimate the capability of U.S. industry to produce and install new electrical generation equipment, it was assumed that a doubling of the production rate for windmills and diesel motor-generator sets could be achieved every three years. This rate is typical of production rates that have been achieved historically for new products.

Results

The results of the analysis are shown in Tables 1, 2, and 3, which summarize estimated electricity production by QFs for 1985, 1990, and 1995 respectively. The results are shown by census region for each technology that may be stimulated by PURPA. Figure 2 depicts these regions and the estimated numbers and types of facilities that will be operational or deferred as the result of PURPA by 1995. Appendix A describes the methodology, analysis and estimates of regional avoided cost and electricity prices in detail.

These results indicate this program will not provide significant incentives to accelerate the development of biomass (excluding municipal solid waste), geothermal, solar photovoltaic and solar thermal. However, this program will accelerate the development of industrial and commercial cogeneration, small-scale hydropower at existing dams, municipal solid waste and wind power. Figures 3 through 7 show that significant encouragement to these four technologies will not occur in the near-term but rather indicate steadily increasing growth.

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KEY:

(+) FACILITIES IN OPERATION

IC = INDUSTRIAL COGENERATION (20-50 MW)
CC = COMMERCIAL COGENERATION (0.5 MW)
SSH = SMALL-SCALE HYDROPOWER (≤ 30 MW)
MSW = MUNICIPAL SOLID WASTE (60 MW)
LSW = LARGE WIND SYSTEMS (2.5 MW)

(-) FACILITIES NOT BUILT

C = COAL (500 MW)
N = NUCLEAR (1000 MW)
LSH = LARGE-SCALE HYDROPOWER (150 MW)
CC = COMBINED CYCLE (250 MW)
GT = GAS TURBINE (75 MW)

REGION	IC	CC	SSH	MSW	LWS	C	N	LSH	CC	GT
PACIFIC	+17	+0	+248	+4	+0	-3	-0	-1	-1	-3
MOUNTAIN	+0	+0	+58	+0	+144	-1	-0	-0	-0	-1
WEST NORTH CENTRAL	+9	+0	+6	+0	+160	-1	-0	-0	-0	-1
WEST SOUTH CENTRAL	+0	+0	+0	+0	+395	-1	-0	-0	-1	-3
EAST NORTH CENTRAL	+23	+0	+138	+2	+0	-2	-0	-0	-2	-1
EAST SOUTH CENTRAL	+0	+0	+5	+0	+0	-0	-0	-0	-0	-1
NEW ENGLAND	+4	+0	+39	+0	+15	-0	-0	-0	-1	-1
MIDDLE ATLANTIC	+17	+5000	+88	+0	+46	-3	-1	-1	-2	-4
SOUTH ATLANTIC	+0	+0	+44	+0	+0	-0	-0	-0	-0	-3

Figure 2. LOCATION, BY CENSUS REGION, TYPE, AND NUMBER OF FACILITIES THAT WILL BE IN OPERATION OR DEFERRED BECAUSE OF PURPA BY 1995.

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Table 1.—*1985 Electricity Production by QF's Resulting From PURPA*[a]

[These are estimates of the incremental increases in capacity and energy caused by PURPA]

	United States		New England		Middle Atlantic		South Atlantic		East North Central	
	MW	10^6 MWh/y	MW	10^6 MWh/y	MW	10^6 MWh/y	MW	10^6 MWh/y	MW	10^6 MWh/y
Technology Cogeneration:										
Industrial	1,136	8.5	60	0.4	288	2.1			365	2.7
Commerical	180	0.8			180	0.8				
Small Power Production Facilities:										
Biomass	0	0								
Silviculture	0	0								
Sewage	0	0								
Agriculture Residue	0	0								
Municipal Solid Waste*	0	0								
Other Wastes	0	0								
Geothermal	0	0								
Hydropower	1,180	4.2	50	0.2	190	0.2	70	0.2	197	0.7
Solar	0	0								
Photovoltaic	0	0								
Thermal	0	0								
Wind	140	* 0.4	2.5	0.007	7.5	0.02				
Total installed capacity in MW	2,636		112.5		665.5		70		562	

[a] Totals may not add because of rounding.

*When municipal solid waste is 50% or more biomass.

Table 1.—*1985 Electricity Production by QF's Resulting From PURPA*[a]—Continued

	East South Central		West North Central		West South Central		Mountain		Pacific	
	MW	10^6 MWh/y	MW	10^6 MWh/y	MW	10^6 MWh/y	MW	10^6 MWh/y	MW	10^6 MWh/y
Technology Cogeneration:										
Industrial			110	0.8					313	2.3
Commercial										
Small Power Production Facilities:										
Biomass										
Silviculture										
Sewage										
Agriculture Residue										
Municipal Solid Waste										
Other Wastes										
Geothermal										
Hydropower	17	0.7	23	0.07			150	0.5	483	1.8
Solar										
Photovoltaic										
Thermal										
Wind			32.5	0.09	70	0.18	27.5	0.07		
Total installed capacity in MW	17		165.5		70		177.5		796	

[a] Totals may not add because of founding.

* When municipal solid waste is 50% or more biomass.

Table 2.—*1990 Electricity Production by QF's Resulting From PURPA*[a]

[These are estimates of the incremental increases in capacity and energy caused by PURPA]

	United States		New England		Middle Atlantic		South Atlantic		East North Central	
	MW	10^6 MWh/y	MW	10^6 MWh/y	MW	10^6 MWh/y	MW	10^6 MWh/y	MW	10^6 MWh/y
Technology Cogeneration:										
Industrial	2,273	16.7	120	0.9	576	4.3			730	5.5
Commercial	690	2.8			690	2.8				
Small Power Production Facilities:										
Biomass	360	2.3								
Silviculture	0	0								
Sewage	0	0								
Agriculture Residue	0	0								
Municipal Solid Waste*	(360)	(2.3)							120	0.8
Other Wastes	0	0								
Geothermal	0	0								
Hydropower	2,358	8.7	100	0.4	380	1.3	140	0.5	392	1.4
Solar	0	0								
Photovoltaic	0	0								
Thermal	0	0								
Wind	550	1.46	10	0.03	32.5	0.06				
Total installed capacity in MW	6,231		230		1,676.5		140		1,242	

[a] Totals may not add because of rounding.

*When municipal solid waste is 50% or more biomass.

Table 2.—*1990 Electricity Production by QF's Resulting From PURPA* *—Continued

	East South Central		West North Central		West South Central		Mountain		Pacific	
	MW	10^6 MWh/y	MW	10^6 MWh/y	MW	10^6 MWh/y	MW	10^6 MWh/y	MW	10^6 MWh/y
Technology Cogeneration:										
Industrial			220	1.7					627	4.7
Small Power Production Facilities:										
Biomass										
Silviculture										
Sewage										
Agriculture Residue										
Municipal Solid Waste*									240	1.5
Other Wastes										
Geothermal										
Hydropower	33	0.13	47	0.16			300	1.1	966	3.5
Solar										
Photovoltaic										
Thermal										
Wind			115	0.3	287.5	0.75	105	0.3		
Total installed capacity in MW	33		382		287.5		405		1,833	

*Totals may not add because of rounding.
*When municipal solid waste is 50% or more biomass.

Table 3.—*1995 Electricity Production Resulting From PURPA**

[These are estimates of the incremental increases in capacity and energy caused by PURPA]

	United States		New England		Middle Atlantic		South Atlantic		East North Central	
	MW	10^6 MWh/y	MW	10^6 MWh/y	MW	10^6 MWh/y	MW	10^6 MWh/y	MW	10^6 MWh/y
Technology Cogeneration:										
Industrial	3,410	25.4	180	1.3	865	6.4			1,095	8.2
Commercial	2,500	10			2,500	10				
Small Power Production Facilities:										
Biomass	360	2.3								
Silviculture	0	0								
Sewage	0	0								
Agriculture Residue	0	0								
Municipal Solid Waste*	(360)	(2.3)							120	0.8
Other Wastes	0	0								
Geothermal	0	0								
Hydropower	3,540	12.7	150	0.6	570	2.0	210	0.7	590	2.1
Solar	0	0								
Photovoltaic	0	0								
Thermal	0	0								
Wind	1,900	5.3	38	0.1	114	0.3				
Total installed capacity in MW	11,710		368		4,049		210		1,805	

*Totals may not add because of rounding.
*When municipal solid waste is 50% or more biomass.

Table 3.—*1995 Electricity Production Resulting From PURPA* *—Continued

	East South Central		West North Central		West South Central		Mountain		Pacific	
	MW	10^6 MWh/y	MW	10^6 MWh/y	MW	10^6 MWh/y	MW	10^6 MWh/y	MW	10^6 MWh/y
Technology Cogeneration:										
Industrial			330	2.5					940	7.0
Commercial										
Small Power Production Facilities:										
Biomass										
Silviculture										
Sewage										
Agriculture Residue										
Municipal Solid Waste									240	1.5
Other Wastes										
Geothermal										
Hydropower	50	0.2	70	0.2			450	1.6	1,450	5.3
Solar										
Photovoltaic										
Thermal										
Wind			399	1.1	968	2.7	361	1.0		
Total installed capacity in MW	50		799		968		811		2,630	

*Totals may not add because of rounding
*When municipal solid waste is 50% or more biomass.

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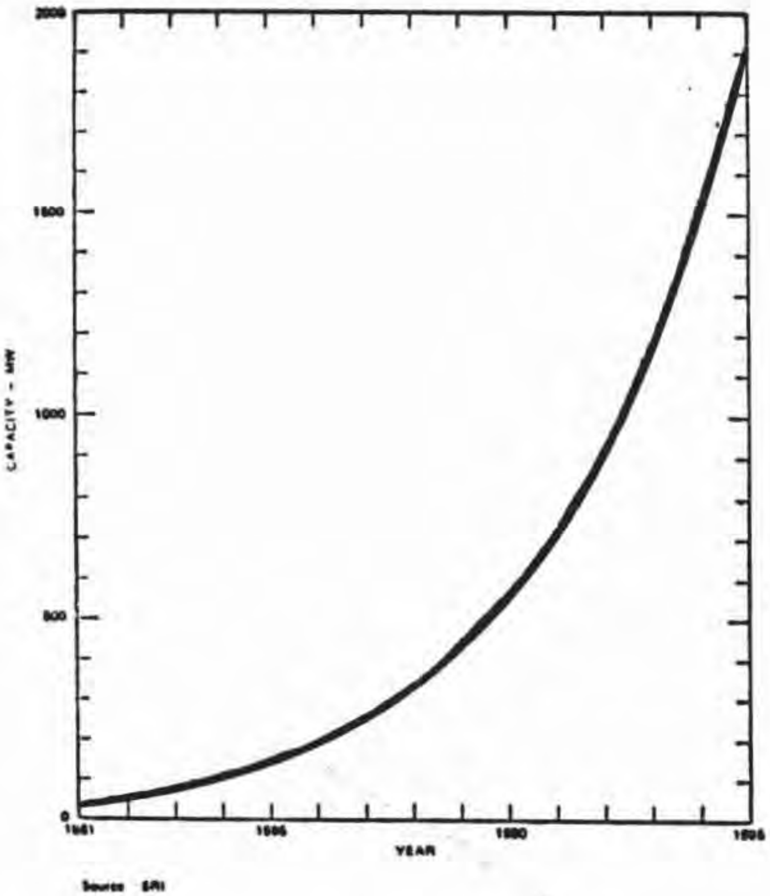


FIGURE 3. TOTAL U.S. ELECTRIC POWER CAPACITY OF WIND GENERATORS DEVELOPED DUE TO PURPA.

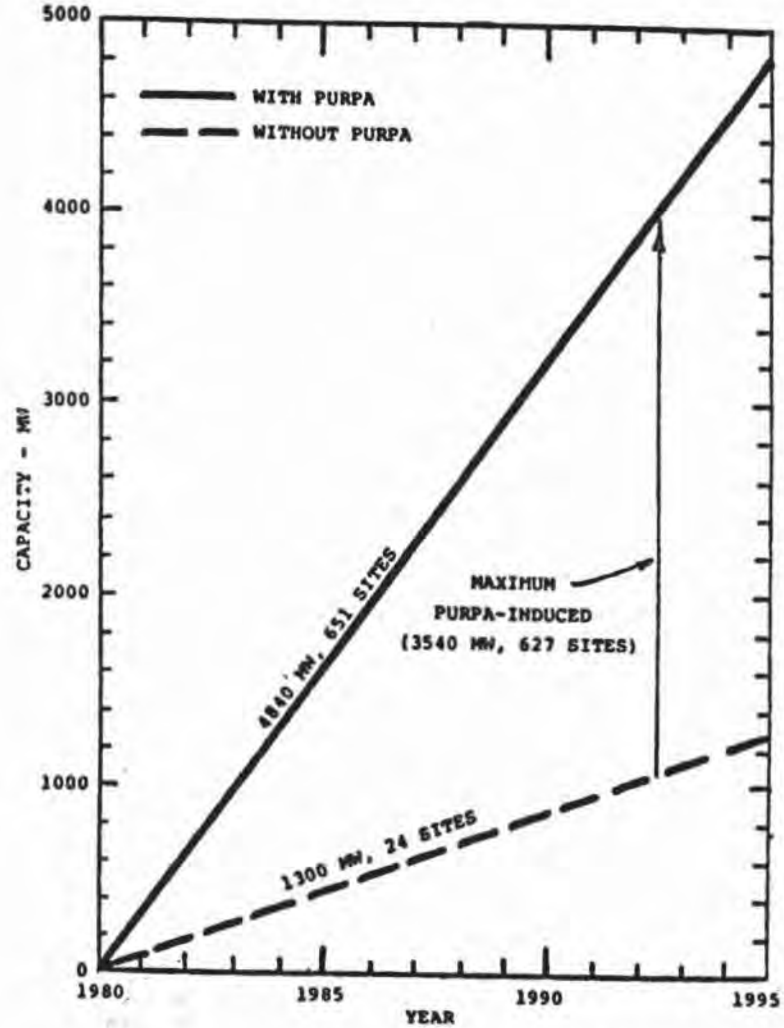
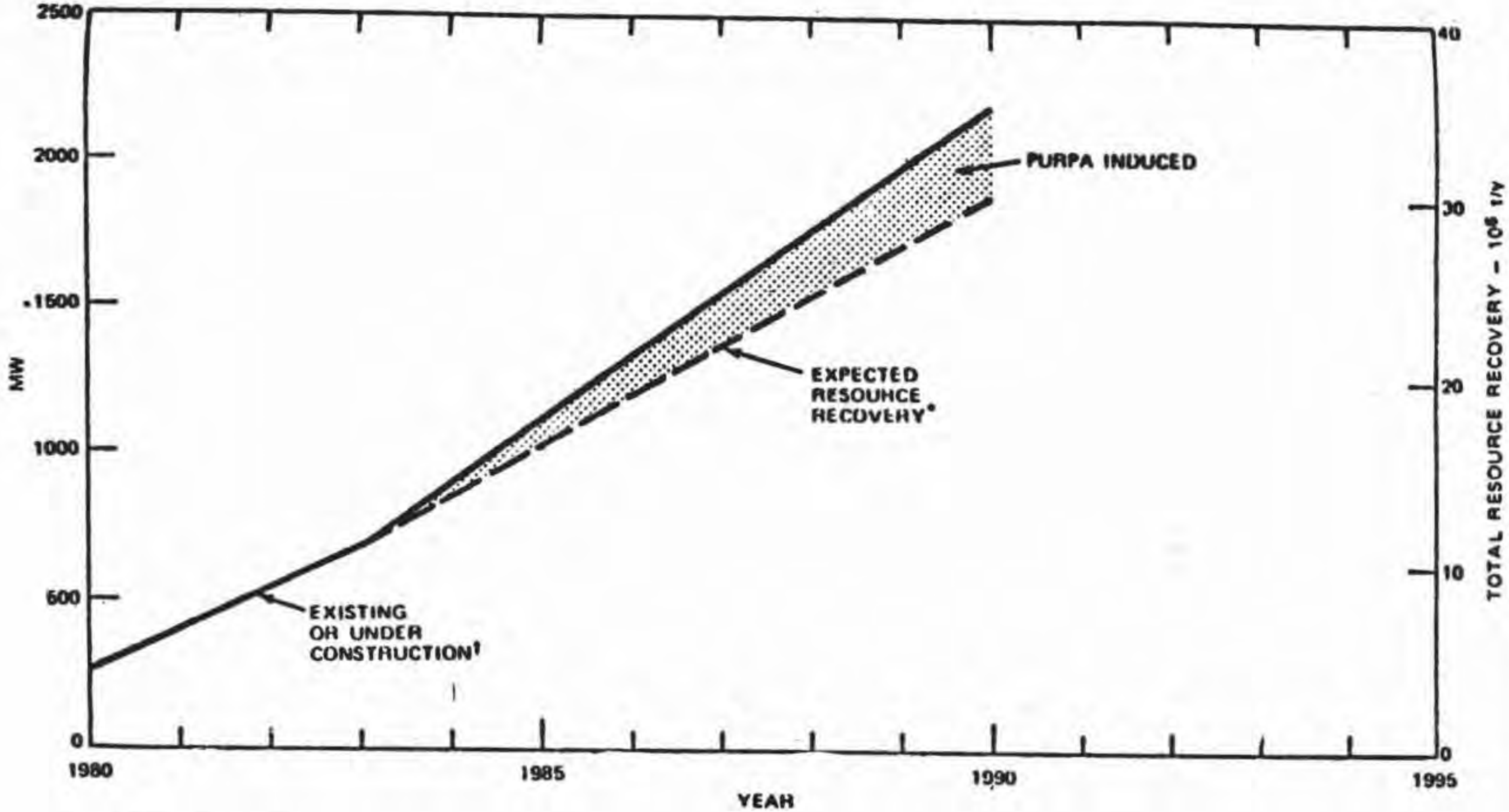


FIGURE 4. TOTAL U.S. POTENTIAL PURPA-INDUCED ELECTRIC POWER CAPACITY AT EXISTING SMALL-SCALE HYDROPOWER DAMS.



* GORDON (1978)
† NCRR (1979b)

FIGURE 5. TOTAL RESOURCE RECOVERY EXPECTED BY 1990 WITH AND WITHOUT PURPA

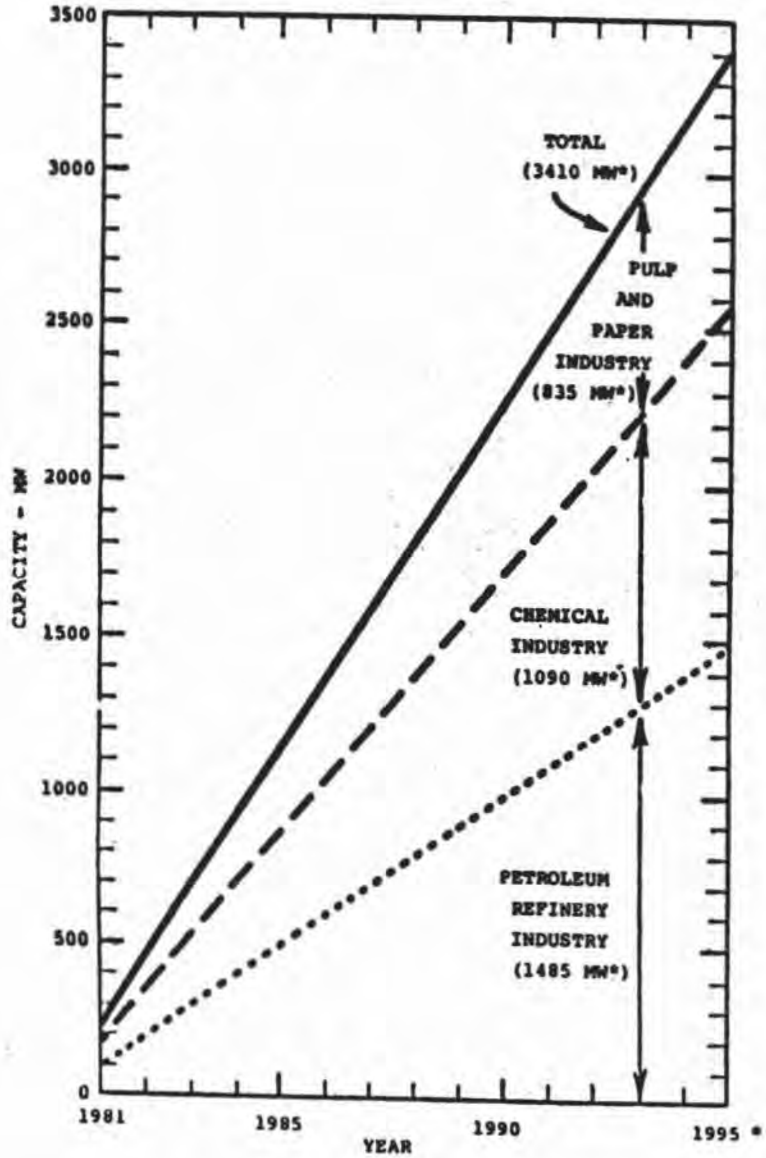


FIGURE 6. TOTAL U.S. POWER CAPACITY OF INDUSTRIAL COGENERATION UNITS DEVELOPED BECAUSE OF PURPA.

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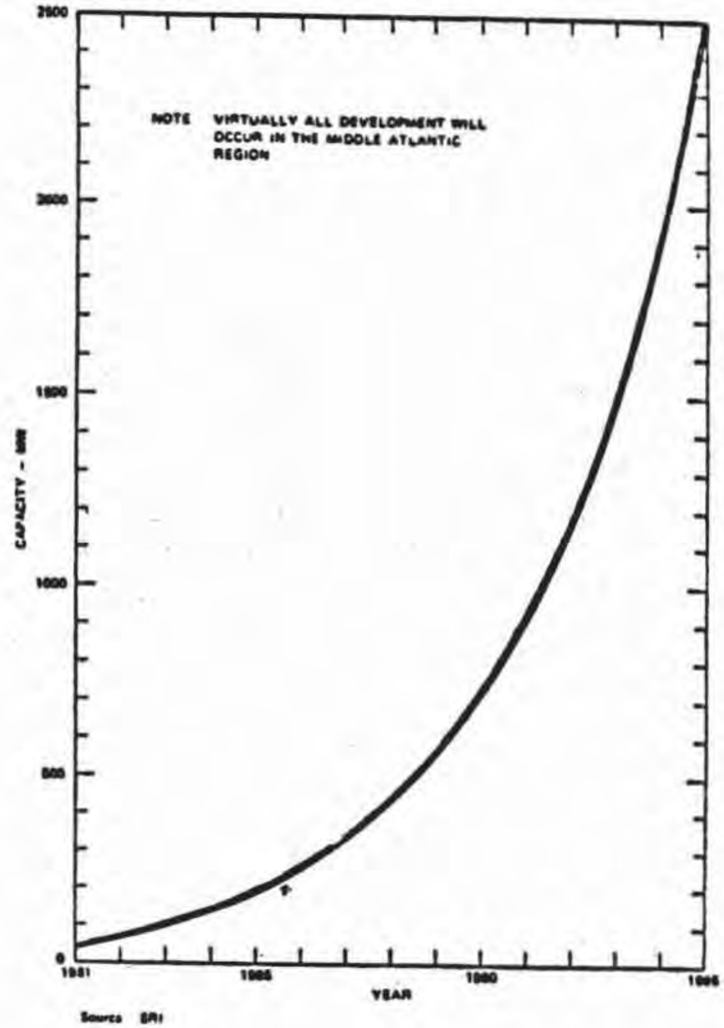

FIGURE 7. TOTAL U.S. POWER CAPACITY OF COMMERCIAL DIESEL CO-GENERATION UNITS DEVELOPED BECAUSE OF PURPA.

4.3 Environmental Impact Assessment

The environmental effects associated with the technologies eligible for qualification have been extensively analyzed by the Department of Energy and other Federal agencies.[1] These detailed assessments, appropriate EISs, written comments on the rulemakings, comments and data presented during public hearings held on cogeneration, as well as numerous other sources of information have been utilized by staff to determine the significance of the impacts associated with each technology.[2] The technologies are grouped for general discussion in three categories based upon the severity of known or potential effects that could be expected from the maximum potential development of each technology, irrespective of PURPA. PURPA-selected effects are described in the general discussion of each technology and summarized in the section on Environmental Findings.

I. *Minimal environmental effects.*—Generally small-scale facilities operating at decentralized locations close to the user. Effects will be site-specific.

II. *Moderate environmental effects.*—Mostly technologies that exist commercially, but where certain aspects of the technology may present impacts unless mitigated. Effects will usually be site-specific.

III. *Significant environmental effects.*—Deployment in sensitive areas or use of new processes may result in severe impacts.

Technologies With Minimal Environmental Effects

For these technologies, the likelihood of finding unexpected adverse environmental effects that could delay deployment is considered to be quite small. While there may be selected problems with the technologies, these are expected to be easily manageable with existing control technologies. Siting in sensitive environments will be the most difficult problem to overcome, requiring site-specific attention at the planning stage. Also, it is likely that these technologies will produce net environmental benefits as they may be substituted for existing, fossil-fuel based technologies.

Included in this group are:

- Solar Thermal Power Systems
- Small Wind Systems (<2 kW)

4.3.1 Solar Thermal Power Systems

Solar thermal systems collect and concentrate the sun's radiant energy in order to heat or vaporize a working fluid at high temperatures. The thermal energy thus produced can be applied to industrial processes directly or converted into electrical or mechanical power. Two generic methods presently exist for the utilization of solar thermal energy: the central receiver system and the distributed collector system. The central receiver, "power tower," systems may provide power up to 500 Mw. Distributed collectors are to be used in 0.5- to 10-Mw applications, powering irrigation systems or as components in total energy systems. *(3, 4)*

In the case of the central receiver, a site near Barstow, California, was selected in 1978 for a 10-Mw pilot plant. *(5)* The plant will adapt a high-temperature solar heat collection subsystem to supply steam to a turbine plant provided by a public utility. Scale-up to 25 Mw is scheduled for 1981. Operational 50- to 300-Mw systems will be ready for testing by 1983.

During 1978, dispersed power applications activity made progress toward initial operation of three large-scale total energy system experiments at Ft. Hood, Texas; Shenandoah, Georgia; and Blytheville, Arkansas. Another component of the dispersed power application are two developmental solar irrigation projects initiated during 1977 as part of the effort to provide experimental systems on privately owned and operated farms. One system, installed at Willard, New Mexico, is currently providing a demonstrated capability for using small solar thermal systems for irrigation. A second larger experiment to be located at Coolidge, Arizona, has been scheduled for operation. Lower systems costs through higher operating temperatures and high efficiencies are sought in this experiment.

Tables 1–3 indicate that solar thermal systems development will proceed without the incentives of PURPA. The basic reasons that PURPA will not induce significant development are twofold: first, the commercially economic size will probably be greater than 80 Mw. Secondly, utilities will most likely be the entities which will invest in this technology.

Key environmental concerns are:

- There are significant land and water requirements for central STPS, which may conflict with existing land use and ecosystems;
- Consequences of misdirected solar radiation from heliostat arrays pose serious health and safety problems;
- Alteration of microclimate may adversely affect indigenous flora and fauna.

4.3.2 Small Wind Systems

Wind systems or wind energy conversion systems (WECS) convert the kinetic energy of wind to mechanical motion, which may then be used to drive an electric generator. Designs under evaluation have wind-driven rotors on a horizontal or vertical axis. The horizontal-axis machines, popularly referred to as windmills and once widely used in rural areas, are the most technologically developed at present. About 70 percent of the 3,500 units currently sold in the United States each year produce less than 1 kW of power and are used to drive agricultural water pumps.*(6)*

Only selected areas of the U.S. are suitable for WECS deployment.*(7)* Wind speed variability, which effects reliability, makes small WECS more suitable for isolated or independent operations than for interconnected service.

Small WECS, for the purposes of the PURPA regulations, are those that generate 2 kW or less. Generally the diameter of the blades on these machines are between 10–25 feet, allowing them to be mounted on homes, farm buildings and short towers or telephone-type poles. Of the total 1,900 Mw expected by 1995 from all WECS (Table 3), it has been estimated that up to 50 Mw of that total can be produced by small WECS. This is equivalent to 50,000–1 kW installations that will receive encouragement from PURPA, especially from the buy-back provisions. Figure 3 shows the total installed capacity of wind generation expected during the next 15 years. In the near-term, about 140 Mw are expected, with about 5 Mw from small WECS. Appendix D contains a detailed discusion of the market-penetration analysis for this technology. A commercialization or mass-production program that can produce more cost-effective units could increase the potential for reaching or exceeding this amount of capacity.

The principal environmental, health, and safety concerns related to small scale machines are:

[1] Each technology has been the subject of a DOE Environmental Development Plan and a DOE Environmental Readiness Document. Certain technologies were also assessed in detailed Environmental Assessments and EISs.

[2] Four public hearings were held pursuant to section 210(a) of PURPA to afford an opportunity for interested persons and agencies to submit oral as well as written comments on various issues. As part of FERC's environmental scoping process, opportunity was afforded for submittal of comments on environmental issues. Meetings were held in Seattle, WA (Nov. 19, 1979), New York City, NY (Nov. 20, 1979), Denver, CO (Nov. 30, 1979), and Washington, D.C. (Dec. 4–5, 1979).

- Structural safety of the blade and tower under sudden gusts;
- Electromagnetic interference, especially to UHF and VHF video signals.

Technologies With Moderate Environmental Effects

Several technologies appear to have a moderate probability of serious adverse environmental impacts. Design options are available in most of these technologies will mitigate serious effects within acceptable control costs limits. Included in this group of technologies are:

- Fuels from Biomass,
- Photovoltaics,
- Small-scale hydropower—Category I dams,
- Energy Recovery Systems for Municipal Solid Wastes, and
- Large Wind Systems.

4.3.3 Fuels From Biomass

The biomass definition contained in the rules implementing section 201 of PURPA contemplates the use of any organic material not derived from fossil fuel including all forms of plant materials including high-yielding field crops, peat tree species and aquatic plants. Biomass conversion processes are thermochemical (direct combustion, gasification, and liquefaction) and biochemical (anaerobic, digestion, fermentation and biophotolysis). These include conversion of agricultural and municipal solid waste. Municipal solid waste is discussed later in this assessment.

Biomass offers a significant potential for reducing this country's dependence on fossil fuels through the conversion of a renewable energy source to electric energy. Conversion of forest products to electric power and steam is currently carried out at competitive costs in several parts of the United States. Residues supply fuel for the production of electricity to many U.S. industrial facilities and, in some cases, supply power to local communities from industrial or central conversion sites.(*8*)

By the end of this century, the potential contribution of biomass to the national energy requirements is estimated at 7 quadrillion Btu (quads) per year.(*9, 10*) The market projections reflected in Table 3 show that biomass-derived electricity will not be PURPA-induced at least until after 1995, except for 360 MW from MSW. The reasons for these market projections are discussed subsequently.

Biomass can be used to produce electricity in two basic ways. First, biomass must either be burned directly to produce electricity or converted into low Btu fuel gas or methane. If converted into fuel gas, this product may either be burned directly (to produce electricity) or upgraded to pipeline quality for marketing to commercial pipelines.(*11*)

Sizable amounts of organic material, such as wood residues, wood pulp, corn stalks, and other plant materials and by-products can be converted to fuel gas by either biological (anaerobic digestion) or thermal gasification processes. Wood chips and pulp materials and by-products may be converted to fuel gas by pyrolysis and methanization. Because of the seasonal nature of agricultural production, the product materials and by-products may also be seasonal and thereby limit the activity of the qualifying facility's operation. The cost of most facilities (and associated transportation systems if necessary) are very high when compared to the avoided cost, even given a range of financing success and feedstock prices. This is true even for a woodchip boiler installation which is the most efficient and inexpensive type of conversion. Most industries with suitable feedstocks, such as sugarcane operations and pulp and paper plants, are already using all of the biomass by-products for cogeneration and other in-plant needs. Therefore, PURPA incentives would not appear to resolve these institutional issues and encourage this technology.

The methanization of cattle manure from feedlots is relatively new. The amount of manure from swine and poultry operations may not be of sufficient quantity at individual locations to make it economical for a methanization plant. The size of the cattle feedlot industry in Arizona, California, Colorado, Kansas, Nebraska and Texas appear to make the conversion of cattle manure to methane economically feasible. It is possible that in areas where chicken farming is extensive, such as the Delmarva peninsula, there might be an adequate source of raw material to operate a gas plant. Because animal manure cannot be economically transported very far to a methanization plant it appears that large cattle feedlots offer the best animal source for methanization of manure. The newer feedlots produce manure with a higher percentage of sand and grit than the older concrete feedlots. This creates greater disposal problems which provides incentives for on-site conversion to fuel. Currently the few animal waste conversion systems in operation either produce fuel gas for on-site needs or upgrade the fuel gas to methane for sale to natural gas pipelines.

Sewage sludge, the sewage/water mixture produced from waste-water treatment operations, can be converted to energy either by direct combustion or from burning a sludge-derived fuel gas called digester gas. The latter method, an anaerobic process, is the most widely used conversion method and produces a gaseous mixture of methane (CH_4) and carbon dioxide (CO_2), having a heating value of 500–600 Btu/cu. ft. Based upon the amount of sludge produced in a waste-water treatment plant, the electric power generated on site from digester gas only meets about 70 percent of the total daily electric power demand of a plant. Since the availability of the feedstock sludge, is relatively fixed, there is no apparent way to produce excess digester gas-derived electricity for off-site sale.

Potential environmental effects from conversion of biomass into electric energy may arise at three district stages: (1) biomass production, (2) biomass transportation, and (3) biomass conversion.

Production and transportation of the biomass fuel, from the harvest area to the point at which it will be processed, will impact air quality. Other aspects of the environment may be effected due to development of new communities, roads, railroad facilities, and other infrastructures.

In most cases, however, biomass energy conversions systems utilizing biomass that would otherwise be disposed of would have net environmental benefits due to reduction of current disposal problems for these materials and the infrastructures needed to carry out that disposal.

The impact of biomass conversion on the atmosphere is critical in the commerical development of biomass use. Direct combustion of biomass can emit quantities of carbon monoxide, partially burned hydrocarbons and particulates, and lesser amounts of nitrogen oxides and sulfur oxides as air pollutants. Other thermochemical conversion processes (gasification, pyrolysis, and liquefaction) emit potentially harmful pollutants such as phenols, photochemically reactive compounds, and potential carcinogens; tars and oils are also generated. Very little work has been done to characterize and monitor the production of pollutants from processes utilizing biomass feedstocks and to develop appropriate control technologies or disposal practices.

The major potential water quality impact of intensive forest cultivation for biomass production is sedimentation in surface water caused by rain erosion or irrigation runoff from exposed soils. The sediment loads from large energy farms may be of equal, or even higher, magnitude to that of conventional crop or forest lands since residual materials, which normally protect the soil from wind and water erosion, are removed.

Major environmental concerns related to biomass development are as follows:

- Emission of undesirable quantities of CO, hydrocarbons and particulates from direct combustion of biomass.
- Clear-cutting with removal of all slash causes a loss of ground cover that leads to faster runoff, increases soil erosion, degradation of water quality, and destruction of ecosystems sustained by the decaying organic material.
- Soil erosion carried by the action of wind and water on open farmland following removal of crops can lead to increased particulate air pollution, increased sedimentation of surface water supplies, and impaired productivity of exposed cropland due to loss of soil, organic binders, and nutrients.
- Effluents emitted from the operation of anaerobic digesters can cause degradation in water quality.
- The liquefaction and gasification of biomass may produce gases and oils that may be hazardous to health and safety and to ecological communities.
- Large land and water requirements for terrestrial biomass production may create significant ecological disturbance. A 50 Mw biomass fueled plant, for example, could require up to 25 square miles of production land, and create resource conflicts.

4.3.4 Photovoltaics

Photovoltaic technology includes the collection of incident solar radiation, its conversion to electrical energy by means of photovoltaic cells, and alteration of the resultant electrical energy to a form compatible with the desired application. It also may include storage of the energy produced. (*8, 12*)

The major types of technologies that may be commercially available are:

1. Flat panel arrays with silicon cells or cadmium sulfide and other thin film photovoltaic cells.

2. Concentrating arrays using silicor or gallium arsenide films.

3. Combined collectors employing solar-thermal components as well as photovoltaics.

Numerous technological breakthroughs will be necessary before there is widespread development of photovoltaic systems which will be interconnected to utility grids.

Projected growth in this technology within the next 10–15 years appears to be in remote, non-grid-connected applications. Table 3 reflects this by showing no significant electricity production due to PURPA through 1995.

A salient feature of the photovoltaic technologies is the relative absence of hazardous residuals at the end use. The only significant pollutant is heat, released from the collectors to the atmosphere.

The most serious environmental concerns with the use of photovoltaics are:

- Large land requirements per kilowatt;
- Microclimatic and ecological changes where large arrays are deployed;
- Health and safety hazards due to accidential over-temperature conditions in an array; and
- Mining operations to support manufacture of silicon, cadmium and other components of the cells.

4.3.5 Small-Scale Hydropower—Category I

Two categories of small-scale hydropower dams have been identified for purposes of this assessment. Category I dams currently maintain a pool and would not be repaired or modified to increase the normal maximum surface area or normal maximum surface elevation. Category II dams either, (1) are not in existence and impounding water on the date of issuance of regulation allowing qualifications of Category I structures, or (2) require repairs or modifications to increase or maintain the normal maximum surface area or maintain the normal maximum surface elevation of its impoundment. Partially or totally breached dams fall within Category II, which are discussed on page 41. In almost all cases, both categories of dams require a license from the FERC.

There are approximately 5,000 existing dam sites in the United States in the capacity range of 0–25 Mw at which approximately 8,800 Mw of hydropower could be developed. (*13, 14*) Small-scale dams, generally less than 65 feet in height with impoundments of 500 acres or less, can be developed for local power supplements in at least four ways: (*15*)

a. Reactivation of the many existing hydropower stations with installed, but idle, turbines and generators;

b. Installation of turbines in outlet works;

c. Use of a siphon to move water over a dam and through a bulb turbine; and

d. Construction of a power house with tube turbines driven by impounded water flowing through offset piping.

The market penetration analysis has forecasted PURPA-induced hydropower development at existing dams of 1,180 Mw by 1985, 2,358 Mw by 1990, and 3,540 Mw by 1995 (Tables 1, 2, 3). This represents a significant proportion of the overall small-scale hydro capacity projected by the year 2000. Appendix F contains a detailed discussion of the market-penetration analysis for this technology.

Of the 627 sites expected to be developed due to PURPA by 1995, shown in Figure 4, 83 percent (520) are in the capacity range of 0.05–15 Mw, 15 percent (92) would have capacities of 15–25 Mw, and two percent (12) would be as large as 30 Mw. Based upon the projected rate of development shown in Figure 4, it appears that about 185 Category I dams could be developed due to PURPA in the near-term, with the majority of these sites in five regions: New England (12); Middle Atlantic (30); East North Central (40); Mountain (15); and Pacific (88).

These hydroelectric facilities may impose various degrees of control on the streamflow. Minimal modifications would involve rerouting water from a spillway through a turbine without changing the downstream flow. This run-of-river mode contributes to base load power generation. However, peak load production could involve fluctuations in the impoundment level and downstream flow that could be environmentally damaging. (*16, 17*)

Environmental effects associated with retrofitting and management of Category I hydropower plants are as follows:

- Aquatic and semiaquatic organisms may be adversely impacted if reservoir level fluctuations occur. Careful design and management would limit the fluctuations to variations caused by peak demands. The presence of endangered species will bar development in some locales.
- Downstream environment and ecosystems could be impacted from the release of abnormal amounts of impounded chemicals, sediments, and silts.
- There may be conflicts with established recreational use of impoundments.

In almost all cases, these facilities must obtain a license from the FERC because of the breadth of the licensing requirements under section 23(b) of the Federal Power Act. Since the application for license must involve an environmental report that discusses the environmental effects listed above, early identification of issues, results and problems can be eliminated or mitigated prior to construction. A detailed environmental assessment of the development of small-scale hydropower is included in Appendix G.

4.3.6 Municipal Solid Waste (MSW)

Organic materials can be converted into fuel gas which can be used to fire boilers to produce electricity. The fuel gas generally would be of low-Btu content. Municipal solid waste can be burned to reclaim energy that can be converted into electricity. (*18*)

Many of the basic environmental issues and problems are similar to those occurring in the biomass technology since similar processes may be used to convert the organic material to useful energy sources.

Currently, less than 1 percent of the Nation's total MSW is processed for energy recovery, although up to 65 percent of the energy contained in MSW, 1.95 quads per year by the year 1985, is deemed to be recoverable. Current estimates indicate that about 0.33 quads will be recovered by 1985 if the DOE and EPA programs for MSW energy recovery are successful. Table 3 shows that PURPA will encourage the development of 360 Mw of electricity by 1995. Figure 5 shows that in the near-term PURPA-induced capacity will first become evident around 1983, with under 100 Mw of capacity by 1985 due to PURPA. Appendix E contains a detailed discussion of the market-penetration analysis for this technology.

The basic processes for converting MSW to energy are combustion, pyrolysis, and bioconversion. The latter two processes require some mechanical preprocessing to separate the MSW into a refuse derived fuel and noncombustible materials. Ferrous metal is routinely recovered today, and the technology program will encourage the increased recovery of energy-intensive materials such as aluminum and glass.

Combustion in waterwall boilers is the most developed of the energy recovery processes, with eight plants commercially operating in the United States. Co-combustion with coal in existing suspension-fired furnaces is being demonstrated at several locations. One advantage of co-combustion is that the low sulfur content of urban waste can be used to offset the sulfur emissions from coal combustion. Qualification of co-combustion activities would be subject to fuel use standards.

Several pyrolysis processes have been tested in pilot plants. These include the Refu-Cycles, Occidental (Garrott), Purox and Landgard systems. They vary in input material requirements, costs, energy and environmental results. The Purox and Refu-Cycles processes produce low-Btu gas, the Occidental process produces oil, and the Langard process produces steam using on-site auxiliary boilers. (*19*)

The pyrolysis concept has a reduced potential for air pollution compared to incineration systems. The Landgard system, however, has caused some air pollution problems from on-site waste heat boilers. Where chars are produced, they represent a potential heavy metals pollution source. The Purox and Refu-Cycles slugging process produces a sterile, chemically inert material which should reduce pollution problems. However, quenching of the by product material may represent a minor environmental problem in liquid effluent disposal. The full effect of pyrolytic products on the environment is still unknown.

All municipal waste energy recovery processes (except those recovering methane from land fills) reduce landfill requirements.

There are four areas of environmental concern:

- Air emissions (fly ash, hydrocarbons) from combustion and pyrolysis processes may impact ambient air quality in urban areas.
- Effluents from bioconversion, combustion, and pyrolysis processes and disposal sites may pose a hazard to water resources and ecosystems.
- Landfills and impoundments of waste process residuals may pose a hazard to water supplies through leaching.
- Mechanical preprocessing may pose an industrial health hazard and cause siting problems.

4.3.7 Large Wind Systems

Large WECS, with blade diameters up to 300 feet can generate up to 3 Mw of power. Test units of various sizes and configurations with capacities of up to 2 MW have been installed. Tests on 8 kW and 200 kW systems are scheduled to be completed in the FY 1980–81 time, frame. As shown in Table 3, PURPA is expected to encourage the deployment of 1,900 Mw of wind generation by 1995, concentrated in the West South Central (1,000 Mw), West North Central (420 Mw), and Mountain region (360 Mw). As indicated previously in the discussion on small WECS, about 50 Mw of these totals could be from small systems.

Figure 3 shows the total installed capacity of wind generators expected during the next 15 years. In the near-term about 140 Mw are expected, with about 95 percent generated by large wind systems, especially those in the 2.5 Mw range. Appendix D contains a detailed discussion of the market-penetration analysis for this technology.

Large WECS require up to 40 acres per unit. Wide scale commercialization will require extensive manufacturing with associated environmental control costs. (*20*) The other principal concerns related to large scale wind systems are:

- Unresolved conflicts related to land use and the alternate uses of proposed sites and associated resources, specifically in the northeastern U.S.
- Structural safety of the blade and tower under sudden gusts.
- Electromagnetic interference, especially to UHF and VHF video signals, may limit acceptance of WECS.
- Visual impacts will require particular care in siting, especially for large systems or arrays.
- Noise becomes an increasing problem as the size of the WECS increases.
- Potential hazard to low-flying aircraft and birds.

Technologies With Significant Environmental Effects

Technologies for which the probability of adverse environmental effects is relatively high are:

- Geothermal,
- Cogeneration,
- Small-scale, hydropower—Category II dams.

Site location, controls and disposal techniques present problems on a selective basis that can delay deployment on a commercial scale, and some local and institutional impacts may be of major societal importance.

4.3.8 Geothermal

Geothermal resources are convective systems of water or steam trapped in fractured rocks or sediments by impermeable earth layers. A geothermal resource is classified as "vapor" or "liquid" dominated, according to the physical state of the fluid released when such systems are tapped by drilling. Large scale utilization has only recently been demonstrated in the United States, but has been successful in New Zealand, Iceland, Mexico, and Japan. (*8*)

At present, the only geothermal power plant in the United States is the 900 Mw hydrothermal plant located at the Geysers in California. However, DOE has estimated that by 1990, the electrical generation from geothermal sources could rise to 9,490 Mw (5,940 Mw in California and Hawaii, 2,350 Mw from the Midwest, and 1,200 Mw from the Gulf Coast). (*15, 21*) Table 3 indicates that none of this capacity is expected to be influenced by PURPA since most installations, to be economically viable, will be larger than 30 Mw.

A recent estimate of total geothermal resources in the United States shows a potential for generation of about 3,400 quads (10^{15} Btu). (*22*) The hot geothermal fluid may be used either to generate electricity or for space and industrial process heat. Geothermal resources suitable for heating applications (50°C to 150°C) are more numerous than those for electric generation which requires higher temperatures.

Three types of conversion cycles can be used in the application of geothermal energy for the generation of electricity:

1. Dry Steam: Scrubbed steam drives a turbine generator, with condensate water used for cooling;

2. Direct flash: High-temperature steam is produced by flashing the brines from a well; the spent brine may be reinjected;

3. Binary cycle: This system, generally employed to utilize lower temperature brines, uses secondary fluid in a closed system. The secondary fluid (isobutane, propane, Freon, or ammonia) is vaporized via a heat exchanger. The brine side of the heat exchanger may operate as a closed system by having the spent brine injected into a disposal well.

The relative importance of the environmental problems associated with geothermal energy are dependent on the conversion cycle used and are also highly site-specific; water requirements and airborne emissions, particularly hydrogen sulfide (H_2S) are of major concern in all cases. (*23, 24, 25*) The continued operation of the present plants at Geysers, California, is contingent on successful demonstration of the H_2S emissions abatement system.

Primary environmental concerns are as follows:

- Fugitive airborne emissions and objectionable odors are present from all conversion cycles.
- Effluents from cooling tower drifts may affect local ecology and human health.
- Waterborne effluents, spent brine (direct flash and binary cycle techniques), and secondary fluids will require great care during disposal or replacement.
- High noise levels, particularly with the dry steam cycle.
- Possible enhanced seismicity and subsidence can result from either extraction or reinjection of subterranean brine.
- Water requirements for cooling towers may pose resource conflicts since most of the prime geothermal sites are in water-deficient areas of the U.S.

4.3.9 Cogeneration

The majority of cogeneration installations are expected to be based upon the use of fossil fuels, in conjunction with steam turbine systems, combustion turbine systems, or internal combustion engines. However, because there is no restriction on the size of a qualifying cogeneration facility, there may be a greater magnitude of effect at a particular site for a cogeneration facility than for equivalent generation by a group of dispersed small power production facilities. Also, a cogeneration facility is likely to be in an industrial or populated area. This can be a factor in assessing its overall environmental effect.

Conventional generation of electric power, whether by steam turbines, combustion turbines or diesel engines, produces more than half of the primary energy consumption being discharged into the environment in the form of low-grade heat. Cogeneration facilities utilize this heat.

A further benefit available from cogeneration plants is reduced transmission losses due to the proximity of the plant to its load center.

The national potential for cogeneration in the industrial sector could be 16,600 Mw by 1995, of which 3,410 Mw would be PURPA-induced (Table 3). (*26, 27*) The three largest industrial segments that are likely to participate in PURPA-induced cogeneration are the pulp and paper, chemical, and petroleum refining industries. The primary fuels that would be used as input energy by these industries and the types of cogeneration technology utilized will vary. In general, pulp and paper plants and petroleum refineries will utilize steam-topping boiler cycle installations, with pulp and paper plants using wood and other process by-products, augmented with oil or gas for an estimated capacity of 835 Mw. Petroleum refineries will generally use various refinery products and off-gases derived from petroleum to fuel an estimated capacity of 1,485 Mw. The chemical industry is expected to cogenerate with either gas-fired combustion turbines or steam-topping cycle installations using various process-derived fuels or natural gas. Each type of facility is estimated to produce about 50 percent of the 1,090 Mw of capacity projected from the chemical industry. Figure 6 shows the relative capacity contribution of each industry. Appendix B discusses the market penetration analysis for industrial cogeneration.

The market penetration analysis shows that PURPA will induce 2,500 Mw of commercial cogeneration by 1995, almost exclusively in the Middle Atlantic Region. Diesel engines and dual-fuel use engines are likely to be the primary equipment choice for commercial cogeneration. Commercial cogeneration users will use natural gas as a fuel for dual-fuel engines whenever gas is available or less expensive than diesel fuel. In rural areas and in some urban areas of the Middle Atlantic region, no natural gas pipelines exist, and distillate fuel will be used. Thus, in these areas cogenerators will choose diesel engines. In large urban areas, because natural gas is available for potential cogenerators, congenerators will install dual-fuel engines to take advantage of low-priced natural gas, even though a dual-fuel engine costs 20% to 30% more initially. The percentage of the commercial capacity that will be developed in rural or small urban areas, is difficult to determine; however, it is estimated that cogeneration in larger urban regions may account for 25% to 75% of the total 2,500 Mw by 1995. It is expected that PURPA will act to encourage the use of diesel engines for commercial cogeneration, but that other factors, expecially favorable natural gas prices, will act as overriding incentives for development of dual-fuel type cogeneration. On this basis, and for the purpose of this assessment, all PURPA-induced cogeneration is assumed to be diesel powered. Figure 7 depicts the development of this technology in the commercial sector. Appendix C discusses the market-penetration analysis for commercial cogeneration.

If cogeneration were not used, a facility would utilize a low-pressure steam boiler, or a furnace, to obtain its thermal requirements, and would purchase electricity from a utility. The environmental effects of cogeneration are therefore limited to any increases or qualitative changes in the type or quantity of emissions produced by cogeneration, rather than that from the separate production of thermal energy and utility electricity.

A common characteristic of cogeneration systems is that the electrical generation equipment is located at a site at which a non-congeneration facility would otherwise be used to supply thermal energy, with the result that little or no new land use impact is involved. The resulting reduction in demand upon the utility grid reduces the requirement for central station generating capacity thus conserving land and reducing associated pollutant emissions.

Bottoming-Cycle Cogeneration

In a bottoming-cycle cogeneration facility, electricity is generated from a source of waste heat—typically a stream of hot gases emitted from an industrial process heating facility. For example, bottoming-cycle equipment can be retrofitted to such industrial heating processes as annealing furnaces, cement kilns, and glass production furnaces. If retrofitted to an existing industrial facility, a bottoming-cycle is unlikely to lead to an increase in environmental emissions since no additional fuel is burned. Even in new facilities, the use of bottoming-cycle equipment is unlikely to lead to increased fuel use and resulting emissions since most industrial heating processes cannot be substantially modified to operate at higher temperatures.

In both retrofit and new bottoming-cycle applications, additional fuel can be burned as supplementary firing. In this case, fuel is burned to increase the efficiency of the electrical generation equipment. No extra heat is added to the industrial thermal process. Supplementary firing is not expected to result in significant air quality effects, because the fuel is burned in an external combustion application since internal combustion engines are not suitable for bottoming-cylce use.

Little market penetration is projected for bottoming-cycle cogeneration. Industries generally can find other ways to use waste heat (such as combustion air preheating) that cost less than bottoming-cycle equipment. Additionally, as energy costs increase, conservation practices will reduce the amount of waste heat available for use in bottoming-cyle facilities.

Topping-cycle Cogeneration

Topping-cycle facilities utilize the energy input first to produce power, and then use the waste heat from power production to provide useful heat. For steam turbine systems, the fuel combustion system is essentially a boiler. The emissions are identical in nature to the emissions of an industrial boiler facility producing steam alone, without cogeneration. By adding cogeneration equipment, however the industrial facility burns somewhat more fuel than a facility producing industrial process steam. Thus the quantity of emissions may be increased while the characteristics remain unchanged. Table 4 shows the relative emission rates for the major classes of topping-cyle prime movers.

In general, the environmental effects of fuel-burning steam cogeneration can be pictured as a moderate increase in the fuel consumption and stack emissions of a large industrial facility. However, the total emissions will be less than those which would occur if the power and heat systems operated separately. In addition, the resulting reduced demand upon the utility grid generally results in less consumption of fuel by the utility and hence less environmental effects.

For cogeneration facilities employing internal combustion engines or combustion turbines, the emissions will be essentially the traditional outputs from these units. Since diesels produce a very high ratio of electricity to thermal energy and, further, cannot produce the moderately high temperature and pressure steam needed for some industrial applications, these units are not expected to find much industrial cogeneration use. Combustion turbines will be more common in industry, especially where a relatively high ratio of electrical to thermal output is desired and the requirement for premium fuels poses no special problem. The environmental effect of the cogeneration equipment is not likely to be significant.

Table 4.—*Emission rates (g/kWh) of topping-cycle prime movers*

	SO_2[1]	NO_x[1]	CO[1]	HC[1]	TSP[1]
Steam-Topping-Boiler (Oil)	0.88	0.19	0.05	0.03	0.09
Steam-Topping-Boiler (Gas)	0.0009	0.19	0.03	0.01	0.03
Diesel (Oil)	1.12	17.30	2.41	(4)	0.30
Dual Fuel Engine[2]	0.11	11.00	2.68	(4)	(4)
Spark Ignition (Gas)[3]	(4)	4)	(4)	(4)	(4)
Gas Turbine (Oil)	1.28	3.05	0.69	(4)	0.22
Gas Turbine (Gas)	0.003	2.09	0.69	(4)	0.07

[1] SO_2 (sulfur dioxide); NO_x (nitrogen oxides); CO (carbon monoxide); HC (hydrocarbons); TSP (total suspended solids).
[2] Dual fuel engines normally operate on a mixture of approximately 90 percent natural gas and 10 percent diesel oil.
[3] Emission characteristics are similar to those of dual fuel engines.
[4] No data.

General Operating Conditions

Cogeneration facilities may use a variety of fuels. For example, steam turbine systems can burn any fuel. Combustion turbine systems, and spark-ignition internal combustion engines, and dual-fuel engines burn liquid and gaseous fuels—chiefly distillate fuel oil and natural gas. Diesel engines ordinarily burn distillate fuel oil. The industrial or commercial application process, the cogeneration technology, and the fuel selection and controls used, all determine the environmental characteristics.

With regard to application of this technology in commercial settings, typical applications include large apartment complexes, university campuses, hospital facilities, and shopping centers. Since the primary product desired is electricity, and the thermal output need not be at a high temperature, gas-fuel internal combustion engines or diesel engines are the favored prime movers. Major environmental problems are not likely to arise from individual units but could arise from a number of installations in a single airshed.

A number of factors may interact to produce adverse environmental impacts from a topping-cycle cogeneration facility. (*28*) These factors include the following:

- *Type of prime mover.*—Diesel engine, dual-fuel engine, spark-ignition engine, or combustion or steam turbine.
- *Fuel use.*—Light petroleum fractions and natural gas are the most common fuels although some large facilities may be able to burn lighter grades of residual oil.
- *Type of pollution control equipment.*—Numerous technologies exist for control of pollution from such facilities. Catalytic converters similar to those used in automotive applications are feasible for the control of some pollutants (chiefly hydrocarbons and carbon monoxide). Other means are available to control particulate emissions.
- *Siting.*—In urban areas, adjacent structures can cause the exhaust to downwash to ground level or alternatively the exhaust plume may impinge upon other downwind structures.
- *Stack height.*—A tall stack can mitigate the air stagnation and blocking effects of nearby structures in an urban location.
- *Atmospheric conditions.*—Wind speed, air stability, air temperature, humidity, and solar radiation.

Diesel Engines

Diesel cogeneration units employ an exhaust heat recovery boiler or a water jacket heat exchanger to generate steam or hot water from the heat rejected by the diesel engine. Currently, standard industrial diesel engines burn only distillate fuels. The future adaptation of heavy residual oil-fueled diesel engines to industrial cogeneration applications appears promising. The major emissions from diesel engines are particulates, nitrogen oxides, gaseous hydrocarbons, sulfur oxides, carbon monoxide, odor constituents, and noise. Currently, a significant contribution to the total atmospheric concentrations of the first three pollutants emanate from diesel sources, as shown in Table 4.

The emissions from diesel engines has been most effectively controlled by modifying the combustion process itself rather than the post-combustion stage. However, current research indicates that more time will be required before a satisfactory technical solution to the diesel emission problem can be attained.

In major high-density urban areas, the significance of environmental impact from an air quality point of view will be a function of the number of diesel units operating and the efficacy of environmental controls utilized. The national ambient air quality standards within a region will become a controlling factor for the potential number of units which may be sited therein. (*29*) Noise levels and odor also pose environmental problems in urban areas. Noise impact and annoyance factors can be particularly serious from residential and commercial cogeneration facilities due to induced piping or building vibrations.

Dual-Fuel Engines

A dual-fuel engine can operate on either fuel oil or natural gas and a small quantity of oil known as pilot oil. During fuel oil operation, a dual-fuel engine operates essentially as a diesel engine. During gas operation, the engine operates much as a spark-ignition engine, with ignition accomplished by an injection of pilot oil rather than a spark. The pilot oil serves only to ignite the gas-air mixture and contributes only a small percentage of the total energy input during full-load operation. Typically, conversion from one fuel to another is automatic. Should gas pressure decrease to some predetermined level, a control valve automatically shuts off the gas and the engine reverts to diesel operation.

Dual-fuel engines are more costly than either diesel or spark-ignition engines. They are typically installed when natural gas is available at lower cost than fuel oil but on an interruptible basis. The efficiency of a dual-fuel engine operating at full power is approximately the same as that of a diesel engine of similar size. However, at partial loads the performance decreases in the same manner as a spark-ignition engine.

The environmental impact of dual-fuel engines clearly depends upon the fuel use, in addition to the other engine parameters such as size and speed. Table 4 shows that when operating in its normal mode (90/20 mixture of natural gas and diesel oil) SO_2 emissions are significantly lower than a diesel, and NO_x is about one-third less. Generally, natural gas is available during the spring, summer, and fall. Interruption of gas supply, with the resulting diesel operation, would likely occur during the winter, if at all. This fact should mitigate the air quality impacts, since gas operation would be the norm during the summer months when air quality problems are generally most pronounced.

Retrofit of heat recovery equipment to an existing dual-fuel engine will pose no adverse environmental impact as no additional fuel will be burned. For the same reason, granting qualifying status to an existing dual-fuel cogeneration facility will have no adverse environmental impact.

Combustion Turbines

Combustion turbines are widely used to produce electric power. They are used by electric utilities for peak power applications and do not require large quantities of cooling water. However, their thermal efficiency is lower than that of steam generating sets because of the higher exhaust temperatures. (*30*) Efficiency is improved by using them in conjunction with steam turbines, known as a combined cycle system, but electricity is the only product and this application is not cogeneration.

Combustion turbine cogeneration provides for use of the waste heat directly for industrial processes or for space heating. Combustion turbines produce more electricity per unit of thermal energy ouptput compared to steam turbines, and can provide a better match for the energy needs of some industrial facilities than other alternatives. Another characteristic affecting selection of a combustion turbine is the fact that capital costs per kilowatt are relatively low, but because premium fuels are required, fuel costs are high. Generally, industrial or commercial installations of combustion-turbine units are economic only if the waste heat is effectively used. The increased rates for sales to electric utilities, coupled with lower natural gas fuel costs available through the Commission's rules, are expected to result in larger numbers of combustion turbine installations. The opportunity for qualifying facilities to burn lower cost natural gas should encourage some reductions in oil burning and result in improvement of air quality.

Steam Turbines

The operation of a steam-turbine generating plant can cause a variety of environmental impacts which may range from inconsequential to potentially important. The impact is primarily due to emissions to the atmosphere. Thermal discharges to water bodies are typically less than is a non-cogeneration, electric generating facility. Noise levels can be significant at the turbine, but may be mitigated on a site-specific basis.

Emissions to the atmosphere may include particulates, sulfur oxides, nitrogen oxides, hydrocarbons and carbon monoxide. Sulfur oxides and particulate emissions are the pollutants of primary importance. Control for those pollutants is available either by removing them from the exhaust gas stream, changing the fuel, or dispersing the exhaust gases via a well-designed stack. Nitrogen oxides and carbon monoxide emissions can be controlled to some extent by proper combustion technology. Lack of pollution controls can cause adverse effects on human health, degrade visibility, and cause deterioration of the built environment through chemical effects on structures. The extent of these effects will depend upon the size of the facility in question and the proximity to other sources of similar pollutants.

The ash removal from the boilers fired with solid fuels may present a solid-waste problem in some locations. Storage of coal or solid waste poses groundwater and fugitive emissions problems. However, it is not expected that coal-fired steam turbine cogeneration will achieve significant market penetration during the next 15 years.

The largest steam turbine cogeneration facilities may produce effects on air quality similar to those of a central station generating unit and would require similar pollution control systems. However, most cogeneration systems will be smaller and will generally provide increased dispersal of environmental effects as compared to central generation. In any event the incremental air quality effect from a topping-cycle steam turbine cogeneration facility will be small compared to the air quality effects of a boiler producing the required thermal energy supply.

Overall, the use of steam turbines for cogeneration resulting from the Commission's rules should not pose significant environmental impacts because of the inherent higher efficiency and reduced emissions from such systems compared to the separate production of heat and power.

Spark-Ignition Engines

A spark-ignition engine when used for cogeneration applications, typically uses natural gas. Propane or liquified petroleum gas (LPG) gas may be used, but high fuel costs limit this practice to short periods of time. Heat recovery is achieved from the exhaust or the engine cooling system Approximately 30 percent of the total energy input to the engine appears as heat in the exhaust. About 60–65 percent of this thermal energy can be recovered. For all spark-ignition engines the overall heat balance depends upon the load placed on the engine. At partial loads, engine efficiency decreases, and the fraction of energy input ending up as heat increases.

Addition of waste-heat recovery equipment to existing spark-ignition engines will not add to the environmental effects of the original equipment since no additional fuel is consumed during operation even with a moderate increase in fuel consumption. Instead, a net environmental benefit would be expected from these facilities since waste heat normally expelled to the air is captured for use.

Construction of new facilities will result in some localized environmental impacts, but the impact of individual units is expected to be minor. Although a spark-ignition engine will emit much more carbon monoxide than an equivalent diesel engine, emissions of sulfur dioxide are negligible. Emissions of nitrogen oxides have been found to be extremely dependent on engine output, but in any case, they are much less than those from a diesel engine.

Environmental Effects of Cogeneration

The significant environmental effects associated with the development of PURPA-induced cogeneration are mainly those caused by diesel cogeneration, therefore most of the effects listed here are related to that technology.

- Diesel engines that use distillate as fuel generate 50 to 80 times the particulate matter that natural gas fueled engines emit. The effect on human health is not fully known. New source performance standards (NSPS) for stationary diesel engines are currently being developed by EPA.
- The performance standards currently being developed may require control techniques to limit NO_x emissions.
- NSPS standards, which do not recognize the fuel savings inherent in cogeneration, could inhibit the market penetration of cogeneration technology.
- Environmental control costs for flue gas desulfurization or low-sulfur oil and regulatory uncertainties (EPA's proposed short-term NO_x standard may affect NSPS permits for cogeneration) associated with direct-fired steam boilers may impede their acceptance for steam turbine cogeneration.

4.3.10 Small-Scale Hydropower—Category II

There are about 3,000 undeveloped sites in the U.S. with the potential for small-scale hydropower development that correspond to Category II dam or locations. These sites have a potential for 15,700 Mw.(*13*) However, the market-penetration analysis, contained in Appendix F, showed that the cost of a new dam would increase the cost of the facility so much that avoided costs would not result in sufficient economic incentives to justify this category of dams.

Recent filings with the FERC for small-scale hydropower have almost been exclusively for existing dams. The average construction costs in these filings are $2,000/kWh of installed capacity. Cost estimates developed for Category II hydropower have ranged from $3,000–$5,000/kWh, which are significantly higher than avoided costs, even for municipalities and cooperatives which have the ability to obtain the lowest cost financing.

Figure 4 depicts the national picture of development for small-scale hydropower by 1995. Appendix F discusses the market-penetration analysis of this technology. A detailed technical and environmental assessment of small-scale hydropower is found in Appendix G.

Based on the market-penetration analysis, and the recent experience with small-scale hydropower filings at FERC, it does not appear the PURPA will encourage a measurable amount of Category II development in the near-term. Development of this high cost form of hydropower will probably appear when fossil fuel (mainly oil) prices reach levels where its development is cost-effective. Regions where this might be expected by 1995 include New England, Middle Atlantic, and the Pacific (Alaska and California).

Environmental concerns associated with construction, repairing or modification of Category II dams are as follows:

- Aquatic ecosystems are converted from those of free-flowing streams to those of standing water.
- Inundation of land resources, including wildlife habitats, forests, and agricultural lands.
- Inundation of human habitats (home sites, towns, industrial and commercial locations, scenic and historic sites, etc.)
- Aquatic and semiaquatic organisms may be adversely impacted if reservoir level fluctuations occur. Careful design and management would limit the fluctuations to variations caused by peak demands. The presence of endangered species will bar development in some locales.
- Downstream environment and ecosystems could be impacted from the release of abnormal amounts of impounded chemicals, sediments, and silts.
- There may be conflicts with established recreational use of impoundments.

Environmental Findings

The market penetration analysis and the environmental analyses presented in the previous sections provide the basis for these environmental findings:

1. The regulatory program, taken as a whole on a national basis, will not have a significant impact upon the quality of the human environment within the meaning of section 102 of NEPA, primarily for the following reasons:

- Most of the technologies rely upon operating principles that are unique to each technology and the environmental effects associated with the basic operation of each are dissimilar and not cumulative. Technologies that involve combustion of fossil fuels and biomass are special exceptions.
- The geographical distribution of PURPA induced technology development shows few cases where cumulative effects could occur, even on a regional basis. This is shown in Figure 8. Careful evaluation of regions where potential cumulative effects might occur (Pacific, East North Central, Middle Atlantic) indicates that only in the Mid-Atlantic region is there potential for two technologies to interact to produce cumulative environmental effects. For example, in the Pacific region, most industrial cogeneration will occur in the northern part of the region, whereas municipal solid waste development is expected in the southern portion, so adverse air quality effects would not be cumulative.

Technologies	Census regions: PAC	MTN	WSC	WNC	ESC	ENC	SA	MA	NE
Industrial cogeneration	X			X		X		X	X
Commercial cogeneration								X	
Municipal solid waste	X					X			
Small-Scale hydropower	X	X		X	X	X	X	X	X
Wind		X	X	X				X	X
Summary	**PAC**	**MTN**	**WSC**	**WNC**	**ESC**	**ENC**	**SA**	**MA**	**NE**
Potential for cumulative adverse environmental effects	No	No	No	No	No	No	No	Yes	No

Figure 3. Regional occurrence of PURPA-induced technologies and potential for cumulative adverse environmental effects (see map (Figure 2) for delineation of census regions).

PAC—Pacific; MTN—Mountain; WSC—West South Central; WNC—West North Central; ESC—East South Central; ENC—East North Central; SA—South Atlantic; MA—Middle Atlantic; NE—New England.

- In the near-term, only one technology, commercial cogeneration, was found to reach a level of development that might cause potentially significant environmental effects. These effects would only be expected in one region.

The Commission notes that certain benefits have been found as the result of this program that tend to mitigate possible environmental effects, as well as improve the Nation's energy picture. These include the potential deferral or cancellation of some eleven 500-MW coal-fired steam plants, one 1,000-MW nuclear plant, a number of 75-MW gas turbines, certain large-scale hydropower facilites, and some combined cycle installations with all associated effects due to construction and operation being avoided. (See Figure 2.) In addition, PURPA-induced facilities are projected to save an estimated 40,000 bbl/day of oil, 40,000 bbl/day equivalent of natural gas, and 120,000 bbl/day equivalent of coal by 1995.

2. The projected market penetration of technologies which can qualify under PURPA is shown in Table 5 (also see Tables 1–3). Certain technologies, will not, as the result of incentives under PURPA, reach levels of development that create significant environmental impacts. Solar thermal and solar photovoltaic, biomass fuels and geothermal technologies fall in this category, and a finding of no significant impact (FONSI) is appropriate for these technologies.

3. Qualification of existing facilities utilizing any of the cogeneration or small power production technologies encompassed under PURPA, including existing diesel engines, is not expected to create significant PURPA-induced environmental effects because these facilities are likely to continue to be operated with or without the incentives of PURPA. The Commission has made a finding of no significant impact (FONSI) for this category of facilites and will proceed with qualification thereon.

4. The incentives of this program will encourage the development of only one technology, commercial cogeneration primarily by new diesel engines, at a level where significant environmental effects may occur in the near-term. These effects are expected to be limited to the Mid-Atlantic region. The Commission will not grant qualifying status to this technology until it completes and evaluates an EIS.

5. The Commission is establishing a monitoring program to alert the Commission to the likelihood or extent of market penetration by technologies which qualify under PURPA. This procedure is designed to produce mid-, and long-term information that may be relevant to taking appropriate environmental protection action before these technologies reach a stage of investment or commitment likely to determine subsequent development or restrict later alteration.

Table 5.—*Market Penetration/Environmental Assessment Results*

Technology	Market penetration from PURPA		Environmental effect at projected market penetration of PURPA-induced market penetration	
	Near term by 1985	Long term by 1995	Near term by 1985	Long term by 1995
Solar Thermal	None	None	None	None.
Wind:				
Small	Minimal	Significant	Minimal	Minimal.
Large	None	Significant	None	Moderate.
Biomass Fuels (except MSW)	None	None [1]	None	None. [1]
Municipal Solid Waste	None	Moderate	None	Moderate.
Photovoltaics	None	None	None	None.
Small-scale hydro:				
Category I	Moderate	Significant	Minimal	Moderate.
Category II	None	Moderate	None	Significant. [2]
Geothermal	None	None [1]	None	None. [1]
Cogeneration:				
New Diesel	Moderate	Significant	Significant	Significant.
Other	Minimal	Moderate	Minimal	Moderate.

[1] While the market penetration analysis show little or no PURPA-induced market penetration, the comments in this rulemaking indicated that the encouragement provided by this program may result in some development of this technology, the extent of which remains unclear.

[2] The Commission notes that hydroelectric projects generally must be licensed by the Commission under Part I of the Federal Power Act. License applications are evaluated on a case-by-case basis to determine the significance of the environmental impacts and the need for a site-specific EIS. In addition, impacts of individual projects on a waterway may be cumulative, and the Commission reviews each project in relation to others on the waterway under the "comprehensive development" standard of section 10(a) of the Federal Power Act. Therefore, requirements of NEPA will be met as each application is filed.

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