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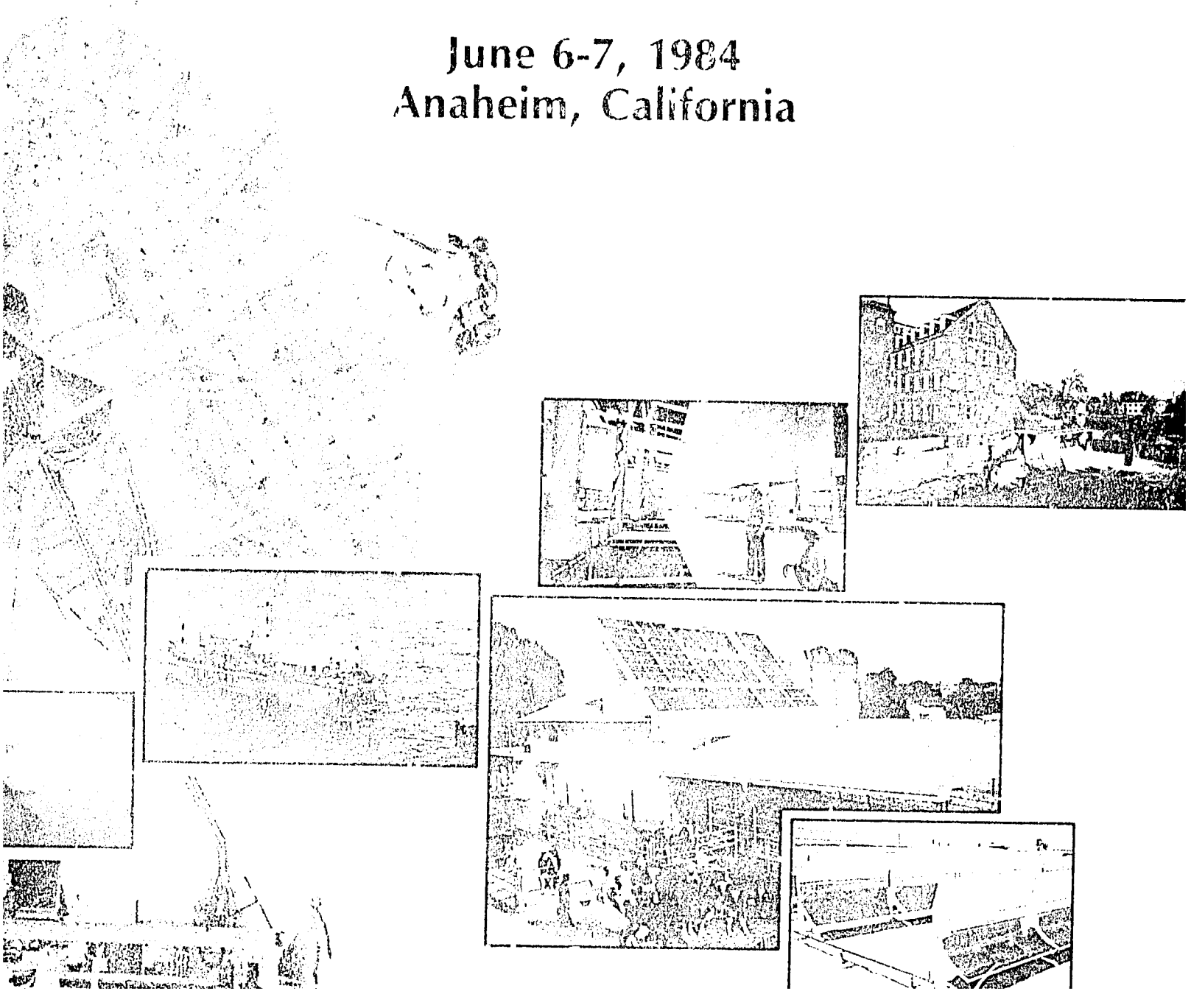
Renewable Energy Institute

IIED INTERNATIONAL INSTITUTE FOR ENVIRONMENT AND DEVELOPMENT

International Roundtable

On Renewable Energy

June 6-7, 1984
Anaheim, California



Renewable Energy Institute

INTERNATIONAL INSTITUTE FOR ENVIRONMENT AND DEVELOPMENT

International Roundtable
On Renewable Energy

June 6-7, 1984
Anaheim, California

THE ADMINISTRATOR
UNITED NATIONS DEVELOPMENT PROGRAMME
One United Nations Plaza • New York, N. Y. 10017

18 May 1984

Dear Enrique and Maurice:

You both deserve high credit for your initiative in convening the International Roundtable on Renewable Energy, under the sponsorship of the Renewable Energy Institute and the International Institute for Environment and Development. As a member of IIED's Council, I wish I could join you but I will be in Europe during the entire period of the Roundtable.

I regard this Roundtable as an important complement to last year's workshops in Jamaica, Kenya and the Philippines, which were designed to catalyze private sector investments in the field of new and renewable energy. We at UNDP were pleased to have been one of the co-sponsors of those workshops. We believe they identified a number of attractive projects.

I hope your Roundtable will focus attention on the critical role that major institutions such as electric utilities must play if new energy sources are to be introduced successfully on a widespread scale.

I wish you every success in your undertaking and look forward to hearing from you about what I know will be very productive results.

With highest esteem and warmest personal regards to you both, I am,

Sincerely,

Bradford Morse

Messrs. Enrique Iglesias
and Maurice Strong
c/o The Renewable Energy Institute
1516 King Street
Alexandria, Virginia 22314

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Renewable Energy Institute

IIED INTERNATIONAL INSTITUTE FOR ENVIRONMENT AND DEVELOPMENT

INTERNATIONAL ROUNDTABLE ON

RENEWABLE ENERGY

Introduction to the Program

We are extremely pleased to present this opportunity for all the distinguished participants at the International Roundtable to join us in California. The state of California offers a setting unmatched anywhere in the world to observe commercial applications of renewable energy, and to examine the types of governmental policies that have helped lead to the use of renewable energy sources.

I wish to pay particular tribute to the two individuals who have served as conveners of this program, Mr. Enrique Iglesias and Mr. Maurice Strong. The work of these two men over the years -- including their roles as Secretaries General of major United Nations conferences, one on environment and the other on renewable energy -- has done much to set the scene for us today.

We have learned a great deal about renewable energy during the past few years. We have learned that it is not an instant answer to all the world's energy needs. But we have also made great technological strides in a good number of the renewable energy technologies. And as the record here in California shows, renewable energy is at a stage where it can make an important contribution to supplying utility-scale generation of electricity, as well as providing important dispersed energy applications.

We have two objectives in this program. The first is to let you observe first-hand some of the major electricity-producing renewable energy projects here in the State of California. You will be able to do that through the site visits we have arranged in Southern California on Wednesday, and Northern California on Friday and Saturday. You will also have an excellent opportunity to inspect a wide range of renewable energy technologies at the RETSIE Technology Exposition.

Our second objective is to explore with you some of the major types of policy instruments, including incentives and regulatory programs, that have a role in bringing renewable energy technologies out of the laboratories and into the marketplace. We have tried a good number of programs here in the United States, particularly in California. We know that the countries of some of the participants in this Roundtable have considerable experience with programs as well, and that other countries are considering programs.

We want to compare notes. We want to tell you what our experience has been, to give you an indication of what types of programs we have found to be effective in establishing an environment in which renewable energy can be developed commercially. We hope we will learn the same from you, as you describe your experiences and needs.

The focus of the Roundtable meeting is policy, not technology. In the program, as in this briefing book, we will provide summary information on the various renewable energy technologies so that we all have a common base of information. The main part of the meeting, however, will be devoted to discussions of experience with policy programs, and experience of electric utilities using renewable energy. The briefing paper in this notebook provides a wealth of information on the experience with major policy programs in California, elsewhere in the U.S., and in several other countries.

As you read through the briefing paper, and as we proceed through the discussions, several questions will help focus your thoughts:

- What experiences has your country had with moving renewable energy projects out of a laboratory setting into the commercial stage?
- What, if any, government policies helped lead to positive results in renewable energy projects?
- What types of policies have proven ineffective?
- What is the potential role of renewable energy for electric power generation in your country, and what institutional barriers need to be addressed to reach the potential?

I sincerely encourage you to contribute your thoughts on these and other relevant points as the program takes place. We have structured the program informally to allow participation by all those in attendance.

Finally, I want to point out that this International Roundtable is part of on going processes by the Renewable Energy Institute (REI) and the International Institute for Environment and Development (IIED). Both of these organizations have done a great deal of work on the subject of policies and programs to support the transfer of renewable energy technology from the laboratory to the marketplace. These activities have included studies (for instance, IIED's recent publication entitled "Competition and Collaboration in Renewable Energy: The Problems and Opportunities of Technology Transfer to the Developing Countries" and REI's series of Trade and Investment Law reports for several countries). These efforts have also included procedural activities. IIED, for instance, conducted a series of workshops last year in developing countries that brought policy questions and renewable energy projects into joint focus. REI is moving toward the establishment of an International Policy Council to parallel its U.S. oriented policy-development body.

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The International Roundtable is a natural progression in these activities of the two organizations. On behalf of William Clark, President of IIED, and myself I wish to extend our thanks to you for joining in this important work. We look forward to continuing to work with you, building from the lessons of this meeting.

Jack T. Conway

Chairman of the Board
Renewable Energy Institute
and
Chairman
International Roundtable on Renewable Energy

Renewable Energy Institute

IIED INTERNATIONAL INSTITUTE FOR ENVIRONMENT AND DEVELOPMENT

Acknowledgments

The International Roundtable has been made possible by generous support and/or in-kind assistance from the following government agencies and private corporations:

Corporations:

ARCO Solar Industries
Luz Industries, Ltd.
Pacific Gas & Electric Company
Southern California Edison Company
Standard Oil of Ohio
Union Geothermal Corporation
U.S. Windpower

Government Agencies:

U.S. Department of Energy
U.S. Agency for International Development
U.S. Department of Commerce
U.S. Trade and Development Program
U.S. Department of State
California Energy Commission

Renewable Energy Institute

IIED INTERNATIONAL INSTITUTE FOR ENVIRONMENT AND DEVELOPMENT

INTERNATIONAL ROUNDTABLE

ON RENEWABLE ENERGY

Program Agenda
and
Site Visit Itinerary

Tuesday, June 5

Morning:
10 a.m. VIP Tour of RETSIE Technology Exposition at Anaheim Convention Center (adjacent to Marriott Hotel)

Afternoon Optional: Attend RETSIE Symposium sessions (Marriott Hotel)
or
Free Time

Evening

6:30 p.m. Reception & Dinner for International Roundtable Participants

Host: ARCO Solar Industries
Location: Orange County Ballroom, Salon 5
Marriott Hotel

Wednesday, June 6

8:00 a.m. Continental Breakfast Available in Orange County Ballroom Salon 5, Marriott Hotel

8:30 a.m. International Roundtable Convenes
Orange County Ballroom Salon 5, Marriott Hotel

- Introductory Remarks:
  Jack Conway
  Roundtable Chairman
  and
  Patrick Collins
  Under Secretary, U.S. Department of Energy

- Brief Technology Reviews for:
  Solar Photovoltaics
  Solar Thermal
  Solar Heating and Cooling

- Experience with Renewable Energy by Electric Utilities:
  How Well Does It Work?
  Can Technical Obstacles Be Overcome?

11:00 a.m. Departure for Site Visits in Vicinity of Barstow, California

(Charter bus and lunch provided, courtesy Luz International, Ltd.)

- Project Sites to be Visited:

  Solar One -- 10 megawatt solar thermal central receiver

  SEGS I -- Luz Engineering solar thermal electric generating facility (parabolic trough)

  ARCO Solar one-megawatt photovoltaic facility at Hesperia

6:00 p.m. Return to Anaheim Marriott Hotel

7:00 p.m. RETSIE International Reception for all participants of Exposition, Symposium, and International Roundtable.

Location: Veranda Terrace, Marriott Hotel

Remainder of Evening: Free Time

Thursday, June 7

8:30 a.m. Assemble for departure from Anaheim Marriott to Long Beach (charter bus provided). Note: Entire program for Thursday will take place on board the Queen Mary, in Long Beach Harbor

9:30 a.m. International Roundtable Reconvenes, on Board the Queen Mary

- Brief Technology Reviews for:
  Wind Energy
  Biomass
  Geothermal
  Cogeneration

- Discussion: Experience in U.S. and Other Countries with Policy Actions to Assist Renewable Energy Development

12:00 noon Luncheon

1:00 p.m. International Roundtable Reconvenes

- Renewable Energy for Electric Power: Strategic Planning Considerations of Utilities

- Concluding Discussion: Thoughts by Roundtable participants on the possible role of renewable energy for electric power in their countries, and institutional barriers that must be addressed.

4:30 p.m.	Roundtable Adjourns Depart Queen Mary via charter bus
5:00 p.m.	Reception for Roundtable Participants Courtesy - Newton Becker, Chairman, Luz International, Ltd.
7:00 p.m.	Return to Anaheim Marriott Hotel (charter bus)

Remainder of Evening: Free Time

Friday, June 8

6:45 a.m.	Check-out, Anaheim Marriott
7:15 a.m.	Assemble in front of Marriott for transit to Orange County Airport (charter bus)
8:35 a.m.	Depart Orange County Airport, AirCal #11
9:45 a.m.	Arrive Oakland Airport
11:15 a.m.	Depart for site visits (Charter bus and box lunch provided courtesy PG&E)

- o Altamont Pass Wind Farms
- o Fairfield Muncipal Cogeneration facility
- o MOD 2 Wind Turbine (Fairfield)

6:00 p.m.	Arrive Chateau Hotel, Napa Dinner (courtesy U.S. Windpower)
7:00 p.m.	Arrive Miramonte Restaurant, St. Helene Dinner (courtesy U.S. Windpower)

Saturday, June 9

9:00 a.m.	Depart Chateau Hotel (charter bus provided courtesy PG&E)

Project sites to be visited:

- o Geysers geothermal

Lunch and winery tour, Souverain Winery (courtesy Union Geothermal)

- o Methane fermentation facility (Marindale Farm)

5:30 p.m.	Arrive Bedford Hotel, San Francisco

Farewells

Renewable Energy Institute

IIED INTERNATIONAL INSTITUTE FOR ENVIRONMENT AND DEVELOPMENT

INTERNATIONAL ROUNDTABLE

ON RENEWABLE ENERGY

Participants

Conveners:

Mr. Maurice Strong
Chairman, Canada Development Investment Corporation

Mr. Enrique Iglesias
Executive Director
Economic Commission for Latin America

Roundtable Chairman:

Mr. Jack Conway
Chairman, Renewable Energy Institute

Countries of Participants:

Abu Dhabi
Brazil
Egypt
India
Indonesia
Israel
Italy
Jamaica
Jordan
Kenya
Mexico
Peoples Republic of China
Philippines
Thailand
United States

Also Represented:
The European Community

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Federal Electric Commission
MEXICO

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Project Manager
Energy Research & Development Center
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Goodberg PG&E
Cheatham, Hoa Sitan

INTERNATIONAL ROUNDTABLE ON RENEWABLE ENERGY

POLICY BACKGROUND PAPER

Policy Framework: The Importance of Government Incentives in Renewable Energy Development

This paper was prepared by the International Institute for Environment and Development under the direction of Todd Bartlett. Background research for the paper was provided by Carlo La Porta and Judith Stammers. Kevin Finneran served as editor.

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Renewable Energy Institute

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EXECUTIVE SUMMARY

Policy Framework: The Importance of Government Incentives in Renewable Energy Development is a background paper prepared for the International Roundtable on Renewable Energy, held at RETSIE in June 1984. This document is a factual summary of worldwide experiences with incentives for renewable energy for use as a reference document by speakers and participants at the meeting.

Policy Framework is not intended to be a comprehensive summary of all experiences with incentive systems for renewable energy in the world. Its task is much narrower, to highlight those programs which have had the greatest impact, for good or bad, on the commercial development of non-conventional energy sources in the past five years. It gives primary attention to those instances where public investment has catalyzed private investment on a sustainable basis.

The paper is divided into three sections which present background information and a concluding section which raises points for discussion in the meeting:

SECTION I introduces the reader to the types of incentives systems that exist and why these are so critical to the commercial development of renewable energy.

SECTION II highlights California and is divided into two parts. The first part is a general review of the energy and energy policy situation in the state. The second part discusses in detail three important incentives that have been successful in promoting private investment in renewable energy in California. These include tax policies, regulations encouraging utilities to buy power from independent power producers, and government-backed loan programs.

SECTION III briefly reviews the experiences of other selected countries that have attempted to accelerate the commercial development of renewable energy by government incentives. These incentives range from regulations requiring installation of solar collectors in Israel to loan programs for biogas plants in India.

SECTION IV contains preliminary conclusions and points of discussion for the roundtable.

SECTION I

INTRODUCTION

Renewable energy has steadily progressed in the past ten years from its early position as a concern of appropriate technologists and social philosophers. Today, it has become an important policy and business consideration to governments, utilities, entrepreneurs, and consumers around the world.

As a tour of the Renewable Energy Technologies Symposium illustrates, progress in technology has not been confined to the laboratory. An economically viable industry to produce and distribute these technologies has progressed from its infancy to adolescence and is responding to the signals of a growing market.

The agents for change have been many, but it is undeniable that energy policy makers in governments and public and private utilities have played an important role in this change. Rising costs of conventional energy sources and consumer disgruntlement have forced a fundamental reexamination of the strategies employed by governments and utilities to ensure the delivery of affordable electric power, heat, and liquid fuels.

Ironically, the same local utilities and power generation authorities who at one time dismissed renewable energy have become key in the commercialization of solar collectors, wind machines, biomass-burning equipment, and other alternative energy technology.

In California the change in the position of local utilities and private investors has been dramatic. Nonconventional sources, which made practically no contribution in 1975, supplied more than 7 percent of California's electricity in 1983 and continue to grow at an increasing rate. Southern California Edison exemplified the new direction when it announced in 1981 that alternative energy sources would provide 30 percent of its new generating capacity in the coming decade. SCE board chairman William Gould explained:

> "It is the policy of Edison to devote our corporate resources to the accelerated development of a wide variety of future electrical power sources which are renewable rather than finite. These include wind, geothermal, solar, fuel cells, small hydroelectric, and continued emphasis on co-generation, conservation and load management. We now believe that some forms of power generation which a few years ago were speculative or unproven have progressed to the point that they can be aggressively developed and relied upon to provide a significant part -- perhaps about 30 percent -- of the electricity to supply the additional needs of our customers later this decade. We are convinced that our society in general, our customers and our company will benefit from the success of renewable and alternate energy sources. This policy shift should both improve the environment and reduce our dependence on expensive foreign oil."

What has caused this change in attitude on the part of California utility officials?

- Utilities, public and private, have been put under financial strain by the rise in fuel costs for existing generating stations and the high capital costs for new plants and transmission systems. This has led to a rapid rise in electric rates and widespread consumer opposition.

- Governments have limited utility options by imposing regulations aimed at safeguarding the environment from nuclear accidents and air pollution caused by burning fossil fuels.

- The economics and technical readiness of renewable energy have continued to improve as the costs for conventional generation have risen.

- Incentive systems, created to spur the commercial adoption of renewable energy in the late 1970s, are only now beginning to be effective. Though some of these incentives supported only research, development, and demonstration, a few persuaded utilities, governments, and investors to consider nonconventional technologies, and in fact made it financially advantageous for them to do so.

Why should a government consider the use of incentive systems for renewable energy?

- Rapid development of renewable energy can help a country reach its political and economic goals -- including increasing self-reliance in energy sources (and decreased foreign exchange requirements for oil), development of local enterprise and skilled workers, and distribution of benefits of electricity or other energy to rural areas.

- Incentives push people and institutions to take risks they might otherwise have avoided and to experiment with new technologies.

- Incentive systems properly employed are a way of leveraging private and semi-public capital with public money. In the past, renewable energy research and development was funded from the public treasury. Both for industrialized and developing countries, public expenditures have come under increased fire. Future government programs must therefore use small amounts of seed capital as leverage to move other money, for it is unlikely that the government sources will suffice to cover the whole bill.

- Incentives are a way of bringing new actors on board to assist in the promotion of renewable energy. Not only utility officials, but investment bankers, private developers, and households can play a critical role.

- Incentive systems can assist technology producers by stimulating adequate sales to justify investment and production facilities and lower price through economies of scale. By helping to lower prices incentives can reduce the price differential between conventional and nonconventional sources of energy.

What kind of incentives exist?

Tables 1-4 on the next four pages review the four major types of incentives:

- financial incentives - including grants, credits, subsidies, low-interest and long-term loans, loan guarantees
- fiscal incentives - including taxation exemptions, deductions, credits rebates
- regulatory/legal incentives - including laws, codes, and regulations
- promotional incentives

What are we trying to do in this briefing document?

- Provide policy makers in governments, utilities, and industry with a detailed description of how some of the largest commercialization programs worked -- and didn't work.
- Outline the conditions that seem to favor successful implementation of these incentives.
- Point out the relevant issues that have arisen in California, Europe, and elsewhere during the implementation of these incentive efforts. None of the descriptions or discussions in this paper are intended to suggest that any of the incentive systems applied in California (or anywhere else) can be transferred to any other country or state without careful examination of local goals and conditions.

Section II of this briefing document reviews California's experiences in greater detail, and particularly concentrates on those incentives that had the most impact. Section III contains several specific examples of incentives applied elsewhere in the world. Conclusions outlining broad themes and further points for discussion are contained in Section IV.

TABLE I

FINANCIAL INCENTIVES FOR RENEWABLE ENERGY DEVELOPMENT
BY INCENTIVE TYPE

FINANCIAL INCENTIVES -- Grants, credits, subsidies, low-interest and long-term loans, loan guarantees.

	DESCRIPTION	ACTORS	ADVANTAGES	DISADVANTAGES
Funding for Research Development and Demonstration (RD&D)	Support of basic research, product development, and demonstration aimed at commercialization	Governments, research laboratories, industry	Government shoulders risk for development of non-proven technologies and focuses R&D programs.	Requires well-developed RD&D establishment R&D programs without parallel market incentives for commercial sales may lead to stress scientific accomplishments rather than practicality
Procurement	Direct funding of equipment production; purchasing of equipment or product (e.g. alcohol fuels).	Governments	Supports industry while market develops and equipment is refined	May result in uneconomic and unmarketable product by guaranteeing purchase regardless of quality or efficiency. Potentially very expensive for developing countries especially if product is imported, not produced locally.
Guaranteed-purchase of non-commercial power (PURPA model)	Purchase of elec. from independent producers using renewable energy technology	Large utilities, independent producers	Puts financial and technical burden for renewable projects on private developers not on government or utilities. Is competitive with expensive new generation capacity.	Can effect consumer electricity rates as purchase of power is at rate higher than older generating plants. Limits exist on amount of non-baseload power which utilities can use. Assumes existence of integrated utility system that is able absorb and distribute power.
Capital expense relief to equipment purchasers	Up-front grants or loans to ease burden of capital investment in new equipment	Government (national, state, local) purchasers of equipment (institutional, commercial, homeowner)	Allows purchasers to replace fossil fuel equipment with renewable equipment in greater numbers	Requires careful and comprehensive administration to successfully process and evaluate grant/loan requests. Assumes expertise is available and properly utilized.
Export Promotion	Government support of product to make it more competitive overseas through such measures as trade fairs, commercial exchanges, grants to purchasing countries, special credit arrangements.	Governments, commercial sector, foreign governments	Gives local or national industry parity or competitive edge in export trade, thus increasing rate of growth of renewable energy exports. Relatively inexpensive to implement.	May protect inefficient or poor quality manufacturers. Distorts market by giving edge to countries with most favorable export assistance rather than best product
De-subsidization of conventional and traditional fuels.	Removal of government subsidies and price controls that keep energy prices artificially low	Governments	Makes renewable fuels more cost-competitive, encourages conservation of conventional fuels. Net revenue enhancer through increased profits on fuels or electricity	Politically unpalatable if not impossible in much of the world; creates hardships for consumers (particularly urban poor and middle classes) during transition. May encourage growth of black market in fuels.

Source: International Institute for Environment and Development, Worldwide Incentives for Renewable Energy Usage: A Selective Survey, IIED: Washington D.C. and London, 1983.

TABLE 2

FISCAL INCENTIVES FOR RENEWABLE ENERGY DEVELOPMENT
BY INCENTIVE TYPE

FISCAL INCENTIVES taxation (including exemptions, deductions, credits, rebates) and tariff liberalization

	DESCRIPTION	ACTORS	ADVANTAGES	DISADVANTAGES
R & D Shelters	Allows write-offs for tax purposes of research and development expenses in combination with other business investment credits.	Government, commercial sector	Offsets cost of development of new products and alleviates risk for commercial firms	Abusive shelter schemes possible. Assumes existence of effective revenue authority. May become very expensive.
Support for end use purchasers and investors	Provision of tax credits or depreciation schemes by federal or state governments to partially offset investment costs. May be granted directly to user or to investor (purchaser of system	Governments, private consumers, builders, manufacturers, investors	Greatly reduces effective purchase price of renewable energy equipment. Third party credit allows investors to purchase large numbers of units for commercial operations	Can become legally complex if both local and national tax measures are applied. Abusive tax shelter schemes possible. Requires effective revenue or taxing authority
Taxation of Conventional Fuels	Increased sales tax on conventional fuels; reduction or elimination of tax on renewable fuel.	Governments, producers, distributors, consumers	Makes renewable fuels more cost-competitive with conventional fuels	May discourage cost-cutting developments in production of renewable fuels. Politically unpalatable. Important role of effective revenue authority.
Import Liberalization/ Concessions for Renewable Energy	Exemptions from import tariffs, tax holidays, strengthened patent protection, government financing, liberal repatriation of profits, reduction in paperwork.	Governments, Commercial sector	Encourage producers to locate in country granting concessions. Inexpensive to implement; gain in revenues easily offsets loss in taxes, etc.	Can hinder development of local industry. Equipment and material imports are foreign exchange drain without which renewable energy exports or oil substitution will not be recovered. Requires existence of organization with necessary expertise to monitor and evaluate incoming investments.

Source: International Institute for Environment and Development, Worldwide Incentives for Renewable Energy Usage: A Selective Survey, IIED: Washington D.C. and London, 1983.

TABLE 3

REGULATORY AND LEGAL INCENTIVES FOR RENEWABLE ENERGY DEVELOPMENT
BY INCENTIVE TYPE

REGULATORY AND LEGAL INCENTIVES --Laws, codes, regulations, legislation

	DESCRIPTION	ACTORS	ADVANTAGES	DISADVANTAGES
Zoning and access requirements	Legislation requiring use of certain renewable technology in certain locations or under specific conditions. Laws requiring access to sunlight.	National and local governments, courts	Creates ready-made market for required technology. Encourages conservation.	Enforcement of laws may result in excessive litigation or oppressive bureaucracy.
Consumer protection product certification	Creation of performance standards, rating codes, systems of certification, consumer protection systems, warranties	Government agencies, manufacturers associations, courts.	Develops consumer confidence in products and technologies Establishes uniform standards which the industry must adhere to. Virtually cost free to implement.	Too strict or unevenly applied codes can discourage manufacturers. Assumes existence of capable bureaucracy. Possibly very difficult to monitor.
Distribution, pricing and buyback rules for petroleum cos & electric utilities	Regulations governing utilities & petroleum companies on how they can set prices & contracts for buying and selling power and fuels.	Utilities, fuel producers, indep. power producers government	Sets limits on quantities and prices of conventional fuels allowing for market penetration of renewables	Requires diligent monitoring & enforcement
Transnational investment promotion	Encouragement or discouragement of investment by foreign-based corporations	Governments, foreign investors	Regulates amount of foreign ivestment in specific areas, allowing ideal mix between local manufacturing and foreign.	Too much outside investment can result in foreign control of country's energy sources.

Source: International Institute for Environment and Development, Worldwide Incentives for Renewable Energy Usage: A Selective Survey, IIED: Washington D.C. and London, 1983.

TABLE 4

PROMOTIONAL INCENTIVES FOR RENEWABLE ENERGY
BY INCENTIVE TYPE

PROMOTIONAL INCENTIVES

	DESCRIPTION	ACTORS	ADVANTAGES	DISADVANTAGES
Familiarization/ extension services for producers, financiers, bureaucracy, consumers	Programs that encourage producers and consumers to manufacture and use technologies that are locally relevant.	National and state governments trade associations, businesses	Raises awareness and acceptance of renewable technologies in areas where they were previously unknown.	Unless effort is monitored, inappropriate or potentially poor quality systems may be encouraged by interested businesses/trade associations. Requires coordinated policies and capability to publicize them.
Advertising and poster campaigns	Public relations programs that educated and encourage citizens to conserve energy or switch to renewable energy.	Government agencies, commercial sector	Relatively inexpensive and requires no institution to enforce this incentive.	Unless campaign is sustained, effects will be limited. Financial assistance must be available if campaign asks citizens to buy new equipment

Source: International Institute for Environment and Development, Worldwide Incentives for Renewable Energy Usage: A Selective Survey, IIED: Washington D.C. and London, 1983.

SECTION II

CALIFORNIA—A POLICY LABORATORY FOR RENEWABLE ENERGY

California is blazing the trail for alternative energy development in the United States. It has been a testing ground not only for the technologies themselves, but also for the policy initiatives to promote the development of new sources of energy. California's success results from the opportune combination of key policy actions with favorable resource and economic conditions. The forces that contributed to California's success include:

- financial incentives--to help consumers pay the high initial cost of an alternative energy system
- regulations that support small-scale independent power production
- energy resources--solar, wind, geothermal, biomass, small hydro, unused industrial process heat, waste
- available capital and risk-taking entrepreneurs
- increasing energy demand
- high energy costs
- open-minded (or coercible) utility officials

California's aggressive state government under Governor Jerry Brown took the reins in 1975 with the creation of the California Energy Commission (CEC) to guide energy development. The state legislature provided much of the regulatory and financial framework by passing tax credits and other incentives for alternative energy development. The state Public Utilities Commission (PUC), which approves rates and construction plans, pushed the utilities toward increased use of alternative energy strategies.

U.S. federal government policy underpins California's efforts. Federal tax credits are as important as the state credits to renewable energy projects, and federal depreciation allowances are more important than those offered by the state. It was federal legislation that required utilities to interconnect with independent power producers and set off the boom in cogeneration, wind farm, and small hydroelectric development. California has led the way among the states because of its interpretation and application of federal law.

The results of these innovative policy tools have been impressive. Retail sales of solar energy and wind energy systems in California now exceed $500 million a year--about half the U.S. total. Since 1980, more than $200 million has been invested in biomass energy projects in the state. More than fifty firms are involved in cogeneration, and more than 600 megawatts of capacity from cogeneration are already on line. Regulatory officials cannot keep up with the applications for hydroelectric facilities. Fifteen geothermal plants are already operating, eight more are under construction, and nine are in the planning stages. The 10 Mw Barstow solar thermal electric plant and the 6.5 Mw Carrisa Plain photovoltaic plant are the largest facilities of their kind in the world.

These achievements did not come easily. Battles were fought in legislatures, courts, and regulatory hearing rooms. And winning the battle was no guarantee that the programs would succeed. No one knew how to commercialize a new and diverse technology, and everyone made mistakes. Unanswered questions remain about the effectiveness of these policies, the cost to taxpayers and utility ratepayers, and the long-term social, economic, and environmental benefits of alternative energy production. Nevertheless, we do know that California has enjoyed more successes than anywhere else and can provide a standard by which to measure the efforts of government to promote the commercial expansion of alternatives to oil, coal, and nuclear power.

This section reviews the California energy situation, describes the institutions involved with energy policy and the actions each took, and evaluates the effectiveness of the various policy tools used. Although the interaction of the various policy initiatives is what stimulated rapid alternative energy growth in California, each initiative is evaluated separately to simplify the discussion.

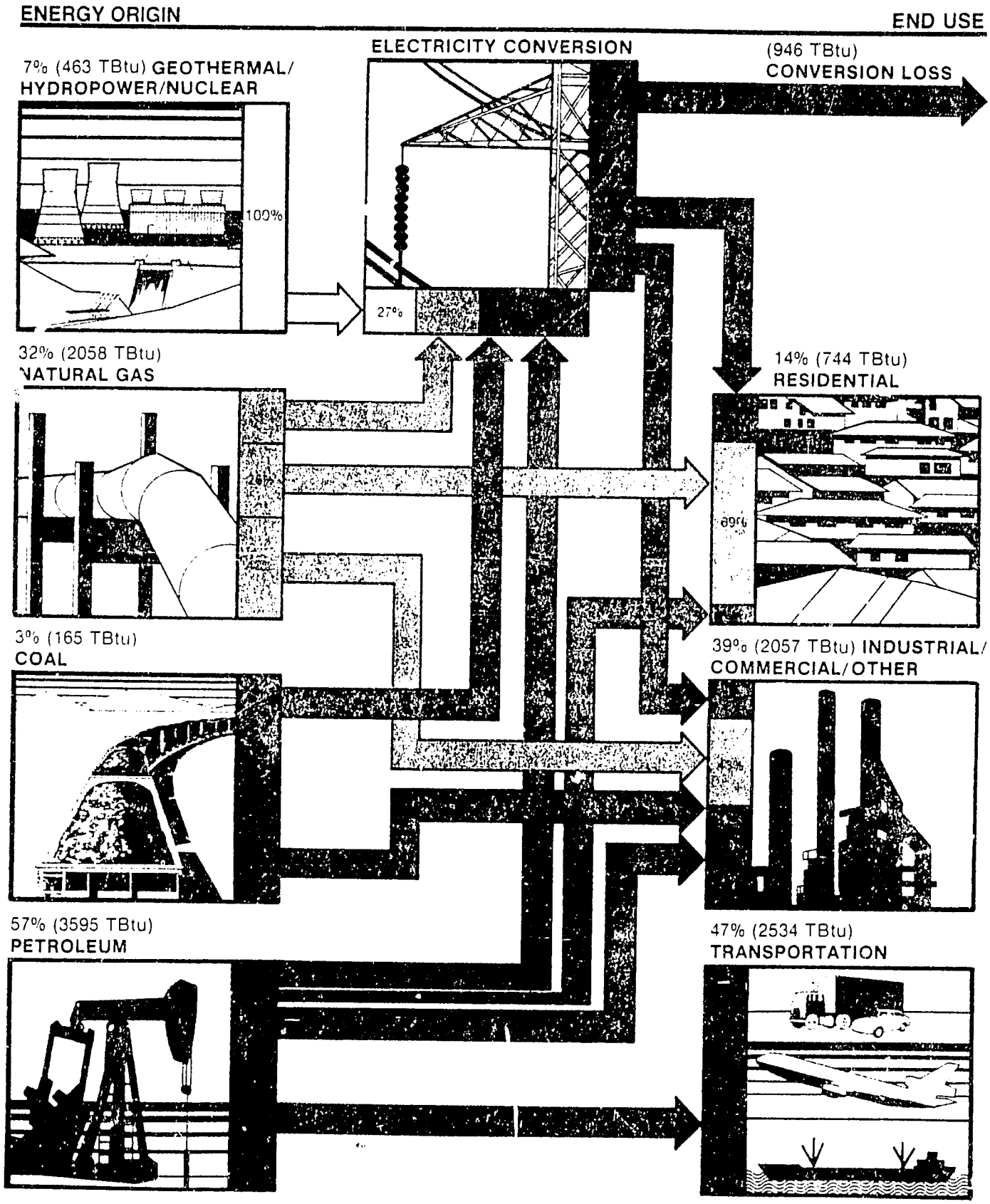
California Energy Today

By American standards, California uses an unusually large amount of oil and devotes a disproportionately large share of its energy to transportation. Oil provides 58 percent of the primary energy supply, and natural gas 32 percent. Transportation consumes 47 percent of the state's energy, compared to a national average of 25 percent. And while the nation devotes 28 percent of its energy to the residential sector, California uses only 14 percent of its energy in the home. Figure 1 summarizes the California energy picture.

Gas and Oil

California imports 90 percent of its natural gas from out of state, including 18 percent from Canada and 6 percent from Mexico. Two utilities distribute 95 percent of the gas. The average gas price has steadily risen from from $1.93 per million Btu in 1977 to $5.20 in 1982.

FIGURE 1
CALIFORNIA ENERGY NETWORK 1981



Note: Percentage numbers may not add to 100 percent due to rounding

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In 1976 California imported 40 percent of its oil from foreign sources. By 1981, ninety percent came from within the state or from Alaska.

Electricity generation consumes 24 percent of California's primary energy supply, but provides only 10 percent of the state's end-use energy. The rest is lost in conversion and transmission. Electricity satisfies 25 percent of residential energy needs and 19 percent of industrial and commercial requirements. Five investor-owned utilities -- Pacific Gas & Electric, Southern California Edison, San Diego Gas & Electric, Pacific Power & Light, and Sierra Pacific account for 95 percent of electric generation.

What sources produce electricity?

Oil and gas account for 50 percent of electric generation, and hydroelectricity for 21 percent. Nuclear power is only 3 percent of capacity, but that will increase when the Diablo Canyon plant is allowed to begin low-power operation in the near future.

Coal, which provides more than 50 percent of U.S. electricity, supplies only 6 percent of California's power, and two-thirds of that comes from plants outside the state. The desire to preserve air quality prevents greater use of coal plants in the state.

Figure 2

1981 ELECTRICAL GENERATION CAPACITY BY TECHNOLOGY

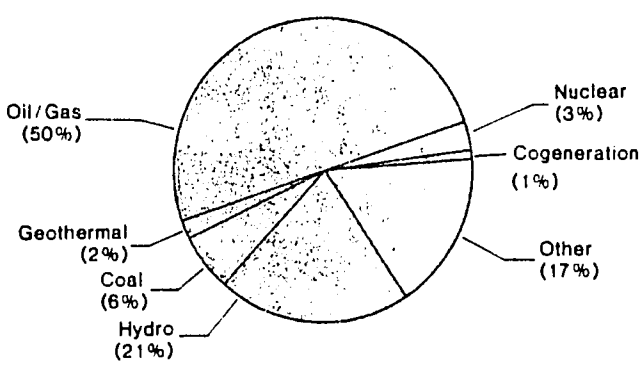
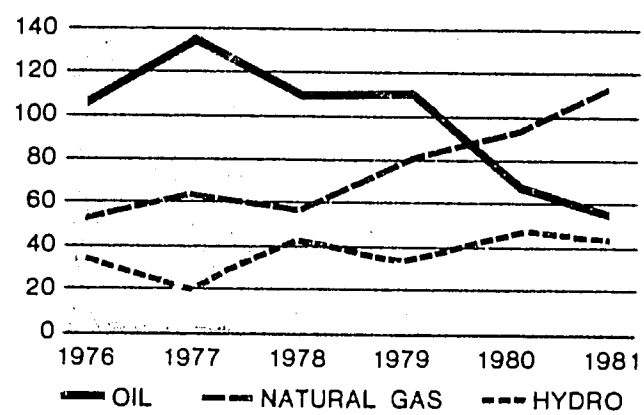


Figure 3

ELECTRIC UTILITY CONSUMPTION OF OIL, NATURAL GAS AND HYDRO
Million Barrels of Oil Equivalent



Source: Securing California's Energy Future. California Energy Commission. 1983

Alternative generating sources--geothermal, cogeneration, small hydro, wind, photovoltaics, and solar thermal--supply 7 to 8 percent of California's electricity detailed in Table 5 below..

TABLE 5

ALTERNATIVE ENERGY'S CONTRIBUTION IN CALIFORNIA
(In gigawatt hours/year)

	1975	1983
Geothermal	3,200	8,648
Cogeneration	NA	3,274
Small Hydroelectric	NA	1,505
Wind	Negl.	47
Solar	Negl.	2

Source: California Energy Commission

How fast is energy demand growing?

Peak electric demand in California increased 6.5 percent a year from 1965 to 1975. From 1976 to 1981, increased energy conservation helped slow the rate of increase to 3.2 percent, and it would have dropped below 3 percent except for an unusually hot summer in 1981. The commercial and industrial sector cut energy use by 12 percent from 1979 to 1981. Conservation measures helped the residential sector cut electricity use 5 percent and gas use 23 percent from 1979 to 1981. Nevertheless, household energy costs increased 33 percent.

California's Energy Policy

Like most of the world, California felt the shock of the 1973 oil embargo and suffered from the economic fallout of higher prices. To help the state adjust to the changing energy scene, Governor Jerry Brown proposed creation of the California Energy Commission (CEC) in 1975 to coordinate and control energy planning, and the legislature approved it. The Commission, composed of five people appointed by the governor (and approved by the state senate) for staggered five-year terms, immediately established four principles to guide state energy planning:

Reasonable cost . . . . . Supplies should be the lowest cost possible

Environmental protection . . . . Supplies should be as environmentally benign as possible

Security . . . . . Supplies must be secure, not prone to disruption

Social equity . . . . . Supplies and costs must be equitably distributed among consumers

Working from these principles, the CEC departed from existing state and national policy by emphasizing a policy of energy conservation and alternative energy development.

> Increasing energy efficiency is preferable to conventional supply projects for displacing oil because it offers lower costs, speedier implementation, more reliable results, and minimal environmental impacts. Conservation was also judged the least expensive method of expanding the use of available energy supplies and consequently flattening the spiral of inflating utility costs. Alternatives and renewable resources were found to offer stable fuel prices, less environmental risk, and greater diversity and flexibility than their conventional counterparts. (Emphasis added) ---California Energy Commission

What does CEC do?

Having agreed that alternative energy development would benefit the state, the CEC members decided that market forces alone would not make this development happen quickly enough. They moved to offset market distortions that they felt favored conventional energy sources. The CEC efforts included:

- Public information programs
- Economic incentives
- Mandatory efficiency standards
- Changes in energy pricing policies

In this way, the Commission tried to create an economic climate more favorable to alternative energy development.

Underlying the CEC strategy is the fear that the market underestimates the danger of oil supply disruptions and other drawbacks of conventional energy sources. The commissioners want to avoid a rerun of previous disruptions with their attendant price leaps, government panic, demand reduction, and economic turmoil.

Looking ahead, the Commission sees continued instabilities. The CEC projects that oil and gas will supply as much as 79 percent of California energy needs at the turn of the century. Price increases for natural gas could stimulate oil demand. Although California oil production has increased, the mix of crude for refineries includes more heavy oil, and additional refinery capacity may be needed to handle the heavier mix. The resurgent economy could increase energy demand and national reliance on foreign sources of oil.

Created by the state legislature to provide independent analysis of California's energy needs and policies, the CEC does not have the power to change the structure of the market. That is the role of the legislature, and the most powerful tool for shaping the market has been the tax system. Table 6 summarizes major state and federal legislative actions.

TABLE 6
LEGISLATIVE ENCOURAGEMENT OF ALTERNATIVE ENERGY

Federal Laws	California Laws
CENTRAL ENERGY AGENCY	
• Created Federal Energy Office (FEO) (1973) • Created Federal Energy Agency (FEA) (1974) • Created Energy Research Development Administration (ERDA) (1975) • Created Department of Energy (DOE) (1977). Current administration has proposed to dismantle DOE	• Established the Energy Commission with broad authority covering power plant siting, energy planning, and forecast development of energy conservation standards and alternative energy resources (Warren-Alquist Act of 1975)
POWER PLANT SITING PROCESS	
• Streamlined process for small hydroelectric projects under 5 MW (Federal Power Act)	• Streamlined process established for geothermal cogeneration, and coal gasification power plants (SB 2066 and SB 1805 of 1980
FINANCIAL INCENTIVES	
• 40 percent residential solar tax credit -- does not include swimming pools or passive solar features (Energy Tax Act of 1978) • Business tax credits for biomass, cogeneration, small hydroelectric geothermal, wind, and solar • Federal accelerated depreciation • Alcohol fuel excise tax exemption	• 55 percent solar tax credit for all residential applications (AB 1558 of 1977) • 25 percent commercial tax credit for solar and wind only (AB 1558 of 1977) • Allow accelerated depreciation of alternative energy equipment (AB 1404 of 1979 and AB 2893 of 1980) • Gasohol tax exemption (SB 1324 of 1980) • Alcohol conversion tax credit (SB 178 of 1981) • Solar property tax exemption (SB 1306 of 1980)
GOVERNMENT SPONSORED FINANCING ENTITIES AND PROGRAMS	
• Small business loans -- Small Business Administration • Solar bank • Synthetic Fuels Corporation • Wind commercialization (defunct)	• SAFE-BIDCO -- small alternative energy business loans (SB 16 of 1980) • CAESFA (AB 2324 of 1980) bonding authorities CPCFA (AB 2646 of 1980) bonding authorities • Sunny-Mac -- secondary mortgage market for solar loans (SB 921 of 1979) • Biomass demonstration. Agriculture and forestry residue as a source of energy (SB 771 of 1979) • Agricultural sector alternative energy demonstrations (AB 3048 of 1980) • Earmark annual funds from oil tidelands revenues for energy development (AB 2973 of 1980). Provided gkrants to local entitites for geothermal planning and development (AB 1905 of 1979)
ALTERNATIVE FUELS	
• PIFUA -- Reduce use of oil and gas by encouraging use of alternative fuels (National Energy Act of 1976)	• Explore use of ethanol and methanol in motor vehicle fleets (SB 3048 of 1980) • Explore use of cleaning burning fuels in transportation and utility power plants (SB 771 of 1979) • Authorize the use of methanol fuel in motor vehicles (AB 1401 of 1979) • Gasohol exemption from gasoline volatility test for three years (AB 2004 of 1980)
ENCOURAGE ALTERNATIVE ENERGY DEVELOPMENT	
• PURPA -- avoided cost rates for small power producers (National Energy Act of 1978)	• Accelerate wind commercialization (AB 2976 of 1978) • Establish standards for solar equipment and production of design tools for industry (AB 1512 of 1977) • Conduct passive solar design competition (AB 3046 of 1978) • Provide solar access rights and easements (AB 2984 and AB 3247 of 1978) • Define utility role in solar development (AB 2984 and AB 3247) of 1978) • Establish emission offset bank for cogeneration projects (AB 524 of 1979 and AB 1862 of 1981) • Give local government entities authority to generate small hydroelectric power (several laws in 1980 and 1981)

Source: Securing California's Energy Future. California Energy Commission. 1983

Tax Policies for Renewable Energy

Tax incentives are the most popular means of shaping economic choices in the United States. Through a uniquely elaborate system of deductions, credits, and allowances, federal and state governments seek to structure the market so that the economic choices most beneficial to the society will also be most attractive for the individual or company. The goal is to make social concern a factor in a free market decision.

For renewable energy investments, the government perceives a societal advantage in reducing dependence on conventional energy sources that entail environmental, safety, or economic liabilities. Tax incentives are a way for the society to assume the cost of the societal benefits of an individual decision, and the tax credit was the first initiative California's legislators took to promote alternative energy development.

Tax credits have effectively spurred residential and commercial alternative energy use in California. The combination of state and federal tax credits plus the energy savings enables a California homeowner buying a solar system to take in more money than he spends in the first year -- a powerful incentive to buy a system. For third-party investment in alternative electric generating facilities, the tax credits are undoubtedly the prime motivation. The package of tax credits and other tax benefits available for alternative energy investments is very attractive for high-income people -- and a wealthy population is one of California's prime resources. Although other conditions are necessary to grease the wheels of alternative energy development, tax credits are the force that set the wheels in motion.

When were the tax credits introduced?

California introduced a 10 percent solar tax credit in 1976 -- two years before the federal tax credit began. One of the first in the nation, it allowed individuals and businesses that purchased renewable energy equipment to produce heat or electricity to deduct 10 percent of the cost, including installation, from their state taxes. The tax credit legislation included no specific goals for the credit. The legislature simply wanted to encourage consumers to buy solar energy systems and thereby help start a new industry down its learning curve.

In its subsequent effort to justify the credits, the California Energy Commission has identified seven goals for the solar and conservation credits:

- To save energy and reduce energy bills
- To develop new jobs and businesses
- To accelerate cost effectiveness of energy saving measures
- To increase security and reliability of energy supplies
- To accelerate technological development
- To achieve environmental benefits
- To counter-balance subsidies to conventional energy sources.

In September 1977, after the federal solar research, development, and demonstration program was well underway and interest in the potential of solar energy utilization was growing, California passed additional legislation to increase the solar tax credit to 55 percent with a $3,000 maximum.* (The credit was cut to 50 percent in 1984). For non-residential systems costing more than $12,000, a 25 percent credit applied, with no upper limit. Wind energy systems became eligible for the credits in 1978, and similar credits for conservation were established in 1981. A California homeowner must reduce the value of his California credit by the value of any federal tax credits. If he claims the 40 percent federal credit in 1984, he will receive a 10 percent California credit. Business systems can claim the full state and federal credits.

How do the credits work for a homeowner?

The initial benefit of the tax credit to a homeowner is easy to see. Someone who buys a solar water heater that costs $4,000 installed can deduct 40 percent of the cost ($1,600) from his federal tax bill and $400 (50 percent California credit minus the federal credit) from his state tax bill. He thus saves $2,000 on the cost of the water heater.

The long-term benefits vary with each installation. The efficiency of the system, the cost of a conventional system, the price of fuel for a conventional system, the amount of hot water used, the homeowner's tax bracket, and the method of financing all affect the long-term economics of the investment. The interaction of these variables is evident in the following hypothetical example.

Assume that a homeowner in a 30 percent tax bracket buys a $4,200 solar water heater with a seven-year 15 percent home improvement loan, saves $275 in energy costs compared to a conventional heater in the first year, and energy costs rise 10 percent a year.

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* A tax credit allows an individual or corporation to reduce tax the bill by that amount. A tax deduction reduces taxable income. For someone in the 50 percent tax bracket for earned income, the highest in the U.S., a $1,000 tax credit would reduce his tax bill by $1,000. A $1,000 tax deduction (such as a depreciation allowance) would reduce his tax tax bill by $500.

TABLE 7

RESIDENTIAL WATER HEATER INVESTMENT PROFILE

Year	Solar Savings	Interest Deductions Earnings	Federal Tax Credit	Calif. Tax Credit	Total Earning	Debits Annual Payment	Balance Annual Position	Balance Cumulative Annual Position
1	$275	$207	$1,680	$630	$2,792	$973	$1,829	$1,829
2	302	178	---	---	480	973	-493	1,326
3	333	163	---	---	496	973	-477	847
4	366	123	---	---	489	973	-484	365
5	403	90	---	---	493	973	-480	-116
6	443	58	---	---	501	973	-472	-587
7	487	23	---	---	510	973	-463	-1050
8	536	---	---	---	536	---	+536	-51
9	590	---	---	---	590	---	+590	+36
10	649	---	---	---	649	---	+649	+735

Source: California Solar, Wind, and Conservation Tax Credits, CEC. 1983.

As can be seen in Table 7, over the seven years the value of the energy savings increases with fuel price hikes, and the interest paid is tax deductible. The first year cash saving from the tax credit puts the homeowner ahead, so that the system doesn't cost anything until the fifth year. By the eighth year the loan is paid off, and the homeowner profits from energy savings. Net cash flow is positive in the ninth year, and savings should continue for the life of the system -- say an additional ten years. The owner could also choose to reinvest his tax savings to reduce the loan principal, and make his positive cash flow occur sooner.

What about a commercial project like a windfarm?

Commercial projects involve not only more up-front money but more players. A developer chooses a site and a technology, estimates costs, plans for operation and maintenance, and conducts negotiations with the utility to sell electricity. The utility agrees to a contract that specifies rates, terms, and other conditions. Individual investors provide the capital for the project, claim the benefits of the tax credits, and receive a share of the income from power sales. The following example, based on the prospectus of a major wind farm developer, illustrates the economics of a wind farm now operating in California.

A San Francisco-based developer buys land in Altamont Pass in the Bay Area of Northern California and plans a 60 megawatt wind farm composed of about 500 machines. Construction costs will run about $103 million, and related management expenses will cost an additional $9 million. The developer estimates that the project will produce 140 million kilowatt hours of electricity a year. The utility has agreed to pay $.09 a kilowatt hour for the power until 1991 and then to pay 82 percent of avoided cost. Until 1991, the developer is counting on a steady income of $12.6 million a year.

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An investor agrees to put up $75,000, in effect buying about 40 kilowatts of wind capacity. The tax benefits for the first year are formidable.

Federal Incentives		
Energy tax credit	($75,000 at 15%)	$11,250
Regular investment tax credit	($75,000 at 10%)	7,500
Depreciation	(65,625 x 15% x 46%)	4,528
California Incentives:		
Solar tax credit	($75,000 at 25%)	$18,750
Depreciation (15 years)	($6,250 x 2 x 9.6%)	720
First year cash savings		$42,748

In subsequent years, the investor will continue to benefit from depreciation allowances and will receive about $4,000 a year net profit from electricity sales. Income from electric sales will increase after the fixed rate ends in 1991, and the developer projects that annual income will rise steadily to $11,000 by 1999.

Although this explains the essence of what happens, most investments are usually more complicated. Many investors will not actually put up the $75,000 in the first year. Instead they sign a five-year non-recourse note at 9 percent interest, and pay the developer in installments. The interest is tax deductible. This enables an investor to claim the tax credits and still have the cash in hand for other investments. By the time the investor pays off the $75,000 note, he will have earned more than $79,000 in tax benefits and income. At the end of ten years his cummulative cash flow should equal $93,000, according to the prospectus.

Why are tax credits necessary for wind farm development?

The cost of delivered energy from a medium-sized wind machine (20 to 50 Kw) costing about $1800 to $2200 per kilowatt of rated capacity ranges from 10 to 15 cents per kilowatt hour. Utilities are not directly buying such equipment because the cost of delivered energy exceeds by a factor of two what they are required to pay independent energy producers as avoided costs and capacity factor payments. With tax incentives, independent developers can generate power at a competitive price and make a profit. As many as fifty to seventy wind farm developers (three-quarters located in California) are putting together multimachine windfarm projects, selling them to investors, and managing them for power sales to utilities. The combination of tax credits, depreciation, and the income stream from a utility are enough to provide investors in high tax brackets with an attractive rate of return. They are frequently sold through investment firms, or by the developers. The entry price for an investor may be as low as $10,000 to $15,000, yet some projects exceed $50 million in total cost.

Who invests in alternative energy projects?

Thus far, individual investors are the most active in renewable energy projects. Doctors, lawyers, and movie stars, usually with net worth of at least $1 million, were the first to invest. As the business expanded and became more established, opportunities opened for individuals with $10,000 or $20,000 to invest.

The people investing in projects like the windfarm described above are probably in the 50 percent tax bracket (individuals earning in excess of $50,000 per year of taxable earned income) and want to "shelter" that income. The investment and renewable energy tax credits reduce their tax bills directly, and depreciation allowances reduce taxable income. You do not have to be a solar advocate to appreciate the economics of alternative energy investments under this tax code.

Several years of field experience have reduced the risk associated with wind technology, and the tax credits provide a reliable enough safety net so that wind farms are no longer as risky a venture as they first were. At present, wind farm investors expect a 25 percent rate of return to justify the perceived risk. Very high risk ventures for unproven technologies or new companies usually must offer a minimum return on investment after taxes of 40 percent, with a promise of much higher returns should the project succeed.

Institutions - investment funds, insurance companies, pension funds and venture capital pools - are another potential source of equity capital for renewable energy projects. Thus far, insurance companies have not been interested, and pension funds, which are tax-exempt, lack the major incentive. Investment funds and venture capital pools, which are essentially channels for individual investment, are becoming more involved.

Corporations are another source of equity capital for projects. Because corporations often have little or no tax liability, tax credits are not an effective incentive for them. They are most likely to invest in a facility they will own and use, such as a cogeneration system.

How does California justify the cost of the tax credits?

When George Deukmejian became governor of California in January 1983, he promised to eliminate the renewable energy tax credits. He claimed that the state had no business interfering in the energy market and that the tax credits were simply a tax dodge that helped the wealthy and hurt the state.

In response to this attack, the California Energy Commission identified the following justifications for the credits:

- State Revenue Losses. CEC argued that the state treasury losses from the credits were less than estimates by the Governor's budget officials. In 1983, state tax expenditures for solar and wind systems were estimated to be $78 million. CEC claims that of the $78 million in credits granted in 1983, $50 million eventually returned to the state in related business taxes, of which $25 million could be attributed directly to the tax credits.

Over the life of the systems installed in 1983, CEC calculated that all but $10 million of the $118 million lost to the state through tax credits and depreciation allowances will eventually end up in the state treasury. The CEC report concludes that ninety-two percent of the original expenditure for solar credits is projected to be returned to the state treasury through increased tax revenues directly caused by the credit. (See Table 8 below)

The ultimate net cost of the tax credits to California's treasury is a slippery issue, which depends on how strictly one defines their economic effects. Everyone agrees that increased tax revenue from sales, business profit, personal income, and property taxes related to renewable energy business should be at least partially counted to offset the cost of the tax credits. But deciding what level of business activity would have occurred without the credits -- and which therefore should not be considered in accounting -- is not easy.

TABLE 8

ESTIMATES OF REVENUE EFFECTS OF 1983 SOLAR AND ENERGY CONSERVATION TAX CREDITS FOR THE PERIOD 1983-2003 (In Millions of 1983 $)

	Amount of Monies Spent for Tax Credits or Alternative Purposes	Revenues Generated from Energy-Related Investments		Revenues Minus Spending on Credits		Revenues as a Percent of Spending on Credits	
		Total	Attributed to Credits	Total	Attributed to Credits	Total	Attributed Credits
Spending on Energy Credits							
Solar Credits	$118	$199	$108	$81	-$10	169%	92%
Energy Conservation Credits	49	63	19	14	-30	129%	39%
Total Energy Related Credits*	$167	$261	$127	$94	-$40	156%	76%
Alternative Use of Monies -- A General Tax Reduction	$167	$ 81	$ 37	-$86	-$130	49%	22%

*Detail may not add to totals due to rounding.

Source: California Energy Commission, California's Solar, Wind and Conservation Tax Credits, Dec. 1983, p.33.

4

- Energy Savings. CEC estimates that energy produced by renewable energy systems that claim the tax credits will be worth $2.6 billion over the life of the systems, with wind turbines and solar water heaters the major contributors.

- Environmental Benefits. The CEC estimated that increased investments in renewable energy will result in improved air quality for the state. The systems and equipment installed or expected to be installed because of the present solar and conservation credits should avoid environmental pollution by an amount equal to a 300 Mw natural gas electric generation facility operating for 20 years.

- Industry Growth -- The total number of solar-related firms grew 500 percent in California from 1977 to 1982, while in the rest of the United States the number only doubled. A 1982 survey estimated that 1,500 businesses were directly working in the solar field, with an additional 5,000 companies involved on a part-time basis. Table 9 on the next page provides a summary of data on solar industry growth in the United States and California.

  In 1982, solar heating and cooling applications led the industry with sales of $300 to $350 million. Wind was next with sales of $108 million. Large wind farm development has grown incredibly since it began in 1981, and early reports indicate that wind farm business in California could have taken the lead from solar heating and cooling in 1983.

  The California Energy Commission estimates that seventeen biomass projects sponsored by a state program since 1979 have stimulated $54 million in capital investment and generated $200 million in sales. The projects include direct combustion, methane fermentation, and gasification. Direct combustion in the forestry and agricultural sectors dominates the market.

- Employment. The number of direct employees in the low and medium temperature solar industry has increased from about 2,000 in 1977 to 12,500 in 1983. Employment in advanced high temperature solar thermal companies has increased from about 150 in 1977 to 400 in 1983.

  In the wind energy field, only a few manufacturers of wind equipment are located in Calfornia, so most of the work is in installation. Employment rose from 319 direct jobs in 1981 to 1,761 in 1983. Biomass projects created about 3,000 jobs.

  About one-third of the photovoltaic companies in the United States are located in California. Employment in California rose from an estimated 700 direct jobs in 1977 to an estimated 1,500 jobs in 1983.

TABLE 9

SUMMARY DATA OF SOLAR INDUSTRY GROWTH

UNITED STATES (Excluding California)	Number of Firms		Employment		Production		Sales (Millions of $	
	1977	1982	1977	1982	1977	1982	1977	1982
Low and Medium Temperature Solar Thermal	321[a]	325[a]	c	c	6,100,000 ft^2	9,100,000 ft^2	254	329
Advanced and High Temperature Solar Thermal	15[a]	21[a]	c	c	113,000 ft^2	209,000 ft^2	2.6	5.2
Wind Energy Conversion[b]	Insig.	173	c	c	Insig.	2,010	Insig.	15
Photovoltaics	5[a]	12[a]	400	1,100	200 kWp	1,600 kWp	11.6	23.4
SUBTOTAL	341	531	400	1,100	N/A	N/A	262.2	390
CALIFORNIA								
Low and Medium Temperature Solar Thermal	283	1,500	1,500	10,900	4,600,000 ft^2	10,400,000 ft^2	54	335
Advanced and High Temperature Solar Thermal	8	8	139	379	82,000 ft^2	235,000 ft^2	1.9	6.6
Wind Energy Conversion[b]	Insig.	25	Insig.	992	Insig.	1,000	Insig.	108
Photovoltaics	7[a]	6[a]	1,100[a]	2,300[a]	180 kWp	3,110 kWp	5.5	30.8
SUBTOTAL	298	1,539	2,339	13,471	N/A	N/A	62.5	535
TOTAL U.S	639	2,070	2,733	14,571	N/A	N/A	324.7	925

a. Manufacturers only
b. Number of Firms data equals dealers and manufacturers only. Production data equals the number of installations.
c. No data is available for this category

Source: California Solar, Wind, and Conservation Tax Credits (CEC, 1983), p. 67

What are the arguments against the credits?

The renewable energy industry has relied heavily on the solar tax credits to propel development of its markets. While they have enjoyed broad support, the credits have not been immune to attack. The major criticisms include:

- Revenue Losses. In a period of mounting concern over the large federal budget deficit, any policy that costs the Treasury revenue is likely to be scrutinized. Treasury analysts estimate that the solar and conservation tax credits cost the federal government $1.1 billion in 1981 and will cost billions more in 1982, 1983, and 1984.

- Tax Code Complexity. Critics contend that the tax system has become overly complicated, and that government should seek alternative ways to promote new technologies.

- Free Market Impact. Valuable talent and resources are being devoted to a technology incapable of supplying energy in the near or mid-term in any quantities meaningful to national needs or security. The free marketeers propose decontrolling conventional energy prices rather than providing assistance to new technologies.

- Uneven Business Development. Both sides in the debate agree that the beginning and end of the tax credits disrupt the normal growth pattern of solar businesses, making planning difficult. Businesses suffered in the 1970s as Congress debated the credits and consumers waited for the outcome.

- Consumer Protection Costs. When the federal and state governments provided incentives for new technologies, they also took on the responsibility to implement consumer protection regulations, increasing government and industry expenses.

- Industry Dependence. A subsidized industry can become too dependent on the subsidy and will avoid investing funds necessary to become competitive without the subsidy.

- Incentives Hold Up Prices. Some of the most strident criticism facing tax credit proponents is that the credits artificially inflate the price for the technologies that are already competitive.

- Incentives Are Abused. A Texas contractor reportedly sold a $4,000 solar water heater for $8,000 by offering a free air conditioning system worth $4,000 as a bonus. He told consumers they could claim a $3,200 tax credit (40 percent of $8,000) and thus pay only $800 for the solar system. Developers of commercial generation projects have also been accused of overvaluing their projects to boost the tax credits. Such schemes are illegal and can damage the industry's reputation.

Regulation: The California Utilities and PURPA

Producing energy won't do you any good if you can't use it or sell it. In the United States and virtually everywhere else, electricity is produced and sold under strictly regulated conditions. This leaves little opportunity for entrepreneurial pioneers to introduce new technologies, and the lack of competitiveness leaves electric utilities with little incentive to innovate.

Recognizing this, the U.S. Congress passed legislation in 1978 to promote independent power production using alternative sources of energy. Though a crucial step, the legislation in itself was not sufficient to guarantee alternative electric generation, and many states have seen little progress in expanding their sources of electricity. California, however, is enjoying dramatic alternative power growth thanks to aggressive state regulators, open-minded utility officials, growing electric demand and other favorable conditions. As a result, California has become the world leader in alternative electric generation interconnected with utilities.

How is the U.S. utility industry structured?

In the United States production and delivery of electrical power is principally a private sector enterprise. Four hundred investor-owned utilities generate 78 percent of U.S. electrical power. Publicly owned utilities and municipal utilities provide the rest.

Government has granted utility companies a controlled monopoly, under state and federal regulation. State public utility commissions, elected or appointed, set rates and approve construction. The Federal Energy Regulatory Commission (FERC) implements and administers federal law and executive orders. The Nuclear Regulatory Commission, the Securities and Exchange Commission, and the Environmental Protection Agency also control aspects of utility operation.

What led to the enactment of PURPA?

Although gasoline and heating oil prices were the most evident sign of skyrocketing oil prices in the 1970s, electric rates soon followed. Even though electric utilities relied on petroleum for only 9.9 percent of their energy needs in 1976, oil price increases pulled up prices of other conventional fuels, and electric rates rose. Their climb was not immediate because long-term contracts and the regulatory process build in a delay, but as soon as utilities won the right to pass through fuel price increases to their customers as a surcharge, an upward price spiral began. Consumers saw their electric rates rise for the first time in decades.

At the same time, nuclear power was coming under attack for being dangerous and more expensive than anticipated. Construction costs rose as regulators found many plants wanting in adequate safety measures. Public protests intensified, creating further delays. The combination of inflating interest rates and longer construction times put many utilities in a bind. Then rising prices encouraged conservation and a switch to other energy sources, thereby cutting electricity demand and rendering utility growth forecasts useless. Utilities found themselves in the unhappy position of financing and building very expensive new plants that were not needed.

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At the same time, businesses were discovering that they could economically generate their own electricity with cogeneration, and renewable energy entrepreneurs were eager to produce electricity from wind turbines, photovoltaic cells, and small hydroelectric facilities and to sell this power to utilities. However, a number of hurdles stood in the way of developing these alternatives:

- the reluctance of utilities to tie independently-produced power into the grid
- low purchase prices offered by the utilities for their electricity
- high costs of auxiliary power from the utility
- uncertainty about state public utility regulation.

PURPA was designed to remove these hurdles.

What is the Public Utility Regulatory Policies Act (PURPA)?

The federal government enacted the Public Utility Regulatory Policies Act (PURPA) in 1978 as one of five major legislative energy initiatives of the Carter administration. This bill ordered all state utility commissions to "consider" by November 1981 the implementation of standards to promote "conservation, efficiency, and equity" in utility policies through voluntary changes in rate structure and other practices. Utilities were directed to publish detailed statistics on their cost of providing electricity, a requirement essential for determining their marginal costs for providing additional energy.

PURPA sections 201 and 210 have had the most impact on alternative energy production and raised the most controversy. These provisions require utilities to buy power from small power producers that meet certain qualifications and to sell them auxiliary power at nondiscriminatory rates.

The original purpose of PURPA section 210 was to provide an incentive to cogeneration as a means of improving the efficiency of the electric utility system. The forestry, petrochemical, and oil refining industries were already producing some of their own power, and energy planners estimated that a great deal more potential existed if cogenerators could receive a price for their energy that reflected more closely a utility's marginal rather than average cost of power.

PURPA addressed these impediments to alternative power production by:

- Requiring state public utility commissions to remove constraints and establish requirements under which any qualifying independent power producer (of less than 80 megawatts) can tie into the utility grid

- Streamlining the licensing process by exempting all qualifying cogeneration and renewable energy facilities of less than 30 megawatts from certain regulatory procedures

- Requiring the Federal Energy Regulatory Commission to publish rules governing establishment of "just and reasonable rates" for the buying and selling of power to utilities by qualifying facilities, specifying that, "no such rule...shall provide for a rate which exceeds that incremental cost to the electric utility of alternative electric energy."

Before changes could begin to occur under PURPA, the Federal Energy Regulatory Commission (FERC) had to establish rules implementing the major provisions of the act. Then it was up to the states to establish specific procedures and guidelines for the utilities under their jurisdiction.

How did the utilities respond?

When FERC published its PURPA rules in 1980, the utility industry responded by challenging the rules in court. Many utilities objected to mandatory interconnection with independent power producers and to FERC's decision that utilities must buy the power at "full avoided cost" -- what it would cost the utility to produce the additional power by conventional means. Most states, meanwhile, began establishing their rules and criteria for implementing PURPA according to the FERC rules.

Utility objections were based on the belief that:

- Full avoided costs establish a false price for renewable energy systems

- It would burden states and utilities to make them have to justify other than full avoided costs

- Mandated full avoided costs are not necessary to induce development of cogeneration or small power production facilities

- Mandatory interconnection would preclude FERC interconnection rules that protect the utility system and customers

- Just and reasonable rates are needed, but should also serve the interests of consumers, who deserve equitable electric power rates

- Empowering states to determine rates of purchase and to be involved in interconnection issues to a greater degree will cause unequal and inconsistent implementation of federal policy.

The Edison Electric Institute, the utility trade association, went even further and charged that full avoided cost rate would raise costs to consumers, allow states to establish rates above avoided costs, reduce the reliability of the electric utility grid, and inhibit full development of alternatives. Its spokesmen contended that 100 percent of full avoided costs failed to balance the interests of the public, ratepayers, and qualifying facility developers.

Proponents of FERC's rules defended full avoided costs by pointing out that the utility system would benefit from development of small scale power resources the utilities would overlook and that a more efficient system would result because independent power producers:

- Use no fuel or use it more efficiently
- Disperse sources of power supply, thereby creating more system security
- Allow utilities to add power in smaller increments
- Reduce financing costs by shortening lead times.

While the court battles raged, independent power producers waited. FERC received only seven small power applications totalling 187 megawatts in 1980 in California and seventeen totalling 796 megawatts in 1981.

Did PURPA make a difference?

In spring 1983, the Supreme Court upheld the Federal Energy Regulatory Commission rules implementing PURPA. With the uncertainty removed, the pace of alternative energy development accelerated. In California alone, alternative energy capacity almost quadrupled from 1981 to 1983. In 1981, cogeneration supplied less than 200 Mw of capacity in California. By summer 1983, 379 projects totalling 751 Mw were on line, and an additional 5,500 Mw were in some stage of project conceptualization, development, or negotiation. Existing and planned projects included:

Oil/gas cogeneration	28 percent
Biomass and waste-to-energy	23 percent
Wind	23 percent
Small hydro	8 percent
Solar electric	4 percent
Geothermal	3 percent

The rise in wind energy utilization after 1981 is one of the most dramatic indications of the impact of PURPA. Total installed capacity of wind energy systems in the U.S. tripled from 1982 to 1983, and output quadrupled from 15,000,000 to 60,000,000 kwh. Applications for new facilities rose at a similar pace.

The potential for alternative energy utilization remains strong, despite an apparent slowdown due to the decline in oil prices, which is reducing avoided cost rates. The California Energy Commission still projects that over 2,000 Mw of cogeneration systems, 2,000 Mw of wind systems, and 1,400 Mw of small hydro could be on line by 2002 in California.

What else contributed to PURPA's impact?

Crucial as it is, the PURPA legislation was only the first step in stimulating independent power production. Implementation of PURPA varies considerably from state to state, and nowhere has its effect been more pronounced than in California. While availability of capital and extensive alternative energy resources explain some of California's progress, aggressive regulatory pressure is the most significant cause of growth.

The California Energy Commission saw the utilities, and hence their state, in a particularly vulnerable position. Likewise, the California Public Utility Commission (PUC) was pushing the utilities to tap alternative energy sources even before PURPA was passed. In March 1976 the PUC ordered utilities to report on current waste heat use and plans for future use. In January 1978, it ordered utilities to publish rates and policies for purchasing power from small power producers and cogenerators. Then at the end of 1979, the PUC directed Pacific Gas & Electric Company to file price offers to 11,000 potential cogenerators and small power producers at full avoided costs. This was two months prior to promulgation of the FERC rules on interconnection and purchase rates. All regulated utilities in California were required to file offers by July 1, 1980. By the time it was passed, PURPA simply gave California agencies more authority to do what they were already doing.

How does one determine purchase rates for privately produced power?

High avoided cost levels are a sine qua non for substantial market penetration of cogeneration and independent power production. Furthermore, capacity credits, amounting to about 10 percent of the income an independent energy producer earns from a utility, often provide the margin of profit. FERC rules provided considerable latitude to states in determining avoided costs and capacity credits. No prescribed calculation method was set forth, nor does anything prevent utilities and qualifying facilities from negotiating their own rates and contract terms. The FERC rules merely require that certain factors be taken into account.

California has been one of the most aggressive states in its implementation of PURPA. Unlike most states, which rely on utility filings for determining avoided costs, the California PUC established its own methodology and closely supervises utility compliance. The avoided cost rates in California include fuel cost, operation and maintenance costs, line losses, administrative expenses, transmission and distribution investment costs, and capacity costs.

As a result of this procedure and their reliance on oil and gas, the utilities in California had the high avoided cost rates -- more than $0.07 per kilowatt hour -- needed to stimulate independent energy production.

California also has a continuing need for new electric generating capacity. In many other states, the utilities have too much capacity and want to discourage more production.

What role did the utilities play?

Another key element supporting alternative energy production under PURPA is the evolving attitude of the state's major utilities. While state regulators have applied pressure from without, utility staff economists encouraged their management to consider conservation and alternative energy resources.

Utility economists recognized that deferring capacity expansion under the general economic conditions in the late 1970s and early 1980s was a clear advantage to utilities. Nuclear construction delays and cost overruns were a headache. Credit was tight and interest rates high. Regulatory scrutiny made it uncomfortable to propose continued rate increases and business as usual. Alternative energy projects met a friendlier reception and were often a valuable public relations tool. Adding capacity in small increments gave the utility more flexibility, and the utility did not have to raise capital to expand capacity.

Who else was important?

Private investors have been critical to development of alternative energy. When the national administration changed in 1980, the federal philosophy towards introduction of new energy technologies shifted to support of long-range, high-risk research, leaving commercialization to the private sector. In California, an aggressive, forward looking industrial sector accepted the risk of entering a new energy era. California's healthy economy, with a GNP larger than all but six countries in the world, provided the economic surplus the entrepreneurs needed. Capital has been forthcoming for financing new energy companies, creating alternative energy divisions in existing companies, and for financing projects.

What does an independent power producer have to do to sell power?

Once a private producer has created and prepared a preliminary finance package for a project, he must negotiate an agreement with a utility company. The difficulty and expense of negotiating a contract with the utility discouraged many potential independent power producers. To overcome this problem, the California Public Utilities Commission required utilities to draw up "standard offer" contracts to simplify negotiations. Now the major California utilities have several standard contracts that specify prices, terms and conditions for various cogeneration or renewable energy projects. A small power producer who is not satisfied with the standard offers is free to negotiate an individual contract, and most large projects choose to do so.

For the independent power producer, the key items in the contract are:

- the price per kilowatt hour paid by the utility;
- the amount of the capacity payment, which is determined by the size and reliability of the project;
- the interconnection fee.

California Energy Commission chair Charles Imbrecht identifies the negotiation of a long-term contract for utility sales as the "premier issue" for attracting private investment for alternative energy projects. But even this may not be enough to get a bank loan because most of the contracts involve a variable electric rate tied to the utility's estimate of avoided cost. The banks usually prefer a long-term fixed rate so that they can estimate precisely the project's future income.

Should independent power producers pay for transmission systems?

The latest controversy raging between the California Public Utility Commission and Pacific Gas and Electric Company (PG&E) is an excellent example of the issues surrounding PURPA. PG&E wants to modify its standard offer to independent power producers by including charges to upgrade the PG&E transmission system to accommodate the growing number of independent generation plants. Some electric lines have already become incapable of handling the power available from cogenerators and alternative energy power plants.

At issue is who should pay for new transmission capacity. The power producers are arguing that PG&E was ordered to plan on having 2,000 MW of cogeneration on line by 1985 and should be better prepared. The independent power producers worry that PG&E will hit them with unexpected charges, creating damaging uncertainty in the minds of potential investors. The Public Utilties Commission is upset that PG&E is tampering with a standard contract offer that took four years of wrangling to create. As independent power production grows, utilities are certain to want to pass on some of their infrastructure costs.

Who pays for promoting independent power?

Another unanswered question raised by PURPA is who should bear the cost and who should reap the advantages of turning to alternative energy sources. With mandated full avoided costs, the independent producers are receiving a greater share of the advantages from their entrepreneurial ventures than they probably would otherwise. The utility pays the same cost for new independent energy sources as it would for additional conventional sources, in spite of its doubts about the reliability of small independent power units. The stockholder's dividends remain unchanged, and no capital is spent. The ratepayer sees new capacity come on line for the same ostensible cost with or without PURPA. Arguing on behalf of ratepayers, utilities argue that 80 or 90 percent of avoided costs should be the standard so that ratepayers would benefit economically. Thus far, ratepayers and taxpayers have borne most of the cost for alternative electric power generation.

In some cases, utilities themselves have offered to pay rates higher than avoided costs. In these cases, they point to a need for extra incentives to advance technolgies still in the development stage. They contend that ratepayers can be legitimately asked to help cover the risk associated in commercializing unproven technologies. The California PUC has approved rates above avoided cost, but with the provision that after a certain period a project will "repay" the utility by receiving less than avoided cost for its electricity. Other state commissions have denied such requests outright.

Are avoided cost rates fair?

At the root of this debate is a difference between long-range and near-term perceptions. Some observers point out that current procedures for determining avoided costs really understate the value of independent capacity to a utility. They argue that many hidden costs of conventional technology are not reflected in the FERC guidelines or in state procedures.

Many utilities have had to write off the cost of partially built nuclear plants that were cancelled. Public Service of New Hampshire and the Long Island Lighting Company risk imminent bankruptcy as they try to complete construction of the Seabrook and Shoreham nuclear plants. Avoiding capacity investment may be worth more than just the value of deferred investment and all associated regulatory and environmental considerations. Such calculated risks as potential bankruptcy are hard to quantify in dollars, but regulators cannot ignore them in avoided cost calculations.

Most utilities now set avoided cost at the price of power from their most expensive operating plant. Many independent power producers argue that avoided cost should be set at the price of power from a conventional plant it would start building now. The cost of any new power plant is dramatically higher than existing capacity. For example, one California utility with an avoided cost of 6 cents per kilowatt hour is considering construction of a new pulverized coal plant that would deliver energy starting in 1992 at 12 cents per kilowatt hour ($1983). If this latter figure were the avoided cost rate for an independent power producer, many more alternative systems would become competitive, and independent entrepreneurs might be building a significant portion of California's energy capacity for the 1990s.

Why are California utilities not investing in alternative energy facilities on their own?

For the most part, California's utilities are not investing in alternative energy facilities on their own One reason is that PURPA limits utility ownership of cogeneration and renewable energy small power facilities to a 49 percent share. The limit is meant to prevent utilities from unfairly competing against the new energy companies and from increasing avoided cost rates to benefit themselves at the expense of ratepayers. Furthermore, utilities are not eligible for the tax incentives or favorable depreciation schedules private investors enjoy. They have to finance and operate alternative energy facilities at regulated rates of return, and the technological risk remains too high.

What can we conclude from California's experience with PURPA?

The lesson of PURPA is that legislation to promote independent power production will succeed if regulators implement it aggressively, utility officials approach it with an open mind, financial and energy resources are available, entrepreneurs are willing to take risks, and electric demand is growing. Other states have not made the same progress as California.

While we can see that PURPA stimulates independent energy production and attracts capital that otherwise would not be invested in electric generation, it is too soon to evaluate the long-term benefits of alternative energy development.

We can see that cogeneration facilities are more energy-efficient than power plants that do not use waste heat, that renewable energy is more environmentally benign than conventional fuels, that adding generating capacity in small units makes the electric system more flexible and less dependent on long-range forecasts, that reducing energy imports frees capital for other uses. But all of this does not guarantee that independent power production using alternative sources of energy will ultimately be beneficial or that the incentives used in California are the most sensible way to guide energy choices.

Entrepreneurs could reap all the benefits and ratepayers bear all the costs. The reliability of the electric system could diminish. Business and industry could produce all their own electricity, leaving residential consumers paying higher rates for utility-generated power.

While all of these undesirable results are possible, California provides one unambiguous success story. While utilities in other states with ambitious conventional power construction programs are asking for dramatic rate increases this year to cover escalating costs, and some utilities even face bankruptcy, Southern California Edison, which is three years into an ambitious alternative energy development program, is decreasing its rates this year.

Loan Incentives: Tapping Biomass Resources

Biomass energy development does not respond to the same stimuli as other alternative energy sources. Residential tax credits are not effective because, except for wood stoves, biomass technologies are not useful for homeowners. And because biomass resources are so diffuse and transportation is so expensive, only small facilities that use local resources are economically justified. These small facilities are not able to attract venture capital. Biomass energy systems make the most sense for agricultural and forestry operations that have biomass residue that they have to dispose of in some way. Most of these businesses do not pay enough taxes to be interested in tax credits. For them, the barrier to alternative energy investment is lack of capital.

The California Energy Commission estimates that biomass could satisfy up to five percent of California's energy needs in the year 2000. Even more telling, by using biomass residue, the forest and agricultural industries could produce 89 percent of the 53 million barrels of oil equivalent they use each year. In its fuel price projections for 1985, the Commission estimated that the cost of biomass fuels transported less than 50 miles will range from $1.40/Mbtu for forestry residues to $2.60/Mbtu for orchard prunings. Coal, gas, and oil are expected to range from $3.62 to $5.95 per million Btu. In spite of the apparent advantages of using biomass, California uses only 2 percent of its biomass residue for energy.

Why is biomass ignored?

The major impediments to biomass energy development are uncertainty about the technology, the lack of infrastructure to harvest and deliver the material, the high cost of converting to a biomass system, and the seasonal nature of the resource. Farmers and foresters need capital and technical assistance to minimize the risk of trying a new technology. Biomass systems are eligible for a 10 percent federal investment tax credit, a 10 percent federal energy credit, accelerated depreciation, and several other tax incentives, but the California Energy Commission decided that tax credits were not the best approach. The Commission recommended a program of loans to help build demonstration projects.

What was the policy response?

The California legislature passed the State Agricultural and Forestry Residue Utilization Act of 1979 (SAFRUA) to fund demonstration projects to examine the feasibility, efficiency, environmental acceptability, and reliability of biomass systems and equipment in commercial applications. The program focused on direct combustion, fermentation, and gasification.

The state created a $10-million revolving fund to provide interest-free loans for up to 50 percent of the cost of a biomass facility. The state and project developer negotiate performance criteria, and the developer promises to pay back the loan ninety days after meeting the performance test. To minimize the risk, the state agreed to negotiate a reduced repayment of the loan or to accept the equipment for resale in lieu of repayment if a project fails. When a loan is repaid, the funds are loaned to another project.

What projects have been funded?

In California, orchard and vineyard prunings were the first residues chosen for energy production because of their high cost of disposal. Residues from cotton stalks, corn stalks, and rice, wheat, and barley straws also have potential, but collection and conversion efficiencies are too poor to justify significant activity. Nut shells and fruit pits are already used by the food processing industry as fuel.

The SAFRUA loan fund has already granted loans to direct combustion, collection, and methane fermentation projects, most of which are under construction or in preliminary operations.

- The Farmers Cooperative Gin in Buttonwillow burns cotton gin trash and wheat and barley straw to cogenerate heat and electricity. The state provided a $970,000 loan toward the $3.3 million facility, which should produce 10 million kilowatt hours of electricity and 47 billion Btu of process heat a year. If early technical problems can be solved, the cooperative could generate all its energy from its own waste and residue of local farmers.

- A $2.1 million state loan helped the Superior Farming Company in Bakersfield purchase a $10 million cogeneration system fueled by orchard prunings and almond shells from its 37,000 acres of land. The 26 million kilowatt hours of electricity and 60 billion Btu of process heat produced each year provide the energy for the company's hydrator and cold storage facilities, saving the equivalent of 56,000 barrels of oil a year. Superior expects to earn a net profit of $420,000 a year from the system by selling excess electricity to Pacific Gas and Electric.

- An $85,000 loan enabled the Marindale Dairy in Novato to solve its waste disposal problem and become energy self-sufficient. Marindale purchased a $142,000 system to capture fermented gas from manure and burn the gas to produce electricity. The 50 kilowatt generator produces 330,000 kilowatt hours of electricity a year. Waste heat from the generator heats water for the milking parlor. Fermented solids are used for animal bedding and have a potential market as soil additives and animal feed supplement. Remaining liquids may be added to animal feed as a protein supplement for heifers and nonlactating cows. Marindale expects to recover its investment in four years.

What impact has the loan program had?

The project has succeeded in its first goal: to leverage private sector investment in biomass conversion demonstration projects. The state has loaned $8.8 million to energy projects, and the private developers have contributed $45.6 million for an impressive 5-to-1 leverage rate. The projects have produced $200 million in gross sales and $68 million in gross income and created 3,000 new jobs. But at this stage, the experience with new technology for harvesting and using biomass residue is more important. Although many of the projects are producing energy, they are still being operated on an experimental basis. Their commercial potential cannot properly be evaluated until they are operating full-time.

Has the program had any other effects?

In the process of managing this and other alternative energy programs, the California Energy commission has accumulated valuable expertise in resource evaluation, technology assessment, and economic planning. The Commission began in late 1983 to offer the benefits of its experience to local communities in their negotiations with project developers. Local governments use energy in buildings and other operations and need help in contracting for energy services. In addition, local communities often control energy resources, such as geothermal reserves, that they want developed. Yet they often lack the expertise to take advantage of alternative technologies or negotiate contracts with developers. Under the new public/private partnership program, the state serves as a "friendly broker" between local government officials and private project developers by providing:

- Technical assistance to review alternative energy and conservation opportunities with local government entitities, helping them understand what potentail resources they possess and the technical and economic feasibility of particular projects

- Assistance in negotiations between local governments and third party investors

- Direct financial incentives for smaller projects to help overcome their transaction cost overhead burden and enhance their attractiveness to investors.

SECTION III

EXPERIENCES WITH INCENTIVE SYSTEMS ELSEWHERE IN NORTH AMERICA AND THE WORLD

California is by no means the only place to use incentives for renewable energy development. Most other states in the U.S., nearly every industrialized country, and an increasing number of developing countries have incentive programs to promote research, development, and demonstration of renewable energy technologies. A number of countries have also attempted to accelerate the commercial development and purchase of marketable systems of new energy equipment.

Not all experiences have been happy ones, and some incentives have been so poorly planned and implemented that they had a short-term detrimental effect on the market for renewable energy services and hardware. Others have succeeded admirably. The brief descriptions of various incentive efforts in this section illustrate the range of possibilities that seem to have had the greatest impact, for good or bad, in the past five years.

Table 10 on the next three pages shows in greater detail some of the incentives that have been put into place in a number of countries in the past five years.* In very few cases have these programs for commercialization been in place long enough to allow a full evaluation of whether or not they will be effective either in their short-term goal of expanding the market or in their long-term goal of altering national energy consumption patterns.

Section III presents short summaries that seem to have had the greatest impact, for good or bad, in the past five years.

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* Table 10 was compiled by IIED from the sources used in the preparation of its Worldwide Incentives briefing paper and does not purport to be exhasutive. Many countries with incentive programs are not listed, and not all programs of the listed countries are included.

TABLE 10

SUMMARY OF INCENTIVES IN PLACE FOR ENCOURAGING USE OF RENEWABLE ENERGY, BY INCENTIVE TYPE AND COUNTRY, 1983

	FINANCIAL INCENTIVES						FISCAL INCENTIVES				LEGAL/REGULATORY INCENTIVES				PROMOTIONAL INCENTIVES	COMMENTS
	F	Pc	G	K	E	D	R	S	Tx	I	Z	C	DI	Tr	Pr	
CANADA	F	Pc			E		R	S							Pr	Two interlocking programs, PUSH (Purchase and Use of Solar Heating and PASEM (Program of Assistance to Solar Equipment Manufactures) established by government to support development of national industries, guarantee markets and encourage exports.
FRANCE	F			K	E		R	S							Pr	Agence Francaise pour la Maitrise de l'Energie (AFME) has $143 million (1983) for development and demonstration of French renewables. Major focus of program is export incentives (over 10% of national solar energy budget devoted to renewables). France is biggest per capital spender of state funds on renewables.
WEST GERMANY	F		G	K	E		R	S							Pr	Germany's program for RD&D is similar to France's although its export promotion activities are not as extensive. Germany has an extensive program in the development of biogasification technologies. Its development of a local market for solar collectors has been less successful.
ITALY	F	Pc		K			R	S				C			Pr	In 1982, Italy passed Public Law #308 which provided substantial incentives to producers and consumers of renewable technologies in various sectors of the economy. The National Energy Plan (1981/82) established a 10-year $1.1 billion budget for R&D of various renewable technologies and purchases of the equipment.
SPAIN	F	Pc		K				S		I					Pr	Spain's modest program includes incentives for large industrial firms to install renewable energy/conservation systems, a 95% import duty reduction for government approved equipment, and money set aside for procurement.
GREECE				K				S								The Greek incentive system has been criticized for being applicable only to high income brackets. To gain concessions, an investment of at least $43,000 is necessary.

KEY

FINANCIAL INCENTIVES

F - Funding for R & D
Pc - Procurement
G - Guaranteed Purchase of Non-Conventional Power
K - Capital Expense Relief to Equipment Purchasers
E - Export Promotion
D - Desubsidization of Conventional Fuels

FISCAL INCENTIVES

R - R&D Shelters
S - Support for End-Use Purchasers and Investors
Tx - Taxation of Conventional Fuel
I - Import Liberalization

LEGAL/REGULATORY INCENTIVES

Z - Zoning and Access Requirement
C - Consumer Protection, Product Certification
DI - Distribution & Pricing Regulations
Tr - Transaction Investment Promotion

PROMOTIONAL INCENTIVES

Pr - Promotion/Outreach

	FINANCIAL INCENTIVES						FISCAL INCENTIVES				LEGAL/REGULATORY INCENTIVES				PROMOTIONAL INCENTIVES	COMMENTS
	F	Pc	G	K	E	D	R	S	Tx	I	Z	C	DI	Tr	Pr	
UNITED KINGDOM	F	Pc	G												Pr	Britain phased out its R&D support for solar energy in 1981, feeling the private sector could do a better job. Virtually all of the nation's incentive programs are focused on wind energy and biomass system. The government has a goal of establishing a Mw-scale wind power park by 1990, if the technologies prove viable.
SWEDEN	F	Pc		K												Sweden has a large grant/loan program designed to encourage district heating schemes, renewable energy technology and conservation measures. A large part of the research budget goes towards biomass technology.
ISRAEL	F			K	E	D	R	S		I	Z	C			Pr	Israel actively promotes the use of solar energy through a wide range of incentives. This includes the mandatory use of solar water heaters in all new construction under 12 stories. In addition, loan/grant programs, tax relief and intense public information programs are in place. Israel has reduced its electricity demand over 4 percent since the incentive laws were enacted.
AUSTRALIA	F		G	K	E			S			Z	C			Pr	Australia is the second largest user of photovoltaics in the world, after the U.S. Since 1978, the Australian government has been deeply involved in supporting RD&D, as well as setting up a comprehensive program of tax and investment incentives, standards and zoning requirements.
JAPAN	F			K	E		R								Pr	Japan is aggressively promoting RD&D of photovoltaics through its "Project Sunshine." This program, a combination of public information, investment incentives and export promotion, is aimed at developing a commercially viable and diversified renewable energy industry in the near future.
BRAZIL				K		D		S	Tx						Pr	Brazil has perhaps the largest single organized renewable energy promotion program in the world. Over $5 billion has been invested in the PROALCOOL program which is aimed at replacing some 45% of the country's petroleum consumption with locally produced alcohol. While recently plagued with economic and technical problems, the program has been extremely successful in bringing about large scale production of the fuel.

KEY

FINANCIAL INCENTIVES

F - Funding for R & D
Pc - Procurement
G - Guaranteed Purchase of Non-Conventional Power
K - Capital Expense Relief to Equipment Purchasers
E - Export Promotion
D - Desubsidization of Conventional Fuels

FISCAL INCENTIVES

R - R&D Shelters
S - Support for End-Use Purchasers and Investors
Tx - Taxation of Conventional Fuel
I - Import Liberalization

LEGAL/REGULATORY INCENTIVES

Z - Zoning and Access Requirement
C - Consumer Protection, Product Certification
DI - Distribution & Pricing Regulations
Tr - Transaction Investment Promotion

PROMOTIONAL INCENTIVES

Pr - Promotion/Outreach

	FINANCIAL INCENTIVES						FISCAL INCENTIVES				LEGAL/REGULATORY INCENTIVES				PROMOTIONAL INCENTIVES	COMMENTS
	F	Pc	G	K	E	D	R	S	Tx	I	Z	C	DI	Tr	Pr	
SOUTH KOREA	F			K				S		I	Z				Pr	Korea instituted a massive-scale solar housing program in the late 1970s. The program aimed at building huge numbers of solar heated houses through a system of tax incentives, loans/grants and tariff reductions. The program has not been very successful due to poor quality equipment and a smaller market than anticipated.
INDIA	F			K				S		I					Pr	India's main experience with incentives has been a program aimed at assisting purchasers of biogas digestors through a loan/grant program. The program has been somewhat successful, although it has been plagued with a default rate of up to 95%. More recently, import liberalization programs have been enacted for solar technologies.
PHILIPPINES	F			K		D		S	Tx	I					Pr	The Philippines has decided to focus its incentive plan on solar thermal, biomass, geothermal and small hydro applications. Included in the scheme are very liberal producer incentives, consumer incentives, desubsidization of commercial fuels and liberal import incentives.
UNITED STATES	F	Pc	G	K	E	D	R	S	Tx	I	Z	C	DI	Tr	Pr	Virtually every type of incentive available is being used in the United States. Among the more noteable are: PURPA (Public Utilities Regulatory Policies Act) -- Its major incentive is the requirement that utilities must purchase power from and sell power to small independent producers. Energy Tax Act (1977) -- Established federal tax credits for the installation of renewable energy systems. State incentives including: tax credits, public information activities, zoning and installation laws, consumer protection laws, loan guarantees, design competitions, etc.

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Source: International Institute for Environment and Development, Worldwide Incentives for Renewable Energy Usage: A Selective Survey, IIED: Washington, D.C. and London, 1983.

Other Incentives in North America

State programs in the U.S..

Most other states in the United States have passed legislation favoring increased utilization of renewable energy. The programs for solar energy are the most widespread, and tax provisions for promoting its use are detailed in Table 11. In all cases, these are add-ons to the federal programs (such as the federal tax credits and PURPA) that were described in Section II.

The Tennessee Valley Authority's Solar Water Heating Program

The Tennessee Valley Authority (TVA) is one of the largest electricity production and distribution systems in the world. Covering all of Tennessee and parts of Kentucky, Virginia, North Carolina, Mississippi, Alabama, and Georgia, TVA is publicly owned and is administered by a federally appointed board. Realizing that deferral of new capacity through the use of conservation and alternative energy strategies has significant benefits, TVA instituted a wide range of research and commercialization efforts to promote alternative energy development. The programs were introduced in an area not known for social or technical innovation and not particularly interested in new energy sources. Indeed, solar companies in the region have acknowledged that TVA created markets where none existed.

One of its first initiatives was a solar water heating program, which provided utility customers with a solar assessment of their homes and offered low-interest loans to install a solar water heater. The customers repay the loan through their utility bills. TVA inspectors visit the home after system installation to ensure that the work was done properly. Originally available only in Memphis, Nashville, and Middle Tennessee, the program now extends to all TVA customers through an Energy Package program that also offers loans for energy conservation efforts.

The TVA solar assessment is an extension of the Residential Conservation Service, a federal program that requires gas and electric utilities to provide energy audits of their customers' homes and to recommend economical energy-saving home improvements. The state-implemented program has met with resistance from some states and from many utilities. TVA, however, not only set up its audit program quickly, but used it to aggressively promote renewable energy improvements as well as conservation measures.

TVA tests all solar systems before making them eligible for the program. If a system passes the test, TVA includes the company on a list of approved suppliers from which customers must buy their equipment in order to qualify for a loan. The list includes the average installed price of each system and the estimated annual energy output. Many solar companies objected to this aspect of the program because it gives the "best" system on the list an unfair marketing advantage. TVA listened to the criticism but maintained the list in order to protect its consumers.

TABLE 11
U.S. STATE TAX INCENTIVES FOR SOLAR, 1983

STATE	FOR RESIDENTIAL SOLAR SYSTEMS*			FOR NON-RESIDENTIAL USERS OF SOLAR ENERGY		
	PROPERTY TAX EXEMPTION	INCOME TAX INCENTIVE	SALES TAX EXEMPTION	PROPERTY TAX EXEMPTION	INCOME TAX INCENTIVE	SALES TAX EXEMPTION
Alabama	no	up to $1000 credit	no	no	no	no
Alaska	no	up to $200 credit	not applicable	no	35% credit; $5000 maximum	not applicable
Arizona	exemption	up to $1000 credit	exemption	exemption	election of 35% credit with $1000 maximum or 36 month depreciation	exemption
Arkansas	no	100% deduction	no	no	100% deduction	no
California	no	up to $3000 credit per application	no	exemption	election of 25% to 55% credit or depreciation over 12 or 60 months	no
Colorado	exemption	up to $3000 credit	no	exemption	30% credit; $3000 maximum	no
Connecticut	local option	not applicable	exemption	local option	no	exemption
Delaware	no	$200 credit for DHW systems	not applicable	no	no	not applicable
Florida	exemption	not applicable	exemption	exemption	no	exemption
Georgia	local option	no	refund	local option	no	refund
Hawaii	exemption	10% credit	no	exemption	10% credit	no
Idaho	no	100% deduction	no	no	no	no
Illinois	exemption	no	no	exemption	no	no
Indiana	exemption	up to $3000 credit	no	exemption	25% credit; $10,000 maximum	no
Iowa	exemption	no	no	exemption	no	no
Kansas	exemption; refund based on efficiency of system	up to $1500 credit	no	exemption	30% credit with $4500 maximum; 60 month depreciation	no
Kentucky	no	no	no	no	no	no
Louisiana	exemption	no	no	no	no	no
Maine	exemption	20% credit; $100 maximum	refund	exemption	no	refund
Maryland	exemption state-wide + credit at local option	no	no	exemption state-wide; credits at local option	no	no
Massachusetts	exemption	up to $1000 credit	exemption	exemption	no	no
Michigan	exemption	up to $600 credit	exemption	exemption	no	exemption
Minnesota	exemption	up to $2000 credit	no	exemption	no	no
Mississippi	no	no	exemption for colleges junior colleges and universities	no	no	no
Missouri	no	no	no	no	no	no
Montana	exemption	up to $125 credit	not applicable	exemption	no	not applicable
Nebraska	yes	up to $2500 credit	refund	yes	up to $5000 credit	refund
Nevada	limited exemption	not applicable	no	no	no	no
New Hampshire	local option	not applicable	not applicable	local option	no	not applicable
New Jersey	exemption	no	exemption	exemption	no	exemption
New Mexico	no	up to $4000 credit	no	no	up to $4000 credit	no
New York	exemption	up to $2750 credit	no	exemption	no	no
North Carolina	exemption	credits from 10-20% for various renewables; $1000 max.	no	exemption	credits from 10-20% for various renewables; $1000 max.	no
North Dakota	exemption	5% credit for three years	no	exemption	5% credit for each three years	no
Ohio	exemption	up to $1000 credit	exemption	exemption	10% credit against corporate franchise tax; 10% for individuals and partnerships	exemption
Oklahoma	no	35% credit; $3500 maximum	no	no	30% credit	no

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U.S. STATE TAX INCENTIVES FOR SOLAR, 1983

	FOR RESIDENTIAL SOLAR SYSTEMS			FOR NON-RESIDENTIAL USES OF SOLAR ENERGY		
STATE	PROPERTY TAX EXEMPTION	INCOME TAX INCENTIVE	SALES TAX EXEMPTION	PROPERTY TAX EXEMPTION	INCOME TAX INCENTIVE	SALES TAX EXEMPTION
Oregon	exemption	25% credit; $1000 maximum	not applicable	exemption	35% corporate tax credit	not applicable
Pennsylvania	no	no	no	no	no	no
Rhode Island	exemption	10% credit; $1000 maximum	refund	exemption; local option on any locally imposed tax	10% credit; $3000 maximum	refund
South Carolina	no	25% credit; $1000 maximum	no	no	25% credit; $1000 maximum	no
South Dakota	exemption	not applicable	no	partial credit	no	no
Tennessee	exemption	not applicable	no	exemption	no	no
Texas	exemption	not applicable	exemption	exemption	60 month depreciation for corporations	exemption
Utah	no	10% credit; $1000 maximum	no	no	10% credit; $3000 maximum	no
Vermont	local option	25% credit; $1000 maximum	no	local option	25% credit; $3000 maximum	no
Virginia	local option	25% credit; $1000 maximum	no	local option	25% credit; $1000 maximum	no
Washington	exemption	not applicable	no	exemption	no	no
West Virginia	no	no	no	no	no	no
Wisconsin	exemption	18% credit for retrofits; $1800 maximum	no	exemption	18% credit for retrofits; $18,000 maximum	no
Wyoming	no	not applicable	no	no	no	no

*Source: U.S. Department of Energy, Franklin Research Center, Renewable Energy Inquiry and Referral Service; David Godolphin, "Current Status of the State Tax Credits", in Solar Age, May 1983, pp. 46-47.

More than 3,000 TVA customers have bought solar water heaters through the program, a small number compared to the almost 200,000 systems installed through the California utility program. Numerous reasons explain TVA's limited success:

- TVA did not mandate an installation goal as California did
- The program was voluntary and lacked the effective advertising necessary to stimulate consumer interest
- State governments did not cooperate in the effort and did not offer tax incentives
- Cultural patterns in the TVA service area tend to be more conservative and less prone to change than in California
- Large hydroelectric capacity in the area has kept electric rates low and stable.

Georgia: A Slow and Uncertain Program

In Georgia, the largest state east of the Mississippi River, early market development has been very slow, with only about $1.4 million in sales in 1983. One of the major reasons for this was the lack of political support for renewable energy. The small solar industry in the state had been trying for years to convince the legislature to adopt a tax incentive, but a state solar tax credit did not go into effect until January 1, 1984.

A solar industry spokesman in Georgia has pointed out a number of reasons for the slow growth. First, Georgia has two major utility companies, which produce over 90 percent of the electricity, but more than thirty municipal companies, which distribute half the power. Consequently, there is no coordinated state-wide policy or program at the utility level. Indeed, since the companies that distribute half the power do not produce it, they have little interest in conservation or alternative energy production.

A second factor discouraging solar use is the availability of relatively inexpensive natural gas for water heating. Over 40 percent of Georgians live in the Atlanta area. They typically use natural gas for water and space heating, and solar heating is much less competitive with gas than with electricity. There are about 300,000 to 500,000 electric water heaters in the state, but electric rates are usually less than 6¢ per kilowatt hour. Furthermore, most of the electric water heating service is in outlying rural areas, which are harder to reach for the solar industry. As local solar company representatives admit, there has not been sustained, quality, aggressive solar salesmanship in the state, due in part to the low costs of conventional power. Solar water heaters, without a state tax credit, had to sell for $3,000 to $3,500 a system. This price is so close to the margin that solar installation companies have not been able to finance more aggressive marketing campaigns.

Housing characteristics and topography pose two additional problems. Unlike Californians, upper-income homeowners in Georgia tend to own traditional, two-story "colonial" homes and are much more reluctant to place solar collectors on their roofs. In California, most homes are single-story ranch styles with easy access. New construction in Georgia also remains largely traditional in nature and the state is densely forested. Thus, many homes cannot be equipped with a solar energy system without the added cost of cutting a sunpath through surrounding vegetation.

Canada's Government Procurement Program

The Canadian government began to support development of a solar energy industry in 1978 and has spent upwards of $60 million in this effort. Its approach differs fundamentally from the U.S. strategy. Instead of using the tax system to provide incentives for consumers of solar equipment, Canada chose to support the industry with research funds and direct purchase of hardware.

Under the Ministry of Energy, Mines and Resources, two interlocking programs were created, PASEM and PUSH. PASEM, Program of Assistance to Solar Equipment Manufacturers, provided grant assistance to ten Canadian companies, chosen from 150 applicants on the basis of their stated requirements for plant expansion, product development, and marketing capabilities. The government worked very closely with these companies in refining company business plans and manufacturing projections. For each firm, PASEM provided 50 percent of capital and 75 percent of noncapital expenses up to $300,000 over a 14 month contract period. Companies were required at the end of this period to deliver three production prototypes of each product developed under PASEM to the government for testing.

PUSH, Purchase and Use of Solar Heating, appropriated $125 million to buy solar heating systems for federal government buildings, including one of the Parliament buildings in Ottawa, a fish hatchery in New Brunswick, a Canadian National Railways train car washing facility, and the Halifax airport. Sales under PUSH enabled the PASEM companies to generate the revenue for their portion of expansion expenses under the cost-sharing terms of the PASEM contracts.

The PUSH program aimed to provide an initial market for Canada's solar industry in order to increase the scale of solar manufacturing in Canada and to accelerate the development of competitive products for export. Almost 500 solar hot water, space heating, and industrial process heat installations have resulted from PUSH. To accelerate the private market, Canada provided grants to consumers toward the purchase of solar heating equipment.

Despite four years of heavy government investment, the Canadian solar industry remains small. In 1981, Canadian companies sold $7.7 million worth of solar equipment and earned an additional $3.1 million for research, consulting, and installation of hardware.

The fundamental reason why this incentive package has not succeeded is that Canada has cheap electricity. Hydroelectricity supplies all the power at a very low cost everywhere except in Alberta, which uses some oil and gas, and Ontario, which is 30 percent nuclear. Canada has no legislation to encourage independent power production. All the utilities are publicly owned and have strongly resisted any initiative to encourage independent power production.

Europe

Nearly all European countries and the European Economic Community have set up programs for renewable energy research, development, and demonstration. Few countries, however, have commercialization incentives.

Italy

Heavily dependent on imported oil, Italy is eager to develop alternative energy sources. Total energy consumption in 1981 was 135 million tons of oil equivalent (mtoe), 86 percent of which was imported. Aware of how vulnerable this made the country, the Italian government prepared a national energy plan in 1981 to limit energy consumption to 155 mtoe in 1985 and 165 mtoe in 1990. To reduce oil dependence, the plan calls for an increase in the use of coal (especially for electricity generation), gas, nuclear power, and renewable energy.

Ente Nazionale Elettricita (ENEL), the national electric utility, has a central role in implementing the national energy plan. As a start, ENEL planned coal-fired power stations for Brindisi (Puglia) and Gioai Tauro (Calabria) and 2,000 Mw nuclear plants for Lombardia, Piemonte, and Puglia.

In June 1981, the government passed a law (# 309) that authorized ENEL to promote and offer incentives for more rational energy use. ENEL decided to strengthen its solar water heating research program at the Phoebus research center in Southern Italy. Phoebus staff developed technical specifications for all solar components and a methodology for testing collector performance and durability.

ENEL was eager to encourage the widespread adoption of solar water heating with financial incentives and promotional advertising, but could not afford incentives. Instead, it borrowed money from the European Investment Bank to finance solar installation loans. Customers repaid the loan and interest.

For the first stage, which began in June 1983, ENEL set a goal of encouraging the installation of 100,000 square meters of collectors for water heating, 55 percent in the south of Italy and 45 percent in the north. ENEL tested and approved components and registered installers.

A potential customer could go to his local ENEL business service and relations office for information on solar systems and a list of approved installers. The loan given for each approved system depended on the useful area of collector and the type of application. For a system put into an existing residential building, ENEL loaned up to £55,000 ($332) for each square meter. For a system put into a new building, it loaned £450,000 ($272) per square meter. In practice, the loan amounted to about 70 percent of the cost of the installation. The customer was then able to pay back the loan (plus interest) in installments through his electricity bill to ENEL. The repayments amount to between £15,000 and £30,000 ($9-$18) every two months.

The program was a great success in the north of Italy, where it sold out within a few weeks, but less successful in the poorer (but sunnier) south. ENEL plans a revised second stage this year.

The ENEL program, coupled with the general government backing for solar systems, has enabled the industry to get back onto its feet following a drop in sales in 1981 and 1982 (see Table 12 below).

Table 12

Sales of Solar Collectors in Italy

Year	Thousands m2
1976	5
1977	10
1978	20
1979	40
1980	100
1981	50-60
1982	30-40
1983	100

ENEL's success is due not only to the imaginative planning of its directors and its strong research capacity, but also to its clear management line from headquarters to local offices that allowed for timely implementation.

By contrast, an Italian government grant program had difficulty getting off the ground because of lack of cooperation and understanding between the central government and the regions. In May 1982 the Italian government passed law # 308, which required the Ministry of Industry, Commerce and Crafts in conjunction with other relevant ministries to ensure that conventional forms of energy are saved and to encourage energy conservation and the use of renewable resources and techniques such as heat recovery and cogeneration. The government set aside £405,000 million ($245 million) for these activities in 1981 and £475,000 million ($280 million) in 1982.

To encourage energy savings in buildings, the government developed a three-year program whereby they gave a 30 percent grant for approved energy conservation (including solar energy) measures, with a limit of £50 million ($30,800) on the total value of the system. Applicants were to submit proposals to regional government departments for assessment using a computer program developed by Italian Alternative Energy Agency (ENEA). The proposals would be ranked according to their energy saving potential. Two years after it was begun, the grants program is just going into operation in a few regions. The delay was caused by the difficulty of developing an assessment method that all officials could use and the need for regional governments to approve regulations for distributing grants.

Spain

Spain has initiated a series of renewable energy incentives similar in intent to those of the Italians. As in Italy, the Spanish electric utilities are playing a major role in delivering solar water heating systems to the residential sector.

The Spanish government set aside $622,000 in 1982 to pick up 30 percent of the cost of solar installations Perhaps more important for the encouragement of commercialization than this direct subsidy to consumers is the Spanish government's support of the domestic solar industry. INISOLAR, a state-owned collector manufacturer, has installed half the solar systems operating in Spain. ENHER, the national utility, designed and built Spain's largest solar water heating system at the Barcelona Hospital. Spain also reduces by 95 percent the import duty on any equipment not manufactured in Spain that is required for renewable energy projects approved by the Ministry of Industry and Energy.

Greece

The Greeks have three major renewable energy incentive programs.

Tax relief for solar systems. In 1978 Greece introduced a tax deduction of up to 30,000 Drs ($290) for home or office solar installations. This plan, coupled with a promotional program by the government, encouraged individuals to purchase solar water heating systems. Unfortunately, the tax incentives have only been used by people in the higher tax brackets.

Table 13
Greek Sales of Solar Collectors

Year	Thousand m^2
1975	2
1976	5
1977	10
1978	20
1979	40
1980	70
1981	90
1982	80
1983	100

Eight-five percent of collector sales were for residential water heaters for dwellings, 10 percent for commercial buildings, and 5 percent for public buildings. The Greek solar industry itself admits that without incentives sales would have been reduced 15 to 25 percent.

Bank loans for individuals purchasing solar systems. Greek banks are allowed to give loans only for the purchase of certain approved goods. Solar systems were added to this special list in January 1980. Banks could then give an individual purchasing a solar system a three-year loan of up to 30,000 Drs ($290) at 17 percent interest (attractive for Greece, where the normal commercial rate is 24 percent). Because the program was not keeping up with inflation, the loan ceiling was changed to 70 percent of the system cost.

Neither the industry nor the National Energy Council considers this incentive successful. Banks rarely grant loans, and no loan has exceeded 30,000 Drs. The willingness of banks to grant loans varies from branch to branch. Most institutions feel that such small loans are not worth the paperwork.

Grants for renewable energy and energy saving industrial and commercial investment. The general motive of these investment incentive laws is to increase industrial investment in Greece and promote industrial productivity. Extra help is given for energy saving investments.

Law #849, passed in 1978, authorized low-interest loans for all industrial or commercial development. Law #1116 of 1981 added grants of 20-30 percent of the cost of solar water heating systems. This incentive was seldom used and was rescinded in 1981.

In 1982 law #1262 authorized grants of 30-35 percent of the cost of conservation and renewable energy investments. The size of the grant depends on the industry and geographical location. Applications are submitted to a government review committee, which rules on the proposal in two to six months. Grantees are also eligible for low-interest loans.

Only a few hotels and industrial companies have applied for the grants. The solar industry and government officials agree that the lack of interest stems from the unstable economic and political climate that discourages investment of any kind.

France

The French offer residential solar tax deductions for homeowners and purchase solar equipment for new government housing. The tax deduction equals about 80 percent of the installed cost of a solar system. Low income occupants of government-subsidized housing are eligible for a 20-year, 7 percent loan for up to 40 percent of the cost of a solar system.

In addition to these tax relief measures for individual consumers, the French government provides subsidies to solar manufacturers and state funding of new housing fitted with solar equipment. The government distributed $28.5 million in 1982 to 29 accredited solar collector manufacturers to underwrite product development and capital costs. The Agence Francaise pour la Maitresse d'Energie (AFME) has signed an agreement with industry, environmental ministries and residential builders' trade associations to equip at least 10 percent of new French housing with solar water heaters. The government funded the construction of 5,000 solar heated homes in large housing complexes in 1981-82. AFME is negotiating solar use agreements with the national meteorological department, the defense ministry, the health ministry, and the parks authority.

France also wants to involve regional governments in solar development. AFME splits the cost of solar feasibility studies of public buildings with regional, provincial, and municipal authorities These regional solar plans will be implemented by twenty-two new local solar administration offices directly concerned with the installation of solar equipment in public buildings.

West Germany

The Federal Republic of Germany has ambitious large-scale renewable energy demonstration projects and an aggressive export promotion program, but the government has failed to stimulate consumer interest. Domestic solar collector sales are declining in spite of government incentives.

In the late 1970s, the Modernization and Energy Conservation Act set aside DM 4.35 billion (US$1.6 billion) for grants to cover 25 percent of the cost of energy conservation or renewable energy measures. The grant had to be at least DM 4000 ($1500) and not more than DM 12000 ($4500) per household. The funds were quickly claimed, primarily for weatherization and efficiency improvements to conventional heating systems. Only 6 percent of the total went to solar systems and heat pumps because the public doubted solar efficiency in the German climate. Faced with the task of reducing public spending, the government replaced the grants with a 10 percent solar tax credit each year for ten years.

Under the revised Investment Subsidy Law, industrial and commercial firms can apply for a 7.5 percent grant toward the purchase and installation costs of energy saving equipment such as solar collectors, heat pumps, improved wall insulation, or double windows. In lieu of the grant, a firm can take a tax deduction of 10 percent of the energy investment each year for ten years.

Perhaps the German program's relatively low refund rate and tax deduction allowance are accountable for the lack of noticeable public or commercial response. Another factor is certainly the German regional states' enactment of regulatory statutes affecting the local administration and the application of the federal Modernization Law. Whereas in the United States, state-legislated programs in the great majority of cases add incentive benefits to the federal programs, in Germany the state administrations have interpreted and applied the federal law in widely varying ways, usually involving limiting provisions. Some states have introduced an income ceiling, others a maximum monthly rent. While these local measures are no doubt egalitarian in intent, in practice they eliminate an effective solar incentive for high-income families.

The Rest of the World

Israel

Israel is almost totally dependent on imported oil and gas for its energy demands (imports equalled 98 percent of demand in 1980). The Israelis have used a more direct approach, imposing requirements for solar water heating in all buildings. These requirements were introduced in stages. First, it was mandatory that all new blocks of flats of up to eight stories have a communal solar water heating system with storage tanks in the cellar, rather than on the roof. This was later extended to all new dwellings. In 1983, new regulations obliged all hotels, hospitals and educational institutions to install solar water heating equipment. The regulations specified the size of the installation and, in contrast to previous legislation apply to buildings up to 12 stories. Since the law was enacted, over 500,000 units have been installed, saving the country approximately 4 percent of its overal electricity demand. As an incentive to use solar water heating, the government will finance 10 percent of the installation costs of both new and retrofitted solar units. Further, taxes, which amount to some of the 60 percent of the installation cost, will be cancelled.

This approach has been very successful. In fact, because of the legislation the Israeli market is quickly reaching saturation, and solarcompanies are having to seek export markets to maintain their sales.

The Philippines

The Philippines has established one of the world's most comprehensive legislative programs to encourage renewable energy use. In the last three years the Philippines' renewable energy program has undergone considerable changes. Concerned about its unfocused demonstration program, the Ministry of Energy redefined the program around some clearly identified priorities. Officials decided that the most promising technologies for their country were biomass, geothermal, solar thermal for commercial and industrial applications, gasifiers, small-scale hydro and energy conservation. In early 1983, the government began a new commercialization program based not on the promotion of a particular technology but on a survey of energy users' needs and finances. As part of the package, electricity price controls are set so as to discourage "affluent consumption" (above 650 kWh per month). In addition, gasoline prices have been pushed up, reducing private travel and causing a widespread conversion to diesel fuel. On the energy production side, the Philippines has set up various programs to guarantee markets for producers of alternative energy systems and supplies and to encourge potential alternative energy producers (such as sugarmill owners) to enter the marketplace.

Tax concessions and concessional credit for renewable energy investments. The Philippines offers renewable energy tax deductions, grants, and loans. Presidential decree #1068 was issued in 1977 to establish complete tax deductions of expenses to those "who would install non-conventional devices for use in their houses or business establishments." Unfortunately, there is no concrete statistical information available on the effects of this incentive.

The Energy Research and Development Center (ERDC) provides grants and loans for a variety of renewable energy demonstration projects that have ranged from a solar water heating installation at a hotel to a biogas installation at a pig farm. Though called demonstrations, however, these projects are widespread enough to be deemed "incentives."

Incentives for Producers. To attract local and foreign investment in new energy industries, the Philippines government introduced the following incentives:

- Deduction of organizational and preoperational expenses from taxable income over a period of not more than 10 years from start of operation
- Deduction of labor training expenses from taxable income equivalent to 1/2 percent of expenses, but not more than 10 percent of direct labor wage
- Accelerated depreciation
- Carry-over as deduction from taxable income of net operating losses incurred in any of the first 10 years of operation, deductible for the six years immediately following the year of such loss
- Tax credits equivalent to 100 percent of the value of compensating tax and customs duties that would have been paid on machinery, equipment and spare parts (purchased from a domestic manufacturer) had these items been imported
- Right to employ foreign nationals in supervisory technical or advsiory positions within five years from registration
- Deduction from taxable income in the year investment was made of a certain percentage of the amount of undistributed profits or surplus transferred to capital stock for procurement of machinery and equipment and other expansion
- Protection from government competition
- Exemption from all taxes under the National Revenue Code, except income tax on a gradually diminishing percentage
- Post-operative tariff protection
- Concessional loan rates ranging from 8 percent to 16 percent depending on the technology.

In late 1981, the government tightened somewhat its renewable energy incentives program through executive Order 860 and Presidential Decree 1853. EO 860 imposes an across-the-board 3 percent tariff duty on all imports except those filling governmental contracts. PD 1853 establishes that letters of credit will not be granted until such duty is paid.

In addition to the specific incentives mentioned above, the government has established two programs to force the production of particular renewable fuels. The first of these was the "alcogas" program, set up in 1979 to encourage sugarmill owners to switch excess plant capacity to the production of alcohol fuels. The program never got off the ground because sugar prices rose, encouraging mill owners to stay with sugar production, and consumers were dissatisfied with fuel from a pilot plant.

More recently, the government has started a program to blend diesel fuels and coconut oil. The "coco-diesel" program actually does not entail a complicated change in production (as the alcogas program had did). Rather, it simply requires the Philippine National Oil Company to buy a fixed amount of coconut oil production at a guaranteed price and to blend it with diesel fuel.

One underlying virtue of the Philippine program is the government's willingness to try new ideas and to drop programs that do not produce results.

Brazil

Brazil has perhaps the largest organized government program to promote the widespread use of a single renewable fuel. The government has invested more than $5 billion since 1973 in the nationwide alcohol fuels program called PROALCOOL. Between 1970 and 1979, the alcohol fuels industry in Brazil grew 31.9 percent annually. A substantial idle productive capacity in the sugar industry prior to 1970 allowed business to profit handsomely when a series of government incentives for alcohol production became effective shortly after the Arab embargo in 1973.

Brazil has heavily subsidized the alcohol fuels program by providing tax benefits and direct financing aid of up to 80 percent of a project's cost. But government actions have not always been enough to assure alcohol's successful introduction as a transport fuel and have even been counterproductive in some cases.

Demand for alcohol and alcohol-fueled vehicles was growing so rapidly in the late 1970s that the government raised prices to decrease demand and prevent a supply crisis. Consumer fear of shortages, compounded by reports of poor performance of alcohol-fueled vehicles and the higher alcohol price, created disastrous drop in demand for the cars. Between January and May of 1981, sales of alcohol-fueled automobiles dropped from 42,000 vehicles per month to 12,000 per month. The feared shortage actually became a glut, and sugar and alcohol surpluses filled storage facilities to capacity.

The PROALCOOL program has been remarkably successful in stimulating production and use of a renewable fuel, but that is not the only measure of success. Indirect social and economic impact -- on land ownership, plantation and distillery management, labor distribution in the sugar cane/alcohol industry, and the environment -- need closer examination before reaching a verdict on the program's success.

South Korea

Among developing countries, South Korea has the dubious distinction of having the coldest winter climate. Energy consumption, especially in the domestic sector, has traditionally been high because of space heating requirements. Its renewable energy industry has grown in fits and starts, hindered in part by the severity of the climate.

South Korea began what is probably the developing world's largest solar housing program in the late 1970s. The government introduced a number of sweeping incentives to promote active solar water and space heating systems. Active solar homes were exempted from all local taxes, including registration and property purchase taxes. Solar home builders were not required to purchase the normally mandatory housing bonds, and solar houses were exempted from certain building-size regulations that are usually strictly enforced because of a shortage of space in South Korea's major cities. Twenty-year low-interest loans were made available -- 14 percent if the floor area was less than 540 square feet and 16.5 percent for larger homes. A generous loan program was instituted for manufacturers that produced at least 64,000 square feet of collectors a month. Duties on imported components and raw materials for solar collectors were reduced to 25 percent of their previous levels. Duties on complete solar collectors were similarly reduced from 60 to 15 percent.

The effect of these incentives has been disappointing. The 1980 target was to complete 2,200 active solar homes, 1,500 independent units, and 500 multifamily buildings. By the end of 1980, only 173 houses had been built, and another 859 were under construction.

The primary reason for the disappointing results was that the government had not tested the viability of the technology in South Korea's climate. Seasonal temperature extremes were particularly wearing on solar water heating systems. In the summer, the systems often overheated and developed extensive leaks. In the winter, below freezing temperatures caused breakage. The need for back-up systems during the colder months made it doubly expensive for householders to go solar.

One of the conditions of the low-interest loans that were awarded to solar manufacturers was that repairs on the systems would be guaranteed for a period of two years after installation. Widespread system failures made any comprehensive maintenance program virtually impossible. Many companies went out of business, and the solar industry gained a terrible reputation. The incentive system clearly backfired. Perhaps more than anything, the Korean experience emphasizes the need to assure the technical and economic soundness of new and untested technologies. In Korea's case prematurely offered incentives ended up hindering the commercialization process.

India

India has extensive experience with alternative energy incentives, particularly for biogas technologies. The state-funded Khadi Village Industries Commission (KVIC), had been primarily responsible for the promotion of biogas digesters. In 1974 commercial banks and state agriculture departments assumed the KVIC's grant and loan disbursing role. From 1974-1980 the following incentives were provided for biogas plants:

- Individual Subsidies. Capital assistance was arranged through the Ministry of Agriculture. A 25 percent subsidy was provided for the construction of small 2-3 cubic-meter plants installed by subsistence or small-scale farmers. A 50 percent subsidy was provided to individuals installing gas plants in hilly and lesser developed areas. A 20 percent subsidy was available to all other individuals.

- Institutional or Cooperative Society Subsidies. Capital assistance in the form of grants from the KVIC was available. The KVIC provided between 25 and 100 percent of installed plant costs.

- Commercial Loans. Both the KVIC and some commercial banks provided loans to individuals, cooperative societies, and institutions that passed technical assessments. Loans were repayable over a period of four years in half-yearly installments. The banks accepted mortgages of land, animals, and other personal property as security.

- Additional Financing. Commercial loans were available for financing the construction of latrines (Rs 400 per unit), for purchasing gas-powered equipment (at a rate of Rs 1200 per horsepower), and for obtaining other gas utilization equipment such as additional pipes and fittings. State-level financial assistance was also available in some cases. The state of Uttar Pradesh, for instance, provided subsidies of Rs 550 to Rs 1000 for the installation of 2-6 cubic meter plants.

This program of loans and subsidies met with only limited success. Between 1962 and 1980, over Rs 80 million was disbursed by the Ministry of Agriculture through the KVIC for biogas plant construction. Of this amount, 75 percent was in the form of direct grants and subsidies. No adequate data has been kept by the KVIC on loan repayment but the rate of default has been estimated to be nearly 95 percent.

The main drawbacks with the loan program were mostly procedural problems associated with loans drawn on personal property, third party guarantees, or on other securities. Many banks insisted that borrowers should own at least 5 or 6 animals and have a minimum of 5 acres of cultivated lands. Farmers also had to undergo the time consuming process of obtaining clearance certificates from their local cooperative societies. There was also dissatisfaction with the high interest rates and the four to six month waiting time in negotiating loans. Advances and subsidies were based on official cost estimates and did not take into account regional cost variations in construction materials. All these limitations of the credit system have produced inequalities in the degree to which access to biogas technologies has been available. The program of subsidies has also had its share of problems. There is some evidence that problems involved in the disbursal of subsidies prevented them from becoming a major incentive.

SECTION IV

CONCLUSIONS AND POINTS FOR DISCUSSION

That renewable energy has undergone a remarkable renaissance in California is clearly documented in this background paper. The renewable energy boom in that state has taken technologies from laboratories to the marketplace at a pace nearly unparalleled in history. Even more impressive than the technological progress is the fact that the investment capital that has flowed into these risky new ventures has come in large part from the private sector, although there is no denying that it was enticed with substantial state and federal government subsidies to these new energy sources.

Less clear still is whether or not California can serve as a model for other national, state, or local governments in the rest of the world. Incentive systems and access to some public funds themselves do not seem to be enough, as was found in a review of other commercial incentive systems in Europe and several developing countries. California has managed to pioneer this field because of a coincidence of favorable circumstances (political, economic, and social) that are quite unique in the world. Will such fertile conditions be necessary to get renewable energy into the market in every case? If this is so, it means that the spread renewable energy technology will be limited to the most affluent and entrepreneurial societies. Or with California having broken the ground, will these technical and commercial advances allow other countries or regions to popularize and disseminate renewable energy on a substantial scale? And particularly will it allow other countries to do this without substantial expenditures of public funds?

There are four factors at work in California that seem to be relevant to how effectively incentives--financial, fiscal, regulatory or promotional--might work elsewhere.

- An interventionist government with political commitment to new energy options is needed to get the ball rolling. The reasons for this commitment will vary, but usually are related to long-term development planning to assure self-reliance in energy sources, to protect the environment (air, water and land), to defer investments in very capital-intensive generation plants, and in some cases to provide for growth in rural areas. To make these incentives work, however, there must an institutional structure in place to handle the increased bureaucratic work load, particularly when regulatory or tax incentive systems are employed. For private investors, the clarity of purpose, application, and continuity of these incentives is a foremost consideration in whether or not to enter the market.

- A physical resource base (sun, water, biomass, wind, wasted industrial heat, etc.) must exist and should be clearly identified before specific technical solutions are suggested. Any incentive programs that are put in place should be strucured so as to use available resources to meet the needs of end-users. The most successful programs have identified users (utilities, households, agricultural processors) and then specifically structured the incentives to deliver the products they needed (electric power or power displacement, hot water, process heat.) Thus the technology only becomes a means to an end, not the end itself.

- Utilities faced with increased demand for electric power or with a need for restructuring their generation capacity can be critical partners in the development of alternate energy, although often unwilling ones. Those which are not facing growth or change will not be so likely to reexamine their investment policies as those that are.

- Entrepreneurship and the Ability of Consumers to Adapt to New Technologies were critical elements in California's role as groundbreaker. These elements could become less critical as the technologies become better known and accepted.

- The Availability of Capital was no problem in California, but for much of the world it is the central problem. The difficulty is compounded in countries where private investors are very risk averse (often with good reason) and government spending is the only recourse. Yet past experience has shown that "solar technology giveaways" have yielded as many disappointments for the receivers (who had no stake in the investment in the first place) as they did for the donors.

Three points are important for government and utility policymakers to consider as they evaluate whether or not incentives might be useful in their countries:

First, what are the country's resources and end-use priorities?

What renewable energy resources are available for exploitation in the country or region? For what end-use applications, e.g. where does conventional or traditional fuel use need most to be alleviated? What technologies are commercially available in the country and from the outside to satisfy these needs with these resources?

Second, who is to benefit from the incentives?

Once the needs, end-uses, and technologies are identified, the key targets or "beneficiary groups" of incentive programs must be identified -- not only the users (villagers, small commercial establishments, etc.) but also the potential manufacturers of renewable energy equipment and prospective investors, local and foreign, whose capital could help catalyze domestic production of such systems. How shall the costs be shared and who shall receive immediate benefits from any incentive system that might be imposed?

Third, what about implementation?

When program objectives and incentive beneficiaries are identified, which agencies should implement the various incentive systems? How comprehensive should the incentives be? With what government/ private sector roles? With what degree and kind of international support or involvement? All incentive programs should include mechanisms for monitoring the cost-effectiveness of the incentives themselves: What is the appropriate life-cycle for each incentive measure, e.g. when is the commercialization threshold achieved and phase-out of the incentives in order?

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BIOMASS

TECHNOLOGY DESCRIPTION

Biomass energy comes from converting a feedstock, like plants or trees, which have stored the sun's energy, into a liquid, gaseous, or solid fuel. A biomass energy system refers to the feedstock-conversion-end use process. The term biomass is often used to include organic industrial and municipal waste resources, as well as plants used to produce alcohol fuels (which is discussed in the "Renewable Fuels" section). Biomass energy systems are best described as a set of energy systems each consisting of feedstock (e.g. wood, animal manure), a conversion mechanism to produce energy or fuel (e.g. direct combustion, anaerobic fermentation or digestion), and an end-use or end-product (eg. electricity, methane gas).

Biomass systems are the only fuel-based renewable energy source. One obvious implication of this fact is that there are no direct energy storage problems. Since biomass feedstocks can be converted to liquid, gaseous, or solid fuel they can find end-uses in all markets. Another implication of biomass's fuel-based nature is that the upfront capital costs of a biomass system (e.g. an industrial wood boiler) may be much lower than for other renewable energy systems, although there will be continuing fuel costs. In this sense, biomass is similar to conventional fossil fuels. Finally, as a fuel-based energy, source one final important concern is the set of environmental issues associated with the production or harvesting of biomass, as well as with its conversion (e.g. wood stove emissions) and end-use.

The six major conversion processes are:

Thermochemical Conversions

- Direct combustion: Burning solid biomass fuels (eg. wood, wood wastes, agricultural wastes, municipal solid wastes) with an energy content as high as 8,000 Btu/lb.

- Gasification: Using air or oxygen under high heat and pressure to break down the chemical structure of biomass to produce gas with an energy content of 5,000 - 6,000 Btu/lb.

- Pyrolysis: Heating biomass (such as manure and agricultural, wood, and municipal wastes) in the absence of oxygen to form liquid fuels, gases and charcoal with energy content ranging from 8,000 to 11,500 Btu/lb.

- Liquification: Mixing biomass with carbon monoxide (CO) and a catalyst under high pressure and heat to produce a heavy, low-grade oil.

Biological Conversions

- Anaerobic digestion: Using bacteria to break down biomass (such as manure, water plants, paper wastes and sewage) in an oxygen free environment to produce biogas (methane and carbon dioxide gas) with an energy content of 12,000 Btu/lb. Purified, this gas can directly replace natural gas.

- Fermentation: Converting biomass (such as corn or sorghum) into basic sugars which are then converted by yeast or other microorganisms into alcohol and distilled to form ethanol with an energy content of 12,000 Btu/lb (see Renewable Fuels section).

APPLICATIONS

Electricity production is derived from the combustion of solid, liquid or gaseous biomass fuels to create steam to run a turbine. Biomass resources can be used to replace fossil fuels in utility boilers or in cogeneration processes in industrial applications.

Thermal energy for agricultural and industrial processes can and is being derived from the combustion of wood and agricultural wastes in order to replace more expensive sources of energy. Lower temperature applications (such as crop drying) can be derived from the heat generated in the anaerobic digestion of wastes.

Solid biomass fuels (primarily wood) are being widely used for residential space and hot water preheating through the use of fireplaces, wood stoves and small furnaces.

Household heating requirements for cooking can be met by burning methane generated form anaerobic digestion processes. This is primarily used in small-farm applications where wastes are readily available.

TECHNOLOGY STATUS

In general, biomass conversion processes are basic and well understood technologies whose current status are governed by their ability to be commercialized in order to replace other more expensive fuels.

Thermochemical Conversion

Direct combustion of solid fuel biomass is well known and has been practiced for many centuries in the U.S. Recent technological developments have included wood chipping and pelletizing processes. Wood chips can be produced on-site and offer easier transportation and more efficient and complete combustion. Wood chippers range from $4,000 to $20,000. Pelletized or densified biomass is heated and compressed saw dust, leafy material, municipal wastes and most bulky biomass to form a fairly dry, dense pellet. The process is more sophisticated and costly, but the resulting product has 30% greater energy content and can use a variety of inexpensive inputs.

A 50 MW wood chip fired utility project has been established in Vermont which will cost approximately $1,400 per installed kilowatt and produces electricity at 10 cents per kilowatt hour.

The development of many kinds of biomass gasification technologies offer a cost-effective retrofit to natural gas or oil fired industrial boiler. These include fixed-bed down-draft, fixed-bed up-draft, moving bed, and fluidized bed systems.

For residential wood heating, the recent introduction of fireplace inserts, airtight wood stoves, secondary combustion stoves, and catalytic heaters offer cleaner, more complete combustion and enhanced efficiencies of up to 30%.

Biological Conversion

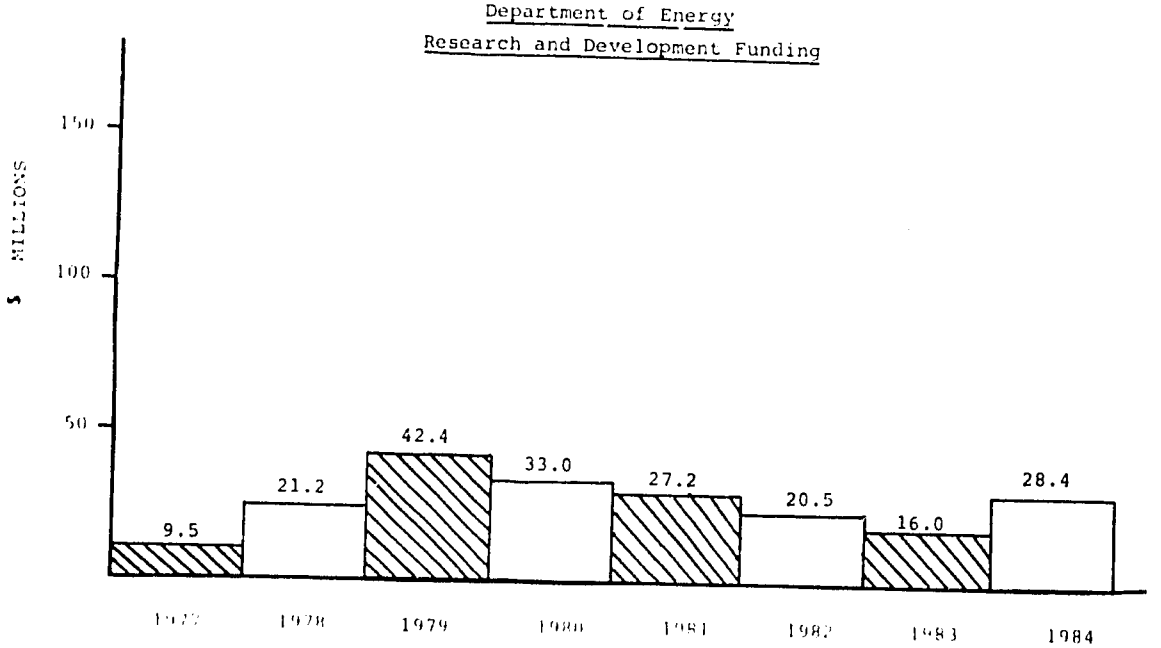
Before 1970, anaerobic digestion was mostly done in the U.S. for stabilization of wastewaters, and the methane produced was generally flared. Since that time, considerable research has been done to improve the conversion process so that it can be applied to biomass as well as wastes. Today, there exists custom designed anaerobic digestion systems for handling sewage, manures, stillage, canning factory wastes, and other resources.

An important future direction for biomass is the development of special energy crops - particularly those that can grow on marginal lands (e.g. grasses, aridland crops) or in water (e.g. aquatic crops) or at higher yields than conventional crops (e.g. short-rotation hardwood trees) or can directly produce fuels or chemicals (such as Euphorbia, milkweed).

FEDERAL SUPPORT PROGRAMS

Funding for biomass research and development has come primarily from the Department of Energy and has averaged about $20 million in each of recent years. According to DOE the primary goal of the department's Biomass Energy Technology program is to concentrate on fundamental research and development of the technology base for feedstock production and energy conversion which will enable the private sector to develop new energy supply technologies. The program is investigating the means to increase biomass energy feedstock through species screening and genetic engineering. Attention is also focused on the development of economic conversion processes capable of producing solid, liquid and other gaseous fuels from biomass sources. The FY 1984 budget for Biomass activities is 28.4 million dollars.

Department of Energy
Research and Development Funding



There is a federal business energy tax credit of 10% for the investment in biomass energy technologies. This includes all direct-burn, biogas, and fermentation facilities. This credit is scheduled to expire at the end of 1985.

INDUSTRY STATUS

The suppliers of biomass feedstock and conversion equipment are disaggregated and diffuse, with most of them probably unaware they are even in the "biomass" business. Thus, for example, most of the biomass energy systems today utilizes wood processing wastes which are owned and used by the forest products industries. Similarly, agricultural residues and manures are owned and used by individual owners. Residential firewood is either owned and harvested by the wood stove owner, or supplied on an informal basis by an individual woodlot owner.

More widespread use of wood energy is likely to depend on a network of small individual operators of wood chipping equipment coupled with a network of wood energy brokers and distributors. New energy crops are likely to be commercialized by a range of different types of organizations depending on the type of crop, the size of capital and technology investment required, and the results of public and private research and development efforts.

The wood stove industry is consumer-oriented with many small suppliers including a number of imported lines. No single company dominates and there is relatively little R&D conducted. Much the same may be said of the wood boiler industry which, by and large, grew out of traditional equipment suppliers to the forest products companies. It is likely that future wood burning equipment (and the associated handling and environmental equipment) will be supplied by the same companies who have developed that expertise for other solid fuels.

The gasification and anaerobic digestion conversion technologies industry is presently in the early stages of commercialization. This segment of the biomass industry is characterized by a relatively large number of small, under-capitalized, innovative firms. There are perhaps twenty such firms active in one aspect or another of gasification, and half a dozen in the digestor business.

(See also Renewable Fuels)

MARKET STATUS

The U.S. today obtains about 4% of its total energy from biomass sources (approximately 2.6 Quads per year), and this has been increasing at a rate of 10% per year since 1980. Of this total, the largest contributions are made from industrial and residential burning of wood and wood wastes (industrial - 1.6 Quads and residential - 1.0 Quads). For the forseeable future, biomass will provide more energy than all other renewable energy sources (excluding only large-scale hydropower).

05

The combination of rising fossil fuel prices and federal legislation to encourage independent power production (PURPA) have escalated the use of biomass resources for commercial power production. By the close of 1983, electric utilities had installed over 176 MW and non-utility sources (including small power production, cogeneration, and municipal facilities) had added an additional 1,216 MW of capacity. The two tables below detail utility and non-utility power generation activities.[1]

UTILITIES USING BIOMASS: STATUS BY FUEL TYPE

in Kilowatts (Number of Facilities)

FUEL	PLANNED	UNDER CONSTRUCTION	OPERATING	TOTAL
Wood Waste	100,000 KW (2)	—	130,725 KW (8)	230,725 KW (10)
Agricultural Residues	—	—	22,500 KW (2)	22,500 KW (2)
Animal Manure	—	—	—	—
SUBTOTAL	100,000 KW (2)	—	153,225 KW (10)	253,225 KW (12)
Municipal Solid Waste	—	18,400 KW (2)	15,400 KW (3)	33,800 KW (5)
Landfill Methane	—	—	—	—
Sewage Methane	—	—	7,970 KW (2)	7,970 KW (2)
SUBTOTAL	—	18,400 KW (2)	23,370 KW (5)	41,770 KW (7)
TOTAL	100,000 KW (2)	18,400 KW (2)	176,595 KW (15)	294,995 KW (19)

BIOMASS-FUELED SMALL POWER PRODUCTION, COGENERATION AND MUNICIPAL FACILITIES: STATUS BY FUEL TYPE

in Kilowatts (Number of Facilities)

FUEL	PLANNED	UNDER CONSTRUCTION	OPERATING	TOTAL
Wood Waste	188,505 KW (16)	115,630 KW (10)	850,217 KW (42)	1,154,352 KW (68)
Agricultural Residues	102,700 KW (3)	56,000 KW (3)	61,050 KW (7)	219,750 KW (13)
Animal Manure	—	10 KW (13)	925 KW (2)	935 KW (3)
SUBTOTAL	291,205 KW (19)	171,640 KW (14)	896,192 KW (50)	1,359,037 KW (83)
Municipal Solid Waste	640,450 KW (24)	286,500 KW (12)	283,610 KW (12)	1,210,560 KW (48)
Landfill Methane	39,550 KW (15)	29,650 KW (14)	20,045 KW (12)	89,245 KW (41)
Sewage Methane	164 KW (2)	2,700 KW (1)	250 KW (1)	3,114 KW (4)
SUBTOTAL	680,164 KW (41)	318,850 KW (27)	303,905 KW (25)	1,302,919 KW (93)
TOTAL	971,369 KW (60)	490,490 KW (41)	1,216,097 KW (76)	2,677,956 KW (177)

1 A Survey of the Use of Biomass as a Fuel to Produce Electric Energy in the United States; James L. Easterly and Elizabeth C. Saris, 1984.

Residential wood use will continue to grow under the impetus of rising natural gas prices. Wood stove sales of several hundred thousand per year will persist unless thwarted by environmental problems. Sales of large wood burning industrial and utility equipment should continue at a modest pace. The real growth of wood combustion and gasification equipment markets will come from the spread of industrial interest to the non-forest products companies, and that will depend on the assurance of a reliable wood fuel supply.

Sales of small gasifiers and anaerobic digestion systems to agricultural users have stagnated in recent years because of the poor economic conditions of most farmers and because of the availability of less expensive energy alternatives in today's marketplace. Improved farm prosperity and changing energy economics should allow this market to grow slowly.

Direct combustion of municipal solid wastes offers tremendous near-term potential. Refuse-to-energy systems offer the double benefit of relieving mounting solid waste disposal concerns, while generating electricity (under PURPA guidelines) and providing revenue to the municipality.

Biogas production from municipal landfill sites offer another potentially growing biomass market. Currently, there are 20 such conversion facilities in operation with over a thousand additional sites deemed suitable for recovery.

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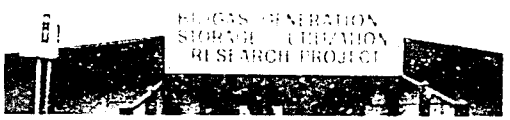
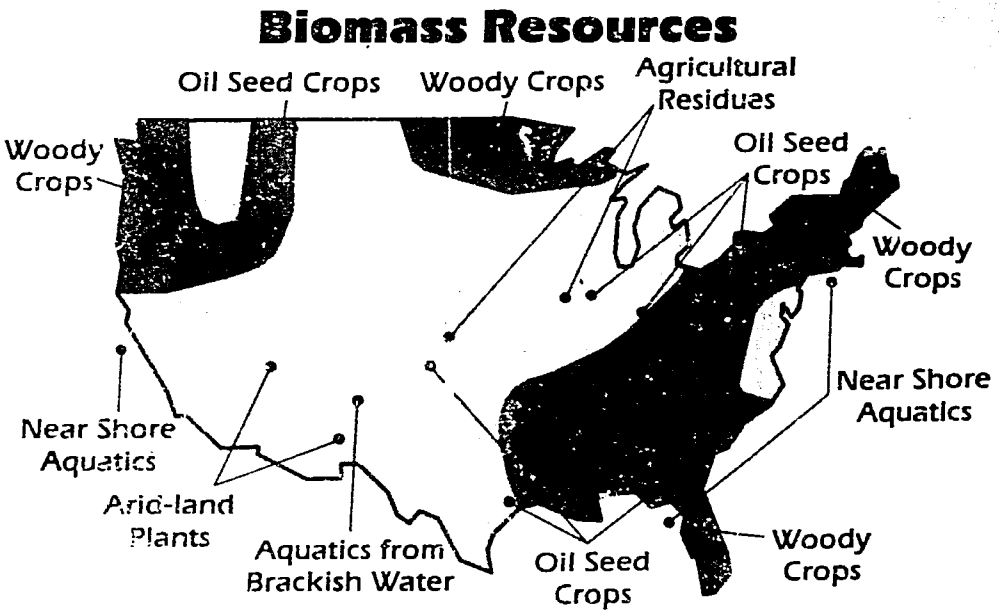

RESEARCH PROJECT


Biomass Resources
Oil Seed Crops
Woody Crops
Agricultural Residues
Woody Crops
Oil Seed Crops
Woody Crops
Near Shore Aquatics
Near Shore Aquatics
Arid-land Plants
Aquatics from Brackish Water
Oil Seed Crops
Woody Crops

GEOTHERMAL

TECHNOLOGY DESCRIPTION

Geothermal energy resources are concentrations of the earth's thermal energy stored in subsurface rocks and fluids at accessible depths. In the order of technological readiness, the four principal types of geothermal systems are hydrothermal, geopressured, hot dry rock, and magma.

Hydrothermal systems contain hot water and/or steam trapped in fractured or porous rock relatively near the surface.

In geopressured systems, moderate-temperature brines containing dissolved methane are trapped under high pressures in deep sedimentary formations.

Hot dry rock systems are accessible geologic formations that are abnormally hot, but contain little or no water. Usable energy is extracted from these formations by circulating a heat transfer fluid, such as water, through deep man-made fractures in the rocks.

Magma is molten rock, the temperatures of which may exceed 1100°C, and as such represents a tremendous potential resource.

The development and utilization of the geothermal resource involves several phases of activity and requires a variety of services and equipment. The first step in this process is exploration to find and confirm the geothermal resource.

A variety of techniques, many borrowed from the oil and gas industry, are being utilized to help find and estimate geothermal resources. These include studying geologic maps and satellite photos, measuring patterns by which electricity or shock waves travel through the earth, and drilling shallow holes to take temperature and heat flow measurements.

Hot water geothermal resources are located in many areas of the United States but are most common in the West. A somewhat different kind of resource, called the geopressured zone, is found along the Texas and Louisiana Gulf Coast. Recent studies suggest that a moderately hot geothermal resource exists in the Dakotas, Arkansas, central Texas, and along the Atlantic Coast.

Once a potential geothermal resource is identified development of the field for production begins. It is important to note that since geothermal water and steam cannot be transported for long distances economically, they must be used or converted to more portable forms of energy at their production site. Thus the actual development of the resource includes, most often, the construction of a power plant or other conversion facility.

The use of the geothermal resource is environmentally benign when compared to conventional nonrenewable energy sources. However, some problems, including: hydrogen sulfide emissions, subsidence, noise, and the diposal of brines, could delay exploitation or expansion at some sites.

APPLICATIONS

Electric power generation is predominantly from hydrothermal resources using naturally-occurring steam directly, direct flash evaporators, or binary conversion cycles in which the heat of moderate-temperature fluids is transfered to a working fluid.

In most instances, the resource is developed by a company that then sells the produced electricity to the electric utility.

Thermal applications include utilizing the geothermal resource for direct applications for residential and commercial space heating and cooling or for industrial and agricultural process heating applications.

These direct uses of geothermal fluids can be supplied by much shallower wells than are required for power production and operate satisfactorily with fluids at lower temperatures. The equipment for this type of use is quite varied, and therefore draws from a variety of suppliers. Some examples include piping systems and collection equipment for large district heating systems and the diverse needs of geothermal greenhouses, home heating and cooling through groundwater source heatpump systems, aquaculture ponds, and industrial processes.

TECHNOLOGY STATUS

Geothermal technologies for space and process heating are known and are being incorporated for a variety of end-uses wherever resources are available.

As a result of improvements in exploration, well-drilling, and electric conversion technology over the last 5-10 years, it is now economic (7-10 cents per kilowatt-hour) to generate power with steam or very hot hydrothermal liquids.

In the near term it is anticipated that steam flash, binary and total flow (Rotary Separator Turbine) technologies will vigorously compete for new hydrothermal applications. Which of these technologies is utilized is, in large part, determined by site specific conditions at each reservoir.

Assisting the development and utilization of the hydrothermal resource, in general, is the recognition by developers, investors and utilities that small (1-10 MW) modular constructed geochermal power plants are as cost-effective as large (50 MW) installations.

Technologies are in development for commercial use of the binary cycle. According to analysts active in the field, however, the decline in current oil prices and the capital-intensive nature of generating equipment, has delayed the commercialization of these technologies.

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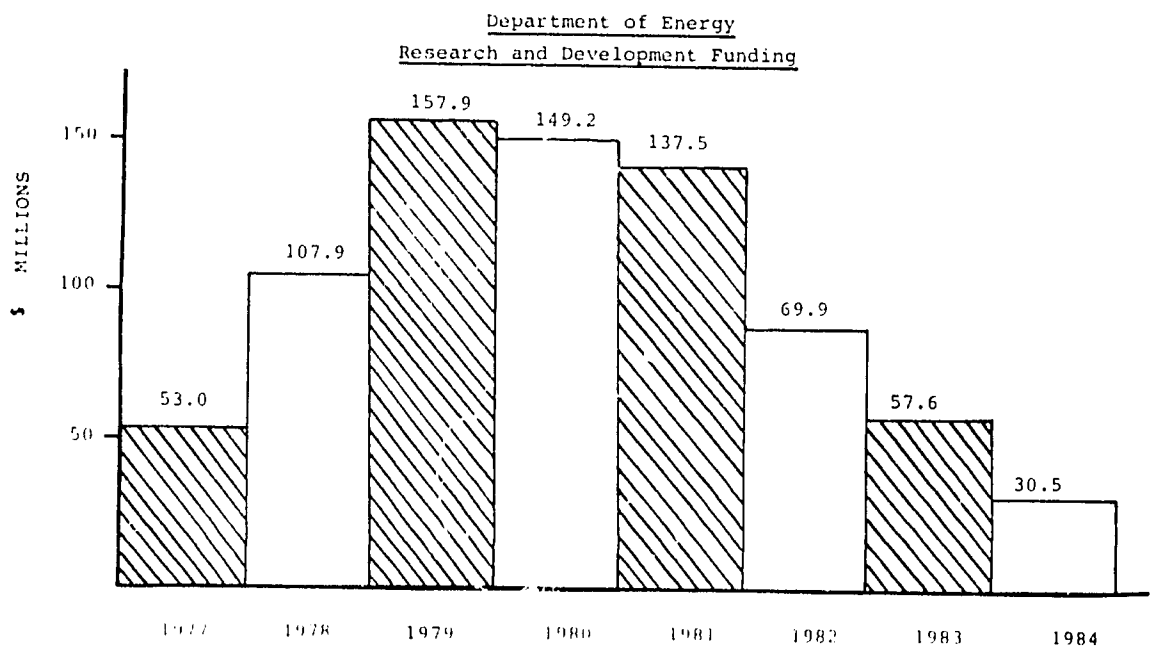
At present, there is no commercial power generation with the heat of hot dry rock, geopressured, or magma resources.

FEDERAL SUPPORT PROGRAMS

In 1984, the role of the Department of Energy's Geothermal Energy Program is to assist the private sector in advancing the use of geothermal technology through research and development, demonstration projects, and a geothermal resources development fund. The FY 1984 Geothermal Program budget is $30.5 million. This is targeted to provide for comprehensive analysis of long duration geopressured resource flow test data; final phase construction of the Fenton Hill, New Mexico, Hot Dry Rock thermal loop; and hyrdothermal technology, hard rock penetration and magma energy extraction research.



The aim of the geothermal resources development fund is to assist and accelerate the development and utilization of geothermal energy through energy loan guarantees which induce allocation of private credit to geothermal projects. Six loan guarantees are currently authorized for a total of $ 93.3 million; three additional loan guarantees totaling $ 151.1 million have been conditionally approved.

There is a federal business energy tax credit of 15% for investments in geothermal energy systems. A 40% residential energy tax credit is also available, but is limited to $4,000 or 40% of a $10,000 investment. The credits are applicable to resources in excess of 60°C. Both the business and residential tax credits are scheduled to expire at the end of 1985.

INDUSTRY STATUS

Electricity generation Many of the major oil and natural gas companies in the United States have become active in the geothermal power generation industry.

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Thermal applications The non-electric portion of the industry is smaller and is represented by specialized geothermal consultants as well as deep-water drilling companies.

Combining these two sectors, the U.S. geothermal industry has spent, to date, approximately $1 billion for geothermal exploration and development.

MARKET STATUS

Currently, ninety-seven percent of the geothermal power production in this country is located at the Geysers dry steam field in California. However, a number of flash steam plants utilizing hot water are under construction or planned in several areas. In addition, a 45 MWe binary plant, the first commercial operation of this type, is under construction in Imperial Valley, California, as a joint project of the Department of Energy and private industry.

Production of Electricity from Geothermal Sources[1]

	Year-End Capacity On Line (Megawatts)	Production (Million Kilowatt-hours)
1960	12	33
1961	12	94
1962	12	100
1963	27	168
1964	27	204
1965	27	189
1966	27	188
1967	55	316
1968	84	436
1969	84	615
1970	84	525
1971	203	548
1972	322	1,453
1973	441	1,966
1974	441	2,453
1975	559	3,246
1976	559	3,616
1977	559	3,582
1978	559	2,978
1979	742	3,889
1980	939	5,073
1981	1,005	5,686
1982	1,129	4,843
1983	1,331	6,075
1984 Est.*	1,542	na
1985 Est.*	1,888	na

1 Annual Energy Review 1983; Energy Information Administration, 1984.
* Ben Holt; Ben Holt Company

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Over the last four years these figures suggest a growth rate in the United States of about 30 % per year. This kind of growth rate, if sustained, creates a substantial market for large-scale electrical generating facilities, both domestic and overseas. For example, between 1982 and 1985 a 3-fold increase in worldwide generating capacity of 3,284 MW is expected. This represents a total investment of at least $5 billion in a 3-year period for new generating facilities alone without taking into account the cost of drilling wells and producing either steam or hot water.

Industry analysts looking toward the end of the decade foresee an annual growth rate of about 15.5% per year worldwide. At this rate the 1990 installed capacity would reach about 8,740 MW, representing an increase of over 6000 MW in the period from 1982 to 1990.

The market for small thermal systems for district and space heating applications, as well as agricultural and industrial process heating, is emerging. In this market, the use of ground-water as a geothermal resource has been limited by the 60°C qualifacation in the tax code.

According to DOE sources there are three operating projects devoted to agri-business, one to industrial process systems, seven to district heating systems, and six to institutional heating systems. Capital for these projects is generated primarily from third party investors who have often teamed-up with various governmental bodies. Well drilling companies also share the market. Due to the diverse nature of this non-electric portion of the industry it is difficult to estimate the capacity of this part of the industry.

In general, the export market for geothermal hardware is dominated primarily by the Japanese and some western European countries. The Japanese are successfully exporting hardware to the U.S., particularly turbo-generator equipment.

GEOTHERMAL

HYDROPOWER

TECHNOLOGY DESCRIPTION

Hydropower systems produce energy from "falling water"; that is water which flows through a turbine during its passage from a greater to a lesser elevation, and in the process converting a substantial part of the mechanical potential energy of the water into electricity.

Conventional hydropower systems use dams and waterways to restrain rivers and streams to create "head" (pressure). As the water is released or allowed to flow, the falling water runs through a turbine, spinning a generator, and thus producing electricity. In some cases, the water is stored up in a reservoir and released during periods of peak electrical load. In many cases, storing the water is not practical and it must be used as it passes down the watercourse or its potential energy is lost. Facilities designed to capture the energy from this type of flow are called "run-of-river".

Pumped storage systems are similar to conventional hydroelectric facilities; however, they also have the ability to pump the water from the lower to the higher elevation. In most instances this is accomplished by running the electrical generator backwards as a motor, with its turbine running backwards as a pump. Energy is consumed for such "pump-back" operation and the overall efficiency is typically between 60- 70% (kilowatt hours produced during generation versus kilowatt hours consumed during pumping). Nonetheless, such facilities are often justified because they enable utilities to use surplus power from other sources in off-peak hours to store the water so that it can be utilized during periods of peak demand.

In general, hydropower systems enjoy several major advantages over thermal power facilities: their expected lifetime is longer, unscheduled outages are less frequent, and downtime for overhaul is shorter because hydropower equipment is relatively simple. As a result, operation and maintenance (O&M) costs are relatively low, and in many cases, hydropower plants are designed for remote control. In addition, hydropower facilities can provide peaking power in seconds when needed, a capability unmatched by any other form of power generation. Finally, hydropower efficiency is about 85%, or more than twice that of a thermal plant.

APPLICATIONS

Conventional hydropower and pumped storage systems are used almost exclusively for electricity production. Normally, their output is fed directly to a utility grid, although they can also be used singularly for power generation in remote locations.

Since the passage of the Public Utility Regulatory Policies Act (PURPA) in 1978, the majority of the development of hydropower resources have concentrated on small-scale hydroelectric development. The term "small-scale" refers to those hydropower projects that have 30 MW or less capacity. This capacity has been adopted by the Federal Energy Regulatory Commission (FERC) for licensing purposes to distinguish between major and minor projects. These projects generally involve developing relatively low head (usually less than 100 feet) resources. "Micro-hydro" is a subset of

small-scale hydro and refers to very small units (unit sizes go as low as 2.5 kw). These systems are often used to provide power to supplement or displace electricity usage of a household or farm.

TECHNOLOGY STATUS

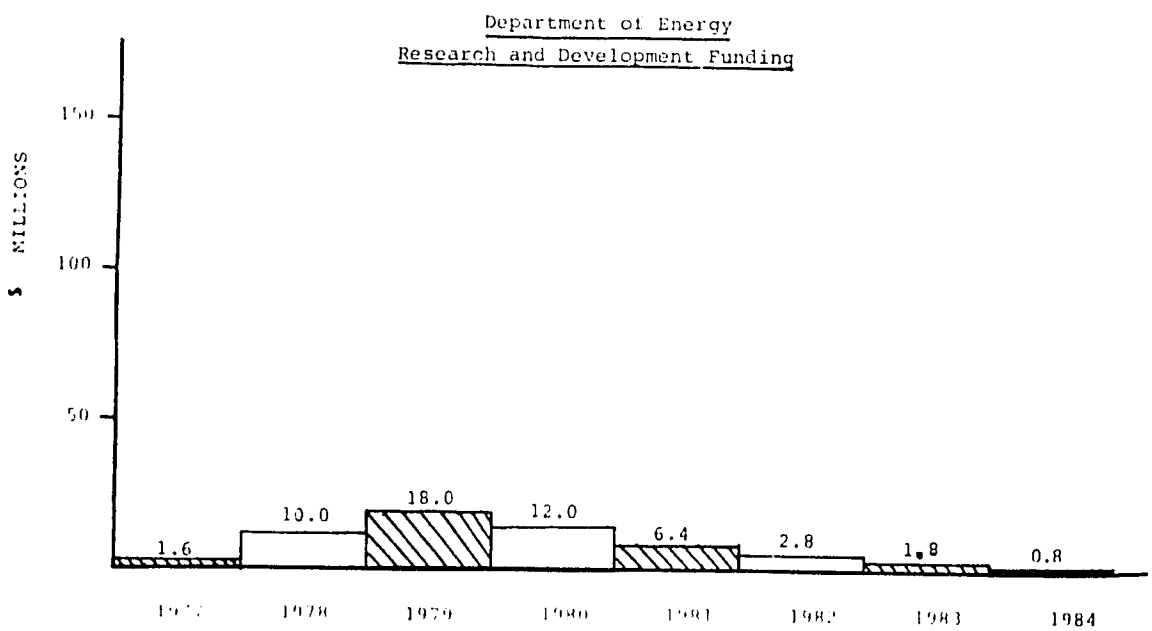
The turbine - a compact, submersible energy exchange mechanism - was invented in France in 1820, and first linked to a generator to produce electricity in Wisconsin in 1882. Although a number of refinements in the technology have occurred since that time, it is very well understood compared with most renewable energy technologies.

Since the early 1900's, hydropower development has moved, primarily, from meeting base-load to peaking power needs. Today, many of the projects are small (less than 10 MW) and use run-of-the-river power or existing dams. Each site varies considerably and, therefore, hydropower equipment does not normally come in standard packages. Consequently, the use of custom manufactured machinery greatly increases the cost of the project. Overall cost for micro-hydro and small-scale hydroelectric projects range from 5-25 cents per kilowatt hour. Turbines and generators are being marketed commercially today in a size range extending from 2.5 kw to 750 MW.

Recent innovations in hydropower have included the incorporation of vertical circulating pumps (run in reverse) and marine thrusters, primarily for ultra-low head applications.

FEDERAL SUPPORT PROGRAMS

The stated goal of the Department of Energy's Small-Scale Hydropower program is to develop a technology base to help reestablish a vigorous small-scale hydropower industry. However, it is the Department of Energy's position that "higher energy costs have made smaller hydroplants economically viable without Federal subsidy". Based on that premise the Department began a reduction of budget support in FY 1981 with FY 1984 funding at $0.8 million.



There is a federal business energy tax credit of 11% for investments in small-scale hydroelectric systems which is available to both private developers and utilities. This credit is scheduled to expire at the end of 1985. However, an affirmative commitments provision in the tax law extends the 11% tax credit through 1988 for projects begun before the end of 1985 and which meet certain conditions.

Under guidelines established by the FERC, facilities that are under 5 MW in capacity and the operation of which does not pose a "high hazard" are exempt from the licensing process.

INDUSTRY STATUS

Some 60-90 companies in the U.S. and Canada manufacture either hydropower turbines or equipment directly related to hydroelectric generation, such as valves and generators. Notably, during this last year, one of the larger manufactures began importing equipment from the Peoples Republic of China. The PRC has substantial experience in small-scale hydropower, having developed over 90,000 sites in China since 1952.

Systems of all sizes are being sold and installed at this time, and equipment availability is not a major constraint to hydropower development. However, the site specific variation, which has led to custom manufacturing practices, has prohibited extensive mass-production.

MARKET STATUS

A large potential resource remains to be developed. The National Hydroelectric Power Study, authorized by Congress in 1976 and carried out by the U.S. Army Corps of Engineers, identified about 2100 sites (about 40% of which had existing dams) where an estimated 57,000 MW of hydropower capacity could be installed. If fully developed, this capacity would be a substantial addition to the 73,000 MW of current hydroelectric capacity. Furthermore, the U.S. could add an additional 14,000 MW of electric generating capacity by upgrading the 1,288 hydropower sites in operation at the time of the study.

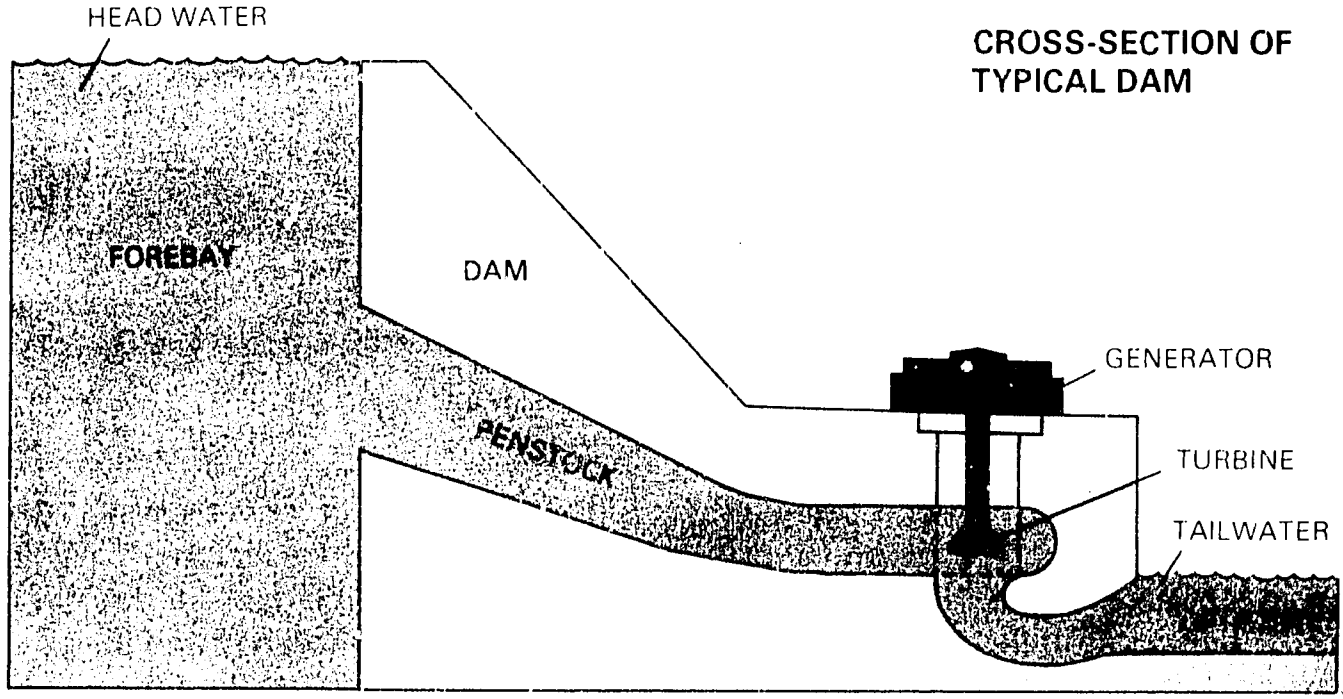
Following the enactment of PURPA, small-scale hydropower development has increased significantly. Although developers have staked claims on many of the potential sites, complex and lengthy licensing and permitting processes, as well as growing environmental concerns, have inhibited wide-spread development.

Analysts active in the field state that until these problems are resolved, small-scale hydropower development will continue to be severely hampered. Modest, but sustained growth appears likely during the next several years.

Small-Scale Hydro Projects Brought on Line Since the Enactment of PURPA (1978-1983)

	Number of Projects Licensed or Exempted	Cumalative Capacity MW
In Service	138	272.05
Under Construction	164	299.70

HYDROPOWER


HEAD WATER
CROSS-SECTION OF TYPICAL DAM
FOREBAY
DAM
GENERATOR
PENSTOCK
TURBINE
TAILWATER

OCEAN ENERGY CONVERSION SYSTEMS

TECHNOLOGY DESCRIPTION

Ocean energy conversion refers to the set of systems and technologies which utilize the renewable properties of the ocean in an attempt to produce useable forms of energy. Ocean energy conversion relies on energy being derived from two distinct sources: the energy transfer and conversion of kinetic and potential energy found in the tides, waves and currents; and the energy transfer and conversion of energy stored in "gradients" in the ocean such as thermal gradients and salinity gradients.

This factsheet reviews those technologies either currently being developed or with near term potential.

Ocean Thermal Energy Conversion (OTEC) Ocean thermal energy conversion is an example of the gradient mechanism of energy transfer -- in this case a thermal gradient. The OTEC concept utilizes the temperature difference between warm surface waters and deep cold waters to drive a turbine-generator by the flow established as a working fluid is alternately vaporized and condensed. Because this temperature difference is low (20°-24°C) compared with conventional steam power plants, large heat exchanger volumes (0.1-1 m per kw gross) and seawater flow rates (1-10 kg/sec per kw gross) are required in order to realize net power production.

Two power system concepts have been proposed for converting the ocean thermal resource into useable electric power. In the closed cycle concept, warm seawater is pumped through an evaporator, where a low boiling point working fluid, such as ammonia, is vaporized. This vapor expands through a low pressure turbine and is condensed by cold seawater pumped from the depths. The working fluid condensate is then collected and returned to the evaporator to complete the cycle. In the open cycle concept, a small fraction of the warm seawater itself is vaporized, under a partial vacuum. Flow of this water vapor towards the condenser may be used either to drive a low-pressure turbine (Claude cycle) or to lift the vapor and associated liquid to a height where the condensate can fall through a hydraulic turbine (lift cycles). The fresh water condensate may be either discharged or recovered as a marketable by-product.

Tidal Power Systems Tidal power systems attempt to capture and convert the kinetic and potential energy of the tides into a useful energy form. The tide results from the rise and fall of a body of water due to the gravitational pull of the moon, which generally takes place twice daily. While in the open sea this rise may not exceed 2 feet, in shallow seas bordering continents it may be more than 20 feet, and in narrow tidal estuaries this rise may measure up to 40- 50 feet per cycle.

In the simplest tidal power system, a dam is built across the mouth of a cove to form a pond, which fills with water through a sluice-way as the tide comes in. At high tide the sluice-way is closed, and the remaining body of water returns to the ocean, at ebb tide (low tide), through a turbine from which power is produced. As with hydropower, the cost of producing electricity is determined chiefly by the cost of the dam and turbines. A tidal power plant should have a long and reliable life (in the order of 75-100 years).

One disadvantage of tidal power is that it is intermittent. A conventional tidal plant produces power only half the time, when the level of water in the enclosed pond is higher than the level of the receding tide. Furthermore, the time of day that power can be generated varies because tidal motion follows the lunar day, which is 25 hours long.

APPLICATIONS

Ocean Thermal Energy Conversion Due to the ocean thermal gradient being relatively insensitive to short-term weather changes, OTEC has primarily been considered for baseload power production. An alternative to transmitting OTEC-produced power directly to shore is the production of transportable fuels or energy-intensive products. This alternative does not require the OTEC plant to be located at a permanent site, and has given rise to the concept of a mobile plantship. Plantships would operate in a "grazing" mode, searching out the best thermal resource areas in which to carry out on-board production activities.

Tidal Power Systems The historic use of tidal power has been chiefly to power small milling operations. Current emphasis, however, is almost entirely for the production of electricity. Due to the intermittent nature of the resource, tidal power plants operate primarily as a fuel saving electric technology, feeding power into the grid whenever possible, thus displacing more costly fuels.

TECHNOLOGY STATUS

Ocean Thermal Energy Conversion It presently appears that closed cycle power systems have the greatest potential for successful application in near-term commercial OTEC plants, and a demonstration 50 kWe (gross) barge-mounted system (Mini-OTEC) verifying this concept was assembled from off-the-shelf components and operated successfully off the island of Hawaii in August of 1979. Open-cycle power systems require research and development in a number of areas before a baseline design will be feasible.

Tidal Power Systems To date the largest and most successful tidal power plant is located in the estuary of the River Rance, in Brittany, France. This 240 MW power plant was completed in 1967 and has performed to all expectations since that time.

During 1984 North America's first tidal plant will come on line. A 17.8 MW capacity tidal power unit is currently being installed in the Bay of Fundy at Annapolis Royal, Nova Scotia as part of a pilot project to determine the potential of such turbines for larger scale installations in the Bay of Fundy. A joint Canadian/ United States study of the Bay of Fundy estimated that a total of 4915 MW of capacity could be installed at just three favorable sites in the area.

FEDERAL SUPPORT PROGRAMS

Ocean Thermal Energy Conversion The U.S. Department of Energy (DOE) has been involved with OTEC development since DOE's inception in 1977. During this period, DOE has conducted an extensive research and development (R&D) program as well as sponsoring a number of design studies for fully integrated plants ranging in size from 1- 450 MW.

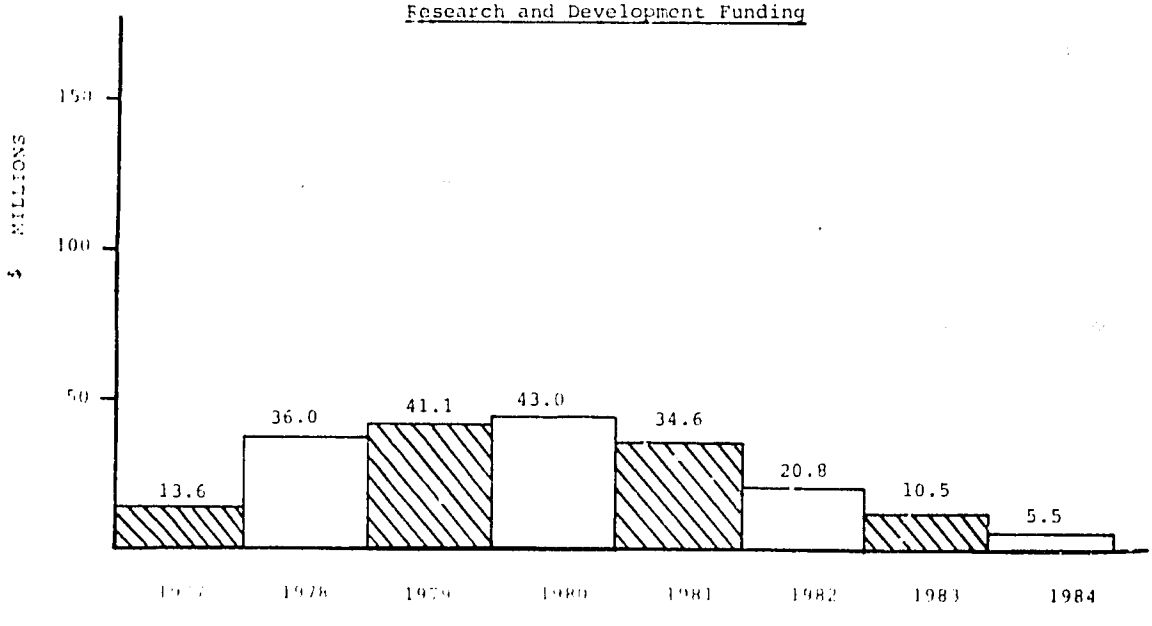
Paralleling its R&D program, DOE has initiated a proof-of-concept experiment, designed to demonstrate the economic feasibility of closed cycle OTEC at a scale representative of commercial application (40 MW net). Two industry teams were selected for Phase 1, which was completed in May of 1983. Both conceptual designs were for shelf-based plants located off Kahe Point, Oahu, Hawaii, with the produced electricity cabled to an existing onshore power grid. One contractor was selected to continue into Phase II, Preliminary Design, which is now underway and is expected to be finished in November of 1984. At that time, it is anticipated that major government participation in the project will cease, and the contractor will be required to seek private financing to proceed with detailed design, construction and operation.

The DOE OTEC budget authorized for FY 1984 is $5.5 million, down from a high of $43 million in FY 1980. This funding supports R&D efforts, with emphasis placed on open cycle power system components, cold water pipe and platform installation techniques, and long-term materials performance.

Tidal Power The Department of Energy's support for tidal power has been limited to two studies, conducted by the Small-Scale Hydropower office. One was a two-volume extensive resource assessment for the U.S. The other, completed by 1980, was a feasibility study of a 12 MW (two 6 MW turbines) tidal power plant in Half- Moon Cove, Maine. Since that time tidal power has received no further DOE support.

The U.S. Army Corps of Engineers' Civil Works Division has been responsible for any ongoing feasibility studies done in recent years.

Department of Energy
Research and Development Funding



There is a federal business energy tax credit of 15% for investment in OTEC facilities. This credit is scheduled to expire at the end of 1985.

INDUSTRY STATUS

Ocean Thermal Energy Conversion There is presently no industry supplying OTEC plants for commercial purposes. Those plants which have been built or are in the planning stage are primarily for demonstration purposes, with the goal of verifying design tools and performance predictions, thereby reducing perceived risks.

Thus far, industry participation in OTEC has been closely linked to the availablility of government funding, and there is yet no evidence of industry involvement at the level of commercialization requiring extended production capability or new production capacity.

Tidal Power With no commercial tidal power stations in the U.S. and little more than feasibility studies done to date, it is safe to say that there is no domestic tidal power industry. When proposed projects do become realized, architecture/engineering firms and civil engineering firms (especially those most familiar with low-head hydropower systems) would be responsible for most of that business. Until that time, the U.S. Army Corps of Engineers would, most likely, be involved in any research, development and demonstration efforts.

MARKET STATUS

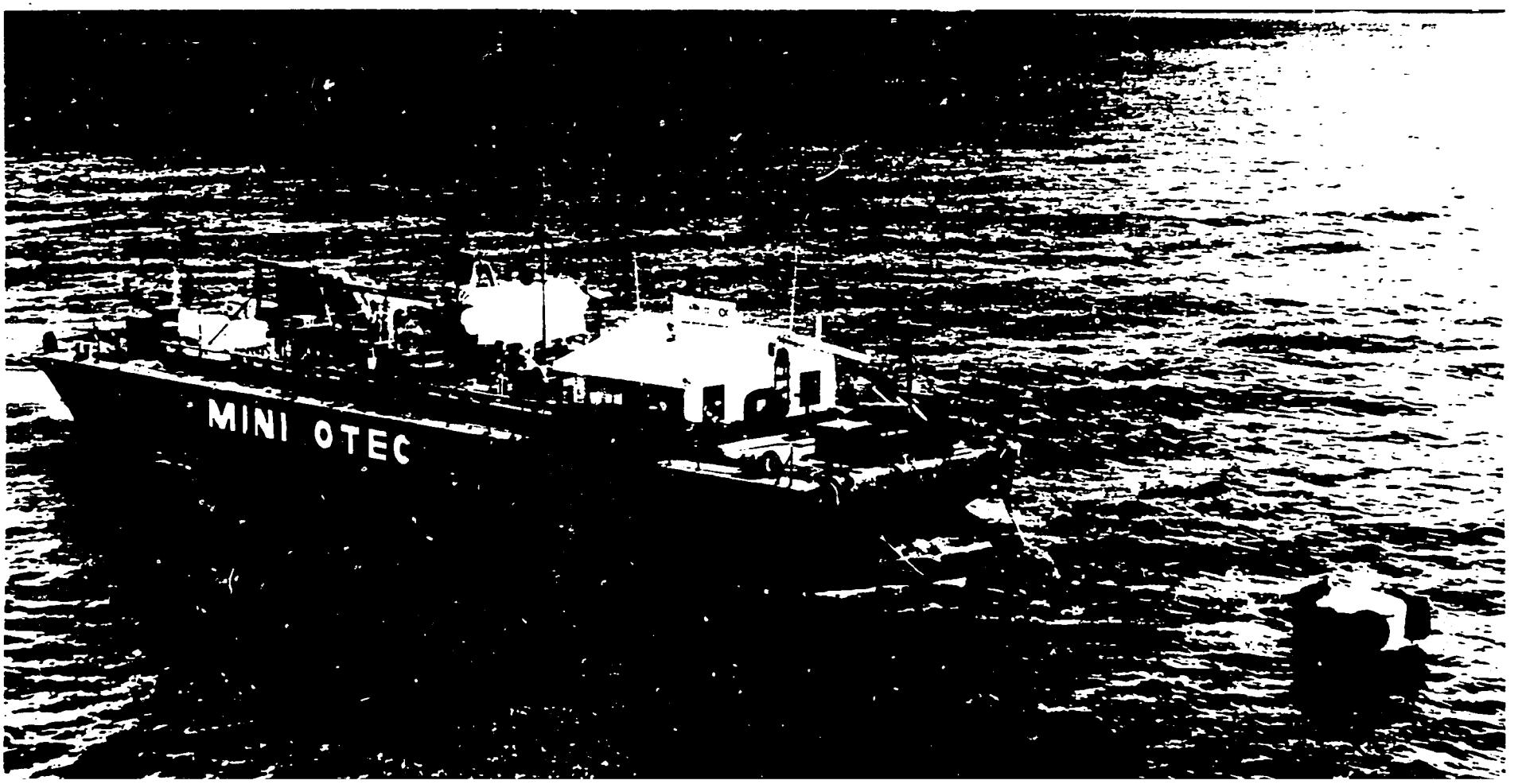
Ocean Thermal Energy Conversion To date, the OTEC market has consisted of government sales either in support of R&D programs (test article fabrication, test operation) or in support of economic evaluations or small-scale demonstration projects (design studies).

Penetration of mainland utility markets (primarily along the eastern Gulf of Mexico) will only occur after OTEC has been demonstrated to be commercially successful in tropical island applications. Island applications are felt to have a much greater potential for near-term commercial development due to their greater need to relieve dependence on imported fuels, the high cost of electricity generated from these fuels, and the close proximity of a large and seasonally more constant ocean thermal gradient.

The island market is being actively pusued by the French and Japanese governments, as well as several foreign private firms. For example the French government, together with a consortium of private companies, is proceeding with site survey work and subsystem design for a 10 MW land-based plant in Tahiti, with a decision on whether to proceed with construction expected in 1985.

Tidal Power Two tidal power projects for the Cobscook Bay, Maine have ben studied recently. A preliminary design has been sponsored for a 12 MW plant estimated to cost $3,000 to $4,000 per installed kilowatt. The Army Corps of Engineers has investigated two sites for tidal plants that would generate up to 250 MW each. However, given the lack of DOE support for tidal power research, development and demonstration, and the high cost of installing, operating and maintaining the system, it is unlikely that these or any other U.S. tidal resources will be developed in the near future.

OTEC TEST FACILITY



RENEWABLE FUELS

TECHNOLOGY DESCRIPTION

The term renewable fuels refers to the group of liquid fuels which are derived from renewable-based feedstocks.

Ethanol Ethanol, or ethyl alcohol/grain alcohol, is produced from biomass by the conversion process known as fermentation. Currently, the major feedstock for production of ethanol is corn. The fermentation process of producing ethanol from the starch portion of grains, actualy enhances all the original protein, vitamins, and minerals retained in a concentrated high protein by-product.

Methanol Methanol, or methyl alcohol or wood alcohol, can be made from a variety of sources. While including renewable-based sources such as the methanol produced from the cellulose in wood or grasses, methanol is predominantly derived presently from coal and natural gas feedstocks and occasionaly from municipal wastes. Methanol derived from renewable feedstocks is produced through a distillation process in which wood or grass heated in the presence of a little air decomposes into charcol, carbon dioxide, and hydrogen. When pressurized in the presence of catalysts these gases become a liquid -- methanol.

APPLICATIONS

Ethanol Ethanol is a high octane liquid fuel that is blended with gasoline in a 10% mixture to form a product which is commonly refered to as "gasahol". The use of fuel ethanol is primarily as a replacement for lead as an octane enhancer.

Fuel ethanol is an environmentally benign material recognized by the United States Environmental Protection Agency (EPA) as safe in terms of air, water, and handling.

Methanol There has been only very limited actual application of methanol from renewably-derived feedstocks. However, the use and applications of methanol as a high-grade liquid fuel alternative and/or fuel extender which have been demonstrated from methanol produced from fossil fuel sources apply to renewable-based methanol as well. Methanol can be used at levels up to 15% as an octance enhancer and substitute for lead in gasoline, or utilized as a strict liquid fuel alternative in modified gasoline engines. In addition, methanol can, and has been utilized as an industrial chemical and solvent.

The use of methanol/cosolvent blends in gasoline has many of the same benefits ascribed to ethanol blends. Exhaust emissions of hydrocarbons are reduced up to 25 % and carbon monoxide by up to 45 %; and while methanol combustion does produce an emmission of formaldhyde, according to recent EPA studies, present catalytic converters can be adjusted to contain this problem.

TECHNOLOGY STATUS

Ethanol The fuel ethanol industry has undergone significant technological advances, especially in such areas as process energy requirements. There has been concern that fuel ethanol production and utilization had a "negative energy balance". However, a joint investigation by the U.S. Department of Agriculture (USDA) and the U.S. Department of Energy (DOE) stated that "The energy balance in a modern well managed facility is 1.5 : 1", or that it produces one and one half times more energy than was used, even when the energy inputs required for planting the crop are counted.

Capital investment costs per gallon per year ("annual gallon") are approximately $1.50 to $2.00 for ethanol. Raw materials comprise between 60 and 70% of the total cost of producing ethanol, manufacturing costs approximately 20%, and return on investment makes up the remainder.

Methanol In contrast to ethanol production, methanol production requires little energy from external sources since heat is generated when the feedstock is gasified.

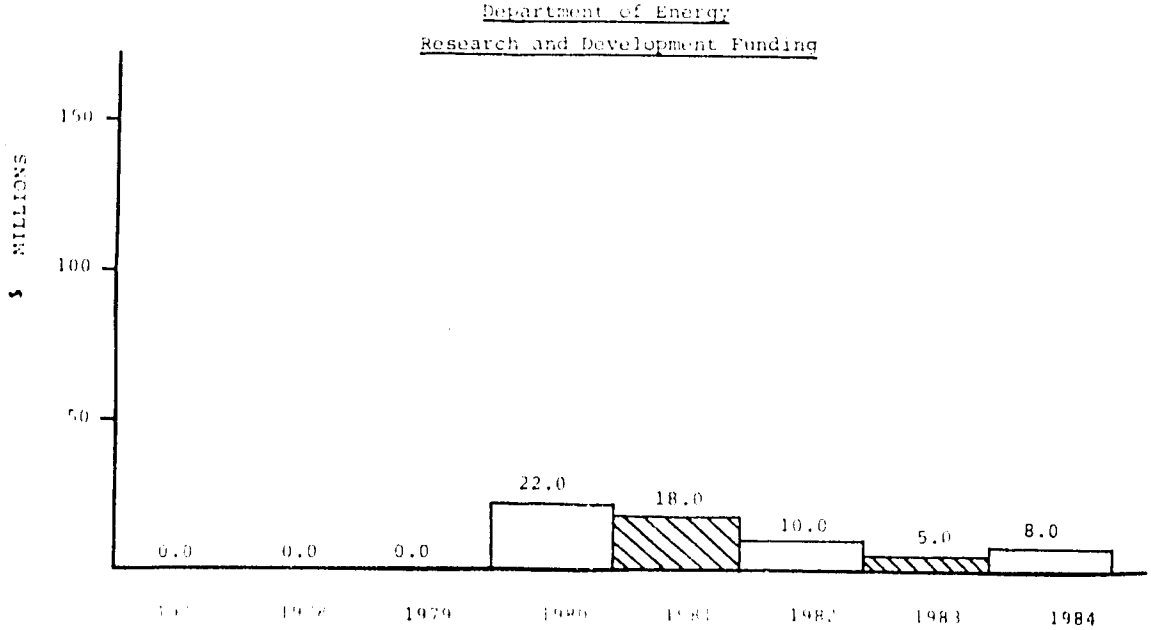
For methanol, the cost of potential raw materials is lower than for ethanol but plant investment costs are significantly higher and larger volumes of raw materials are required.

Cellulose conversion, genetic engineering, and new energy crop breeding will all play a major role in advancing the use of ethanol and methanol through the utilization of lower priced feedstocks.

FEDERAL SUPPORT PROGRAMS

The Department of Energy (DOE) budget for research and development (R&D) of alcohol fuels in FY 1984 is $8.0 million and is funded under the Biomass Energy Technologies Program. The thrust of DOE's R&D efforts is in the conversion technologies, primarily ligno-cellulosic conversion, or the conversion of wood, and agricultural wastes/crop residues to ethanol. DOE also supports research and development of alcohol burning engines through the Office of Transportation and Conservation.

Department of Energy
Research and Development Funding



Congress recently reaffirmed its support for the ethanol industry by increasing the exemption given to ethanol-enhanced fuels from the fuel excise tax on gasoline to a total of 5 cents per gallon. Currently, 32 states also provide tax incentives to ethanol/gasoline blends by exempting the blend from a portion or all of the state gasoline tax.

A 10 % federal business energy tax credit is available for invesstments in the production of ethanol. This credit is scheduled to expire at the end of 1985.

There exists only one federal subsidy for fuel methanol. Neat-methanol or pure methanol derived from either coal or wood is exempt from paying federal tax on its use as a fuel. However, at present this is a little used federal support.

INDUSTRY STATUS

Ethanol Over the past four years ethanol the has become the principal commercial scale, high grade liquid fuel alternative in the United States. The United States fuel ethanol industry has quadrupled in capacity and production since 1979. For 1983, the U.S. capacity for ethanol production was 500 million gallons; however, actual production levels reached only 350 million gallons. Over 80 operating fuel ethanol production facilities, dispersed geographically throughout the U.S., have been constructed since 1979 representing the investment of hundreds of millions of dollars.

In 1984, the industry will provide a new market for well over 200 million bushels of feedgrain (up from 150 million bushels in 1983), and in the process reduce U.S. oil imports by nearly 25 million barrels (gasoline equivalent), or roughly $700 million in imported oil costs alone. This, coupled with the recent EPA tightening of lead-in-gasoline standards, means an even greater role for ethanol in the future as new cars and unleaded gasoline use increaes demand for octane. As domestic production increases, market growth in the industrial solvents and chemical industries will also grow.

Analyst active in the ethanol field state that if current trends of industry growth and support from the federal and state governments continue, the ethanol industry could provide one 1 billion gallons of high grade liquid fuel by 1990.

Methanol In 1983 over 1 billion gallons of methanol were produced in the United States. The vast majority of this capacity was methanol use as an industrial or chemical solvent. Further, over 90% of this production was from natural gas feedstocks with coal feedstocks representing almost all the remaining 10%. Commercial production of methanol fuel from renewable resource feedstocks was, for all intents, zero in 1983. Although the fuel methanol market is being assisted by a growing number of both private and public programs of purchasing fleets of straight methanol-burning automobiles and buses demand for "neat methanol" (85% or greater methanol) is more than being served by present supply. Worldwide, there is a surplus of methanol which currently amounts to 2 billion gallons per year, and which is expected to grow to over 3 billion by the end of 1985.

A further problem facing the methanol fuel industry is that due to its only containing one-half the energy equivalence of gasoline it requires roughly twice as much fuel to travel the same distance. While, on the one hand, cost per gallon of methanol fuel are roughly one-half of gasoline (65-75 cents per gallon in 1983) it pays twice the amount of federal tax because the tax is levied on a per gallon basis.

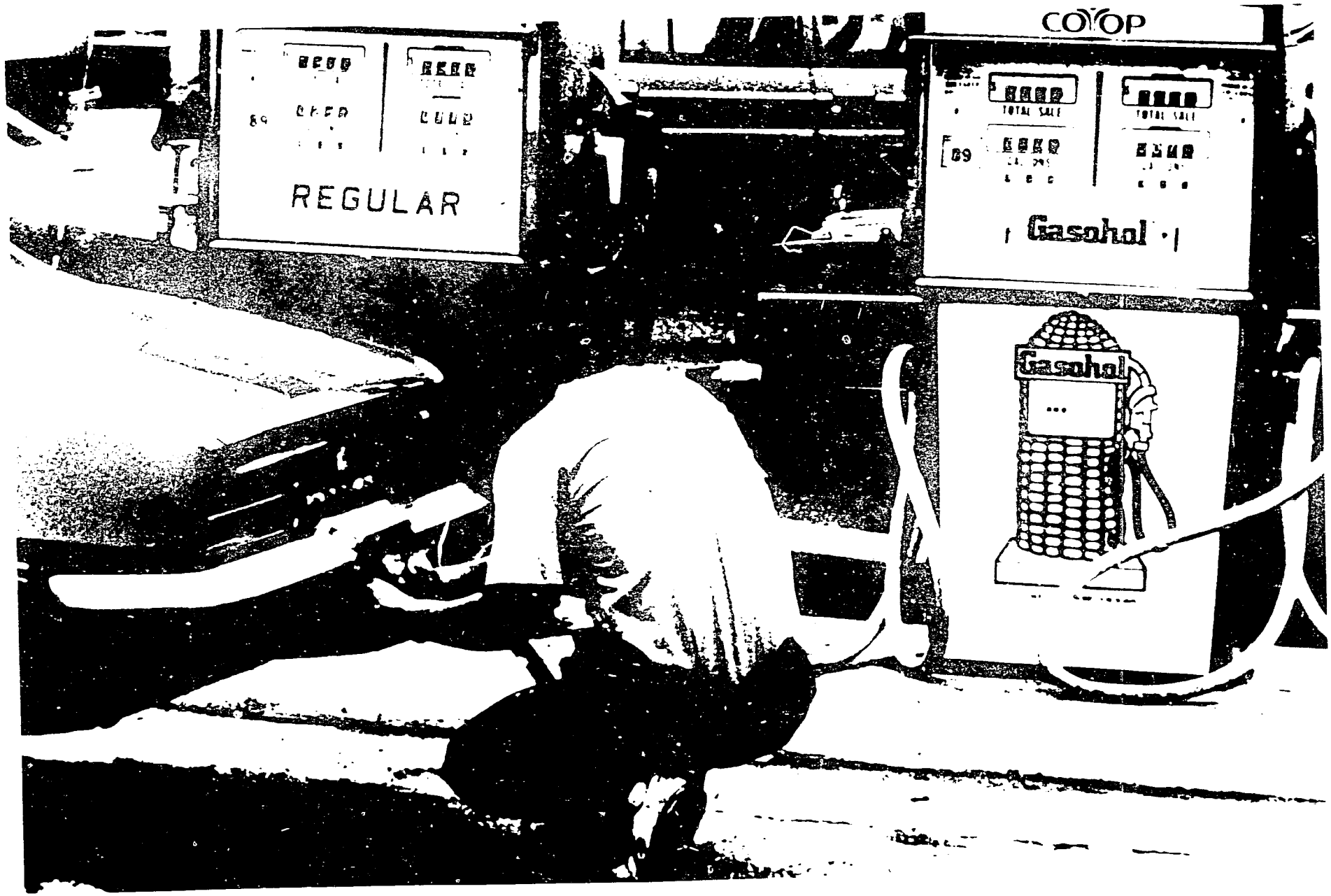
MARKET STATUS

Ethanol The fuel ethanol industy's ability to lower aquisition costs to blenders and distributors, while simultaneously increasing octane, has created a growing demand and market for the product. In the past six years, the production and use of fuel ethanol in the U.S. has increased dramatically, from less than 400 million gallons of 10% ethanol-enhanced fuel in 1978 (40 million gallons of ethanol) to roughly 4 billion gallons (400 million gallons of ethanol) in calendar year 1983, and over 5 billion gallons (500 million gallons of ethanol) projected for calander year 1984. This 1984 figure will represent over 5% of the nation's gasoline market up from slightly over 4% in 1983.

Ethanol imports in 1983 were roughly 58 million gallons. The two major countries exporting ethanol to the U.S. were Brazil and Spain. Brazil was by far the largest exporter of fuel ethanol capturing about 15% of the U.S. market. The Brazilian market share is expected to decrease in 1984 accompanying government import quotas.

Methanol Methanol was commercially introduced in 1982 as a gasoline blending component. A number of reoccurring problems stemming from misuse and overblending of methanol have adversely affected the methanol market. Nevertheless, methanol use as a transportation fuel has grown to over 2% of total gasoline consumption in only its second year of use. While, none of this use represents renewable-based feedstocks, it is widely assumed that the development of a renewably-based methanol market will depend on the growth of the demand and utilization of methanol fuels in general.

ETHANOL



PASSIVE SOLAR DESIGN

TECHNOLOGY DESCRIPTION

The term "passive solar" encompasses a wide range of strategies for designing and building to take advantage of the environment and natural resources, thus reducing a building's need for conventional energy. In "active solar," mechanical means such as roof collectors, pipes, pumps and tanks are used to capture the sun's energy for water and space heating. Passive solar, in contrast, uses very few, if any, mechanical devices. Rather, the building itself collects, stores and uses solar energy, and is designed to take advantage of the site specific features for natural heating, cooling and lighting.

Heating: A complete passive solar heating system will include collection of energy, through south-facing glass, storage of energy, through the use of thermal mass, usually in the form of concrete, brick, water or phase change material, regulation of energy, which may be as simple as providing overhangs, shades or other insulating material for windows, or providing a door to close off a sunspace at night, and distribution of energy, which may consist of vents, dampers or small fans.

The three most common passive solar heating systems are:

- Direct gain: In this system, the sun shines directly, through south-facing windows, into the space to be heated. Thermal storage is provided to absorb and store the energy, and to prevent overheating on sunny days. The use of overhangs, which allow the low winter sun to penetrate the living space, but protect the space from the higher summer sun, also work to keep living areas comfortable. "Suntempering" is a relatively low-cost direct gain technique which simply maximizes south-facing windows and uses minimal amounts of thermal mass.

- Indirect gain: This system generally uses mass wall, or Trombe wall, directly behind the south-facing glass, separated from the glass by a small airspace. The Trombe wall is usually built of concrete block, brick or stone. Energy is absorbed in the wall, which can store large amounts of heat for radiation into the living space long after the sun has gone down.

- Isolated gain: Energy is collected and stored in a space "isolated" from the rest of the house, commonly in a sunspace, attic or greenhouse. Sunspaces are a popular remodeling or retrofit option.

Cooling: The passive solar cooling techniques for building design are perhaps better labelled as natural cooling mechanisms, in that, they require no pumps or fans for their operation, but may not use the sun's energy directly.

Methods of passive solar cooling include solar control (eg. the use of operable shades, overhangs, awnings, and surrounding vegetation), ventilation (using natural air flows and breezes by creating an opening on two opposing sides of a house or room, or using the "stack" or "chimney" effect where convective air flow is induced through the use of cupolas, attic vents, belvederes, wind vanes, and wind scoops), evaporative cooling (using roof sprays or ponds, or indoor bodies of water), radiational cooling (using unobstructed hortizontal roof or ceiling glazing to take advantage of clear, nighttime "sky" radiation), and ground cooling (berming or building underground, or using tubes to draw warm air through cooler earth or groundwater sources).

Lighting The use of natural lighting or "daylighting" to reduce a building's energy load is another passive solar design technique. Some of the most common are light shelves, a reflective device, usually located near a window, which reflects and disperses sunlight onto ceilings and walls; a clerestory, an upper zone of a wall pierced with a window to admit light and air; roof mirrors, raised sections of a roof with openings, louvers or windows (not parallel to the roof plane) used to admit light and air; and skylights, the familiar glazed roof apertures which are parallel with the roof plane. Windows themselves, if properly designed and located, and atria are other daylighting options, and should be considered when designing buildings.

APPLICATION

Passive solar energy has made inroads into the design of single and multi-family dwellings, institutional (eg. schools and hospitals) and commercial buildings.

Residential buildings (single and multi-family) are considered "skin dominant", which means energy use depends, in large part, on the building envelope --how well it protects against heat or cold, how well-insulated or well-sealed against infiltration it is. Because of this, the best or most cost-effective designs are a balance between passive solar features and energy-conservation techniques.

Institutional and commercial buildings, on the other hand, are considered "load dominant", because, their energy use depends more on internal factors --lights, inhabitants activities, machines, and the building's use. Since lighting represents from 25-50% of most commercial buildings' energy use, daylighting or using natural lighting is perhaps the most cost-effective passive solar application.

TECHNOLOGY STATUS

Passive solar or climate sensitive designs have been in existence and documented since the beginning of modern civilization. However, accompanying cheap and more available fuels sources, architecture moved away from energy conscious design. Today, the incorporation of passive solar design is becoming more common and solar heating, cooling and daylighting offer attractive, cost-effective alternatives to conventional building designs.

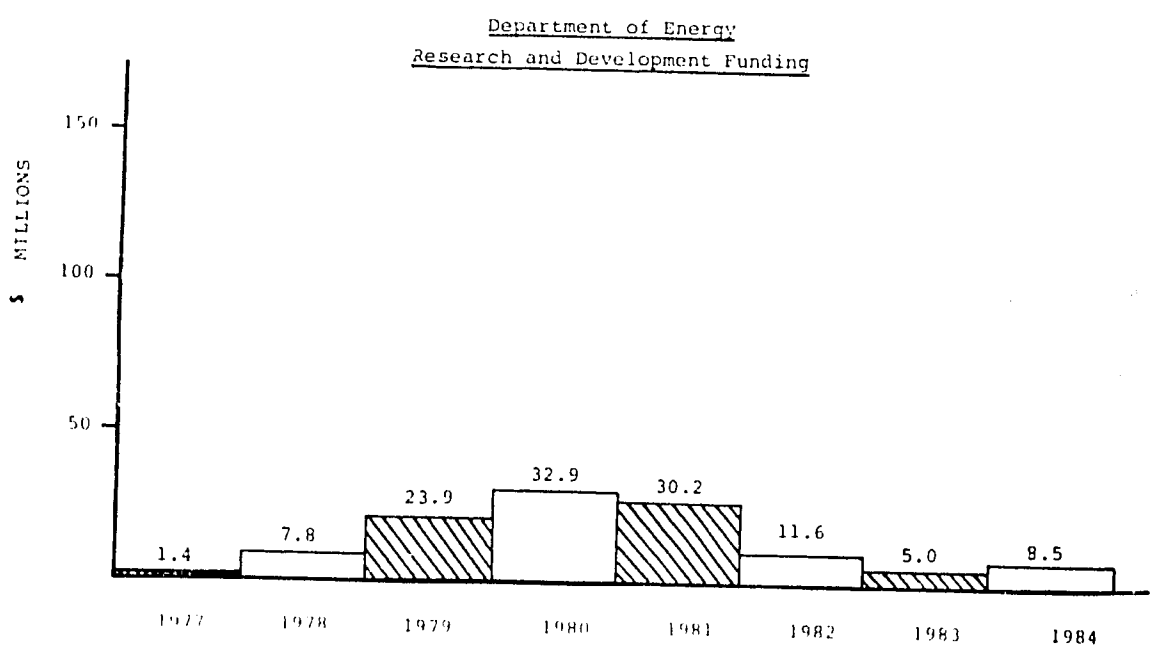
Through research, development and demonstrationconducted at the Department of Energy, government labratories, utilities and private companies, standardized formulas and computer design tools have been established to assist builders, architects, and engineers in predicting the performance of passive solar features.

Passive solar homes can reduce from 20% (in suntempered, modest systems) to 75% or more (in more sophisticated systems) of the energy required by a conventional home. Experience to date shows that these modifications cost, on the average, $5,000 to $10,000 more and do not necessarily change the appearance of the structure.

Likewise, operating experience and predicted performance of commercial buildings indicate that for only a modest increase (5-15%) in first costs, passive commercial buildings can offer a 50% or greater annual reduction in energy consumption and costs. The best passive commercial designs integrate natural energy sources with mechanical heating, cooling and lighting systems, and are specifically designed for the inhabitants to fine-tune.

FEDERAL SUPPORT PROGRAMS

The FY 1984 Department of Energy budget for passive solar heating and cooling is $ 8.5 million, and is contained in the Solar Building Energy Research Program. The program stresses new materials development and thermal science research and reinforces the historical design tool development activities, while continuing to refine the ability to predict and measure whole building performance.



Specific research is being conducted in the following areas:

- o high r-value transparent insulation
- o optically switchable glazing and transmission materials
- o solid-to-solid phase change materials (PCMs)

INDUSTRY STATUS

The passive solar industry is made up of a diverse group of architects, designers, engineers, and builders. Because there are few passive solar system packages, as compared to active solar, research is conducted primarily by the manufacturers of components. These would include chemical companies, glass or glazing manufacturers, masonry companies and others. It has been stated that 40% of U.S. builders are now constructing at least some solar homes, or homes with passive solar features, and that an estimated 60,000-80,000 full-fledged passive solar homes existed at the end of 1982.

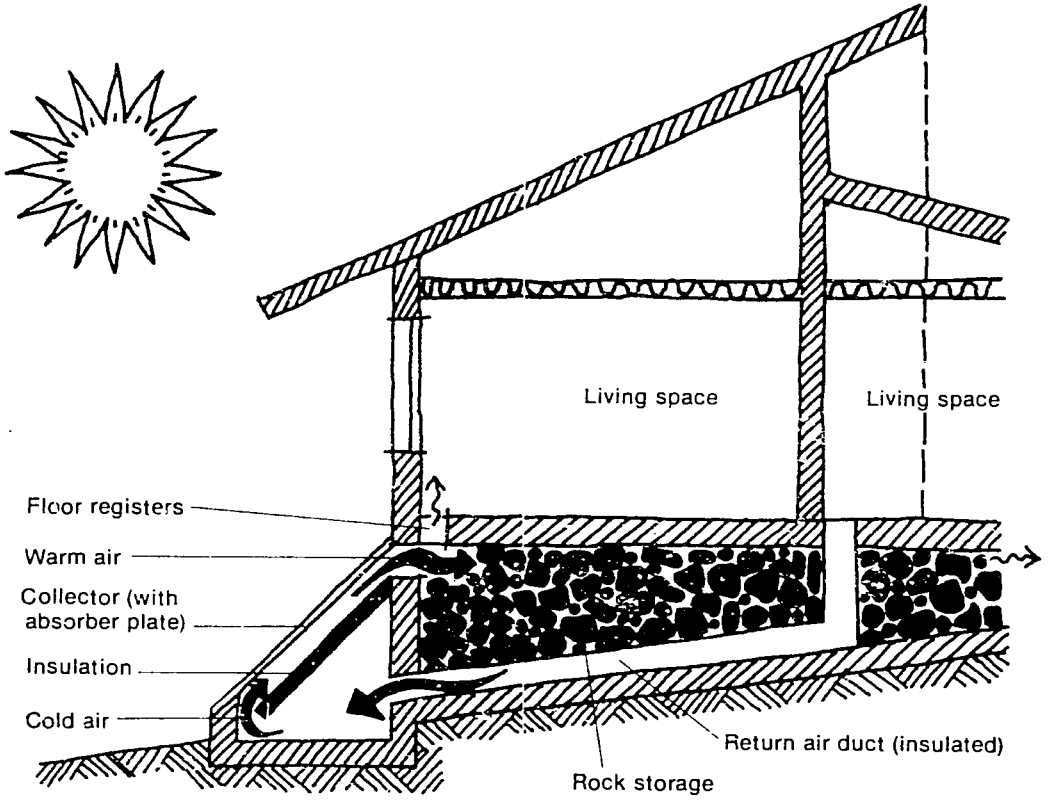
MARKET STATUS

The barriers to more widespread use of passive solar are not really technical, since the technology is well-proven. The barriers tend to be informational --builders do not yet know exactly how to incorporate the technology, how much it will cost, and what the benefits will be. Further, the average home-buyer is also likely to have little knowledge about the advantages of passive solar. The net result of this situation is that although passive solar heating techniques, and some cooling techniques, are well defined only a very small percentage (estimates range from less than 1% to about 5%) of new housing is built with passive solar design. Compounding this problem is that of this percentage, some of the installation and construction has not been properly designed and thus has experienced problems with overheating, glare, etc.

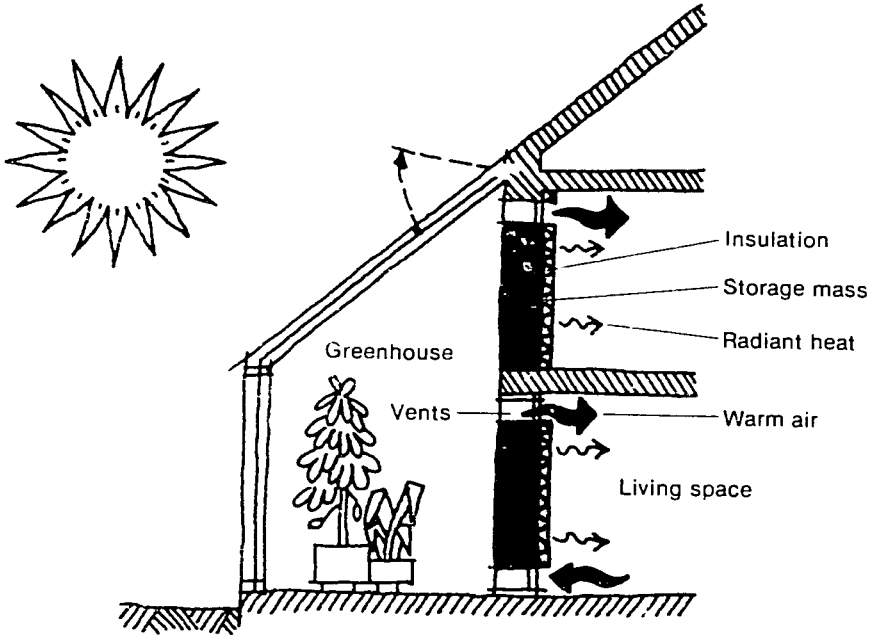
Perhaps the greatest challenge facing the passive solar industry is how to effectively educate the building industry, the general public, and mortgage lenders about the potential benefits of passive solar design, and the savings these options provide. A growing movement has developed in the industry to promote and develop passive solar. Central to this campaign is an effort to stress the notion that buildings use over a third of the total energy consumed in this country, and the potential for energy savings in this sector is great. The potential stimulus to the building industry, if passive solar were to become popular, is also large, since passive solar in general uses traditional building materials and techniques. It is a message which now appears to be finding an audience; according to the National Association of Home Builders, by 1986 it is estimated that 50,000 new passive houses will be added annually.

One potential market for passive solar is that of manufactured or prefabricated housing. An estimated 25% of all U.S. homes, in 1984, will be constructed in factories, and that by the end of the decade this will grow to over half. The Swedish have already established a thriving market for solar prefabricated houses and could capture this market in the U.S.

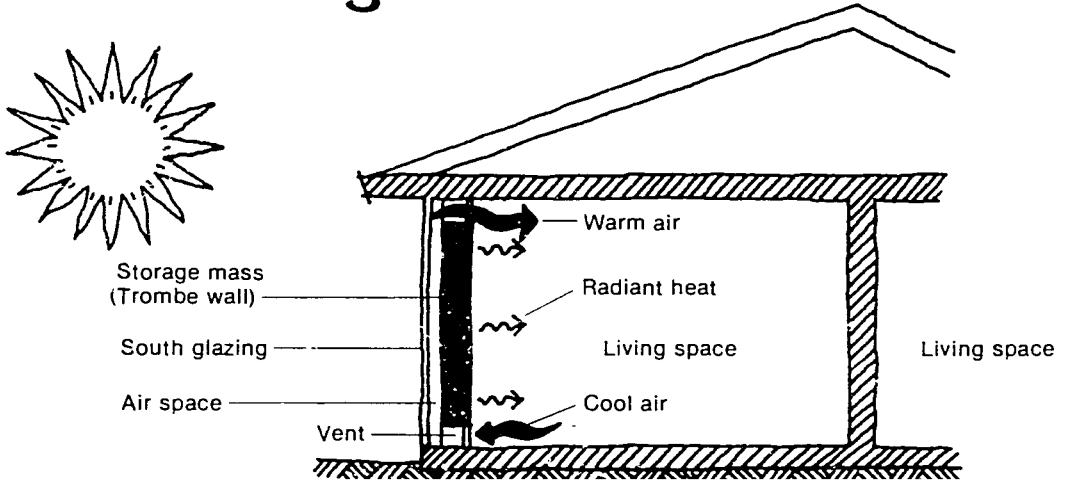
Thermosiphon



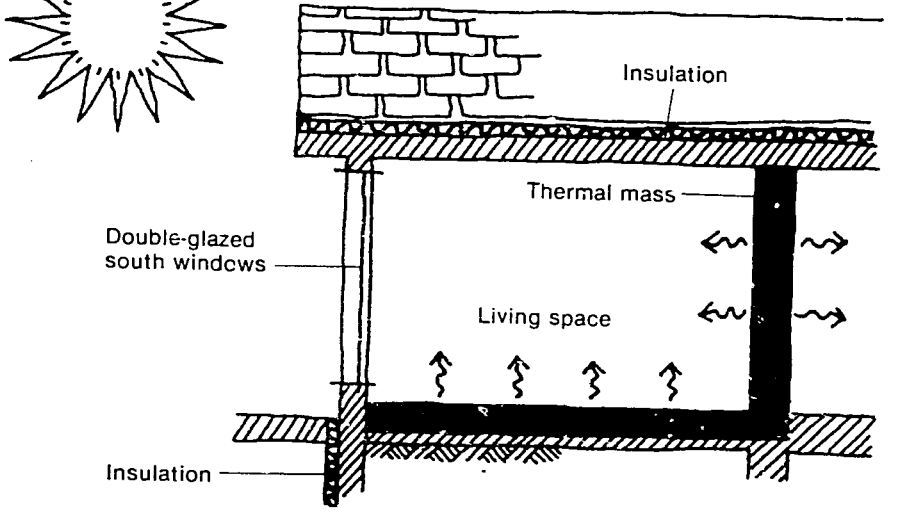
Sunspace



Thermal storage wall



Direct gain



PHOTOVOLTAICS

TECHNOLOGY DESCRIPTION

Photovoltaic (PV) energy systems convert solar radiation directly into electricity. Photovoltaic cells are thin layers of semiconductor material specially prepared to cause an electron flow -- electric current -- when exposed to light (radiation). Most solar cells are fabricated out of wafers sliced from crystals of pure silicon grown in a high-temperature furnace. Alternatives to crystal-growing include casting of blocks, or growing thin ribbons or sheets of silicon. After the wafers are grown, they are chemically treated to make them able to separate the positive and negative electric charges (via a semiconductor p-n junction), and metal contacts are applied front and back to extract the electricity so that the cells may be wired into circuits and packaged into either assembled flat plate sealed panes, (photovoltaic modules), or used with a lens or reflector (concentrators).

APPLICATIONS

The power output from photovoltaic systems range from a few watts to megawatts in size. Photovoltaic power systems can be designed to provide electrical energy for almost any application. They may be used in nearly all sectors of the economy. Five broad applications/markets can be identified:

- Consumer products including small electronic products such as watches, calculators and portable appliances
- Small power systems (irrigation, desalination, refrigeration, communication/signalling devices, cathodic protection, daytime loads, pumping, residential, off-grid)
- Fuel saver (village power, pumping, light industry, hospitals)
- Grid connected systems (independent power producers, residences, schools, light industry, and commerce)
- Central station power generation (utility-scale systems)

TECHNOLOGY STATUS

PV modules currently can convert about 10% of the sunlight they receive to electricity, or about 100 watts per square meter at noon on a clear day. A typical silicon flat plate module is 4 ft^2 and delivers 30-40 watts peak power at 20 volts, or about 50-75 kilowatt hours per year. Systems may consist of a small cell and battery (calculators, watches) or modules, batteries and power conditioning equipment (inverter and transformer) to convert the DC electricity produced by the cells to AC current.

Over the last decade, photovoltaic technology for terrestrial use has been characterized by dramatic efficiency improvements and cost reductions. Six basic photovoltaic cell technologies may be identified, each with different cost, performance and efficiency characteristics.

	Cell Efficiency		Module Efficiency	
	1982	1983	1982	1983
Single Crystal Silicon	12%	12-14%	10%	10-11%
Semi or Polycrystal	10.5%	12%	10%	10-11%
Silicon Ribbon	12%	12%	10%	10%
Amorphous Silicon	5%	5-7%	5%	5-6%
Optical Concentrator	15-17%	15-19%	12-13%	12-15%
Advanced Thin Films	na	10-11%	na	na

In the last five to seven years:

- Single crystal silicon modules have dropped from $100/per peak watt (wp) to less than $10/wp in 1982 and in 1983 to less than $5/wp factory cost. This $5/watt price was achieved by applying mass production and automation to the single-crystal silicon technology.
- Amorphous silicon cell efficiency rose from 1% to 10% (laboratory) in 1982 to 10% to 12% (laboratory) in 1983.
- Ribbon and polycrystalline cell technology is now 20% of the world market
- Concentrator cells achieved over 20% efficiency in laboratory.
- Multilayered cells promise over 30% efficiency.

The photovoltaic's industry invested over $80 million in research and development in 1983. Over two dozen key research efforts are ongoing, and the promise of major cost and performance breakthroughs remains high. No one can predict, however, which of many technological avenues will achieve market acceptance: thin films, multilayered-thin films, electrochemical, or very high effeciency single crystal.

FEDERAL SUPPORT PROGRAMS

The Department of Energy research and development budget for photovoltaics in FY 1984 equalled $50.4 million (down from $150 million in 1980). The thrust of the department's program is concentrated on achieving technological advances that would result in higher cell efficiency or lower cost. This includes materials and cell research, cell theory and validation studies, and testing and reliability studies.

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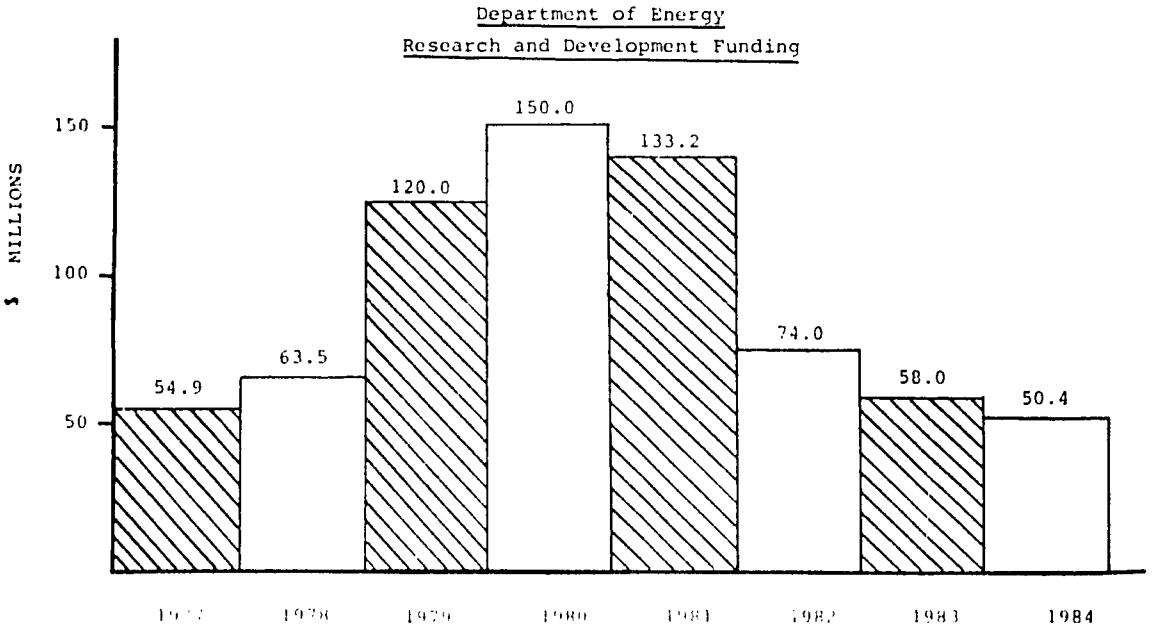


There is a federal business energy tax credit of 15% for investments in photovoltaic systems. A 40% residential energy tax credit is also available, but is limited to $4,000, or 40% of a $10,000 investment. Both the business and the residential tax credits are scheduled to expire at the end of 1985.

STATUS OF THE INDUSTRY

The photovoltaics industry consists of approximately 50 to 80 firms actively engaged in significant research and/or sales. According to the Energy Information Administration (EIA), 18 U.S. manufacturers shipped modules in 1983 with a total capacity of 12,620,313 peak watts. In 1983, major corporations (frequently having purchased small firms) still have a vital role in innovation and in commercialization of current technology. Seven large oil companies are key industry participants. Private industry investment in PV from 1972 to 1982 was about $350 million (federal funding for the same period, $628 million). In 1983 the total figure for private investment reached $450 million.

The industry may be divided into three distinct segments based on technical activity:

- Current technology (crystalline silicon, flat plate and concentrator)
- Amorphous silicon and other thin film technology with near-term market potential
- Long-ranged advanced R&D

Three years ago, U.S. firms accounted for 70% of world-wide sales. Their portion has slipped to 50%. Some analysts also fear U.S. technological leadership is slipping as well, but it is not yet clear that this is the case.

The industry is characterized by constant movement forward. The industry may still be characterized as fragile, but extremely promising.

MARKET STATUS

The current market is dominated by flat plate crystalline silicon technology (60+% share). U.S. sales growth has been strong.

U.S. Production and Sales (MWp)

1979	1980	1981	1982	1983	1984E
1.4	3.2	4.5	6.9	12.5	20

U.S. Cumulative Installed Capacity (MWp)

1979	1980	1981	1982	1983	1984E
0.8	3.3	6.6	11.7	23.2	40

1982 world market was 9-10 MWp; in 1983 the world market was 18-20 MWp.

To date, the majority of photovoltaic production has been single crystalline technology. In 1984, 10 MWp of new amorphous silicon cell capacity is projected to be available.

The total photovoltaics production figure for 1984 is anticipated to reach 31 MW. By 1990 this figure has been predicted to grow to 500 MWp or $1 billion dollars.

As illustrated by the last three years, there has been a dramatic shift in the sectors utilizing photovoltaic power. Two notable trends:

- Residential sector growth has been higher than expected
- Large-scale systems built exclusively to sell power to utilities (noted as commercial end-use below) are being encouraged by various incentives and regulations.

Production By End-Use Sector (MWp)

	1980	1981	1982	1983	1984E
Residential	0.11	0.31	0.83	0.21	2.00
Commercial	0.55	0.66	3.48	10.55	12.50
Industrial	1.79	1.51	1.64	0.59	0.70
Agriculture	0.13	0.08	0.22	0.11	0.40
Other	0.22	0.25	0.72	1.15	0.80
Exports	0.83	1.19	1.81	1.50	2.50

The 9 MWp figure for commercial production for 1983 represents a 6 MWp installation in Carrisa Plain, California with the remaining 2-3 MWp resulting from other third-party investor financed central station power generation projects also located in California. It should be noted that due to the use of optical concentrators, which increases overall system effeciency, the actual output from these systems will be closer to 9-11 MWp.

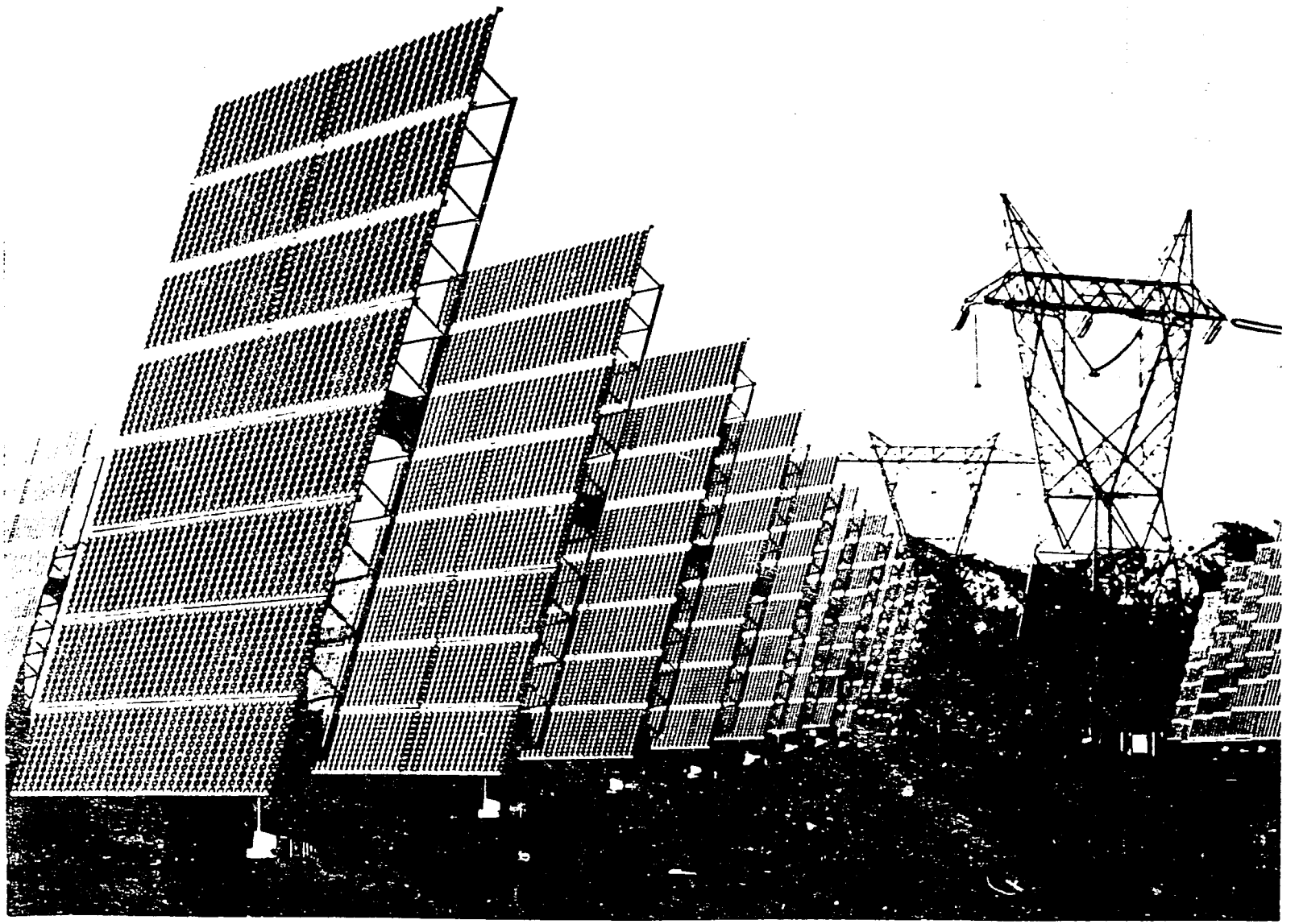
In 1983 single crystal silicon modules accounted for 45% of production, and cost per watt for single crystalline modules ranges between $5 and $10/wp with complete photovoltaic systems delivering conditioned power (AC) at between 20-32 cents per kilowatt hour for large megawatt installations and 35-49 cents per kilowatt hour for residential grid connected or stand alone systems.

Production Costs ($/wp)

	1982	1983	1985E	1990E
Single Crystal Silicon	10	4-10	4-5	3
Semi or Polycrystal	9	5-10	4-6	2
Silicon Ribbon	10	10-12	6-8	3
Amorphous Silicon	20	6-10	4	2
Optical Concentrator	7	6-10	3-5	2

At today's prices, photovoltaic systems provide a cost-effective alternative for small, remote applications. However, for silicon technology to compete unsubsidized with present grid-produced power, a 10 fold cost reduction will be required from present costs.

PHOTOVOLTAIC UTILITY APPLICATION



SOLAR HEATING AND COOLING

TECHNOLOGY DESCRIPTION

Active solar energy systems employ mechanical means to transfer energy from a collector to the end-use or storage system. Active systems may operate in a temperature range from 80 to 220°F. A system typically consists of a collector, which may be a flat plate (glazed or unglazed), an evacuated tube, or a concentrator; a thermal transport system including a pump or blower; and a storage system. Typical solar collectors for medium temperature applications (100-190°F) sandwich a metal absorber plate (to collect radiation and transfer it to a fluid, liquid or air) between a transparent cover and backing insulation, encased in a metal frame.

Passive solar water heating systems, unlike active solar systems, do not require any pumps or fans in the collection and storage of solar energy. The two most common designs are the integral collector storage (ICS) or batch systems and the thermosyphoning systems. A batch or ICS (also sometimes referred to as "breadbox") system combines both the storage and collection process such that they are inseparable. Typically, batch or ICS systems are comprised of a storage tank, with absorber coating (usually flat black), enclosed in a well insulated housing covered with as many as three layers of glazing to minimize heat loss. Often these systems include reflectors and nightime insulation to enhance overall performance.

A thermosyphon system consists of an insulated tank placed above a solar collector(s). Flow through the collector to the storage tank is driven by natural convective forces. The storage tank can be mounted on the roof, either separately or as part of the collector, or inside the roof. For tanks mounted within the roof, special structural supports may be necessary in order to support the large mass of water.

Compared to active systems, passive water heating systems are considered to be simpler, to require less routine maintenance, and should experience fewer failures in the field. However, because these systems do not employ mechanical means of optimizing performance and storage temperatures, they are often undersized and are used as, or with, a back-up hot water system.

APPLICATIONS

Active solar systems are employed primarily in the buildings sector for heating swimming pools, domestic hot water, and space heating or cooling. For cooling purposes, active solar collectors provide the input temperatures to run an absorbtion cooling system (usually with lithium-bromide-salt solution) or a vapor-compressor cooling system (similar to a conventional refrigerator run in reverse). Active solar systems are also used in commercial, industrial and agricultural applications for space conditioning, water heating, process heat, and grain drying.

Passive solar water heating systems are used almost exclusively for single family domestic hot water applications. However, systems can be combined to meet institutional and multi-family dwelling's hot water needs.

TECHNOLOGY STATUS

Active solar collecting systems have been refined over the last five to seven years, and industry-wide standards on quality and performance are being developed. Active solar technology has been commercialized for low temperature applications (mainly non-metallic collectors for swimming pool heating) and medium temperature applications (domestic water heating, mainly metallic collectors). Systems and hardware improvements for current technology come from application engineering and some research. Further cost reductions associated with lower production costs and increased consumer awareness will be necessary to improve competitiveness absent current tax credits (the national average installed cost for active solar domestic water heaters about $3000).

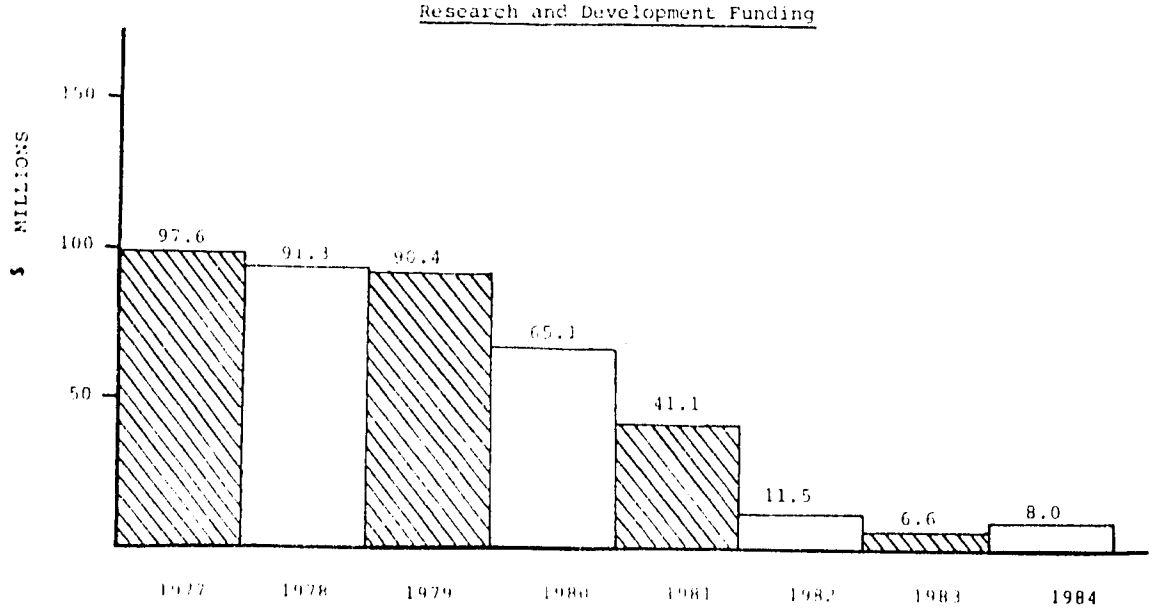
Passive solar hot water heaters have been used since the beginning of the century and there has been little variation in overall designs. Performance and reliability improvements have been associated with industry conducted materials research. The use of freon or propylene glycol-water mixtures as heat exchanger fluids have arrested concerns of thermosyphon system freezing in northern climates. Even electric coil heat exchangers have been adopted to optimize thermal output and eliminate freezing. Passive hot water heater systems range from $800 - $4,500, but are generally considered to be less expensive than their active counterparts.

Industry research and development for solar heating and cooling is minimal, and industry representatives appear to think further cost reduction will mainly occur from production economies of scale. The industry now relies heavily on selective and semi-selective coatings, low-iron glass covers, advanced plastic covers, and non-outgassing insulation and gasket materials. Some analysts expect that light-weight plastic collectors which could be fabricated in a very high-speed process of laminating absorber, flow channels, and glazing to form complete collectors will be necessary for any substantial improvement in solar collector cost performance.

FEDERAL SUPPORT PROGRAMS

Federal research and development support equals $8.0 million for FY 1984 and is concentrated on materials research and advanced solar cooling concepts.

Department of Energy
Research and Development Funding



There is a federal business energy tax credit of 15% for investments in active and passive solar heating and cooling systems. A 40% residential energy tax credit is also available, but is limited to $4,000 or 40% of a $10,000 investment. Both the business and residential tax credits are scheduled to expire at the end of 1985.

INDUSTRY STATUS

Approximately 224 collector manufacturers form the core of the solar heating and cooling industry, and are a barometer of industry performance. Material and component suppliers upstream, and the distribution and installation businesses downstream form the whole industry. Ultimately, system suppliers will be regarded as the core of the industry. The companies vary in size from divisions of Fortune 500 firms to small privately held firms, some with significant market shares. The majority however, are small, with 80% of collector companies reporting fewer than 20 employees. A rationalization of this industry continues, with high turnover due to low rates of return, acquisitions or failures, and the relatively low cost of entry.

Over the last two years, the solar heating and cooling industry has suffered through a recession. However, even with this set-back there has been an industry-wide improvement in the quality of products in the market place. The emergence of state and national standards and certification programs coupled with consistent testing centers have provided for increased overall reliability and performance.

One significant industry trend for 1983 was the addition of passive ICS or thermosyphon collector manufacturing to what was predominately an active solar system industry. Today, many solar companies offer both active and passive product lines.

MARKET STATUS

Gross sales in 1983 totaled from $700 million to $1 billion for active and passive solar systems, up from just over $600 million in 1981. California, Arizona, and Florida provided the largest markets. Production figures for 1983 show that 40% of production came from California companies, and 17% from Florida companies, and 12% from New York companies

Cumulative installation of active systems through 1983 was approximately 600,000 systems, up from 500,000 systems in 1982. According to a recent a Energy Information Administration (EIA) survey total square footage of active solar collectors shipped 1983 declined from 1982 and was the lowest annual total since 1979.

Active Solar System Applications By End-Use (in ft^2)

	1983	%	1982	%
Pool heating	4,839,000	29	7,035,000	38
Hot water	9,323,000	55	7,444,000	40
Space heating	2,082,000	12	2,367,000	13
Space cooling	25,000	*	73,000	*
Industrial	174,000	1	295,000	2
Agriculture	106,000	1	107,000	*
Other uses	279,000	2	1,301,000	7
TOTAL	16,828,000	100	18,621,000	100

* less than 1%

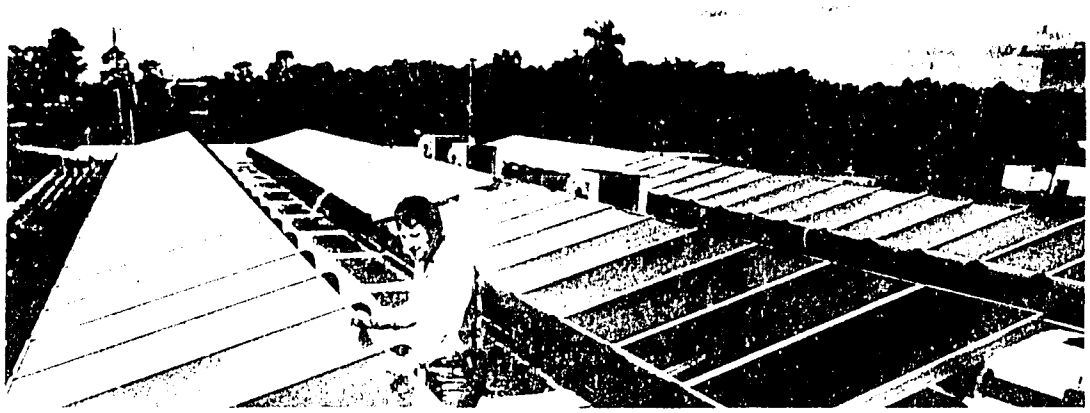
Installed costs for active systems in 1984 are :

Domestic Hot Water Systems	\$ 50-60/ft^2
Swimming Pool Applications	\$ 20-25/ft^2
Heating Applications	\$ 30-40/ft^2

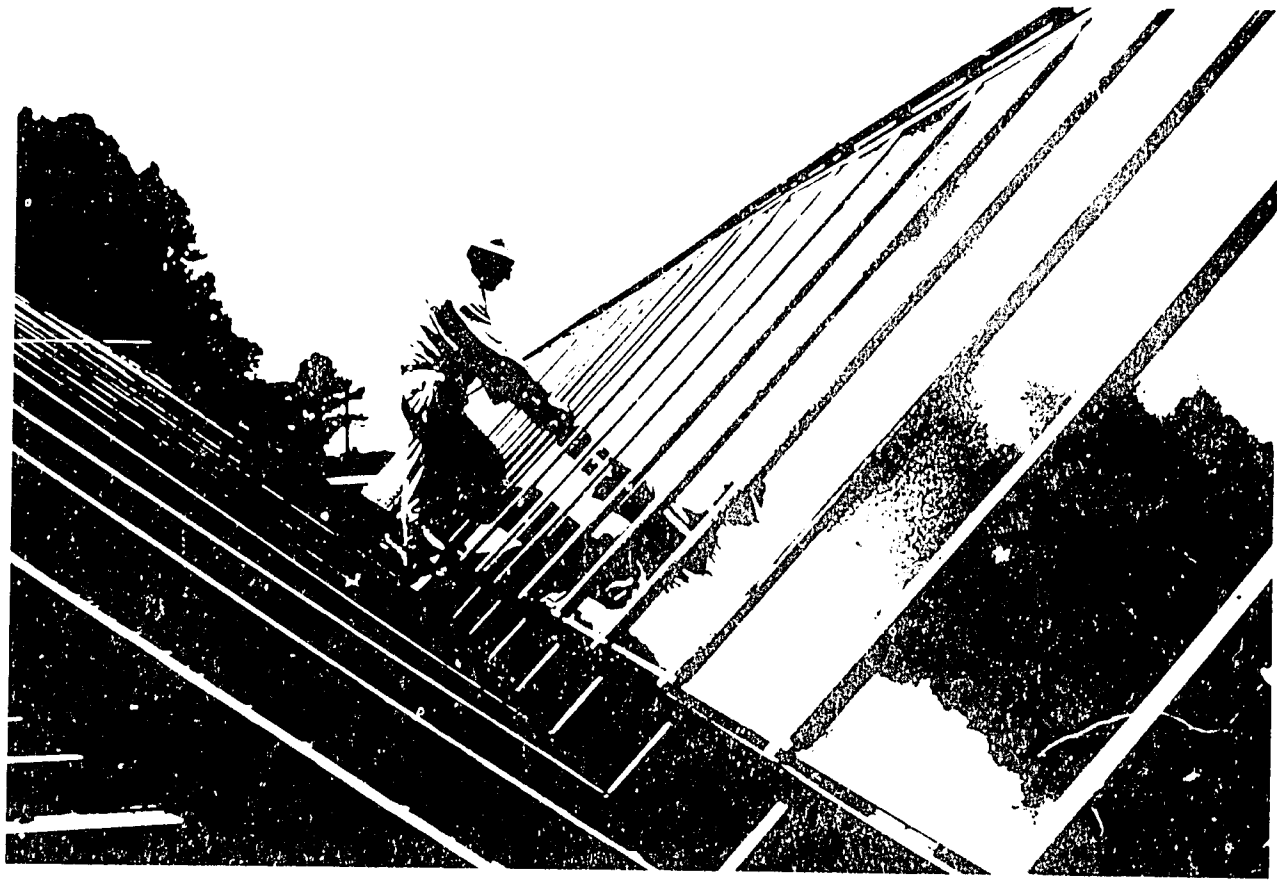
The recent growth of passive ICS and thermosyphon systems may be responsible for the overall decline in active solar production for 1982 and 1983. In California an estimated 38% of the 75,000 residential water heating systems sold in 1982 were passive according to the California Energy Commission. Some industry analysts believe this may have reached 40% in 1983 and will account for nearly half of the residential market in 1984. Of the passive solar water heaters manufactured, at this time, 65% are batch or ICS systems and 35% are thermosyphoning. It is expected that passive water heating systems will enjoy the same market penetration for many of the other "sun-belt" states as well.

It is expected that the domestic hot water market will continue to thrive despite uncertain energy prices and threatening termination of tax credits. However, according to one industry spokesperson, until the American public becomes more familiar with solar heating and cooling equipment, the marketing and sales related costs of a system will continue to account for nearly 75% of the delivered cost of the system.

ACTIVE SOLAR



Flat plate collectors, like the rooftop unit providing energy for an air conditioning system at a Florida Power & Light Co. facility, are used to collect solar energy for water heating and the space heating and cooling of buildings.



SOLAR THERMAL

TECHNOLOGY DESCRIPTION

Solar thermal energy and solar thermal electric systems convert solar radiation to thermal energy which can be used for industrial or chemical processes, or used to generate electricity. Solar thermal covers five technologies: solar ponds, hemispheric bowls, parabolic troughs, parabolic dishes, and central receivers.

Except for solar ponds, the concept is uniform: sunlight on a flat or shaped mirror is concentrated and heats a working fluid. The fluid delivers the thermal energy to the end-use or to storage.

Solar ponds are large bodies of water used to collect and store lower temperature solar energy (up to 200°F). Salt-gradient solar ponds inhibit convective heat losses by means of a density gradient (salt) which increases with depth . Shallow solar ponds are bodies of fresh water which employ a moveable surface insulating layer to minimize radiant heat losses during the night and periods of minimal solar radiation. For both technologies, the heat that is absorbed and stored is then removed and run through a heat exchanger. The large volume of water enables the system to provide thermal or electric energy at all times.

Parabolic troughs consist of a long parabolic mirror which tracks the sun in one axis and directs radiation onto a receiver tube. The tube absorbs the concentrated energy and converts it to heat (up to 750° F).

Parabolic dishes track the sun horizontally and vertically. The radiation is concentrated at a single focal point, and the thermal energy (200 - 2000° F) may be used for several application.

A central receiver system consists of a field of flat mirrors (heliostats) which track the sun horizontally and vertically to focus radiation on a tower-mounted receiver. A working fluid transfers the high temperature heat (500 - 2,500° F) to the end-use or storage.

APPLICATIONS

Solar pond applications include district heating and cooling, industrial and agricultural process heating, desalination, and electricity production.

Parabolic trough and parabolic dish systems may be used for industrial applications (hot water or steam), for building energy systems (electricity or thermal energy), and agricultural applications (heat, grain drying, irrigation pumping).

Parabolic dishes with focus-mounted heat engine-generators may also be used as intermediate sized (25 kw per dish) electric power generators singularly in remote locations or in multiple units connected to a grid.

Parabolic trough systems can be used (in large numbers) for utility scale steam generated electricity.

Central receiver systems may be used as baseload utility power plants, for enhanced oil recovery, industrial process heat, cogeneration systems, or to produce fuels and chemicals.

TECHNOLOGY STATUS

Solar Ponds Thermal uses of solar ponds are well known with on-going research conducted at unversities and some utilities. System costs range from \$5 to \$50/ft^2 and offer thermal conversion effeciencies on the order of 20-30%. The use of solar ponds (salt-gradient only) to generate electricity has received increasing attention in Israel where a 150 kw pond has been operating successfully for several years, and the completion of a 5 MW facility is expected in early 1984. Utility scale systems, using organic Rankine turbines, range from \$3,000 - \$5,000 per kilowatt installed system cost, with overall effeciencies of 2-3%.

Parabolic Troughs Market ready parabolic trough systems exist, due to an extensive series of DOE funded demonstrations. Cost and efficiency goals set by DOE have been met, and application engineering and generic research and development efforts will further improve systems and their performance. Current state of the art technology (operating at 600+ °F and 65% efficiency) can deliver solar thermal energy at \$8 per million BTU's (using federal and state incentives on a life cycle cost basis). Trough systems for power production range from \$4,000 - \$4,500 per kilowatt of installed system cost. The Department of Energy and industry have completed a series of mass-produceable design studies.

Parabolic Dish A prototype parabolic dish/Stirling engine system has achieved the highest net conversion of sunlight to electricity (26 %). Organic rankine cycle engine and brayton (hot air) engine systems are also under development. Dish technology is still using early prototype generators, however. The dish mounted Stirling engine systems range between \$10,000 - \$40,000 per kilowatt installed. Yet, one current prospectus inicates costs as low as \$4,239 per installed kilowatt for thermal collection using a single generator.

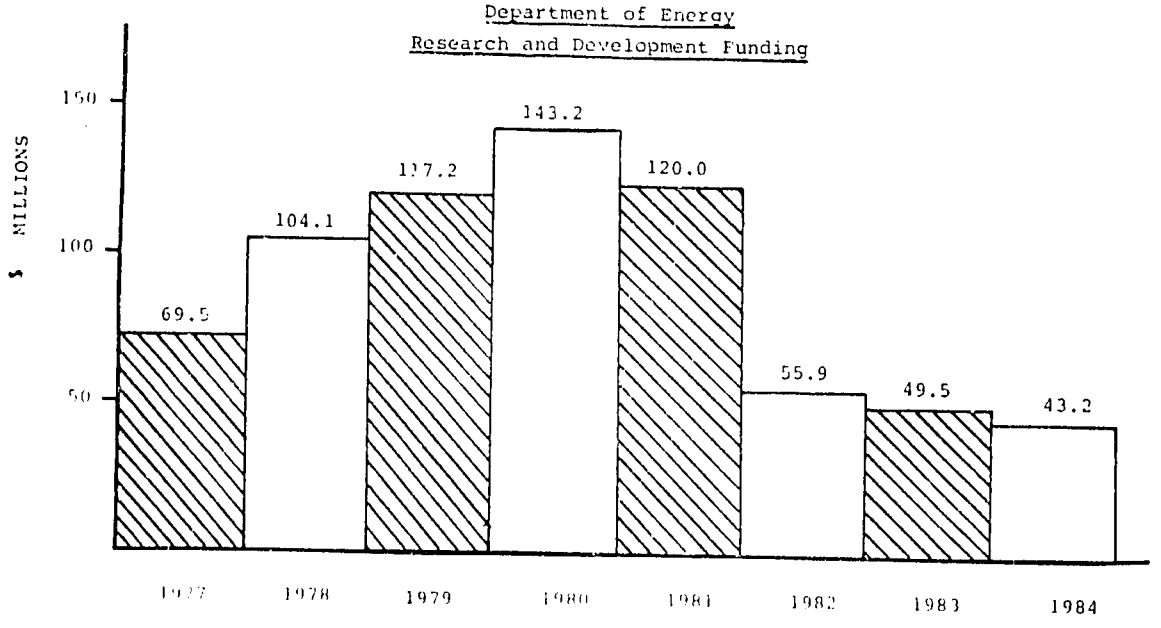
Central Receiver Central receiver technology has been successfully demonstrated at the pilot plant level by Solar One -- a 10 MW plant in California. Solar One, in its first year of operation, produced over 2 million kilowatt-hours with a conversion efficiency of approximately 22%. Because of the demonstration nature of Solar One, installed capacity costs are abnormally high. However, other design proposals indicate costs per installed kilowatt as low as \$4,000.

Analysts active in the field state that the economically viable size for central receiver systems is closer to 100 megawatts. To accomplish this scale of technology will require a significant reduction in heliostat costs from over \$250 per square meter to \$170 - \$180 per square meter. Ultimately, heliostat costs are expected to fall below \$100 per square meter. New plastic-based technology may be required, however.

Improvements in thermal efficiency and storage technology are also required for successful commercialization.

FEDERAL SUPPORT PROGRAMS

The solar thermal program at Department of Energy for FY 1984 is $43.2 million; of which $14 million is for parabolic dish research and development with a large share of the remainder devoted to central receiver development as well as generic research and development efforts (e.g. materials research) and supporting facilities. Solar pond research is carried on at a minimal level, and no commercial scale demonstration has been funded yet by the federal government.



There is a 15% federal business energy tax credit for investments in solar thermal systems. A 40% residential energy tax credit is also available, but is limited to $4,000, or 40% of a $10,000 investment. Both the business and the residential tax credits are scheduled to expire at the end of 1985.

INDUSTRY STATUS

The solar thermal industry consists of about 50 companies involved in the several technologies. They range from small high technology firms to large aerospace and petroleum companies. Production levels directly correspond to confrimed contracts. Industry, to date, has been largely dependent on federal funding for research and development. The three main segments of the industry, troughs, dishes, and central receivers, are in different commercial development stages.

Two main parabolic trough suppliers (for industrial and agricultural process heating, as well as power production) remain in business and appear to be on the verge of commercial success. Several other companies (less than 10) produce small-scale parabolic trough systems, primarily for commercial and institutional hot water requirements.

The parabolic dish industry (devoted to electric or total energy systems) is the least advanced commercially, and highly dependent on continued government research and development efforts.

The central receiver companies dominate the solar thermal industry and face the most complicated problems regarding commercialization. Large government support stopped before a commercial scale plant was built. It is not clear whether the risk and cost of financing a large scale central receiver plant(s) will be too high for the private sector to handle without federal assistance.

The interest of several utility companies has led to several important commercial-scale plant initiatives, but the transistion from a 10 MW pilot plant to a commercial scale plant is proving to be a difficult one.

Currently, there exists no domestic industry for the development of solar pond technologies. However, an Israeli firm has sucessfully commercialized a utility scale system.

MARKET STATUS

Solar Ponds By the close of 1983, project designs were approved for the first U.S. salt-gradient solar pond power project. A 12 MW installation is currently under construction at Danby Dry Lake in California. This represents the first stage of a planned 48 MW facility which, upon completion, will cover 144 acres in the southern Mojave Desert. Solar pond systems are particularly appealing to utility applications because their large integral storage capacity allows them to be used for base-load power production.

Parabolic Dish A third-party financed parabolic dish project, located in Warren Springs, California is currently under construction which when completed will incorporate 700 dishes and produce 4.4 MW.

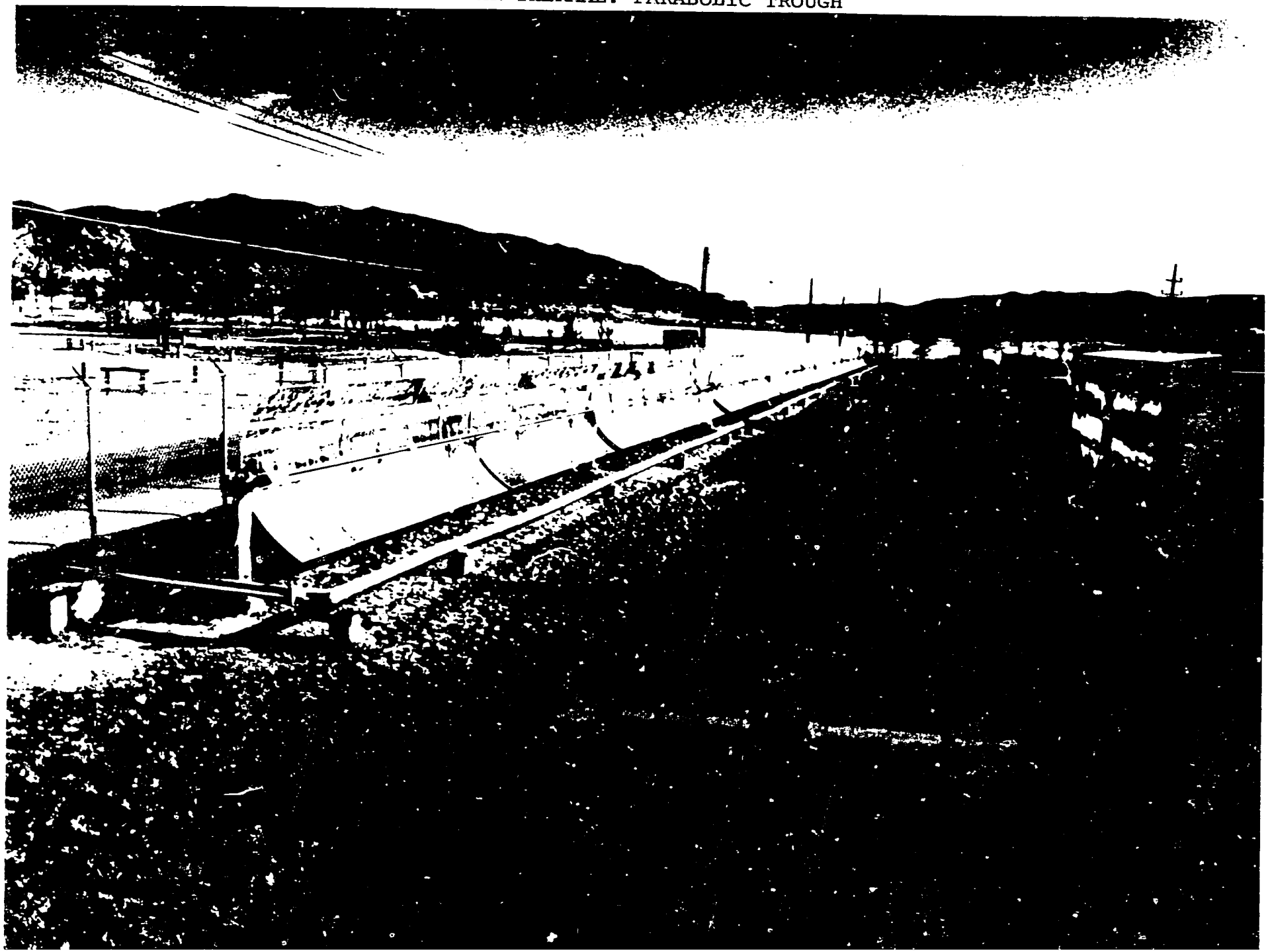
Parabolic Trough This sector of the industry is in transition from a posture in which the government was its main customer (over 2 million square feet installed) to a small level of commercial sales ($2 - $4 million per year). The industry may be on the verge of selling privately funded industrial process heat systems, but the market appears limited to only 2 to 3 such projects a year. A 60,000 square foot parabolic trough system was completed in Arizona, and the first stage of 771,000 square foot (13.8 MW) system began construction in southern California in 1983.

The central receiver industry is attempting to bridge the gap between a successful 10 MW pilot plant project and a 100 MW commercially viable plant. This industry believes it needs 500 MW of projects to ensure a smooth start up and industry commitment.

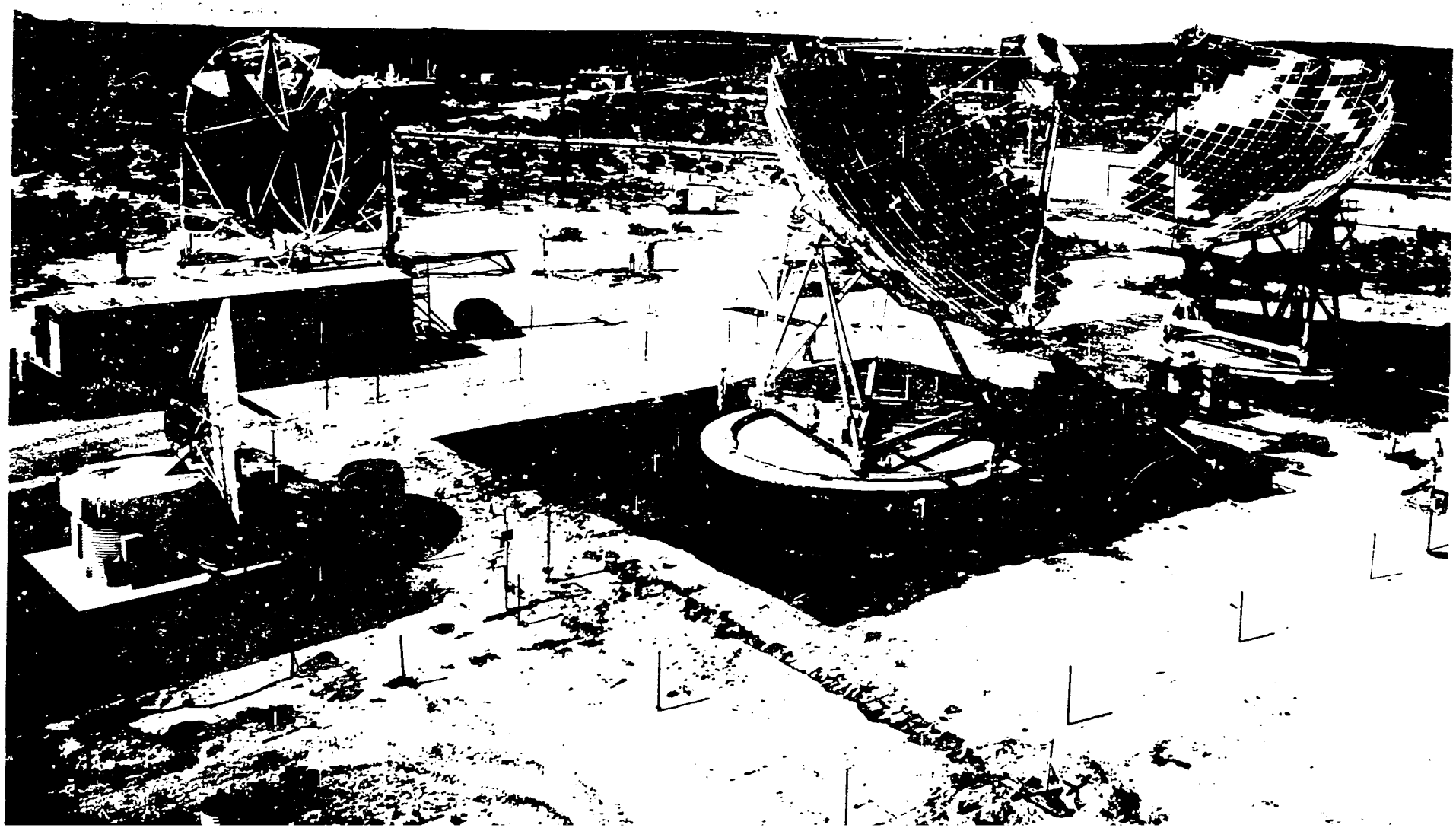
One utility is negotiating with the Public Utilities Commission and vendors to realize a 100 MW plant financed by third party investors. Of four repowering plant design projects funded by DOE and industry, two utility scale projects could evolve (30 MW and 60 MW, respectively). A second utility has tentatively forecast four 100 MW plants.

At present, no firm sales commitments exist for the commercial scale plant or plants needed to open the large scale solar thermal market. Early market penetration should come in the utility sector, although the largest market is likely to be industrial process heat and fuels and chemicals production. This industry's success remains dependent on continued research and development efforts as well as continued ecomnomic incentives.

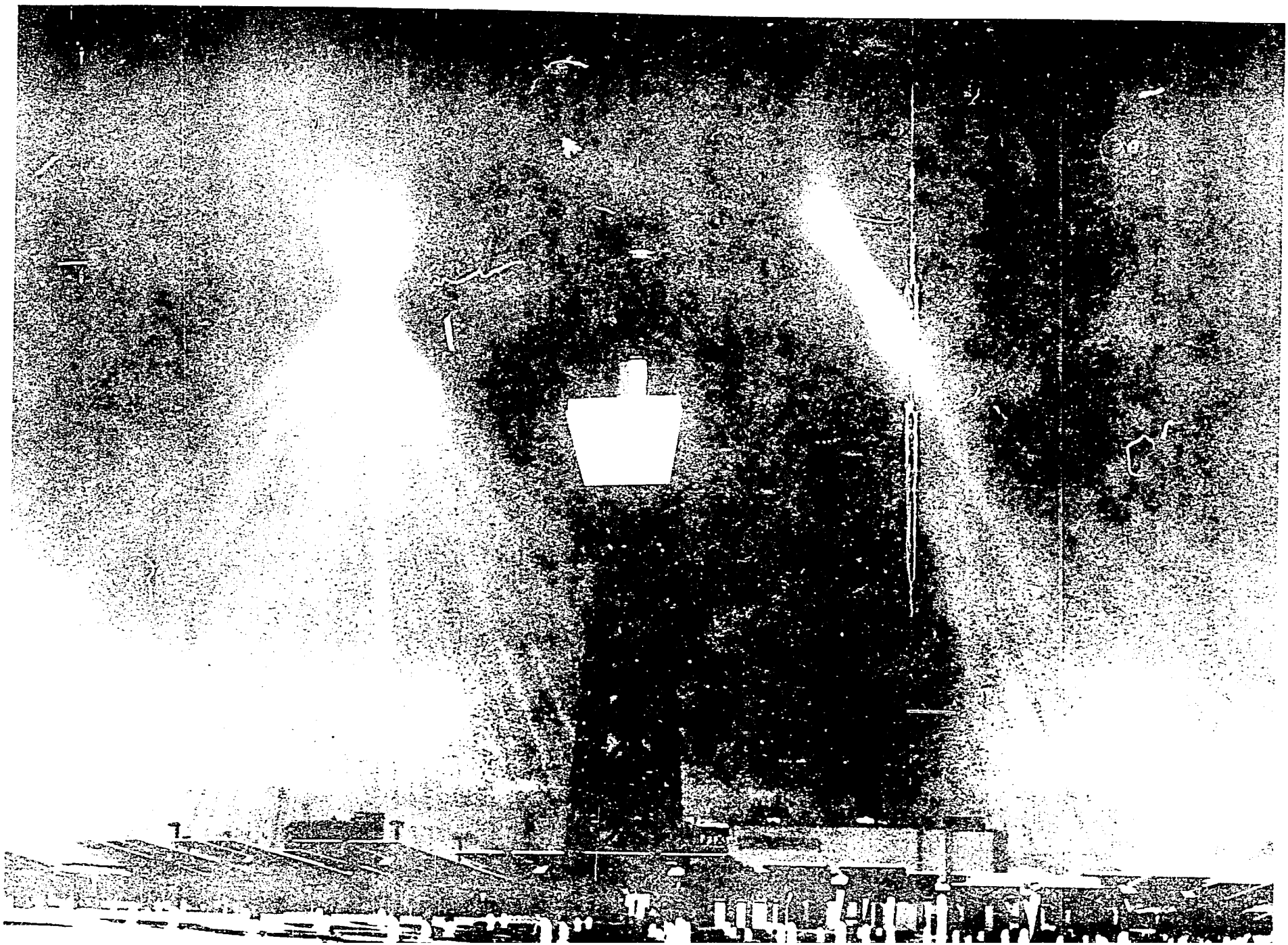
SOLAR THERMAL: PARABOLIC TROUGH



SOLAR THERMAL: PARABOLIC DISH



SOLAR THERMAL: CENTRAL RECEIVER POWER PLANT



WIND ENERGY

TECHNOLOGY DESCRIPTION

Wind energy systems convert the kinetic energy in the wind, which is caused primarily by unequal heating of the earth's surface by the sun, into more useful forms of energy such as electricity, heat and mechanical power.

This conversion is accomplished by using a rotating mechanism mounted on a tower which is driven by the wind and which turns a shaft.

Direct heat systems use the shaft power to agitate water or other fluids and thereby produce heat. They have not advanced beyond the prototype stage to date.

Mechanical systems use the shaft power directly, normally to pump water for irrigation or other purposes.

Electrical systems use the shaft power to run a generator or alternator which produces electricity. A variety of equipment configurations exists to ensure that the electricity produced is usable either by the utility grid or by electrical appliances.

Both electrical and mechanical systems can be further subdivided into horizontal-axis and vertical-axis systems.

APPLICATIONS

Mechanical systems may be used for a number of applications, but water pumping is by far the most common.

Electrical systems are quite flexible, with applications being mainly a function of size:

- Very small systems (1-2 kw or less) may be used for remote applications such as the powering of navigational equipment, cathodic pipeline protection, telecommunications relays, or to charge batteries on sailboats.

- Residential/agricultural-size systems (3-40 kw) may be used for agricultural applications (heat, grain drying, irrigation pumping) or to supply household electrical needs (including resistance heating), with excess energy being sold to a utility.

- Windfarm/utility-size systems (15 kw and over) may be used as electric power generators, singularly on remote locations or in multiple units connected to a grid.

TECHNOLOGY STATUS

Mechanical wind systems have been in use for thousands of years for pumping water and grinding grain. Water-pumpers have been sold commercially in the U.S. since the 1850's, and are still being sold by several companies today. The technology is well-understood and well-proven.

Market-ready wind electric systems exist in sizes ranging from under 1 kw to 4 MW, having been developed both within the DOE program and independently. Both horizontal-axis and vertical-axis systems are commercially available, with horizontal-axis designs predominating.

Trends in wind energy conversion systems (WECS) design include the use of 2 or 3 blades made from fiberglass, wood laminate, or fiberglass reinforced plastic.

Thousands of wind electric systems are currently operating and producing power, both in individual residential/agricultural and windfarm applications.

Initial problems with reliability in the residential/agricultural size range appear to have been largely overcome, at least by the major manufacturers in the field. Current applications in this sector include the use of taller (greater than 80 feet) towers.

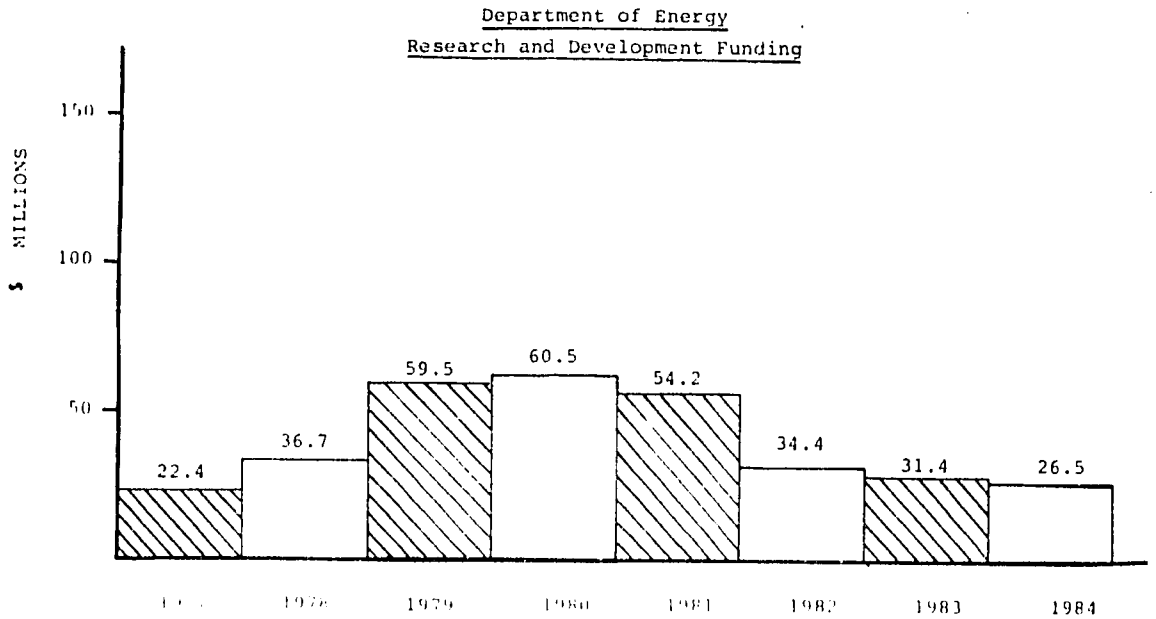
Windfarm/utility size systems, for the most part, are in a somewhat earlier phase of technical development. Some operating experience has been gained, mostly under the DOE program, with systems 200 kw in size and larger, but commercial sales in this size range are still limited to a handful. The size, engineering capability and experience of firms in the windfarm/utility sector vary widely, however, making generalizations difficult.

The unsubsidized cost of electricity from state-of-the-art residential/agricultural systems is moving into the 15 cents per kilowatt hour (kwh) range, down from about 20 cents/kwh two years ago, even though systems are still being manufactured on a production basis of 30/month or fewer. The unsubsidized cost of electricity from windfarm/utility scale machines is currently estimated at 7-12 cents/kwh.

FEDERAL SUPPORT PROGRAMS

The Department of Energy's budget for Wind Power support in FY 1984 is $26.5 million. The current emphasis of DOE's research and development efforts are to proceed in aerodynamics research on large wind systems and Darrieus vertical axis wind turbines, and on research aimed at overcoming structural fatigue resulting form high cyclical loads and amplified dynamic stress.

Most (about 60% in FY 1984) government support for wind is currently directed at completion of the MOD-5, an advanced multi-megawatt system being introduced by two contractors under parellel contracts for DOE and intended for the utility market. However, since one of the contractors has announced its decision not to continue in the program, the government's effort is expected to shift to a more broadly-based approach to technology development.



A 15% federal business energy tax credit is available for investments in wind energy systems. A 40% residential energy tax credit is also available, but is limited to $4,000, or 40% of a $10,000 investment. Both the business and residential tax credits are scheduled to expire at the end of 1985.

INDUSTRY STATUS

The domestic market for mechanical wind systems is dominated by three firms which have been in business for many years. Its business environment is generally stable.

Some 50-75 companies are currently manufacturing or developing wind electric systems in the U.S. The few larger, Fortune 500, firms in the industry are aiming their interests at the utility market with systems of 500 kw in size or larger.

The balance of the industry, both residential/agricultural and windfarm/utility consists almost exclusively of small companies manufacturing only wind turbines, although a few of these have attracted financial backing from major companies.

Most manufacturers are making machines for the residential/agricultural market. A number of new firms, however, have entered the windfarm/utility market, and that segment of the industry is growing rapidly. Since there is little operating experience to date with windfarms and, in some cases, with the companies' turbine designs, a shakedown period of accumulating experience and changing designs is likely.

Accompanying the explosive growth in the wind farm/utility market is the tendency toward vertical integration. That is, more firms are engaging themselves in system manufacturing, project development, as well as being responsible for the operation and maintenance (O&M) of the project.

MARKET STATUS

Systems of all sizes are being sold and installed at this time.

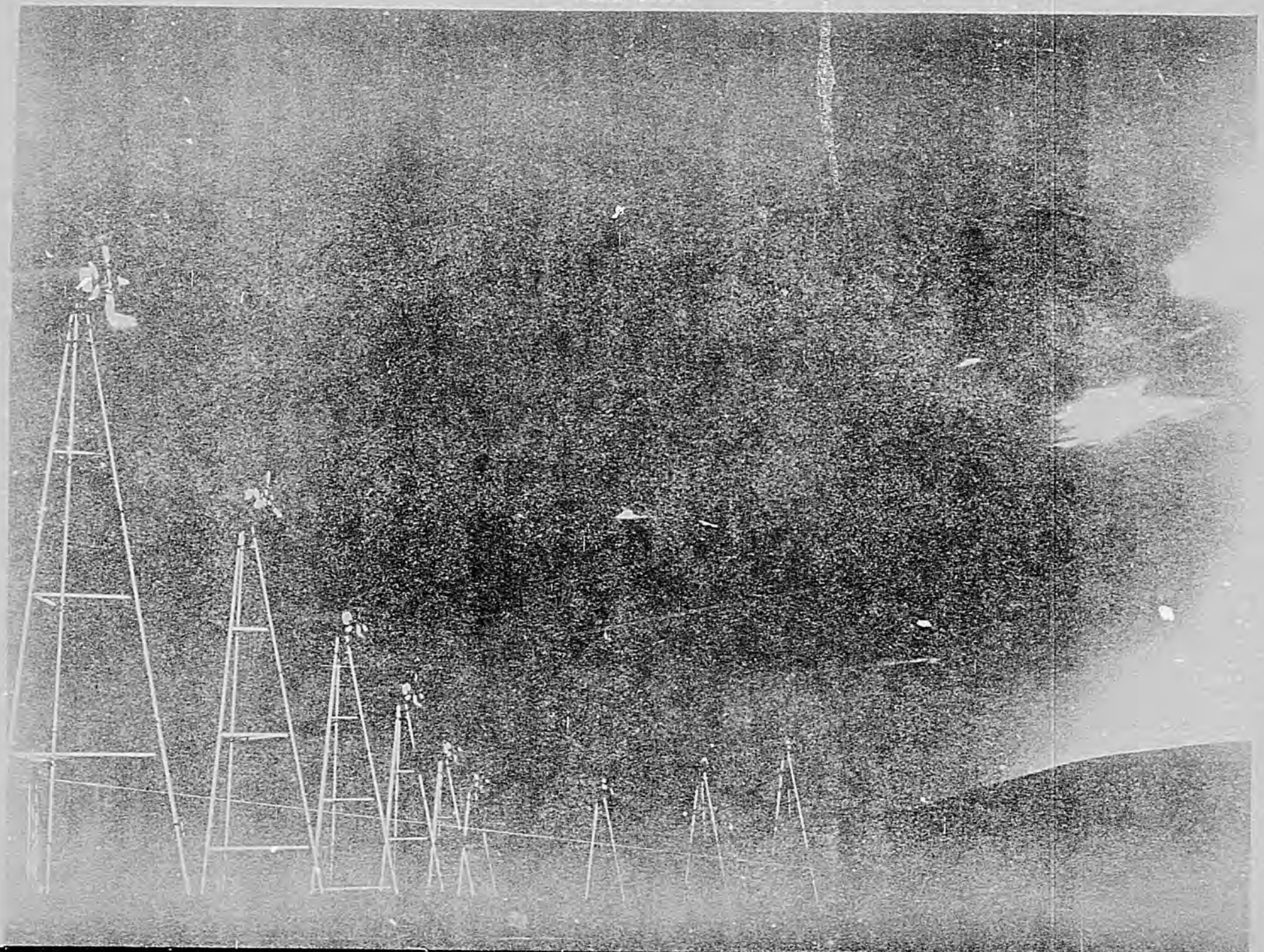
In 1982, about 1,500 systems, averaging about 3 kw in size, were sold in the residential/agricultural market. In 1983 this figure grew to approximately 1,700 systems installed. Altogether, about 18 MW of cumulative capacity are in place in the residential/ agricultural market. Initial equipment reliability problems appear to have been overcome -- more manufacturers are beginning to market systems nationwide, indicating greater confidence in equipment. Greater sales volume is needed, however, to bring prices down.

The windfarm/utility segment is growing rapidly on a tax-shelter-driven basis, with 50 MW installed nationally in 1982, 195 MW in 1983 and an additional 500 MW anticipated to come on line during 1984. Its dependence on tax incentives has meant high sensitivity to proposed tax, depreciation and regulatory changes, and an uneven pattern of sales.

The recent growth in the wind farm/utility segment of the market has attracted a number of Dutch, Danish and other Western European firms, who in 1983 captured 15% of this market.

Although an industrial/commercial market for wind systems also presently exists, little has been done to define or exploit it to date.

WIND FARM



Public Utility Regulatory Policies Act of 1978

(PURPA)

Title II: Sections 201 and 210

Title II—Certain Federal Energy Regulatory Commission and Department of Energy Authorities

Sec. 201. Definitions.

Section 3 of the Federal Power Act is amended by inserting the following before the period at the end thereof:

"(17)(A) 'small power production facility' means a facility which

"(i) produces electric energy solely by the use, as a primary energy source, of biomass, waste, renewable resources, or any combination thereof, and

"(ii) 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;

"(B) 'primary energy source' means the fuel or fuels used for the generation of electric energy, except that such term does not include, as determined under rules prescribed by the Commission, in consultation with the Secretary of Energy—

"(i) the minimum amounts of fuel required for ignition, startup, testing, flame stabilization, and control uses, and

"(ii) the minimum amounts of fuel required to alleviate or prevent—

"(I) unanticipated equipment outages, and

"(II) emergencies, directly affecting the public health, safety, or welfare, which would result from electric power outages,

"(C) 'qualifying small power production facility' means a small power production facility—

"(i) which the Commission determines, by rule, meets such requirements (including requirements respecting fuel use, fuel efficiency, and reliability) as the Commission may, by rule, prescribe; and

"(ii) which is owned by a person not primarily engaged in the generation or sale of electric power (other than electric power solely from cogeneration facilities or small power production facilities);

"(D) 'qualifying small power producer' means the owner or operator of a qualifying small power production facility;

"(18)(A) 'cogeneration facility' means a facility which produces—

"(i) electric energy, and

"(ii) steam or forms of useful energy (such as heat) which are used for industrial, commercial, heating, or cooling purposes;

"(B) 'qualifying cogeneration facility' means a cogeneration facility which—

"(i) the Commission determines, by rule, meets such requirements (including requirements respecting minimum size, fuel use, and fuel efficiency) as the Commission may, by rule, prescribe, and

"(ii) is owned by a person not primarily engaged in the generation or sale of electric power (other than electric power solely from cogeneration facilities or small power production facilities);

"(C) 'qualifying operator' means the owner or operator of a qualifying cogeneration facility.

"(19) 'Federal power marketing agency' means any agency or instrumentality of the United States (other than the Tennessee Valley Authority) which sells electric energy.

"(20) 'evidentiary hearing' and 'evidentiary proceeding' mean a proceeding conducted as provided in sections 554, 556, and 557 of title 5, United States Code;

"(21) 'State regulatory authority' has the same meaning as the term 'State commission,'

except that in the case of an electric utility with respect to which the Tennessee Valley Authority has ratemaking authority (as defined in section 3 of the Public Utility Regulatory Policies Act of 1978), such term means the Tennessee Valley Authority;

"(22) 'electric utility' means any person or State agency which sells electric energy; such term includes the Tennessee Valley Authority, but does not include any Federal power marketing agency."

Sec. 210. Cogeneration and Small Power Production.

"(a) Cogeneration and Small Power Production Rules.—Not later than 1 year after the date of enactment of this Act, the Commission shall prescribe, and from time to time thereafter revise, such rules as it determines necessary to encourage cogeneration and small power production which rules require electric utilities to offer to—

(1) sell electric energy to qualifying cogeneration facilities and qualifying small power production facilities and

(2) purchase electric energy from such facilities.

Such rules shall be prescribed, after consultation with representatives of Federal and State regulatory agencies having ratemaking authority for electric utilities, and after public notice and a reasonable opportunity for interested persons (including State and Federal agencies) to submit oral as well as written data, views, and arguments. Such rules shall include provisions respecting minimum reliability of qualifying cogeneration facilities and qualifying small power production facilities (including reliability of such facilities during emergencies) and rules respecting reliability of electric energy service to be available to such facilities from electric utilities during emergencies. Such rules may not authorize a qualifying cogeneration facility or qualifying small power production facility to make any sale for purposes other than resale.

(b) Rates for Purchase by Electric Utilities.—The rules prescribed under subsection (a) shall insure that, in requiring any electric utility to offer to purchase electric energy from any qualifying cogeneration facility or qualifying small power production facility, the rates for such purchase—

(1) shall be just and reasonable to the electric consumers of the electric utility and in the public interest, and

(2) shall not discriminate against qualifying cogenerators or qualifying small power producers.

No such rule prescribed under subsection (a) shall provide for a rate which exceeds the incremental cost to the electric utility of alternative electric energy.

(c) Rates for Sales by Utilities.—The rules prescribed under subsection (a) shall insure that, in requiring any electric utility to offer to sell electric energy to any qualifying cogeneration facility or qualifying small power production facility, the rates for such sale—

(1) shall be just and reasonable and in the public interest, and

(2) shall not discriminate against the qualifying cogenerators or qualifying small power producers.

(d) Definition.—For purposes of this section, the term "incremental cost of alternative electric energy" means, with respect to electric energy purchased from a qualifying cogenerator or qualifying small power producer, the cost to the electric utility of the electric energy which,

but for the purchase from such cogenerator or small power producer, such utility would generate or purchase from another source.

(e) Exemptions.—(1) Not later than 1 year after the date of enactment of this Act and from time to time thereafter, the Commission shall, after consultation with representatives of State regulatory authorities, electric utilities, owners of cogeneration facilities and owners of small power production facilities, and after public notice and a reasonable opportunity for interested persons (including State and Federal agencies) to submit oral as well as written data, views, and arguments, prescribe rules under which qualifying cogeneration facilities and qualifying small power production facilities are exempted in whole or part from the Federal Power Act, from the Public Utility Holding Company Act, from State laws and regulations respecting the rates, or respecting the financial or organizational regulation, of electric utilities, or from any combination of the foregoing, if the Commission determines such exemption is necessary to encourage cogeneration and small power production.

(2) No qualifying small power production facility which has a power production capacity which, together with any other facilities located at the same site (as determined by the Commission), exceeds 30 megawatts may be exempted unaer rules under paragraph (1) from any provision of law or regulation referred to in paragraph (1), except that any qualifying small power production facility which produces electric energy sotely by the use of biomass as a primary energy source may be exempted by the Commission under such rules from the Public Utility Holding Company Act and from State laws and regulations referred to in such paragraph (1).

(3) No qualifying small power production facility or qualifying cogeneration facility may be exempted under this subsection from—

(A) any State law or regulation in effect in a State pursuant to subsection (f),

(B) the provisions of section 210, 211, or 212 of the Federal Power Act or the necessary authorities for enforcement of any such provision under the Federal Power Act, or

(C) any license or permit requirement under part I of the Federal Power Act, any provision under such Act related to such a license or permit requirement, or the necessary authorities for enforcement of any such requirement.

(f) Implementation of Rules for Qualifying Cogeneration and Qualifying Small Power Production Facilities.—(1) Beginning on or before the date one year after any rule is prescribed by the Commission under subsection (a) or revised under such subsection, each State regulatory authority shall, after notice and opportunity for public hearing, implement such rule (or revised rule—for each electric utility for which it has ratemaking authority.

Small Qualifying, Power Production Facilities.—(1) Beginning on or before the date one year after any rule is prescribed by the Commission under subsection (a) or revised under such subsection, each State regulatory authority shall, after notice and opportunity for public hearing, implement such rule (or revised rule) for each electric facility for which it has ratemaking authority.

(2) Beginning on or before the date one year after any rule is prescribed by the Commission under subsection (a) or revised under such subsection, each nonregulated electric utility

shall, after notice and opportunity for public hearing, implement such rule (or revised rule).

(g) Judicial Review and Enforcement.—(1) Judicial review may be obtained respecting any proceeding conducted by a State regulatory authority or nonregulated, electric utility for purposes of implementing any requirement of a rule under subsection (a) in the same manner, and under the same requirements, as judicial review may be obtained under section 123 in the case of a proceeding to which section 123 applies.

(2) Any person (including the Secretary) may bring an action against any electric utility, qualifying small power producer, or qualifying cogenerator to enforce any requirement established by a State regulatory authority or nonregulated electric utility pursuant to subsection (f). Any such action shall be brought only in the manner, and under the requirements, as provided under section 123 with respect to an action to which section 123 applies.

(h) Commission Enforcement.—(1) For purposes of enforcement of any rule prescribed by the Commission under subsection (a) with respect to any operations of an electric utility, a qualifying cogeneration facility or a qualifying small power production facility which are subject to the jurisdiction of the Commission under part II of the Federal Power Act, such rule shall be treated as a rule under the Federal Power Act. Nothing in subsection (g) shall apply to so much of the operations of an electric utility, a qualifying cogeneration facility or a qualifying small power production facility as are subject to the jurisdiction of the Commission under part II of the Federal Power Act.

(2)(A) The Commission may enforce the requirements of subsection (f) against any State regulatory authority or nonregulated electric utility. For purposes of any such enforcement, the requirements of subsection (f)(1) shall be treated as a rule enforceable under the Federal Power Act. For purposes of any such action, a State regulatory authority or nonregulated electric utility shall be treated as a person within the meaning of the Federal Power Act. No enforcement action may be brought by the Commission under this section other than—

(i) an action against the State regulatory authority or nonregulated electric utility for failure to comply with the requirements of subsection (f) or

(ii) an action under paragraph (1)

(B) Any electric utility, qualifying cogenerator, or qualifying small power producer may petition the Commission to enforce the requirements of subsection (f) as provided in subparagraph (A) of this paragraph. If the Commission does not initiate an enforcement action under subparagraph (A) against a State regulatory authority or nonregulated electric utility within 60 days following the date on which a petition is filed under this subparagraph with respect to such authority, the petitioner may bring an action in the appropriate United States district court to require such State regulatory authority or nonregulated electric utility to comply with such requirements, and such court may issue such injunctive or other relief as may be appropriate. The Commission may intervene as a matter of right in any such action.

(i) Federal Contracts.—No contract between a Federal agency and any electric utility for the sale of electric energy by such Federal agency for resale which is entered into after the date of the enactment of this Act may contain any provision which will have the effect of preventing the implementation of any rule under this section with respect to such utility. Any provision in any such contract which has such effect shall be null and void.

(j) Definitions.—For purposes of this section, the terms "small power production facility," "qualifying small power production facility," "qualifying small power producer," "primary energy source," "cogeneration facility," "qualifying cogeneration facility," and "qualifying cogenerator" have the respective meanings provided for such terms under section 3(17) and (18) of the Federal Power Act.

Amendments to Federal Power Act and Public Utility Regulatory Policies Act

Sec. 643. (a) The Federal Power Act is amended—

(1) by inserting "geothermal resources," after "renewable resources," in section 3(17)(A)(1);

(2) by inserting "geothermal power producer (including a producer which is not an electric utility)," after "Federal power marketing agency," in section 210(a)(1); and

(3) by striking out "Any electric utility" at the beginning of section 211(a) and inserting in lieu thereof "Any electric utility, geothermal power producer (including a producer which is not an electric utility)."

(b) Section 210 of the Public Utility Regulatory Policies Act of 1978 (Public Law 95-617 is amended—

(1) by inserting ", and to encourage geothermal small power production facilities of not more than 80 megawatts capacity," after "to encourage cogeneration and small power production" in the first sentence of subsection (a),

(2) by striking out "qualifying cogeneration facilities" in subsection (e)(1) and inserting in lieu thereof "geothermal small power production facilities of not more than 80 megawatts capacity, qualifying cogeneration facilities,"; and

(3) by inserting ", or 80 megawatts for a qualifying small power production facility using geothermal energy as the primary energy source," after "30 megawatts" in subsection (e)(2).

Regulations

Sec. 644. All regulations made with respect to this subtitle shall be promulgated not later than six months after the date of the enactment of this Act.

GLOSSARY OF TERMS

ACRS (Accelerated Cost Recovery System) - The Economic Recovery Tax Act of 1981 generally replaced the class life ADR System of depreciation for property placed in service after 1980 with ACRS. Under ACRS most renewable energy property other than that owned by regulated utilities, can be depreciated over five years.

Active System - A solar heating or cooling system that requires external mechanical power to move the collected heat.

Anaerobic Digestion - A type of bacterial degradation of organic matter which occurs only in the absence of air (oxygen).

ASHRAE - The American Society of Heating, Air-conditioning and Refrigerating Engineers.

Avoided Cost - The costs a utility avoids because of the power contributed by small producers and cogenerators, including savings on fuel and postponed or cancelled construction; required by federal law to be the basis for rates that utilities pay for electricity they buy back from small producers and cogenerators.

Base Rates - User rates designed to recover the cost of providing electric service, excluding costs recoverable through adjustment clauses.

Binary (heat exchange) system - Electrical generating system in which geothermal energy heats a working fluid (with a low boiling point) to power turbines.

Biogas (also Gobar gas, Marsh gas) - The fuel gas product of anaerobic digestion, predominantly methane (CH_4) and carbon dioxide (CO_2).

Biomass - Any material derived from growing organisms such as agricultural products and residues, trees, wood and bark residues, animal manure and algae.

Calorie - A unit of heat (metric measure); the amount of energy equivalent to that needed to raise the temperature of one gram of water 1°C. One calorie is approximately equal to 4 Btu's. (British Thermal limits = energy to raise one pound of water 1°)

Capacity Credit - payment from a utility to an independent energy system owner, based on the system's ability to reduce the utility's need for generating capacity.

Capacity Value - Market value of power which is assigned to dependable capacity.

Cellulose - Long chains of sugar molecules which are not digestible by humans or non-ruminant animals.

Central Power - The generation of electricity in large power plants with distribution through a network of transmission lines (grid) for sale to a number of users. Opposite of distributed power.

Central Receiver - One of three principal types of concentrating solar thermal power systems which consists of a field of tracking mirrors which intercept and redirect sunlight to a centrally located receiver mounted on top of a tower.

Cogeneration - Process which either uses power plant waste heat to satisfy industrial heat requirements, or uses industrial waste heat for the steam generation of electricity.

Combustion - The energy (heat) releasing, burning process occurring when oxygen combines with energy-rich organic compounds (e.g., wood, food, peat) and results predominantly in carbon dioxide (CO_2) and water.

Concentrator - Any of several solar collectors that use mirrored surfaces or lenses to contentrate solar radiation on a smaller area.

CWIP - Construction work in progress, is the balance of work orders for a utility plant in process of construction but not yet placed in service.

Distributed Power - Generic term for any power supply located near the point where the power is used. Opposite of central power. (also Decentralized)

Economic Resource Zone - Proposed zone of ocean space in which the adjacent coastal state would possess exclusive rights with respect to living and non-living ocean resources.

EPRI - The Electric Power Research Institute, Palo Alto, California; the research arm of the electric utilities in the United States.

FERC - The Federal Energy Regulatory Commission; federal agency in the Department of Energy which licenses non-federal hydropower projects and regulates interstate transfer of electricity. Formerly the Federal Power Commission (FPC).

Flash System - Electrical-generating system in which high temperature geothermal fluids under pressure rapidly vaporize at atmospheric pressure to power turbines.

Flat-plate Collector - A solar collection device in which sunlight is converted to heat on a plane surface, without the aid of reflecting surfaces to concentrate the rays.

Firm Power - Reliable power with assured availability; producers of firm power receive higher payments from a utility than producers of intermittent power.

Fuel Cells - A battery-like apparatus for converting a chemical fuel (e.g., hydrogen and oxygen gases together) to electrical current.

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Generator - Machine which converts mechanical energy into electric energy.

Gigawatt (GW) - Power unit equal to 1,000 megawatts, 1 million kilowatts, or 1 billion watts.

Greenhouse Effect - An increase in the earth's temperature due to the insulating effect of gases (CO_2) or particles (dust) in the atmosphere.

Grid - The utility network for transmission and distribution of electricity. Small power producers and cogenerators that use utility power as back-up or feed excess electricity into the grid are called "grid connected" or "grid-parallel".

Heat Exchanger - Device consisting of a long coil of metal pipe or a multifinned radiator, used to transfer heat from one fluid inside it to another outside it, without bringing the two fluids into direct contact.

Heliostat - Planer mirror (two axis tracking) used in central receiver power system to focus solar radiation on the receiver

Hybrid System - solar heating system that combines active and passive techniques.

Hydrocarbon - A chemical compound containing hydrogen, oxygen, and carbon. Generic term for fossil fuels.

Hydrothermal Reservoir - A subsurface system containing geothermally heated fluids. If dry steam is produced (as at The Geysers in California), the reservoir is characterized as vapor-dominated; if steam and hot water are produced, the reservoir is liquid-dominated.

Indirect System - A solar heating or cooling system in which the solar heat is collected exterior to the building and transferred inside using ducts or piping and, usually, fans or pumps.

Interconnect - Physical linkage of one electric system to another system, by a customer or other user.

Inverter - A device for converting direct current to alternating current.

Kilowatt (KW) - A unit of power equal to 1,000 watts, or to energy consumption at a rate of 1,000 joules per second.

Kilowatt-hour - The unit of energy equal to that expended in one hour at a rate of 1 kilowatt.

Leverage - The ratio of debt to total capital. The larger the debt ratio, the greater the leverage.

Life-cycle Costing - An estimating method in which the long-term costs such as energy consumption, maintenance, and repair can be included in the comparison of several system alternatives.

Load - Electric power being consumed at any given moment. The load that a utility must carry varies greatly with time of day and to some extent with season of the year. Also, in an electrical circuit, any device or appliance that is using power.

Maintenance Power - Energy or capacity supplied by a utility during scheduled outages of a cogenerator or small power producer, presumably scheduled when the utility's other load is low.

Marginal Cost - The cost of one additional unit within a group of like units.

Megawatt (MW) - The unit of power by which the capacity of utility-scale production of electricity is usually measured. A megawatt is 1 million watts or 1000 kilowatts.

Methane - A colorless odorless flammable gaseous hydrocarbon that is a product of decomposition of organic matter in marshes or mines or of the carbonization of coal. It is used as a fuel and as a raw material in chemical synthesis.

Negative Load - A technique by which utility system controllers subtract the power supplied to the grid by customer-operated generating equipment from the overall system demand and dispatch the utility's generating units to meet the remainder of the demand, rather than dispatching customers' equipment.

Nitrogen Fixation - The chemical or biological process by which inert nitrogen gas is complexed into a more reactive form, (e.g., as with hydrogen).

Ocean Thermal Gradient - Difference in temperature of the ocean water at various depths.

OTEC - Ocean Thermal Energy Conversion. OTEC plants use the differential temperatures of surface and deep waters to generate electricity (see fact sheet).

Ozone - A molecule of three oxygen atoms (O_3) whose presence in the earth's atmosphere results in the absorption of potentially damaging (mutagenci) ultraviolet sunlight.

Passive System - A solar heating or cooling system that uses no external mechanical power to collect and distribute solar heat. (see fact sheet).

Peak Load - Maximum load, produced or consumed, in a stated period of time.

Peak Watt - The maximum power produced by a photovoltaic device under optimum radiation conditions.

Photosynthesis - The green plant (plus some bacteria) mediated conversion of light energy to chemical energy (ultimately sugar).

Photovoltaic Cells - Semi-conductor devices that convert solar energy into electricity. (see fact sheet)

Power Coefficient - The ratio of power extracted by a wind machine to total power available; a measure of the efficiency of the machine.

Power Conditioning - Changing the characteristics of electrical power; for example, from DC to AC, or from 12 volts to 32 volts.

Preliminary permit - Permit issued by the Federal Energy Regulatory Commission (FERC) allowing a prospective developer up to 3 years to study the feasibility of a proposed hydroelectric project.

Pumped Storage Plant - A hydroelectric powerplant which generates energy for peak load use by using water pumped to a storage reservoir during off-peak hours.

Purchase Power - Customer-generated electricity supplied to the grid and purchased by a utility.

PURPA - Public Utility Regulatory Policies Act of 1978. PURPA is, among other things, intended to encourage renewable energy power production by non-utility small power producers. (see fact sheet).

Quad - One quadrillion (10^{15}) Btu's, equivalent to 180 million barrels of oil. Current U.S. energy consumption is about 78 quads/year.

Qualifying Facility - A cogenerator or small power producer that meets the requirements specified in PURPA. Qualifying small power producers must be within specified megawattage size limits.

Radiation - The flow of energy across open space via electromagnetic waves, such as visible light.

Rankine Cycle - The thermodynamic cycle which describes the operating cycle of an actual steam engine.

Rate Base - The value established by a regulatory authority upon which a utility is permitted to earn a specified rate of return. The largest part is electric plant in service.

Rate Structure or Rate Schedule - A utility's approved schedule of charges for billing utility service rendered to various classes of its customers.

SERI - The Solar Energy Research Institute at Golden (Denver), Colorado. Established by Congress in 1974 (Solar Energy Research, Development, and Demonstration Act) to lead the nation's solar energy research and development program.

Small Power Producer - Non-utility producers of power from renewable resources. Small power production within specified megawattage size limitations can qualify for regulatory and price incentives under PURPA.

Space Conditioning - Heating or cooling residential or commercial buildings for human comfort.

Stand-Alone - An isolated photovoltaic system not connected to a grid; may or may not have storage, but most stand-alone aplications require battery or other form of storage.

SWECS - "Small Wind Energy Conversion System"; a wind system whose maximum output is less than 100 kw.

Watt - Unit of power produced by an electric current of one amp acting in a potential of one volt.

Waste Heat - Thermal energy that is exhausted rather than being captured and used.

Wheeling - Transmission of electric energy from one electric system, across second system, for distribution in a third electric system.

Wind Farm - A collection of several wind machines at the same location.

Wind Generator - a wind machine that converts wind power into electric power.