Chapter IV

PROGRAM REVIEW

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The program efforts of the Department of Energy (DOE) are the vehicles for translating legislation and administration goals into real world actions. This chapter contains issues, comments, and questions pertaining specifically to program operation and decisionmaking. It is not an exhaustive list, but includes areas of immediate importance and areas that should be considered for continuing review. The issues are grouped by technologies (solar electric, biomass) and by end-use function (transportation, buildings, and industrial conservation).

Solar Electric Applications

The major solar technologies being developed specifically to produce electricity are wind, photovoltaics, solar thermal power, and ocean thermal energy conversion (OTEC). Some hybrid systems also produce mechanical or thermal energy or both. The contribution to the maximum practical scenario for the year **2000** of the Domestic Policy Review (DPR) from these technologies is 3.2 Quads.

Both wind and photovoltaics systems are currently being sold for commercial applications on a limited basis. These two technologies account for **2.7** of the 3.2-Quad contribution for **2000.** The other two solar electric technologies, solar thermal and ocean, account for the remaining 0.5 Quad.

Direct funding for the solar electric applications program has increased from **$189.7** million in fiscal year 1978 to **$371.7** million in fiscal year 1980 (table 4). The DOE estimate of $376.5 million for fiscal year **1981** indicates decreasing support for the solar electric technologies in real dollars.

Photovoltaics and solar thermal have received the majority of the funding for fiscal years 1978-80, totaling $315.9 million and $283.9 million respectively. For the same time period, wind has received $158.4 million and ocean systems $110.4 million.

Table 4.—Budget of the Solar Electric Applications Program, Fiscal Years 1979-81 (in millions of dollars)

	FY 1979	**FY** 1980	**FY** 1981 **estimate**
Photovoltaics	**$103.8**	**$147.3**	$140.0
Wind	59.6	63.4	80.0
Solar thermal.	98.3	121,0	117.5
Oceans systems . . .	41.1	40.0	39.0
Total	$302.8	$371.7	$376.5

SOURCE *Program Summary Document,* Solar Energy, FY 1981, Department of Energy, January 1980, p 1-4

A major portion of the above funding is for large projects. The most expensive project is the 10-MW solar thermal powerplant at Barstow, Cal if., whose total estimated cost (as of July **1979)** was **$108** million ($10,800/kW). The next two most expensive projects were the OTEC-1 test facility at a cost of $33 million and the MOD-2 wind turbine project at a cost of $27.3 million.

To date, the only program-specific legislation Congress has passed concerns photovoltaic energy systems. First, the Federal Photovoltaics Utilization Program (F PUP), contained in Title V of the National Energy Conservation Policy Act (NE CPA – Public Law 95-619), established a 3-year $98 million authorization for the purchase of photovoltaics at Federal facilities.

Second, Congress passed the Solar Photovoltaics Energy Research, Development, and Demonstration Act of 1978 (SPERDD– Public Law 95-590) which had among its goals the total cumulative production of approximately 4 million peak kW of photovoltaics and the reduction of the average cost of installed solar photovoltaic energy systems to $1,000 per peak kW by 1988. The Act required DOE to form an outside advisory panel to advise the Secretary of DOE and to formulate a plan for demonstrating applications and facilitating the use of photovoltaics in other nations.

Issue 20

Wind Energy Strategy

Wind technology appears close to commercial readiness but the DOE programs don't reflect this near-term payoff.

Summary

The DOE Wind Program documents indicate that: 1) wind energy is currently competitive in specialized markets, and 2) wind energy systems currently being developed for use in 1983 should be cost competitive for wide-scale use. Increased production will probably foster more cost reductions than will improved designs, particularly for small wind machines. However, operational plans to achieve the 1985 (and later) commercialization goals are currently lacking.

Questions

1. How will DOE implement the commercialization plans?
2. Would DOE geographically distributed cooperative funding (or other cost-sharing type approaches) speed deployment on a large scale, after the current design development programs are completed? If so, is such funding contemplated?
3. What steps are being taken to ensure the deployment of wind energy conversion systems by those Federal agencies that could successfully deploy them?
4. Why has funding for implementation and market development been zeroed out for 1981 ?

Background

DOE has estimated that if wind energy conversion systems reach a cost range of 4.6 to 5.7 cents/kWh (in 1980 dollars), markets adequate to justify mass production will emerge. Moreover, an energy cost goal of 2.3 to 3.4 cents/kWh (in 1980 dollars) has been established for both small (up to 100 kW) and large (1 to 3 MW) machines. Wide-scale deployment of wind energy conversion systems will be possible if these goals are met.

DOE expects the development of both small- and large-scale wind energy conversion systems by 1983 will meet these latter goals. Further, DOE estimates that wind energy conversion systems costs are already sufficiently low to support early production quantities. The DOE estimates can be justified by recent utility interest in two high-wind areas. In California, U.S. Wind Power is negotiating the sale of twenty 50-kW machines; in Hawaii, Windfarms Ltd. has contracted to supply 80 MW of wind energy to Hawaiian Electric.

On the basis of the DOE research developments, DOE estimates that wind energy has a potential market penetration of **0.17** Quad (fossil-fuel equivalents) in **1985 (0.51** Quad in 1990, 3.04 Quads in 2000). Approximately 600 large machines and .50,000 small machines would be required to meet the 1985 goal.

Achievement of the cost goals does not ensure the attainment of the energy goals. There are barriers between the development of wind turbine designs and their acceptance for widespread application. Demonstration of machine reliability and at least several years of field experience in power production and operation and maintenance will be required to instill customer confidence. Additional uncertainties include the availability of information on wind data, systems, economics, and market identification. Operating experience will be necessary to resolve these questions.

Insufficient funding may result in these areas being inadequately addressed. DOE must determine as soon as possible, the Federal responsibility for overcoming these barriers.

Issue 21

Large v. Small Wind Systems

The steps required to achieve commercialization of large and small wind machines are different and DOE programs must recognize and accommodate these differences.

Summary

Both large and small wind machines are expected to make a substantial contribution to the Nation's energy supply in 2000. DOE has formulated commercialization plans for both small and large wind energy conversion systems. These plans indicate that the commercialization requirements and the timing may be substantially different for small and large machines. However, the organization and funding of the Wind Energy Program do not indicate that the requirements of both small and large wind machines will be adequately addressed.

Questions

1. Has DOE adequately addressed the needs of both large and small wind machines?
2. Is the large-scale wind program structured to ensure the development of a competitive industry?
3. Is C&SE involved in the development of simple guidelines and methods for State Public Utility Commissions to use in developing fair and reasonable buy back/backup rates pursuant to the Public Utilities Regulatory Policies Act (PURPA)?
4. Should DOE fund additional utility interface experiments with large numbers of small-scale machines on a single grid?

Background

Both large- and small-scale wind machines must contribute to meeting the Quad goals for wind suggested by the DPR (1.7 Quads of fossil-fuel equivalent in 2000) and of higher goals suggested in various DOE commercialization plans (3.04 Quads in **2000).** While large machines are likely to contribute the major share in **2000, small machines are estimated to have** the **larger impact** in the midterm **(1990).**

DOE funding for wind energy machines has concentrated on product development. This emphasis was necessary for large machines and has resulted in the development of the MOD-1 and a substantial improvement, the MOD-2. However, for small machines, nonhardware problems currently are more important and failure to adequately consider these problems may result in failing to meet the midterm goals.

PURPA required the Federal Energy Regulatory Commission (FERC) to establish guidelines for backup/buyback rates for small power producers. FERC has established guidelines which indicate that backup rates charged small power producers must be nondiscriminatory and that buyback rates must be essentially margin priced. Within a year State Public Utility Commissions must issue rates structures for buyback and backup rates. The outcome from these commission hearings could have a significant, favorable effect on the economics of wind energy. DOE has the authority to intervene in State Public Utility Commission hearings and can use this authority to ensure that the electrical output from wind machines (and other decentralized solar technologies) is sold at the true marginal cost and that wind machines owners are provided nondiscriminatory rates for electricity backup.

Other nonhardware areas that need more attention for small-scale machines are utility interface problems, user awareness and acceptance, market analysis, and the development of a competitive industrial wind systems manufacturing capability and supporting infrastructure. DOE should determine its role in these issues and the extent to which lack of available funding has hampered the ability of DOE to deal with them.

Issue 22

Photovoltaic Program Strategy

The DOE photovoltaic program may not be adequate to meet the administration goal of 1 Quad in 2000.

Summary

The administration has announced its intention of achieving the potential for solar indicated in the DPR. This intention implies the achievement of the maximum practical estimate of 1 Quad listed in the DPR. Congress has expressed its support for photovoltaics through SPERDD, FPUP, and other legislation. In SPERDD Congress required DOE to **formulate a goal-oriented plan, to establish an outside** advisory panel, and to formulate an international photovoltaics plan. None of these were completed within 1 year after the passage of the Act. Moreover, Congress authorized $98 million for Federal purchases of photovoltaics in fiscal years 1979-81 through FPUP. DOE has been reluctant to request funding for this program and less than two-thirds of the monies authorized for the years 1979-81 may be spent.

Questions

1. Why has DOE been so slow in complying with its responsibilities as required by SPERDD? Will the recently formed advisory panel play an important role in setting photovoltaic priorities?
2. Why has DOE been reluctant to request authorization under FPUP? What can be done to ensure that the Federal agencies to which DOE has transferred FPUP dollars obligate those dollars in a timely and judicious manner?
3. DOE is currently sponsoring research into at least four materials (polycrystalline silicon, cadmium sulfide, gallium arsenide, amorphous silicon) for advanced photovoltaic cells. How does DOE decide the level of funding for each of these materials?
4. How will other Federal agencies (e.g., the Federal Buildings Program, the Department of Defense construction budget, the Agricultural Extension Service) be encouraged to utilize photovoltaic technologies where appropriate?
5. Congress set a goal of photovoltaics energy systems costing $1 per peak watt (in 1978 dollars) in SPERDD. The solar array is anticipated to account for half of the cost while the balance of system components is anticipated to account for the other half. While DOE has a detailed plan to attempt to reduce the cost of the solar array, a comprehensive development plan to reduce the cost of the balance of system components is currently lacking. Why has DOE been slow in formulating a plan to reduce the balance of system costs for photovoltaic energy systems?

Background

Congressional support for photovoltaics has been strong, yet DOE programs have not carried out this congressional interest. In 1978 Congress passed SPERDD to establish an aggressive research, development, and demonstration (RD&D) program for photovoltaics. Research on solar cells had progressed significantly since their early use in space missions. It was thought that an aggressive program could speed the commercialization process from the normal 30 or so years to perhaps only a decade. Congress set as the goals of the Act:

1. to double the production of solar photovoltaic energy systems each year during the decade starting with fiscal year 1979, measured by the peak generating capacity of the systems produced, so as to reach a total annual U.S. production of solar photovoltaic energy systems of approximately 2 million peak kW, and a total cumulative production of such systems of approximately 4 million peak kW by fiscal year 1988;
2. to reduce the average cost of installed solar photovoltaic energy systems to $1 per peak watt by fiscal year 1988; and

3. to stimulate the purchase by private buyers of at least 90 percent of all solar photovoltaic energy systems produced in the United States during fiscal year 1988.

In section 4 of this Act, the DOE Secretary was given the authority to achieve these goals. Section 9 required DOE to form an outside advisory panel to advise the Secretary of DOE regarding RD&D, and utilization of photovoltaics, Moreover, Congress recognized the importance of the international market in establishing a competitive photovoltaics industry. (In many overseas areas photovoltaics may be cost competitive even though they are not competitive domestically.) I n section 11, of the Act, DOE was required to consult with other Government agencies and to formulate a plan for demonstrating applications and facilitating the use of photovoltaics in other nations. None of these were completed within 1 year after the passage of the Act.

Congress has also attempted to support the development of the photovoltaics industry through Federal purchases. NE CPA (part of the National Energy Act) contains FPUP, which authorized $98 million for Federal purchases during fiscal years 1979-81. DOE has been reluctant to request money for this program. In **1980,** DOE **initially requested no funds, Congress eventually appropriated $10 million. Less than two-thirds of the amount authorized may be spent under this program.**

Issue 23

Polysilicon Shortage

A shortage of polysilicon material may develop unless DOE supports new production facilities that would use either unproven or outmoded technologies.

Summary

SPERDD suggested as a goal the cumulative production of approximately 4 million peak kW of photovoltaics by fiscal year 1988. Studies (for example, DOE/JPL-1012-33) have indicated that these goals may be unobtainable due to a shortage of polysilicon material manufacturing capacity using current production processes. DOE-sponsored research promises to develop significantly less expensive production processes in the next few years, thus inhibiting investments i n new facilities using current technology. According to the present DOE schedule, which may be somewhat optimistic, commercial quantities from the new processes are not expected before 1986.

Questions

1. Should the Government take action to stimulate production with present processes? If so, what type of action should be considered ?
2. Is there any reasonable way to speed implementation of the new lower cost process u rider development?
3. Has DOE estimated the long-term (year 2000) effects of the impending shortfall ?

Background

One of the photovoltaic program's objectives is the development of a national capability to manufacture photovoltaic arrays by 1986 at a price of less than $0.70 per peak watt in 1980 dollars. Since the price of silicon material is a large proportion of the cost of s i l icon arrays, DOE has been sponsoring considerable research into processes that would lower the cost of silicon material. DOE has as its cost objective the development of processes for producing silicon for applications at a market price of less than $14/kg in 1986 (in 1980 dollars). Several processes have been suggested that may lead to the achievement of approximately these cost goals The achievement would be a substantial reduction in the price of obtaining silicon from today's conventional process (Siemens process), which is approximately $87/kg

This anticipated abrupt price decline has deterred manufacturers from expanding capacity using the existing expensive process that may be outmoded in the next few years. Consequently, expansion of polysilicon manufacturing capacity may be limited in the next few years until these new **processes are justified. This failure to expand manufacturing capacity may make the goals implied by SPERDD and the DPR unobtainable.**

Issue 24

Solar Thermal Power Strategy

The solar thermal demonstration strategy must be carefully planned and justified.

Summary

The technologies and applications of solar thermal systems are unusually diverse. DOE has evidently shifted from an emphasis on large-scale, central receiver power systems to a broader approach including smaller scale and distributed receiver systems. it is not yet clear which technology or scale will be most advantageous. Detailed evaluation of the initial markets and planning of the most efficient demonstration programs to prove the feasibility of these applications will be required to avoid unnecessarily large expenditures. Some elements of this planning are evident in the DOE documents, but alternative strategies should be considered. For instance, unexpectedly high costs for components of the 10-MWe Barstow central receiver demonstration plant have evidently forced a reduction in the performance of the plant. If analysis shows that central receivers can still be viable competitors, DOE should investigate the possibility of moving immediately to assisting utility repowering demonstrations.

Questions

1. When will cost comparisons of central and distributed receiver systems be available? Which is likely to have a larger near-term market ?
2. Has DOE adequately analyzed the market for small- and large-scale solar thermal systems? If small central receiver systems prove successful, will private industry invest in large ones without further demonstrations by DOE?
3. How much has the expected performance of Barstow been reduced from a year ago? How will this affect its value as a demonstration? How will this experience affect ultimate cost projections?

Background

Solar thermal power technology concentrates the Sun's heat to heat water or some other fluid to produce electricity or provide steam for industrial and agricultural processes. These systems can be utilized in either centralized or dispersed applications and can be sized to suit specific needs.

Central receiver solar thermal powerplants have been a major focus of the solar thermal program. Although the plants can be as small as 1 MWe, DOE has estimated the optimal size for certain bulk electrical production application in the 100- to 300-MWe range. DOE has initiated the construction of a 10-MWe demonstration plant at Barstow, Cal if., to demonstrate the feasibility of central receiver solar thermal plants. Barstow is the largest and most expensive solar thermal project, so it has been subjected to many audits and assessments, which have caused delays and cost increases. Nevertheless, costs for construction and operation of the plant still need careful monitoring, particularly in the present phase of construction.

Larger pilot plants will cost considerably more, These demonstrations are particularly vulnerable to cost overruns because of the limited size of the manufacturing runs and conservatism on the part of the designers, who may have inadequate data to assure optimal performance (part of the reason for the demonstrations). if such overruns do develop, DOE can:

- seek additional funds to build the plant as designed;

- eliminate the demonstration and concentrate on distributed systems that may not require large-scale demonstrations, delaying the implementation of centralized systems;
- delay other projects and transfer their funds to the centralized demonstration plant; or
- reduce the size or performance of the demonstration, thus reducing its value to the program leading to large centralized facilities.

DOE-sponsored studies indicate that there is a near-term market to repower (convert) existing gas- and oil-fired utility plants in the Southwest. Repowering is the addition of solar power collectors to an existing powerplant, not to increase total power but to decrease the *use* of fossil fuels. DOE should consider the feasibility of reducing or eliminating funding of demonstration plants if major cost overruns occur and substituting them with a larger amount of repowering projects. In these projects, cost sharing with utilities is available, and utilities will have strong incentives to help control costs.

Distributed receivers collect the Sun's energy at each concentrator rather than at a central power tower. Since each unit (parabolic troughs, bowls, and dishes) is virtually identical to the others, scaleup is simple and large demonstrations might be unnecessary. Direct cost comparisons are not yet conclusive. However, a specific experiment to compare directly the costs and advantages of central v. distributed receiver systems is under construction by the International Energy Agency at Almeria, Spain (U.S. support comprises approximately 20 percent of the project). Both a central and a distributed receiver system are being built at the same site. Results from this facility should be used to test the validity of the DOE emphasis on central receiver systems.

An important and potentially large application for solar thermal power will be cogeneration applications (using steam for both electrical generation and heat generation) and applications in industrial processes heat markets. Detailed analysis by DOE of the amount of each type of solar thermal power (distributed or central) that may best suit these markets is currently lacking. Distributed systems may be best for many industrial process heat and cogeneration applications and may offer more near-term applications. DOE should also accelerate the removal of barriers that tend to discourage cogeneration (see Issue 37).

Issue 25

OTEC Strategy

A comprehensive plan for the development and implementation of OTEC has not been prepared. Without such a plan, the total program cost–which will be high–cannot be accurately estimated.

Summary

The DOE program documents indicate that a crucial point in the OTEC Program occurs in fiscal year 1982 with the decision to proceed on the construction of the first 10- to 40-MW pilot plant. Congress is considering legislation to expedite this schedule. An affirmative decision will necessitate a substantial increase in the level of OTEC funding. The Congressional Budget Office (CBO) estimates that a single plant of this size will cost $300 million. The full development program may require several such plants and several larger demonstration plants. If this decision does not consider the total costs and technological uncertainties based on a comprehensive development plan, then DOE will risk entering an undefined program where potential costs may be far above those now envisioned. Further, criteria measuring interim success or failure must be established so that the program can be revised up or down in accordance with explicitly determined estimates of the risks and benefits of proceeding at any given pace, The Federal involvement and investment must be balanced against the potential benefits to ensure that

Federal funds are effectively spent. DOE has evidently not performed such a detailed analysis.

Questions

1. Why has DOE failed to estimate the total cost and involvement required to bring OTEC to commercialization? What legal, environmental, insurability, and other noncost questions must be resolved?
2. What is the DOE pilot-plant strategy? How many pilot plants and their sizes will be required in the DOE commercialization plan? What is the purpose of each plant? What goals will be accomplished by the first OTEC pilot plant and what goals will remain?
3. When will DOE complete a detailed resource assessment of the potential for OTEC?
4. Has DOE analyzed the potential for other forms of solar energy (wind, photovoltaics, solar thermal, biomass, and geothermal) in the potential markets for OTEC?

Background

OTEC is a concept for using the temperature difference that exists between warm water at the surface of oceans and cold waters in the deep oceans to release stored energy to power a turbine. This concept could provide an important source of energy for the generation of electricity or power for manufacturing energy-intensive products such as ammonia and aluminum. The main Federal research goal in OTEC is the construction of a new type of baseload powerplant. Thus, unlike the other solar technologies of solar thermal, wind, and photovoltaics, OTEC could continuously produce electric power without the necessity of storage.

No scientific breakthroughs are needed to build an OTEC plant but the technology is not in routine use. The technical problems are by no means minor, and the satisfactory solutions to the critical engineering problems will require long-term laboratory and at-sea testing, (OTA completed an assessment of these technical problems in May 1978, and updated that review in April 1980).

The DOE program documents, including the Multiyear Plan, are incomplete as to the total Federal cost and involvement that will be required to bring OTEC to commercialization. CBO estimated that a commercialization plan suggested by congressional legislation **(S-1830** and HR-5796) would cost $1 billion by 1986 alone. DOE program documents indicate that a 1-MW test facility (OTEC-1) will be deployed in 1980, and that a crucial decision to begin construction of a 10- to 40-MW pilot plant will be made in fiscal year **1982.** However, the program documents do not indicate the number of additional pilot or demonstration plants (and their sizes) that will be needed before Federal involvement is ended.

A comprehensive development plan for OTEC is necessary in order to estimate the total Federal cost and involvement. This development plan should have a well-defined pilot-plant strategy delineating the goals that will be accomplished for each pilot plant. Criteria to determine the interim success or failure of the program must also be established.

The Federal investment in OTEC must be balanced against its relative value. Currently, even under its present level of funding of $40 mill ion per year, OTEC has the lowest ratio of energy payoff compared to the present budget level as shown in Issue 2. An accelerated program could, if successful, produce much more than 0.1 Quad in 2000, but a commitment to such a program now would entail much higher (but as yet undetermined) expenditures with uncertain prospects for producing a viable economic power source.

The worldwide potential for OTEC is clearly very great if the technology proves economic, Application to the U.S. market is not so clear since most of the U.S. coast has only moderate temperature differentials. DOE has identified islands (especially Hawaii and Puerto Rico) as being the initial candidates since their present energy costs are high and they are near attractive OTEC sites. This is a reasonable first approximation, but by the time OTEC is commercially available, other options may be more attractive. For instance, Hawaii has large geothermal and wind resources. Even coal will be a competitor for several decades since ocean shipment is quite inexpensive. The United States already ships large quantities of coal to Japan and South America. OTEC may in fact prove to be the least costly of these options, but DOE has not completed either an adequate resource assessment or a detailed market survey to determine where OTEC is likely to be the preferred alternative, and any cost projections are highly speculative until larger plants are actually built and tested.

Alternative strategies to building subsequent pilot plants should be considered, Proposed OTEC designs use standard heat-engine cycles which are typical of those used in all powerplants when the heat from burning fuel is converted into electrical power. OTEC is designed to create useful power from the temperature difference between the surface and depths of the ocean; this difference is not much greater than that discarded as unusable in some conventional power plants. Heat exchangers, which are designed for that purpose, could be tested in a less expensive manner in the bottoming cycle at nuclear powerplants.

Other countries have expressed interest in OTEC and in cooperative agreements (among these countries is Japan). There is a uniquely attractive site at Abidjan, in the Ivory Coast, in which the French are already actively interested. Exploitation of this opportunity could provide invaluable construction and operating experience at minimal risk. These cooperative agreements should be explored to lower the Federal costs of RD&D for OTEC systems. The possible delay in implementing cooperative agreements should be balanced against the reduction in Federal investment.

Biomass

Biomass currently provides approximately 1 **5 Quads (2** percent) of U.S. energy requirements each year. The goal of the DOE Biomass Energy Systems (13 ES) Program is to provide an additional 0.5 to 1.5 Quads/yr before 1985, through the direct combustion and conversion of biomass to gaseous and alcohol fuels; an additional 6 Quads/yr before 2000, through improved biochemical and thermochemical conversion technologies; and a total of 8 to 10 Quads/yr after 2000. The goals are more ambitious than those of the DPR discussed in Issue 1.

The BES Program s the largest and most visible biomass program **in the Federal Government, and has the responsibility for integrating and coordinating national efforts The major emphasis of the program has** been on the direct combustion and gasification of wood, and the production of ethanol from crops, crop residues, and wood, To a lesser extent, DOE efforts are directed toward onfarm anaerobic processes from a variety of feedstocks.

The program is structured according to the kinds of R&D activities needed at different stages of technology development. For near-term technologies (expected to enter the marketplace by 1985), activities focus *on* achieving process improvements and demonstrating commercial-scale applications. Mid-term technologies (1 985-2000) are supported by laboratory-scale investigations, studies of process economics, and development of engineering models. Longer term technologies are supported primarily by applied research. The actual elements of BES are: 1) technology support (commercialization expected before 1985); 2) production systems (after 1985); 3) conversion technology (after 1985); 4) research and exploratory development; 5) administrative support and other. Table 5 shows the BES Program budget for fiscal years **1979-81.** In fiscal year 1978, the total program budget (then called Fuels From Biomass) was $20.2 million.

The Solar Energy Research, Development, and Demonstration Act of 1974 (Public Law

Table 5.—Biomass Energy Systems Program Budget, Fiscal Years 1979-81
(in thousands of dollars)

Biomass energy systems	FY 1979 appropriation	FY 1980 appropriation	FY 1981 base	FY 1981 request
Technology support:				
Operating expenses	$16,406	$16,000	$16,000	$19,500
Construction	0	0	0	2,500
Subtotal	16,406	16,000	16,000	22,000
Product ion systems:				
Operating expenses	5,085	5,700	5,700	11,600
Conversion technology:				
Operating expenses	14,695	22,500	22,500	9,500
Construction	0	2,000	2,000	2,000
Subtotal	14,695	24,500	24,500	11,500
Research and exploratory development:				
Operating expenses	4,713	7,800	7,800	13,650
Capital equipment	500	500	500	750
Subtotal	5,213	8,300	8,300	14,400
Support and other:				
Operating expenses	1,001	1,500	1,500	3,500
Total:				
Operating expenses	41,900	53,500	53,500	57,750
Capital equipment	500	500	500	750
Construction	0	2,000	2,000	4,500
Total biomass	$42,400	$56,000	$56,000	$63,000

SOURCE *Congressional Budget Request, FY 1981,* vol 2, Department of Energy, January 1980, p 48

93-473) is the principal law which authorized broad-based research programs for all solar energy, including "products of photosynthetic processes." The law also directed that RD&D be initiated on "the conversion of cellulose and other organic materials (including wastes) to useful energy or fuels. " Furthermore, this Act directed DOE to carry out research on incentives to commercialize these solar technologies.

The 96th Congress is considering several bills to accelerate biomass production through increased research and financial incentives for biomass energy facilities. In particular, S.932 contains several features aimed at fostering synthetic fuels production from wood and agriculture. The enactment of S.932 would likely affect subsequent DOE program development.

Issue 26

DOE Support for Biomass Energy Systems

Despite the recognized potential of biomass as an energy source, DOE support for biomass programs has lagged well behind that for other solar technologies.

Summary

Although the DPR recognized biomass as the single most important solar technology in terms of its potential future energy contribution, DOE funding and staffing levels are still well below those for solar thermal, wind, photovoltaics, and active heating and cooling programs. The biomass program's growth is due in large part to repeated congressional budget increases. Furthermore, DOE's biomass programs have consistently been understaffed. It appears that sufficient personnel slots have been budgeted and mandated by Congress, but some have yet to be filled. This has hampered the program's effectiveness. The lack of coordination between DOE and the U.S. Department of Agriculture (USDA) has also hindered bioenergy development although there is reason to believe this is improving. The passage of S.932 into law would require substantial reevaluation of the relative roles of the two agencies.

Questions

1. Has DOE analyzed funding and staffing levels needed for the various biomass projects in order to achieve its goals?
2. The DPR "maximum practical" estimate of about 5.4 Quads by 2000 is about the same as OTA's projected level assuming only a continuation of present subsidies and moderate energy price increases. Will DOE accept the more ambitious BES goals?
3. What have been the benefits of the transfer of funds to USDA for biomass R&D?

Background

DOE has been designated the lead agency in bioenergy development and has responsibility for integrating and coordinating national efforts. Until recently, DOE considered biomass a low-priority item. This was reversed in the latest DOE solar energy PSD, perhaps as a result of the DPR's recognition of biomass as the single most important solar technology. Even so, DOE funding is still below that for other solar technologies ($56 mill ion in fiscal year 1980), and most of the biomass funding increases were mandated by Congress.

BES has also experienced severe understaffing, which has affected the day-to-day operation of the program. Within the last year, two to three full-time professionals managed the $56 million budget at DOE headquarters. Program management also changed several times in the last few years. These shortcomings have contributed to program operating deficiencies such as the lack of an adequate program plan, lack of coordination with other Federal agencies, and the lack of commercialization activities. The absence of a clearly defined plan has resulted in numerous changes in priorities, often to the detriment of the program. Many biomass projects require long-term R&D commitments. The intervention or premature termination of a project or project element(s) will often void the entire effort.

Despite recent interagency agreements between USDA and DOE, very little has been done to coordinate and develop joint RD&D programs or parallel/complementary bioenergy commercialization plans. However, there are indications that DOE/USDA coordination may improve in the future. For example, recent interagency agreements define a more explicit role for both agencies, and USDA is expected to receive a significant portion of the DOE biomass budget via pass-through funding for the purpose-of administering some biomass development projects. Such cooperative efforts will probably require careful monitoring.

Within DOE, more than 10 distinct programs support bioconversion activities with apparently no significant coordination. For example, seven different offices in DOE have been involved in alcohol fuels development. Each office has in the past conducted its activities largely independent of the others, though the new Office of Alcohol Fuels has now been designated as the responsible agency.

Finally, little attention has been given to commercialization. No strategy has been developed to convert program R&D results to practice. This has resulted in neglect of nearterm technologies, such as the use of wood. The forthcoming OTA report, *Energy* from Biological Processes, shows that wood in the single largest potential source of biomass and that production of methanol from wood is nearly commercial. However, the DOE program almost totally ignores methanol production,

Within the last year, the BES Program has undergone reorganization in order to rectify some of its management problems. DOE's fiscal year 1981 budget request stated that reorientation of the BES Program would be complete in fiscal year **1981.** Although some changes have been made in budget and staff allocation, the adequacy of these measures s still to be demonstrated.

Issue 27

Scale and Emphasis of Biomass Fuel Production Facilities

DOE has inadequately emphasized smaller scale biomass systems and approaches that integrate the energy and nonenergy parts of these systems.

Summary

In the past, DOE has emphasized large-scale, long-term biomass systems and approaches dedicated solely to the production of fuel. This approach is flawed because it: 1) reduces the quantity of bioenergy that could otherwise be obtained from smaller scale and/or multi product systems; 2) ignores the potential benefits of integrating energy with nonenergy objectives; and 3) ignores the fact that dedicating large areas of land suitable for food crops to biomass energy will compete with food production. The development of multi product/multipurpose biomass systems, generating high-value food/feed/fiber, in addition to fuels, is very likely a more rational approach. Recently, DOE has proposed smaller scale conversion processes for onfarm production of methane and alcohol. However, it is not clear whether these actions represent a change in DOE biomass policy. Also, DOE apparently still is not addressing the need to integrate energy with nonenergy objectives for biomass.

Questions

1. Most of the projects supported by the BES Program emphasize large-scale, long-term single-purpose fuel production systems. Has this emphasis been changed? I f so, how?
2. What steps does DOE intend to take to integrate energy objectives with nonenergy objectives (e. g., increased forest management) i n the development of bioenergy systems?
3. What fraction of the budget will be allocated to onfarm and other small-scale applicat ions?
4. Will the long-term research and exploratory development component of the BES Program remain essentially focused on the ocean farm project? What are the alternatives?

Background

Biomass-derived fuels are, at present, mostly byproducts or waste products of agricultural, forestry, and related activities, Lumber and paper mill residues make up the largest fraction of currently used biomass fuels. Municipal solid wastes, animal residues, food-processing wastes, and spoiled or excess crops can and, in some cases, are beginning to be used as feedstocks for alcohol or methane production and steam generation. Fuelwood is also used extensively.

Over the past 5 years, DOE has almost exclusively supported the development of large-scale systems whose sole product is a fuel. Specific examples of this policy include: greater emphasis on large systems for algae biomass production rather than integrated algae biomass/waste treatment processes, emphasis on large-scale biomass energy farming, and neglect of onfarrn systems for animal waste conversion to methane or production of alcohol. The reasons for this policy can be attributed to DOE's view that: 1) it should not be involved in agricultural or forestry systems (traditionally a USDA area); 2) small-scale systems would result in severe diseconomies of scale in fuel conversion processes due to small feedstock flows; 3) large-scale systems would tie in with established energy distribution systems (e. g., pipelines); and 4) the problems of providing a reliable supply of biomass can best be solved with dedicated energy plantations. This policy is too narrow and neglects a major potential of bioenergy.

The OTA assessment of bioenergy, currently being completed, indicates that the largest potential source of bioenergy in the near to mid-term is residues from increased forest management. Because of the importance of the Nation's forests in providing nonenergy products and the potential for severe environmental damage to the forests if logging increases, it is important that the objective of wood energy be integrated with and complement the objectives of environmental protection of the forests and increased production of nonenergy forest products.

Similarly, most other major near- to mid-term sources of bioenergy cannot be isolated from other sectors of the economy. (Even large energy farms would require land that could probably be used for food production.) Consequently, it is important to integrate the energy and nonenergy objectives for each source of bioenergy in order to avoid inflationary competition for feedstocks and to exploit any nonenergy benefits that bioenergy production end use can provide.

Because the major near- to mid-term sources of biomass are dispersed, OTA's analysis indicates that a significant potential exists to utilize the biomass in smaller scale dispersed systems, such as small industrial applications. The high transportation costs for biomass means that economies of scale cannot be exploited to the same extent as with coal conversion facilities. Thus, maximum exploitation will require an emphasis on small- to medium-sized conversion facilities.

Issue 28

Biomass Liquid Fuels

DOE must carefully plan a strategy for integrating alcohol fuels into the petroleum system to optimize the use of the resources.

Summary

Because of its limited production potential and its physical and chemical properties, ethanol's best use may be as an octane-boosting additive to gasoline. Such use would also maximize its petroleum displacement potential. However, while gasoline/alcohol blending can contribute to reducing petroleum needs, it may also aggravate the shifting of gasoline supplies from urban to rural areas during al location periods.

Blending methanol with gasoline may cause more problems with the existing automobile fleet than would ethanol, Although new cars can be designed to accept methanol blends, problems such as evaporative emissions and acceptable effluent water disposal in the distribution systems and refinery are less easily resolved. Consequently, various end uses of methanol (such as blends with gasoline, a standalone fuel, or an intermediate in liquid hydrocarbon production) should be examined for potential refinery and distribution problems to ascertain the most effective and economical strategies for introducing methanol as a liquid fuel.

Questions

1. What are the best strategies for methanol refining, distribution, and end use?
2. Will DOE continue to neglect methanol production? Has DOE carried out any analysis of small-scale methanol plants (1 50 ton/d or less)?

3. Are potential environmental concerns with alcohol-gasoline blends (i. e., evaporative emissions and effluent water disposal) being adequately addressed?
4. Is C&SE cooperating with the Economic Regulatory Administration to prevent a distortion of supplies from urban to rural areas caused by unleaded gasoline assignments for gasohol blending?

Background

When the alcohol is manufactured using nonpetroleum process energy and used as an octane-boosting additive, ethanol use can make a contribution to reducing crude oil needs. Experience to date has shown that gasohol (lo-percent anhydrous ethanol in gasoline blends) can best be handled logistically by blending the gasohol at terminals and exercising care to keep service station tankage dry. With an expanded program, however, additional concerns may develop. These concerns, recently expressed by the Environmental Protection Agency (EPA), are: 1) the use of ethanol would Slightly increase vapor pressures and require exclusion of about 2 percent of the butanes in the gasoline to avoid increased evaporative emissions; and 2) phase separation is more likely, presenting a problem of acceptable disposal of the effluent water containing alcohol.

Some experts have expressed concern that gasohol blending may shift gasoline supplies away from urban toward rural areas during allocation periods, The currently proposed DOE assignment of unleaded gasoline by refiners to blenders/resellers and alcohol manufacturers could result in gasoline being diverted from historic base period customers, largely those in urban markets.

Methanol from biomass or coal can be produced in significantly larger quantities and at lower costs than ethanol. Although methanol's octane-boosting properties provide a potential energy savings at refineries if it is used in gasoline blends, methanol's physical and chemical properties pose problems not present, at least to the same degree, with ethanol. First, blending 10 percent methanol with gasoline would require removal of about 8 percent of the butanes and other light gasoline components to avoid excessive evaporative emissions. The removal of these components from the gasoline pool would largely negate the contribution of methanol to expanding gasoline supply, unless automobiles using the blends are engineered to accept a more volatile fuel without vapor lock or excessive evaporative emission. Second, methanol also is more susceptible to separation from gasoline in the presence of very small amounts of water; disposal of large quantities of a separated fuel would be a related problem. Cosolvents or drying of the gasoline before blending could conceivably reduce these problems. A blend containing 2.5 percent methanol and 2.5 percent t-butanol (another alcohol) is being test marketed by Sun Oil Co., and may answer some of the questions. Third, service station underground tanks may also be damaged by methanol blends and require replacement.

Although all of the problems with methanol blends are technically solvable in several different ways, it is unclear whether the use of methanol blends would be the most economical strategy for consumers or the optimal way to introduce methanol as a liquid fuel. Other possible high-value uses for methanol include: 1) as a fuel by itself in captive fleet automobiles (12 percent of the U.S. automobiles are in captive fleets, such as taxis, corporate fleets, etc.); 2) in gas turbines for peakload electric generation; 3) in diesel engines with a dual-fuel capability with later expansion to methanol-fueled vehicles that are not part of a captive fleet; and 4) further conversion of methanol to gasoline.

To provide early guidance for methanol policy decisions, an accelerated analysis should be undertaken to examine the relative attractiveness of alternative methanol strategies. This should include an examination of the entire liquid fuels systems from refineries through distribution to the various potential end uses; it should also quantify the costs and delineate and analyze the constraints associated with the various options for using methanol.

Transportation Programs

The Office of Transportation Programs (OTP) is an end-use division in the Office of the Assistant Secretary for C&SE, and has four major program areas: Vehicle Propulsion RD&D, Electric and Hybrid Vehicles RD&D, Transportation Systems Utilization, and Alternative Fuels. The goals of OTP are to reduce the transportation sector's energy consumption and its nearly complete dependence on petroleum by developing and commercializing alternative transportation and fuel technologies, as well as disseminating information and conducting educational programs to encourage energy efficiency. The programs within OTP are based on legislative mandates, budgetary considerations, industry estimates, technology expectations, and market assessments. Table 6 gives the OTP budget for fiscal years 1979-81.

The principal laws mandating R&D activities on electric vehicles (EVs) and automotive propulsion systems are the Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1975 (Public Law **94-413)** and the Automotive Propulsion Research and Development Act of 1978 (Public Law 95-238). Public Law 94-413 authorized $60 million for programs which would evaluate and demonstrate some 7,500 EVs. In addition, the law authorized a $60 million program for loan guarantees to aid small manufacturers, and directed DOE to contract for the production of a number of urban passenger and commercial EVs. Public Law 95-238 also provided for ongoing R&D on EVs and established an Electric and Hybrid Vehicle Development Fund for the purpose of carrying out loan guarantees and assistance programs. The Automotive Propulsion R&D Act of 1978 established within DOE an R&D program to ensure the development of advanced automobile propulsion systems. The law directs DOE to: 1) establish and conduct new projects and accelerate existing ones; 2) give proper attention to the development of advanced propulsion systems; and 3) ensure that the program supplements and does not duplicate or supplant industry programs.

Table 6.–Office of Transportation Programs Budget, Fiscal Years 1979.81
(in thousands of dollars)

Transportation	FY 1979 appropriation	FY 1980 appropriation	FY 1981 base	FY 1981 request
Vehicle propulsion RD&D:				
Operating expenses.	$46,300	$ 59,500	$ 59,500	$ 55,400
Capital equipment	1,500	1,000	1,000	500
Subtotal.	47,800	60,500	60,500	5,900
Electric and hybrid vehicle RD&D:				
Operating expenses.	37,500	41,000	41,000	42,100
Transportation systems utilization:				
Operating expenses.	6,100	6,700	6,700	6,700
Alternative fuels utilization:				
Operating expenses.	5,800	5,200	5,200	4,300
Capital equipment	0	100	100	1,000
Subtotal.	5,800	5,300	5,300	5,300
Total:				
Operating expenses.	95,700	112,400	112,400	108,500
Capital equipment	1,500	1,100	1,100	1,500
Program direction	1,949	2,923	3,000	3,000
Total transportation.	$99,149	$116,423	$116,500	$113,000

SOURCE *Congressional Budget Request FY 1981* vol 2 Department of Energy, January 1980, p 48

Issue 29

Advanced-Engines RD&D

Government support for advanced engines RD&D should be evaluated in light of the engines' potential contribution to energy conservation.

Summary

A major part of DOE's transportation energy conservation program is the development of advanced engines, specifically the gas turbine and Stirling engines. The advanced-engines RD&D project accounts for about half of the fiscal year 1981 budget request ($11 3 million). While it is possible that advanced engines could meet future exhaust emissions standards and achieve multifuel capability, there are serious technical obstacles to meeting fuel economy goals. DOE is making progress, but it is not certain that advanced engines will be able to attain fuel efficiencies sufficiently beyond those expected for internal combustion and diesel engines to justify a major shift by the automobile industry to turbines or Stirling engines. In view of the time and effort already given to these programs and the lack of major breakthroughs, Congress should perhaps direct DOE to reassess these programs and their prospects for meeting fuel economy and emissions goals within the established time and budget. Otherwise, the programs may continue on their own momentum without assurance that the goals are still attainable and relevant to national needs. Other approaches or other forms of technology may offer greater promise of attaining the same goals.

Questions

1. Could the automobile industry meet fuel economy and emissions goals without Government R&D assistance?
2. Will these engines, if perfected, offer sign if i cant advantages over stratified-charge or diesel engines? If not, would it be less costly for DOE to develop improved spark-ignition and diesel engines instead?
3. Will these engines have a role if the expected improvements in fuel consumption are not realized ?

Background

The Advanced Heat Engine Development Program was first established in EPA in **1971 and** its primary goal was the reduction of exhaust emissions. Later, a second goal of fuel economy was added and responsibility for the program was given to the Energy Research and Development Administration/DOE. The Automotive Propulsion R D&D Act of 1978 further emphasized the need for developing advanced automotive systems, to improve fuel economy and lower exhaust emissions, and directed DOE to support private industry efforts. However, DOE was not limited to support activities and was authorized to initiate projects not undertaken by industry. The Government undertook the alternative engines program in the belief that the automotive industry was unwilling to make a major commitment to developing. new engines and vehicle propulsion systems.

While much of the R&D in the automobile industry has concentrated on short-term improvements to spark-ignition and diesel engines, there has been some rather limited work on the gas turbine (Brayton cycle) engine. In the 1950's and 1960's – as an outgrowth of development of the gas turbine for aircraft — experimentation was conducted on the use of gas turbine engines for trucks and stationary applications. Several years ago, both General Motors and Ford were close to offering large turbines in trucks and buses, but the engine was not marketed. The present GM gas turbine development program is quite active. Within the last 6 months, DOE has signed two cost-sharing contracts with industry to develop and demonstrate a gas turbine engine. A $56.6 million contract was signed with A i Research Manufacturing Co. and Ford Motor Co,; the Federal share was $53 mill ion. A second contract was signed with Detroit Diesel Allison, a division of General Motors, for $65 million, with the Federal share amounting to $59.8 mill ion, Until recently, most experience with the Stirling engine has been in the research laboratory The only commercial application of the Stirling cycle has been in a cryogenic machine for producing liquid air, Some development was done for the potential application of the Stirling in heavy-duty trucks and some minor production for military hardware.

The major thrust of DOE's program is to develop gas turbine and Stirling engines because they offer the potential for meeting fuel economy and low exhaust emissions goals and have multifuel capability. The programs' objectives include increasing fuel economy 30 percent over the best 1984 gasoline internal combustion engine (ICE) vehicle of equal performance, meeting exhaust emissions, and producing engines with multifuel capability. No major propulsion system development is planned specifically for trucks and buses because many of the automotive technological advances achieved can be applied to trucks and buses.

Both engines have a high probability of meeting future emissions standards and achieving multifuel capability. However, it appears doubtful that fuel economy goals can be met within established time frames. The gas turbine's poor part-load efficiency is the major obstacle to achieving fuel economy, Greater fuel efficiency depends on reaching higher operating temperatures, which will require the use of special materials — ceramics. The substitution of ceramic materials for the expensive, high-alloyed metals presently used will also reduce costs. DOE has emphasized the testing and development of ceramic materials for critical components (turbines and nozzles). However, DOE considers the development of these materials to be technically risky, requiring long-term testing and evaluation. Without the development of these materials, the use of gas turbines would be improbable.

The Stirling engine has received considerable attention in Europe (Phillips in Holland and United Stirling in Sweden) since the 1800's. Only within the last few years have Stirling engines been demonstrated in passenger cars. The inherent advantages of the Stirling, which make it attractive as an alternative engine, are its high theoretical efficiency, low level of noise, low carbon monoxide and hydrocarbon emissions, and fuel versatility The major disadvantages of the engine include its high initial cost and high specific weight. In order to penetrate the automotive market, experts have concluded that engine cost and weight must be reduced and efficiency improved. Therefore, DOE R&D efforts have focused on improving fuel economy through the development of a higher temperature engine and reducing size and weight through lightweight con struction and system matching (engine/vehicle). According to DOE, reducing the weight of the Stirling so that it can be used in automobiles (4 lb/hp) will be difficult but improving fuel economy will be less of a problem.

Even if both engines meet their fuel efficiency goals, a question still remains concerning the extent of their commercial application, The automobile industry is continuing research on improving the fuel efficiency of spark-ignition and diesel engines, It is noteworthy that the DOE work on gas turbine and Stirling engines very likely plays an important role in motivating the industry research, In any event, it is not clear **that the difference in efficiency between gas turbine and Stirling engines and spark-ignition and diesel engines, assuming their respective R&D goals are met, will be sufficient to justify substantial industry conversion. The capital costs needed** to tool up for completely new engines will be very large, and the gas turbine and Stirling engines will have to be significantly superior to current engines for industry to make this investment. It the DOE program is to be justified because it motivates industrial research, analysis should be done to see how this compares to regulation in achieving the same end.

Issue 30

Electric Vehicles

Extensive commercialization of EVs is improbable unless improved batteries are made available.

Summary

The goal of the EV program is to promote and accelerate the commercialization of personal and commercial use of EVs. The major obstacle to extensive commercialization is the limited storage capacity of present-day batteries. Currently operating EVs use lead-acid batteries which are expensive and provide very limited performance. Improved lead-acid batteries may be forthcoming, but are still unlikely to be adequate to lead to a significant reduction in gasoline consumption. Most experts agree that EV commercialization would be greatly accelerated if batteries with improved service life and performance were developed. However, the current battery R&D budget amounts to less than 20 percent of the total EV budget of $42 million (fiscal year 1981 request).

Quest ions

1. Is the present demonstration program justifiable given the current state of battery development?
2. **Is** DOE's EV program duplicating the efforts private industry could be expected to make if adequate batteries were available to power a mass-marketable vehicle?
3. What energy/petroleum savings can be expected as a result of this program over the next several decades? At what cost?
4. What other benefits (and negative impacts) might be expected to accrue as a result of widespread EV use?
5. How much new utility capacity might be necessary to handle charging during peak-load hours, such as late afternoons when commuters arrive home and expect to plug in?

Background

The EV program budget accounts for a large percentage (37 percent) of the fiscal year 1981 transportation energy conservation budget request of $113 million. The program was enhanced by the passage of the Electric and Hybrid Vehicle RD&D Act of 1976 (Public Law 94-413) as amended by Public Law 95-238. These laws established requirements for EV demonstrations, provided financial incentives to industry, and emphasized the commercialization process. The goal of the EV program is to promote and accelerate the introduction of EVs into the national transportation fleet. The DOE program consists of four main elements: demonstration, incentives, product engineering, and R&D. The Product Engineering Branch and the National Battery Testing Lab are responsible for work in near-term battery development. DOE has concentrated on three battery types: lead-acid, nickel/iron, and nickel/zinc. In addition, research has recently been started on the zinc/chloride battery which, according to DOE, shows great promise.

A major obstacle to extensive commercialization of EVs is the high cost, weight, and relatively short service life of present batteries. The present range of EV's is approximately 50 miles between recharges, and battery life expectancy is 18 months to 3 years, depending on maintenance procedures. In addition, replacement costs for battery packs now range from $800 to $1,600. Nevertheless, improvements have been made in lead-acid batteries. Before the program started, lead-acid batteries typically stored 30 watthours per kilogram (Wh/kg). Recent tests show that improved lead-acid batteries will store more than 40 Wh/kg. Nickel/zinc batteries show a storage capacity of 60 Wh/kg. The near-term battery project's goal is to achieve 20- to 30-percent improvements in performance and life. The most promising batteries will then be used in vehicle testing. Federal support for battery R&D appears to be necessary and should be given proper emphasis.

Some experts feel that major automakers could readily build EVs if improved batteries were available, and that commercialization would not be a serious problem. Several companies in the private sector are currently designing and building EVs and industrial markets for specialized EVs already exist, such as industrial fork trucks, However, DOE has concluded that the demonstration of a small number of vehicles operated in "sheltered" environments would be a positive force toward commercialization and that optimization of non battery equipment is still necessary. DOE's demonstration project is oriented towards identifying, testing, and proving market sectors where EVs can be used. The demonstration project also provides necessary market support infrastructure.

EVs have the potential to become a preferred mode of transportation in urban areas for commuting and for small commercial and industrial shipments and limited personal transportation. EVs are less polluting and quieter than conventional vehicles in congested areas, and reduce the need for liquid petroleum. However, the EV's potential for petroleum savings will not be realized unless used in large numbers.

Buildings

Both the Office of Solar Applications for Buildings and the Office of Buildings and Community Systems have programs dealing with energy use in buildings. Solar Applications is responsible for active, passive, and hybrid solar systems for building heating and cooling as well as photovoltaics, which are discussed in Issues 22 and 23, Buildings and Community Systems is responsible for programs to improve the efficiency of energy use in buildings, building components, appliances, and community designs. These two offices are treated together here as a single DOE "buildings program" to highlight their complementary character and the need for a unified approach to innovation in the building sector.

The programs in Solar Applications include both system development and market development activities. Systems development focuses on the engineering phases of product development, while market development includes market testing and product support along with programs in information dissemination, training, education, building codes, standards, testing, and certification. Buildings and Community Systems contains major programs in community systems, consumer products, appliance efficiency standards, and building energy performance standards (BEPS). It is also responsible for the Residential Conservation Service (RCS) and the Federal Energy Management Program. The budgets for these programs from fiscal years 1979-81 are shown in table 7.

The solar energy DPR estimated that active heating and cooling systems could provide 2 Quads of energy while passive heating and cooling could provide 1 Quad by 2000. DOE has subsequently discussed short-term goals for 1985 of 0.2 Quad for active systems and 0.1 Quad for passive systems. Goals for energy conservation in buildings are less explicit. The DPR on solar energy contained an implied conservation goal of limiting demand to 95 Quads in 2000. What that level of demand might mean for the building sector is suggested by the report of the demand/conservation panel of the recently published Committee on Nuclear and Alternative Energy Systems (CONAES) energy study. In the panel's scenario involving 94 Quads of primary energy consumption in 2010, the building sector used 13 Quads — a reduction of 6 Quads from the 19 Quads used in buildings in 1978. The OTA report Residential/ Energy Conservation also supports the conclusion that dramatic reductions in building energy use are achievable.

Authorization for solar energy programs is scattered through legislation enacted from the 93d Congress (1973-74) to the present. The Solar Energy RD&D Act of 1974 established an Office of Solar Energy Research within the

Table 7.—Buildings and Community Systems and Solar Applications Program Budget Requests, Fiscal Years 1979-81 (in thousands of dollars)

	FY 1979 appropriation	FY 1980 appropriation	FY 1981 base	FY 1981 request
Buildings and community systems (CS):				
Building systems:				
Operating expenses	$17,600	$ 17,350	$ 17,350	$19,565
Capital equipment	900	750	750	500
Subtotal	18,500	18,100	18,100	20,065”
Appliance standards—operating expenses	*4,950*	*6,000*	*6,000*	*7,925*
Community systems:				
Operating expenses	*19,400*	*16,550*	*16,550*	*15,550*
Capital equipment	*300*	*250*	*250*	*250*
Subtotal	*19,700*	*16,800*	*16,800*	*15,800*
Urban waste:				
Operating expenses	*8,500*	*13,000*	*13,000*	*10,100*
Capital equipment	*0*	*0*	*0*	*800*
Subtotal/	*8,500*	*13,000*	*13,000–-*	*10,900*
Technology and consumer products:				
Operating expenses	*20,350*	*29,600*[a]	*29,600a*	*22,040*
Capital equipment	*0*	*0*	*0*	*200*
Subtotal	*20,350*	*29,600*[a]	*29,600a*	*22,240*
Analysis and technology transfer—operating expenses	2,800	5,400	5,400	5,900
Residential conservation service:				
Operating expenses	0	4,600	4,600	5,000
Capital equipment	0	0	0	200
Subtotal	0	4,600	4,600	5,200
Federal energy management program—operating expenses	500	700	400[b]	2,700
Small business—operating expenses	*500*		700	750
Emergency building temperature restrictions program—operating expenses		3,675	3,675	
Program direction—operating expenses	3,533	5,137	5,284	6,120
Total				
Operating expenses	78,133	102,412	102,559	95,650
Capital equipment	1,200	1,000	1,000	1,950
Total buildings and community systems	$79,333	‘$103,412	$103,559	$97,600
Solar applications:				
Systems development(CS):				
Operating expenses	$ 40,000	$ 52,000	$ 52,000	$ 54,500
Capital equipment	1,000	1.000	1,000	1.500
Subtotal	41,000	53,000	53,000	56,000
Market test and commercial applications				
Buildings:				
Operating expenses	(55,00)	(35,750)	(35,750)	(17,000)
Capital equipment		(1,000)	(1,000)	(1,000)
Subtotal	(55,000)	(367%0)	(36,750)	(18,000)
Agricultural and industrial process heat—operating expenses	(11,000)	(14,000	(14,000)	(20,800)
Photovoltaic—operating expenses	(15,000)	(10,000)	(10,000)	(35,200)
Total market test and commercial applications				
Operating expenses	81,000	59,750	59,750	73,000
Capital equipment	0	1,000	1,000	1,000
Subtotal	81,000	60,750	60,750	74,000
Market development and training (CS)—operating expenses	2,800	20,500	20,500	39,500
Solar international applications (CS)—operating expenses				4,000
Program direction (CS)—operating expenses	2,230	2,341	2,664	2,786
Total				
Operating expenses	126,030	134,591	134,914	173,786
Capital equipment	1,000	2,000	2,000	2,500
Total solar applications	$127,030	$136,591[c]	$136914	$176,286

NOTE Programs printed in italics are not specifically discussed in this document
[a]Includes $9 million for 40 kW fuel cell demonstration
[b]A supplemental request for $2.3 million has been approved by OMB and will be forthcoming
[c]Funding does not include $156.000 for cost of increased personnel contained in FY 1980 Supplemental Request

SOURCE *Congressional Budget Request FY 1981* VOl 2 Department of Energy January 1980 pp 24 and 27

Federal Government, and the Solar Heating and Cooling Demonstration Act of 1974 provided for commercial demonstrations of heating and cooling systems. The National Energy Act of 1978 contained an Energy Tax Act which provided purchaser tax credits for home installation of solar devices and an investment tax credit for businesses that install solar systems. The National Energy Act also contained NECPA, which authorized a program to install solar heating and cooling equipment on Federal buildings and a program of loans for solar devices operated through the Federal National Mortgage Association. The Energy Supply Act would create a Solar Bank to provide low-interest loans to purchasers of solar systems and also to provide for coordination of solar information dissemination programs. Other laws provide incentives to small businesses and farmers, encourage international programs, and mandate the use of solar equipment in military construction.

In the area of building conservation, the Non-Nuclear Research and Development Act of 1974 mandated RD&D to promote efficient energy use in residential and commercial buildings. The Energy Policy and Conservation Act of 1975 (EPCA) established programs in appliance efficiency standards and BEPS. NECPA created RCS and the Federal Energy Management Program.

Not all activities within the Office of Buildings and Community Systems are specifically examined in this analysis.

Issue 31

Retrofitting Buildings

DOE's conservation and solar buildings programs should cooperate closely to define and promote a strategy for retrofitting existing buildings with the most cost-effective combinations of conservation measures and solar energy systems.

Summary

DOE conservation and solar research programs focused on new buildings are important, but they have greatly overshadowed retrofit opportunities that could have an even larger impact on near-term energy availability. The oil and gas that could be saved by an aggressive retrofit program during the next 10 years is equivalent to discovering two Alaskan oilfields. The prospect of low economic growth and a tight capital market makes it essential to determine how conservation measures, passive additions, active solar systems, storage, and backup systems can be combined most economically for different kinds of buildings and climates, Developing a "least cost retrofit strategy" can be an opportunity for achieving a better integration of DOE's conservation and solar buildings programs.

Questions

1. Does DOE have a long-term strategy for retrofitting existing buildings? I f not, why not?
2. What is the balance of funding in the buildings research program between new buildings and retrofits? Between single-family and multifamily residences? Between residential and commercial buildings?
3. Have retrofit programs adopted a strategy for combining conservation measures and solar energy systems? Is consideration being given to the development of standards for existing buildings?
4. How much effort does the passive program allot to retrofit technologies and retrofit commercialization ?
5 What institutional and behavioral barriers are the major roadblocks to an aggressive retrofit program, and what Federal policies have been developed to remove these barriers? Is sufficient attention being given to behavioral research related to retrofit barriers?
6 How will the Department integrate what it learns in the weatherization and RCS programs, the active and passive solar buildings programs, and other related programs, to meet President Carter's goal of retrofitting 90 percent of the Nation's housing stock by 1 995?

Background

Over the decade of the 1980's, improving the energy efficiency of buildings can reduce U.S. dependence on depletable fuels more rapidly and at less cost than virtually any other energy policy action. OTA analyses indicate that cost-effective investments in conservation technologies could actually **decrease residential** energy use in 2000 (compared to 1977) with no loss of comfort and despite a substantial amount of new construction. Saving energy in buildings is a rare situation where the fastest and least expensive investments are also preferable because of the opportunities they present for individuals to protect themselves against rising fuel prices and for the Nation as a whole to improve environmental quality and generate new employment.

The current DOE buildings programs in both conservation and solar energy emphasize R&D related to new buildings. This reflects the large proportion of resources allocated to implementing BEPS, developing and testing new passive designs, and lowering costs on promising new conservation and solar technologies. While programs focused on new buildings are important and should be maintained, OTA research indicates that even more oil and gas can be saved over the decade ahead by programs to retrofit existing buildings. It will take over 50 years to replace most of the existing building stock, and most of these buildings are very inefficient because they were built during a period of cheap energy when there was little incentive for conservation (1 940-73). Substantial funding is earmarked for the schools and hospitals and weatherization programs, which directly affect existing buildings.

Table 8 indicates the potential impact of implementing an aggressive program for retrofitting U.S. residences and setting strict standards for new construction. It demonstrates that approximately two-thirds of the potential savings result from retrofits, with the remaining third resulting from improvements in new construction practices.

[1] *Residential Energy Conservation* (Washington, D.C.: Office of Technology Assessment, July 1979), OTA-E-92.

Table 8.— Potential Energy Savings by 1990 From Housing Retrofits and Strict Building Standards (millions of bbl/d oil equivalent)

	Oil and gas	Other	Total
Retrofit savings	1.9	0.4	2.3
Strict building standards. . .	0.7	0.9	1.6
Total savings	2.6	1.3	3.9

Assumptions
— Baseline case continues present construction practices to 1990 and includes no further retrofits
—Retrofit savings are based on 50°. heating savings and 20°. hot water savings in all existing housing still used in 1990
—Strict building standards Incorporate BEPS and 35% hot water savings in new buildings

SOURCE Testimony of Dr Henry C Kelly, OTA, before the Subcommittee on Energy Conservation and Supply of the Senate Committee on Energy and Natural Resources, July 31 1979

The potential retrofit savings of oil and gas by **1990** is equivalent to 1.9 million bbl/d of oil. That is over three times as much energy as the U.S. imported from Iran before their revolution and approximately half the total amount of recent imports from the Middle East. Moreover, the estimates in the table reflect only the potential savings available in residential buildings. Since commercial buildings use approximately 60 percent as much energy as is consumed in the residential sector, and since these buildings are often even less efficient than residential buildings, equally dramatic savings are possible through retrofitting buildings used for commercial and public services.

Still more oil and gas can be saved by incorporating solar **energy** systems in retrofit programs. To do this in the most cost-effective way will require research to determine the performance and economics of various combinations of conservation measures, solar energy systems, storage, and backup technologies for different types of buildings and climates. Information is needed on how much of a role passive solar additions can play in building retrofits, and how passive and active systems can best be combined. Above all, better information is needed to clarify what combinations of conservation measures and solar energy systems can be more cost effective than the conservation measures alone. Preliminary evidence indicates that "tight" conservation retrofits can reduce the collector area needed to meet building heating loads enough to improve the economics of solar heating. In addition, neighborhood-scale district heating systems using coal or solar energy may prove economically attractive as part of retrofit programs in dense urban and suburban areas.

The fact that many cost-effective retrofit products are not being used at present suggests that a successful retrofit strategy must address institutional and behavioral issues as well as technical issues. For example, financing is usually a more difficult problem for retrofits than for new construction. Some situations, such as retrofitting inner city multifamily rental dwellings, will require new Federal policies to remove barriers and provide incentives. Aggressive information and outreach programs are needed to influence the investment decisions of homeowners, landlords, commercial building operators, bankers, installers, and other groups.

Developing a least cost retrofit strategy addressing both technical and institutional issues will require closer cooperation between the buildings programs in conservation and solar. These programs already cooperate both formally and informally in several areas. The effort to define and promote the most cost-effective combinations of conservation measures and solar systems can provide an opportunity for these programs to reduce institutional divisions still further and to move toward an integrated DOE "buildings program."

Issue 32

Residential Conservation Service

DOE should conduct marketing research to identify the barriers to widespread public acceptance of energy audits and home weatherization measures as part of the planning for RCS. Its program design should take into account regional conditions such as local energy resources, previous consumer education, and local utility practices.

Summary

The RCS Program of DOE is based on the assumption that providing people with information about the cost effectiveness of weatherizing their homes will cause them to make such investments. Conflicting evidence exists about the validity of this assumption, and suggests that consumer response will vary in different areas according to regional energy conditions, utility programs, or prior State efforts to encourage energy conservation.

Quest ions

1. On what basis has DOE determined that the 35-percent response rate to the RCS Program is likely?
2. What research has DOE conducted to identify the barriers preventing people from investing in home energy efficiency?
3 Does DOE have plans to stimulate home weatherization should consumer response to RCS fall below expected levels?
4 Is a 5-year period long enough to allow residents to take maximum advantage of the program? To allow utilities to maximize return?

Background

The goal of the RCS Program is to offer energy audits to 95 percent of U.S. households by 1985, and to bring about a reduction in energy use in at least 35 percent of those homes through voluntary actions by homeowners. The program is based on the assumption that lack of information has prevented people from making energy-efficient improvements in their homes.

Despite the clear grounds for concern, no funds have been budgeted to identify **empirically** the barriers that may exist to the widespread enthusiastic public acceptance of this expensive, large-scale, high visibility, voluntary program. The $5,2 million currently budgeted for fiscal year 1981 is specifically meant for the operation of the program, e.g., review of State plans, development of model audit procedures, liaison and assistance to States, qualification of additional conservation measures, etc.

Lack of information may not be the only (or even a major) barrier to conservation. Evidence suggests that response to the RCS Program will vary in different regions, and will reflect energy costs, audit costs, public information campaigns, community action efforts, and the methods used by the utility to encourage participation. An analysis of consumer actions and attitudes, conducted in various regions and localities, would identify the real barriers facing RCS, For example, while ignorance about energy conservation might be the barrier in some areas, other considerations such as regional climate, availability of equipment, community concern, or previous utility experience with audits might prove to be more important than information in motivating people. In the State of California, utilities have already received a large volume of requests for audits, yet in other States, demand for audits has been small. Modification of the State programs to reflect these variations would contribute to the success of RCS.

In addition to conducting market research as part of its program design activities, DOE could build in an ongoing evaluation of RCS to assure that the solutions it offers continue to be appropriate, As energy costs continue to rise, RCS may well require modification to reflect changing economic conditions.

Issue 33

Passive Heating and Cooling

The passive heating and cooling program should emphasize designs and products that integrate passive, active, and conservation concepts. Greater efforts are needed on design tools, performance analysis, product development and testing, and basic R&D.

Summary

The passive program should cooperate closely with the active solar program and building conservation programs to identify and promote least cost solar building designs. **In general, the most cost-effective designs appear to be substantially "tighter" than typical construction practices today, leading to changes** in solar design philosophy. An expanded passive program will require increased staff and funding.

While the amount of R&D needed for a technology as "simple" as passive heating and cooling may seem surprising, optimizing the performance of passive systems actually requires a far more scientific approach to building design than has yet been attempted. Better data is needed on passive system performance, especially in multizone applications. Product development and test activities need to be expanded to include components for commercial as well as residential buildings. Basic R&D is needed on energy utilization in buildings, climate characteristics, and other environmental and physical phenomena that influence the performance of passive systems. Additional R&D is needed on passive cooling to determine its potential, which is not well understood.

Questions

1. Has the passive cooling program adopted a least cost strategy for combining passive solar features with conservation measures and active solar systems in new building designs?
2. Are detailed performance data being gathered from passive solar buildings of widely varied design, including designs with extensive conservation measures?
3. How much funding for product development and testing is being devoted to products for commercial buildings?
4. IS sufficient effort being devoted to basic R&D on energy utilization in buildings, climate characteristics, and environmental and physical phenomena affecting passive system performance?
5. How adequate are existing passive solar design tools?

6. To **what extent can passive cooling combined with dehumidification substitute for more expensive cooling** systems in residential applications?

Background

Passive systems represent a promising method for dramatically lowering energy demand. In the design of new buildings, as **in retrofits (see Issue 31), the passive heating and cooling program** should cooperate closely with the active solar program and building conservation programs to develop a more coherent "whole systems" approach. The goal should be to identify and promote designs that contain the most cost-effective combinations of passive solar features, conservation measures, and active solar systems for different types of buildings and climates

Table 9 shows the annual heating requirements of several types of recently built houses. The Balcomb house has a heating load of one-twenty-fourth the size of the typical U.S. house built in 1978 (some part of this difference can be accounted for by differences in climate and building size). Its heating load is so small that it can be met entirely by passive heating with a backup system The "tightest" house in the table, the well-known "Conservation House" in the cold climate of Regina, Saskatchewan, has such a low heating load that it can be met with modest passive features (mainly south-facing windows), a little more collector area than would otherwise be needed for solar water heating alone (9..5 percent of the floor area), and reasonably sized water storage (2.8 percent of house volume). The increased cost of its extensive conservation measures is largely offset by the reduction in required collector area and the elimination of a conventional furnace and heat distribution system.

Table 9.—Annual Heating Requirements of Selected Existing Houses (oil heat at $0.80/gal)

Typical U S. construction practice in 1978 scaled to correspond to a 1,400-ft² house in a 4,762 degree-day climate	$360
Bowman house near Gaithersburg, Md., 2,050-ft² house retrofitted by the National Bureau of Standards for $2,650	$200
Hart houses, Alexandria, Va., average for five speculative homes built in 1978 for an Incremental cost of $1,000 to **$2,000**	**$120**
Robinson house, Minneapolis, Minn., well-insulated house Incorporating passive solar heating .	$ **90**
Saskatchewan (Canada) Conservation House—super-Insulated house with modest passive solar system and small active system.	$ 20
Balcomb house, Santa Fe. N. Mex., heavily Insulated house with extensive passive solar features	$ 15

SOURCE Of fice of Technology Assessment

These particular buildings may prove to be extreme examples, but they illustrate the major changes in solar design philosophy that can occur as the Nation moves toward buildings with higher thermal integrity. Evaluating new designs like these, and many other possible combinations of conservation measures and solar systems, would almost surely lead to major changes in the DOE buildings programs as the most economical approaches are identified and refined.

The amount of scientific knowledge needed to optimize "simple" passive and hybrid designs is quite extensive. The effort is justified because the knowledge gained is likely to lead in time to a "scientific revolution" in the building industry. Moreover, design mistakes on passive buildings are big mistakes, difficult and expensive to correct. Research is needed to prevent such mistakes that could make builders and the public skeptical of the feasibility of passive solar design.

Better data on passive system performance are needed to guide further R&D efforts. Test cell and field-measured performance data are needed on a wide variety of systems, including clusters of relatively similar designs, because little is known about the sensitivity of performance to minor design changes and variations in environmental conditions Special attention should be given to identifying integrated passive heating and cooling designs that appear more effective for multizone commercial applications. Better quantification of passive system performance would also be valuable for the BEPS Program.

Product development and testing efforts are inadequate relative to the variety of geographical areas and building types for which new materials and components are needed. Glazings, absorber surfaces, storage systems, movable insulation, reflectors, shading devices, heat exchangers, sensors, actuators and controls, and other components all require further development and testing. Little product development has been done for commercial buildings, yet this area presents greater challenges than the residential area.

Passive designers need better data on climate characteristics, including information on local microclimates, day lighting, and cloud cover. More extensive basic physical studies are needed in solar insolation, landscaping, ground properties, atmospheric effects, night sky radiation properties, and heat exchange mechanisms. Data collected in these basic physical studies need to be integrated with system performance data to create better passive and hybrid solar design tools such as guidelines, handbooks, computer programs, and thermal models.

Additional R&D and information dissemination are needed on passive cooling. Some analysts believe passive cooling techniques, combined with dehumidification in humid climates, may eventually prove more cost-effective than active cooling or even conventional air-conditioning in many residential applications, but little is known about such systems today.

These areas of effort will require additional staff as well as a larger budget. The passive program has suffered substantially from the burdens of funding increases with no change in the size of the program staff.

Issue 34

Active Solar Hot Water and Space Heating

Nonhardware activities such as market development and the formulation of better "off-budget" policies should be emphasized in the active solar program, and R&D should be focused on long-term, high-risk, or generic problems.

Summary

The use of active hot water and space heating systems can now be accelerated more by market development activities, incentives, and other "off-budget" Federal policies than by Federal RD&D efforts. In recognition of this fact, the Off ice of Solar Applications for Buildings has been phasing out demonstrations and adopting a more comprehensive approach, supporting the development of the emerging solar industry in all phases of product development. This shift, which includes increased support for information and education programs, merits support. R&D funding should be maintained and focused on projects that are long-term, high-risk but high in potential rewards, or that involve generic problems and nonpatentable processes that industry is not likely to explore. Reducing the cost of active solar systems should be a prime goal in both systems development and market development activities.

Questions

1. How do the potential benefits of nonhardware actions for accelerating the use of active hot water and space heating systems compare with those of technology improvements?
2. Does DOE have the analytical capacity and level of staffing needed to design better "off-budget" policies to accelerate commercialization of solar systems?
3. Are programs for standards, testing, certification, professional and installer training, information dissemination, and education adequate to forestall constraints in the future?
4. Is Federal R&D on solar hot water and space heating systems duplicating efforts underway in the private sector or pushing into areas where the private sector would otherwise have a strong interest?
5. Is R&D being focused on long-term, high-risk, and generic problem areas such as materials research?

6. What cost reduction may occur from these R&D and market development activities?

Background

As a result of technical success over the past several years, the effort to accelerate the use of active solar hot water and space heating systems has shifted from R&D to field testing and market development activities, and is now supported by purchaser tax credits. This shift has been resisted to some extent, especially by the Office of Management and Budget, largely because present benefit/cost methods tend to discount benefits of nonhardware actions (e. g., solar information and education programs), which are difficult to quantify. This shift toward supporting all phases of product development appears fully appropriate, given the well-developed state of active hot water and space heating products. There is actually a risk that overemphasis on R&D directed at near-term results could tend to retard rather than accelerate investments in the private sector because of loss of market incentives such as proprietary know-how and patent protection.

A **great deal remains to be done to fully support the commercialization of these solar technologies beyond the** R&D stage. Many of the most effective measures involve "off-budget" Federal policies which have often been neglected in the past (see Issue 6). These include larger tax credits, loan programs, incentives, utility rate reform to prevent discrimination against solar homeowners, legislation and policy changes to equalize access to financing and equalize tax treatment, and initiatives to foster the development of institutional innovations like solar municipal utilities, solar co-operatives, or utility programs to finance and certify the installation of solar systems. An expanded capacity for economic and policy analysis is essential for developing better "off-budget" policies.

Many "on-budget" market development activities also merit increased support. For example, the lack of public confidence in solar systems is a major barrier. While too specific a set of performance standards could stifle cost-cutting innovations in the solar industry, it is important to increase support for the development of improved standards and testing and certification procedures. At present, the bewildering variety of State warranty and information laws makes it difficult for solar manufacturers to meet widely varying requirements.

Another major barrier is the widespread lack of adequate technical, economic, and market information. Few building professionals understand solar technology (active or passive) or appreciate its potential. Few heating, ventilating, and air-conditioning contractors or other potential installers are adequately trained. Expanded training programs could do a great deal to remove this barrier. Better information dissemination is also needed to consumers, industry, builders, bankers, State and local government officials, utilities, real estate appraisers, insurance agents, land use planners and other groups. Consideration should be given to expanded funding of the National Solar Heating and Cooling **Information** Service to allow it to market solar information more aggressively and to begin supplying conservation information. The demand for solar curriculum materials now greatly exceeds the supply at all levels of public education, and at the present level of funding only a small number of teachers and school administrators are able to participate in DOE-sponsored workshops and programs.

R&D on active hot water and space heating systems should be maintained and focused more specifically on areas that industry is not likely to explore. The understandable tendency to choose low-risk, high rate-of-return projects that can be preplanned for major milestones should be resisted; it tends to push R&D funding into areas where the private sector already has considerable self-interest, reduces market incentives for industry investment, and may lead to neglecting important new ideas and fundamental scientific advances. Thus it seems advisable to give priority to those R&D **areas in which risks are too great, the time** for commercialization too long, or the potential returns too low for private industry to countenance.

Key R&D **areas in** need of support include materials development, systems integration, selective surfaces, and thermal storage techniques. Materials R&D is especially critical because of the high and increasing cost of conventional materials, such as copper and glass, and the possibility of constraints on resource availability in the future. Research is needed on materials substitutes such as inexpensive plastics that can withstand high temperatures, ultraviolet light, inclement weather, and corrosive agents for periods of 25 years or longer.

Cost reduction should be a prime goal in R&D **as well as in market development activities.** As **recently** as 3 years ago, R&D on active solar heating did not treat the expense of proposed designs as a prime consideration. Perhaps the aerospace background of many researchers and policy makers entering the field of solar energy was a contributing factor to the emphasis on expensive, high-performance systems designed to maximize the energy extracted per square foot of collector surface. Now, however, there is a general understanding that a system must be cost effective to be good, no matter how excellent its technical performance. R&D should be directed at developing systems that are both technically efficient and cost effective, and at systems that are extremely low cost (even at some loss of efficiency). An immediate priority in this regard is the development of low-cost site-built systems applicable to new and existing homes of traditional design.

Issue 35

Solar District Heating

The potential importance of neighborhood-scale solar district heating systems in dense urban and suburban areas is not recognized in the C&SE budget.

Summary

DOE has done virtually no RD&D on neighborhood-scale solar district heating systems (10 to 1,000 dwelling units). Yet district systems may be the only feasible way to meet a large proportion of the heating load with solar energy in some high-density residential areas. These systems also appear likely to be economically attractive compared to individual building hot water and space heating systems in dense urban and suburban areas (more than eight people per acre) due to economies of scale in storage and collector operation. **In**creased RD&D funding also appears justified for the related, advanced concept of using solar ponds for community energy systems that provide both district heat and electricity.

Quest ions

1. Why has the Department done virtually no RD&D on solar district heating?
2. How much can the costs and land requirements of solar district heating be reduced by increasing the energy efficiency of the building stock?
3. Given a comparable degree of building tightness, how do the costs of solar district heating compare with the costs of solar units on individual buildings at different density levels?
4. What are the major technical problems involved in retrofitting neighborhoods with distribution mains under the streets and retrofitting houses with hot water pipes, heat exchangers, and ducts?
5. What institutional arrangements and financing mechanisms are necessary for building and operating district heating systems? Could local solar cooperatives play a major role?
6. Does DOE agree with SERI's finding that **solar** ponds are technically and economically feasible and capable of providing 1 Quad of energy annual l y by 2000?

Background

Solar district heating systems offer several potential advantages over individual building hot water and space heating systems in dense residential areas. Individual structures that are difficult to retrofit with solar systems can be served. The problem of "solar rights" can be minimized. Rather than having to create a solar "envelope" around each building– limiting the height of adjacent structures and trees to prevent the obstruction of sunlight—only the locations of clusters of collectors would need to be protected. In high-density neighborhoods where a large portion of the buildings lack the surface area to provide their own solar heating, district systems appear to be the only way to meet the heating load with solar energy,

The economics of solar district heating may be more favorable than is commonly realized, OTA's study of the *Application of Solar Technology to Today's Energy Needs* analyzed the cost of providing different forms of district heating and electricity to a new community of about 30,000 people living in an area a little more densely populated than the denser neighborhoods of Washington, D.C. (about 7,000 housing units per square mile). With fuel prices at historically low levels, district heating and cogeneration systems using conventional fuels cost less than any form of solar district heating **As** fuel prices rise, however, some of the less expensive solar district heating methods show a total monthly cost substantially less than the conventional district heating.

Solar heating with neighborhood-scale systems may prove cheaper than with individual building systems in many high-density residential areas because of significant economies in both storage and collector operation. The large shared-storage tanks now under consideration are cheaper and more efficient than the equivalent distributed-storage capacity. Large tanks can be better stratified than small tanks, or segregated into vertical cells They eliminate the need for storage in individual buildings and they can be backed up by a single cogenerator rather than individual furnaces in each dwelling unit. Because large-tank storage can operate on a true seasonal cycle, collectors can run at full capacity all year round. Collectors can be sited and oriented for optimal performance with less restriction, utilizlng areas like the space over parking lots and highways as well as building surfaces.

The major cost problem in district heating systems — the laying of distribution mains — may be reduced substantially if flexible plastic unrollable heat cables prove effective. Plastic heat cables are therefore an important area for R&D emphasis. In new developments, distribution mains could be laid along with other utilities. If natural gas pipelines were no longer installed, the overall cost of utility installation would not have to increase significantly because the amount of piping would remain constant. Some analysts (e. g., T. B. Taylor, A. B. Lovins, M. Ross, and R. Williams) believe properly designed neighborhood-scale solar systems could be less expensive than current individual building heating systems using electricity or oil.

Research is especially needed on the feasibility of retrofitting solar district heating systems into existing high-density areas. Some analysts believe it would be cost-effective to begin building small group and district heating systems in urban areas in the early 1980's, to be fueled by wastes or coal. They could be linked into larger, neighborhood-scale systems and converted to solar energy over time.

For existing urban areas, the most obvious technical difficulty with solar district heating is the land use requirement. The various ways of providing solar heating to the communities analyzed in the OTA study **all** require between one-quarter and one-half of the available land, which simply would not be feasible in many existing neighborhoods that are of high enough density to support district heating. This land use problem highlights the importance of increasing the energy efficiency of the housing stock to minimize the collective heating load and the collector area required to meet it. As a result, district heating retrofits may be most practical when combined with a more comprehensive building retrofit strategy.

The greatest barriers to solar district heating are probably institutional rather than technical. While municipal governments appear to have the jurisdiction to deal with the land use requirements of installing and operating district systems, new city and neighborhood-scale financing mechanisms and management arrangements are needed to allow communities to act in concert to realize the advantages of solar district heating. The lack of well-organized and well-financed neighborhood-scale constituencies is part of the reason why solar district heating has received so little attention.

A related, advanced concept, the use of solar ponds for integrated community energy systems, also merits increased RD&D funding. Ponds can provide district heating, low-temperature industrial process heat, seasonal heat storage, and electricity generated from heat engines that utilize the temperature variations that occur in salt-gradient ponds. A recent SERI study estimates that solar ponds could supply 1 Quad of energy annually by 2000, with an ultimate potential of up to 10 Quads. The low-level funding that solar ponds have received over the past few years is reduced in the fiscal year 1981 budget, despite the recommendation of the SERI study that ponds appear technically and economically feasible and should be vigorously pursued in the U.S. solar energy program.

Industrial Energy Conservation Programs

The potential for energy conservation in industry, which consumes **38 percent of the** U.S. energy budget, is very large. The sharp energy price rises of the 1970's left most industrial plants using energy at rates far above the economically optimum level. Most industry, in fact, was built when oil cost only $2/bbl.

The technical barriers to industrial energy conservation are not great, but institutional difficulties, especially in financing capital investments for energy conservation, can be severe. DOE's Office of Industrial Programs (OIP), however, is alloted only 0.6 percent of the total DOE non-Defense budget to meet this considerable challenge.

OIP will spend most of its $59 million fiscal year **1981** budget on demonstration programs (table 10). These programs, the cost of which DOE shares with private industry, are geared to demonstrate the technical and economic feasibility of existing and new energy-conserving devices and processes. The basis of this

Table 10.—Industrial Energy Conservation Program Budget Requests, Fiscal Years 1979-81 (in thousands of dollars)

Industrial energy conservation (CS)	FY 1979 appropriation	FY 1980 appropriation	FY 1981 base	FY 1981 request
Waste energy reduction:				
Operating expenses	$14,740	$16,450	$16,450	$19,800
Capital equipment	500	0	0	0
Subtotal	15,240	16,450	16,450	19,800
Industrial process efficiency:				
Operating expenses	14,400	20,675	20,675	19,000
Capital equipment	0	0	0	1,000
Subtotal	14,400	20,675	20,675	20,000
Industrial cogeneration:				
Operating expenses	5,000	10,750	10,750	12,000
Capital equipment	0	500	500	0
Subtotal	5,000	11,250	11,250	12,000
Implementation and deployment:				
Operating expenses	3,160	9,800	9,800	4,500
Program direction	2,193	2,067	2,131	2,600
Total:				
Operating expenses	39,493	59,742	59,806	57,900
Capital equipment	500	500	500	1,000
Total industrial energy conservation	$39,993	$60,242	$60,306	$58,900

SOURCE *Congressional Budget Request, FY 7987,* VOI *2,* Department of Energy, January 1980, p 48

approach lies in the belief that industries will not adopt unproven or unfamiliar technologies until it is demonstrated that the risk in their use is acceptably low relative to the potential for energy cost savings.

OIP selects, for the most part, unsolicited proposals which it finds consistent with its objectives and criteria. OIP's stated objectives are to:

- achieve maximum penetration of existing and new energy conservation technologies in as short a period as possible;
- substitute, where possible, abundant fuels for scarce fuels; and
- minimize the energy embodied in waste **streams of all types (discarded products, materials, and energies).**

Projects are selected to meet these objectives on the basis of high energy-saving potential, their effect on accelerating market penetration, nonredundancy with efforts of private industry, the degree to which benefits accrue to fragmented industries without research funds, and the degree and appropriateness of cost sharing. In addition to the foregoing, the following, more specific criteria must be met:

- return on investment for the investing industry must equal at least 15 **percent;**
- **the risk** to an industry of adopting the process or device involved is greater than industry is willing to accept;
- an industry is willing to share the cost of the demonstration project with OIP; and
- the value of energy saved by the project will be no less than 10 times as great as the Federal investment.

In addition to its RD&D efforts (authorized by the Federal Non-Nuclear R&D Act of **1974),** OIP conducts other programs in conservation. These include: setting and monitoring voluntary goals for energy and materials conservation [required by EPCA and NE CPA); funding of three pilot Energy Analysis and Diagnostic Centers (EADCs), which may be considered prototypes for an industrial energy extension service; and other programs for promoting the adoption of industrial energy conservation, including workshops, symposia, distribution of manuals, audiovisuals, and other materials. OIP must also evaluate the efficacy of mandatory efficiency standards for industrial equipment (pursuant to NE CPA), and works with the Internal Revenue Service (IRS) in drafting regulations for tax credits for investments in certain energy-conserving industrial equipment (in accordance with the Energy Tax Act of 1978).

Issue 36

Criteria for Selection

Improved criteria are needed for allocation of DOE funds to OIP, and for selection of projects within OIP.

Summary

Although OIP has established an analytical procedure for selecting industrial energy conservation R&D projects, there are indications that they may not be selecting the major conservation opportunities. First, the criteria used to select among industry groups for priority in funding projects do not seem to distinguish adequately among most of these groups. Second, budget constraints and OIP decisions have limited funding to relatively small demonstration projects. While this is not unproductive, it means that there is no opportunity to demonstrate new industrial processes or even large process steps that could result in major energy and cost savings. Third, fuel-switching projects, unless carefully structured to consider the unique properties of the target fuel, may not result in any increase in energy efficiency, It would be helpful in this connection for OIP to work in close cooperation with the program offices responsible for research on the fuels in question. Finally, it is possible that increased emphasis on an energy extension service, modeled after OIP's highly successful EADCs pilot programs, could be the best way to promote energy conservation in the next few years, Coupled with an effective OIP R&D program, this service could reach many indus-

trial operations currently lacking the resources to determine the best steps to take in reducing energy use.

Background

OIP has established a set of criteria for funding projects based on the amount of energy used by the industry, the fragmentation of the industry, the quality and type of fuel used, the difficulty of putting in a parallel process step, the private funds expended on RD&D, and the degree of secrecy connected with the process, **Using these criteria,** OIP has established a weighting system to judge the industry groups with the most potential for conservation through Federal R&D. The analytical methodology for selecting the best projects is commendable, but the process could be improved. The ratings for most of the industrial groups fall within **15 percent of each other which is probably too close to allow setting priorities among the various industries. This system provides no criteria for choosing among major energy-using equipment within one industry or across industries,** For example, examination of the OIP list of projects to be funded in fiscal year **1981** shows that industrial equipment that operates at high temperatures receives far more attention than devices that function at relatively low temperatures. Five types of equipment, ranging from furnaces with typical efficiencies of almost 50 percent (second-law efficiency), to ovens and heaters with efficiencies of an average of 23 percent, consume 30 percent of all industrial energy. Relatively low-temperature devices such as distillers, evaporators, dryers, washers, and sterilizers require 20 percent of U.S. industrial energy, but operate at efficiencies of only 0.3 to 6.0 percent (second law efficiency). Thus, the case could be made that devices with the greatest potential for improvement, that is, low-temperature equipment, are not receiving adequate attention.

The rating system does not truly clarify what OIP's priorities are, and it is difficult to evaluate its performance without better explanation of the selection process. It is clear, however, **that there are many** more opportunities to save energy that could benefit from DOE participation.

Another difficult in ensuring that the OIP projects accelerate industrial energy conservation is the limitation imposed by the budget and OIP decisions to fund small projects. **It** is not possible for **OIP** to demonstrate entire processes or even large process steps that could substantially reduce energy use and costs. In the past, industry could be counted on to introduce new processes because rapid economic growth allowed experimentation with new capacity production facilities,[2] Because growth may be slower in the near future, new energy-efficient processes will not be rapidly adopted except as replacements for old processes. Here the economic advantage of the new process will have to be great enough initially to offset the advantage the old plant has with its recovered capital investment (and its much lower initial price, because of subsequent rapid inflation). Without some way to demonstrate new processes that may be very energy efficient but are of high risk, their introduction will be greatly hindered.

Fuel switching can offer opportunities for more efficient processes, especially if account is taken of the unique properties of the new fuel. Most current fuel-switching projects in OIP, however, seem to be examining ways existing equipment can be altered to use different fuels. For example, most process furnaces are designed to burn oil or natural **gas. If they are modified to burn coal, they are likely to be less efficient even though a** more abundan fuel is burned. Designing a new process of process step around the fuel itself, however could result in a tar more energy-efficiency operation. The direct reduction of alum i nun project currently being undertaken by **OIP** is a good example; a fossil fuel process would be substituted for electricity with a significant in

[2] C A Berg, "Energy Conservation in Industry The Present Approach, the Future Opportunities," Council on Environmental Quality, Washington, D C, May 1979

crease in efficiency. Because of the necessity **for making the new fuel a major focus** in these cases, there should be a much greater role for the program off ice responsible **for that fuel,**

The complexity and diffuse nature of the Nation's industrial capacity may require that more than demonstration programs are needed to accelerate conservation. DOE should expand its excellent EADCs to a full nationwide industrial energy extension service to augment the demonstration program. Revision of the tax code to provide incentives for conservation investment, such as the 10-5-3 proposal for accelerated depreciation, could also bring Federal leverage worth billions of dollars per year to bear on the problem of industrial energy conservation.

Issue 37

Cogeneration

OIP should more effectively promote industrial cogeneration.

Summary

Industrial cogeneration could add perhaps 20 percent to existng U.S. electric generating capacity by using available, economical sources of industrially produced steam. Yet DOE spends only 0.1 percent of its budget on Industrial cogeneration. Although some of this money is used to demonstrate systems using conventional diesels and steam turbines, the principal effort is on systems that do not depend on gas or oil In addition to these needed demonstrations, more emphasis should be given to technical assistance for industrial cogeneration investments. A deeper problem n this connection is that the Fuel Use Act of 1978 and IRS tax regulations on tax credits for cogeneration equipment discourage the use of gas- and oil-fired systems. OIP should work with IRS, FERC, and Congress to promote the use of cogeneration where natural gas and/or esidual oil have to be used.

Questions

1. Would DOE assistance to industry in making technical and economic evaluations of possible systems hasten the adoption of cogeneration?
2. Would OIP recommend reviewing current policy about using oil and natural gas for cogeneration to see if systems using these fuels should be allowed the various tax credits now reserved for more abundant fuels?

Background

Industrial cogeneration, according to some sources, could add 100 gigawatts of electrical generation capacity for the United States with the retrofit of existing industrial sites. The use of this capacity would generally produce power at a cost savings of 1 cent or more per kilowatthour. DOE's promotion of industrial cogeneration, at a funding level of $12 million per year, or 0.1 percent of the DOE nondefense budget, is small relative to cogeneration's potential.

Proposed demonstration efforts may be less productive than would be provision of legal, financial, and technical expertise– in short, an extension service — to interested industries and utilities. The rate of acceptance of EADC recommendations for major capital investments for conservation in industry averages about 50 percent, and usually provides saving 10 times as great as the Federal investment in the extension service itself. This service typically consists of about 10 **days** of analyses, including a l-day audit, collection of energy consumption data, and benefit/cost analyses. The EADC service could be invaluable to the market penetration of industrial cogeneration.

Steam turbine and **diesel cogeneration systems are not new technologies,** and are not in need of technical demonstration. Institutional barriers to cogeneration are far greater than technical barriers. Natural gas and oil may be used very efficiently in these systems, and their use may be reasonable in existing industrial plants. The Fuel Use Act, the Energy Tax Act, and the Windfall Profits Tax Act all discourage this highly efficient use of oil and gas, however, either by prohibiting their use of these fuels outright, or by making such systems ineligible for tax credits. The recent IRS decision to make diesel cogeneration systems ineligible for these credits is a prime example of the Federal Governments' inconsistent position on cogeneration. DOE, IRS, FERC, and Congress should arrive at a consistent policy on this issue in order to promote the most efficient cogeneration systems.

Issue 38

Solar Agricultural and Industrial Process Heat

R&D for agricultural and industrial process heat should be focused on lower cost approaches, and should include work on demand analysis and high-temperature storage.

Summary

Continuing efforts should be made to reduce the cost of agricultural and industrial process heat (AIPH) systems through the development and testing of low-cost-collector designs and through R&D on materials, trackers and controls, and other components. A major effort is needed to better understand the demand for process heat — both today and in the future – and to clarify what process heat needs can best be met by solar energy, by cogeneration, and by other energy sources. Exploratory R&D is also needed on the feasibility of high-temperature thermal storage systems.

Questions

1. What R&D areas show the most promise for reducing the installed cost of AIPH systems?
2. What are the actual terminal temperatures required today by different industrial processes? What spectrum of temperatures would be required **if the preheat of process** material from ambient temperature is taken into account?
3. What is the temporal pattern of process heat demand? Could the development of high-temperature storage technologies make **solar systems more widely applicable and cost-effective?**
4. **What process heat needs can be met most** economically by solar energy, cogeneration, and other sources?

Background

Projected costs for solar process heat, even including presently understood opportunities for technical improvement, are considerably higher than industrial costs today. Consequently, the greatest R&D need in this area is for reducing the installed cost of **AIPH** systems. The AIPH program is already working in several important areas related to cost reduction, including the development and testing of low-cost line focusing collectors, large area collectors, dish-type collectors, site-built air heaters for crop drying, improved low-cost trackers and controls, and materials research. This emphasis on cost reduction should be reinforced and extended to every aspect of the program.

Critical to the development of solar systems to meet industrial demand for thermal energy is an understanding of the demand itself, today and in the future. A detailed survey of the temperature spectrum of U.S. industrial process heat should be undertaken by DOE and closely coordinated with the AIPH program and OIP, Since much heat of high thermodynamic availability is wasted today because it is used for low-temperature applications, the survey should identify the actual temperatures required by different processes rather than the temperature at which heat is currently provialed. It should examine not only the termina temperature desired, but also the correspond ing spectrum of temperatures required if the preheat of process material from ambient tern perature is taken into account. Consideration should be given to changes in demand that might occur as a result of waste heat recover} and process modification, I n addition, in order to establish the requirements to be met by thermal storage systems, the temporal pattern of demand should be investigated.

Many systems development and market development activities would eventually benefit from closer cooperation between the Off ice of Solar Applications for Industry and OIP. Joint participation in a major survey of industrial demand for process heat, and cooperation in related research to clarify what process heat needs can be met most economically by solar energy, cogeneration, and other sources, could provide an opportunity for these two programs to begin working together in a more coordinated approach to industrial energy problems.

There is disagreement concerning the need for R&D on high-temperature thermal storage systems. Some analysts believe that the industrial need to have energy available in spite of time of day or weather implies a priority need for R&D on high-temperature thermal storage systems, Others believe that storage is not an important consideration because high-temperature process heat applications will draw heat as fast as it can be provided by solar systems, or because storage would not be cost-effective compared to backup systems. An exploratory research effort to clarify these issues appears advisable. No work on high-temperature storage is being funded at present.