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FORUM on

ENERGY CONSERVATION IN BUILDINGS: IMPLICATIONS FOR TRANSPORTATION

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FOREWORD

In a transportation-dependent society constrained by potential shortages and the high costs of conventional fuels, as well as by sometimes conflicting national objectives for increased energy conservation, improved environmental quality, enhanced safety and decreased dependence on foreign petroleum supplies, the Department of Transportation has the responsibility to formulate policies that ensure the efficient, continued operation and performance of the nation's transportation system. In order to accomplish this task in the context of the above constraints, reliable information on transportation energy and the transportation system is required.

There are two general paths to decreased dependence of transportation on imported petroleum: (1) develop alternative transportation fuels derived from the domestic resource base, including the fuel made available for transportation due to increased conservation by other energy consuming sectors; and (2) utilize conventional transportation fuels more efficiently by maximizing transportation fuel economy or by other techniques such as increased mass transit, more efficient use of conventional automotive transportation, and fuels substitution. Currently, there is some consensus that each path appears plausible with appropriate research and development. There is considerably less agreement about the nature, magnitude, and implications of the impacts associated with each approach. Each path to decreased dependence on imported petroleum, while interdependent, is very different and has very different resource requirements, environmental impacts, technological development needs, economic consequences and other social, financial, and institutional effects. Furthermore, each path contains a wide assortment of options which are themselves interdependent. Thus, a very real need exists to develop a better understanding of each path, of the options within each path, and of the implications of the transitions involved in terms of their potential impacts on the transportation system and society.

In partial fulfillment of that need, the Transportation Systems Center (TSC) provides support to the U.S. Department of Transportation (DOT) Research and Special Programs Administration (RSPA) under the Transportation Energy Research Program. The objective of this program is to develop the information necessary to permit technological, economic, and institutional assessments of the options which may reduce transportation's dependence on imported petroleum. This program is being implemented by the Energy Demand Analysis Branch of the Office of Energy and Environment under the executive direction of RSPA's Office of Multimodal Research.

As one mechanism for obtaining the perspectives required, a series of discussion forums is being conducted to examine, in a selective way, the benefits, costs, and implications of some of the ways in which the dependency of the transportation sector on imported petroleum may be reduced. The forums are designed around specific issues and are not intended to be all inclusive. Discussion foci are determined on the basis of relevance, timeliness, and program requirements.

The second discussion forum, "Energy Conservation in Buildings: Implications for Transportation," was held December 9, 1980, under the joint leadership of Professor Arthur H. Rosenfeld, Professor of Physics, University of California at Berkeley, and Program Leader, Energy and Environment Division, Lawrence Berkeley Laboratory, University of California, and Mr. John K. Pollard, Economist, Transportation Systems Center, U.S. Department of Transportation. Professor Rosenfeld and Mr. Pollard organized the forum and identified the major issues to be discussed. Professor Rosenfeld accepted chairmanship of the forum and selected participants able to present current knowledge on the forum's topic. Prior to the forum, all participants received a copy of the discussion materials for the August 1980 Santa Cruz Summer Study entitled "Energy Efficient Buildings - Technical Potentials and Policy Recommendations for Conservation and Renewable Resources:

A Least Cost Scenario, 1980-2000,"* authored by A.H. Rosenfeld, D. Goldstein, J. Harris, D. Claridge and K. Gawell.

The forum proceedings were transcribed and edited to prepare this summary report. Several participants provided prepared papers which are included in this report. Mary D. Stearns and the TSC staff prepared the summary report based on the transcription and the papers submitted. The forum presentations clearly established that enhanced energy conservation in buildings will markedly reduce energy consumption by the year 2000. This reduction is tantamount to locating an alternative domestic fuel supply for transportation. It is forecast that, with conservation, by the year 2000, buildings will consume only 60 percent of their current levels, despite an anticipated population growth of 25 percent. It is possible to save this energy at an equivalent cost of $10 per barrel.

Conservation measures applied to different building sectors yield different savings. Adoption of proposed appliance standards will save 5 to 6 quads annually. Retrofit of existing residential and commercial buildings will save 4 to 5 quads of energy, respectively. Conformance to DOE's proposed Building Efficiency Performance Standards (BEPS) can save 1 quad of energy in new residences and 2 quads of energy in new commercial buildings.

The possibilities and difficulties of conservation vary markedly by sector. Retrofitting existing buildings requires considerable development of an institutional infrastructure to facilitate implementation of presently available techniques. Widespread adoption of state-of-the-art building standards to make new buildings maximally energy efficient requires cooperation between many levels of government. Public utilities, at present, are in the forefront of the institutions trying to encourage increased conservation in both existing and new buildings.

*Preparation of these discussion materials was supported by DOE under Contract W-7405-ENG-48. These discussion materials are part of the Solar Energy Research Institute (SERI) study, known as the "Sawhill" Study, much of which was incorporated in "A New Prosperity-Building a Sustainable Energy Future, the SERI Solar/Conservation Study," Brick House Press, 1981.

The magnitude of energy savings available through conservation in buildings was identified at this meeting. It also specified the present obstacles to enhanced conservation which, in most cases, are due to a lack of infrastructures and distribution mechanisms. The conservation "know-how" is lacking. In conclusion, substantially increased conservation in buildings appears to be attainable in the near future, given more attention to making it happen.

ABSTRACT

ENERGY CONSERVATION IN BUILDINGS: IMPLICATIONS FOR TRANSPORTATION

A workshop, held at the Transportation Systems Center on December 9, 1980, examined energy conservation in buildings to determine how much energy would be freed to, in effect, create an additional domestic supply of energy for transportation. A paper, distributed to the participants prior to the meeting, described the technical potential for energy conservation in buildings and gave a technical background for the opening presentation on Energy Conservation in Buildings. Subsequent presentations at the workshop included:

- The Public Utility's Role in Residential Energy Conservation,
- A Public Utility's Experience with Conservation,
- Household Energy Conservation: The Record and the Prospect,
- National Policy Issues Related to Energy Conservation,
- Conservation and National Policy, and
- Creating New Choices: Innovative Approaches to Cut Home Heating and Cooling Costs.

The major conclusion of the workshop, echoed by all participants, is that substantial amounts of energy can be saved in buildings, but the institutional infrastructure necessary is inadequate. With conservation, buildings in the year 2000 will use 60 percent of the energy presently consumed, despite a 25 percent growth in population. The following savings are possible by 2000: efficient appliances would save 5 to 6 quads, residential retrofits 4 quads, commercial retrofits 4 to 5 quads, energy efficient construction of new residential and commercial buildings, 3 quads.

It is possible to save half the oil currently consumed at a one-time cost of $10 per barrel. Approximately 8 million barrels of resource energy can be saved annually by installing presently available conservation techniques.

The workshop participants clearly recognize that attaining these levels of energy conservation is a massive undertaking. By 2000, 80 million existing dwelling units will need retrofits, and the projected 20 million new dwelling units will each need an additional $2,000 worth of conservation features. In addition, the 35 billion square feet of commercial space will need retrofitting. The total cost of this undertaking ranges between $300 and $425 billion. Accomplishing this requires the diversion of $150 billion of new capital for 20 years, or $20 billion per year.

It will be a major undertaking to attain the levels of conservation currently technically possible. Workshop participants included the following issues to be addressed:

- Conservation is affected by local characteristics. It is difficult for federal programs to be sufficiently varied and sensitive to local features. Federal programs should support, not dictate, conservation efforts.
- There is a general belief among policymakers that, if conservation is so clearly cost justified, it will happen regardless of government intervention. This may actually impede conservation because it fails to recognize the institutional and infrastructure problems limiting adoption of conservation.
- Cost estimates for installing energy conservation features are $200 billion for dwelling units, $100 billion for commercial buildings, and $125 billion for appliances. Installation of energy conservation features would cost approximately $2000 for each existing and new dwelling unit.
- The Residential Conservation Service (RSC) is now in place and offers a major opportunity to facilitate conservation.

However, it needs better audit procedures and more skilled "house doctors."

- Spending money to improve conservation in buildings is actually an investment in the energy supply. Structurally, conservation investments cannot be treated that way. Creative ways to finance conservation need to be identified.
- Conservation requires development of a knowledge-intensive service industry able to combine simple material, get the information into the field, and obtain consistent results.
- Households make decisions about conservation based on the inefficiency of their house, their knowledge of, and confidence in, conservation contractors, their available financial resources, a pay-back period shorter than anticipated length of residence, generally five years, and a perceived greater return on equity from conservation than from alternative investments.
- Approximately one-third of the dwelling units in the United States are tenant-occupied. Neither tenants nor owners have incentives to conserve energy. New programs such as Pacific Gas and Electric's (PG&E) Zero Interest Plan (ZIP) may offer incentives to landlords.
- Retrofitting should not be too hasty and result in "cream-skimming" because a second retrofit is very expensive. Retrofits should be comprehensive enough to approach the marginal cost of energy.
- Utilities have taken the lead in encouraging conservation, yet current definitions of utilities' rate base make such efforts to maximize the rate base of questionable financial value.
- California's utilities are in the forefront encouraging customers to conserve and providing financial incentives to do so, because of their lack of excess generating capacity. California's utilities must encourage conservation or build new central power plants.

- PG&E has a major conservation effort oriented to marginal cost. They have offered conservation opportunities in a state with an inverted rate structure and a variety of conservation programs tailored to various markets. They expect that, by the year 2000, demand will be reduced 25 percent.
- Successful conservation programs must address cost, the decision-making process, availability of delivery systems, and information transmission. Most current programs fail to consider these four criteria for acceptance of conservation.

PART I

INTRODUCTION TO FORUM

Richard John
Director, Office of Energy and Environment
Transportation Systems Center
U.S. Department of Transportation

The Transportation Systems Center (TSC) is concerned with the future of the automobile industry and with the implications for transportation of energy conservation in buildings. It is necessary to know how much fuel can be saved and how much fuel our buildings will use. As we look ahead to the year 2000, the answers to these questions will tell us how much pressure there will be on the energy supply in the future.

TSC has been very involved in studies of the future of the automobile industry which started in the early 1970's with the question "What is the energy conservation potential for the automobile?" In 1975, TSC began to provide information to the Department of Transportation to carry out the Energy Policy and Conservation Act. As part of this Act, the Secretary of Transportation had to define "economically practical" fuel economy standards even though the concept "economically practical" was unspecified. Because this term was potentially quite inclusive, TSC began to generate an information base on the motor vehicle system which included the technological trends, the trends in the manufacturing industry, the nature of the auto industry structure in this country, the location of auto plants, and the number of people working at auto plants. TSC also examined the motor vehicle industry structure worldwide.

The basic question considered was the future demand for fuel economy technology. What would occur in the worldwide automobile industry and, in particular, what pressures would be placed on the automobile industry in the United States? What sort of economic dislocation could be anticipated in terms of job and community dislocations?

Because of the information base developed on the motor vehicle industry, TSC has been able to provide information for major national public policy issues, specifically, the Chrysler Loan Guarantee Act and, more recently the International Trade Commission deliberations on import quotas and tariffs. For example, at the time of the Chrysler deliberations, TSC participated in a task force with the Treasury Department to try to anticipate what would happen if Chrysler collapsed. TSC identified the Chrysler plants, how many people worked there, and the unemployment levels in these communities. The magnitude of the impact of Chrysler's collapse was awesome. This is a classic problem. The society does not want to maintain collapsing or inefficient industries. However, if Chrysler collapsed, there would be 100,000 to 150,000 people unemployed. The first year's payments for unemployment funds and trade adjustment assistance would be $1.5 to $2 billion. The last figure is an OMB approved estimate.

TSC explored the nature of the transition to improved automotive fuel economy. If market forces push consumers so that they want four-passenger, 50 to 75 MPG cars, could consumers obtain these cars? The answer is yes. Where would these cars be built? It is quite conceivable that the United States could have a 50-75 MPG car fleet, but it would put a strain on the nation in terms of community and employment dislocation in the Midwest.

The first forum in a similar series, "Regional Impacts of Petroleum Alternatives," asked the question, "What are the impacts of the use of synthetic fuels and of the production of one to two million barrels per day of this fuel?" It treated this problem in the same framework as the auto problem, from a national perspective and then from the regional and community perspective.

This forum discusses the near and long-term implications of energy conservation in buildings. If there is major energy conservation in buildings, what are the implications relative to the auto industry, the synthetic fuel industry or, indeed, to industrial energy conversion, which will be the subject of a forthcoming forum.

PART II

PROGRESS IN ENERGY-EFFICIENT BUILDINGS*

(The Potential For Having 8 Million Barrels of Oil a Day By The Year 2000 At a Cost of $10 Per Conserved Barrel.)

Arthur H. Rosenfeld
Professor of Physics
University of California

There is considerable potential for energy conservation in buildings through the year 2000, as well as opportunities for cost effective energy conservation, i.e., improvements in energy efficiency. If a least-cost scenario is followed, energy consumption in 2000 would be half that predicted by the conventional forecasts of the Department of Energy's Energy Information Administration (DOE/EIA).

In 1981, the United States buildings sector will use approximately 13 million barrels of oil equivalent per day (Mbd), 6 Mbd of "fuel" (gas and oil), and 7 Mbd of resource energy to generate electricity. DOE/EIA projects that this 13 Mdb will become 15 Mbd in the year 2000; 5 Mbd of fuel (down from 6) and 10 Mbd of resource energy for electricity (up from 7). However, if the buildings sector followed a least-cost scenario, as described in the forthcoming "Building a Sustainable Future," the usage could be 7 Mbd, (from 15) while providing exactly the same goods and amenities.

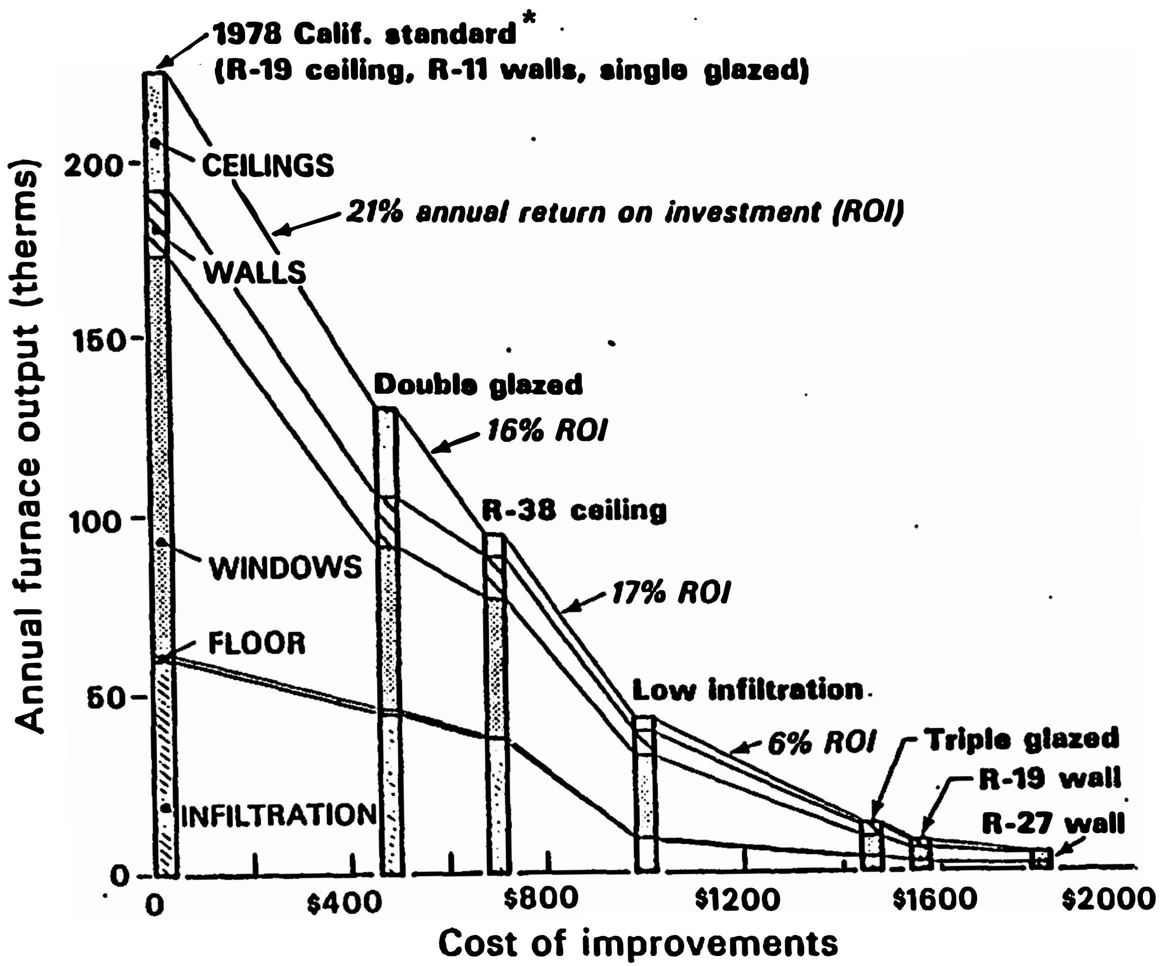
The 7 Mbd level is the "least-cost potential" and is calculated in the following way. Assuming the same numbers of houses (100 million), square feet of commercial buildings (50 billion),

*This paper is based on the author's work as Chairman of the Buildings Section for the Solar Energy Research Institute Study (SERI). It is a joint effort of the Lawrence Berkeley Laboratory (LBL) and SERI. LBL contributors include A.H. Rosenfeld, P. Cleary, D. Goldstein, J. Harris, J. Wright; SERI contributors were D. Claridge, K. Garwell and H. Kelly. Peter Cleary produced this overview statement.

refrigerators, and swimming pools, etc. in 2000, as used in the conventional DOE/EIA projections, ways were considered to reduce the energy use of each unit, each house, each commercial building, and each refrigerator, etc. The cost of each energy-conserving measure and its energy savings were calculated. Figure 1 shows the savings possible on the reduction in furnace output for a 1978 California standard house, if the windows are double glazed. There is a 21 percent return on investment; with an extra R-19 in the ceiling, there is a 16 percent return.

Computer simulations were compared with hundreds of retrofitted homes to ensure realistic calculations. The comparison is shown in Figure 2 and Table 1. Computer analyses of space heating retrofits of existing U.S. houses may be seen in Figure 2, a "supply curve of conserved energy." Figure 3 shows the cumulative energy saved by conservation measures taken in the optimum sequence and the cost of saving each successive unit of energy. A prudent approach to conservation would be to invest in energy efficiency until the cost of saving the last unit of energy was the same as today's average price. The large potential investment in energy efficiency is illustrated in Figure 3.

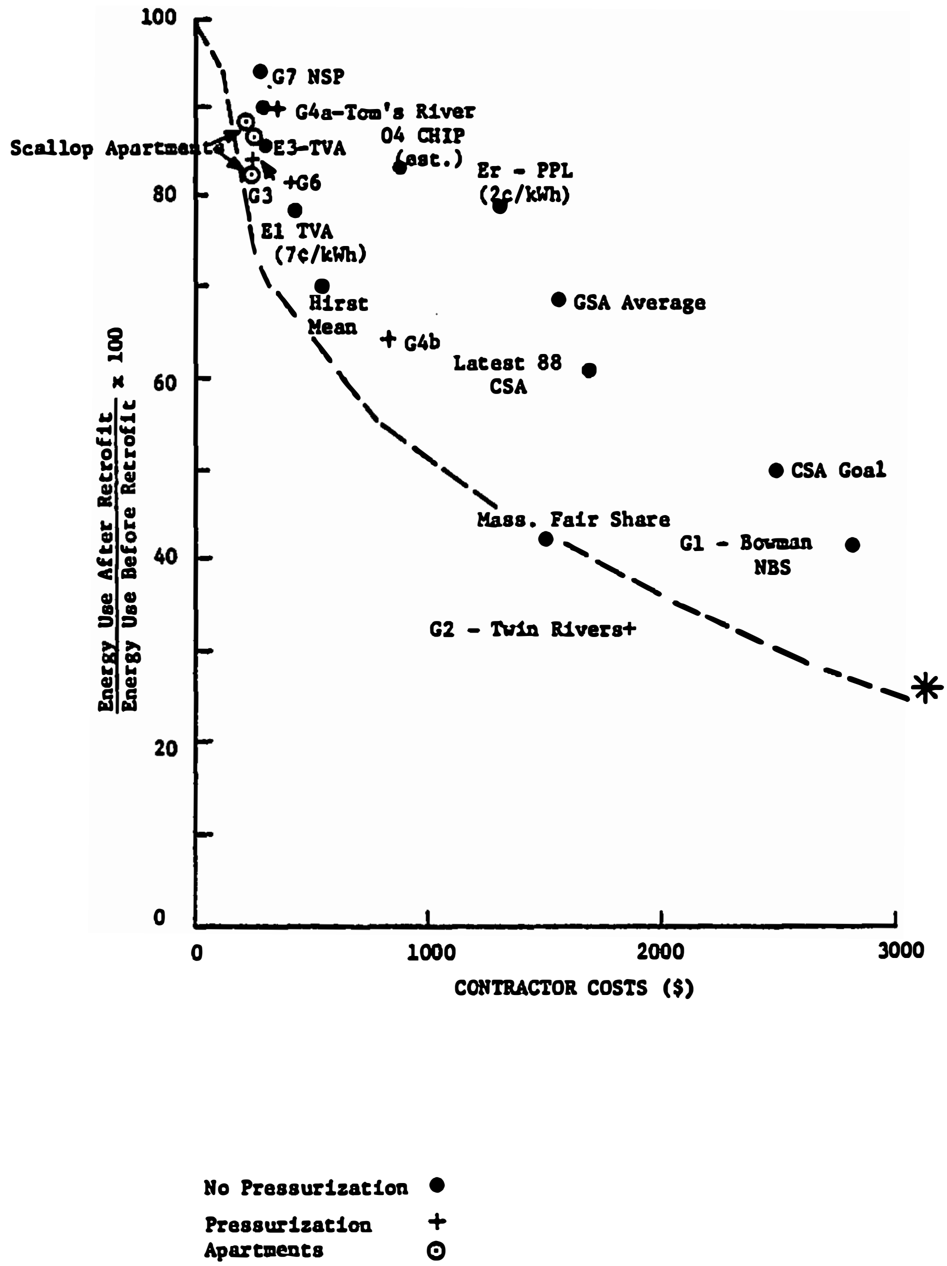
These analyses assume that the amenities provided by energy should remain the same or be improved; only the efficiencies were changed. Figure 4, an example of this, shows the cost of reducing the energy consumption of a frost-free refrigerator. By taking the first four steps shown in Figure 4, the energy consumption of this refrigerator can be reduced by almost 60 percent, for a $50 retail cost. At a 3 percent real interest rate, the cost of conserved electricity is 0.34¢/kWh saved. At today's price of 5¢/kWh, these improvements are cost effective. The Amana Corporation has already produced a prototype frost-free refrigerator which incorporates many of these improvements and uses only 65 kWh/mo. Because of the current interest in nuclear power, it is interesting to compare electricity use by U.S. refrigerators and freezers and the total U.S. nuclear electricity production. In 1980, refrigerators and freezers consumed 60 percent of this valuable electricity. In



*The base case bar at the left represents 1978 California standards for new houses (R-19 ceilings, R-11 walls, single glazed). This will be revised by 1982 to match new fuel prices. The Returns On Investment (ROI) assume that after deregulation (by 1985) gas will cost 60¢/therm (= oil at $35/bbl).

Source: Reference 6.

FIGURE 1. HEATING ENERGY USE OF A NEW SACRAMENTO, CA, HOUSE UNDER VARIOUS "TIGHTNESSES" OF INSULATION AND INFILTRATION.



*The dashed line is a derived form of the supply curve for fuel heated homes. (See Table 1 for labels and locations of retrofitted and Gas Heated homes.)

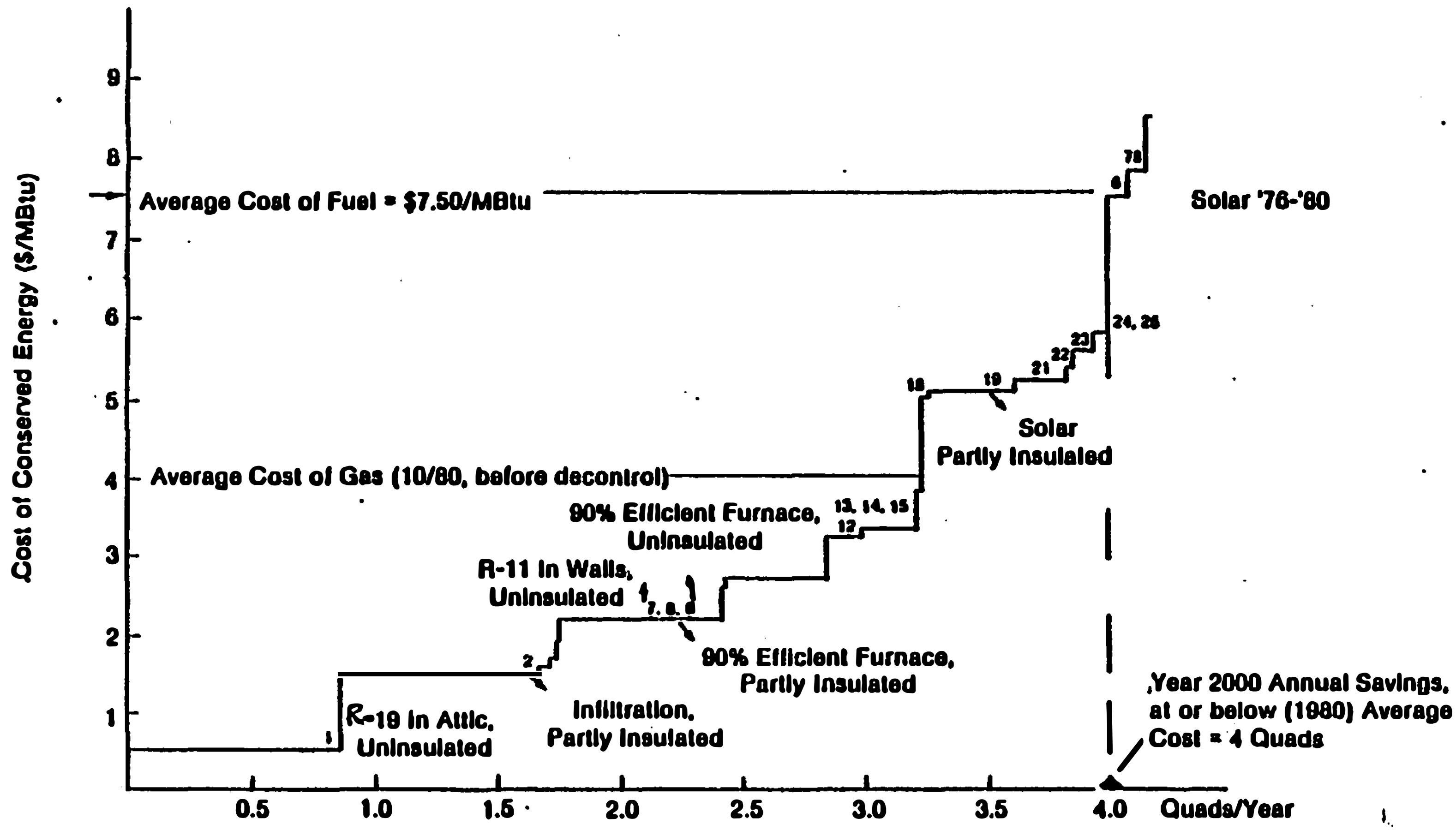
FIGURE 2. RETROFITS ALREADY CARRIED OUT ON HOMES IN THE U.S. AND CANADA COMPARED WITH THE RETROFITS ASSUMED IN THE CALCULATION ON THE SUPPLY CURVES.

TABLE 1. RESIDENTIAL RETROFIT SURVEY, GAS HEATED HOMES

Label	Number of Homes	Location/Sponsor	Annual $Saved / $Invested	Energy (MBtu)	Annual After/Before	Savings (MBtu)	Cost of Conserved Energy at 6.7% Capital Recovery Rate	Heating Heating/ and Hot Water	Comments
G1	1	Bowman House, MD NBS total	$175/$2840	52/125	- 41.5%	73.	$2.59/MBtu	H	
		(a) storm windows	$75/$780	93/125	- 74%	32.	$1.65/MBtu	H	
		(b) insulation	$100/$1870	83.0/125	- 66.7%	41.8	$3.00/MBtu	H	
		(c) infiltration	$0/$190	125/125	- 100%	0.		H	
G2	1	Twin Rivers, NJ Princeton	$120/$1750	20/60	- 33.3%	40.	$2.93/MBtu	H	
G3a	5	Freehold, NJ Princeton	$84/$220	96/120	- 80%	24.	$.61/MBtu	H	No Hot Water System Retrofits
G3b	5		$105/$260	143/173	- 83%	30	$.58/MBtu	H&W	This Included the Hot Water Retrofit
G4a	6	Tom's River, NJ Princeton	$25/$200	60.5/67.5	- 89.6%	7.	$1.91/MBtu	H&W	This Was a Partial Retrofit
G4b	6		$87/$800	42.5/67.5	- 63%	25.	$2.14/MBtu	H&W	This Was a Complete Retrofit
G5	1	Miller House, NJ	/$1000	83/113	- 73%	30.	$2.24/MBtu	H	
G6	1	Settles House	/$500	35/59	- 59%	24.	$1.40/MBtu	H	
G7	84	Ramsey County, MN Northern States Power	/$289	180.4/192	- 93.9%	11.6	$1.67/MBtu	H	
G8	8	Oakland, CA CSA	/$257		- 93%	3.	$5.76/MBtu	H	
G9	10	Atlanta, GA CSA	/$876		- 76%	36.	$1.62/MBtu	H	
G10	20	St. Louis, MO CSA	/$1752		- 82%	27.	$6.35/MBtu	H	
G11	10	Tacoma, WA CSA	/$1779		- 53%	81.	$1.48/MBtu	H	
G12	10	Chicago, IL CSA	/$2162		- 59%	120.	$1.21/MBtu	H	

TABLE 1. RESIDENTIAL RETROFIT SURVEY, GAS HEATED HOMES (CONTINUED)

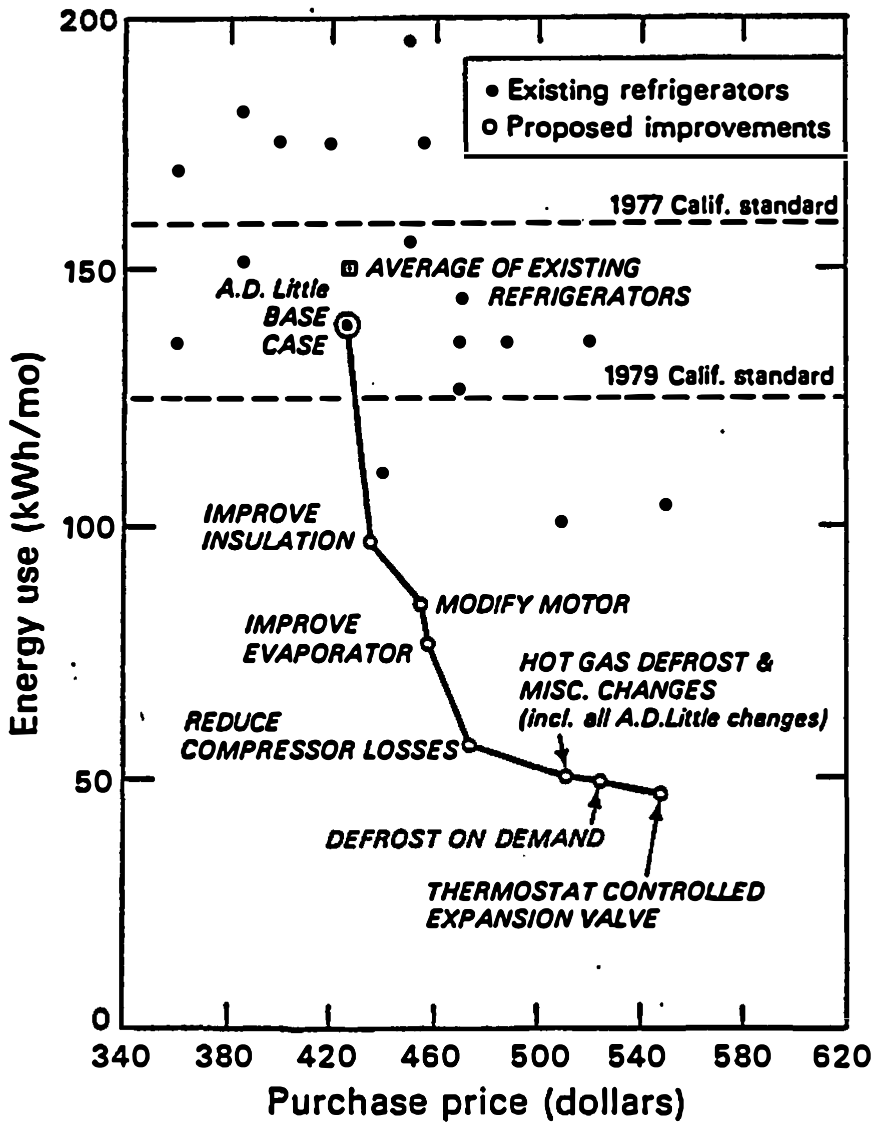
Label	Number of Homes	Location/Sponsor	Annual $Saved / $Invested	Annual Energy (MBtu)	Annual After / Before	Annual Savings (MBtu)	Cost of Conserved Energy at 6.7% Capital Recovery Rate	Heating Heating/ and Hot Water	Comments
G13	17	Minneapolis, MI CSA	/ $1761		- 78%	54.	$2.19/MBtu	H	
G14	13	Fargo, ND CSA	/ $1638		- 59%	90.	$1.22/MBtu	H	
G15	17	Colorado Springs, CO CSA	/ $1852		- 50%	120.	$1.03/MBtu	H	
G16	14	Charleston, SC CSA	/ $996		- 73%	15.	$4.65/MBtu	H	Bottled Gas
O1	12	Portland, ME CSA	/ $2083		- 60%	120.	$1.15/MBtu		
O2	12	Easton, PA CSA	/ $934		- 74%	33.	$1.90/MBtu		
O3	4	Washington, DC CSA	/ $2922		- 67%	94.	$2.08/MBtu		
O4	7-800,000	Canada CHIP	/ $410	800-850 / 1000	- 80-85%	150-200 gal.	$.14-.18/gal		Estimate No Measurement
E1	500	Tennessee TVA	$61 / $310	7937 / 10,148	- 78%	2211.	.9¢/kWh		Savings Only For Heating
			$17 / $310	2014 / 2646	- 76%	632.	3.3¢/kWh		Savings Only For Cooling
			$78 / $310	9951 / 12,794	- 78%	2843.	.7¢/kWh		Combined Heating and Cooling
E2	138	Tennessee TVA	/ $150-$300	12,379 / 16,490	- 75%	4111.	.24-.48¢/kWh		Attic Insulation Only
E3	81	Tennessee	/ $440	11,367 / 17,488	- 65%	6121.	.48¢/kWh		Weatherization
E4	1896	Oregon Pacific Power and Light	/ $1335	17,066 / 21,305	- 80%	4261.	2¢/kWh		



Note: The year-2000 baseline for this annual use is 5.5 quads.

Source: Reference 1.

FIGURE 3. YEAR 2000 SUPPLY CURVE OF CONSERVED ENERGY (IN QUADS/YEAR) FOR SPACE HEAT OF FUEL-HEATED DWELLINGS BUILT THROUGH 1980.



Note: The closed circles in the upper half of the Figure represent 16.0-17.5 cu. ft. top-freezer, frost-free refrigerators sold in California in 1976. The open circles in the lower half represent proposed redesigned refrigerators. California standards for maximum energy use allowable for refrigerators of this type are shown. Federal standards cannot be displayed because they involve weighted averages over all classes and sizes rather than class-specific maximum energy consumption.

Sources: LBL surveys of the cost and energy use of refrigerators currently available in California (Reference 8) and a 1977 report by Arthur D. Little, Inc., "Study of Energy-Saving Options for Refrigerators and Water Heaters."

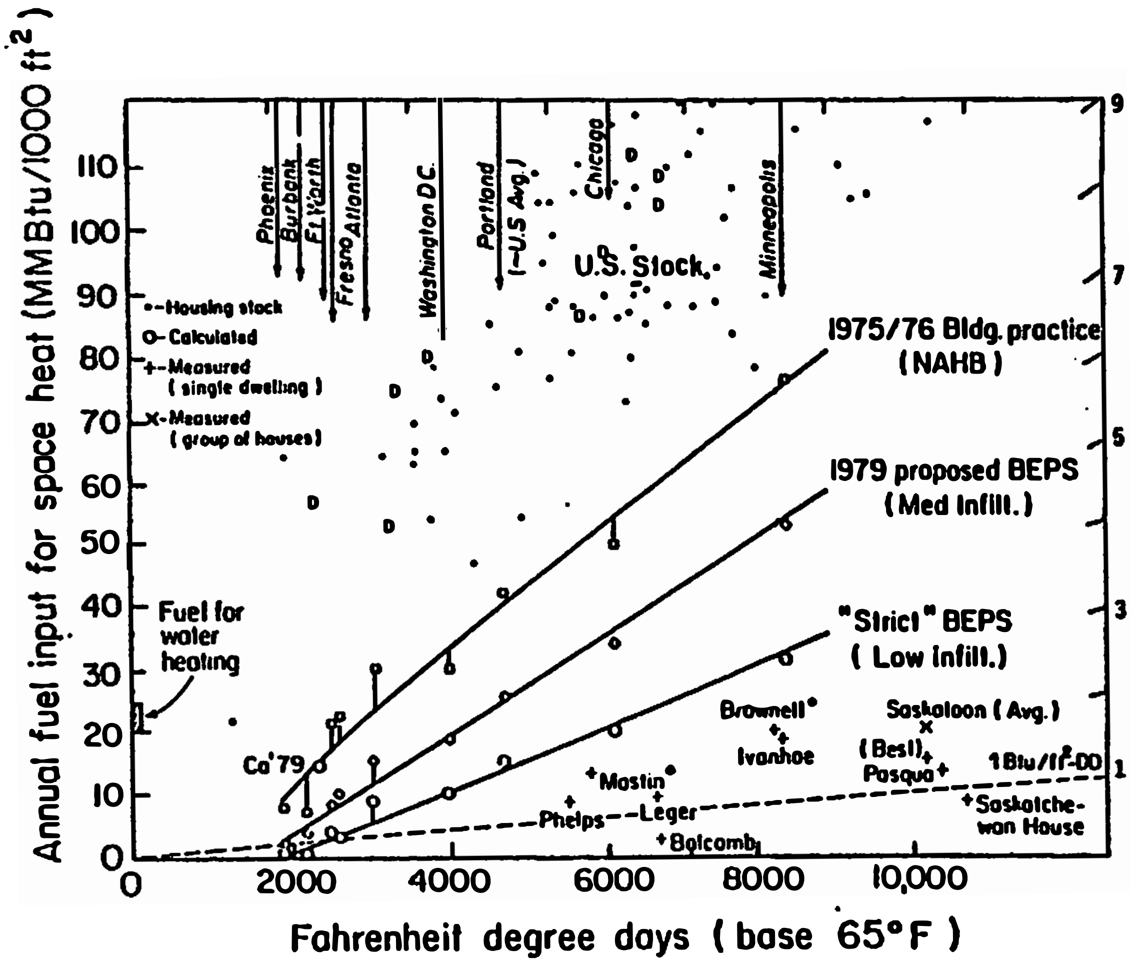
FIGURE 4. ENERGY USE VERSUS PURCHASE PRICE FOR A NUMBER OF EXISTING AND PROPOSED REFRIGERATORS

addition to refrigeration, the performance of freezers, ranges, clothes dryers, air conditioners, water heaters, and other household appliances was also analyzed to determine which improvements in energy efficiency were most cost effective.

For new houses, computer analyses, carried out at LBL for the Building Energy Performance Standards (BEPS) were compared with the energy consumption of a number of well-built houses in the U.S. and Canada. The results of this research are shown in Figure 5. From left to right in Figure 5, the climate gets harsher, and fuel consumption increases. The dots towards the top of the Figure are actual gas sendout to typical homes in 1978. The uppermost diagonal line represents 1975/1976 building practice, as shown by the National Association of Home Builders data. These houses consume far less energy than the existing stock, and this trend continues through the various proposed versions of BEPS. The crosses show actual cost effective houses, varying in location from New Mexico to Saskatchewan. None of the new houses in the study, even for the year 2000, get as low as these existing houses in energy usage. New house estimates may be high as far as energy for space heating is concerned.

Figure 6 shows the results for space heat, water heat, and appliances combined, as well as 1980 energy consumption by residences. Consumption in the year 2000, assuming no improvements in efficiency and the least-cost technical potential may also be seen. The supply curves for conserved energy appear as Figures 9(A) and (B). Further details of how the numbers were derived may be obtained from "A New Prosperity: Building a Sustainable Energy Future," (Reference 1).

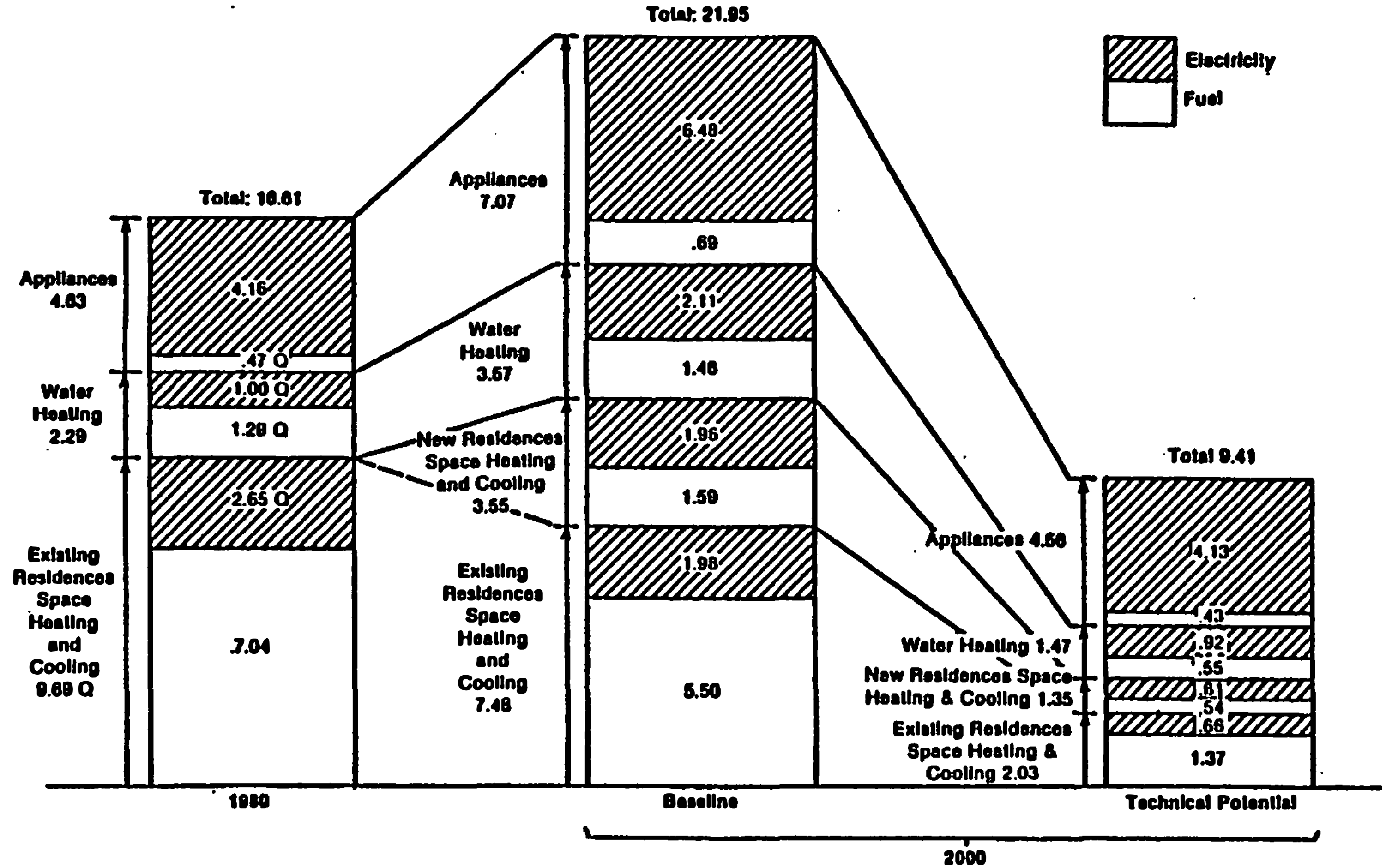
A similar analysis was carried out for commercial buildings. To illustrate the opportunities for energy conservation, the energy consumption of buildings and cars are compared in Figure 7. On the left of Figure 7 is the recent drop in fuel consumption by automobiles, with competing imported models for comparison. On the right is the similar picture for commercial offices, including the voluntary standards drafted by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). The orig-



Note: Dots are actual gas sendout to residential customers for space heat for calendar 1978. 1979 proposed BEPS leaves infiltration at current practice levels of 0.6 air changes/hour (ach); strict BEPS reduced infiltration to 0.2 ach but restores 0.4 ach with mechanical ventilation through a heat exchanger. Approximate extra costs for conservation above 1975/76 practice: BEPS, $1000; tight BEPS, $1500; better-than-BEPS houses, several hundred to several thousand dollars.

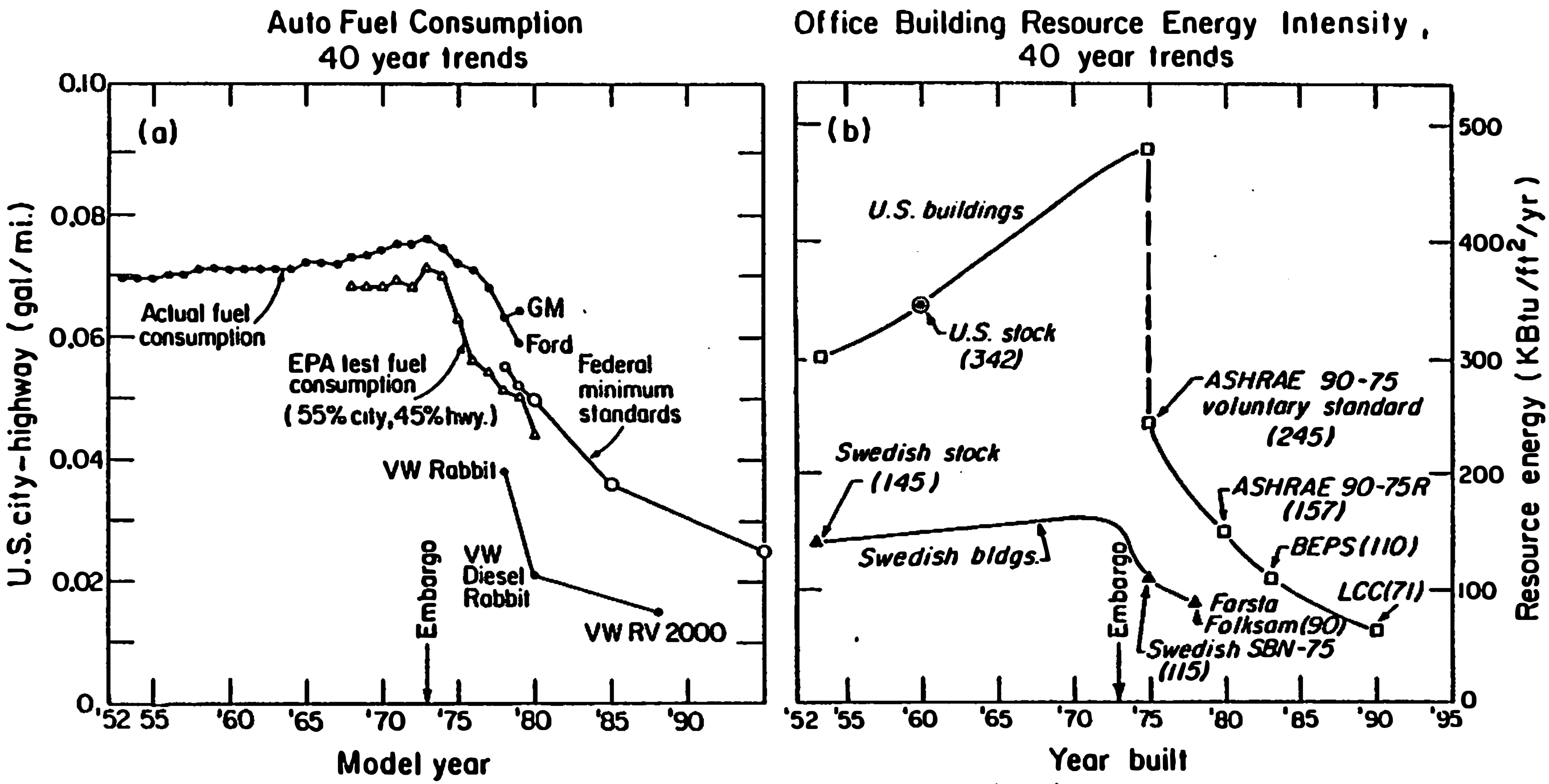
Source: Reference 7.

FIGURE 5. ANNUAL FUEL INPUT FOR SPACE HEAT IN SINGLE-FAMILY U.S. HOMES



Source: Reference 1.

FIGURE 6. GRAPHIC COMPARISON OF ANNUAL ENERGY USE, IN QUADS (2.1 QUADS = 1 MILLION BARRELS OF OIL EQUIVALENT PER DAY), 1980 AND 2000. BASELINE AND TECHNICAL POTENTIAL, RESIDENTIAL SECTOR.



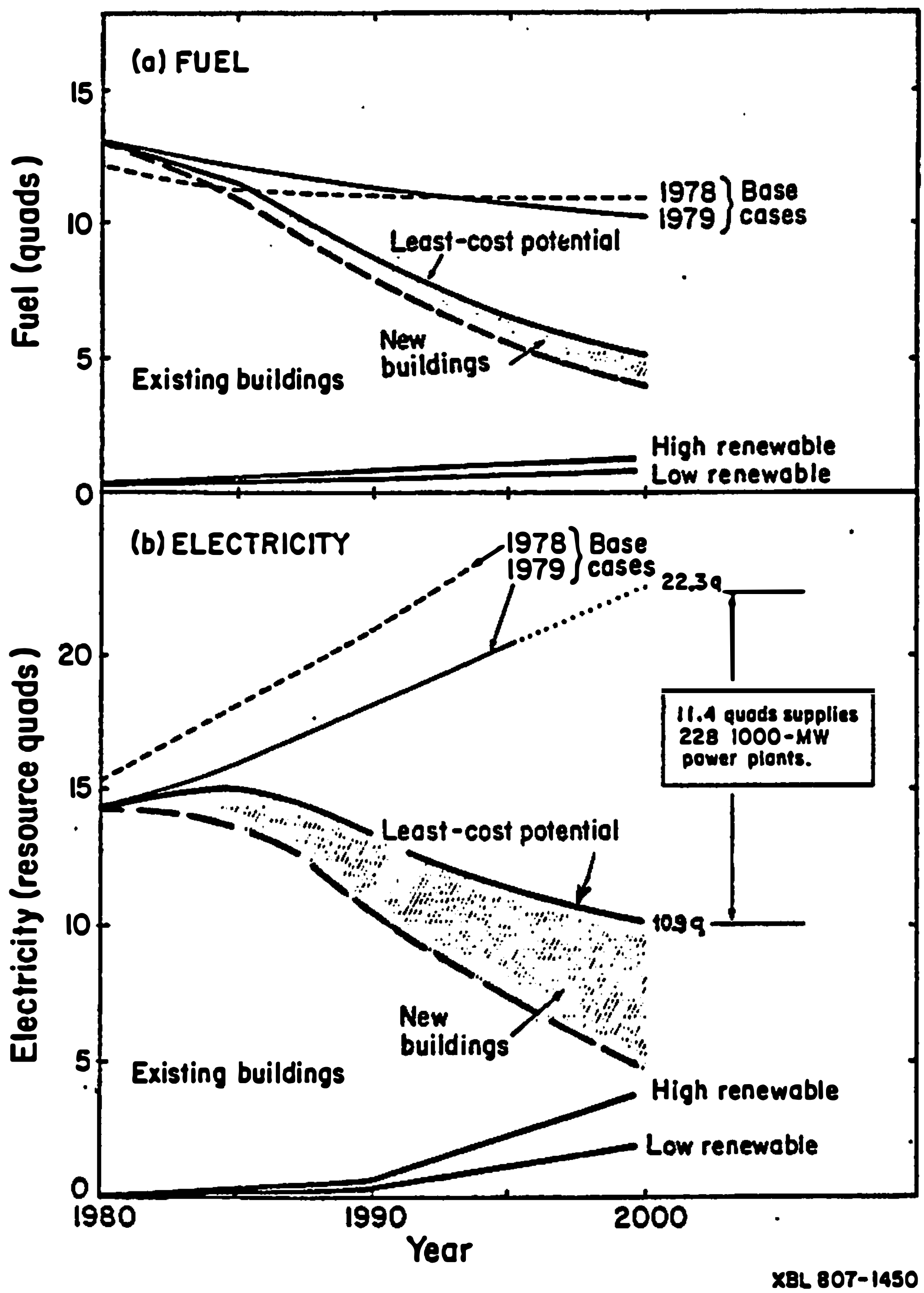
Sources: Society of Automotive Engineering Transactions, 750957; J. Pierce, 1975, Scientific American 232.1 (January 1975); F. von Hippel, 1980, "U.S. Transportation Energy Demand - Draft Report," (July, 1980). Office Buildings: Energy Efficient Buildings - Draft Report, LBL 11300, EEB 80-6.

FIGURE 7. HORSEPOWER RACE, AUTOS VS. OFFICE BUILDINGS. A 40-YEAR PERSPECTIVE, MEASUREMENTS VS. CALCULATIONS.

inal 1975 Standard 90-75 was so successful that it was upgraded to 90-75R and is being drafted for 1985. The redrafted standards will probably come out at the level labelled "BEPS", which is the 1980-proposed Building Energy Performance Standard for office buildings. Figure 7 also shows preliminary "LCC" point from the BEPS research program for a least life-cycle cost building.

Figure 8 and Table 2 show the effect that a least-cost investment program would have on U.S. energy consumption. Most of the reduction is in the consumption of existing buildings, since new buildings are assumed to be built to high standards. The potential drop to one half the conventional DOE/EIA projection is clear. To achieve this reduction in both cost and energy use, about $2000 should be invested in each existing and each new dwelling unit, requiring a total investment of $200 billion. Similarly, about $2 should be invested in each square foot of new and existing commercial floorspace, for a total of $100 billion. Finally, about $1250 per home should be invested in efficient appliances, furnaces, heat pumps, air conditioners, heat exchangers, water heaters, freezers, refrigerators, low-flow shower heads etc., for a total of $125 billion. The total investment is $425 billion. This $425 billion, over 20 years, i.e., $20B/year, is small compared to the 1977 annual capital investment of approximately $75 billion (1980 dollars) made in energy supply industries. Further, an attractive difference between more efficiency and more supply is that once a power plant or a synfuel plant is built, it still has to be supplied with coal, oil, or shale. An energy-efficient building needs no annual investment in inputs and produces no environmental impact.

The average cost of saving each barrel of oil equivalent is about $10, calculated as follows: Assuming a 20 year lifetime for the typical investment and a real discount rate of 3 percent (in constant 1980 dollars), the $425 billion investment costs $28 billion per year. The savings achieved by this investment are 8 million barrels of oil per day, or 2.9 billion barrels per year. Each barrel thus costs about $10 in this analysis. The cost analysis is explained in detail in "A New Prosperity: Building a Sustainable Energy Future."



Note: Projections are from the Department of Energy's Energy Information Administration, potentials from the building section of Reference 1.

FIGURE 8. PROJECTIONS AND POTENTIALS FOR ENERGY CONSUMPTION BY THE U.S. BUILDING STOCK IN 2000.

TABLE 2. SUMMARY OF PRESENT AND YEAR 2000 ENERGY CONSUMPTION

	Year 1980			Year 2000: Baseline			Year 2000: Conservation Measures to Current Cost of Oil and Electricity			Year 2000: Conservation and Solar Measures to Current Cost of Oil & Electricity		
A) Residential	Fuel(Q)	Elec. (Q resource)	Total	Fuel(Q)	Elec. (Q resource)	Total	Fuel(Q)	Elec. (Q resource)	Total	Fuel(Q)	Elec. (Q resource)	Total
Existing Residences Space Heating and Cooling	7.04	2.65	9.69	5.50	1.98	7.48	1.95	0.88	2.83	1.37	0.66	2.03
New Residences Space Heating and Cooling	-	-	-	1.59	1.96	3.55	0.74	0.92	1.66	0.54	0.81	1.35
Water Heating	1.29	1.00	2.29	1.46	2.11	3.57	0.75	1.26	2.01	0.55	0.92	1.47
Appliances	0.47	4.16	4.63	0.68	6.67	7.35	0.43	4.13	4.56	0.43	4.13	4.56
Residential Total	8.80	7.81	16.61	9.23	12.72	21.95	3.87	7.19	11.06	2.89	6.52	9.41
B) Commercial	Fuel(Q)	Elec. (Q resource)	Total	Fuel(Q)	Elec. (Q resource)	Total	Fuel(Q)	Elec. (Q resource)	Total	Fuel(Q)	Elec. (Q resource)	Total
Existing buildings	4.8	5.6	10.4	3.2	10.1	13.3	1.6	2.4	4.0	1.6	2.4	4.0
New buildings							0.2	3.1	3.3	0.2	3.1	3.3
Commercial Total	4.8	5.6	10.4	3.2	10.1	13.3	1.8	5.5	7.3	1.8	5.5	7.3
C) TOTAL	13.6	13.4	27.0	12.4	22.8	35.2	5.6	12.7	18.3	4.7	11.0	16.7

Source: Reference 1.

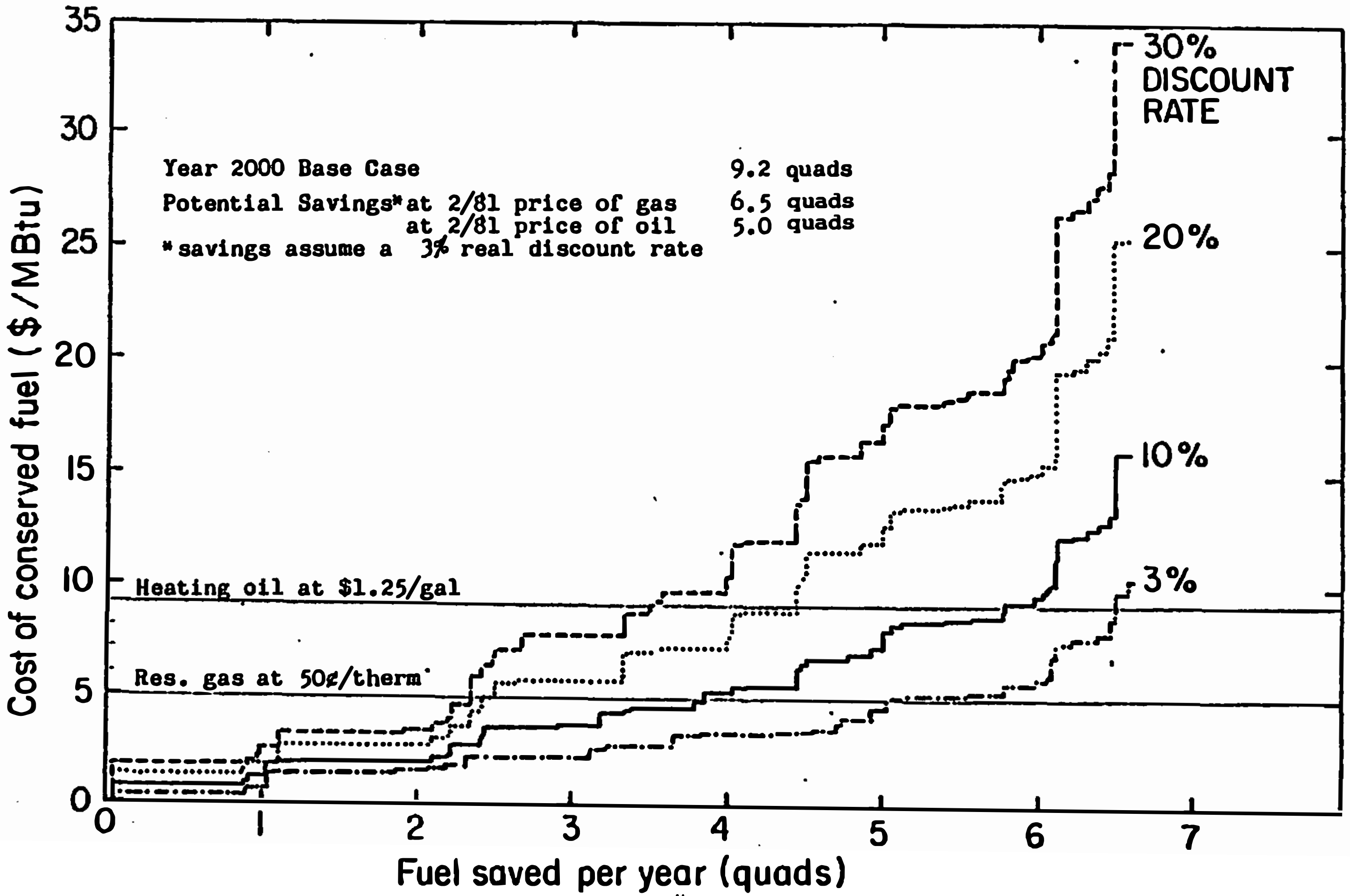
Note: These baseline entries (for the commercial sector only) come from the 1979 DOE/EIA Annual Report to the Congress, which does not disaggregate its year 2000 projected usage between buildings built before and after 1980. The conservation and solar technology potential is based on conservation measures with a cost less than 7.5 $/million Btu or 5.7¢ per kWh. The additional savings for all measures with a higher cost is 0.70 quads.

The cost of conserved energy varies with the discount rate chosen. Although 3 percent in real dollars for the residential sector and 10 percent in real dollars for the commercial sector were used, a sensitivity analysis for other rates was performed. The results for residences are shown in Figures 9A and B. Tables 3A and 3B repeat the information of Figures 9A and B and associate dollar investments with energy saved. Note that the potential electric savings, 500 BkWh, is the output of 100 typical plants. By moving from one discount rate to another in Figures 9(A) or (B), it is possible to estimate the effects of research in building science or information programs or incentive programs.

The more confidence consumers have in an investment, the lower the discount rate they demand. A banker lending money on a house in return for a mortgage typically demands 3 percent real. A home-owner investing in energy efficiency has little faith in the claims or competence of his builder or contractor, so he tends to demand 20-50 percent annual return on investment, i.e., a pay-back time of only a few years.[2,3]

Confidence can be increased by information programs and, particularly, by energy labels on all new and existing homes and non-residential buildings. Programs to train builders and contractors, to warrant their work, and to introduce more quality control will make the labels credible and give faith to financiers to lend money more cheaply. This could slowly drop the consumer's implied real discount rate from 30 percent to 3 percent.

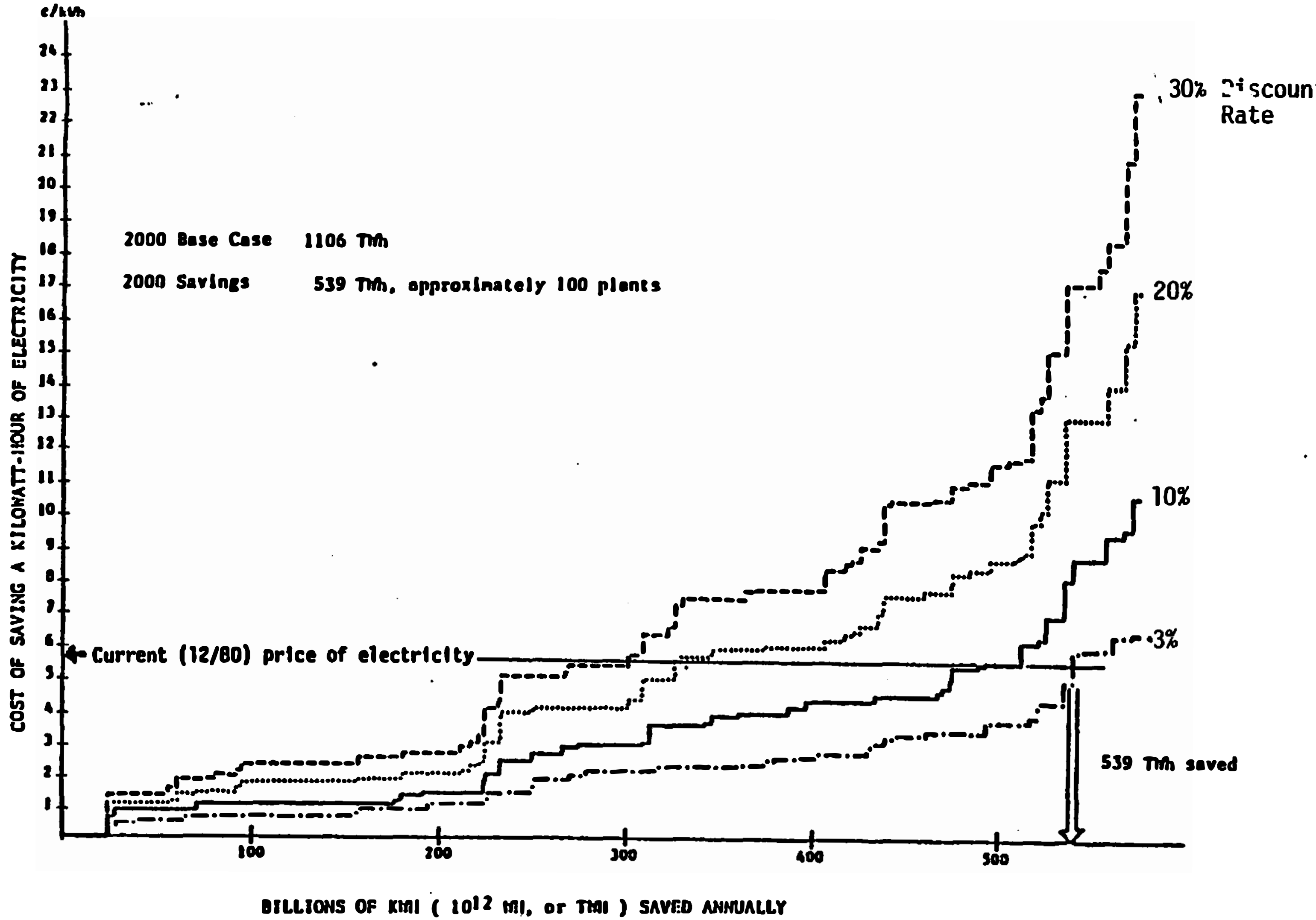
At any given energy price and 30 percent interest only approximately half of the potential savings are captured and less than half the investments are made. (See Figures 9A and B) These are the most lucrative investments, and they will be made anyway over the next 20 years, independent of government programs. Government and utility programs could easily build enough consumer and financial confidence to reduce their discount rate to 10 percent, possibly in 10 years. Most of the remaining savings would be captured by the year 2000.



Note: Retrofit of stock plus 20 years of construction. Four curves are plotted, each for a different real discount rate.

Source: Reference 2

FIGURE 9(A). SUPPLY CURVES OF CONSERVED FUEL FOR THE YEAR 2000 FOR U.S. RESIDENTIAL SECTOR



Note: Retrofit of stock plus twenty years of construction. Four curves are plotted, each for a different real discount rate.

Source: Reference 2

FIGURE 9(B). SUPPLY CURVES OF CONSERVED ELECTRICITY FOR 2000 FOR U.S. RESIDENTIAL SECTOR

TABLE 3A. RESIDENTIAL FUEL SUMMARY SUPPLY CURVE OF CONSERVED ENERGY

CONSERVATION MEASURE	A. MARGINAL COST OF CONSERVED ENERGY ($/MBTU)	B. AVERAGE COST OF CONSERVED ENERGY ($/MBTU)	C. ENERGY SUPPLIED PER MEASURE (TERABTU/YEAR)	D. TOTAL ENERGY SUPPLIED (TERABTU/YEAR)	E. TOTAL DOLLARS INVESTED (MILLIONS)
1. WINDOW TO SOUTH 91-2000	0.	0.	24.8	25.	0.
2. WINDOW TO SOUTH 86-90	0.	0.	13.5	38.	0.
3. R-19 IN ATTIC UNINSULATED	.5	.5	851.2	890.	7144.
4. 1981-1990 GAS RANGES	.7	.5	13.6	903.1	7280.
5. 1991-2000 GAS RANGES	.8	.6	132.3	1035.	8750.
6. INFILTRATION PARTLY INSULATED	1.5	.9	545.4	1581.	16022.
7. INFILTRATION REDUCTION UNINSULATED	1.5	1.0	273.6	1854.	19670.
8. LOW FLOW DEVICES	1.6	1.0	169.8	2024.	21985.
9. DIY* SOLAR PARLY INS.	1.6	1.0	45.5	2070.	23131.
10. DIY SOLAR UNINSULATED	1.7	1.1	27.4	2097.	23824.
11. THICKER INSULATION, WATER HEATER	1.7	1.1	102.9	2200.	25367.
12. EFFICIENCY TO 75% 1981-85	1.8	1.1	21.7	2222.	25710.
13. SWIMMING POOL COVERS	1.8	1.1	70.0	2292.	25960.
14. DIY SOLAR 76-80	1.9	1.1	7.6	2299.	26182.
15. DIY SOLAR 81-85	1.9	1.1	9.1	2308.	26451.
16. EFFICIENCY TO 82% POST-85	2.1	1.2	120.1	2428.	28652.

Note: This Table shows the measures plotted in Figure 9(A) and the dollar investment needed for a given energy savings. The 3% interest curve of Figure 9A is a plot of Column A vs. Column D; the new dollar information is in Column E. We do not need to tabulate other column A's for other interest rates because once a given measure and investment has been identified with this Table, the cost of energy conserved at other interest rates can be read directly from Figure 9A. Note that 1 Tera Btu (tBtu) = 10^{12}Btu, so 1000 TBtu = 1 Quad.

*DIY-"Do It Yourself"

TABLE 3A. RESIDENTIAL FUEL SUMMARY SUPPLY CURVE OF CONSERVED ENERGY (Continued)

CONSERVATION MEASURE	A. MARGINAL COST OF CONSERVED ENERGY ($/MBTU)	B AVERAGE COST OF CONSERVED ENERGY ($/MBTU)	C. ENERGY SUPPLIED PER MEASURE (TERABTU/ YEAR	D. TOTAL ENERGY SUPPLIED (TERABTU/ YEAR	E. TOTAL DOLLARS INVESTED (MILLIONS)
17. R-11 IN WALLS UNINSULATED	2.2	1.3	395.2	2824.	41724.
18. 90% EFF. FURNACE PARTLY INSULATED	2.2	1.4	181.8	3005.	47784.
19. 90% EFF. FURNACE UNINSULATED	2.2	1.4	91.2	3097.	50824.
20. EFFICIENT CWIS* 1981-85	2.2	1.4	6.3	3103.	50967.
21. EFFICIENT CWIS-POST-85	2.6	1.4	70.6	3174.	52825.
22. 90% EFF. FURNACE 81-85	2.6	1.4	20.5	3194.	53645.
23. 90% EFF. FURN. 76-80	2.6	1.4	14.7	5209.	50235.
24. R-27 IN ATTIC PARTLY INSULATED	2.7	1.6	424.2	3633.	71809.
25. 90% EFF. FURNACE 86-90	2.9	1.6	23.6	3657.	72859.
26. SPARK IGN. RETROFIT 86-90	3.2	1.6	2.3	3659.	72923.
27. SPARK IGN. RETROFIT 81-85	3.2	1.6	6.8	5666.	73117.
28. SPARK IGN. RETROFIT 76-80	3.2	1.6	15.7	3681.	73561.
29. SPARK IGN. RETROFIT PARTLY INSULATED	3.2	1.6	90.9	3772.	76136.
30. SPARK IGN. RETROFIT UNINSULATED	3.2	1.7	45.6	3818.	77428.
31. DISHWASHER WATER SAVINGS	3.3	1.7	40.9	3859.	79000.
32. SOLAR I. UNINSULATED	3.3	1.7	82.1	3941.	83187.
33. SOLAR I. PARTLY INS.	3.3	1.8	136.4	4077.	90168.
34. INFILTRATION & HEAT EXCH. 91-2000	3.3	1.8	207.0	4284	100794.
35. BEPS SHELL 91-2000	3.4	1.9	276.0	4560.	119562.

*CWIS-Clothes Washer

TABLE 3A. RESIDENTIAL FUEL SUMMARY SUPPLY CURVE OF CONSERVED ENERGY (Continued)

CONSERVATION MEASURE	A. MARGINAL COST OF CONSERVED ENERGY	B. AVERAGE COST OF CONSERVED ENERGY	C. ENERGY SUPPLIED PER MEASURE	D. TOTAL ENERGY SUPPLIED	E. TOTAL DOLLARS INVESTED
	($/MBTU)	($/MBTU)	(TERABTU/YEAR)	(TERABTU/YEAR)	(MILLIONS)
36. BEPS SHELL 86-90	3.5	2.0	142.5	4703.	129612.
37. SOLAR I. 76-80	3.6	2.0	22.9	4726.	130950.
38. SOLAR I. 81-85	3.9	2.0	27.4	4753.	132578.
39. SPARK IGNITION STACK DAMPER	4.0	2.1	172.1	4925.	138581.
40. 90% EFF. FURNACE 91-2000	4.4	2.1	82.8	5008.	144101.
41. EXTRA R-19 IN ATTIC, 81-85	4.8	2.1	60.8	5069.	148585.
42. EX. R-19 IN ATTIC 76-80	5.0	2.2	46.9	5116.	152203.
43. STORM WINDOWS UNINSULATED	5.1	2.3	273.6	5389.	173483.
44. EXTRA R-19 IN ATTIC UNINSULATED	5.1	2.3	69.3	5459	178913.
45. SOLAR A	5.1	2.4	100.6	5559.	186836.
46. STORM WINDOWS PARTLY INSULATED	5.2	2.5	212.1	5771.	203804.
47. RE-SIDE R-5 PARTLY INSULATED	5.4	2.5	20.0	5791.	205471.
48. SOLAR PACKAGE 86-90	5.6	2.6	101.3	5892.	214178.
49. SOLAR II. PARTLY INS.	5.6	2.6	92.7	5985.	222196.
50. SOLAR II. UNINSULATED	5.8	2.6	46.5	6032.	226394
51. SOLAR II, 76-80	5.8	2.6	22.9	6055.	228405.
52. SOLAR II, 81-85	6.0	2.7	27.4	6082.	230908.
53. 1991-2000 GAS DRYERS	6.8	2.7	29.9	6112.	233402.
54. SOLAR B	7.4	2.8	100.6	6213.	244847.
55. SOLAR III, PARTLY INS.	7.5	2.8	92.7	6305.	255483.
56. SOLAR PACKAGE 91-2000	7.6	2.9	74.5	6380.	264177.
57. SOLAR III. INSULATED	7.8	2.9	46.5	6426.	269703.

TABLE 3A. RESIDENTIAL FUEL SUMMARY SUPPLY CURVE OF CONSERVED ENERGY (Continued)

CONSERVATION MEASURE	A. MARGINAL COST OF CONSERVED ENERGY	B. AVERAGE COST OF CONSERVED ENERGY	C. ENERGY SUPPLIED PER MEASURE	D. TOTAL ENERGY SUPPLIED	E. TOTAL DOLLARS INVESTED
	($/MBTU)	($/MBTU)	(TERABTU/YEAR)	(TERABTU/YEAR)	(MILLIONS)
58. SOLAR III. 76-80	7.8	2.9	22.9	6449.	272489.
59. SOLAR III. 81-85	8.0	3.0	27.4	6477.	275767.
60. DUCT SEALING PARTLY INSULATED	8.5	3.0	9.7	6486.	276494.
61. DUCT SEALING UNINSULATED	8.5	3.0	9.1	6495.	277178.
62. SOLAR C	9.6	3.1	100.6	6596.	292019.
63. 1981-1990 GAS DRYERS	10.2	3.1	.7	6597.	292112.

TABLE 3B. RESIDENTIAL ELECTRIC SUMMARY SUPPLY CURVE OF CONSERVED ENERGY

CONSERVATION MEASURE	A. MARGINAL COST OF CONSERVED ENERGY	B. AVERAGE COST OF CONSERVED ENERGY	C. ENERGY SUPPLIED PER MEASURE	D. TOTAL ENERGY SUPPLIED	E TOTAL DOLLARS INVESTED
	(¢/KWH)	(¢/KWH)	(TERAWH/ YEAR)	(TERAWH/ YEAR)	(MILLIONS)
1. 1991-2000 TELEVISION	0.	0.	7.8	8.	0.
2. 1981-1990 TELEVISION	0.	0.	.9	9.	0.
3. CAC-LOAD REDUCTION 91-2000	0.	0.	4.0	13.	0.
4. CAC-LOAD REDUCTION 86-90	0.	0.	1.8	15.	0.
5. CAC-LOAD REDUCTION 81-85	0.	0.	.6	15.	0.
6. CAC-LOAD REDUCTION 76-80	0.	0.	.6	16.	0.
7. LOAD REDUCTION PRE-76	0.	0.	5.1	21.	0.
8. WINDOWS TO SOUTH 91-2000	0.	0.	1.3	22.	0.
9. WINDOWS TO SOUTH 86-90	0.	0.	.8	23.	0.
10. 1981-1990 FREEZERS	.4	.1	4.0	27.	282.
11. FROST FREE 1981-90	.5	.2	11.0	38.	1208.
12. 1991-2000 FREEZERS	.6	.4	24.3	62.	3994.
13. LOW FLOW DEVICES	.7	.5	32.1	94.	5844.
14. FROST FREE 1991-2000	.7	.5	60.3	155.	12011.
15. MANUAL REFRIG 1991-2000	.9	.6	5.3	160.	12714.

Note: This Table corresponds to Figure 9B. The 3% interest curve of Figure 9B is a plot of Column A vs. Column D; the new dollar information is in Column E. We do not need to tabulate other column A's for other interest rates because once a given measure and investment has been identified with this Table, the cost of energy conserved at other interest rates can be read directly from Figure 9A. The caption is the same as the caption for Table 3A except for the units: 1 TWh = 10^{12} Wh = 1 BKWh.

*CAC-Central Air Conditioning

TABLE 3B. RESIDENTIAL ELECTRIC SUMMARY SUPPLY CURVE OF CONSERVED ENERGY

CONSERVATION MEASURE	A. MARGINAL COST OF CONSERVED ENERGY	B. AVERAGE COST OF CONSERVED ENERGY	C. ENERGY SUPPLIED PER MEASURE	D. TOTAL ENERGY SUPPLIED	E. TOTAL DOLLARS INVESTED
	(¢/KHW)	(¢/KHW)	(TERAWH/YEAR)	(TERAWH/YEAR)	(MILLIONS)
16. THICK INSULATION WATER HEATER 1981-85	.9	.6	3.1	163.	12988.
17. INFILTRATION PRE-1976	.9	.6	20.8	184.	14596.
18. 1991-2000 ELECT. RANGES	.9	.6	5.5	189.	15286.
19. 1981-1990 ELECTRIC RANGES	.9	.6	.5	190.	15544.
20. EFFICIENT CWIS 1981-85	.9	.6	1.2	191.	15458.
21. MANUAL REFRIG 1981-90	.9	.6	1.0	192.	15605.
22. DIY SOLAR PRE-76	.9	.6	1.3	193.	15798.
23. FOAM INSULATION WATER HEATER 86-2000	1.1	.7	17.1	211.	17717.
24. EFFICIENT CWIS 86-2000	1.1	.7	13.1	224.	19201.
25. DIY SOLAR 81-85	1.2	.7	.8	224.	19339.
26. DIY SOLAR 76-80	1.2	.7	.6	225.	19452.
27. DISHWASHER WATER SAVING	1.5	.7	7.3	232.	20708.
28. ADD R-27 TO ATTIC PRE-76	1.5	.8	16.8	249.	24594.
29. CAC-HIGH EER PRE-1976	1.9	.8	16.3	265.	28338.
30. SOLAR I. PRE-76	1.9	.8	4.0	270.	29508.
31. CAC-HIGH EER 1976-80	2.0	.9	7.3	277.	31290.
32. 1986-1990 ROOM AC'S*	2.1	.9	1.6	278.	31645.
33. INFILTRATION & HEAT EXCHANGE 91-2000	2.2	1.0	16.3	295.	37112.
34. BEPS SHELL 91-2000	2.2	1.0	21.3	316.	46768.
35. BEPS SHELL 86-90	2.3	1.1	11.1	327.	51860.
36. IMPROVED LIGHTING NEW HOMES	2.3	1.2	34.2	361.	58864.
37. SOLAR A	2.4	1.2	9.9	371.	62495.
38. SOLAR I. 76-80	2.4	1.2	1.8	373.	63180.

*AC-Air Conditioning

TABLE 3B. RESIDENTIAL ELECTRIC SUMMARY SUPPLY CURVE OF CONSERVED ENERGY (Continued)

CONSERVATION MEASURE	A. MARGINAL COST OF CONSERVED ENERGY	B. AVERAGE COST OF CONSERVED ENERGY	C. ENERGY SUPPLIED PER MEASURE	D. TOTAL ENERGY SUPPLIED	E. TOTAL DOLLARS INVESTED
	(¢/KHW)	(¢/KHW)	(TERAWH/ YEAR)	(TERAWH/ YEAR)	(MILLIONS)
39. SOLAR I. 81-85	2.4	1.2	2.3	375.	64030.
40. CAC-HIGH EER 1981-85	2.5	1.3	3.8	379.	65208.
41. STORM WINDOWS PRE-76	2.6	1.3	9.5	389.	68960.
42. 1991-2000 ROOM AC'S	2.6	1.3	13.2	402.	72476.
43. CAC-HIGH EER 1986-90	2.7	1.3	4.3	406.	73879.
44. 1991-2000 ELECTRIC DRYERS	2.7	1.4	13.2	419.	78274.
45. CAC-HIGH EER 1991-2000	2.7	1.4	9.7	429	81552.
46. SOLAR II, PRE-76	2.9	1.4	4.0	433.	83331.
47. HEAT PUMP, COP-* 2.5, 81-85	3.0	1.5	4.4	438.	84926.
48. RE-SIDE R-5 PRE-76	3.1	1.5	1.1	439.	65428.
49. HEAT PUMP COP-2 76-80	3.2	1.5	3.5	442.	87799.
50. SOLAR B	3.3	1.5	9.9	452.	91815.
51. EXTRA R-19 IN ATTIC 76-80	3.3	1.5	3.6	456.	93651.
52. EXTRA R-19 IN ATTIC 81-85	3.3	1.5	4.5	460.	95952.
53. IMPROVED LIGHTING	3.4	1.7	33.2	493.	105968.
54. SOLAR II, 76-80	3.8	1.7	1.8	495.	107027.
55. SOLAR II, 81-85	3.8	1.7	2.3	497.	108339.
56. HEAT PUMP COP=2.5 86-90	3.8	1.7	8.4	506.	112244.
57. HEAT PUMP COP=2.5 PRE-76	3.8	1.6	10.8	516.	117336.
58. SOLAR III, PRE-76	3.9	1.8	4.0	521.	119736.
59. SOLAR C	4.3	1.8	9.9	530.	126218.
60. IMPROVED DISHWASHER	4.3	1.8	4.7	535.	128566.

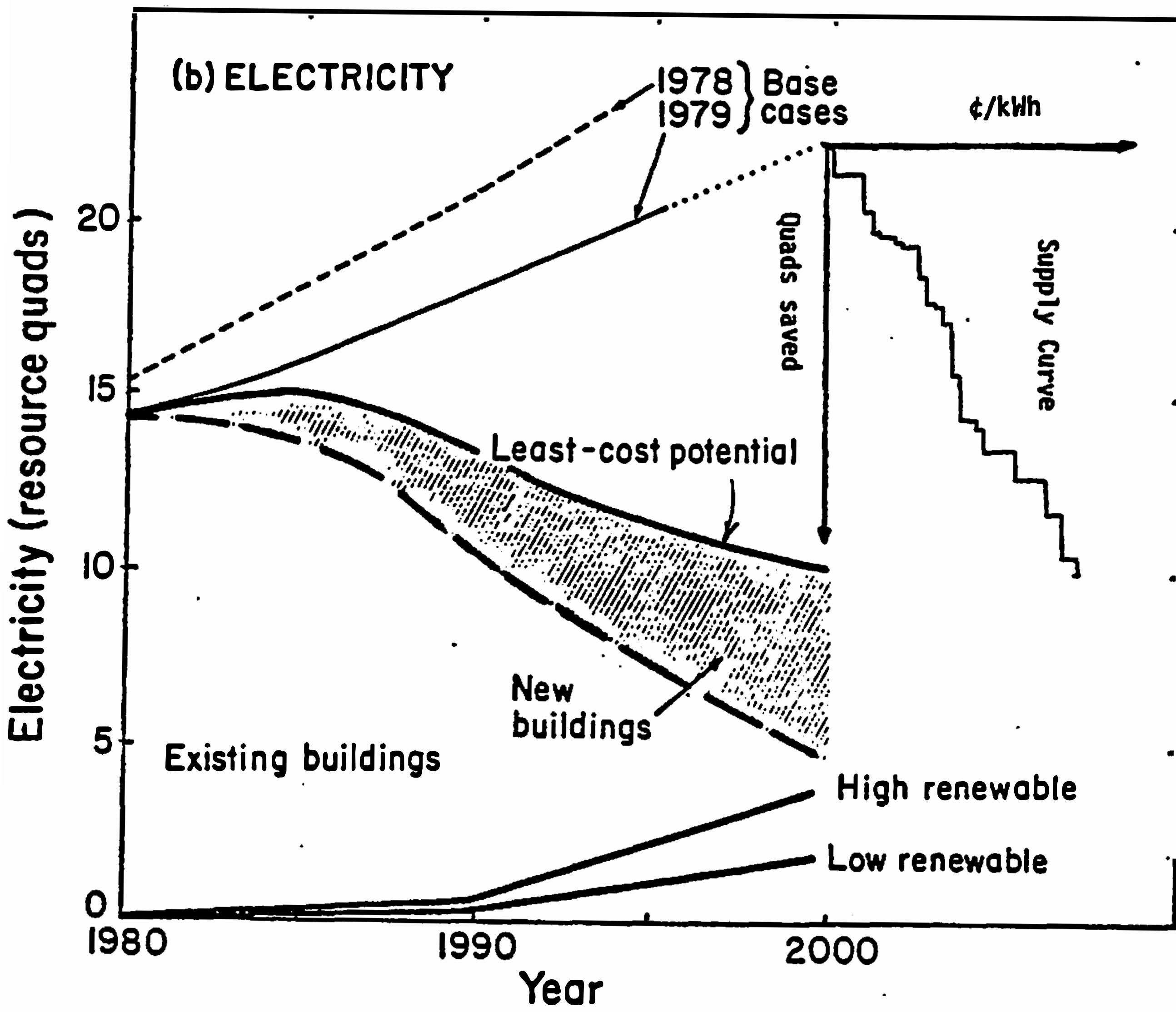
*COP-Coefficient of Performance

TABLE 3B. RESIDENTIAL ELECTRIC SUMMARY SUPPLY CURVE OF CONSERVED ENERGY (Continued)

CONSERVATION MEASURE	A. MARGINAL COST OF CONSERVED ENERGY	B. AVERAGE COST OF CONSERVED ENERGY	C. ENERGY SUPPLIED PER MEASURE	D. TOTAL ENERGY SUPPLIED	E. TOTAL DOLLARS INVESTED
	(¢/KWH)	(¢/KWH)	(TERSWH/ YEAR)	(TERAWH/ YEAR)	(MILLIONS)
61. SOLAR III, 81-85	5.0	1.9	2.3	537.	130307.
62. SOLAR III, 76-80	5.0	1.9	1.8	539.	131715.
63. SOLAR PACKAGE 86-90	5.9	1.9	4.4	544.	138751.
64. HEAT PUMP	6.0	2.0	17.4	561	148541.
65. HEAT PUMP COP=2.5 91-2000	6.4	2.1	9.9	571.	156351.
66. SOLAR PACKAGE 91-2000	6.5	2.1	3.8	575.	160185.

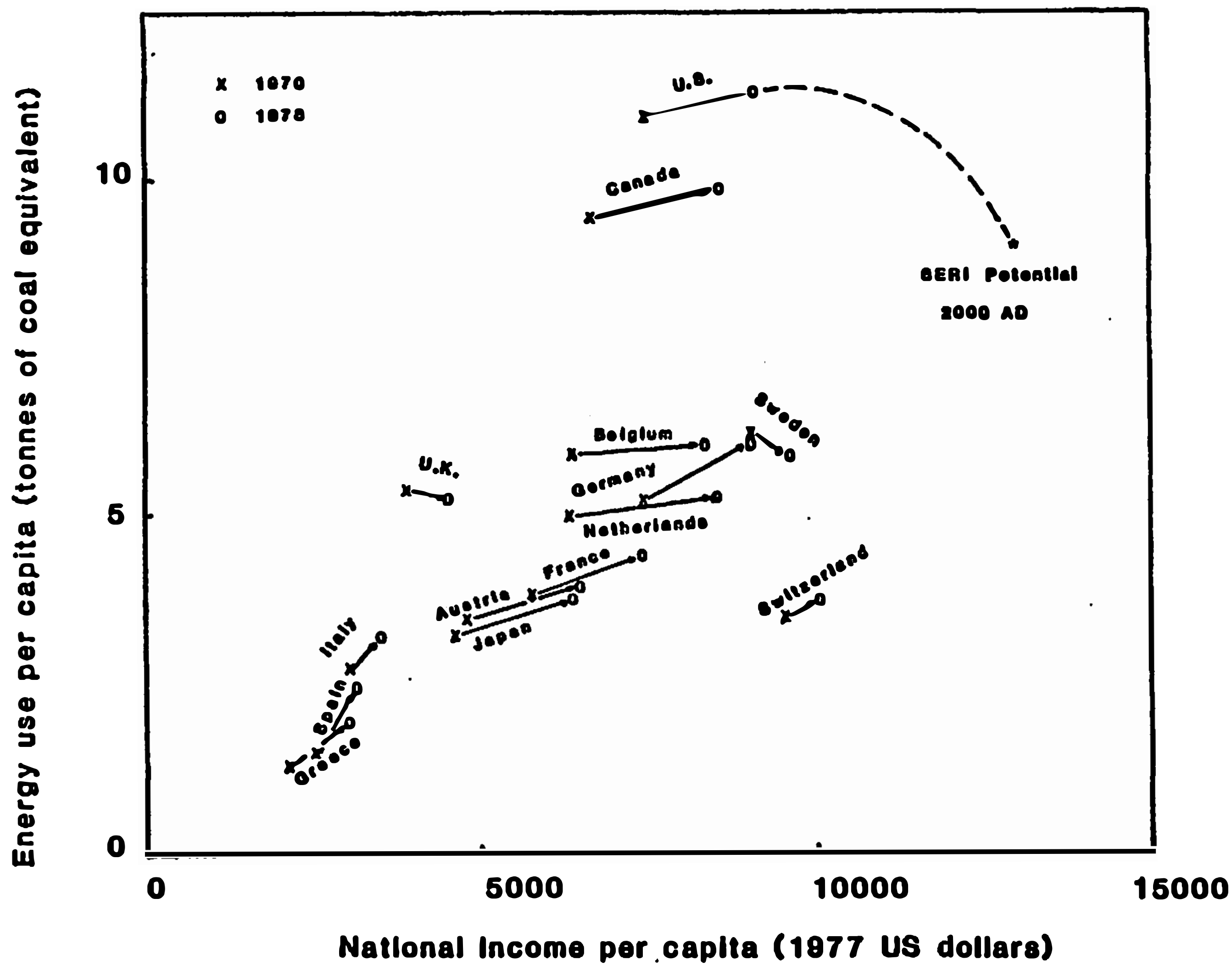
Figure 10 shows how a supply curve bridges the gap between the "projections" and the "potentials" of Figure 8. A supply curve can be drawn for any year, not just 2000. In a recent California Study[4] there are "snapshot" supply curves for the year 1980.

Is it reasonable to expect that all this energy will be saved? In Figure 11 the total energy consumption per capita is plotted against the gross national product (GNP) per capita in 1970 and 1978 for a number of western industrialized nations. There is a main sequence for the nations that have traditionally had high energy prices and anomalies, the U.S. and Canada, which have been blessed with cheap energy until recently. The broken line extending from the 1978 U.S. point shows the energy and gross national product per capita projected for 2000, when energy will be as expensive as it is now for Europe and Japan. From this perspective, the potential savings seem very reasonable.



Note: For details, see Figure 8 and the supply curve of Figure 9(B).

FIGURE 10. PROJECTION AND POTENTIAL FOR U.S. ELECTRICITY CONSUMPTION IN 2000 AND SUPPLY CURVE OF CONSERVED ENERGY



Source: Tables 1583 and 1594, U.S. Bureau of the Census, Statistical Abstract of the United States: 1980 (101st edition), Washington, DC, 1980, Reference 1.

FIGURE 11. ANNUAL PER CAPITA ENERGY CONSUMPTION AND GROSS NATIONAL PRODUCT, 1970 AND 1978, COMPARED WITH THE POTENTIAL FOR 2000 ENERGY AND GNP FOR THE U.S. FROM REFERENCE 1.

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PART III

ECONOMICS OF CONSERVATION: THE PUBLIC UTILITY PERSPECTIVE

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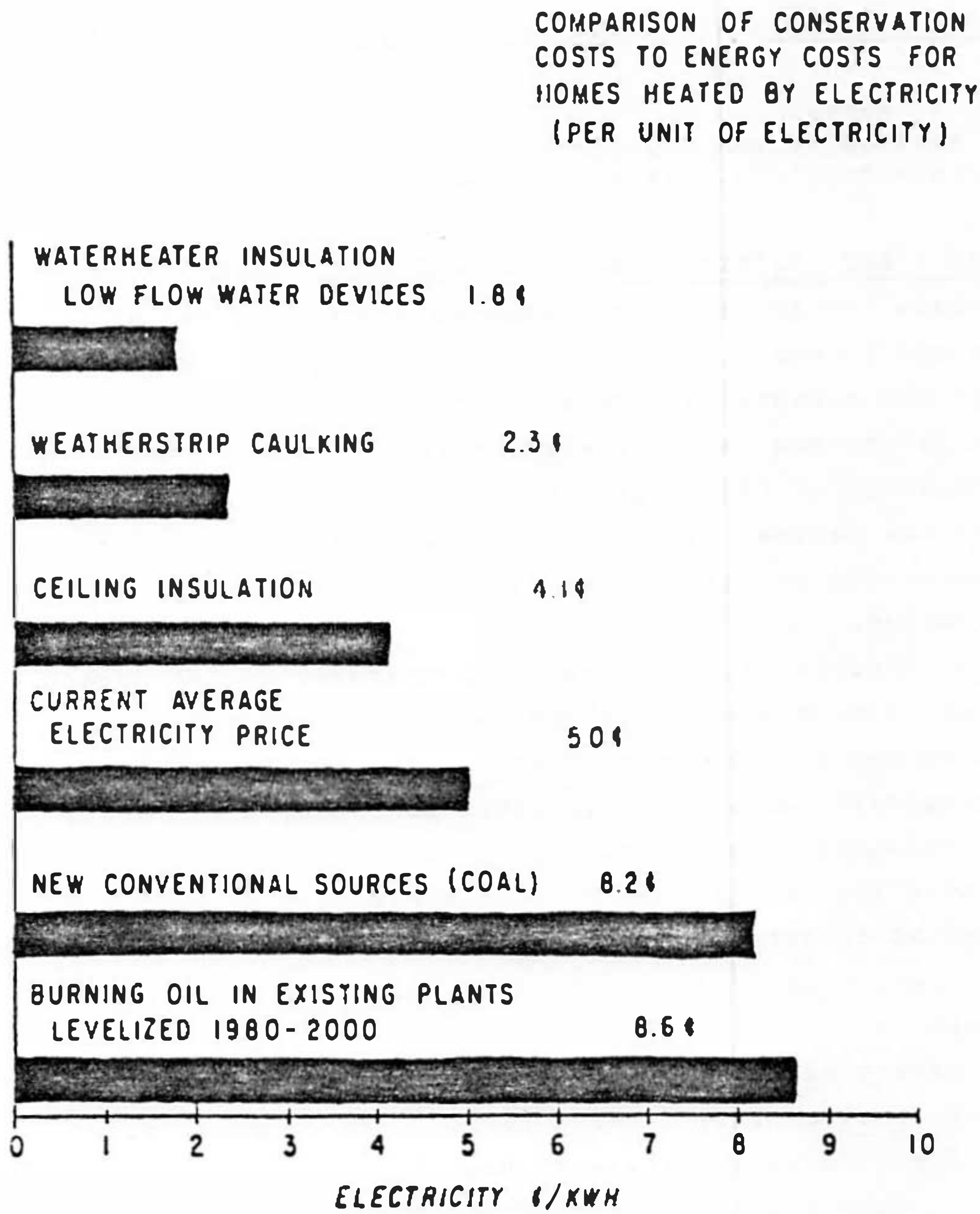
1. THE PUBLIC UTILITY'S ROLE IN RESIDENTIAL ENERGY CONSERVATION

California continues to be a growing state in terms of both population and economic activity. For a variety of reasons, it has neither the expense nor the security of the large amounts of excess generating capacity which exist in some states. To meet the challenge of future growth, California must either build massive new central power plants or make do with a combination of alternative energy sources and a dedicated promotion of energy conservation.

If there is one fact that is comparable to the recent rise in fossil fuel costs, it is the upward spiral in the cost of constructing new central power plants. The combination of complex technological issues, environmental concerns, high interest rates, long regulatory delays, and rising costs of labor and materials has driven the prospective cost of a new nuclear or coal-fired power plant to astronomical levels, far beyond the current ability of many public utilities to finance, and beyond the desires of those who can.

A recent estimate by the California Energy Commission places the cost of electricity from a new coal-fired power plant in the range of 8.2 cents per kilowatt hour (Figure 1). This figure is slightly lower than the anticipated cost of continuing to burn oil in existing plants over the next 20 years, which is estimated on a levelized basis at 8.6 cents per kilowatt hour. These figures are far above the current average price of electricity, estimated last July at about 5.0 cents per kilowatt hour. It is higher now since rates have increased.

By contrast, a variety of residential retrofit measures can conserve energy at far lower costs per kilowatt hour, ranging



SOURCE: CALIFORNIA ENERGY COMMISSION, POLICY AND PROGRAM EVALUATION OFFICE, JUNE 1980.

FIGURE 1. COMPARATIVE COSTS: CONSERVATION VS CONVENTIONAL SUPPLY OPTIONS

from 1.8 cents per kilowatt hour for water heater insulation and low-flow shower heads to 4.1 cents for each kilowatt hour saved through ceiling insulation. These are more cost-effective ways to save energy than the construction of new power plants or the continued use of existing power plants that burn oil.

The proportion of electrically heated homes in the Pacific Gas and Electric (PG & E) service area is 16 percent, the national average; 78 percent of homes are gas heated.

The Alternative: Investment in Energy Efficiency

Investments in enhanced energy efficiency make good economic sense for both the utility and its customers. Over the past five years, several hundred thousand California homeowners have added insulation to their attics. Many more have taken other steps, large and small, to increase the energy efficiency of their homes, from caulking and weatherstripping to the insulation of furnace controls and solar water heaters. Among those who take advantage of the home energy audits available free from California utilities, fewer than half actually take action to install the conservation measures found to be cost effective. This is why the creation of financial incentives through utility investment in residential conservation measures is so important.

Since 1978, several California utilities have offered 8 percent loans with extended payback periods to finance attic insulation and have also provided incentives in the form of modest cash payments or items of energy conserving hardware, such as water heater blankets and low flow showerheads, to their customers who install insulation. These programs have produced energy conservation at relatively low cost. The response, however, has been less than was expected until the price shocks of last year.

The Public Utilities Commission (PUC) concluded that even greater incentives are in order to provide further stimulus for cost effective conservation measures. Consequently, the Commission has encouraged the utilities to propose plans for zero-interest financing of a broad array of home weatherization measures.

The experience of Pacific Power & Light Company (PP&L), a utility which serves a six-state service area including a very small area of far Northern California, shows the cost effectiveness of such investments. Since January 1979, they have offered a zero-interest financing program to their service areas in Oregon, Washington, Idaho and Montana. An analysis of 2,000 insulation and weatherization jobs performed in Oregon shows that the average cost to ratepayers of installing conservation materials was less than 15 mils or 1.5 cents per kilowatt hour saved. PP&L's estimated cost of new generating capacity at that time was, by comparison, 56 mils, or 5.6 cents.

In April 1980, PP&L was authorized to extend its zero interest program to its small California service area where many requests for installation have been received. The implementation has been delayed somewhat by problems of working out the relationship between the utility and the contractors who will carry out the work.

Pacific Gas and Electric has proposed its own variation of a Zero Interest Weatherization Program (ZIP) which would be on a much larger scale than that of PP&L. Twenty-seven days of hearings produced input from public advocates, representatives of low income and minority persons, contractors, and financial institutions. As a result of these hearings some changes have occurred. The Public Utilities Commission will issue an order authorizing such a program for PG&E with some variations from the original proposal.

The Measurement of Cost Effectiveness

One of the main controversies arising from these hearings concerns the proper measure of cost effectiveness used in determining whether a particular conservation measure should be financed by the utility. It is generally agreed that the standard of comparison for judging the value of utility investments in conservation or alternative energy sources should be the marginal cost of a new supply from traditional sources. If the investment obviates a need for new electrical capacity, the appropriate comparison in California is to the per-megawatt cost of a new coal-fired power plant. If the investment simply avoids consumption of energy, whether in the form of electricity or gas, but does not eliminate the need for having capacity available, then the proper standard is the incremental cost of fuel oil or natural gas.

The controversy, however, centers not on what alternative to look at, but on whether this comparison should be made from the perspective of the utility, the society, or the non-participating ratepayer.

From the point of view of the utility, the choice is simply between the cost of saving a unit of energy by enhanced end-use efficiency and the cost of providing that unit of energy. As indicated by Figure 1, a wide array of conservation measures for electrically heated homes are less costly to the utility than building new capacity or even continuing to rely on oil-fired generation. The same is true for homes heated by gas when comparison is made to the prospective cost of a new gas supply, especially the cost of the new gas supply expected in a few years from Alaska, from LNG imports from Indonesia, or from the overthrust belt of the Wyoming-Montana area where much gas is being discovered at considerable cost for extraction.

On the other hand, when viewing cost effectiveness from a societal perspective, the case for conservation investments becomes stronger. There are many social "externalities" favorably affected by lower energy consumption, such as the quality of the environment, the nation's balance of payments, the national security, and in light of the more labor intensive nature of conservation investments, the unemployment rate.

Considering cost effectiveness from the perspective of the non-participating ratepayer, however, introduces a serious complication. Utility rates generally are not structured to recover all fixed costs through fixed charges. Fixed costs include the installation of facilities to distribute the utility service to the customer, monthly billing, and meter reading. A portion of the utility's fixed costs are recovered through the variable charges related to the amount of consumption by the customer. If the customer's consumption decreases, a greater portion of fixed costs must be recovered through other customers' rates. This results in a more restrictive test of cost effectiveness for conservation investments than for supply enhancing investments.

For a regulatory agency obliged to balance a variety of public interests, this creates a dilemma. A program in the general social interest may involve inequities to non-participants. Non-participants are likely to be predominantly renters and persons of low income. In fact, a well-structured zero interest financing program can benefit all ratepayers, including those who do not participate directly. It should emphasize limited cost effective measures and the use of the home energy audit before authorizing measures which are cost effective in some contexts but not in others.

Because energy audits are more expensive than anticipated, it has been necessary to limit them as a precondition to those measures which have uncertain cost effectiveness, so that conservation measures are installed only where the audit shows them to be cost effective. Whereas measures such as attic and water heater insulation are overwhelmingly cost effective on average, there is no need for an energy audit in every case.

Comparing the non-participant group to the participant group, the low income community, the minority communities, and people who are older and perhaps have less ability to make home improvements will, relatively speaking, take less advantage of a program that provides an equal incentive to all. There will be special incentives and outreach efforts to contact these communities as well as the rental market. Because of the disparity of interests between the renter who pays the utility bills and the landlord who would have to make the improvements, it has been hard to reach the rental market.

The appropriate measure of cost effectiveness is discussed in a speech by John Bryson, President of the California Public Utilities Commission.[1] Bryson's paper shows that, even by the test of cost effectiveness for non-participating ratepayers, most of the conservation measures proposed as part of PG&E's ZIP program are cost effective on an average basis.

The Interests of the Utility

There is a question of whether it is appropriate to rely on public utilities to promote energy conservation, even accepting that it is in the public interest to make an investment in that area. It is undeniable that the utilities' direct and regular contact with ratepayers, their professional expertise and creditability in matters relating to energy efficiency, and their access to large-scale financing place them in a unique position to promote energy conservation quickly and effectively. The question is whether it is in their interest to do so.

Public utilities are sellers of energy. The Department of Transportation would not rely on General Motors to encourage the public to leave their cars at home and take the bus. How can public utilities be expected to enthusiastically discourage the sale of their product? One clever answer to this question is that public utilities should become sellers of energy services, rather than merely of energy. They should see their products as warm space and hot water and a ready supply of electric current rather than as simply the units of energy in which they calculate their bills. This approach makes sense conceptually, and it may well be the proper direction for the utilities' future prosperity. In the near term, however, there is a practical question. Does it make financial sense for utility management and stockholders to promote energy conservation today?

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[1] J.E. Bryson. "Energy Utilities and Customers," Remarks to the National Association of Regulatory Utility Commissioners, Houston, Texas, November 11, 1980. (See Appendix)

A public utility's rates are set at a level which will cover projected operating expenses reasonably incurred in the course of business and which will also provide an opportunity to earn a reasonable rate of return on capital investment. The investment on which return may be earned is known as the rate base, and it consists of the investment in plant and facilities currently in use to provide utility services, net of past depreciation expenses. If PG&E were to add a $2 billion coal-fired power plant to its rate base tomorrow, it would be entitled to a drastic rate increase and at least a 20 percent increase in its profits. Energy efficiency does not offer comparable profit opportunities. A proposed solution is to permit the utility to include its conservation investments, such as the principal on zero interest loans in its rate base as well, thus equalizing financial incentives and letting the utility choose the most efficient investment.

In the present financial climate, utilities have little to gain be seeking to maximize their rate base. The hypothetical coal plant referred to does not enter rate base until there has been several years of licensing proceedings and construction work. Sometimes the operating date of these plants and nuclear plants in particular seems to disappear over the horizon.

While the plant is under construction, in planning, but not in rate base, the utility would be incurring extremely high interest charges on borrowed funds without any recovery in rates until the plant goes on line, which is far less than certain, particularly in regard to nuclear plants. By contrast, conservation investments come in small increments with short lead times which is very advantageous to a financially troubled utility.

Because of cash flow problems resulting mainly from large scale construction projects already underway, many utilities are not eager to expand their rate base beyond what is absolutely necessary to service new connections. Instead, they prefer to recover the costs of conservation programs on a dollar for dollar basis as current operating expenses.

PG&E, in its weatherization zero interest program, or ZIP proposal, has taken another approach. PG&E proposes to set up a separate subsidiary to finance its zero interest loans. The subsidiary would be highly leveraged with only 20 percent of its capital consisting of equity contributed by the parent. Such leverage is obtainable only if recovery of all reasonable program costs from the ratepayers is assured. The result promises to be a lower cost of financing the program with the debt costs kept off of PG&E's balance sheet while still providing the utility an opportunity to expand its rate base at a modest pace.

Conservation is a good investment for energy utilities if capacity margins are narrow and marginal costs high. Even where excess capacity exists, as for utilities in the Northeast, the national interest in lessening dependence of imported oil and the high cost of burning that fuel in existing plants will make conservation investments a cost effective use of the ratepayer's dollar.

The scope of details of a residential conservation financing program should vary with the financial position of the utility and with the characteristics of the climate and housing stock in the utility's service area. For this reason, a uniform federally mandated program is probably less desirable than is the implementation by state and local authorities of a variety of programs oriented to local circumstances. The federal government's guidance of local and state institutions towards these goals could be very useful. Such programs offer the potential for substantially enhanced efficiency in the use of energy in the residential sector, as well as the prospect of maintaining reliable utility service at rates which are not beyond the means of our citizens.

2. DISCUSSION OF THE PUBLIC UTILITY'S ROLE IN RESIDENTIAL CONSERVATION

Bernard Frieden asked if the 8 percent loan fund was created by the utility or as a result of PUC pressure.

The legislature passed a bill authorizing the Public Utilities Commission to instruct the state's utilities to offer 8 percent loans for attic insulation with a fairly short payback period. Two utilities were ready to undertake such a program. After the Public Utilities Commission ordered all the states to undertake such a program, several utilities took the PUC to court. The State Supreme Court decided the legislation exceeded the PUC's authority as given under the statute and invalidated the order. It permitted PG&E to continue with its program which it had undertaken voluntarily. Subsequently, the legislature passed another bill authorizing the PUC to encourage what was reasonable and necessary to urge energy conservation. Under these legislative mandates, the PUC ordered all utilities to carry out this change and the utilities have initiated these programs.

Mike Casper inquired about the impact of conservation on the new capacity needs for gas and electricity. Conservation programs will have relatively little impact on the needs for capacity. Because California utilities are summer peaking and weatherization programs avoid heat use, the winter peak may be reduced, but the larger summer peak remains. There is a need for additional conservation measures to be added which will affect the summer peak. As a result, the contrast between gas and electricity and their capacities is not that great.

Steven Carhart asked about the reaction of non-participating ratepayers to low interest loans. He hypothesized that they would be in favor of such a program because non-participating ratepayers' bills would not increase as much, due to decreased needs for capacity. Non-participating ratepayers are not net worse off than they would have been without the program because of the California rate structure. Rates to low priority industrial gas customers are set at alternative fuel prices. They are pegged to the price which the customer would be paying if he switched from gas to oil. What tends to happen is that oil prices increase dramatically and then gas prices take time to catch up. For the last year, oil prices have not been increasing, so the price at which the industrial customer's rates are pegged has not increased. For the last six months, if there were an increase in gas rates, it would go to the residential customers. In that situation, there can be a result that, in the short term, impacts the non-participating ratepayer unfavorably.

Information was requested about the cost of an audit. While the audit is free to the customer, it costs the utility $50-60. The more rigorous audits required by the Federal Residential Conservation Service (RCS) of the National Energy Conservation Policy Act cost $100.

David J. MacFadyen asked if audit results should be given directly to insulation salesmen, reasoning that they had the skill, information, and incentive to get people to install conservation materials.

There was an inquiry about the status of the "house doctor" approach. This program has not yet been formally proposed. There is a pilot program in progress run by the Lawrence Berkeley Laboratory (LBL) and PG&E.

Henry Kelly asked how the utilities run the low interest loan program. PG&E states that to get bank financing for a heavily leveraged operation, it is necessary to assure that the cost will be flowed through to the ratepayer. The rates should be set to offer the utility the opportunity to recover all costs; however, if a catastrophe occurs or there is a severe price increase in the costs of labor and materials between rate cases, the utility could fall short and not make its authorized rate of return. PG&E needs the assurance of a balancing account type of treatment where all costs are debited to this account and will be recovered through rates in order to get bank loans for this heavily leveraged operation. This is similar to preferred stock treatment.

3. A PUBLIC UTILITY'S EXPERIENCE WITH CONSERVATION

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Often energy conservation efforts do not work as forecast in the "real world." Some work better, some work worse, and some have unintended and unforeseen side effects. For example, who would have thought that indoor air pollution from tightly sealed homes would become a concern? Who would have thought that state and federal tax credits for solar and conservation measures would become so complicated that a home energy auditor would have to rely as much on H&R Block as on the ASHRAE Manual? Who would have thought that a zero interest financing program for insulation and other weatherization measures would be opposed by some insulation contractors and some consumer organizations and not opposed by the banks?

This presentation focuses on energy conservation in buildings from the standpoint of a combination gas and electric utility. PG&E has a very positive attitude toward conservation. It is an essential part of PG&E's resource plan. The economics of conservation are different for different utilities, but the economics of it make sense for PG&E.

PG&E serves Northern and Central California, 94,000 square miles which is an area roughly equivalent in size to New York and Pennsylvania combined, or Illinois and Indiana combined. It is populated by about 9.3 million people. PG&E serves this area through 3.4 million electric meters and 2.8 million gas meters.

Energy use by PG&E customers in 1979 totalled 59.7 billion kilowatt hours of electricity and 600 billion cubic feet of gas. This represents 37.5 percent of the electricity and 40 percent of the gas used in California, or 3 percent of the electricity and 4 percent of the gas used in the United States. Residences account for consumption of 47 percent of the gas and 40 percent of the electricity.

In 1979, about 19 percent of the total petroleum supply to end users in the United States was consumed in the residential and commercial sector, and, of this, about 2.7 million barrels a day was in the form of liquid fuel to burn to heat space and water. In PG&E's service territory, relatively few buildings use petroleum directly in this manner. In the residential sector, 73 percent of the homes are heated by natural gas, 16 percent by electricity. Bottled gas heats 1.7 and solar about a tenth of 1 percent.

For water heating, 75 percent of the homes use natural gas, 12 percent electricity, and 3 percent bottled gas. No other fuel is used in more than 1 percent of the homes.

PG&E is a huge user and importer of fuel oil. About one-fourth of PG&E's electricity is generated at thermal plants fired by oil and 85 percent of that is imported. In the 12 months ending August 1, PG&E burned 19.4 million barrels of oil to make electricity. The cost was $441 million.

From the time PG&E began large scale conservation efforts, it has been trying to determine how much energy there is to be conserved. This question has become more important as conservation has become a larger and more definite part of PG&E's resource plan. Three basic approaches have been used: market or program research, based on samples of about 2,400 persons; a biennial Appliance Saturation Survey, most recently based on a sample of 49,000 with a response of 27,000; and a study of energy conservation potential, done this year by Arthur D. Little, Inc.

The market research studies, conducted as part of the control process for conservation programs, indicate that 80 percent of single family owner occupied homes and 47 percent of single family renter occupied homes have ceiling insulation. They also indicate how many have installed other energy conservation materials and devices and how many practice conservation by manual thermostat control actions.

The Appliance Saturation Survey, conducted in 1977 and again in 1979, is notable not so much for the conservation potential information it gives, but because it is so reliable and it covers a large sample. The conversion information asked in 1979 was whether the customer had ceiling and wall insulation. Among persons buying or owning homes, 68 percent had ceiling insulation and 47 percent had wall insulation. Among renters, 20 percent had ceiling insulation and 17 percent had wall insulation. These are lower numbers than the other figures, but renters include apartment dwellers, and the other one was single family renter occupied homes. The figures do not exactly match the market research findings but they are similar.

The study on conservation potential was conducted for PG&E by Arthur D. Little, Inc. to fulfill an order by the California Public Utilities Commission in the last general rate case. The study was conducted in two parts. The first was an engineering estimate of conservation potential and the second estimated how much of that potential could be achieved.

The following are brief descriptions of some of the ways used to achieve conservation; these are residential programs, commercial programs, and load management efforts.

PG&E has a home energy audit program. The home energy audit has become the cornerstone of America's residential energy conservation policy. It is prescribed as the key element in the Residential Conservation Service mandated by the National Energy Conservation Policy Act. PG&E has been performing home energy audits since 1978. During this year, PG&E will accomplish about 60,000. How well do audits work to conserve energy? There is no answer to that question but there is a study currently underway to compare actions to the recommendations made in audits. The results will be available in 1981. In the meantime, the results of a year-long postcard tracking evaluation of audits shows that 90 percent of the respondents plan to take at least one or more of the recommended actions.

In 1977 and 1978, when research on home energy audits was meager, PG&E and the regulators concluded that more savings could be obtained if the home energy auditor had an incentive to offer the homeowner to "sign up" or to make a commitment to conservation at the time the auditor was in the home. This thinking led to the insulation financing program under which a person may finance up to $500 for ceiling insulation at 8 percent with five years to pay back. This service has been offered since February, 1978 and it has successfully reached single family owner occupied homes. In the nearly three years of the program, credit has been extended to 7,000 homes and more than $10 million worth of insulation has been financed.

Although the financing program is open to renters who can get their landlords' permission to insulate, very few have taken advantage of the program because there are not very many incentives to either the landlord or the renter to take avantage of this program.

Earlier this year, with the encouragement of the PUC, PG&E proposed a weatherization zero interest program which should be more attractive to the renters, landlords, and low-income customers. The proposal was the following: Upon conducting an audit to determine the measures needed and their cost effectiveness, the utility would finance up to as many as 11 measures - ceiling, wall and floor insulation; duct insulation, caulking, weather-stripping, storm windows and doors, electronic ignition devices for furnaces, automatic setback thermostats, water heater insulation blankets and the conversion of incandescent lighting to fluorescent. PG&E proposed to finance up to the average installed cost or to PG&E's marginal avoided cost, whichever was less. The homeowner would not be obligated to repay until he sold his house, and, in the meantime, there would be no interest charges on the amount financed. There would be no arbitrary upper limit on the amount that could be financed at one house, although the average would be about $1,500 per home.

PG&E planned to finance the program, Zero Interest Plan (ZIP), through a subsidiary which would get 20 percent of its capital from PG&E (this amount would be rate-based) and the remaining 80 percent from conventional lenders. Ratepayers would pay the administrative costs of the program and the interest costs of the borrowed money that was reloaned to customers at zero percent. We proposed a conservation financing adjustment, or CFA, to recover these costs plus a return on the 20 percent equity portion invested by PG&E in the subsidiary. This CFA would be filed at regular intervals as part of fuel adjustment proceedings. The concept underlying the plan is project financing, in which a flow of funds from the project secures the 80 percent of the capital borrowed in the money market. As of today PG&E has had no decision in this proceeding, but one is pending.

There is another financing program in effect in California for domestic solar water heating. The PUC ordered this program in September of this year following an investigatory process that lasted two years. The California legislature had directed the PUC to look into solar financing and, if action is warranted, to take whatever actions to speed up the adoption and the market penetration of solar in California. The Commission ordered the state's four major utilities to offer a combination of financial incentives to their customers in a three-year demonstration financing program. The objective is to get solar domestic water heating installed on 375,000 dwelling units, of which 112,000 are single family and 263,000 multi-family. Each utility's program is slightly different from the others. The PUC's objective is to see whether financial incentives will speed up the solar process and which incentives work best. PG&E's program provides a combination of solar credits or cash rebates and low-interest long-term financing and direct grants to get 158,040 dwelling units hooked up to solar hot water. These 158,040 break down this way:

- o Solar credits of $20 per month for 36 months to 37,140 single family dwelling units with electric water heaters -- Total credits of $720 each.
- o Solar credits of $20 per month for 48 months to 9,000 single family dwelling units with gas water heaters -- Total credits of $960 each.
- o Solar credits of $8 per month per unit for 36 months for 102,100 multi-family dwelling units with gas water heaters -- Total credits of $288 per unit.
- o Six percent, 20-year loans for 9,000 single family dwelling units with gas water heaters.

o Free solar water heaters for 800 low income customers.

The solar financing program does not require an audit. PG&E had proposed that an audit be a prerequisite to solar financing. However, for the first year of this three-year demonstration program, PG&E is required to inspect 100 percent of qualifying systems to make sure they comply with the state's solar tax credit guidelines and, after January 15, 1981, a more stringent set of standards. PG&E began inspecting a month ago. Of the first 30 inspected, exactly 2 passed. Many of the failures were due to rather easily corrected matters; for example, amending the wording in the contractor's warranty. Others may not be quite so simply corrected. Some systems do not meet sizing guidelines, components are inadequately insulated, and there are an assortment of other shortcomings in the installations. PG&E is working with the industry and regulators and expects to resolve the problems.

Arthur Rosenfeld asked the reasons for failure. He wanted to differentiate between where there was a paper problem with the warranty versus system failures. In response, 20 of the 28 that did not pass were due to the way the warranty was worded. Warranties are the biggest obstacle now. There was no clear predominance of an installation failure or a single type of installation shortcoming among the remainder. PG&E is in the awkward position of offering a customer a rebate and saying he does not quality. PG&E is working with the industry and the regulators to modify the requirements, or train the installers, and explain to them what they have to do.

Martin A. Mattes noted that, during the previous week the PUC had moderated its warranty requirements. The five-year full warranty requirement on parts, labor, and installation, plus a five-year declining warranty, was changed to a single five-year warranty requirement. The terms are now in line with those required by the State Energy Commission to get a tax credit.

There are two programs aimed at appliances rather than the building envelope or solar. The first is PG&E's Salesperson Incentive Program. Its objective is to promote the sale of the more efficient models of appliances by giving participating salespersons merchandise incentives for selling those models. The state has appliance efficiency standards and there is a complete listing of every appliance that can be sold in the State of California ranked by efficiency. Working with Blue Chip Motivation, a sales promotion trading-stamp firm, PG&E has enrolled 2,000 salespersons in this program. Each turns in a scorecard when he sells a qualifying appliance. These records are compiled by Blue Chip, which maintains an account for each participant. Salespersons amass points which they cash in for merchandise from a catalog.

Another program is the Second Refrigerator Removal Program. More than one-fifth of all the single family homes in the service territory have two or more refrigerators. Many of these are in the garage or playroom and are used only to keep cold drinks or fruit. Most second refrigerator owners do not realize how much energy they use. Many other families depend upon a used refrigerator market to purchase their first refrigerator.

While it was important to get some of the second models off the line, it was important not to reduce the source of supply for the Salvation Army, Goodwill, and other agencies that recondition and resell refrigerators. PG&E worked out a cooperative program with charitable agencies. PG&E offered to pay the customer $25 for his second refrigerator. The unit is picked up by a participating charity. If the charity reconditions it and offers it for resale (and they do this on only the more efficient models they pick up), PG&E pays them $5 to help defray their cost of pickup. If they dismantle the refrigerator and take it out of service permanently, PG&E pays the charity another $20. At this time, in the San Francisco Bay area counties, PG&E has collected in less than a year, 3300 refrigerators. Of these, 2500 have been dismantled and 800 have been reconditioned.

There are two other residential conservation programs that are aimed at the new homes market rather than the retrofit market. These are the Energy Conservation Home Program and Suntherm Home Program.

The Energy Conservation Home Program promotes the installation in new homes of energy conserving features exceeding state building code requirements. Qualification for participation is based on a point scoring system, where one point is equal to an estimated annual energy savings of either 3 therms of gas or 30 kilowatt hours of electricity. In order to quality, a home must earn a minimum of 50 points. In return for participation, PG&E offers builders monetary incentives and marketing tools. To help offset the added cost of conservation features installed in these dwellings, PG&E will pay the developer $2 for each point exceeding the minimum of 50 up to $150 per dwelling or $15,000 per subdivision. The marketing tools consist of model home signs, sales brochures, highlight signs for the model house, and energy conservation home certificates for each qualifying dwelling. PG&E sponsors a media campaign to inform the public about the components and benefits of an energy efficient dwelling.

The Energy Conservation Home Program has been successful. During 1979 and 1980, 58 percent of the new homes connected in the service area qualified as Energy Conservation Homes. PG&E verified these with an inspection system that depends on the builder's participation in the program. If a builder has just begun participating, PG&E inspects many of the models in the first subdivision to be qualified as Energy Conservation Homes.

A newer program is Suntherm Home Program and it promotes solar development in residential dwellings. To qualify for this program, the house must <u>first</u> qualify as an Energy Conservation Home. In addition, the house must contain solar water heating and space conditioning equipment that provides at least 50 percent of these energy requirements. As with the Energy Conservation Home Program, financial incentives and marketing tools are offered to encourage participation. The financial incentive ranges from $500 for a dwelling meeting the minimum requirements of the Suntherm Program to $1,000 for a dwelling which 75 percent or more of the water heating and space conditioning needs are provided by the sun.

The ultimate objective of these incentive programs is to phase out once energy conserving installations became commonplace and not the exception to the rule. Program objectives are reached and success achieved when the need for incentives no longer exists. The conservation homes program may be close to accomplishing this objective through a new line extension rule.[2]

A new Rule 15, pending adoption by the PUC, would reduce, or in some cases, eliminate free footage allowances for appliances and establish credits for energy efficient features. Portions of modified Rule 15 have been modeled after the Energy Conservation Home point system, and, if implemented, may award $2.50 per conservation point, with no minimum point qualification necessary. Since the energy conservation credits offered by the revised rule would be contingent upon voluntary participation and since the incentives represent a transfer of credits from the Energy Conservation Home program to the extension rule, the revision tends to augment, but not replace, the Homes program. Upon adoption of the new rule, cash incentives for voluntary participation in PG&E's Homes program will be eliminated, preventing double payment for the same conservation features.

Commercial programs are vitally important to PG&E's conservation efforts. The most important commercial conservation program is the Energy Utilization Analysis, or EUA. The EUA program was originated in 1976 and it is the most effective means of reducing energy waste in the commercial sector.

The EUA program offers an on-site survey and analysis of the customer's business which may take anywhere from one to two days to several weeks, followed by the presentation of a written

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[2] During the years when the marginal cost of new energy was less than the average cost, PG&E sought to build load so that the unit cost of energy used by our customers would be reduced. To encourage this practice, the PUC allowed PG&E and other utilities to extend gas and electric lines free, based on a home's built-in load. This practice, known as Rule 15, line extension credits, is to be changed because it runs contrary to the current emphasis to reduce load.

report. The report outlines specific actions that can be taken by the customer to conserve energy and manage energy load more efficiently. The EUA encompasses the full spectrum of the energy-consuming process, including lighting, HVAC systems, and equipment operation.

Six, 18 and 42 months following the initial survey, callbacks are made. During these callbacks the PG&E representative and the customer review the effectiveness of the audit recommendations as well as the extent to which they have been implemented. Callbacks provide the opportunity to document the energy saved and the specific conservation actions taken, to remind the customer of recommendations that may have been overlooked, and to inform him or her of new products and techniques.

PG&E is committed to performing EUA's for all commercial, industrial and agricultural customers who use more than 100,000 kwh or 50,000 therms per year. About 30,000 of the 350,000 commercial, industrial and agricultural customers fall into this category. To date, PG&E has audited between one-third and one-half of these customers.

In order to provide the most individualized service possible, several specialized audit programs have been developed: a school plant program, a college and university program, a hospital program, and PG&E's oldest conservation effort, the 57 year old pump test program which primarily serves agricultural customers.

A number of support programs, ranging from energy management seminars to free lighting analyses, support the audit strategy.

PG&E is also beginning to offer financial incentives to achieve commercial and industrial conservation. PG&E is just concluding the second year of the California Saver Fluorescent Demonstration program. PG&E offers 50 percent rebates up to $1.00 per lamp to customers who switch from conventional to energy saving fluorescents. Last year PG&E gave rebates on 2.4 million lamps which reduced peak load by 17 megawatts.

There are three other load management programs that are designed primarily to reduce the summer electric peak. A reduction in summer peak is a direct reduction in the use of oil because that is the most expensive form of generation and the last to be used.

The first is a program to shift the use of swimming pool filtering and sweeping equipment off peak. There are between 150,000 and 175,000 swimming pools in the service area and swimming pool equipment runs in the afternoon on the hottest days, peak time. For three summers, PG&E has offered pool owners an incentive of a free chemical test kit and extra time clock trippers. In 1980, PG&E has adjusted equipment on 20,000 pools which has shifted 21 megawatts off peak. It also saves energy because usually cusomters run their equipment anywhere from 10 to 12 hours when they only need to run it about 4. In three years, PG&E has shifted approximately 40 to 50 megawatts.

The second load management program is a "Summertime Break" program in which PG&E gets customers voluntarily to agree to let them install a radio controller on their air conditioners so that they can be turned off by remote control. The compressor on the air conditioner would be turned off for no more than 15 minutes per hour on hot summer afternoons when the generating facilities are operating near capacity. PG&E has installed 20,000 of the intended 60,000 and hopes to have them all installed by the end of 1982.

Finally, in 1980, PG&E initiated a Co-operative Electricity Management Program in three pilot cities. PG&E offered each city $10,000 for each 1 percent reduction in summer peak energy use up to a maximum of 10 percent or $100,000 per city. It is a two-year demonstration program and this was the first summer. The three cities, Davis, Chico, and Merced, all achieved more than a 10 percent reduction and all will get the $100,000 award. It turned out that, although this was a load management program, PG&E had to use an energy measure as a proxy for demand. PG&E estimates if cities could reduce their energy usage between 12 and 6 on a summer afternoon, it would be a reduction in demand. The only strings tied to the award are that it must go for further energy conservation or load management and it must benefit the whole city. It cannot just be something for one plant. The community itself decides how the incentive will be spent.

Now, in addition to all the foregoing, the rate structure is another powerful factor for conservation in California. The rate structure is inverted and it is called lifeline and was begun in 1975. The more gas and electricity used, the more each unit costs.

There are three prices or tiers for each commodity. For gas, the three prices are 29 cents, 57 cents, and 67 cents a therm. In the winter, in the most heavily populated climate zone, 106 therms per month costs 29 cents, another 106 costs 57 cents, and over 212 costs 67 cents. The lowest tier is called "lifeline" rate and represents the minimum amount needed by the average house each month.

For electricity, the three prices are 4 cents, 6.4 cents and 8.9 cents per kilowatt hour. The "lifeline," or 4 cent rate, applies to the first 240 kwh per month, the 6.4 cent rate to the next 240 kwh and the 8.9 cent rate to all above 480 kwh.

In 1980 the projection is that 59 percent of our residential gas sales are at the lifeline rate, 23 percent is in the middle tier and 18 percent is at the highest rate. Seventy-two percent of the residential electricity sales are at lifeline, 22 percent in the middle tier and 5 percent at the highest rate.

This is a brief overview of what PG&E is doing to extract energy from the buildings of its customers. This year the total customer and company conservation programs will cost $78 million, In 1981, PG&E plans to spend $115 million, in 1982, $233 million, and in 1983, $272 million for conservation programs. By 1983, life cycle savings for customer-related programs will exceed 6 billion kwh and 1 billion therms.[3] According to a new long range plan, PG&E expects that, by the year 2000, these conservation and load management programs will reduce peak demand by 7.5 million

[3] PG&E's annual generation rate in 1979 was 60 billion kilowatt hours of electricity.

kilowatts which is almost three and one-half "Diablo Canyons," and that is 25 percent below what it otherwise would have been without the program.

In summary, there is a lot of energy out there. It is the cleanest, cheapest energy available. PG&E wants it, PG&E needs it, and PG&E intends to get it, one way or another.

4. <u>DISCUSSION OF A PUBLIC UTILITY'S EXPERIENCE WITH CONSERVATION</u>

John K. Pollard inquired if there was an estimate of total induced investment, the total spending of PG&E and its customers. PG&E's energy conservation budgets for 1981, 1982 and 1983 do not include the Solar Financing Program or the proposed Zero Interest Plan. The residential conservation programs in 1980 had an impact of $21 million and will be $26 million for 1981.

John Perkins asked how decisions were made on budgets and how money was allocated between programs. PG&E is in a transition period between incrementally going to what it can achieve through conservation. Starting with an Arthur D. Little, Inc. study of how much conservation savings potential is available, PG&E will know how much there is to spend against. PG&E is going in that direction and that is the direction that the PUC is encouraging. It is also the direction that economics is driving toward.

Lee Callaway offered some specific budget information for 1981. The Residential Conservation Service budget is 16.6 million: homes, applicances, and systems, including the Energy Conservation Home Program, the Appliance Salesperson Incentive Program, plus miscellaneous programs not mentioned; 5.8 million dollars: community and consumer services; 4.3 million; commercial, industrial and agricultural conservation service, 15.3 million; program evaluation, 1 million; totalling 43 million for residential and commercial. Other conservation programs which include load management, including the swimming pool program, the community program, and the radio controls on the air conditioning or load managmment, total 25.3 million dollars. Conservation research, development, and demonstration is 2.7 million dollars, co-generation and solid waste, 11.3 million, conservation voltage reduction, 1.1 million, energy from biomass and gas production, 7.3 million. General office improvements for the buildings in which PG&E has its general offices are 18.6 million and street lighting conversion, 6 million. The subtotal of other is 72.3 million dollars, for a total of 115.3 million dollars.

John Perkins remarked that Arthur D. Little, Inc. developed estimates of the most cost effective ways of investing these budgets, and PG&E continually adjusts the budgets based on these estimates.

Lee Callaway responded that, in late 1979, the PUC authorized PG&E's general rates for 1980 and 1981. That decision issued in December of 1979, said that they should take their conservation programs to the margin by expanding its programs until the cost of the last unit of energy saved was equal to the cost of the next unit of energy produced. The first program proposed that achieved this goal was the pending ZIP program.

Henry Kelly asked how PG&E determines the marginal cost which is difficult to define because there are many possible formulations. The PUC has had grueling proceedings on the subject, and in its forthcoming decision it will be defining the PUC's method of calculating marginal cost. This definition uses numbers for a coal fired control power plant that PG&E has proposed. Their new long range plan defers that coal plant which would cost .5 billion dollars, a third of PG&E's total capitalization, until 1993.

Richard Cotton asked whether there is a netting out process included in marginal cost calculations when a new plant is built and there is a new supply. The new supply is sold and revenue obtained. However, if energy is conserved, there is no revenue. The PUC does not have a fixed requirement on netting out revenue. Whether net revenue is netted out of cost is usually determined by whom it is cost effective.

Arthur Rosenfeld noted, in summary, that the real problem has been with tenant-occupied buildings because the landlord is not motivated to save kilowatt hours or therms for his tenants. The zero interest plan is interesting because it does not cost the landlord any interest for a number of years. There is the possibility with ZIP that landlords may do something. A third of the residential property in this country is tenant occupied, and this housing uses a considerable amount of energy.

Steven Carhart added that TVA has been concerned about tenant housing. They have suggested to city councils in their service area that they require landlords to take advantage of a program similar to ZIP.

Arthur Rosenfeld noted that the Berkeley City Council passed a mandatory retrofit bill on point of sale for tenant occupied space.

Martin Mattes added that the Board of Supervisors of Fresno County, which is in a conservative farm belt, is considering a mandatory retrofit ordinance.

PART IV

BEHAVIOR OF BUILDING OWNERS

1. HOUSEHOLD ENERGY CONSUMPTION: THE RECORD AND THE PROSPECT*,**,***

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The Community Energy Impact Study, a research project of the M.I.T. Laboratory of Architecture and Planning supported by the U.S. Department of Energy, has as one of its purposes the analysis and forecasting of household energy consumption in response to changes in the cost and availability of different energy sources. One of the early stages of the research, therefore, has consisted of a review of what is known about household energy decisions based both on other studies and on analyses of relevant data. The findings of this stage will be used to develop behavioral models for later parts of the project.

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***Author's note. I am indebted to many people who helped with this study and who offered critical reactions to an earlier draft report. Special thanks are due to David Birch, my co-investigator on the Community Energy Impact Study at M.I.T.; Virginia Welles and Kermit Baker, who served ably as research assistants; and Henry Lee, Martin Levin, Ben Friedman, and Loren Cox, who gave generous advice and reactions along the way.

Much of the literature on energy consumption is organized around questions of how best to change consumption patterns in the future. One option for change, energy conservation, receives special attention. Our review reflects this concern with conservation as an important strategy.

This paper presents our findings to date in two parts. The first part consists mainly of information on consumption patterns in general, together with an introductory definition of the concept of conservation that underlies much research on energy use. The second part applies these findings on consumption to a consideration of the prospects for changes in consumption resulting from family decisions to conserve energy.

The Pattern of Energy Use

Analysts of the country's energy use disagree on a great many things. They have reached a consensus on one point: that the most practical way to reduce dependence on imported oil in the near future is through conservation. The reasoning behind this conclusion has much merit, but its feasibility has not yet been tested by a careful investigation of household behavior with respect to energy consumption. Advocates of conservation emphasize how much energy it can save, how small the costs will be, and how great the benefits. Daniel Yergin has written in the well-known Harvard Business School report, Energy Future:

> The United States can use 30 or 40 percent less energy than it does, with virtually no penalty for the way Americans live -- save that billions of dollars will be spared, save that the environment will be less strained, the air less polluted, the dollar under less pressure, save that the growing and alarming dependence on OPEC oil will be reduced, and western society will be less likely to suffer internal and international tension. These are benefits Americans should be only too happy to accept.[1]

The arguments in favor of conservation are unquestionably attractive, but the evidence is not yet in on whether or how the large-scale changes of consumption that it implies can be achieved. Price increases since 1973 have certainly prompted consumers to conserve fuel. The best evidence is that total energy use in the

United States declined in 1979, despite a real increase in the gross national product.[2] Although the decline was almost unprecedented for a non-recession year, it was a drop of far less than one percent in energy consumption. Continued price increases may well lead to further conservation, but even the most enthusiastic supporters of conservation do not expect prices alone to lead to the savings of 30 or 40 percent that Yergin anticipates. He calls for public policy initiatives to accomplish what price alone cannot do:

> If we had decades, then the market alone, working through gradual rise in prices, would be sufficient. But the decades are not there. For conservation to make the kind of contribution it should in the relevant time span, there must be found that adroit mixture of signals -- of price, regulation, incentives, and information.[3]

Neither Yergin nor the authors of other recent national energy use studies have been very specific about what combination of regulations, policies, and economic incentives would prompt people to change their consumption patterns.

Conservation depends on decisions about energy use made by millions of families, individuals, and business firms. Energy consumption by households, defined broadly in this paper to include energy for heating, home appliances, and automobile use, is an especially attractive target for conservation efforts. These activities have several things in common. They are all major end-uses of energy in the United States, together accounting for one-third of total energy consumption.[4] For all these categories, great energy savings are technologically possible. All are subject to discretionary decisions by individual households. Yet the major recent books on energy policy give practically no attention to how families respond to changes in the price and availability of energy supplies. As a result, their claim that conservation will make big reductions in our energy needs is premature. An implied assumption is that a conservation strategy would yield big pay-offs, if everyone would only cooperate. However, since cooperation with any national policy is difficult, this is not a strong foundation for an energy strategy.

Only limited research has been done on how households make decisions about energy use. The results that are available, however, reveal many obstacles in the way of reducing energy consumption. To find ways of coping with these obstacles, the first step must be to get a better understanding of household energy behavior.

What is Conservation?

In casual comments on energy matters, conservation is often taken to mean any action that reduces the amount of energy used. The major recent energy studies define conservation in a much more restricted sense, and their advocacy of conservation as a national policy is based on this narrower meaning of the term. The National Academy of Sciences report, Alternative Energy Demand Futures to 2010, notes that during the 1973-74 energy crunch, many people interpreted conservation to mean "belt-tightening" and "heroic and sacrificial denial."[5] To the authors of this report, however, conservation means something else: "an increase in the goods and services delivered per unit of energy used...achieved through improvements in technology and management."[6] To them, conservation means greater efficiency in the use of energy.

Similarly, the Harvard Business School energy report distinguishes among three different forms of energy conservation. One is curtailment, such as the energy saving that is forced when factories are closed as a result of supply interruptions. A second form is overhaul, or a dramatic change in the way people live and work, such as the elimination of parking places so that people would be forced to use transit. The authors of the report considered both these forms of conservation to be undesirable. The form they endorse is adjustment, or "productive conservation," which means such things as insulating houses, making cars more efficient, and encouraging "changes in capital stock and daily behavior that promote energy savings in a manner that is economically and socially nondisruptive."[7]

The study prepared by Resources for the Future, Energy in America's Future, spells out the most complete definition of conservation as efficiency. Its authors define conservation as "the most economical application of energy -- in its joint use with other inputs -- in a given process or activity." They add a very important qualification having to do with cost effectiveness: "To achieve conservation that is cost effective, saving energy alone is not sufficient; the cost involved in saving the energy must be no greater than the cost of the energy that is saved."[8] An example of conservation in this sense is the use of insulation to reduce heat losses from a home at a cost less than what the homeowner saves on his heating bills.

These careful definitions go a long way toward identifying only certain kinds of measures as "true conservation". They still leave unresolved important operational questions, such as deciding within how long a time period a specific investment should pay for itself in fuel cost savings, and whether the savings to be measured are only those accruing to individuals or whether to count other savings for the country at large. The essence of these definitions is to rule out cutbacks in living standards as a means of conservation. The conservation proposed in recent national studies of energy policy speaks of greater efficiency without reductions in personal standards of living. It is not a call for sacrifice but for more rational use of energy and for fuel saving investments that will pay for themselves.

The possibility of achieving great fuel savings through increased efficiency without cutbacks in standards emerges very clearly from a series of experiments conducted by Robert Socolow and his colleagues at Princeton University. They studied the energy characteristics of a group of recently built townhouses in Twin Rivers, New Jersey and experimented with various ways of reducing heating and cooling requirements. By installing insulation and blocking off routes of air infiltration, they managed to make a two-thirds reduction in the amount of energy used for space heating. They estimated the total cost of the job, at retail prices, as $1,245 per house (1978 dollars), not counting the important cost of discovering all the air leaks to be plugged. (Costs in more representative, free-standing older homes would be greater.) At then current prices for gas heating they calculated that the investment would pay for itself in fuel savings in ten years.[9] This is what most analysts of energy policy mean by conservation, and the impressive fuel savings that the Princeton group achieved in the field helps explain why household energy use ranks high on the conservation agenda.

Differences Among Consumers

The same study that demonstrated the potential for conservation in the home also discovered that the behavior of the residents leads to big differences in energy consumption even in houses built to the same plans. The highest energy users typically used twice as much fuel as the lowest, both for gas to heat identical homes in the winter and for electricity to run the air conditioners and other equipment in the summer.[10] When a house changed hands, the new occupants had levels of energy use almost unrelated to those of their predecessors. When a series of houses received the same insulation and caulking, the families living in them maintained their same rank ordering of consumption in spite of the conservation measures.[11] In short, the way families live has a great deal to do with how much energy they use.

Little is known about how the day-to-day habits of household living, shutting doors, turning off lights, opening windows, affect a family's energy consumption. The extent to which such characteristics as age, education, and family composition influence energy use is also largely unknown. However, recent research has identified the strong effect that family income has on energy consumption. The main finding to come out of one of the most informative national household surveys is a simple one:

> ...the more money you have, the more energy you use at home and in your automobile. This is regardless of any other condition -- climate; how and how far you commute to work; the size of your house; your age; number of people in your household; and whether or not

> your house is protected from weather by insulation, for instance. Paradoxically, also, the better off you are, the more likely you are to have equipment that saves energy as well as a house and equipment that uses a great deal of energy.[12]

The top fifth of households, in terms of income, use more than twice as much direct energy, purchases of natural gas, electricity, and gasoline, as the bottom fifth (see Table 1). This trend is even more pronounced if we take into account indirect use of energy, i.e., the energy used to produce and transport the food, clothing, and equipment, and to supply the services that most people consume. Estimates of indirect energy use show the top fifth using almost three times as much energy as the poorest fifth (see Table 1). The greatest differences, however, are in automobile use, with the highest income group using more than five times as much gasoline as the poor (Table 1). The upper middle group in this table, representing the second-highest fifth of households, is close to the top fifth in energy consumption, while the lower middle, covering two-fifths of the population, is closer to the poor.

Well-off families have cultivated a life style that makes them dependent on homes, cars, and appliances requiring a great deal of energy. Robert Perlman and Roland Warren, in their study, Families in the Energy Crisis, have written of the "energy thirst" that afflicts affluent families because of their commitment to energy-using equipment that is already in place (see Table 2). In time, they might replace some of their possessions with more efficient models, but in the short run cutting back on energy use would mean cutting their levels of comfort or convenience. Poor families, on the other hand, are caught in a "price vise" according to Perlman and Warren, trapped between the skyrocketing prices of energy and the climbing cost of food, clothing, housing, and almost everything else.[13]

Other studies have noted relationships between energy use and stages of the family life cycle. Newman and Day found preliminary evidence that energy consumption is greatest when family earning power is at its peak, children still at home, and household size

TABLE 1. INDIRECT AND DIRECT ENERGY USE BY ENERGY SOURCE AND INCOME, 1972-1973[a]

ENERGY USE AND SOURCE	POOR[b]	LOWER MIDDLE	UPPER MIDDLE	WELL-OFF
	BTU INDEX (Poor=100)			
ALL HOUSEHOLDS	100	150	220	280
Indirect	100	160	240	310
Direct	100	140	190	230
Natural Gas	100	110	120	150
Electricity	100	150	200	230
Gasoline	100	250	450	530
	AVERAGE BTU'S PER HOUSEHOLD (MILLIONS)			
ALL HOUSEHOLDS	560	844	1,234	1,573
Indirect	353	549	831	1,095
Direct	207	295	403	478
Natural Gas	118	129	142	174
Electricity	55	81	108	124
Gasoline	34	85	153	180
	HOUSEHOLD'S MEAN INCOME			
DOLLARS	2,500	8,000	14,000[c]	24,500[c]
INDEX (Poor=100)	100	320	560	980

a. Families were asked their income for the previous year (1972), and thus the income groups are defined as of that year. In this table the date in the title refers to the year for household characteristics (1973) or the year for energy consumption data (1972-73).

b. The definition of the poor takes account of both income and family size. For convenience and brevity in this table the poor are referred to as an income group only.

c. The averages for the upper middle and well-off are adjusted using unpublished data from the U.S. Bureau of the Census.

Source: Direct energy use derived from the Washington Center for Metropolitan Studies' Lifestyles and Energy Surveys and indirect energy use from the Ford Foundation, Energy Policy Project, A Time to Choose: America's Energy Future, Cambridge, Mass., Ballinger, 1974, Chapter 5. Dorothy Newman and Dawn Day, The American Energy Consumer, Cambridge, Mass., Ballinger, 1975, p. 90.

TABLE 2. OWNERSHIP OF ENERGY-USING FACILITIES AND APPLIANCES IN SAMPLE HOUSEHOLDS (IN PERCENT)

	LOW	LOW-MIDDLE	MIDDLE	UPPER
NUMBER OF CARS	0.9	1.3	1.6	2.1
PERCENT IN SINGLE FAMILY DWELLING	84	80	89	94
PERCENT OWNING CLOTHES WASHER	56	77	87	95
ELECTRIC DRYER	23	43	60	77
DISHWASHER	7	19	38	64
SPACE HEATER	55	28	22	22

Source: Robert Perlman and Roland L. Warren, Families in the Energy Crisis, Cambridge, Mass., Ballinger, 1977, p. 130.

is greatest.[14] Another study has found connections between annual miles of travel and stages of the family life cycle.[15] Still another study reports that families without children and families where the wife is at least 60 use about 13 percent less energy than families raising children.[16]

The research done so far emphasizes that family income overrides most of these other considerations. Newman and Day have shown that for almost every category of age of household head, household make-up, employment status, education, and owning vs. renting, the well-off consistently use about twice as much direct energy as poor families.

So pervasive is the tendency of people with more money to use more energy that it shows up even in driving habits. Perlman and Warren discovered that before the 1973-74 oil crisis, people in each income group reported driving at faster highway speeds than those in the next lower group. The upper income group in their survey reported averaging highway speeds of 63 miles per hour, in comparison with 58 miles per hour for the poorest.[17] (Perhaps the only way to really enjoy a Mercedes is to drive it faster.) If this information is accurate, the newly imposed federal speed limit of 55 miles per hour is one of the very few acts of public policy in recent times that demands greater sacrifices of the wealthy than of the poor.

All this is not to say that income alone is the best predictor of household energy use. Variations in climate from one part of the country to another can affect energy use to an even greater extent. A typical new home in Minneapolis requires more than four times as much energy for heating and cooling as a typical new Los Angeles home.[18] Aside from location in different climates, the household characteristic that stands out in the limited amount of energy use research so far is income. Household behavior with respect to other economic decisions suggests that families with equal income may in fact behave very differently from one another if they differ in other respects. A young family earning $15,000 may base its decisions on the expectation of increasing income in future years, while a family approaching retirement and earning $15,000 is likely to act on the basis of anticipated reductions in income. Education and occupation are also likely to matter. An attorney's family and a plumber's family in the same income bracket probably live in different kinds of homes, buy different equipment for leisure activities, drive different kinds of cars, take different kinds of vacations, and end up using different amounts of energy. More accurate indicators of energy consumption will have to wait for future investigations that look at the interaction of several family characteristics instead of focusing on a single one.

<u>Who is Willing to Change Energy Use?</u>

Soon after the OPEC embargo brought on the first energy crisis in 1973-74, researchers were concerned to find out whether Americans believed the fuel shortage was genuine. A common assumption of the time was that unless people believed there was an energy crisis, they would have little motivation to reduce their consumption. The early studies revealed a high degree of skepticism about the energy problem. Only 36 percent of the respondents in Perlman and Warren's study of Hartford, Mobile, and

Salem (Oregon) reported that they considered the energy shortage to be real. Most people believed it was contrived by the oil companies to increase their profits.[19] A survey by Harper's and Atlantic found that 86 percent of the respondents thought the fuel shortage "could have been avoided."[20] Other surveys by the National Opinion Research Center found that few people believed the energy shortage was a major or long-lasting problem, and a majority held the federal government and big oil companies responsible for it.[21]

Who the believers were and who the skeptics were remained unclear. Perlman and Warren found a slight tendency for the highest income group to believe in the reality of the crisis more than the lower-income groups in two of their cities, but in the third the reverse was true. Families with higher income in this study were more likely to blame the oil and gas companies for the energy shortage, while those with lower incomes were more likely to blame the government.[22]

With the passage of time, a higher proportion of people came to believe that the energy shortage was real and serious. Cunningham and Lopreato's study of consumers in five southwestern cities in late 1975 found that 42 percent strongly agreed with the statement. "The United States currently has an energy problem," while another 45 percent also indicated agreement, although not strongly. Nearly 89 percent believed that the energy problem would cause major difficulties within the next five years, and 75 percent expected difficulties within the next 20 years. Other studies have also revealed growing and widespread belief in the existence of an energy problem.[23]

Whether belief in an energy problem really motivates people to change their consumption is another question, however. The early studies failed to find any close connection between energy beliefs and energy conservation: believing the energy shortage was real made little difference in people's behavior. In the Perlman and Warren studies, believers and skeptics changed their energy use to about the same extent.[24] The later study of consumers in the Southwest actually found an inverse association between appreciation of energy problems and conservation practices. Cunningham and Lopreato discovered that people with more education and higher incomes were more likely than others to believe there is an energy problem (64 percent of college graduates compared to 45 percent of high school graduates, for example).[25] However, understanding the problem did not lead people to deal with it through conservation:

> While respondents with high income and education appear to be more aware of certain energy issues, such as the depletion of oil and gas, these are not the people with the most involvement and concern over the energy problem. Consumers with low to middle education and income experience more effects on budget and life style. They discuss energy issues, complain about the problem, and make more conservation efforts...Lower-income and middle-income consumers, hit hardest by price increases, may not be very knowledgeable about energy matters, but they are conserving. At the same time, they are hostile about the situation and are likely to become increasingly so as continued price rises make energy a luxury commodity affordable only by the well-to-do.[26]

The implication of these results is that people conserve energy when shortages affect them directly, such as through price increases or unavailability of fuel, but not in response to a general appreciation of energy problems. Perlman and Warren asked people who had reduced their energy use whether they did so because of price, availability, or a sense of duty. Price was by far the most important reason, and this was true at all income levels. Among middle income families, unavailability of gas was almost as important in explaining reduced use of their cars, however.[27]

Although belief in an energy problem turned out to have little to do with consumption, some other differences among people appear to have greater value as predictors of behavior. A national survey made by the University of Michigan's Survey Research Center in late 1974 found some important differences between the young and the elderly. Of the people between 18 and 24, 40 percent reported that they had reduced and could reduce their heating costs easily, in comparison with only 24 percent of those over 65. Similarly with electricity use, 58 percent of the younger group reported that they did and could cut their consumption, while only 26 percent of the older group said the same. While the young were willing to give up some heat and electricity, they wanted to keep driving their cars and were less ready to cut gasoline consumption; the old wanted their heat but anticipated fewer problems with gas conservation.[28]

Not surprisingly, people who pay their own heating bills are more likely to cut back on heat than those whose fuel costs are included in their rent. In the Michigan national survey, 65 percent of people who were charged directly for home heating reported that they had conserved, compared with 45 percent of those whose heating costs were buried in the rent. Other studies confirm the same point.[29]

The most important variable separating people who believed they could adapt easily to reduced energy consumption from people who thought they could not, according to the Michigan survey, was their belief about the adequacy of government policy. Among those who believed government economic policy was being poorly conducted, only 29 percent reported that they could easily adapt to lower heat consumption, compared to 40 percent of those who rated economic policy as "good;" there were similar differences in the reported ability to cope with the reduced consumption of electricity and gas. Although willingness to conserve has little to do with beliefs about the energy problem, this study found it related to people's opinion of how well government deals with the energy problem.[30]

The same survey found no systematic relationship between family income and the inclination to conserve energy. It did find, however, that what people thought about the adequacy of their income was important. People who felt their income was inadequate to provide their family with a comfortable standard of living expected much greater difficulty with future conservation than those who felt their income was adequate. For gasoline conservation, for example, 61 percent of those who considered themselves under financial stress expected difficulty with future conservation, compared with 50 percent of others. The key variable was not the level of income, but the match or mismatch between income and aspirations for living standards.[31]

Household Responses to the 1973-74 Crisis

Most of the behavioral studies cited so far do not report on conservation in the limited sense of that term in recent energy policy studies: achieving greater efficiency in the use of energy. Actual reductions in energy consumption resulted mainly from cutbacks in travel, heating, or other activities, undertaken quickly in response to the fuel shortages and price increases of 1973-74. These are not the adjustments recommended by proponents of conservation, nor are they likely to be as long-lasting as fuel reductions resulting from investments in more efficient cars and home heating equipment.

Still, consumer behavior during the 1973-74 oil crisis tells us something about the nature and limits of household energy conservation. Changes in energy use resulted far more from cutbacks than they did from conservation. In Hartford, Mobile, and Salem, 49 percent of the households surveyed by Perlman and Warren reported that they turned down the thermostat during the winter, and two-thirds of the households with air conditioning reported that they made less use of it in the summer. A high proportion of well-off families turned down the heat than did the poor -- 61 percent in the highest income group, compared with 35 percent in the lowest. However, fewer low-income families had their own heat controls, 81 percent for the poorest, compared with 98 percent for the best-off.[32] The temperature reductions were very small in almost all cases, averaging an overall drop of only 1.5 degrees (from 70.2 the year before to 68.7). In each city, the drop in temperature did not vary more than 0.5 degrees from one income group to another, and the differences between what each income group called its ideal winter temperature and what it actually used for a thermostat setting during the crisis winter did not exceed 1.5 degrees for any income group.[33]

Faced with big increases in the cost of electricity and natural gas, families also cut back their use of appliances. Asked whether they had reduced their use of electricity because of the price, three-quarters of the Hartford and Mobile families said they had, while even in Salem, with electricity prices among the lowest in the country, 58 percent also reported cutbacks. In all three cities, three-fourths or more of the families said they reduced their lighting, while one-fourth to one half reported cutting back the use of other appliances because of fuel price increases.[34] In Mobile and Salem, the highest proportions of families reporting cutbacks in electricity were in the low- and low-middle income groups; while in Hartford the low-middle and middle-income groups ranked highest in this respect.[35]

Families also cut back the use of their cars in 1973-74. In the three cities, 79 percent of the households reported driving less in order to save gas. The major reductions were in shopping trips (cited by 62 percent of the families), and in visits to friends and relatives (reported by 47 percent).[36] Only 15 percent of the workers reported changing the way they traveled to their jobs, with most of the changes involving a switch from driving alone to joining a car-pool.[37] In general, there was little variation among the income groups in vacation trips. Among those who reported changing vacation plans because of the fuel shortage, a higher proportion of low-income families cancelled their vacations, while higher-income families simply shortened their vacations.[38]

In sharp contrast to the large number of people who reduced their energy use by making cutbacks in their standards of living, few reported making investments that would lead to greater efficiency in the use of energy. Seventeen percent added weather-stripping to their windows or doors, at a median cost of $300-$400; and ten percent insulated floors, walls, or ceilings, at a median cost of $100-$200.[39] A small proportion switched to more efficient cars. Nine percent reported selling their cars with a view to saving gas, and 13 percent said they bought cars for that reason. A higher proportion took actions with small energy profits: half the car owners said they had their engines tuned to get better mileage, and one-fourth changed tires for the same purpose.[40] No information is available in this study on the income levels of families who made investments for greater energy efficiency.

The 1973-74 story is basically one of cutbacks, not conservation. In the activities that consume most energy -- heating and transportation -- the lowest income group (with incomes under $5,000) made the steepest cuts, reducing their consumption below 1972-73 levels by 21 percent for transportation and 15 percent for heating. Among families with higher incomes the differences are not great, but those in the highest income brackets made slightly larger proportional reductions in their use of energy for travel and heating. In the less important categories of household appliances and air-conditioning, the highest income families (incomes above $15,000) made the biggest cuts, but the differences among income groups are not large. Overall, families reduced their energy use by an average of 12 percent.[41]

Households at different income levels, however, use vastly different amounts of energy. Low-income families used much less energy to begin with, so that their cutbacks undoubtedly represented greater sacrifices than comparable percentage reductions for the more affluent. But the bottom line in terms of energy use is that families with incomes above $15,000 saved almost three times as much energy per family as those with incomes below $5,000. Before the 1973-74 crisis, the average family in the low-income group used an estimated 201 million btu's annually, while the average family with income above $15,000 used some 498 million btu's. Average savings in 1973-74 amounted to 25 million btu's per family for the low-income group and 68 million btu's for the average high-income family.[42]

A follow-up survey in the fall of 1975 tried to establish whether the adjustments people had made during the 1973-74 crisis would continue afterward. In most respects, families reported that they had kept their energy use stable for a year after the crisis peak. Among the minority who were returning to pre-crisis behavior, though, high-income families reported the greatest backsliding from their 1973-74 cutbacks, particularly with respect to recreational trips.[43] Although the differences among income groups were not great, they were discernible, and they should sound a note of caution about whether those who use the most energy are likely to maintain cutbacks in energy use after a short-term crisis has passed.

Consumption Patterns After the First Crisis

As energy shortages turned from a short-term crisis to a long-term problem, it would be natural to expect an increasing number of people to search for ways of cutting their energy use without cutting their standard of living. More recent studies do show a higher proportion of people who are conserving by increasing the energy efficiency of their homes. Yet the number who are making substantial investments remains small, while the number who sacrifice comfort and convenience to save energy remains large. Further, the evidence at hand indicates that the poor continue to make disproportionate sacrifices in response to price increases, while the well-off can more easily absorb higher energy prices without making as many changes in their own energy use practices.

In October 1975, a research group at the University of Texas sent mail questionnaires to ten thousand households in five southwestern communities: Austin and El Paso, Texas; Flagstaff and Prescott, Arizona; and Albuquerque, New Mexico. Nearly 25 percent returned usable questionnaires, which Cunningham and Lopreato have analyzed at length in their book, Energy Use and Conservation Incentives. They classified conservation measures into three categories: easy, requiring more work/less comfort, and requiring an expenditure.

The easy measures include such items as turning out lights when they are not needed, turning thermostats down in winter and up in summer, closing off unused rooms, turning off heat and air conditioning while away from the house, and washing only full loads in the clothes washer. Most people reported having made "substantial" or "moderate" efforts to do all these things. On most of the easy items, the proportion of families making these efforts ranged from 75 to 85 percent.[44]

The next category involves inconvenience or reductions in living standards, such as using light bulbs with lower wattage, reducing dishwasher use, watching TV less, using less hot water, and hanging clothes out to dry rather than using a clothes dryer. For most of these measures, the proportion of families reporting substantial or moderate efforts ranged from 30 to 50 percent.[45]

The third category is more clearly conservation in the sense of more efficient use of energy without cutbacks in living standards. The measures include installing storm windows or thermopane, buying insulating drapes, adding insulation to the attic, weatherstripping doors and windows, and replacing appliances with more energy-efficient ones. For these items, the proportion of families claiming substantial or moderate efforts ranged mostly from 20 to 30 percent.[46]

Cunningham and Lopreato used factor analysis to identify patterns of conservation behavior among different kinds of households. For each of four clusters of consumer responses, corresponding to increasing levels of inconvenience or cost, they distinguished how people who conserved more differed from those who conserved less. The first factor consisted of items having to do with adjusting thermostats and turning off unneeded lights. Since almost everyone reported making substantial or moderate efforts to accomplish these things, the differences among groups were slight. Nevertheless, people with lower incomes and less education reported more effort than others. About 88 percent of respondents with family incomes of less than $5,000 were classified as "more conserving," with this proportion decreasing to 79 percent of those with incomes of $25,000 or more.[47]

This same pattern was more pronounced for a second factor consisting of items that required more effort, such as turning off heating and air conditioning when away, turning off decorative yard lights, and washing only full loads of clothes. For these items, nearly 85 percent of families with incomes below $5,000 were classified as more conserving, compared with only 51 percent of high-income families. Similarly, 80 percent of those at the lowest education level had high conservation scores, compared with

61 percent of the highest education group. Age was also important. Higher proportions of people under 30 reported substantial to moderate conservation efforts in these terms than did people in older age groups.[48]

A third factor involved items requiring cutbacks and inconveniences, such as using less hot water, watching TV less, using the dishwasher less, defrosting the freezer more often, hanging clothes out to dry, and replacing light bulbs with others of lower wattage. More than 33 percent of the families with incomes under $5,000 were classified as more conserving, with the percentages declining across income groups to a low of 8 percent among people with incomes of $25,000 or more. Similarly, 38 percent of those with the least education ranked as high conservers, compared with 13 percent of those with the most education. The age pattern found in the second factor was reversed here. Only 11 percent of those under 30 ranked as more conserving, compared with nearly 30 percent of those over 60.[49]

Finally, a fourth factor represented conservation in the sense of investing in energy-efficient equipment, such as adding insulation to the attic, installing storm windows, and weatherstripping doors and windows. Since these measures cost money, it would be reasonable to expect low-income families to report less effort. But the opposite is true: nearly 50 percent of the under-$5,000 group ranked as more conserving, falling to 19 percent at the highest income level. From the lowest to highest education levels, the high conservers decline from 44 to 21 percent of the total. Among the age groups, people over 60 reported the most conservation effort, while the middle-age groups had the lowest scores.[50]

This study presents a clear picture of who feels the impact of energy problems. In a system where the main incentive to conserve is the rising price of fuel, low-income people outdo others not only in making cutbacks that lower their living standards, but even investing money to achieve greater energy efficiency.

The same study found, as noted earlier, that higher income groups are more persuaded that the country's energy problems are real. The authors conclude:

> ...the individuals who are making sacrifices to conserve energy appear more frequently to be people in lower socio-economic groups. These latter individuals are frustrated because they are not apt to believe that a true energy problem exists, yet they are forced to lower their standards of living as a result of the high cost of energy.[51]

Information from more recent surveys partly confirms the Cunningham-Lopreato findings and partly contradicts them. The 1977 Annual Housing Survey, undertaken by the Bureau of the Census and the Department of Housing and Urban Development, collected considerable information on energy characteristics of single-family detached homes, both owner- and renter-occupied. In general, the proportion of families living in well-insulated homes increased directly with their income, both for owners and for renters. Among owners, for example, 77 percent of families with incomes of $5,000-$7,000 lived in houses with attic or roof insulation, compared with 94 percent of those with incomes of $25,000-$35,000. Among renters, 51 percent in the $5,000-$7,000 bracket had attic or roof insulation, compared with 76 percent in the $25,000-$35,000 category.[52] The same pattern held true for families that had added home insulation during the past year; the higher the income group, the higher proportion of families invested in insulation. However, families in the very highest income group (over $35,000) are somewhat less likely to live in fully insulated homes or to have added insulation in the past year than those just below them.[53]

Cunningham and Lopreato found that only 20 to 30 percent of families have ever made substantial or moderate efforts to install energy-saving equipment such as insulation, storm windows, or weatherstripping. The Annual Housing Survey found that in the prior year alone 15 percent of homeowners added attic, roof, or wall insulation. Another recent survey undertaken by the Department of Energy, the National Interim Energy Conservation Survey (NIECS), found that during 1977 and again in 1978, one-third of all families reported adding insulation or other energy-saving equipment to their homes. The lower level of activity found in the Cunningham-Lopreato study may reflect a regional bias, since it was conducted in southwestern states with generally mild climates where relatively inexpensive natural gas is the main household fuel. However, most of the activity reported in the NIECS was inexpensive, consisting mainly of weatherstripping and caulking. Each year, only 6 percent of the families in this national sample reported adding roof, attic, basement, or wall insulation; and only 5 percent reported adding storm windows or a new furnace. So the dollar commitment to conservation investments appears small in both the NIECS and the survey of southwestern cities.[54]

In contrast to Cunningham and Lopreato, but like the 1977 Annual Housing Survey, the NIECS found the proportion of people investing in conservation materials to be smaller at low income levels than at higher ones. In almost every category of conservation outlay, the proportion of people with incomes below $5,000 who invested was smaller than in any of the higher income groups. The proportion buying inexpensive insulation was 17 percent of those with incomes below $5,000 in both years, compared with 25 percent or more for most other income levels. For expensive insulation and both inexpensive and expensive equipment, the range was much narrower, usually between 6 and 8 percent for most income groups, but in most cases less than 1 percent for those earning $5,000 or below, and in several cases 11 percent for those with incomes of $25,000 or more. The near-poor group, however, with incomes between $5,000 and $10,000, were as active in making most investments as people in middle-income brackets.[55]

Another recent survey also found the poor slightly underrepresented among families undertaking conservation activities. The city government of St. Paul, Minnesota, conducted a community-wide survey of household energy use in February, 1980, and reached an unusually large sample of 35,000 households through a mail questionnaire. When energy decisions are categorized as cutbacks (closing rooms, lowering thermostat settings) or efficiency investments (new furnaces or insulation), separate patterns appear.

Differences among income groups are neither consistent nor large when it comes to making cutbacks, but higher income families are more likely to make efficiency investments (see Table 3). Other characteristics than income distinguished the more active from the less active conservers; homeowners, the elderly (60 and over), middle-aged families (30-59), and larger households undertook more conservation activities than others. The St. Paul survey agrees with Cunningham and Lopreato in another respect. People were asked whether they thought fuel shortages were a major, minor, or no problem. Almost two-thirds considered fuel shortages to be a major problem, with upper income people more likely to identify the problem as major and low-income people more likely to belive there was no shortage or the shortage was no problem. However, the households that believed shortages were not a problem were more active in conservation than those that considered them a problem (see Table 4).

The Cunningham-Lopreato finding that the poor were over-represented among people making material investments in conservation is not supported by these other surveys. Cunningham and Lopreato also found severe limits to the extent of future investments the poor might make in conservation, and in this they are more in line with the subsequent studies. In their survey, they asked people what would be the maximum amount of time they would be willing to wait to recover various levels of investment in energy-saving equipment in the form of savings on their fuel bills. People in the two lowest income groups (below $5,000, and from $5,000 to $10,000) were willing to wait an average of only six months to recover an investment of $100 on home insulation, and only about 1 1/2 years to recover an insulation outlay of $500. Higher income groups were willing to wait on average about 1 1/2 years for a $100 insulation investment to pay for itself, and up to 4 1/2 years for a $500 investment. Acceptable payback periods for investments in storm windows followed a similar pattern.[56]

TABLE 3. PERCENTAGE OF HOUSEHOLDS MAKING LIFESTYLE SACRIFICES AND ENERGY EFFICIENCY INVESTMENTS, ST. PAUL, MINNESOTA

	HOUSEHOLD INCOME				
	Less Than $10,000	10,000 15,999	16,000 24,999	25,000 or More	Total
LIFESTYLE CUTBACKS					
Close Off Rooms	63	56	56	54	58
Turn Down Furnace Thermostat	85	87	90	92	89
Turn Down Water Heater Thermostat	66	65	70	66	67
EFFICIENCY INVESTMENTS					
Install a More Efficient Furnace	22	23	26	29	25
Insulate Attic	51	50	57	64	56
Insulate Walls	40	39	42	47	42

Source: Saint Paul, Minnesota, Energy Office, Data Tape of Saint Paul Energy Mobilization Survey, Feburary 1980.

TABLE 4. AVERAGE NUMBER OF ENERGY CONSERVATION ACTIVITIES TAKEN BY RESPONDENT PERCEPTIONS OF FUEL SHORTAGES (OF 18 POSSIBLE CONSERVATION ACTIVITIES)

PERCEPTION OF PROBLEM	AVERAGE NO. OF ENERGY CONSERVATION ACTIVITIES	PERCENT OF RESPONDENTS
A Major Problem	8.3	62
A Minor Problem	8.4	19
Not a Problem at All	8.9	2
There Is No Shortage	8.8	11
No Opinion	8.0	6
Total	8.4	100

Source: Saint Paul, Minnesota, Energy Office, Data Tape of Saint Paul Energy Mobilization Survey, February 1980.

In addition, Cunningham and Lopreato collected information on what levels of reductions people thought they would make in the use of different fuels if the prices increased by amounts varying from 5 percent to 150 percent. Here, too, the message was that the poor are less able to cut energy use than other groups. People with incomes below $5,000 indicated they would make reductions in their use of gasoline as prices rose about 30 percent, but beyond that point doubted whether they could make further cuts. For electricity and natural gas, as well, the poor indicated they would cut their consumption in the face of price increases of up to 30 to 40 percent, but beyond that point they foresaw no further level of reduction.[57]

That the poor have little margin for further cutbacks or substantial conservation investments seems clear from these responses, even allowing for some differences between stated intent and actual behavior. But a more startling finding is that the other group least responsive to future price increases consists of families with incomes of $25,000 or more. These families indicate they would make moderate reductions in their use of fuels if prices rise by 40 to 50 percent, but they expect to make few cutbacks beyond that point. Middle-income groups, in contrast, expect to keep cutting as prices keep rising. Cunningham and Lopreato note:

> The assumption is widespread that low-income groups cannot do much about their energy use and that high-income groups will not. The present findings tend to bear out that assumption...It is apparent that price increases are much more effective incentives for some groups of people than for others, and that the high energy users are not those most affected.[58]

These analyses lead Cunningham and Lopreato to a conclusion that seems well founded. With low-income families already cutting their energy use and unable to cut much more, and with upper-income families not overly concerned about the rising cost of energy, the most promising place to look for future conservation is to the middle-income group. Families with near-average incomes are poor enough to feel the pressure of rising prices, but they may have enough resources to be able to invest in conservation, and they may have a long enough time-horizon to accept reasonable payback periods for their investments. The social implications, however, are perverse. Low-income families, who were already spending 15 percent of their income on energy in the early 1970s,[59] were hit hardest by energy price increases, and had to cut back or conserve until they had little margin for any further energy savings. Having exhausted the ability of the poor to absorb further cuts, the energy economy will turn next to those in the next-higher income bracket. Price incentives will then push the middle-class to make further cuts in living standards and further investments in conservation. Meanwhile, families with incomes in the top fifth, who spent only four percent of their earnings for energy in the early 1970s, and who consume by far the greatest amount of energy per family, can afford to keep enjoying a high standard of living without much need for either cutbacks or conservation. This system is neither equitable nor efficient, but it is an inevitable result of relying on price to force conservation.

II. Prospects for Change

Research to date raises serious doubts about whether household conservation is likely to make big reductions in U.S. energy use in the near future. A look at conservation behavior reveals some basic problems. The well-to-do, who have the resources to invest in greater energy efficiency, already have houses that are relatively efficient. In 1973, 94 percent of the well-off (top fifth) of the population had insulation in their homes, as did 86 percent of the upper-middle group (next fifth).[60] They use a great deal of energy not because of inefficiency but because of their life style. Their houses are much larger than those of the poor and the middle-class, and they own more appliances. They also own more second homes and more cars. If conservation means getting more efficient energy use without sacrificing living standards, they have only a limited range for this form of conservation.

There are technological possibilities for them to become still more efficient than they already are, but they want a reasonable payback period for any conservation investments. In the survey of consumers in the Southwest, even people in the highest group wanted to recoup any conservation investments in the form of fuel savings within less than five years, as already noted. Yet the Princeton demonstration of how to reduce energy use for space heating by two-thirds through modest insulation and caulking estimated that its investment would have a 10-year payback period.[61] And the conservation-oriented projection of Resources for the Future's thorough and balanced study, Energy in America's Future, assumes that consumers will make investments if they are justified by a ten-year payback.[62] At a time of double-digit inflation, there is little reason for investors to find a ten percent return attractive, and apparently most do not.

At the other end of the socio-economic ladder, the poor start with low efficiency of energy use. Only 41 percent of the lowest fifth have insulation in their homes and less than a third have storm windows.[63] They drive older cars, manufactured before the new federal mileage requirements took effect, and their aging appliances presumably are less efficient than newer models. Yet they do not use much energy -- only a third as much as the well-to-do, counting indirect energy consumption. They would benefit from greater energy efficiency, but making them more efficient consumers would not save much fuel for the country at large, since they use so little anyway. Even the small savings that they might make are uncertain because they lack the resources for investment, they demand a very short payback period, and a high proportion do not own the homes they live in.

Somewhere in the middle are people who want to conserve and who have the resources to make conservation possible. But the mismatch problems that discourage conservation among the poor and the well-off demonstrate that effective conservation requires a very special combination of consumption patterns, opportunities for greater efficiency, and payback periods. There is no reason to assume that the number of families with the right combination is big enough to bring about conservation on a large scale, at least until more is known about how typical households make energy decisions. The aggregate record of energy consumption in the 1970s provides grounds for no more than moderate expectations. Oil supplies have been disrupted, prices have gone up unexpectedly, and consumers have made cutbacks as well as conservation investments. The net result is that energy consumption per household, which grew substantially in the 1960s, has leveled off and held constant in the 1970s. It has not declined so far, beyond a drop of less than one percent in 1979.

Although the record of energy use so far does not justify much optimism, neither does it provide grounds for concluding that the limits of conservation have already been reached. Even on the basis of current trends, both government and industry have reduced their projections of future energy demand. At the end of 1980, the Department of Energy revised its estimate of the growth in energy demand through 1990 to one percent a year, down from a forecast of 2.5 percent two years ago and down from an actual growth of 4.3 percent a year in the decade before the 1973 oil embargo. The Exxon Corporation cut its energy demand forecast for the year 2000 ten percent below its 1979 estimate.[64] Further price increases have not yet put household energy use to a very severe test. The main increases have been for oil prices, but in most of the country the predominant fuel for home heating is natural gas. Natural gas prices are still controlled at moderate cost levels, and therefore have not yet given most families a strong incentive to reduce their energy consumption for home heating.

Non-Conservation Responses

One of the reasons why the conservation record is not more impressive is that families faced with rising prices can do several other things besides invest in more efficient equipment. Other important alternatives are cutting back on living standards, switching fuels, and increasing labor force participation in order to raise incomes.

Cutbacks

A characteristic response to fuel shortages and price increases has been for people to reduce their standards of comfort convenience by such measures as turning down the heat or making fewer trips. This response does save fuel, but at the expense of living standards. It is not what the advocates of conservation have in mind.

Low-income families may have little margin for cutting energy consumption without jeopardizing their health or basic functioning. As their utility bills go up, however, they may nevertheless be forced to cut back in order to keep paying for other necessities. For the elderly in particular, reducing fuel use can be extremely hazardous. When house temperatures drop into the low sixties, many older people may suffer from accidental hypothermia -- a rapid loss of body heat that can be fatal. Every winter brings newspaper reports of people freezing to death in their homes, usually the poor and the elderly.[65] Some heat waves also bring scores of deaths at home, usually to the poor and elderly who cannot afford to use air conditioning.[66]

The poor also resort to cutbacks in safety standards in order to get their heat. In the winter of 1979, Jose Roman of Boston began to use a space heater because he could no longer pay for oil deliveries. The room heater started a fire that killed his wife and four children. The Boston Globe took up his case in an editorial calling for federal subsidies to help the poor pay their fuel bills. Estimating that an adequate program might cost from $2 billion to $4 billion, the Globe admitted that such a proposal sounds open-ended and expensive, but concluded that it "surely sounds less horrifying than Jose Roman's screams in the Dorchester night."[67]

Those who favor using price increases to push conservation generally concede that special measures are needed to protect the poor. And the federal government has indeed undertaken several programs to help the poor weatherize their homes and pay for fuel emergencies. But all the programs have been very small relative to the need. In the first two years of operation, the main weatherization programs reached less than four percent of low-income housing in need; and the authorizations for emergency energy assistance were enough to meet only a small fraction of the fuel bills of even the most severly affected families.[68]

Cutbacks, in short, produce social consequences that cannot be acceptable, and public policy has yet to find effective ways of coping with them.

Switching Fuels

By 1979, large numbers of families who could afford a conservation investment decided to make a different kind of investment. They converted oil burners to natural gas, or they discarded an oil furnace and installed a new gas boiler. By September 1979, the Long Island Lighting Company received 33,000 requests for residential conversions, while other utilities in the Northeast also reported making many thousands of home fuel conversions. The costs ranged from $500 to change only the burner to $2,000 or more to install a gas-fired boiler. Owners of rental property also switched to gas. In the largest conversion of this kind, the Lefrak Organization in New York converted 54 apartment buildings housing 9,200 families to gas heat.[69] In total, a survey by the American Gas Association indicates that at least 365,000 families converted their heating to gas in 1979, an increase of 155 percent over the 1978 level of 143,000 conversions. More than 80 percent of the 1979 conversions were in three regions where 70 percent of all oil heating customers are located: the New England, Middle Atlantic, and East North Central Census divisions. This volume of conversions marks a return to the trend before 1970, when conversions averaged 393,000 a year as gas pipeline capacity was expanded in residential areas, prior to hook-up restrictions imposed by state regulatory agencies in the early and mid-1970s.[70]

This is a response that saves money without saving energy. The switch is from one limited energy source to another. As a result of price differentials between heating oil and natural gas, conversions in 1979 promised to cut heating bills by about 40 percent for typical single-family homes. But unless the homeowner increased the efficiency of his system at the same time, he would continue to use the same number of btu's under either system, with no net reduction in energy use.

Switching from oil to natural gas posed no problems, but simply failed to conserve energy. Other fuel switches produced objectionable side-results. Many thousands of families in the Northeast switched to wood stoves for some part of their heat. According to a state survey, at least two-thirds of all Vermont houses had wood stoves by late 1979.[71] In Massachusetts, almost one-third of the households burned wood in 1978-79.[72] Switching to renewable sources of fuel could help solve energy problems. Wood is a potentially renewable resource, if forests are managed properly. But a large part of the New England supply comes from private woodlots, whose owners are not managing them to replenish what is cut. Growing use of wood stoves has also led to growing complaints about air pollution. Further, many wood stoves are not installed properly and become fire hazards. In 1979, there were 96 reported deaths in Maine and Vermont attributed to wood stove fires. These states had no such deaths at all a few years earlier.[73] The growing use of wood as a source of energy is also producing a series of environmental objections. When the Burlington, Vermont, Electric Department proposed to build a wood-powered electrical generating plant, both public officials and citizens who appeared at the permit hearings raised objections to potential air pollution problems and to potential damage to sensitive woodland areas near the plant where ash would be dumped.[74]

Increasing Labor Force Participation

When the cost of an important consumer item increases, people do not necessarily invest in ways to use less of it. They may instead find ways to pay the higher price, and indeed may decide to buy even more of it than they did before. This was the story of new single-family homes in the 1970s. Although their sales prices went up faster than median family income, and the full monthly cost of owning a home (including mortgage payments, utilities, taxes and repairs) went up about twice as fast as median incomes, home sales continued at record levels and the proportion of families who were homeowners increased steadily. Further, the new homes that were sold were bigger and better equipped each year.[75] Consumers were very inventive in finding ways to pay the new higher costs while also paying for improvements in quality. One of the important strategies was pooling the incomes of husbands and working wives. Among first-time homebuyers, the proportion of families with two wage-earners was well above the national average.

The upsurge of married women in the labor force is well known: from the late 1940s to the late 1970s their percentage in the labor force more than doubled. By 1978, 48 percent were in the work force, and the Urban Institute projects that by 1990, two-thirds of all married women under 55 will be working.[76] This trend is undoubtedly a response to inflation, at least in part. By adding another wage-earner, large numbers of families have been able to raise their incomes as fast as the cost of living. From 1970 to 1978, the Consumer Price Index was up by 68 percent, but median family income was up by 79 percent. As inflation became more severe, millions of women joined the labor force. That troublesome social problem of only a few years ago -- the loss of the work ethic -- dropped from conversation. If the work ethic had ever been lost, inflation helped people find it again. And for the majority of families whose incomes kept pace with inflation, the price increase of energy was not a severe burden. In constant dollars, the price of gasoline actually fell two percent from 1958 to 1978; electricity dropped 7 percent; while home heating oil rose 47 percent and natural gas 31 percent during that period. Price rises after 1970 reversed a long-term downward trend.[77]

Once more, price increases do not necessarily lead to conservation. They may lead instead to more work and higher incomes. Further, they may not even lead people to adjust their energy consumption so as to maintain a constant standard of living. If recent experience with new housing is a guide, people who raise their incomes will do their best to increase their standard of living. Most energy forecasts speak of fuel requirements to maintain today's standard of living. It seems more likely that the search for continually higher material standards will continue, and that energy requirements of the future will be geared to higher levels of activity and a greater number of possessions.

Beyond Price Incentives

Since price incentives alone are leading to no more than moderate energy conservation, what are the prospects that additional public or private initiatives can induce people to step up their conservation efforts? Many government measures have been put into effect during the past few years, and many more have been suggested. What is most striking about the record so far is that the new policies promise only limited and gradual results. Undoubtedly more will be done in the future, but it is hard to escape the conclusion that accelerating conservation through deliberate action is not going to be a quick or easy process.

One of the ways in which government can help is by making specialized knowledge of conservation opportunities more readily available. The big energy savings accomplished by the Princeton team in insulating houses in New Jersey depended on skills and methods that are not generally available to homeowners and contractors. The researchers made use of infra-red photography and elaborate instrumentation to track down a series of small air leaks that cumulatively wasted a great deal of energy. Under the National Energy Act of 1978, the federal government will fund states to develop energy audit programs. Under the state programs, utility company technicians will inspect homes and recommend to homeowners what they can do to make their houses more efficient. This strategy seems very useful, but of course there is no way to know how thorough the audits will be and how many homeowners will make investments on the basis of the advice they get. The federal official in charge of the new program anticipates that about 7 percent of the homeowners will actually get audits each year. By 1985, he expects the program to save about one percent of the country's current foreign oil consumption -- not an overly impressive amount, but "every little bit helps," according to the director.[78]

Government can make conservation a more attractive investment by using subsidies to shorten the payback period. The main action along these lines is a provision in the Energy Tax Act of 1978 permitting taxpayers to take an income tax credit of 15 percent of the cost of conservation investments they make in their homes, up to a maximum credit of $300. This, too, should be helpful. But how much of a difference will it make? Even in the exceptionally favorable case of the Princeton experiment, which involved new town houses rather than representative older detached homes, the estimated cost of $1,245 (not counting the audit) had a ten-year payback. A 15 percent tax credit would reduce this cost to $1,058, bringing the payback period down to 8.2 years.[79] This is a more attractive return than the ten-year period, but it is still well above the 4 1/2 year payback that most consumers want according to the Cunningham-Lopreato survey of the Southwest. In any event, few people have taken advantage of the energy tax credit: about twelve percent of the taxpayers claimed it in 1978 and five percent in 1979, with the credits going disproportionately to families with high incomes.[80]

Private sector initiatives may well have greater potential in encouraging conservation investments. Individual insulation contractors generally lack both the technical knowledge and the credibility to market a package of suitable home improvements that would achieve substantial energy savings at reasonable cost. Analysts of household energy use have proposed instead the concept of a "house doctor" or energy consultant -- a firm that would specialize in testing homes and identifying a series of investments that homeowners could make in order to improve the thermal efficiency of their homes. As fuel prices continue to increase, it should be possible for business firms to offer these services on a commercial basis. So far the closest approach to this concept has come from certain utility companies and consumer organizations.

Electric utilities in many parts of the country now have incentives to encourage household conservation. At current interest rates, new power plants are very costly to finance. Further, the regulatory and political obstacles to power plant construction are severe. Under these circumstances, power companies may find it more feasible to meet new energy demand by helping their present customers to conserve rather than by expanding their generating capacity. Pacific Gas and Electric, Pacific Power and Light, and the Tennessee Valley Authority have gone furthest in this direction, with the approval of state regulatory agencies in their service areas. Pacific Gas and Electric now offers home audits and recommendations for energy saving to its customers in California, together with below-market loans to help finance weatherization and other measures, at a cost of more than $37 million in 1980. This company has also proposed a new series of zero-interest loans to finance certain cost-effective conservation measures.[81] Pacific Power and Light has already been conducting free energy audits and offering interest-free loans; as of March 1980, this firm had performed energy audits for 14,000 customers, of whom 8,000 had made the recommended installations. As of October 1979, the Tennessee Valley Authority had audited more than 150,000 homes and had made 60,000 interest-free retrofit loans.[82]

Two private non-profit organizations in Rhode Island and Massachusetts have also been active in this field. Rhode Islanders Saving Energy (RISE), backed by local utilities, offers free home energy audits, selects approved contractors to do the home improvement work, supervises and inspects the work, and helps consumers get below-market loans from participating banks. Massachusetts Fair Share does home audits for a fee of $45 and offers training and demonstrations to do-it-yourselfers and interested local organizations. These operations of the public utilities and non-profit organizations have not yet been evaluated systematically to establish the extent of fuel savings they are achieving, but the information available to date suggests that their approach holds real promise for the future.

<u>Regulating the Product</u>

Where price incentives alone do not motivate people to make conservation investments, another governmental approach is to impose conservation standards through product regulation. Under some circumstances, this can be an effective strategy. The case of automobile fuel efficiency illustrates a situation where regulation appears very promising. Even after several years of sharp price increases in the early 1970s, the cost of gasoline alone was still not high enough to motivate customers to buy fuel-efficient cars. At 1978 levels, the cost of gasoline was about 4¢ per mile, or $400 per year for the average car. The Resources for the Future energy report notes that the pattern of car sales by weight in the United States indicated that as of 1978 only a small minority of buyers found the high fuel economy of the smallest cars important enough to overcome other considerations. European experience suggested that gas prices might have to be three times as high in order to persuade buyers to get fuel-efficient cars.[83]

The Energy Policy and Conservation Act of 1975, however, required auto manufacturers to achieve an average fleet mileage of 18 miles per gallon by 1978, rising in stages to 27.5 miles per gallon by 1985 (about twice the average mileage of new cars in 1974). The required technology was mostly already available, since European and Japanese manufacturers had already developed fuel-efficient models. Although the changeover is costly, the auto companies have so far been able to meet the new yearly mileage requirements, and transportation experts expect them to meet the 1985 requirements as well. By 1980, the demand for new cars shifted more decisively toward fuel-efficient models, and General Motors announced plans to exceed the federal requirement by 1985.[84]

Politically, regulations requiring auto manufacturers to make technical improvements in their products have turned out to be very feasible. Alan Altshuler has analyzed the politics of this regulation and has identified several reasons why it generates few objections from the voters. The direct impacts of product performance regulations are felt by a few companies rather than a large number of voters. After losing the initial battle over safety regulations in 1965, the auto manufacturers have not been strongly resistant to extensions of the regulations on their products. Their main concern has been to keep the content of the regulations within the range of technical and economic feasibility. Although consumers ultimately pay the costs of regulation, these costs tend to be "uncertain, blurred, and deferred" -- so that they have not prompted voter protests.[85]

The Resources for the Future study identifies a few problems that limit the effectiveness of the mileage regulations. First, because they apply to new cars only, there will be a lag of several years before they change the average mileage of the actual fleet on the road. Second, certain lightweight trucks that are exempt from the regulations are being used increasingly as passenger vehicles, and their mileage is very low, on the order of 10 miles per gallon. Third, as long as gas prices fail to make drivers want to conserve, there will be a gap between the fuel economy imposed by regulation and the actual fuel economy achieved. Drivers may not maintain their engines in top condition, and they may take advantage of greater efficiency to make more or longer trips. Despite these problems, the Resources for the Future study projects that total national energy consumption for auto transport by the year 2000 will be at least 31 percent below the 1976 level, and possibly as much as 48 percent lower.[86] This is an impressive saving.

Making new houses more energy-efficient through product regulation seems a great deal harder. Homebuyers are willing to spend money to buy extra insulation and more efficient heating systems, but only to a limited extent. Survey teams who questioned people shopping at displays of model homes in early 1979 asked whether they would be willing to buy upgraded insulation, at a cost of $1,750, and double-pane windows, at a cost of $2,500. In the eight cities surveyed; the proportion who wanted extra insulation varied from 64 to 83 percent; the proportion who wanted double-glazed windows varied from 23 to 71 percent. A year earlier, people replying to the same survey had shown much stronger interest: 83 to 97 percent for upgraded insulation and 34 to 91 percent for double glazing.[87]

Surveys of new houses built in 1975-76 show important increases in the levels of insulation and the use of double-glazing in comparison with houses built in 1973 and 1974. Nearly all the new houses in 1975-76 had both ceiling and wall insulation, and the average thermal value of the insulation increased substantially.[88] Data from the National Interim Energy Conservation Survey show a steady trend toward lower energy use per square foot in homes of more recent construction. Average energy use figures for new homes declined by 12 percent from 1950 to 1960 and by another 23 percent from 1960 to the mid-1970s.[89] But these gains represent only a small fraction of the energy savings that are possible: a Department of Energy estimate is that new homes could easily be made

50 percent more efficient than they are. Some confirmation of this view comes from a recent survey by the Tennessee Valley Authority of new homes built in its area. The TVA inspectors found that 83 percent of the new homes had less than adequate attic insulation, including 20 percent with no attic insulation at all, and 85 percent had no floor insulation. According to the TVA director of energy conservation, "Builders are holding costs down by leaving out the stuff people don't see."[90]

One of the main reasons why builders do not make new homes still more efficient is that many of them discover buyer resistance or indifference. A 1978 report from Chicago noted that buyers were passing up beefed-up insulation packages in favor of such luxury options as extra rooms.[91] In 1980, a Long Island builder who tried to market new homes with a wide variety of energy-saving features found them only marginally useful as a selling point. He reached a familiar conclusion: "The people who need energy saving most can't afford to buy new housing, and the people who can afford to buy new housing don't have energy saving as a prime consideration."[92]

Homebuilders try to provide what people want to buy. Can regulation get them to provide more energy efficiency than new homebuyers are willing to pay for when they have a choice? Unlike the automobile industry, homebuilding is a very fragmented, small-firm business. Regulation is in the hands of thousands of local governments. There are 100,000 builders in the United States and some 5,000 local building codes. Both the builders and the local officials have a long record of resisting proposals for uniform building codes.

The federal government has made several efforts recently to move toward uniform thermal efficiency standards that would apply to all new buildings. The Energy Policy and Conservation Act of 1975 requires state governments to adopt mandatory energy efficiency standards for new buildings as a condition of certain federal aid. Federal agencies promoted the adoption of a model building code on the subject; and by the end of 1979, 42 states had adopted some version of it. Early impressions in the field, however, are that it will be a long time before local building inspectors have the technical skill and motivation to enforce the new code effectively.[93]

Meanwhile, the Energy Conservation and Production Act of 1976 required states and localities to adopt building energy performance standards. Performance standards allow greater flexibility in the design of buildings than a typical building code, and architects tend to favor them for this reason. However, they require even higher levels of technical competence on the part of building inspectors, and building inspection has been an underfunded and politically vulnerable activity in most communities. Initial federal proposals for energy performance standards have generated widespread opposition and controversey. The Congressional Office of Technology Assessment has reviewed the situation and issued a warning that is, if anything, understated: "Federal standards that must be enforced by state and local officials face many problems of compliance. There is no indication that the problems of implementation have been given the appropriate level of consideration."[94]

In short, not all regulatory situations are as favorable to energy conservation as that of the automobile industry. Even if the implementation problems with building standards were completely solved, the payoffs would be much slower than with auto efficiency standards. Within relatively few years, newly manufactured cars constitute a high proportion of all cars on the road. In housing, however, new construction in a good year adds only about two million houses to an existing inventory of 80 million, most of which will be in use for many decades to come.

Because housing markets are essentially local, local government may well be the appropriate place for policy initiatives affecting home heating and cooling. Portland, Oregon, has devised an unusually promising approach to the problem of energy efficiency in housing. Any homeowner who wants to sell his house after 1984 will have to certify to the buyer that an energy audit has been done and that all conservation investments that would pay for themselves in ten years have been made. The city will arrange for energy audits to be conducted and will offer help with financing.[95]

Reappraising Household Energy Conservation

Finding effective policies to encourage household energy conservation means finding policies that match the micro-behavior of individual families who will make decisions about conservation investments. This review of energy consumption suggests a number of conditions that must be met before people will decide to make their homes more efficient. First, for a family to decide on conservation investments it must have a home that is relatively inefficient at the outset. Second, people must have adequate knowledge of what to do to make their homes more efficient. They must have confidence in the source of information and confidence, as well, that whatever contractors they hire will do the work competently. Third, they must have the resources to invest. Fourth, they must be persuaded that the payback period for recovering their investment is an acceptable one. An important factor here is the mobility of American families. The average family moves every five years; those who change houses on a timetable close to the national average will probably be reluctant to accept a payback period longer than their own period of residence in a home. Fifth, they must be persuaded that investments in conservation will yield a greater return than other uses of their money -- a difficult condition to meet when money market funds pay more than fifteen percent interest per year.

In addition to matching the decision behavior of individual families, policies to encourage household energy conservation will merit support only if they compare favorably with other energy alternatives in terms of benefits, costs, and risks. The information at hand is far too sketchy to allow firm judgments on these points, but the potential payoffs do appear substantial and the costs and risks less than those of other strategies. It is important, however, to acknowledge that conservation is not risk-free. The 96 deaths attributed to wood-stove fires in two New England states have already been mentioned. One can only imagine the furor that would have resulted if 96 lives had been lost as a result of nuclear power accidents. In addition, a popular insulation material, urea formaldehyde foam, has now been identified as a cause of cancer. In the past few years, an estimated half-million homes have been insulated with this material.[96] Again, one can only speculate on the public reaction to a situation in which half a million families were exposed to carcinogens as a result of nuclear power. Deaths and health hazards should count equally in analyses of all energy alternatives. Conservation involves risks, even though it does not pose the still greater hazards of nuclear power, nor does it raise the environmental threats of greater coal utilization.

A further consideration that emerges from a look at the behavior of people with different incomes is that of equity in public policy. Conservation driven by higher fuel prices demands -- and gets -- greater sacrifices from the poor than from the rest of the population. Yet to win public support for an energy policy, it will be important to demonstrate that whatever sacrifices are necessary will be shared on a fair basis. Policies that increase the long-term dependency of poor people on government programs to help pay their bills are flawed from the start. Weatherization programs to improve the efficiency of poor people's homes could be a more promising way of reducing the impact of fuel prices, with more lasting benefits.[97] However, finding ways to make these home improvements competently and on a large scale will not be easy, partly because of the complicating factor that most poor people live in rented housing.

On balance, the evidence so far should encourage all levels of government to devise and test conservation policies.[98] But this is a time-consuming process. At first glance, conservation may appear to offer the advantage of speed over such alternatives as synthetic fuels and solar energy, which depend on the invention of new technology. Yet designing appropriate policies and programs, building political support for them, and adjusting them to the realities of human behavior takes time as well as ingenuity. The timetable for inventing and adopting workable policies may not be much shorter than the timetable for technological development. Household energy conservation deserves a serious exploration and an effort to make it work. But expectations should be realistic, and the major energy studies so far have advocated conservation as a short-run solution to the nation's energy problem without studying the subject very carefully.

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2. DISCUSSION OF HOUSEHOLD ENERGY CONSERVATION: THE RECORD AND THE PROSPECT

Arthur Rosenfeld opened the discussion by addressing the question of the perceived success or the perceived extra value of energy conservation homes. Lee Callaway responded that PG& E's Energy Conservation Homes Program offers builders incentives to add measures that exceed the state code and cost $100 to $300 per house, depending on the building volume. The incentive provided is between a third and a sixth of the cost. Surveys of people who live in these homes estimate that the added value is somewhere between $600 and $1,000. Owners put a higher value on conservation features than these features actually cost the builder. Telling this to the builders has been very helpful in getting them to participate in the incentive program. In the California housing market a builder does not have to put anything extra on a house to sell it. There is no incentive to get a selling advantage unless a customer might prefer a house with energy conservation features over a house that does not have them.

According to Frieden, the national experience with energy conservation features has been very mixed. Some builders have tried to make a special feature of building highly efficient houses to see if they can sell them and reach a special market. Others conclude that houses are so expensive these days that people who can afford a new house are not likely to worry too much about differences in the fuel bill. Demand on the part of the customers for extra features seems to fluctuate from year to year and from market to market. When buyers have a choice between spending money on extra space, extra kitchen equipment, or extra insulation and energy saving features, they almost always choose space or other things more likely to make a house resaleable.

Richard Wilson reported on a meeting where there was considerable discussion of what terms and features of leases make energy conservation more attractive to building owners compared to an absence of motivation if all conservation benefits are freely enjoyed by the tenants and the investment falls on the building owner. It is important to look into lease provisions that would have these built in incentives.

Robert Ricci asked what data supports the five-year payback. How closely do people look at the economic savings of operating costs versus conservation investment? TSC has been unable to separate these aspects in automobile studies. Initial price seems to be the main criteria by which a person buys a car, and fuel economy is lower valued, number two or three on the scale. What is the five year payback? Is it because one out of five households move annually?

Bernard Frieden commented that the best documentation of the five year payback is Energy Use and Conservation Incentives by Cunningham and Lopreato. This book, based on surveys in a number of cities in the Southwest, was published in 1977 and reflects data from a time period of steadier energy prices. The answers all point to the same conclusion, a five year payback.

John K. Pollard asked whether that was five years at current energy prices or can people be made sensitive to expected increases in real prices of fuels. In automobile buying behavior, there is an accelerator phenomenon in that if it is a time period when gasoline prices are rising 1 or 2 percent or more per month, people focus on fuel economy. If gasoline prices are more or less level, interest wanes. TSC has a simple method devised by K.H. Schaeffer. He compares the price of a used Impala with the price of a used Chevette. The ratio which indexes the importance of fuel economy mirrors the behavior of a whole market.

David J. MacFadyen observed that one effect of the higher operating cost on a home is that it limits the ability of a person to buy. In the real estate industry there is growing investigation into whether an energy efficient home should have some kind of scale or rating so that a person can get a lender to give a better rate of interest on that home. When a lender looks at how much a person can afford to pay for a home, one of the main factors is the cost of running the home, i.e., the gas and the electric bills.

Henry Kelly discussed the concept of Principal, Interest, Taxes, Insurance and Energy (PITIE), trying to persuade lenders to include energy costs in the formula used to qualify potential buyers. The present formula includes principal, interest, taxes, insurance and energy cost. It is reasonable to add energy bills to that formula, but the difficulty is measure E.

David J. MacFadyen worked on a publication for new home buyers entitled "The Energy Buyers Home Buyer." This data indicated that energy is not a practical part of the purchase decision. Fuel bills from similar houses built by the same builder differ because different families live in those houses. There can be one hundred percent variation in bills.

MacFadyen believes that the Department of Housing and Urban Development left out the biggest energy bill in developing this report. The biggest energy decision made in buying a house is location, not the difference between the energy efficiency of the available houses but the energy consumed by transportation. If PITIE is used, E ought to include transportation costs. The most impressive statement in that study was the fact that realtors say that the top three criteria for selling a house are location, location, and location. Secondly, realtors consider layout, space, the kitchen, and other things in selling houses.

In a purchase decision, a person does about a 10-minute analysis of the alternative costs of the house that he considers. He spends ten minutes analyzing the actual structure. It would be very useful to try to give the buyer a reasonable yardstick to judge energy efficiency in his decision. Buyers know they can spend $70,000 or some other number, but most do not include insurance in the cost calculation. PITIE is a good idea but few people apply it. It is PI and, in Massachusetts, T.

David J. MacFadyen continued by noting that buyers look at the differential energy cost between houses even though judging is difficult. It is not a tractable thing. The energy efficiency packages are often talking about very small differentials. In a study for National Homes, MacFadyen found the monthly differential was $4 to $5 for new housing. To get a buyer to think about that amount is unreasonable, when he is trying to decide between a $70,000 and a $90,000 house.

Arthur Rosenfeld observed that PITIE refers to buying used houses, the majority of house purchases where it can have a significant effect. DOE offers forms which include energy pointers that realtors are about to adopt.

Steven Carhart said that, to the degree that the market recognizes the economic returns of retrofit, there are three energy productivity shifts that have had a potential effect in the retrofit market. The first shift was in 1973 and was done by industrial energy managers. They understood profit and loss and cut energy costs. The second shift is automobile fuel economy which really began penetrating the market last year. The auto market is now ahead of standards. The toughest market institutionally to crack is the residential retrofit market because there is the lowest degree of operator sophistication relative to the complications involved. However, the way the market works happens all at once. The market lags for a long time. Under appropriate circumstances, the awareness changes. In the next few years something analogous to the automobile situation may occur; acceptable fuel economy is a necessary condition for the purchase. A watershed may be near depending on prices and on the availability of efficiency equipment in a convenient to buy package which the customer has not had up to now.

Bernard Frieden observed that market penetration may also require a crisis. The awareness of fuel efficiency in cars dates from several experiences with gas lines. It may take something analogous to that in the housing field to make people aware of the energy cost of operating a home.

Richard Cotton asked Professor Frieden if he had any information on the impact of institutions on the decisions. His presentation referred to the individual homeowner and his decision. In terms of the homeowner's decision, there has been discussion about utilities giving incentives to institutions, specifically to salesmen to get into homes, to the utility to get into the business, and to energy service corporations to get into the business.

Bernard Frieden replied that he had thought about the impact of institutions on homeowners' decisions, mainly in connection with getting information and having confidence in the person that is doing the work. It is very important for homeowners to have somebody that they trust doing the analysis and have confidence in the firm that is going to make the solar installation because there is a lack of appropriate institutions that the homeowner can deal with.

Mike Casper inquired about the necessity of requiring certain energy efficient installations at the time of the sale of a home. Frieden replied that a few communities have adopted such laws, but none of them have put them into effect yet. Portland, Oregon has adopted a law of this kind, but it will not take effect until 1984, so it is hard to know what the results might be. Such a law could lead to the abandonment of older housing. That would be the case if it were in a large Northeastern city with a surplus of housing on the market, such as many cities now have. It depends where the standards were set, and whether they refer to something that could be complied with for a few hundred dollars or many thousands of dollars. It is hard to predict how that would work in the absence of looking at the specifics of a city and a set of regulations.

Martin A. Mattes noted that if a mandatory retrofit requirement resulted in the abandonment of housing, that might give either utilities or municipalities an opportunity to take over housing and renovate it, and put it back on the market. Would that be too expensive? Professor Frieden responded that it would depend on the housing. If it is housing that is basically in very good condition but lacks insulation, it is not likely to be abandoned. This might just spur the abandonment of marginal housing.

Lee Callaway added that a standard for the insulation of new homes should be easier to inspect and enforce. PG & E's audits do not have anything to do with enforcing the state code. PG & E's audits of homes built since the state code went into effect show that 35 percent of the homes inspected do not meet the state code. One community, Davis, has a law requiring energy efficient installations at the time of the sale. They have had no problem with it because they had an enforcement mechanism before they put the law into effect.

PART V

NATIONAL POLICY ISSUES

1. NATIONAL POLICY ISSUES RELATED TO ENERGY CONSERVATION

Henry Kelly
Director
Solar Energy Research Laboratory

Building investments should be considered investments in the energy supply industry. The potential energy savings by the year 2000 are in the area of 7 to 8 million barrels a day in total resource energy, as well as somewhere between 2 and 4 quads of energy from renewable resources available from the building sector.

Although some of these forecasts seem larger than might be expected, these estimates are based on standard forecasts for the growth in buildings over the next 20 years, i.e., DOE's Energy Information Administration's (EIA) forecasts of building stock and growth. For example, the EIA forecasts expect the average house to increase in floor area by 30 percent in the year 2000, despite a decrease in family size and it anticipates a 65 percent increase in commercial floor space by the year 2000, which may be greater than the actual growth rate.

This growth can be supported and end up actually reducing consumption at less than the marginal cost. From an investment point of view, things are attractive about conservation investments that are unattractive about supply investments. Conservation investments can be built quickly; they do not require long term financing. The forecasting risk is relatively small since the demand is there.

If conservation looks financially attractive in principle and the technical possibilities are reasonably well defined, the problem of adoption of conservation is not as much technical as behavioral. The following are specific suggestions on how to overcome behavioral obstacles to the use of conservation.

1. Investments in buildings cannot be treated like investments in energy supply. There has been a separation between supply investments and investments of energy consumers. The current viewpoint is that investments are made in supply by producing electrons into a wire and gas into a pipeline. Someone else is responsible for selling energy to customers. This separation has created distortions, the clearest of which is that utilities which recognize the marginal cost of energy are not in a position to make investments in demand. In terms of the market, the gas and electric utilities are the only institutions that have the financial incentive to save energy. Everyone else is trying to sell a storm door or insulation. If there is no profit, only the utilities will have the incentive.

   The financial community has not looked at buildings as energy investment opportunities in the way they look at utilities. There is the possibility of a substantial diversion of capital resources through very different channels if investments are made in buildings rather than power plants. This confusion of the conventional supply industries and the financial industries are reflected in the policies of the Department of Energy (DOE), which has not been able to adapt itself to programs dealing with a diverse set of clients. DOE is used to dealing with a small number of clients.

   There is a problem of self-image in the building industry itself. They do not see themselves as an energy supply industry, nor do they see investments in insulation as a way to make profit any more than the financial community does.

2. Industries will be needed to do retrofits. There are some little companies, and one or two rather large companies, that do retrofits, but the industry is not as large as is needed. There is a need to retrofit 80 million housing units and 35 billion square feet of commercial office space. A major objective of policy has to be to create a retrofit industry.

3. There are rather substantial investment opportunities in the business of efficient appliances. Calculations show that, using a liberal interpretation of what an appliance is, appliances offer as much energy savings as any of the building shell investments.
4. There is little research on building styles, technology, and energy efficiency. Very little research has been directed toward finding the most intelligent, cost effective, prioritized way to save energy in a variety of building styles and climates. The research has been supported by technology and various popular fads. Interesting technologies, from solar to conservation, have tended to dominate the research enterprise. The coordination between solar research and efficiency research has been inadequate. Where does solar fit into the spectrum of alternatives? This is not an easy question because it is totally uncharted territory.
5. There are uncertainties about indoor air quality in an energy efficient structure.
6. There are several problems with energy auditors and installers of energy efficient materials, i.e., poor training, no training at all, and personal safety problems in the course of work.
7. There is a lack of knowledge about present building stock. How many buildings have double brick walls which are hard to insulate? How many older buildings will need residing over the next 20 years? It is crucial information, but it is not available.
8. Condominium conversions are enacted without considering retrofits. A survey in Springfield last year indicated that approximately 25 percent of the buildings in the low income area of Springfield were at risk of being abandoned by the owners under current circumstances. It would not take much in the way of requiring an improper retrofit program to force those abandonments.

The question of long-term contracts was also raised. A survey done by the Building Operators' Association for commercial buildings showed that 20 percent of their members cannot make improvements in the buildings because of long-term leases which prohibit passing through the cost of the retrofit adequately.

9. There is a need for consumer protection against charlatans in the retrofit business.
10. In terms of utilities, overcapacity in large parts of the country is an extremely serious barrier to any efficient utility retrofitting program. There is a question about the soical utility of investing massively in conservation in an area which has already made a large capital investment in supply.

Overall, there is an enormous opportunity to save seven million barrels of oil a day. The question is what fraction of that can you reasonably capture. What do you do and with what priority? Much retrofitting is going to happen even if the federal government does not do anything. The following ideas may provide some answers as to what can be done.

1. There is not one, simple, federally dictated program that will work. The regional sensitivity of retrofitting, depending on climate, the regional utility supply situation, the references of communities, will dictate what happens. The federal role has to be one of orchestrating rather than dictating retrofit efforts.
2. It will be necessary to line up commercial industries who have a profit motive and create a situation where, in principle, if the federal government disappeared, retrofitting would continue. Retrofit programs need to be resilient to political change.
3. Solar energy should be included.
4. All programs encouraging retrofit need to be carefully evaluated to determine what has been accomplished.
5. The retrofit programs that should be implemented are of several types. The least expensive program that can be set up by the federal government would be a set of very rigorous standards and an enforcement program. That type of program internalizes expenses. Even though the burden is borne by the private investor, a strictly enforced standard will get results. A more

expensive step is information and research. It would be relatively low cost, but there is absolutely no confidence in what the outcome would be. It is likely that information and applied research programs could get good results. The most expensive program would include direct assistance demonstration and more potent intervention in the market process. There will be re-evaluation of strategy in this area and examination of what the market could or could not do.

It is useful to describe retrofit programs pertaining to new and old residential and commercial buildings and appliances. Residential retrofit programs can save about 4 quads. The cost of such a retrofit is about $150 billion, to be spent over the next 20 years.

It is also important to create a vigorous retrofit industry. The Residential Conservation Services (RCS) is a legislative mechanism which, with relatively modest perfecting amendments, can be a key in getting this retrofitting accomplished. The things needed are a more effective house doctor audit and skilled auditors. It is necessary to make it as simple as possible for a house owner to get an entire package of audit, ordering of the retrofit, inspection, and financing at the same time.

In order to accomplish what has been discussed above, there is a need for a careful research program to determine what actually can be done to get to the marginal investment in different kinds of buildings in different climates. It is necessary to proceed in an applied research way to find out what can be done, report it, measure what has been done, and continue from year to year for at least five years.

It is also necessary to use this data base to develop a building energy rating system to tell a prospective buyer how much energy the building used, independent of lifestyle. This rating would be entirely a function of the equipment of the house and of the building shell. Such a rating system provides some leverage in the investment market. To the extent that any kind of qualifications are used, either by the homeowner himself or by the mortgagor, the availability of energy efficiency information has to have some influence on the market decision. The federal government can leverage the market decision to some extent by working through the FDIC and FSIC which have considerable leverage in setting standards for the private lending industry.

Energy utilization information, used in California with controversial results, is called Utility Feedback Billing. This type of billing tells the consumer how many kilowatt hours were used, the cost, and how many kilowatt hours were used during the month in the previous year. There are also many publications that inform people about what the cost effectiveness of different kinds of retrofits in their region would be.

These aforementioned programs provide ways to discover what to do and how to get the information to people in a position to make decisions. Assuming these programs are in place, it is possible to attain about one quarter of the retrofit savings. This would constitute a savings of twenty five percent of 4 quads, the total potential retrofit savings.

There is a need for special retrofit programs for low income and rental housing which represents 43 percent of all the dwelling units in the United States. Of all the dwelling units rented, 16 million are units for low income households.

The retrofit program for low income households is a weatherization program which is moving slowly and is encumbered by restrictions. There is in place a $36 billion Congressionally mandated low income assistance program which is used mainly to pay fuel bills. The $36 billion could allocate $2000 for each of the 16 million low income units. Retrofitting these units may be a better investment and could readily be done for $2000 per unit. The question is how to turn direct assistance into capital investment. It is interesting that the $2000 per unit is about 70 percent of the cost of the total retrofit required to save 4 quads of energy.

The Residential Conservation Service programs offer a way to begin national retrofitting and encourage the development of a retrofit industry that works. It is important to create a cadre of trained auditors who are able to take advantage of the retrofit information gained from a research program. The actual cost of a "house doctor" visit is $300 per audit. This audit includes a careful instrumented examination of a house and some $70 worth of on-site retrofit at the time of the audit. The $300 cost includes the $80 materials cost which includes weather-stripping, low-flow showerheads, wrapping water heaters, and caulking.

An issue in connection with the RCS program is whether utility company audits exclude private auditing firms from a potentially lucrative market. Vouchers might be an alternative. If the utility finds that it is worth $200 to them to get a good audit for their customers, it might be reasonable for them to offer this $200 or $300 to any qualified auditor to do the job. The auditor would have to prove to the customer that his audit is better than the utility company audit. At present, there is little competition. The utility company is unique and has an incentive to identify the low-cost retrofit items.

Financial incentives are another way to encourage retrofits. It is important to identify and to use financial incentives selectively where there is a need for an incentive, i.e., in the rental or low income markets, places where existing financial incentives do not work or are not covering things properly. The tax credits now available are irrational; there is a 15 percent credit for conservation, a 40 percent credit for active solar, and zero credit for passive solar. There should be some mechanism for keying these credits to the actual energy efficiency of the house, taken as a unit, with solar treated like any other efficiency investment.

The energy savings impact of retrofitting new residential units is not as large as would be expected. It is a 1 quad savings. These numbers are savings and should be compared to DOE's Energy Information Administration. EIA was more optimistic about how much energy new buildings were going to save than they were about possible retrofit savings.

It is very important for future retrofitting to have a well-defined research program that looks at the problem of saving energy in buildings and energy use per square foot per degree day. There is a need for manuals of recommended practice for the industry that are simple, easy to interpret, and show trade-offs between conservation and solar investment. Such manuals are in the process of being developed. Finally, it is necessary to develop a technique for using the money in this research program to lure the building industry into understanding what these building techniques are, to persuade them that they are not hard to do, and that there is a market for retrofitting. If there is a proper sequence of research cycles, it will be possible to move gradually from simple approaches to some more complicated ones. At present, techniques for doing these things are being tested in Denver with promising results.

The most potent tool for retrofitting new residential units is the Building Energy Performance Standards (BEPS). Probably three, and maybe as many as ten states, are going to adopt some kind of building standard during the next couple of years. There certainly is a need for getting these state standards to be as effective as they can possibly be, to capitalize on the research work that's already been done by the federal government in developing BEPS, and to get uniformity in these standards. At present, three states, New York, California, and Florida, have building standards which are very close to BEPS. They have adopted standards similar to the American Society for Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE), which are not as rough as the BEPS.

2. DISCUSSION OF NATIONAL POLICY ISSUES RELATED TO ENERGY CONSERVATION

There was considerable interchange about the impact of building standards. For certain federal programs, states are required to come up with a standard which usually follows the American Society of Heating, Refrigeration and Air Conditioning Engineers standard, but this requirement has not had any measurable effect on building practices. Evidence suggests that many of California's buildings standards have been ignored one-half to two-thirds of the time. David J. McFadyen commented that he had trouble accounting for the dramatic increase in wall insulation and the uniformity of ceiling insulation at acceptable levels without looking at the state standards. The use of wall insulation has increased, and it is something that can't be seen by the homebuilder who does not have to install wall insulation. The HUD Annual House and Home Survey has shown an exact correlation between state regulatory activity and the increase in thermal features in housing.

In the TVA region, according to Henry Kelly, buildings are using more energy per square foot than they were four years ago. He has not seen a demonstrable correlation between the Annual Builders Survey data and the adoption of state standards. David J. McFadyen added that insulation use is correlated with building standards. Arthur Rosenfeld commented that this association would be easy to check because insulation shipments are known. It would be interesting to know if insulation shipments doubled one year after the state adopted ASHRAE 9-75. There is some evidence that the major industrial producers, National Homes Corporation, Wausau Homes Corporation, and Ryan Homes started installing insulation on the day that the heat standard took effect. The producers of housing are complying with these standards, indicating that standards have an effect. There are enforcement problems, but the major producers cannot take the chance that the inspector will miss their house.

Retrofitting of new commercial buildings will save 2 quads of energy. Henry Kelly emphasized that it is necessary to create an industry that is knowledgeable and that careful research is needed on design and training.

Proper use of natural daylight has been missing from the retrofit analyses. It is probably the most important solar contribution in the commercial building area. Almost a third of a quad impact savings is possible by the proper use of daylight in new commercial buildings. Most people that construct buildings do not understand how to use daylight properly, and most codes that analyze building energy use do not properly account for commercial buildings.

The ASHRAE 90-75 and 90-75R standards have been formally adopted in 45 states. They have had substantial effects. The problem is that many people in construction think that they are following the standards, but, in fact, are not because they do not understand them properly. There is a new ASHRAE standard that is rumored to be as good as the BEPS. It does not have as low a life cycle cost minimum as the BEPS standard of 1990. It will take three years for this standard to complete the ASHRAE concurrence chain, but, by the mid-1980's, the industry's standard should have caught up with BEPS.

Retrofitting existing commercial buildings will save 4 to 5 quads of energy. It is necessary to do some work to expand RCS to small commercial buildings. At the moment there is not much information on how to proceed with audits, and there are not many people who know how to do an audit. Henry Kelly and SERI have recommended a gradual five-year program to get started.

Conserving energy used by appliances could save as many as 5 to 6 quads of energy. An appliance savings mean a direct reduction in demand flow restrictors, more efficient clothes washers that use less hot water, efficient load loss, heating, cooling, ventilating systems and hot water heaters, including heat pumps for these applications and solar hot water. The application of solar hot water is tempered considerably by the competition for the electric heat pump hot water. The trade-off has been rather difficult, and the market penetration issue has not been solved.

The major issues with appliance standards are whether to cover appliances separately as part of an appliance standards program or to put them into other programs, part of retrofit or new construction programs.

It is difficult to determine how to handle small manufacturers of appliances. California can adopt strict appliance standards because small manufacturers can find markets elsewhere. If a national standard is adopted too quickly, small companies are going to have a hard time finding the capital to retool. This is a barrier to taking action in this area.

The question of how to fit solar into appliance alternatives needs to be researched. A good source of venture capital or subsidies available to small companies, in particular, that want to go into the manufacture of more efficient appliances, is not available. If manufacturers are to be encouraged, encouragement should not be a separate program, but it should be a part of an overall program to increase productivity.

There is a need for improved test procedures. The current test procedures are inadequate. There are flaws in the current appliance labelling program; they do not cover enough appliances. Lights are now labelled by their input energy not ther output lumens. There are a number of specific suggestions for rationalizing the appliance standard for 1985. The maximum technical feasible energy efficiency being set by DOE for appliances often falls short of appliances currently on the market in 1980. There is a significant problem of import competition for appliances. Appliances can and probably will be imported from Europe and Japan.

There are a number of simple practical steps to be taken to capture a fairly large fraction of the total potential. The fraction plainly depends on how far one is willing to go along the spectrum of alternatives. Financial incentives are not as crucial to capturing the potential as might be thought. They are crucial for filling certain defects in the system, particularly in the case of low income units. However, much can be done by awakening the financial market to the fact that there is money to be made in retrofitting. Though money is diverted from the conventional channels of energy supply investment into a whole series of new banks and new investors, retrofit is fairly uncharted territory.

There is present the notion that the savings growing out of efficiency and simple solar investments in buildings are somehow alternatives to progress. This is a misunderstanding. Retrofitting is investing in growth in productivity and growth in efficiency. It is not simple growth in output. Retrofit investments really have to be considered practical investment alternatives and, frequently, people in a position to make these investments really have not had the funds to make fair comparisions, though they are rapidly building such a capability. Given the constraints on energy production, this class of retrofit investments, instead of being barriers to national economic growth, are probably essential.

David J. McFadyen asked where the money is to be made in retrofitting. The financial community has seen unhappy occurrences. The insulation manufacturers are losing money. Owens Corning has reported quarterly losses; Honeywell has made some money. Johnson Controls does not believe they are making money. The turnover in insulation vendors is high, and the profitability is non-existent. The companies that are tooling up to make new furnaces and boilers, Hydropulse and GK Technologies, have had some speculative interest. The financial community has to see more stability in financial returns before they become interested. Based on history, it is difficult to establish that much money is to be made.

Henry Kelly answered affirmatively, based on an extrapolation of the last five years. This presentation concentrated on things that have worked, and good examples of people who, from a technical point of view, have been able to get savings for a relatively small investment.

Arthur Rosenfeld commented that there is a difference between saying that there are opportunities for consumers and creating an industry that can capture these opportunities and make a profit from them.

David J. McFadyen added that there are similarities between the beauty parlor business and retrofitting. There has always been a need for somebody to do hair, and yet, beauty parlors operate until the owner has lost his personal capital and sells the beauty parlor to someone else. The insulation business may be similar. The lower cost measures, caulking, window locks, and weather stripping, are hard to justify unless time is valued at nothing. To say that the financial community should get into retrofitting now is uncertain. It is necessary to find reasons why investors should get into the retrofitting business. When a company like Owens Corning loses money for several quarters, the economics of retrofitting needs closer examination.

Steven Carhart interjected that the fundamental question is whether there is a way to make something for $10 a barrel that other people are selling for $30. The first question is whether retrofitting is cost effective. Where is the value in the investment or new ventures? The value of retrofitting is not in the material which is a basic commodity. The value added is in the knowledge - intensive function of combining relatively simple material together in a way that it is equivalent to the $10 worth of oil. This is a knowledge-intensive service business which applies the techniques in the field and gets results. It is going to have a value and an investment potential. What is needed from a business point of view is to learn how to organize the retrofit activity so that it is done reliably and with consistent results. This requires the emergence of some innovative business enterprises that look very different from the delivery systems that are familiar in this area. At that point, there is something that has a value added, that looks like an attractive investment and that can be shown to investors.

Henry Kelly emphasized that the objective of public policy should be to create this type of industry. The service industry must grow if retrofitting is going to become extensive and money is going to be made.

David J. McFadyen warned that it is important to remember that it is difficult to see what the retrofit industry is selling. The idea that fuel bills will be lower next year is difficult to sell. Consumers do not believe the government or utilities whom they feel lack credibility but look at the surveys.

Lee Callaway disagreed that utilities lack credibility with consumers. He feels that it depends on where the survey is taken. In California, PG&E is rated the most reliable source of information about energy and conservation.

David J. McFadyen was referring to consumer surveys in Chicago. Lee Callaway noted that in a place like Chicago, where the utilities historically have not been pushing conservation, consumers would report a lack of credibility.

Henry Kelly summarized the discussion by recognizing what the problematical aspects of the alternative investments are. It is possible to bound the uncertainty on this at least as well as, if not better than, most of the energy supply investments.

Arthur H. Rosenfeld concluded by saying that Honeywell is not making money, but neither are some of the people who operate power plants because it is a difficult time.

3. CONSERVATION AND NATIONAL POLICY

Richard Cotton
Attorney
Califano, Ross & Heinemann

The popular cliche that conservation is the cheapest, easiest, cleanest, and safest form of energy does not necessarily mean that it is cheap, easy, clean or safe. A more accurate statement is that conservation is cheaper, easier, cleaner and safer than the alternatives. However, conservation is difficult and expensive to accomplish.

The most dramatic fact about conservation is that conservation is not yet taken seriously in this country. For example, the utility programs that are highlighted as the leading programs in the country are TVA and PG & E. This year, TVA hopes to conduct 144,000 audits. This number represents 10 percent of the homes in their service area in 1980. It will take TVA, with its present rate of 60,000 audits per year, fifty years to audit its customers. These two utilities are dramatically ahead of the other utilities in the rest of the country.

The public policy challenge is what must be done to encourage conservation. There are barriers deterring the individual's choice to invest in energy conservation. DOE's programs lack coherence because they are the products of Congressional initiatives and are not administrative initiatives. For example, there is funding for the electric vehicle program because it has a sponsor on the Hill. There is a Residential Conservation Service (RCS) program because of Congressional interest. With respect to the DOE programs, particularly the regulatory programs, RSC, BEPS, and appliance standards, the public perception, the Congressional perception, and the perception of the people within the affected industries is highly critical. Regulatory programs are a policy area within DOE that, until now, have had an unfortunate history.

It is important to distinguish two areas of government policy: pricing and marketing support activities. In terms of federal policy, there are two pricing decisions. The first is decontrol at the federal level of oil and gas prices. This area is moving either too fast or too slow, depending upon perspective. Public utility commission issues center on cost, pricing, and rate setting decisions. Gas and electricity prices do not have a free market because they are set by the PUC's. In terms of public policy issues, the government is making these decisons. To the extent marginal cost is factored in and whether the inverted California structure is used are decided by the PUC's nationwide. California and a half dozen other PUC's are dramatically in the forefront in terms of actually moving toward marginal cost pricing.

From a DOE perspective, one of the issues that constantly arises, particularly in regard to pricing, although other interventions are included, is what should be conserved as a matter of national policy. There is a strong feeling within the utility industry that government is trying to conserve only oil and gas. Conservation of electricity generated by coal and nuclear power is not a national policy the government ought to pursue. Therefore, the imposition of BEPS in areas served by coal and nuclear power may be a counter-productive national policy.

The second major area for government policy making is market support activities or subsidies. The government is deeply in the business of subsidizing energy production at this point. Synfuels are an obvious example in terms of $20 billion support. The tax code offers incentives to utilities to increase production of oil and gas. Conservation subsidies, which are beginning to come on line in a tentative manner in the form of solar and the Conservation Bank, and the tax credit on the residential and the commercial side are viewed quite apart from the orientation that exists in federal subsidies toward the production side.

The response of Congress and the administration is that, if conservation is cost justified, it will happen anyway. There is no need for government to do anything. This is the philosophy at DOE. The current view is that conservation will happen in the commercial and industrial sectors since they are oriented to cost. Conservation will happen over a longer period of time in the residential sector, and it should be left to the private market.

To the extent the barriers and market imperfections to conservation exist, there are five possible types of intervention:

- o Subsidy,
- o Support and demonstration programs to develop institutional delivery systems or a knowledge-intensive service industry,
- o Regulatory activity, at the state level, in terms of PUCs, at the local level in terms of building codes and local regulations, and at the national level, in terms of BEPS-like regulations,
- o R&D activities which are more traditional to DOE - technical in terms of what kind of savings can be expected, very important and virtually untouched by DOE, or behavioral questions of how to persuade people, either by economic or sociological approaches, to emulate desired behavior,
- o Development of private market models and determination of the kinds of contractual and legal issues that arise in moving toward private market mechanisms to service this area.

The key to successful intervention remains an institutional delivery system which actually reaches people. There are a variety of potential institutional mechanisms. These mechanisms include utilities; municipalities or some creature of state and local government; non-profit service corporations similar to the one Rhode Island has created; private corporations like Honeywell which move into an energy service corporation format motivated by the profit motive or a "Senator Bradley Plan" which tries to harness the profit motive and combine it with the reimbursement and economic incentive coming from the utilities or an outside enterprise.

The plan advanced by Senator Bradley proposed that, since it is in the economic self-interest of utilities to conserve, if customers become more efficient in using energy, utilities avoid additional cost by not having to construct new facilities. The Bradley Plan requires that an energy service corporation be given permission to retrofit houses. The energy service company corporation would, at no charge to the homeowner, make money by being paid a certain amount per kilowatt hour or per therm of gas that was saved by the utilities over a 20-year period. Given the retrofit investment cost and the energy service company's projection of avoided energy costs over a 20-year period, the retrofit investment would pay off over that time period. Senator Bradley was trying to harness the profit motive and avoid requiring the homeowner to either pay anything or do anything other than permitting retrofit. This plan, since it is potentially profitable to the utility, could create a source of revenue that would be used to pay the energy service company.

The basic issue is how does one go about getting the building owner to actually conserve energy. The variables affecting the building owner are auditing, installing, financing, inspecting, and warrantying work. These variables are the steps in the process of retrofitting. Seed money ought to be given to organizations to facilitate each step in order to see, empirically, which steps most affect the retrofit action. It is important to people that the source of information is a utility, a municipality, or a company that has electronic background and expertise. The following questions arise and should be put at the top of a research agenda:

Is it the subsidy that makes the difference?

Does the way the retrofit is installed make a difference?

Does the warranty make a difference?

What affects the behavior of the decision-maker, the building owner or manager?

The only way there is going to be serious movement in conservation is for people to see experience in the field and to see, on some scale, that retrofitted homes save energy, and that a profit can be made by some institution. Until that experience is in the field, it is difficult to convince people on a theoretical basis, despite good economic projections, that there is a reason to spend money.

4. DISCUSSION OF CONSERVATION AND NATIONAL POLICY

Henry Kelly asked whether utility sponsored audits and retrofits, as suggested by the Bradley Plan, are "cream-skimming" and get the easy 15 percent savings rather than the 50 percent savings potentially available. To prevent this, utilities could offer incremental payments for each kilowatt hour saved. Payments could be structured in the following way: a consumer would be paid a penny for the first kilowatt hour, two cents for the second, three cents for the third, so that there is incentive to save additional kilowatt hours. The plan should be applied to a fixed geographical area to see if it is possible to obtain a high percentage of retrofit. If the goal is door to door retrofit, this ought to be an explicit public policy goal. To obtain this goal, it is necessary to develop ideas and try them to see how they work in practice. It is also important to get more utilities into the business and to work with utilities outside California.

Lee Callaway noted that utilities have difficulty doing house doctor programs because of labor unions. Decisions must be made as to who does the work, whether they are monthly or weekly employees, permanent or contractor employees, which department is responsible for the audits, and under what work rates personnel work. These are real problems. PG& E's auditors are non-union utility company employees.

Richard Cotton noted that the union-non-union question exemplifies the complexities of getting utilities seriously into the conservation business. Questions arise as to whether these costs go on a rate base or get expensed and what are the legal set of relationships in terms of liability as well as rate treatment. If a regulated utility industry is going into the conservation area where the utility will make money and get ratepayer contribution in a competitive field, there are even more unanswered questions. If utilities are the institutional horse that conservation will ride, the problems that could be raised have not even begun to be addressed. California is on the forefront in this struggle.

Martin A. Mattes responded to Richard Cotton's comment that DOE has an attitude that if conservation is eventually cost effective, it will be done. That viewpoint is contrary to the purpose of forming DOE in light of the urgency of the energy problem and of the massive effort being made in synfuels where the market is anticipated.

Richard Cotton answered that this is one theory of what DOE's role should be and there are different views of conservation and of synfuels. To spell out this theory, in the solar area there is a research and development problem because it is appropriate for the government to spend money which might not be spent by small solar manufacturers, uncertain of the payoff, in trying to bring solar technology into commercialization. The synfuels argument is similar. The government is spurring an industry in the context of a cartel pricing situation which does not attract private investors. This is a situation where the Government has to step in because it is too uncertain for private industry. These arguments can be contrasted with conservation. Conservation actions are known and, as the fuel price goes up over time, people will finally invest in conservation. The government should not subsidize investments which are going to be made anyway because they are driven by price.

The response to that argument is twofold. Conservation occurs over ten, fifteen, or twenty years, but the problem of potential oil disruption is now. It is necessary to move that investment up five or ten years even if it would happen over that period of time. Secondly, the amount of money at stake, the difficulties and the information problems override the fact that technically there is a five year payback. However, it might not be economics which causes the investment to be made. Currently people making decisions think conservation should be left to the market.

Caroll Wilson asked whether the conservation experience of other countries has been examined. For example, the Japanese have produced extraordinary results in terms of very little energy increase over the last five or six years. The household portion of this increase is only 12 or 13 percent.

Lawrence Berkeley Laboratories and Lee Schipper have done the cross-national research that is available. There is comparative information on the per capital consumption of energy. Arthur Rosenfeld has used European data on energy use in buildings. DOE has not given much attention to drawing out policy lessons from international comparisons.

Anne Rowland disagreed with the comment that participants believe that the federal government's direct participation can encourage the growth of what is basically a home improvement industry; secondly, she feels that there seems to be an indication that retrofitting has failed so far. If retrofitting is looked at as any other consumer product, it has a consumer acceptance curve and retrofitting is at the beginning. Retrofitting is picking up the innovators, and it is five, six, ten years away from the high point of the curve. It is currently not possible to retrofit 79 million homes in one year because the prices are not right, the equipment is not there, there is no incentive, and there will not be any for several years.

Arthur Rosenfeld noted that an additional problem in encouraging retrofits is that the installation and maintenance infrastructure is inadequate. There are not enough qualified people available to do the work.

Richard Cotton said that the only point to be made from a national policy point of view is that it does not matter what DOE does. In 15 to 20 years, retrofitting will have occurred. It seems inevitable that there will be serious oil supply disruption and, in the near future, none of the production alternatives will be available to supplement sufficiently. The only way to respond to that problem would be a major effort in the area of energy productivity, energy efficiency, or energy conservation. That is not happening. There is no problem in an economic sense about leaving conservation to the normal development of the marketplace. It will almost certainly happen, but there is a national policy perspective which ought to be alarmed.

William Schiffmacher said utilities face multiple conflicting requirements. Utilities are being urged to go into conservation and, at the same time, DOE has or is about to require two-thirds of the oil-producing units to either shut down or convert to coal. It is difficult to expend money to convert and also spend more money for conservation. The short term timing is difficult.

Richard Cotton commented that a sensible energy policy would adopt a least-cost perspective on displacement of oil. Incentives could be provided to utilities to do what was cost effective in terms of displacing oil, whether that proved to be coal or conservation. DOE has not resolved this choice.

David McFadyen emphasized that if houses are initially retrofitted in a sub-optimal fashion, it is dramatically more expensive to come back and get that last 50 percent of the energy savings that is available on a cost basis. The rate of adoption of conservation will affect the effectiveness of things to happen in the future.

5. CREATING NEW CHOICES: INNOVATIVE APPROACHES TO CUT HOME HEATING AND COOLING COSTS

Steven C. Carhart
Director Integrative Analysis, Energy Productivity Center
Mellon Institute

The retrofit market is growing less rapidly than fundamental economics seem to justify. The fertile ground for increased growth in this market does not lie in additional government intervention but in institutional innovation in delivery systems, the businesses that make, sell, install, and get the job done in the field. The innovations would take the form of a highly skilled decentralized service industry that has, as its value added, the intelligence to bring together mundane pieces of hardware and produce significant economic results.

Work in the area of institutional innovations for residential retrofit of the single family market has been done at the Mellon Institute. The Mellon project, "Creating New Choices," emphasizes the creation of new kinds of enterprises, systems that will give the customer a choice beyond just paying the utility or fuel oil bill that he has now, or the traditional insulation or siding which may improve houses from an aesthetic or functional point of view but not improve the economics of energy.[1]

The approach of "Creating New Choices" is an outgrowth of an earlier study, the "Least-Cost Energy Strategy Study," which examined the major investment opportunities in the energy system and the most cost effective kinds of investments. At 1978 prices in the buildings sector, this earlier study identified $147.6 billion of cost effective investments that could have been made at an average cost per MMBTU of $1.15 (See Table 1). The major investment opportunity was improving residential structures.

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[1] Steven C. Carhart, Shirish S. Mulherkar, Sandra M. Rennie, and Alton S. Penz, "Creating New Choices: Innovative Approaches to Cut Home Heating and Cooling Costs," Energy Productivity Report, No. 3, Energy Productivity Center, Mellon Institute, Arlington, VA.

TABLE 1. COST EFFECTIVE INVESTMENTS IN THE BUILDING SECTOR (1978 DOLLARS)

	CAPITAL (BILLION)	ANNUAL CAPITAL/ FUEL DISPATCHED ($/$10^6$ BTU)
RESIDENTIAL STRUCTURES	88.4	1.34
COMMERCIAL STRUCTURES	19.5	1.51
IMPROVED HEATING AND AIR CONDITIONING	11.9	0.6
IMPROVED APPLIANCE MOTORS	7.0	0.33
COGENERATION	17.8	1.94
TOTAL	147.6	1.15

This initial study raised the following questions about the residential sector. How realistic are the initial estimates of savings? These estimates have to be, if anything, conservative in terms of the potential for savings. How long would it take to realize these cost effective savings? Why is the market not moving as fast as economics justify? What action should be taken to accelerate this process?

These questions have now been studied. First, the thermal integrity of existing single family homes was measured; the optimal packages of retrofit that would be cost effective to reduce the cost of heating and cooling were identified, and some institutional innovations which could improve the delivery of one retrofit were examined.

A simulated optimal technology package was designed for typical single family homes in each of four regions for each of the three major fuel types. The work also included a review of the literature and the field experience concerning consumer behavior and attitudes, and the characteristics of existing retrofit delivery institutions, and identified the barriers to consumer acceptance of retrofit technologies.

From these analyses, the criteria that new programs and innovative retrofit delivery systems would have to meet in order to have better market opportunities than the available delivery systems were generated.

Figure 1 shows projected fuel savings on a primary equivalent basis in units of a million barrels of oil per day or the equivalent for retrofitting only single family homes. The stippled bar indicates the level of current activity from a 1978 base. The solid bar columns indicate the potential savings from the present rates of activity which represent about 5 percent of the housing stock being retrofitted each year with an average intensity of about $700 per unit, far below the economic optimum. It represents a savings of one-half a million barrels of oil a day equivalent by 1990.

The maximum potential, using the optimal retrofit package which averages about $2,000 per house and implementing it at the rate of 15 percent of the applicable housing stock in each year, realized a savings of 1.4 million barrels of oil equivalent a year. This seems to be a rough estimate of the outer envelope of what could be achieved in terms of presently available materials and resources. That is about 3 quads from single family homes only. If multi-family, low density, mobile homes were included, the savings would approximate 4 quads of energy savings from retrofit.

Figure 2 shows the consumer savings which were the guiding principle for technology choice in this study. Consumer savings relative to the present rate of retrofitting on an annual basis will add up to under 2 million barrels a day, or $2 billion a year by 1990. If an increased rate of implementation is achieved, it is estimated that the annual consumer savings could amount to $6 billion. These savings are the fuel cost of the previous system with no retrofit minus fuel cost and annualized capital charges for the incremental investment, assuming a 3 percent real interest rate.

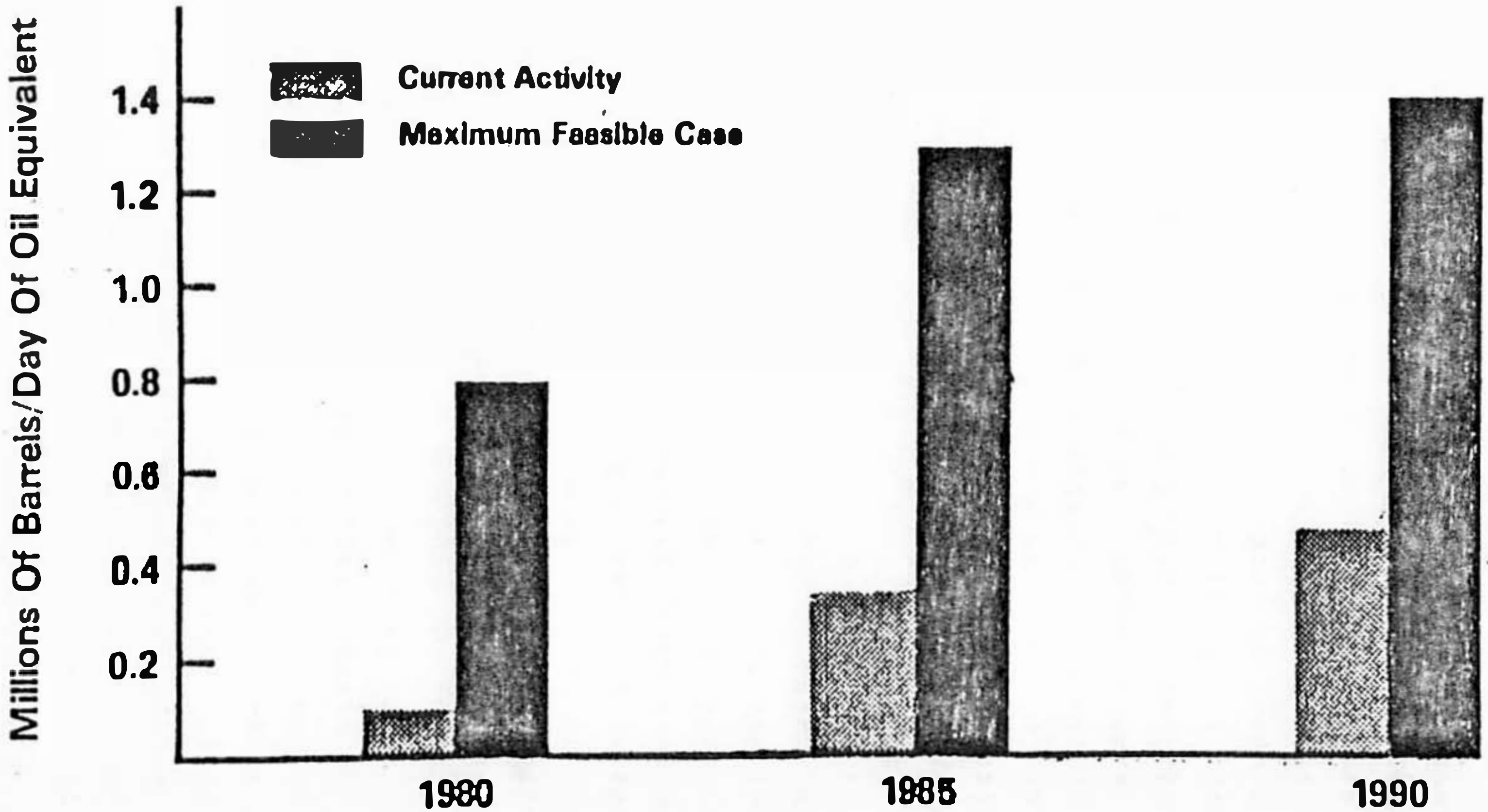

FIGURE 1. PROJECTED NATIONAL REDUCTION IN FUEL CONSUMPTION FROM RETROFITTING OF SINGLE FAMILY HOMES, 1980-1990

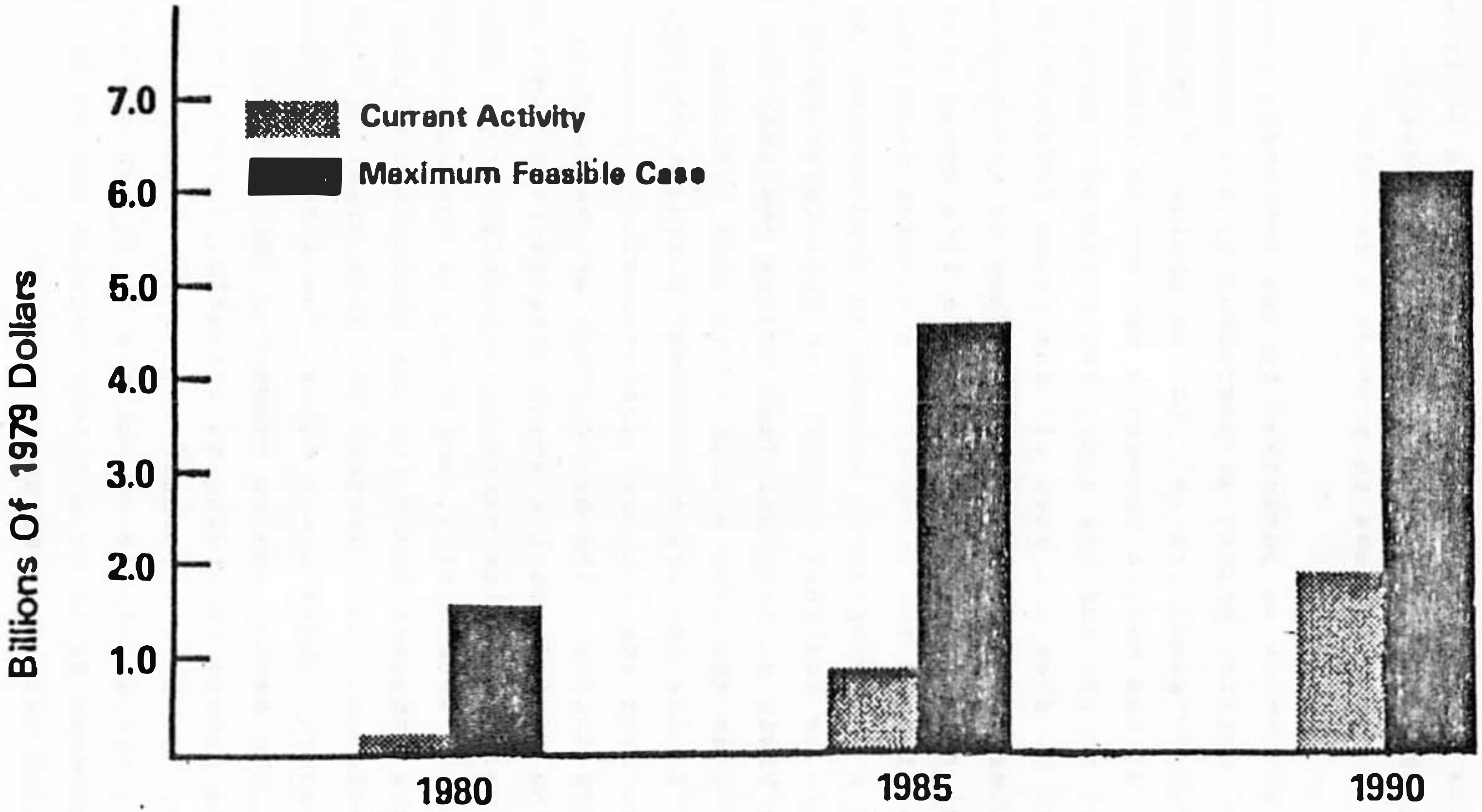

FIGURE 2. PROJECTED ANNUAL CONSUMER SAVINGS FOR HEATING AND COOLING IN SINGLE FAMILY HOMES 1980-1990

The basic question is why things are not happening in the retrofit field. Our study indicated that there were four foci of concern: economics as perceived by the consumer; the decision-making process by the individual consumer; the availability, or lack thereof, of delivery systems to provide a retrofit; and information.

In terms of economics as perceived by the consumer, there are several problems. Utility prices as perceived by the consumer are average prices, not marginal prices. In the choice of optimal social investment at the margin between a new supply incremental and new investment on the end use side, the consumer cannot make the choice because he does not have all the price information.

Cost is another issue for consumers. They do not look at an annualized capital charge or routinely make a life cycle cost analysis as industries do for industrial investment decisions. This suggests that for a new program to succeed in this market the retrofit programs should be designed so that the investment decision is being made on the basis of marginal fuel prices and that the individual consumer does not have a high first cost decision.

With respect to the process of consumer decision-making, this study hypothesizes that the consumer decision-making process is unstructured decision-making. The major steps are perception of the problem, generation of information about alternatives, development of criteria for evaluating alternatives, selection of an alternative, implementation of the alternative, and then, in the dissonance resolution phase, the consumer looks for the confirmation that he made a correct decision. This pattern has been observed with some empirical consistency. These steps differ for different customer groups. In fact, the market can be segmented into different kinds of decision making groups according to criteria, income location, and the propensity for do-it-yourself activity. A marketing approach will have a better chance of success if it can tie into the decision-making process as it is uniquely carried out by different markets of potential retrofit customers.

The retrofit market was looked at in the area of delivery. The opportunities consumers presently have to obtain retrofits were discussed. The present delivery system is such that participants in this market only have one product to sell, i.e., siding, insulation, or windows. Quality assurance is a major issue in the market because the home improvement area is notorious for "fly-by-night" and shady operators. The economic risk to the customer is large if performance is not realized. If the consumer spends $2,000 on a retrofit and does not get the results that were advertised or the results that the Mellon Institute obtains from its theoretical calculations, the consumer will be upset.

The implications for developing new enterprises in this retrofit area are the following: a better chance of succeeding if there is some assurance of field performance of the retrofits; the operating company needs to have a long-term relationship with the customer so that if something goes wrong, the retrofit concern is readily available to the ongoing operation of the house; and finally, the economic risk needs to be spread among consumers and, possibly, even third party investors. For example, if Sears Roebuck or a utility retrofits ten thousand houses, they will expect some to operate above "spec" and some below "spec." The economic returns are dependent upon the mean results. One larger unit does not have the risk that the individual customer has retrofitting one house.

Information is a major problem area in retrofitting that has not been adequately addressed. The information generally available is not perceived as credible according to numerous surveys. Information has not been targeted to specific market groups or to different stages in the decision process. As customers go through their decision process, they need different information, and it has not typically been provided. The information provided must be targeted to different segments of the market, according to what decision making stage they are in, as well as tailored to different classes of customers in order to communicate with those markets more effectively.

To summarize our findings as to the characteristics needed for improved retrofit enterprises, the following have been identified:

- o The investment choice needs to be made on marginal fuel cost.
- o The cost of capital should be based on comparable investments in the economy and be made on a life cycle cost basis.
- o A retrofit program needs to provide the maximum feasible rate of implementation consistent with the availability of materials and labor.
- o There needs to be quality assurance to insure that field performance conforms to expectations and plans.

In terms of presentation and marketing the important criteria for success in the retrofit market include:

- o Segmenting the market and tailoring of marketing approaches in different segments;
- o Developing delivery systems to spread economic risk;
- o Having a long-term relationship with the household so that the second and third visit can be made; and
- o Experimenting to target and test different markets that have the highest opportunity to benefit in terms of energy and economic savings.

The private sector's response to the retrofit need has been inadequate at best until now. There are many reasons for this. One of the most important is least-cost retrofit, not a standard practice in the building industry. The second major reason that the retrofit market has not taken off is that there have been price controls since 1973 which have had a negative effect on providing incentives that are needed to make the retrofit market proceed. Finally, the opportunity has not been well-defined in terms of available information or research that underlies the techniques and understanding of the potential in the retrofit market.

The federal programs which attempted to facilitate the retrofit market have responded weakly to the barriers and problems that have been identified. (See Table 2.) For instance, the new Conservation Bank lowers the cost of capital to customers by

TABLE 2. EFFECTIVENESS OF FEDERAL RETROFIT PROGRAMS

CRITERIA FOR ACCEPTANCE OF RETROFITTING	CONSERVATION BANK	RESIDENTIAL CONSERVATION SERVICE (RCS) ENERGY EXTENSION SERVICE (EES)	WEATHERIZATION	TAX CREDIT
Marginal Cost				
Cost of Capital	X		X	X
Rate of Implementation		X	X	
Quality Assurance		X		
Market Segmentation	X		X	
Spread Risk				
Long Term Relationship				
Targeted Information				

providing interest rate subsidies, but it does not provide subsidies in any targeted way. The bank does not provide any information to customers nor is it closely coupled to any delivery system that is actively selling the retrofit to the customer.

The Residential Conservation Service (RCS) and the Energy Extension Service (EES) both provide various kinds of information and audits, but they are not strongly linked to the follow-up delivery system. There is a bifurcation between the auditing process and the closing of an actual sale when someone goes into the house and makes the installation.

The residential tax credit lowers the capital cost by subsidizing the retrofit investment, but it does not provide information on the relative cost effectiveness of different measures that can be taken nor is it tied into any action-forcing delivery system.

The Weatherization Program which provides a delivery system to low-income persons has had quality assurance and management problems. It is potentially an effective and targeted program, but it has had operating problems.

In conclusion, most of the existing programs are responsive to one or two of the key criteria. All of these programs taken together seem to be going in different directions and only taking a small piece of the problem.

The retrofit business seems to be in a "let-a-hundred-flowers-bloom" period. One can not now say what kinds of organizational entities are really going to succeed in the retrofit market. However, the Mellon Institute has looked at a number of embryonic approaches which appear to offer ways to expand the use of retrofits. There is a need now to foster experimental enterprises, innovative demonstrations of new marketing and delivery concepts, including many different kinds for each individual locality to see what is really going to work in the field.

Some of the currently available examples that point the way towards a more effective and vital marketing and delivery system for residential retrofit will now be discussed. The responsiveness of these programs to our criteria for effective retrofit systems is summarized in Table 3.

TABLE 3. EFFECTIVENESS OF INNOVATIVE RETROFIT PROGRAMS

CRITERIA FOR ACCEPTANCE OF RETROFITTING	TVA/ PPL	ENERGY SHED	REEP (BRADLEY PLAN)	RISE	FAIR SHARE
Marginal Cost	X		X		X
Cost of Capital	X		X	X	X
Rate of Implementation	X		X	X	
Quality Assurance	X		X	X	
Market Segmentation		X			
Spread Risk			X		
Long Term Relationship					X
Targeted Information					

Two of the most innovative utility company sponsored programs are the Tennessee Valley Authority and the Pacific Power & Light programs which have been operating for some time. The major elements of these programs are audits, recommendation of particular measures to individual rate payers, certification of contractors, which is important for maintaining quality and effectiveness in work that is done, post-installation inspection to provide strong quality assurance, and provision of an interest-free loan to remove the first-cost capital availability issue. Some problems remain with rental units.

These utility company programs are more responsive to some of the barriers and issues that seem to have held up the retrofit market. Interest rate subsidies help to make the perceived interest rate, the cost of capital, comparable to the cost of capital experienced by the utility when the utility considers plant expansion. The interest free loan serves to overcome the first-cost resistance on the part of the individual customer. The inspection program provides quality assurance. The scale of the program and centralized management bring much material and labor which greatly accelerates the rate and the planning of retrofit jobs and moves toward doing large blocks in contiguous areas at once.

Another emerging concept is the energy service company which is embodied in the Residential Energy Efficiency Program (REEP) or the Bradley Plan. The basic notion is to have an independent conservation company which will go out, audit, and retrofit large contiguous blocks of homes. This aggregates the market and makes possible large-scale retrofits. The conservation company installs and pays for the improvement itself. It raises capital and retrofits large numbers of contiguous homes. The only thing the individual customer does is agree to be retrofitted. The customer does not pay anything.

The total energy consumption of these homes is monitored before and after the retrofit, and the difference is measured. Measurement is difficult, but the concept is that the difference in consumption is measured, and the utility reimburses the conservation company for the saved energy. This concept offers the opportunity of selling this energy back to the utility at a cost approaching the utility's marginal cost of new supply. It also moves the investment decision away from the individual homeowner to a business which aggregates the market, looks at it as a large-scale investment, and raises capital at a lower rate, analogous to what the utility would experience. As a result, if the conservation company can sell the energy back to the utility at something like the marginal cost, then it will have an incentive to retrofit up to the margin when it goes into the different houses. The company also has the potential to raise capital at lower rates than the individual could and centralize the investment decision so that you have one big investment decision rather than many small ones. This approach shifts the risk of the performance of the different retrofit jobs from the individual customer to the company which again has the incentive to look at the mean performance of a large number of jobs. Also since the payment that is received by the conservation company is based on energy actually saved, the company also has the incentive to make sure that the job is done at a high level of quality and that the results are actually received. Finally, the whole bundle of incentives has the effect of greatly accelerating the retrofit rate in that service area.

Another new enterprise with potential is the integrated energy conservation products store. The Energy Shed in the upper Midwest, the leading example of this, has an extensive technical review of many different products and a high level of technical service so that the individual do-it-your-selfer who comes into an Energy Shed store can get a lot of help in planning his own energy conservation program.

The integrated energy conservation products store effectively segments the market and reaches people who have the propensity to undertake these activities and targets them with the technical services and products they need.

There are also non-profit coordinating services that are developing reputations as effective in their local areas. Rhode Islanders Saving Energy (RISE) is a state-chartered non-profit corporation which is a clearing house and certification agency for retrofit contractors in Rhode Island and provides audits on request to Rhode Island residents. It monitors and certifies contractors to insure that their work is up to "spec" and conducts post-insulation inspections before a job is paid for. Finally, due to its quality assurance and the relatively low risk associated with a job done under its auspices, it gets below market loans from participating banks to provide financing to people who avail themselves of its services.

Another similar operation is Massachusetts' Fair Share which provides audits and conducts demonstrations and workshops for its members. Their approach to retrofit is in line with the concept of conducting an optimal retrofit and making certain that the most effective investments are up to the marginal prices of energy. It also groups neighborhoods or areas where retrofits need to be undertaken for their customers or their members and thus has the effect of aggregating the market and reducing the cost per retrofit.

RISE is effective in reducing barriers to expansion of the retrofit market by reducing the cost of capital, below-market loans, by making information and technical assistance more readily available in its service area, in particular, by its credibility with local residents; and, finally, by overcoming the quality assurance barrier through pre-screening and post-insulation inspection.

Massachusetts Fair Share has many of the same strong points in its program. It is conscious of the marginal cost of fuel issue and the need to retrofit up to that margin. The multiple retrofit program reduces capital cost by contracting for several retrofits at once. It also targets low income, high savings potential markets and delivers information and retrofit capability through a credible, well known channel.

Looking at the effectiveness of some of the innovative programs in terms of their responsiveness to the criteria, there are more "Xs" in Table 3. Whether these innovative approaches are going to be sufficient to move this market as fast as the fundamentals seem to indicate remains to be seen. There are also more new programs that seem to be emerging daily. Some of them were discussed today, i.e., utilities getting involved and local self-help groups.

In conclusion, it should be emphasized that there are technical means to reduce consumer cost and save energy through retrofit. The market to date has been far behind what is justified in terms of technology and economics. The Federal programs to date have only partially responded to the needs and the barriers; there are, however, a number of new programs on the way.

There is no doubt that retrofit can be a major factor in the energy markets in the 1980s. The total potential consumer savings through that period from an optimal retrofit program amounts to $42.2 billion. The energy savings from the single family market alone is at approximately the same magnitude as the Alaskan oil production. The key to expansion of retrofit is to enter the "let-a-hundred-flowers-bloom" phase of the retrofit enterprise and try new approaches at organizing this commercial enterprise.

6. DISCUSSION OF CREATING NEW CHOICES: INNOVATIVE APPROACHES TO CUT HOME HEATING AND COOLING COSTS

Robert Ricci introduced a discussion of the aforementioned Bradley Plan. It appears that the consumer does not pay anything for it. The way the Bradley Plan is set up is that the conservation company will have every incentive to make sure that the marginal dollar invested in one house is just as effective as the marginal dollar invested in a neighbor's house. If one neighbor's house is in reasonably good shape and another has let his house run down, it appears that the latter comes out much better under the Bradley Plan. If one house is in better shape to begin with, the relative benefits from the program are going to be less than the relative benefits to him. The bills accrued to both homeowners will be reduced in absolute terms and no one will be out anything.

Norman Rosenberg noted that there is a fundamental issue of equity as perceived by the consumer, not as defined by some absolute economic standard. It is the consumer's concept of the equity, as well as other things, that will determine the success of a program like The Bradley Plan. Steven Carhart responded that the consumer has two choices. He is offered the opportunity to have his house retrofitted at no cost up to some kind of equivalent, less than the equivalent of $5 gas or whatever. His choice is either one of two things, to have that done at no cost or not. Whether retrofitting is implemented at the PUC and the utility level is not an issue for the individual customer. He only has to decide if he wants to participate. The investment decision is removed to an independent company that shares the risks and is able to raise capital at lower rates and reduce the cost per unit, because the marketing and the transaction costs are lower if they can retrofit a whole contiguous area. No one is worse off as a consequence of the program.

David J. McFadyen commented that the principle of the Bradley Plan needs clarification. The consumer is paying for energy not used. The consumer pays his utility bill which may be reduced from what it would have been had his dwelling not been retrofitted. For example, a person who gets $2,000 of retrofit and is used to spending $1500 a year for fuel oil now pays $800 a year for fuel oil plus $400 a year for energy saved. His cost is now $1200 instead of $1500. With the Bradley Plan, the consumer pays for energy saved. The consumer pays a smaller bill than he would have paid had he not had his house retrofitted, but he still pays for the energy saved. He pays a utility bill of $1200 when, in fact, he's only consuming $800 worth of oil, but he would have been paying $1500 had he not been retrofitted. By paying for the energy not used, the consumer pays for the retrofit.

David J. McFadyen described the specific way the Bradley Plan would operate. The Bradley Plan computes what a fuel bill would have been and it assumes some constancy of behavior. The incentive to keep your thermostat down is somewhat reduced under this plan. Whether behavior is constant is questionable. The plan, as originally proposed, is as follows: assume that a household has a $1500 annual electric heating bill. With the plan an independent contractor will retrofit the house, dropping the bill to $800. The $700 drop is what the consumer is rewarded for, but the consumer pays for the $700 drop by paying about $400 of it. The $400 payment portion is derived from a projection of the energy bill. The energy bill was projected at being $1500 a year, and the bill is being dropped to $1200 because somebody did $2,000 worth of work to a house. The actual electrical delivery to the house is only $800 a year. The $400 a year is what the utility collects to allow it to pay the contractor and save the $700 a year. The structure of the plan allows for a payment to the utility that flows through to the retrofit contracting firm for the energy saved.

Steven Carhart commented that the Bradley Plan's payment structure would add the annualized capital charge of the retrofit to the fuel bill. The fuel cost after the retrofit plus the annualized charge for the capital improvements would be less than the fuel bill.

David J. McFadyen suggested that the rationale for the Bradley Plan is very different. It is selling benefits instead of dealing with cost. The point is if a contractor can go in with one tub of caulk or if a cement block is missing in one basement wall and the contractor stuffs it full of insulation and saves $500 a year, the retrofit contractor gets to recognize whatever benefits he is to receive from the $500 that is being saved. Rather than being paid by cost, he is being paid by savings.

David J. McFadyen noted that there are several unanswered questions regarding retrofits. Why would a consumer keep his thermostat down if he is now paying half the price for energy consumed? Why would he have any incentive to the reduction of energy use?

APPENDIX A
LIST OF ATTENDEES

Lee Callaway	Pacific Gas and Electric Company
Steve C. Carhart	Mellon Institute of Research
Mike Casper	Science, Technology & Society Program
Phillip Coonley	TSC, Energy Demand Analysis Branch
Richard Cotton	Califano, Ross & Heinemann
Cline Frasier	TSC, Energy Programs Division
Bernard J. Frieden	Urban Studies, MIT
Leon Glicksman	MIT
E.P. Irwin	Dept. of Energy, Mines & Resources
Richard John	TSC, Office of Energy & Environment
Charles Kelliher	Draper Laboratory
Henry Kelly	SERI
George Kovatch	Transportation Systems Center
David J. MacFadyen	Technology & Economics, Inc.
Martin A. Mattes	California Public Utilities Commission
John Perkins	Energy Research Group Inc.
John K. Pollard	TSC, Energy Demand Analysis Branch
David Ramsett	U.S. Department of Transportation
Robert Ricci	TSC, Energy Demand Analysis Branch
Anne Roland	American Gas Association
Norman Rosenberg	TSC, Energy Technology Branch
Arthur H. Rosenfeld	Lawrence Berkeley Laboratory
William Schiffmacher	Long Island Lighting Co.
William Schurcliff	Harvard University
Mary Stearns	Transportation Systems Center
Ben Tucker	Technology & Economics, Inc.
Richard F. Walsh	DOT, Office of the Secretary
Carroll Wilson	MIT
Richard Wilson	Harvard University

APPENDIX B

POTENTIAL SUBSTITUTION OF OIL WITH GAS AND COAL IN NON-TRANSPORTATION USES

American Gas Association
Energy Analysis 1980-10
August 28, 1980

A. Introduction

Nearly half the oil used in the U.S. is consumed for non-transportation purposes. At the same time, nearly half the oil used in the U.S. is imported from foreign sources. Given these two facts, together with the fact that non-transportation volumes of oil and of natural gas are nearly the same in the four stationary markets -- residential, commercial, industrial, and utility power plants -- it makes sense to suggest that a substantial potential exists to replace in the near-term (0-5 year time-frame) large quantities of oil with increased use of natural gas in these markets.

The purpose of this analysis is to define in overall national terms that portion of the non-transportation use of oil which can readily be replaced by natural gas and coal, including gas used selectively with coal in large boilers to help meet environmental requirements.

B. Executive Summary

- Out of the 1979 total of 8.4 million barrels per day of crude oil equivalent (mbde) non-transportation use of oil in the U.S., 5.5 mbde was used in combustion applications for which natural gas or gas used selectively with coal, could directly substitute.
- This 5.5 mbde replaceable non-transportation use of oil consists of the following three components: 3.0 mbde of residual and distillate fuel oil burned in industrial boilers and utility power plants, 0.4 mbde of natural gas liquids burned in industry, and 2.1 mbde of fuel oil (largely distillate -- 1.6 of the 2.1 mbde) used for residential and commercial spaceheating and hot water.

- Of the 5.5 mbde substitutible U.S. oil use, 1.1 mbde (or 20 percent) can be replaced nearly immediately with increased gas use because (1) available gas supplies can increase significantly, (2) the nation's gas transmission and distribution system is presently some 10-15 percent underutilized, and (3) numerous industrial oil users currently have direct access to gas systems.
- The 4.4 mbde balance of the 5.5 substitutible oil use can be replaced by gas and coal, including coal with select gas use, and other fuels in the near-term, allowing time for gas system extensions, power plant completions, end-users' installations, permitting, and other requirements.
- The remaining 3.0 mbde non-transportation use of oil consists of feedstocks, natural gas liquid products in remote residential spaceheating and farm applications, still gas, asphalt, lubricant oils, and petroleum coke -- none of which are directly replaceable by other fuels in the near-term.

C. Discussions of Results

In order to formulate an effective national policy to reduce our nation's vulnerability to an oil supply interruption, it is necessary to ascertain what percentage of our domestic fuel oil consumption can be displaced in the near-term 0-5 year time frame by alternative fuels (i.e., natural gas and coal).

Table 1 classified all 1979 non-transportation uses of oil products in the U.S. by sector and by fuel product. This analysis does not address the significant potential for substitution with methane vehicles of petroleum products used in the transportation sector, which consumed 9.2 mbde of the nation's total 1979 oil use of 17.6 mbde. Of the 8.4 mbde of petroleum use in the U.S. shown in Table 1, certain industrial and residential/commercial energy demands cannot easily (quickly) be satisfied by natural gas or the joint use of natural gas and coal. Many other oil consumers who presently have access to gas service can physically convert from oil to gas in the very

TABLE 1

U.S. NON-TRANSPORTATION USE OF OIL PRODUCTS IN 1979

(million barrels per day of crude oil equivalent, mbde)

	DISTILLATE	RESIDUAL OIL	LPG/OTHER*	ASPHALT	TOTAL
RESIDENTIAL	1.1	-	.5	-	1.6
COMMERCIAL	.5	.5	.1	.6	1.7
ELECTRIC GENERATION	.1	1.6	-	-	1.7
INDUSTRIAL GENERATION					
o COMBUSTION	.6	.7	.4	-	1.7
o FEEDSTOCK	.1	-	1.3	-	1.4
o LUBE/WAXES/ PETROLEUM COKE	-	-	.3	-	.3
TOTAL NON-TRANSPORTATION USE	2.4	2.8	2.6	.6	3.4

* Includes other petroleum products used as chemical feedstocks, lube, waxes, and petroleum coke.

Sources: Monthly Energy Review: July 1980 (U.S. Department of Energy, Washington, D.C., July 1980). EIA Annual Report to Congress: 1979, Volume Three (U.S. Department of Energy, Washington, D.C., 1980). U.S. Energy for the Rest of the Century (U.S. Department of Commerce, Washington, D.C., July 2, 1980).

short-term. This analysis, therefore, breaks all non-transportation oil consumption into the following categories:

<u>Category One</u> - oil that can be virtually immediately displaced by gas. In 1979, the American Gas Association (AGA) conducted two surveys of its members to ascertain how much oil they could displace in industrial markets with natural gas and, then, how much they were planning to displace in 1979. Total potential U.S. oil displacements were estimated at 1.5 mbde (1.3 mbde of residual oil and .2 mbde of distillate oil). Actual displacements in 1979 amounted to .4 mbde (.3 of residual oil and nearly .2 of distillate oil). Assuming that there was no change in industrial and electric utility oil consumption between 1979 and the first half of 1980, 1.1 mbde of oil use continues to exist which could quickly be displaced by gas.

<u>Category Two</u> - other oil uses that can in the near-term (0-5 year time-frame) be displaced by gas, and select gas use with coal in dual-capable facilities.[1] This second category of oil use, that which is displaceable in a longer time-frame, consists of some 4.4 mbde replaceable by gas and coal. This category would include oil combustion in industrial and electric utility boilers that are not currently connected with gas systems, as well as liquid petroleum gas (LPG) combusted directly in the industrial sector. Also included in this second category of oil use is the 2.1 mbde of fuel oil use in residential and commercial sectors.

<u>Category Three</u> - oil use that is difficult to displace with alternative fuels. The third category of non-transportation oil use consists of industrial and commercial applications whose use of oil products can only be replaced by alternative fuels in the long term (beyond 5 years). This category

[1] See <u>Analysis of Select Gas Use in Utility Coal Conversion for Limiting Sulfur Emissions</u> (American Gas Association, Arlington, VA, Energy Analysis 1980-4, April 29, 1980), and <u>Analysis of Select Use of Gas to Enhance Coal Conversion</u> (American Gas Association, Arlington, VA, Energy Analysis 1979-8, June 1, 1979).

includes LPG consumption in the residential and commercial sectors (generally in dispersed locations not served by gas utilities); lubricant, wax and petroleum coke products; asphalt; and liquid hydrocarbons used as chemical feedstocks. These oil uses totalled 2.9 mbde in 1979.

The U.S. imported an average of 8.1 mbde of crude oil and oil products in 1979. If the nation had displaced all oil used in category one, imports would have been 12 percent lower (a balance of payments savings of $10 billion at $25 per barrel). If the nation had displaced all oil use in category two as well, the oil import level would have been 68 percent lower (balance of payments savings of over $50 billion). Table 2 summarizes replaceable U.S. oil uses (categories one and two).

D. Sources of Analysis Data

The Energy Information Administration (EIA) in its 1979 Annual Report to Congress[2] provided data on the use of petroleum products in the United States for 1978. The EIA report detailed distillate, residual fuel oil, asphalt and liquified petroleum gas (LPG) consumption for the residential, commercial, industrial and electric utility service sectors. Total oil consumption in the residential and commercial sectors are derived by adding all of the individual petroleum product uses listed in the EIA Annual Report (equalled 3.3 million barrels per day). This consumption level was the same amount listed in the Monthly Review: July 1980 for residential and commercial sectors in 1979.[3] EIA 1978 consumption data for individual petroleum products was, therefore, used to represent 1979 consumption patterns.

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[2] EIA Annual Report to Congress: 1979, Volume Three (U.S. Department of Energy, Washington, D.C., 1980) p. 175.

[3] Monthly Energy Review: July 1980 (U.S. Department of Energy, Washington, D.C., July 1980), p. 20.

TABLE 2

OIL USE REPLACEABLE BY GAS AND COAL

(million barrels per day crude oil equivalent, mbde)

	CATEGORY ONE	CATEGORY TWO	TOTAL REPLACEABLE OIL CONSUMPTION
INDUSTRY			
o LPG in Direct Combustion	-	.4	.4
o Residual Oil	.4	.3	.7
o Distillate	.1	.5	.6
Subtotal	.5	1.2	1.7
POWER PLANT			
o Residual Oil	.6	1.0	1.6
o Distillate	-	.1	.1
	-.6	1.1	1.7
RESIDENTIAL AND COMMERCIAL BUILDINGS			
o Residual Oil	-	.5	.5
o Distillate	-	1.6	1.6
Subtotal	-	2.1	2.1
TOTAL	1.1	4.4	5.5

Note: Category one includes non-transportation oil uses that can virtually immediately be displaced by gas, category two includes other oil uses that can be displaced in the near-term by gas or gas and coal in dual-capable facilities.

Electric utility oil consumption in 1979 totalled 1.7 million barrels per day according to the Monthly Energy Review.[4] It was assumed that all of the fuel used under boilers was residual fuel oil (1.6 mbde) and all of the fuel oil consumed in gas turbines was distillate oil (.1 mbde). The Monthly Energy Review: July 1980 estimated 1979 petroleum coke use in electric generation at .008 mbde, thus this oil use was ignored.

Five major petroleum products are consumed in the industrial sector: distillate, residual oil, LPG, lube and waxes and refinery blending fuels. The EIA Annual Report shows .7 mbde of residual, .6 mbde of distillate oil and .4 mbde of LPG (non-feedstock applications) were used by industry in 1978.[5] The EIA Annual Report also showed 2.1 mbde of oil was consumed as feedstock, raw material or was refinery use of still gas and oil. Between 1978 and 1979 industrial oil use increased by .1 mbde. This increase occurred primarily in the use of LPG, with LPG supplies increasing .2 mbde. It was, therefore, assumed that .1 mbde increase in oil demand was satisfied by raising industrial use of LPG as a feedstock.

Industrial use of petroleum coke and lube/oils were taken from U.S. Energy for the Rest of the Century and the EIA Annual Report: 1979.[6] LPG feedstock requirements were estimated by subtracting LPG uses other than feedstock requirements from total supplies for 1979. Refinery blending consumption, although a stationary oil use, is essentially a transportation feedstock, and is not included in this analysis.

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[4] Ibid, p. 23.

[5] EIA Annual Report to Congress: 1979, Volume Three (U.S. Department of Energy, Washington, D.C., 1980), pp. 64, 66.

[6] U.S. Energy for the Rest of the Century (U.S. Department of Commerce, Washington, D.C., July 2, 1980).

Petroleum product requirements, on a product by product basis, for all service sectors (excluding transportation) was then tabulated to determine total fuel consumption for all non-transportation applications. The transportation use of the petroleum product was then added to the 8.4 mbde use, and then checked against total supplies available for 1979 within each product category. In this way, an energy balance was achieved for each major petroleum product.

APPENDIX C
ENERGY UTILITIES AND CUSTOMER CONSERVATION

John E. Bryson
President
California Public Utilities Commission

CONSERVATION IS NOW AN ATTRACTIVE SOURCE OF ENERGY

The primary objective as energy regulators is to assure that utilities meet customers' demands for reliable, reasonably priced energy. The California Public Utilities Commission (CPUC) is convinced that conservation now provides extradordinary advantages over traditional energy "supplies." Conservation investments produce immediate benefits by reducing fuel needs. They produce few if any local environmental problems. They contribute directly to energy self-sufficiency. Finally, they satisfy energy demand at prices that can be calculated now.

Although some say that "this country did not conserve its way to greatness," the development of ever more efficient uses of resources has been a key to America's prosperity. Conservation means more efficient use of energy. It need not require sacrifice.

The CPUC is basing its comparison of conservation to other supply options on the results in California. Here, utility programs are designed to maximize cost effective utilization of this source. Similar comparisons can be made in other states as future energy demands and supply options are evaluated.

THE RESIDENTIAL SECTOR DESERVES HIGH PRIORITY FOR ENERGY CONSERVATION ACTIVITIES

In California, the residential sector is a very promising target for energy conservation. Potential savings are huge; the residential sector provides roughly one third of energy consumption. If energy were being used "efficiently" in response to current market conditions, these demands would fall considerably.

Second, cost effective energy conservation activities can benefit all consumers whether or not they participate directly in retrofit programs. They will help consumers respond to increasing prices by substituting conservation hardware for energy consumption. Such efforts may provide regulatory commissions with favorable publicity in this era of spiraling rate increases.

Third, most residential ratepayers suffer from similar barriers to conservation, so that a few well-designed programs can reach many ratepayers. Theoretically, if all customers paid the full marginal cost of energy, they would cut energy consumption to "efficient" levels. Rates are undoubtedly very important to reaching efficient energy use. Realizing this, regulatory commissions in many states have restructured rates in recent years. However, nowhere in this country are utility rates set at "full marginal cost," since this would yield revenues far in excess of utility costs. Marginal costs are not used as a reference when setting both "lifeline" residential rates and industrial rates to provide conservation incentives. Additional ways to promote efficient energy use are being explored.

CALIFORNIA UTILITIES ARE ASSUMING MORE DIRECT RESPONSIBILITY TO PROMOTE RESIDENTIAL ENERGY CONSERVATION

California utilities have adopted programs which attack the major barriers to efficient energy use: incorrect price signals; inadequate information; and inappropriate or unresponsive institutions.

The CPUC has completely restructured energy rates to accentuate economic incentives to conserve energy; "lifeline" rates for minimum energy use are now set at 75 percent of average rates, while the residential rate for the highest tier is 125 percent of system cost. Utilities have expanded information programs to tell consumers about cost effective energy conservation opportunities.

One cost-effective program offered by California utilities is the 8 percent loan for customer installation of attic insulation, combined with utility referral of licensed contractors. This program corrects an institutional shortfall by providing convenient financing and installation arrangements.

The utilities can be particularly effective proponents of residential energy conservation. Their monthly contact with ratepayers is used to transmit information about conservation opportunities and benefits. Bills reporting energy use have been redesigned to improve feedback to the customer. Utility service networks are being supplemented in California to expand direct services to customers, such as the residential audit program which will soon be absorbed into the expanded program mandated by the Residential Conservation Service (RCS).

Expanding the utility in energy conservation also reinforces the shift in utility perceptions to recognize the need for more efficient energy use. The utilities, like all American institutions, have taken time to accept changes in the price and supply conditions under which they operate.

The CPUC and the utilities are working together to accelerate the market penetration of cost-effective energy conservation activities. The key steps involve determining which activities are cost-effective for both consumers and the utility, and then designing effective programs.

COST-EFFECTIVE PROGRAMS FOR RESIDENTIAL ENERGY CONSERVATION ARE BEING DEVELOPED

In response to higher prices, thousands of Californians have retrofitted their homes to conserve energy and save money in the past five years. However, many other energy conserving devices would also be cost-effective in most homes. There is also a lack of energy conservation activity in rental housing. Potential programs are scrutinized to determine cost-effectiveness. Conservation costs were compared to the cost of new energy supply projects which would deliver equivalent supplies to customers.

The Cost of Traditional Alternatives

Conservation should be treated exactly like any other option for filling energy needs. Therefore, the unit cost for energy is compared with the marginal cost of new supplies of electricity or natural gas. Marginal cost reflects the company's present resources and demand trends. In California, where electricity demand is rising, this marginal cost includes fuel costs and new generation and production facilities. In states with very high reserve margins, or where demand is constant or falling, the range of cost-effective conservation investments may prove much smaller. Fixed costs would still be due, and only new fuel costs would be avoided.

Revenue Requirements of the Conservation Program

For a financing program the main costs to the utility are the money loaned (later repaid by the participant), the cost of the interest subsidy and administrative expense. These items vary with the program design, particularly loan payback arrangements, program inspection and enforcement and the utility's cost of financing.

Energy Savings from Conservation

For each energy conservation measure, annual energy savings in each single or multi-family dwelling can be projected. Then a stream of energy savings over the expected life of the measure is estimated. Once the overhead costs of the program are added to the installation cost of the device, the cost of the energy savings can be calculated and compared with the marginal cost of new supply.

Defining "Cost-Effectiveness"

On the different ways to define cost-effectiveness, three of the most important are explained below. Exhibit I summarizes the calculations within the three tests.

(1) Ratepayers. Energy conservation which costs less than the marginal cost of avoided supply yields overall economic benefits. From this viewpoint, costs are the administrative and subsidy costs which the utility does not recover from participants. These costs are ultimately spread over all ratepayers.

Ratepayers who particpate in the program will clearly benefit more than those who do not. They will receive both their share of avoided system costs and the direct benefits of lower personal energy use. It is, therefore, useful to look at the program impact on the non-particpating ratepayers.

The Zero Interest Program (ZIP) now being conducted by Pacific Power & Light Company (PP&L) uses a non-participant test when deciding what investments to finance. Non-participants benefit when the net cost to the utility after all participants' payments is less than the difference between the utility system's marginal and average costs of energy. Utilities pay the marginal cost of capacity or fuel supply, but recover only the average cost when selling the energy. The difference between the two defines the subsidy provided to new demand by the regulatory rate structure. If the subsidy provided by an energy conservation program is less than this amount then non-participants are better off than they would have been if new capacity had been built.

A strict requirement for non-participant benefits would limit conservation more severely than other regulatory programs. Cross-subsidies among ratepayers are imposed throughout the regulatory process for practical or political reasons

One of the main functions as commissioners is to establish standardized rates to charge broad classes of customers, with only limited regard for the actual cost of serving a given ratepayer. New customers often impose very large marginal costs on the system, yet pay no more per kilowatt-hour or therm than comparable consumers who have provided steady demand for half a century. The cross-subsidies in energy conservation and efficiency programs should not be subjected to a more stringent standard of equity.

(2) The utility. Increasingly, private utility analysts and utilities recognize great advantages to shareholders from utility energy conservation investments. PG&E has included extensive conservation in its latest resource plan projections of 2 percent load growth. Just last month, Southern California Edison Company announced a revised electricity generation resource plan which also anticipates greatly expanded conservation and load management activities.

The acceptance of conservation as a valuable energy option runs against the traditions of energy utilities and regulators.

EXHIBIT I

CONSIDER ENERGY CONSERVATION AS A SOURCE OF ENERGY SUPPLY

DEVELOP UNIT ENERGY COST FOR EXPECTED ENERGY SAVINGS

- PROJECT ANNUAL REVENUE REQUIREMENTS FOR PROGRAM KEY ITEMS FOR UTILITY FINANCING:
  - ADMINISTRATIVE AND GENERAL (A&G)
  - INTEREST SUBSIDY
  - REVENUE LOANED TO CONSUMERS
- MODEL ENERGY SAVINGS FOR CONSERVATION DEVICE FOR AVERAGE CONDITIONS

  KEY VARIABLES:
  - ANNUAL SAVINGS
  - EXPECTED LIFETIME

COMPARE PROGRAM AGAINST ALTERNATIVES FROM VARIOUS PERSPECTIVES

- ALL RATEPAYERS

$$\text{UNIT ENERGY COST} = \frac{\text{PRESENT VALUE OF A\&G EXPENSE AND INTEREST SUBSIDY}}{\text{TOTAL PROGRAM ENERGY SAVINGS}} + \frac{\text{PRESENT VALUE OF TOTAL REVENUES LOANED}}{\text{TOTAL PROGRAM ENERGY SAVINGS}}$$

  UNIT ENERGY COSTS SHOULD NOT EXCEED MARGINAL COST OF ALTERNATE SUPPLY

- NON-PARTICIPANT

$$\text{UNIT ENERGY COST} = \frac{\text{PRESENT VALUE OF A\&G EXPENSE AND INTEREST SUBSIDY}}{\text{TOTAL PROGRAM ENERGY SAVINGS}}$$

  WILL RECEIVE DIRECT BENEFIT FROM PROGRAM W/O PARTICIPATION IF UNIT ENERGY COST IS LESS THAN DIFFERENCE BETWEEN MARGINAL AND AVERAGE COSTS

$$\text{UNIT ENERGY} = \frac{\text{PRESENT VALUE OF A\&G EXPENSE AND INTEREST SUBSIDY}}{\text{TOTAL PROGRAM ENERGY SAVINGS}}$$

  UNIT ENERGY COST FOR PROGRAM SHOULD NOT EXCEED UTILITY'S MARGINAL COST OF SUPPLY

  ANNUAL REVENUE REQUIREMENTS, POTENTIAL FOR FAVORABLE FINANCING ARRANGEMENTS, RATE OF TURNOVER OF INVESTED DOLLARS, ETC., SHOULD COMPARE FAVORABLY WITH ALTERNATE SOURCES OF ENERGY SUPPLY

Capacity expansions were long justified by declining real costs and unlimited secure supplies. Nothing could be less like the present world. Higher capital costs, supply and demand uncertainties and longer construction lead times jeopardize the ability of utilities to fill ratepayer needs at tolerable prices.

Conservation may enable utilities to "hedge their bets" by cutting back fuel purchases and deferring capacity additions. This reduces the need for new debt and equity issues which carry today's sharply higher cost of money. The cost of new plants with long lead times is literally staggering the utility industry.

Conservation investments can be made in smaller increments and can yield revenues more promptly than capacity expansions. These characteristics can prevent the severe cash flow problems of utilities experiencing cost overruns and construction delays on conventional facilities. The reliability of both demand reduction and repayment should ease the rising risk exposures of the utilities. Conservation may give utilities the opportunity to bring their costs and potential earnings back into line.

Utilities with large reserve margins and level or falling demand may still benefit from conservation. Conservation can be used to back out expensive fuels such as imported oil. This reduces short term cash requirements and frees utilities from the short term shocks of unanticipated supply shortages and price escalations.

(3) Society. Every energy supply choice imposes externalities which confound accurate balancing of costs and benefits. Every such cost could be measured accurately, then a strict dollars and cents analysis would be perfectly appropriate. Instead, the true value of pollution, health and safety hazards can only be estimated. The balance of payments and national security problems accompanying dependence on interruptible imports are probably not appropriate for state review.

Energy conservation imposes fewer external costs than most supply options. Comparing energy conservation with the market valuation of the marginal cost of new supply provides a conservative guide to cost effectiveness.

Figures 2 and 3 show CPUC staff estimates of the unit energy cost of different conservation measures. "Unit energy costs" are those borne by a utility. The staff adapted cost and savings estimates from PG&E's proposed zero interest loan program. Costs of the RCS audit have been deleted, since it is an effort imposed independent of any cost effective concerns. Duct installations and lighting conversions are not cost effective, at least when installed in an all-electric house by a contractor. They would not be financed by the proposed program. The actual calculations would vary with special home characteristics, climate and the willingness of residents to do-it-yourself.

Figure 4 shows PG&E's estimates of cumulative electricity and gas savings under its proposed program.

ADDITIONAL CONSIDERATIONS AFFECT THE DESIGN OF A RESIDENTIAL CONSERVATION PROGRAM

Social and political considerations also demand inclusion in what can be termed as an economic decision. In the hearings and oral arguments held over PG&E's "ZIP" proposal, advocates of industry, and citizen and environmental interests argued vociferously over the broader implications of energy supply decisions

(1) Impact on competition. There is a widespread fear of extending the economic influence of regulated monopolies. This fear apparently produced NECPA's prescription of utility finance programs which was eliminated last summer by the Energy Security Act after substantial efforts by NARUC and many others. Areas of possible noncompetitive impact include financial institutions and the manufacturers, suppliers and installers of conservation materials. Existing institutions and markets should be utilized whenever possible.

(a) Banks. Banks, savings and loans and credit unions have not been very interested in financing residential energy conservation because loans are relatively small. This appears to be changing, however, as the prospective market grows. Also, utilities may choose to centralize management of financing at one or a few financial institutions. Such centralization provides the larger scale which may be necessary to attract private financial interest.

FIGURE 1.

NATURAL-GAS CONSERVATION DEVICES COST EFFECTIVENESS COMPARISON

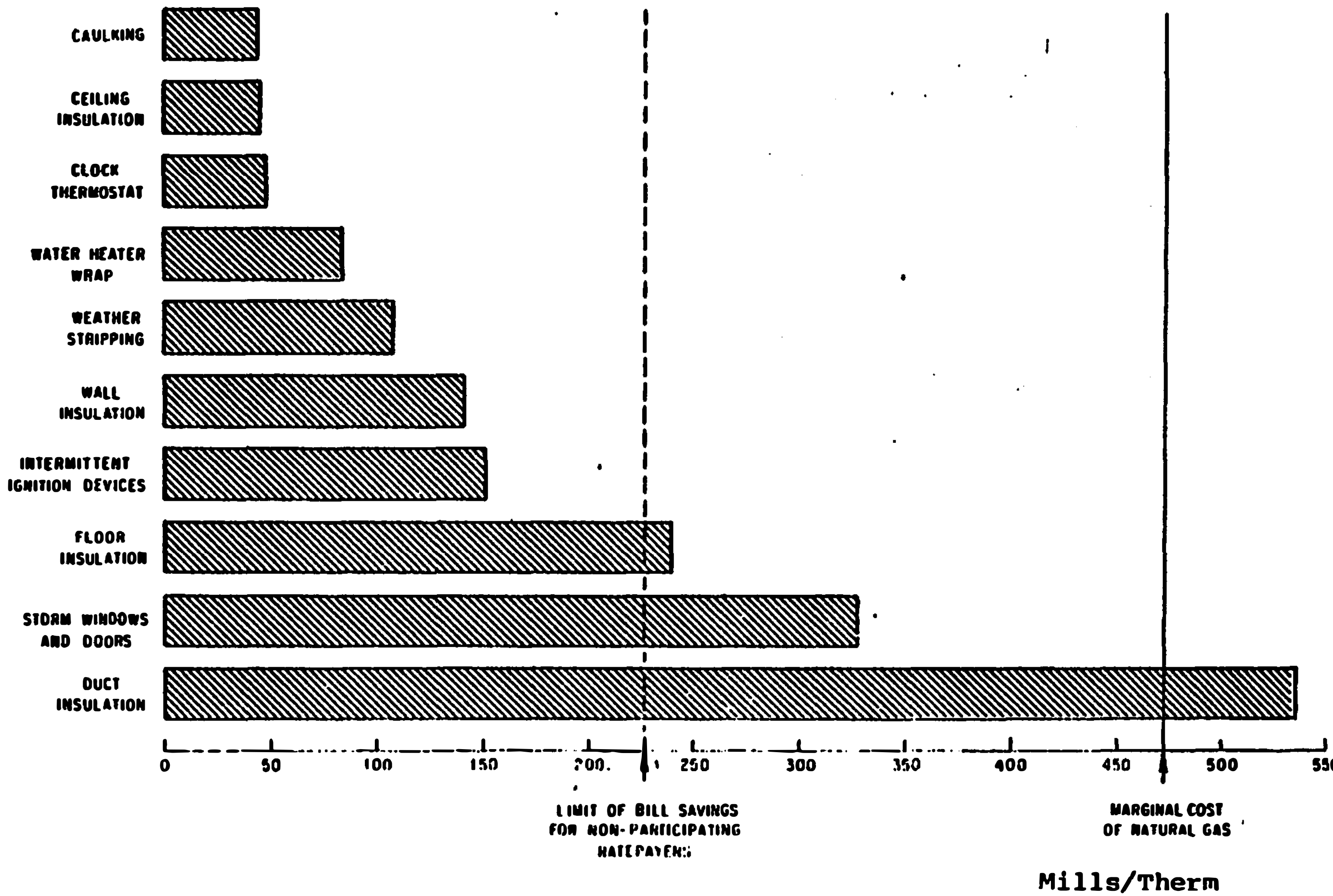


FIGURE 2.

ELECTRIC CONSERVATION DEVICES COST EFFECTIVENESS COMPARISON

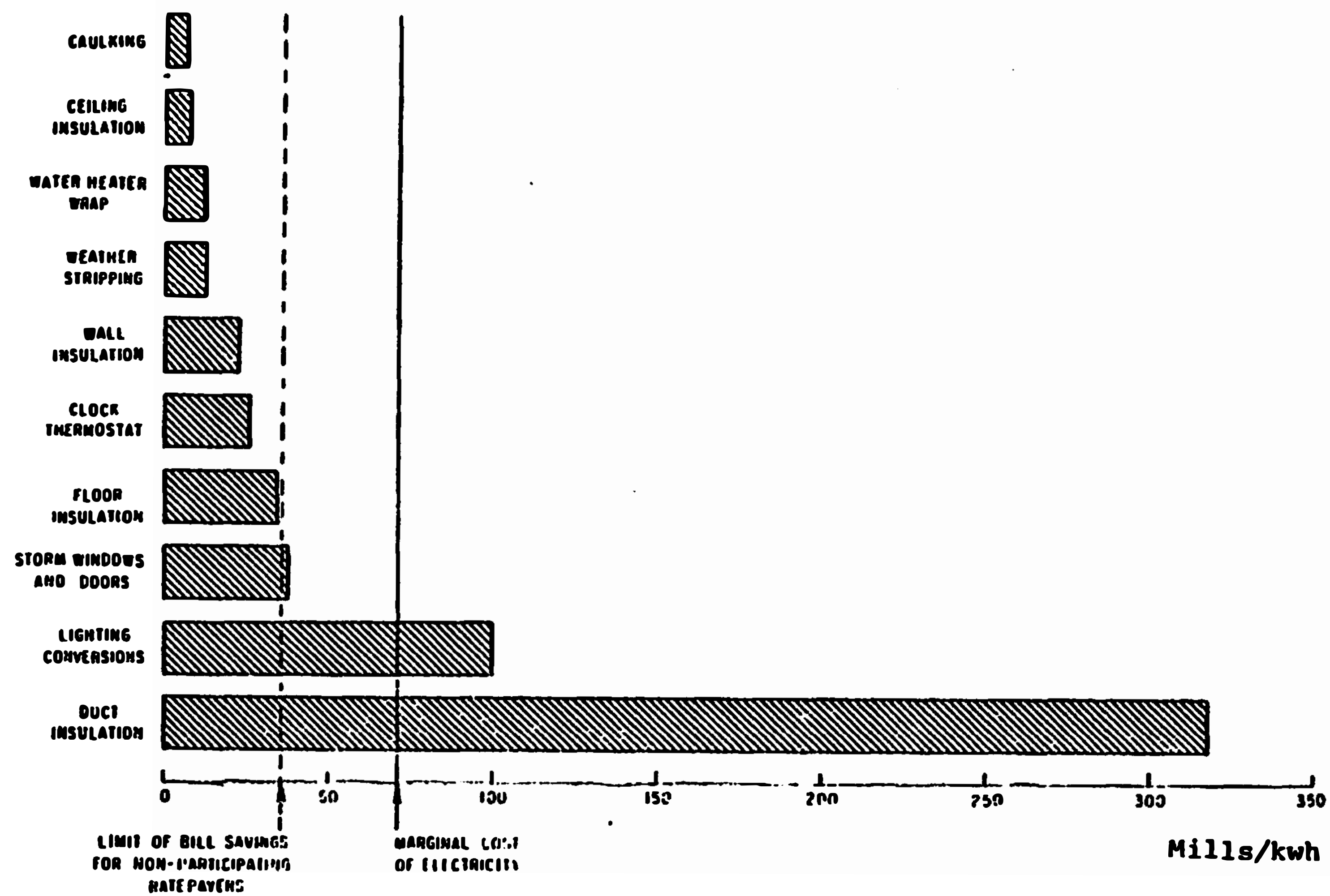
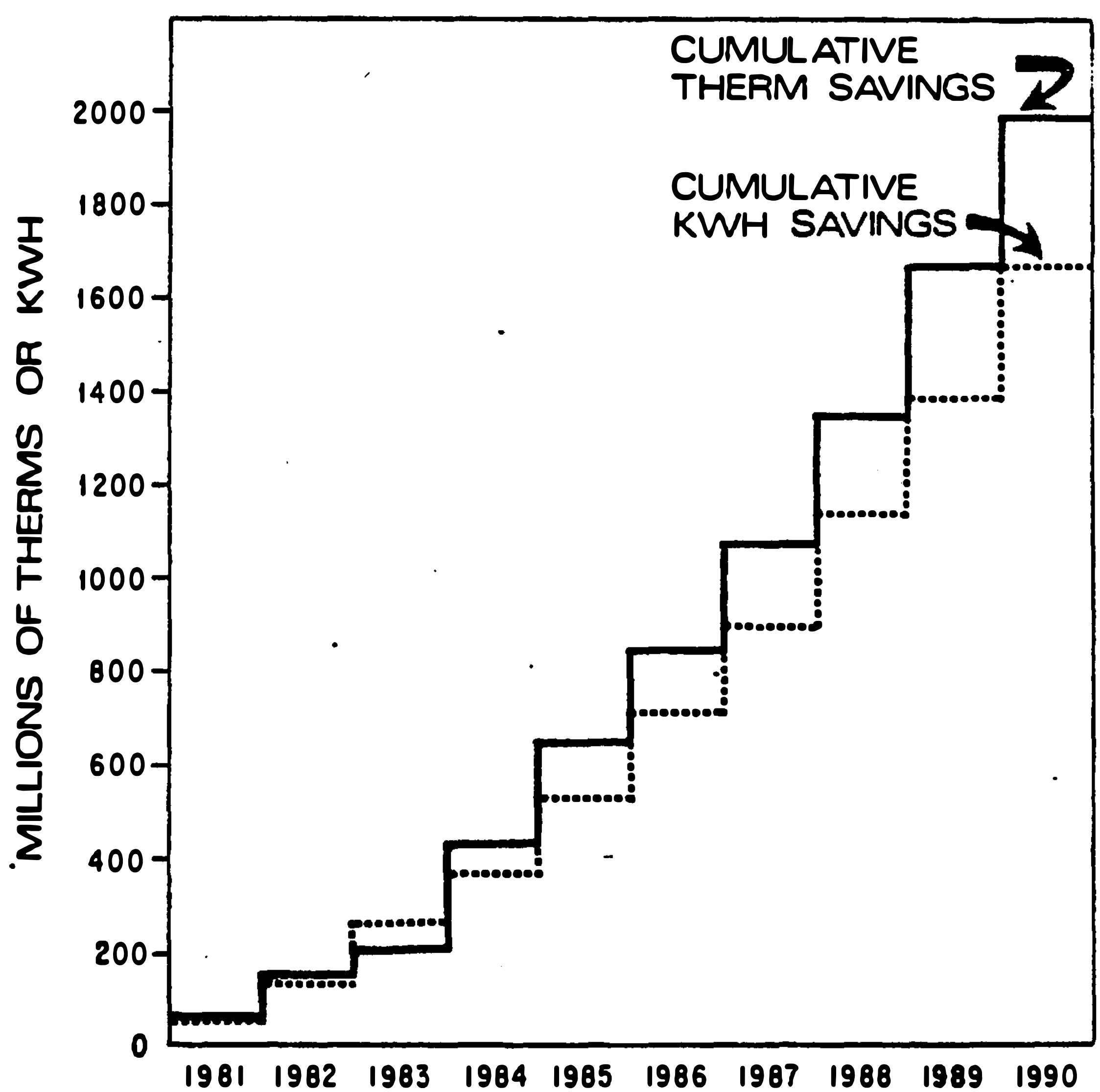


FIGURE 3.

PACIFIC GAS AND ELECTRIC COMPANY PROJECTIONS
OF CUMULATIVE ENERGY SAVINGS



(b) Suppliers. Conservation measure suppliers have objected to RCS as restrictive of markets and competition. Many of the same arguments apply to any utility financing program which contains cost control features. I am inclined to limit the utility role in the consumer's choice of materials and installers to disclosure of information about typical installation prices. Since consumers must ultimately repay at least some of the costs of installation, they should have adequate incentive to limit cost.

(c) Renters. Subsidized loan programs have provided little incentive to landlords whose tenants pay utility bills. Tenants have insufficient incentive to pay for conservation measures which will not pay for themselves until after the tenants have moved. Eight percent loans offered by California utilities have not succeeded in penetrating the rental market. Zero percent may or may not be enough. Mandated energy efficiency standards may prove necessary. If so, tax credits and existing or proposed low interest loan programs will minimize hardship on landlords.

(d) Low income owners. Low income homeowners suffer more severely from the barriers to residential energy conservation. Long term financing can go a long way toward easing perennial cash shortages, but additional efforts may be necessary to clear other barriers. For the many low income consumers who live in substandard housing, the cost effectiveness of a conservation measure may be changed drastically by structural defects. There is no use insulating an attic if all the heat will flow out a hole in the wall. Energy savings calculations should consider these effects. Additional measures may be cost effective and could perhaps be included in the utility program, through explicit cooperation with existing weatherization and rehabilitation programs.

OTHER STATES SHOULD MOVE TO DEFINE COST EFFECTIVE CONSERVATION MEASURES AND ENCOURAGE THEIR INSTALLATION

It is the duty of regulators to encourage least-cost means of filling energy requirements. The changing energy market requires constant reevaluation of what energy uses are cost effective, and of what energy conservation activities can save consumers and ratepayers money. The CPUC is working to create a methodology that will calculate the cost effectiveness of different supply and efficiency measures. Comparable analytical tools to fit the energy supply and demand situations in other states should be developed.