Title

THE POTENTIAL FOR IMPROVED ENERGY EFFICIENCY TO HELP MEET FUTURE ENERGY NEEDS

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Jeffrey P. Harris

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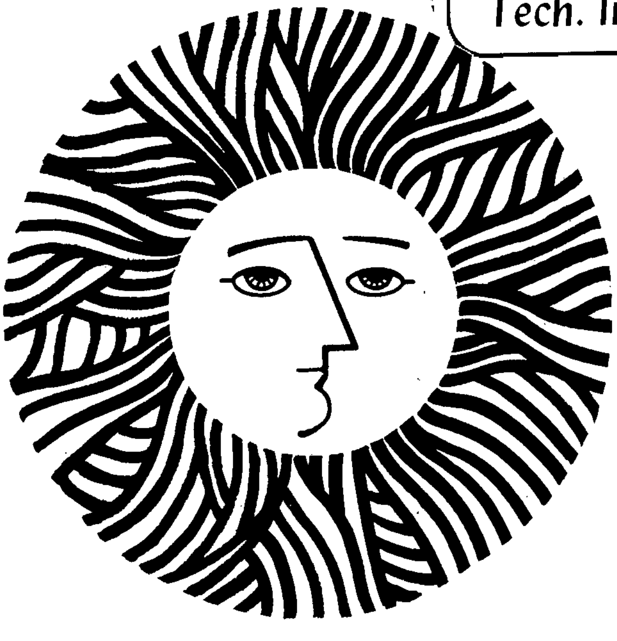

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TESTIMONY BEFORE THE
HOUSE INTERIOR AND INSULAR AFFAIRS COMMITTEE,
SUBCOMMITTEE ON INVESTIGATIONS AND OVERSIGHT
U.S. CONGRESS

HEARINGS ON PROPOSED OCS LEASE SALE 73
SAN FRANCISCO, CALIFORNIA
OCTOBER 9, 1981
(Revised 11/12/81)

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Abstract

The estimated technical potential for cost-effective energy conservation is summarized for both the U.S. and California. These estimates should be viewed as theoretical opportunities for improving energy efficiency; they are not necessarily forecasts of the actual savings that might result from government policies and the market's response to higher energy prices.

Detailed analyses are offered for residential buildings, using "supply curves of conserved energy." This technique allows the quantity and cost of energy "supplied" through improved efficiency to be readily compared with the production potential and unit cost of new conventional energy supplies.

By the year 2000, there is a potential for the U.S. to reduce its annual resource energy consumption from a projected 103 Quads (10^{15} Btu's) to about 62-65 Quads. This savings potential is the energy equivalent of about 18 million barrels per day (MBD) of oil production. Annual savings in the buildings sector alone could be as high as 8 MBD oil-equivalent, or more than the total amount of U.S. oil imports, for all sectors, in 1980.

California's proportional share of this technical potential appears to be of the same order of magnitude as USGS estimates of California's OCS resources, but any more precise comparison may be premature.

To achieve these efficiency gains will require investments of hundreds of billions of dollars over the next two decades, but the savings for businesses and consumers would be even larger. The average cost to save this energy would be about $10/barrel, in today's dollars.

The conservation technical potential for California has not been fully evaluated, but estimates have been made for some end-use sectors. A future "low-energy scenario" for the State, while not specifying the full technical potential, identifies some possible goals for conservation and renewable energy use.

INTRODUCTION

Good afternoon. My name is Jeffrey Harris; I am currently a visiting researcher with the Energy Efficient Buildings Program at the Lawrence Berkeley Laboratory, one of the DOE-funded National Laboratories engaged in basic and applied energy research. Prior to that, I was with the California Energy Commission for five years. Most of that time I was responsible for energy conservation program planning and policy analysis, including estimates of the effects of conservation on future demand for fuel and electricity within the State.

I have been asked to provide the Subcommittee with information on how conservation and alternative energy strategies can be compared with OCS development and production, in terms of economic security, long-range energy independence, and social benefits.

Today I would like to summarize for you some results of recent research, at LBL and elsewhere, on the potential for large improvements in the efficiency with which we use energy. These opportunities exist throughout all sectors of the U.S. economy, but I will focus on the conservation potential in buildings, where the data are generally more detailed and where I have the most direct experience.

Energy conservation is in many ways equivalent to an untapped "reserve" supply of domestic energy. By using energy more efficiently in buildings, factories, and automobiles, we can sustain steady growth in GNP, and satisfy the same consumer demand for products, services, and amenities, while stretching the available supply of fossil fuels, renewable energy resources, and nuclear power. More importantly, improved energy efficiency can lower the cost of energy services to individual consumers, private industry, and the economy as a whole, thus helping to slow inflation.

Later I will present some estimates of the cost of achieving these potential energy savings. In most cases energy can be saved at only a fraction of the cost per million Btu's of meeting the same energy needs from new sources of supply. The potential savings from conservation, and the average cost per million Btu's saved, will then be contrasted in general terms with the potential production levels and costs of oil and gas from new offshore fields.

My purpose in presenting this information in today's hearing is not to argue that improvements in energy efficiency are automatically an alternative to producing oil from new offshore areas, such as the proposed Lease Sale 73. Conceivably, both strategies may be needed and economically justified as part of a long-range energy program.

But it is clear from a growing number of studies, and from the trends already occurring in the economy, that improved energy efficiency, when viewed as an energy resource, is at least as attractive in terms of cost, reliability, and environmental effects, as any new conventional or unconventional source of energy supply.

Further, virtually any source of new energy will be more costly than current supplies. Therefore, if new energy sources are to compete in the marketplace, they will have to be accompanied by continued improvements in the efficiency with which they are used.

The conservation opportunities I will summarize briefly are described in more quantitative detail in the attached Technical Appendix, and in the reports cited as references. Most of the examples I offer are drawn from two recently completed studies. One, prepared by the Solar Energy Research Institute (with LBL responsible for the section on energy conservation in buildings), discusses the potential for improved efficiency and use of renewable resources within all sectors of the U.S. economy [12]. The second study, prepared at LBL, examines energy saving opportunities within California, for the residential sector only [19]. This is supplemented by the results of recent studies by the California Energy Commission and the major California utilities, on conservation potentials in buildings and other sectors.

DEFINING "TECHNICAL POTENTIALS" FOR ENERGY CONSERVATION

Before turning to the quantitative results I want to share with you, let me take a moment to clarify some terms. First, almost all of the energy conservation estimates I will cite are expressed as technical potentials (Figure A-1). This means that they reflect "targets of opportunity," but not necessarily a prediction of what is most likely to occur in the future, under a given set of market conditions, government policies, or regulations.

The estimates of technical potentials for improved energy efficiency are based on measures that are technically feasible with today's off-the-shelf technology. Each measure we considered had to meet a rather conservative test of cost-effectiveness: it had to be economically justified at today's energy costs.

On the other hand, our estimates assume a complete saturation of each technical measure, wherever it was physically possible and economic. It is this last assumption that defines our estimates as technical potentials rather than forecasts.

The methodology we used to estimate technical potentials within the buildings sector started with a careful assessment of average energy savings and costs for a large number of technical measures. These estimates were based on research data, computer model simulations, and, wherever possible, actual field measurements (see Section E of the Technical Appendix for examples of the data sources).

The next step was to rank the individual measures in order of increasing cost per unit of energy saved. The result is one that economists will recognize; it is, in effect, a "supply curve of conserved energy" (Figures A-2 and A-3). Several examples of such supply curves are shown in Sections B, C, and D of the Technical Appendix.

Significantly, in developing these conservation supply curves, we paid close attention to the interactions among energy-saving measures installed in the same building, in particular, the relationships among solar and conservation measures. For example, our technical potentials assume that passive solar space heating systems are designed to serve a home that has already been well-insulated, and thus has reduced needs for solar heat. This approach helps avoid double-counting of either the expected energy savings or costs.

A major advantage of providing data in the form of a conservation supply curve is that it is easy to answer the question: "How much energy can potentially be saved at a unit cost less than x dollars per million Btu's?" Thus, the policy-maker or analyst can readily compare--on a consistent economic basis--energy saved through improved efficiency with energy supplied from any number of possible new sources.

ENERGY SAVING POTENTIALS IN THE U.S.

The basic finding of the SERI/LBL study [12] was that today's energy consumption level of nearly 80 Quads (10^{15} Btu's, resource energy) for the entire U.S. economy, which is projected by the Energy Information Agency to increase to about 103 Quads over the next twenty years [15], could instead be reduced to 62-65 Quads by the year 2000 (Figure B-1 and Table B-1).

This would be accomplished, not by cutting back on economic growth, employment, or consumer comforts and amenities, but by producing goods and providing "energy services" more efficiently (Figures B-2 and B-3). Renewable energy resources could potentially provide 20-30 percent of the remaining energy demand, by the end of the century (Figure B-4).

The major components of this potential for increased energy efficiency are illustrated, by sector, in the Technical Appendix (Figures B-5 through B-10).

By far the largest energy-saving potential is in the buildings sector. Over the next twenty years, it is technically possible to cut projected energy use in residential and commercial buildings by more than half, saving as much as 16 to 17 Quads annually. This is the energy equivalent of over 8 million barrels of oil per day (8 MBD).

The annual savings potential from all sectors of the economy is over twice as large, or the equivalent of about 18 MBD by the year 2000.

For residential buildings, details on these potential savings, by fuel type, end use, and specific energy-saving measure, are provided in the supply curves shown in the Technical Appendix (Figures C-1 through C-10). The savings from each end-use are aggregated, for electricity and for fuel, in the two final supply curves (Figures C-9 and C-10).

Roughly another 3 MBD of potential energy savings is available just from improving the efficiency of autos and light trucks, which now use about half of all energy consumed in the transportation sector. Improved load factors and more sensible travel patterns are important here, but by far the biggest efficiency gain would come from futher increases--technically achievable but beyond what is now anticipated--in the mileage of new vehicles added to the fleet over the next twenty years.

Vehicle efficiency standards may have a role to play, but so could effective labeling of vehicles for energy efficiency, combined with additional economic incentives. The issue of energy performance labeling is one that I will comment on later, in the context of new and existing buildings.

To put these numbers in some perspective, note that our current level of oil imports, for all sectors of the economy, is slightly under 7 MBD [16]. In other words, the savings that we could potentially realize <u>just in the buildings sector</u> are more than equal to our total reliance in 1980 on foreign oil. The oil-equivalent of savings that could be achieved, in all sectors, by the year 2000, is over two and one-half times today's U.S. oil imports.

For another kind of perspective, consider the fact that the energy that could be saved each year would be worth more than $90 billion for the buildings sector alone, and well over $200 billion for all sectors--all at today's energy prices. If we account for future energy price increases, the value of this saved energy could be as high as $165 billion per year for the buildings sector and nearly $400 per year for the entire economy, based on the latest EIA price forecasts [15].

Of course, not all of this would be a net savings to households and businesses. A substantial amount of investment would be required to increase the efficiency of our buildings, factories, and autos (beyond what might otherwise occur), and to install the equipment needed to make use of solar, wind, and other renewable resources.

For the buildings sector alone, we estimate that roughly <u>$425 billion</u> would need to be invested to achieve the full potential for energy conservation. While this amount of investment looks large, it is actually a very good deal, spread out over twenty years and compared to the amount (and replacement value) of energy that would be saved.

The multi-billion dollar investment required to improve efficiency in buildings translates into a cost of about $10 per barrel-of-oil-equivalent saved. In more everyday terms, this means it would cost about 25 cents to save the energy equivalent of a gallon of gasoline. Even in 1981, this looks like a very good deal. Ten or twenty years from now it will obviously look even better.

A little later we will consider how the costs of saving energy might be compared with the costs of new oil supplies, including OCS oil.

CALIFORNIA ENERGY SAVING POTENTIALS

Some illustrations of energy conservation potentials in California are included in the Technical Appendix (Figures D-1 through D-4), based on recent studies by LBL, major California utilities, and the California

Energy Commission (CEC). Again, more detail is provided for the buildings sector.

Care is needed in comparing energy savings estimates for California with those for the U.S. as a whole, not only because of the differences in scale, climate, and characteristics of the current stock of energy-using equipment, but because "base-case" projections for California already envision the State as being on a low-growth curve for energy demand.

For example, the Energy Commission's latest Biennial Report to the California Legislature [4] outlined two possible scenarios for the next twenty years. The business-as-usual case showed statewide energy use declining in absolute terms--despite population and economic growth, from today's level of about 5.6 Quads (end-use energy) to around 5.3 Quads in 2000.

The "alternative future" scenario, as envisioned by the CEC, would make a relatively modest impact on the already declining energy use forecast, reducing consumption by another 0.5 Quads (10 percent) in 2000. The difference (0.8 Quads) between California's energy use today and the CEC's alternative future for 2000, corresponds to about 0.4 MBD of oil-equivalent.

A more detailed view of the energy-saving potential in the existing stock of California residences was provided by a recent study that used the "supply curve" approach [19]. Examples of the conservation supply curves for California are included in the Technical Appendix (Figures D-1 and D-2).

Overall, the study concluded that improved energy efficiency could reduce residential demand for natural gas by one-third, and demand for electricity by nearly one-fourth. (Note that these figures include only improvements to the existing stock--the effects of improved efficiency in newly-built homes were not considered, nor were the opportunities to displace natural gas and electricity use with solar energy.)

The LBL and Energy Commission studies are in reasonable agreement with the results of three other recent conservation studies conducted by the three largest California utilities [7, 13, 14]. The comparisons are shown, for both residential and commercial buildings, in Figures D-3 and D-4 in the Technical Appendix. In both figures, estimates made for different utility service areas have been reduced to a common scale by translating them into average electricity use per household, or average consumption per square foot of commercial building space.

COMPARISONS WITH OCS PRODUCTION AND ECONOMICS

<u>OCS production potential vs. "conservation resource" potential</u>. There are great uncertainties in making predictions in any single category of energy resources; comparisons between different types of resources clearly carry all the more risk. In this instance, the problem is further compounded because I can claim little expertise as a petroleum geologist or an oil resource economist.

Nevertheless, let me outline some very gross comparisons between energy conservation as a resource and California offshore oil, just to give a sense of the relative magnitudes.

By the year 2000, the SERI/LBL study identifies a potential annual savings from conservation and renewables of 38-41 Quads. If one assumes constant progress toward that target over the next twenty years, the average amount of energy "supplied" through greater efficiency would be 9 to 10 MBD for the entire period.

California is one-tenth of the nation for most purposes. This means that California's normal contribution to the U.S. energy savings potential would average nearly 1 MBD throughout the next two decades. This is, however, roughly twice what the California Energy Commission's scenarios anticipate--partly because energy use patterns in the state are quite different from the national average to begin with, and in part because the state's accepted baseline forecast already anticipates energy demand growing more slowly than the EIA base case forecast for the U.S.

But let us assume that the energy savings potential within California is bounded by these two very rough estimates: 0.4 to 0.9 MBD.

On the other side, the production that might be expected from current or proposed OCS lease areas is partly unknown (until further exploration and actual production are underway), and partly proprietary data. Production levels also depend, of course, on the actual lease areas finally selected, and the future economics of oil production and world oil demand. One of the issues, in these hearings and other proceedings, will be just how much oil might economically be recovered from the various OCS areas.

But to choose some rough numbers to complete the picture, the Department of Interior's original press release announcing the proposed lease sale #73 [17] mentioned a USGS estimate of undiscovered resources ranging from 3.5 to 10.9 billion barrels of oil, and 5.5 to 15.0 trillion cubic feet of associated gas (for a somewhat different area than may now be contemplated).

While USGS resource estimates seem to be a moving target, let us choose the midpoint for both oil and gas, and proceed with the calculation. We find that the resource potential of the OCS #73 area may be roughly 52 Quads.

For simplicity, let us again assume a twenty-year production period, which translates into an average annual OCS yield of 2.6 Quads, or about 1.2 MBD. The net energy yield, however, would certainly be lower, once we account for the energy requirements for offshore drilling, well production, and transportation of the oil and gas to refineries, onshore storage, or distribution sites.

In other words, the potential savings from improving energy efficiency in California, and the possible OCS production levels, are of the same order of magnitude. But once again, I would not rely on the above comparison for anything much more precise than an order-of-magnitude conclusion.

Saving energy vs. saving oil. It might be correctly pointed out that translating energy savings directly into "barrels of oil-equivalent" is somewhat misleading, since (except in the transportation sector) the savings also include other forms of energy, mainly electricity and natural gas. However, in the long run, it is reasonable to expect considerable substitutability between oil and gas, at least for large and medium-sized commercial or industrial customers (including utilities).

This means that savings of natural gas in, say, home heating and water heating would make additional gas supplies available to displace oil in large commercial boilers. Similarly, electricity that is saved by end-users can translate into a savings of oil (and gas) used by the utility at the powerplant.

These fuel substitution effects are actually far more complex, varying from one region and one utility area to the next. They depend not only on relative prices of the different fuels, but also on the investments sunk into large energy-using equipment, and of course on regulations affecting fuel use.

In California, for example, nearly 40 percent of the electricity is currently generated by oil-fired powerplants [4], compared to only 12 percent for the U.S. as a whole [16]. This means that for the next few years, saving electricity in California buildings or industry is particularly valuable in terms of oil displacement.

The 40 percent ratio of electricity savings to resultant oil savings is a minimum--the real effect is likely to be much higher. This is because it is often the older, least efficient oil-fired powerplants that utilities will choose to turn off first, whenever electricity demand can be reduced (especially during peak load periods).

Cost comparisons. It turned out that comparing the cost of conserved energy with the prospective cost of OCS oil from the lease areas was even more problematic than comparing production levels.

On the conservation/renewables side, we had already made some estimates in the course of preparing the SERI/LBL study. For the buildings sector, as noted earlier, amortizing the necessary investments over the economic life of each building or appliance resulted in an average cost of conserved energy of about $10/barrel-equivalent.

What will future OCS oil production cost, for each barrel of oil delivered to the refinery? In my naive enthusiasm, I first sought an answer to this question by making phone calls to various likely sources within the industry, government agencies, and the academic community. Some dozens of calls later, I began to realize that the problem probably lay with the question, rather than with my respondents.

There are apparently just too many variables and, for now, too many unknowns, to answer that question with a single dollar value. In particular, historic production costs for offshore areas, which one industry source estimated at about $10/barrel, appear to be a very misleading guide to future costs. This is not only because fields differ (and those fields now in production tend to be among the most favorable ones to begin with) but also because their drilling costs were incurred when both the direct expenses and the cost of capital were far lower than today.

Perhaps the simplest way to deal with the question is to consider that, over the long run, OCS production costs, including delivery to refineries and the costs of required environmental mitigation, should not be too different from the cost of other sources of oil. If costs were significantly lower, there would be great economic and political pressure to increase leasing and exploration until the marginal costs increased. Conversely, if OCS production and transportation costs were to be much higher than refiners' costs to obtain oil elsewhere, it would be difficult to develop and sustain a market.

I fully realize that there are numerous market imperfections in the real world, including but certainly not limited to government regulation of the petroleum industry. Clearly, the "market principles" I am presenting apply only in a gross and long-term sense. But there is another reason why something close to the world oil price should be considered as representative of the future cost of delivered energy from OCS oil. It is rather unlikely that California OCS production volumes will be large enough to affect the world market significantly, so the price to consumers for OCS oil and refined products is still going to be set in that larger context.

This means that energy conservation, at an average of $10/barrel over the next two decades, should be compared with world oil--at about $34/barrel now, and possibly twice that amount (but still in today's dollars) by the end of the century. I'll buy improved efficiency.

A variant on this interpretation is found in the Secretarial Issue Document prepared for OCS lease sale #53 [18]. In that document, the "value" of producing OCS oil was estimated by taking the difference between assumed production costs and the projected world oil price. This difference worked out to be roughly $8.70/barrel.

Even if we accept this estimate (no documentation was offered), saving energy at $10/barrel still looks like a good deal compared with $25/barrel today or $51 in twenty years.

CONCLUSION: ACHIEVING THE POTENTIAL ENERGY SAVINGS

It is not my intent to talk at length today about the most important public and private sector strategies for implementing the conservation technical potentials summarized earlier. However, some broad outlines are noted in Figure F-1 in the Technical Appendix.

There is little question in my mind that the normal market response to rising energy prices has already had a substantial effect in improving energy efficiency throughout the U.S. economy, and that the market will continue to be the dominant factor in the future. But this does not mean that market incentives, by themselves, will work in every case, or generate changes as quickly as one might like.

Large categories of energy-using activities are effectively cut off from the incentives of rising energy prices. A common example is the case of rental apartment units (or leased commercial space), where both the incentive and the ability to save energy are cleanly split between the tenant and the building owner.

A second well-known case is low-income housing. Regardless of the ultimate economic benefits, low-income households may simply be unable to pay the up-front costs of efficiency improvements.

A final example of market failure in part of the home appliance market is less widely known. Higher energy costs, or even energy efficiency labels, have essentially no impact on appliances purchased by someone other than the person who will use them (and pay the energy bills). Adding up the market shares represented by builder-installed appliances, rental units where the landlord supplies the major appliances, and bulk purchases by Housing Authorities and other organizations, the evidence is that more than one-half of the new appliances sold each year are essentially outside any real market incentive structure.

Even where the market works, there may be significant time lags that translate into billions of dollars of energy waste each year. Figure F-2 in the Appendix traces the actual response by one segment of the new home market to rising energy prices. The Figure compares this market response with the level of energy efficiency that would have been optimal for the homebuyer to invest in as of 1973, 1976, and 1979. Under rather conservative assumptions, the data in Figure F-2 suggest that market lag can be well over 15 years for new, all-electric homes.

One important strategy for reducing market lag in the residential sector is to make it easier for homebuyers to comparison-shop, with confidence, for energy efficiency--along with other features of a home. A well-designed system of energy performance rating and labelling, for both new and existing homes, can be a key to overcoming this particular market barrier. The general approach is outlined in Figure F-3.

Preliminary results are shown in figure F-4 for a recent PG&E-sponsored program to rate new homes for energy efficiency and provide incentives to builders who exceed the California energy conservation building standards. In general, it would appear that rating/labelling/incentive programs such as PG&E's, which are now rapidly growing in popularity around the country, can help to close the gap between conservation technical potentials and the unaided market.

One final thought concerns a role that seems especially important for the Federal government to play, since there is no evidence of any alternative within the private sector. This is the funding of a coherent, long-term program of basic and applied research on energy-saving technologies, coupled with an adequate emphasis on communicating new research findings to industry, utilities, state and local government, and ultimately to consumers.

Although it appears (and is) somewhat self-serving, I have to emphasize that without the new ideas, technical guidance, and quality control that come from such a research effort, there is little likelihood of achieving anything close to the conservation potentials I outlined earlier.

An illustration of the significance of new technologies is provided in Figure F-5 in the Appendix. The Figure contains a brief case history of one very successful Federal investment in developing and helping to commercialize a promising new technical innovation: high-frequency ballasts for fluorescent lights. This one product, which will soon be available to a mass market, is likely to save, just in the near term, the energy equivalent of more than three 1000-megawatt powerplants.

There is little question that without an aggressive, Federally-supported research and development effort, the structure and traditions of the lighting industry would have precluded this particular advance for many more years.

A number of other examples of the potential value of an ongoing energy conservation research effort--and the need for Federal funding of it--are contained in reference (11).

These concerns may be particularly timely now that the Administration is contemplating, on top of its 80% cut in conservation funding for FY 82 (compared to the Carter proposals), a further 60% cut for FY 83--or possibly the elimination of all Federal support for energy conservation activities.

Continuing advancements in energy-saving technologies, even beyond the levels contemplated in the SERI/LBL study, are still available in principle, but research and technology-transfer are certainly two of the keys needed to unlock this potential.

ACKNOWLEDGEMENT

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TECHNICAL APPENDIX

A. Defining "Technical Potentials" for Conservation

B. Results for the U.S.

C. Conservation Supply Curves for U.S. Residences

D. Selected Results and Conservation Supply Curves for California

E. Examples of Data Sources

F. Achieving the Energy Conservation Potentials

A. DEFINING "TECHNICAL POTENTIALS" FOR CONSERVATION

FIG. A-1

WHY CONSIDER TECHNICAL POTENTIALS?

- STRENGTHEN DEMAND FORECASTS
  - --BOUNDARY-SETTING
  - --"SURPRISE AVOIDANCE"
- HELP GUIDE PROGRAM PRIORITIES
  - --NEGLECTED OPPORTUNITIES
  - --OVER-EMPHASIS ON AREAS WITH MODEST POTENTIAL (OR HIGH COSTS)
- BASELINE FOR JUDGING CONSERVATION PROGRESS (ALTERNATIVE TO HISTORICAL TRENDS)
- "FORCING FUNCTION" FOR MORE DETAILED, EMPIRICAL DATA AND ANALYSIS

POTENTIAL DANGER: FAILURE TO KEEP <u>POTENTIALS</u> DISTINCT FROM DEMAND <u>FORECASTS</u>.

FIG. A-2

"SUPPLY CURVE OF CONSERVED ENERGY"

DEFINITION:

- IDENTIFIES ANNUAL ENERGY SAVINGS TECHNICALLY ACHIEVABLE AT UNIT COSTS LESS THAN SOME FIXED VALUE (AC, MC, ETC.)
- REPRESENTS A TECHNICAL POTENTIAL, OR TARGET, NOT A "MOST LIKELY" DEMAND FORECAST

FEATURES:

- PRIORITY-SETTING: HELPS IDENTIFY MOST IMPORTANT (LOWEST COST) REMAINING CONSERVATION OPPORTUNITIES--BY END-USE, TECHNOLOGY, ETC.
- FACILITATES UPDATING OF SAVINGS, COSTS, AND LIST OF TECHNICAL OPTIONS
- EASILY "CUSTOMIZED" TO EACH UTILITY AREA'S STOCKS AND SATURATIONS
- SENSITIVITY-TESTING FOR DISCOUNT RATES, COST CUT-OFF LEVEL (VALUE OF SAVED ENERGY), ETC.
- CONSISTENT TREATMENT OF CONSERVATION AND END-USE SOLAR MEASURES
- ACCOUNTS FOR INTERACTIONS AMONG MEASURES IN SAME BUILDINGS (SAVINGS AND COST)
- BRIDGES THE GAP BETWEEN DEMAND FORECASTS AND CONSERVATION TECHNICAL POTENTIALS

CONSERVATION SUPPLY CURVES CAN "BRIDGE THE GAP"
BETWEEN DEMAND FORECASTS AND POTENTIALS :

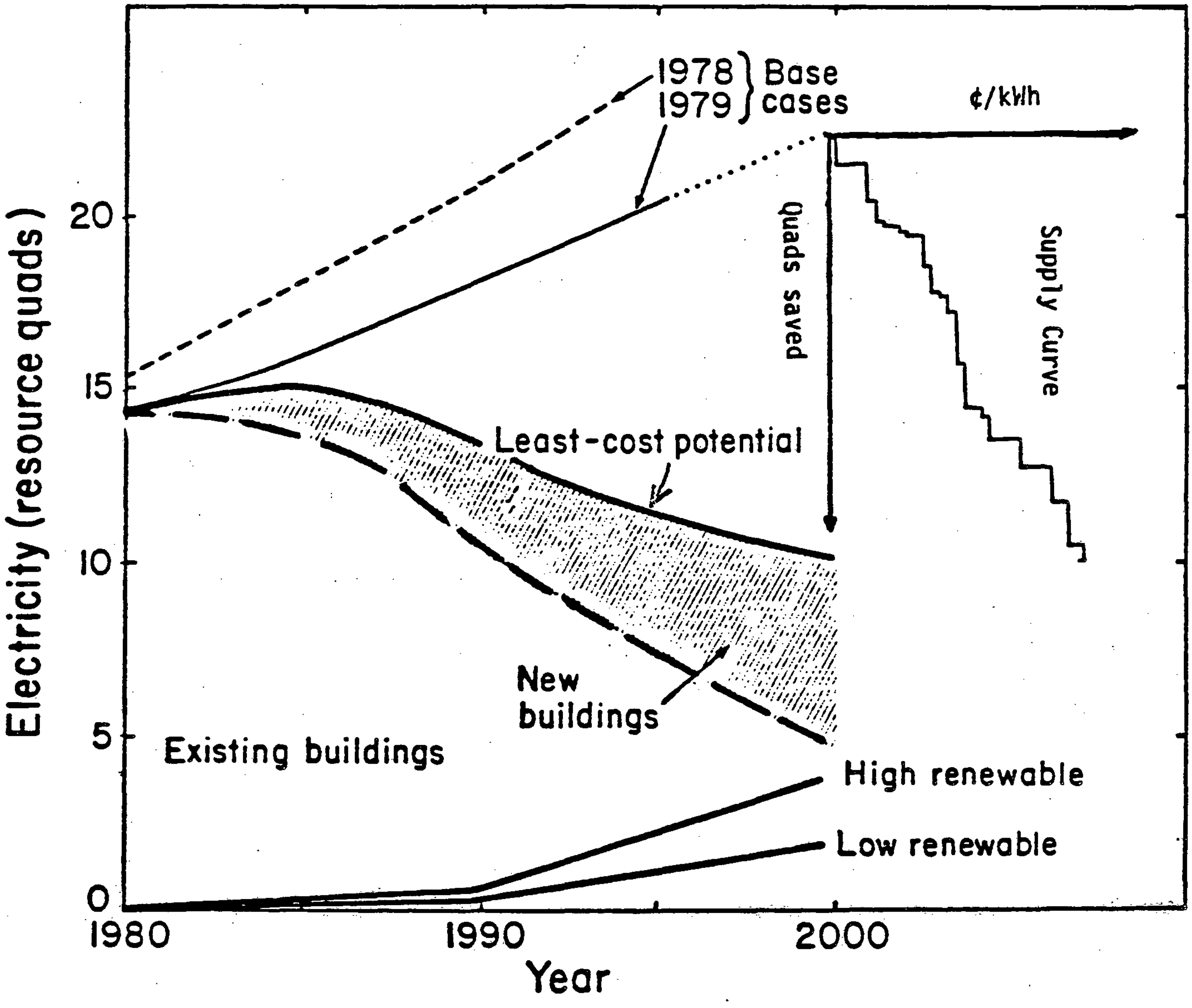
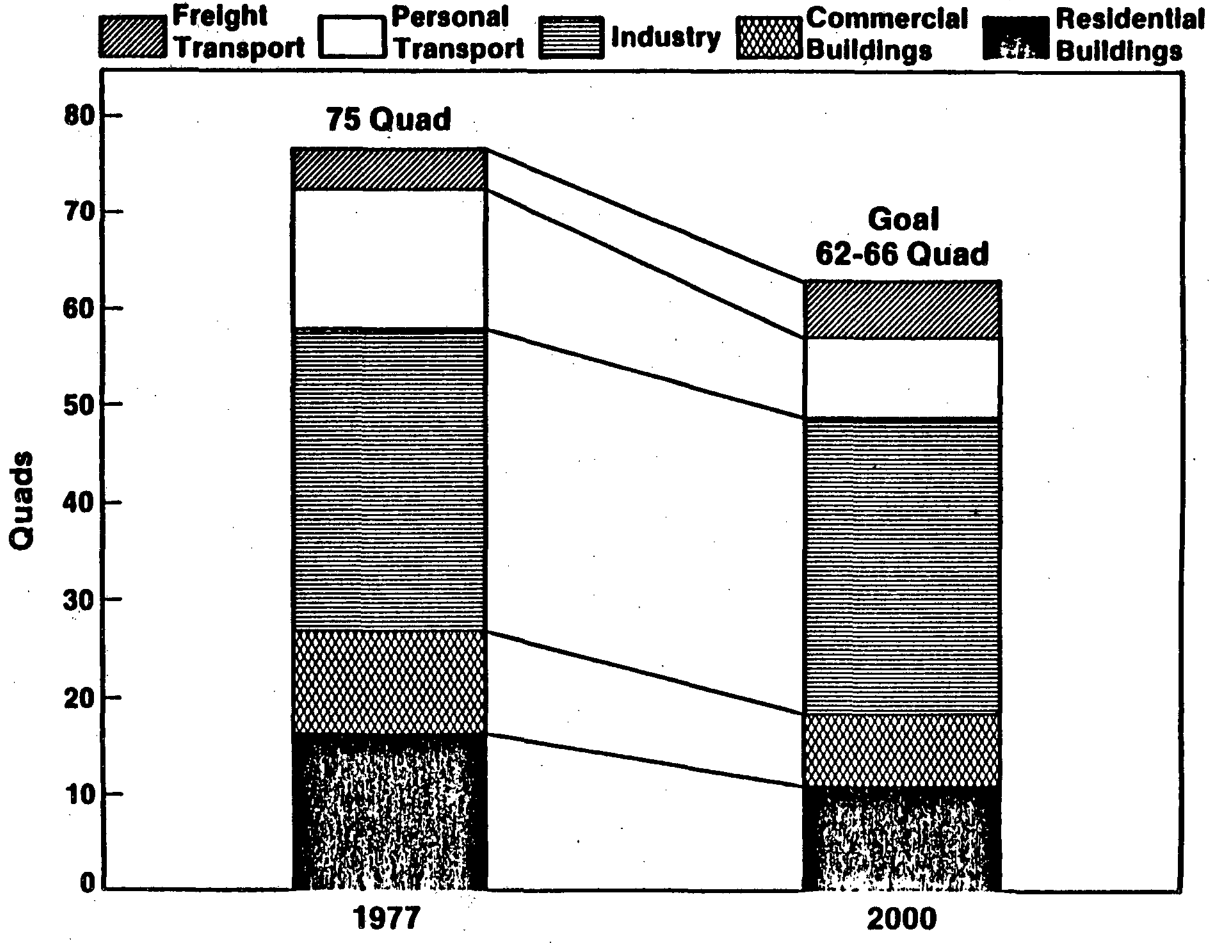


Figure A-3 Schematic drawing based on an analysis of least-cost conservation potentials in U.S. buildings for the year 2000, showing how the conservation supply curve can be used for a detailed specification of the gap between a baseline demand forecast and a conservation potentials study.
Source: SERI/LBL (1981).

B. RESULTS FOR THE U.S.

Figure B-1

Energy Demand
1977 — 2000
(Quadrillion Btus per Year)



Source: SERI/LBL (1981)

Table B-1

END-USE ENERGY DEMAND POTENTIALS (including no renewable contribution)
(Quads* of Oil Equivalent)

Sector	1977***			2000 Potential		
	Fuel	Electric	Total	Fuel	Electric	Total
BUILDINGS	13.2	13.4	26.6	5.5	12.3	17.8
Residential	(8.8)	(7.8)	(16.2)	(3.8)	(7.1)	(10.9)
Commercial	(4.7)	(5.6)	(10.4)	(1.7)	(5.5)	(7.2)
INDUSTRY	19.8	9.3	29.1	18.7	10.7	29.4
AGRICULTURE	1.3	0.3	1.6	1.4	.3	1.7
TRANSPORTATION	19.5	—	19.5	12.6-16.5	**	12.6-16.5
Personal	(15.1)	—	(15.1)	(6.9-10.5)	**	(6.9-10.5)
Freight	(4.3)	—	(4.3)	(5.7- 6.0)	**	(5.7- 6.0)
TOTALS****	53.8	23.0	75.1	38.3-42.2	23.7	62.0-65.9

*One quad per year is approximately equal to 500,000 barrels of oil per day.

**Aggressive rail-electrification and electric-vehicle programs could create between .75 and 1.15 Quad (primary equivalent) demand for electricity in the transportation sector, with the displacement of .46-.76 Quad of petroleum (fuel) demand.

***1979 Total Consumption was roughly 79 Quad.

****Not including about 2 Quad of fuel saving possible through cogeneration

( ) = Not additive within end-use sector.

POTENTIAL RENEWABLES CONTRIBUTION BY SECTOR
(Oil Equivalent Displaced in Quads)

Sector	Solar Thermal	Biomass*	Wind	Photovoltaics	Hydro	Total
BUILDINGS	1.9-2.3	1.0	.8-1.1	.4-.7		4.1-5.1
Residential	(1.6-1.9)	(1.0)	(.8-1.1)	(.3-.45)	—	(3.7-4.45)
Commercial	(0.3-0.4)	—	—	(.1-.25)	—	(.4-.65)
INDUSTRY	.5-2.0	3.5-5.5	—	—	—	4.0-7.5
AGRICULTURE	—	.1- .7	—	—	—	1.-.7
TRANSPORTATION	—	.4-5.5	—	—	—	0.4-5.5
UTILITIES	—	—	.5-3.4	—	3.4-3.7	3.9-7.1
TOTAL	2.4-4.2	4.8-10.5**	1.3-4.0**	.4-0.7	3.4-3.7	12.3-22.5**

*Biomass estimates are given in terms of oil displaced, rather than primary biomass supply.

**These columns do not add; high end of penetration is limited to less than total of potential applications in end-use sectors.

( ) = not additive within end-use sector.

Source: SERI/LBL (1981)

Figure B-2

Goals for Economic Growth

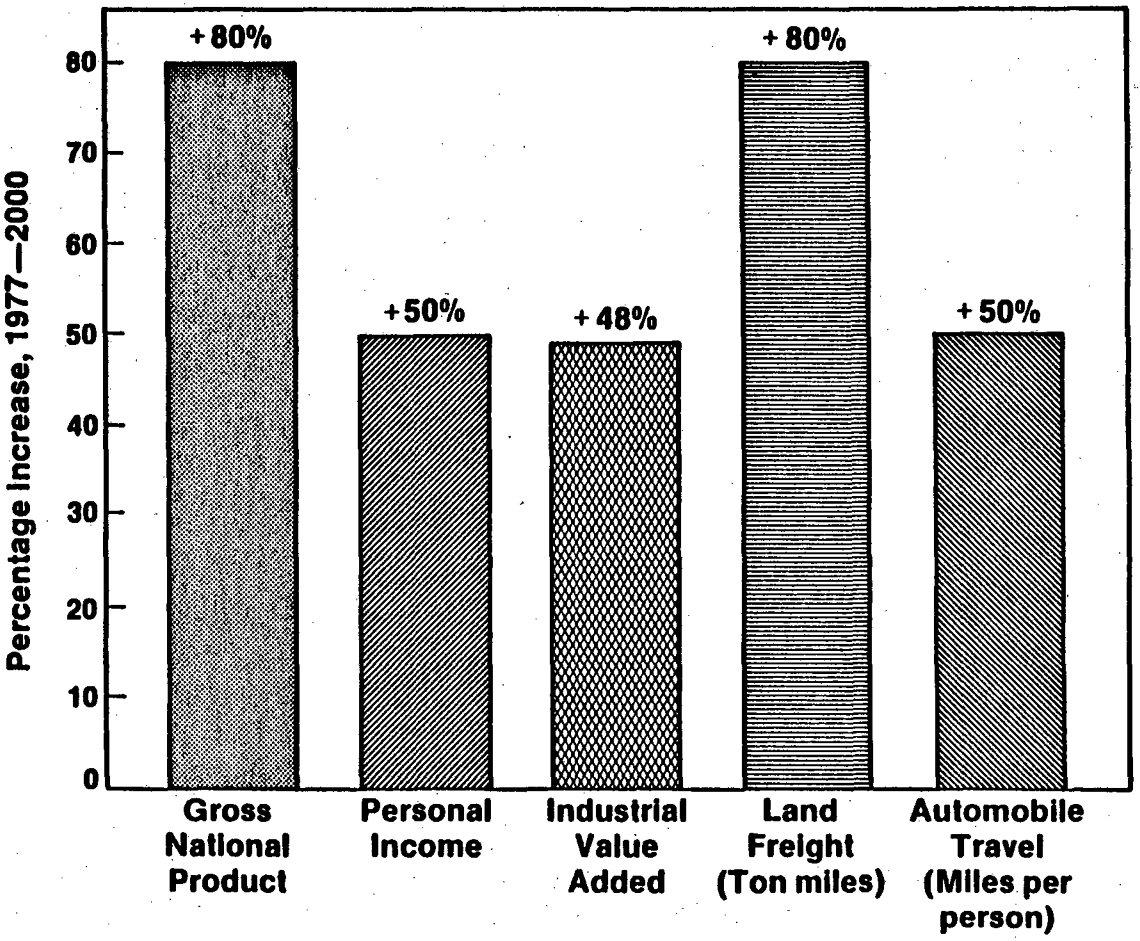
	1977	1985 through 2000
Unemployment	7.4%	4.0%
Annual growth in worker productivity	1.25%	2.0%

Source: SERI/LBL (1981)

Figure B-3

Goals for Economic Growth

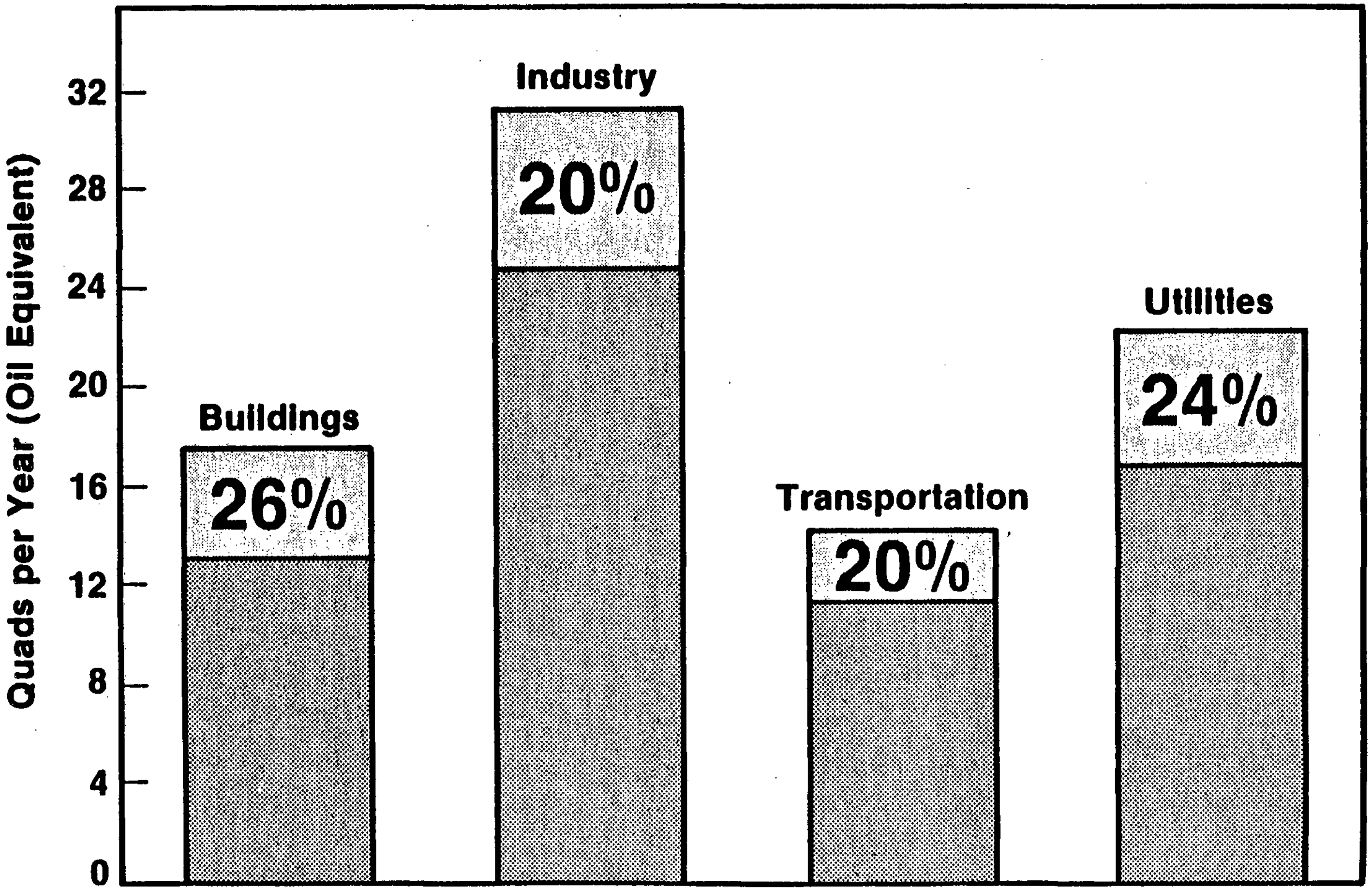
Increases from 1977 to 2000



Source: SERI/LBL (1981)

Figure B-4

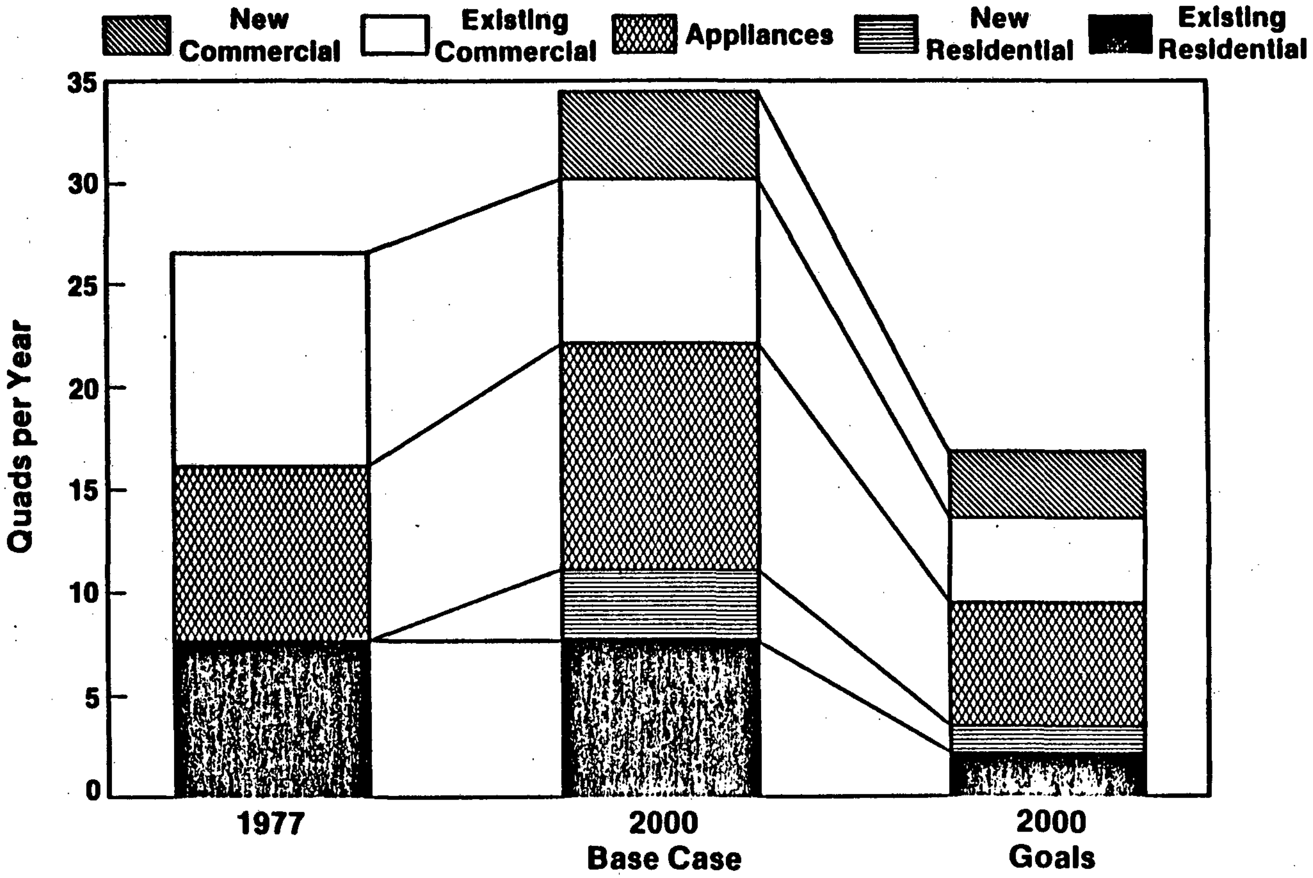
Solar Contribution to Year 2000 Goals



Source: SERI/LBL (1981)

Figure B-5

Energy Use in Buildings
1977 — 2000
(Quadrillion Btus per Year)



Source: SERI/LBL (1981)

Figure B-6

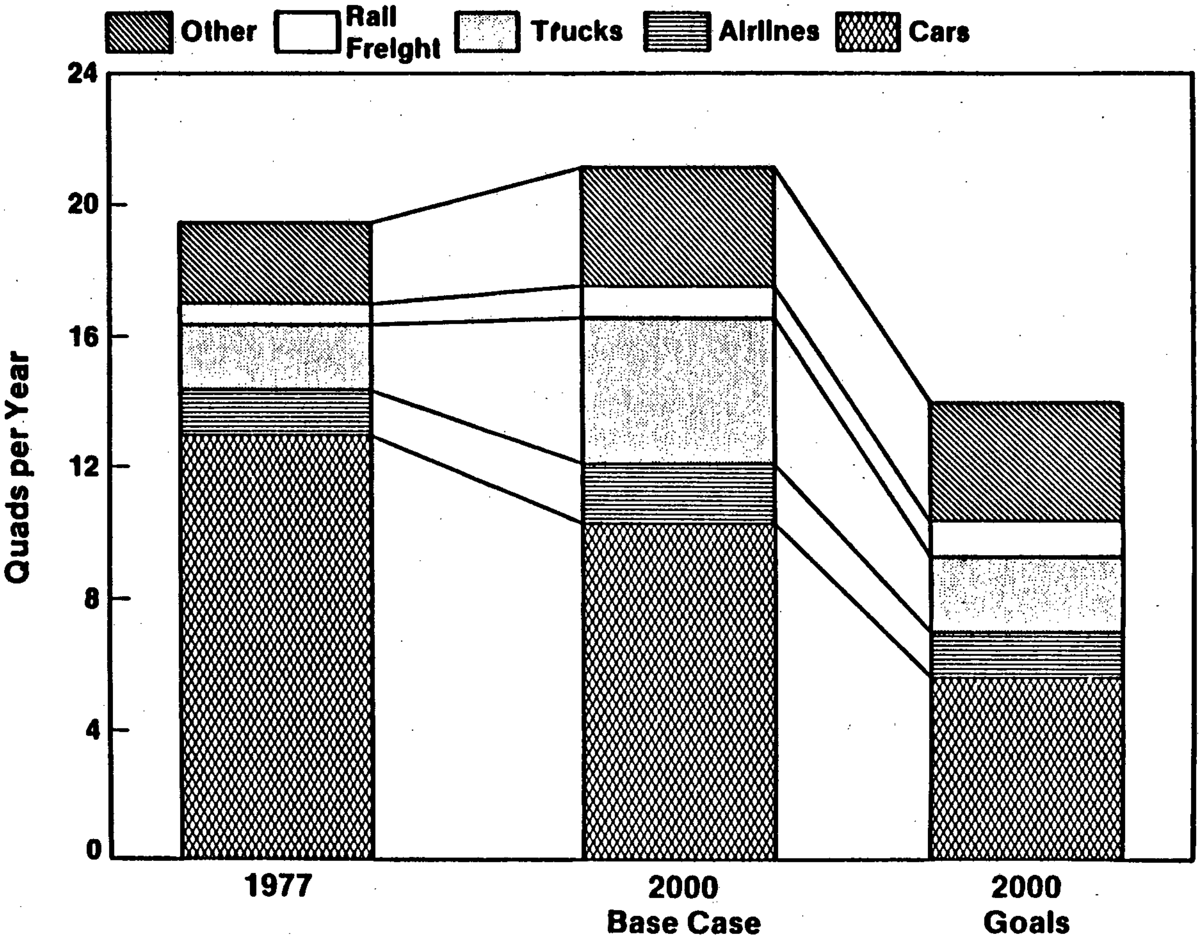
Measures Considered for Buildings

- Insulation
- Building orientation
- Tight construction
- Efficient furnaces and air conditioning
- Efficient refrigerators, freezers, water heaters and other appliances
- Simple passive design
- Solar water heating
- Daylighting

Source: SERI/LBL (1981)

Figure B-7

Energy Use in Transportation
1977 — 2000
(Quads per Year)



Source: SERI/LBL (1981)

Figure B-8

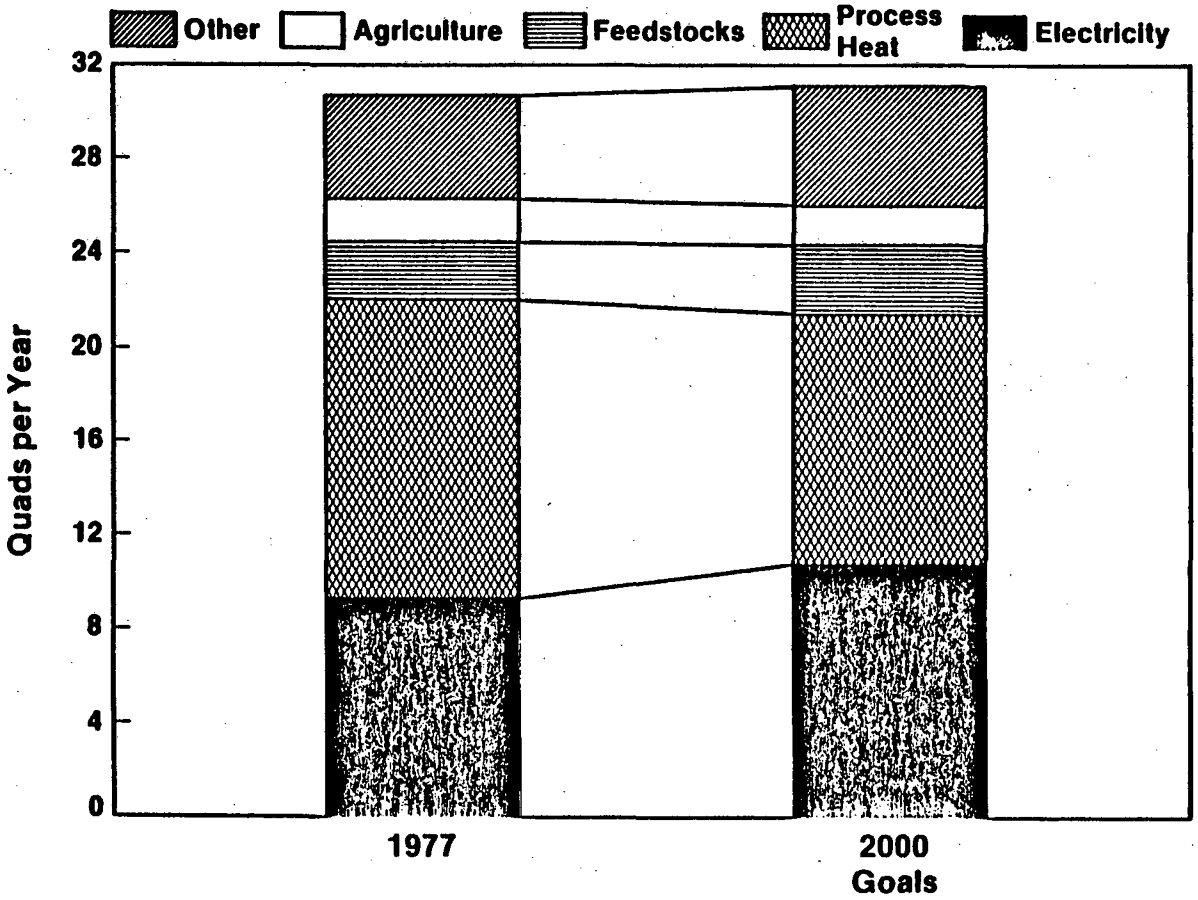
Measures Considered for Transportation

- Modest shift toward four-passenger cars
- 45-65 miles-per-gallon cars using
  - Good aerodynamics
  - Efficient radial tires
  - Diesel or stratified-charge engines
  - Efficient oils and lubricants
- Piggy back rail transport
- Efficiency improvements in trucks and aircraft

Source: SERI/LBL (1981)

Figure B-9

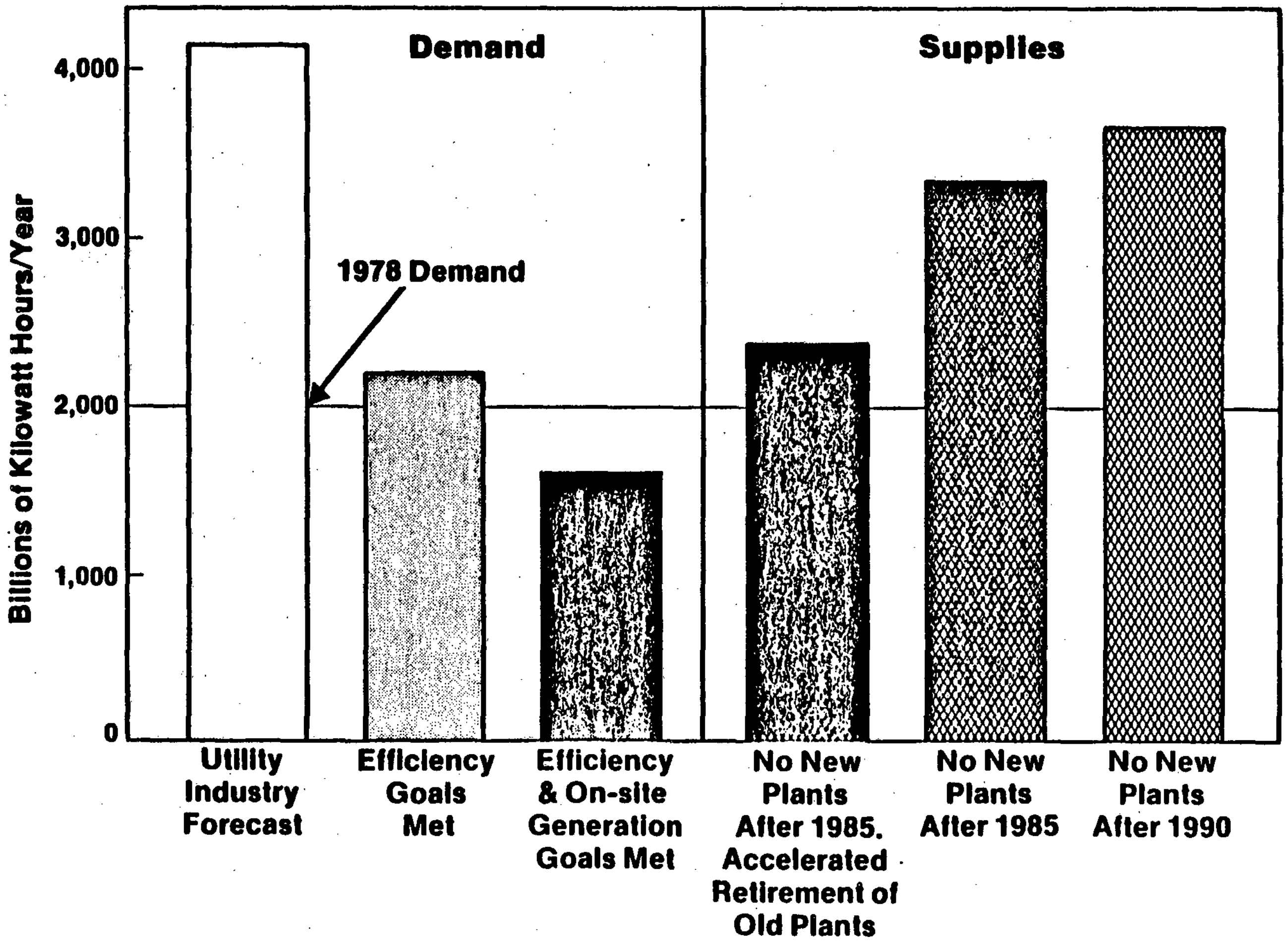
Industrial Energy Use
1977 — 2000
(Quadrillion Btus per Year)



Source: SERI/LBL (1981)

Figure B-10

Electricity Demand and Supplies
Year 2000
(Billions of Kilowatt Hours per Year)



Source: SERI/LBL (1981)

C. CONSERVATION SUPPLY CURVES FOR U.S. RESIDENCES

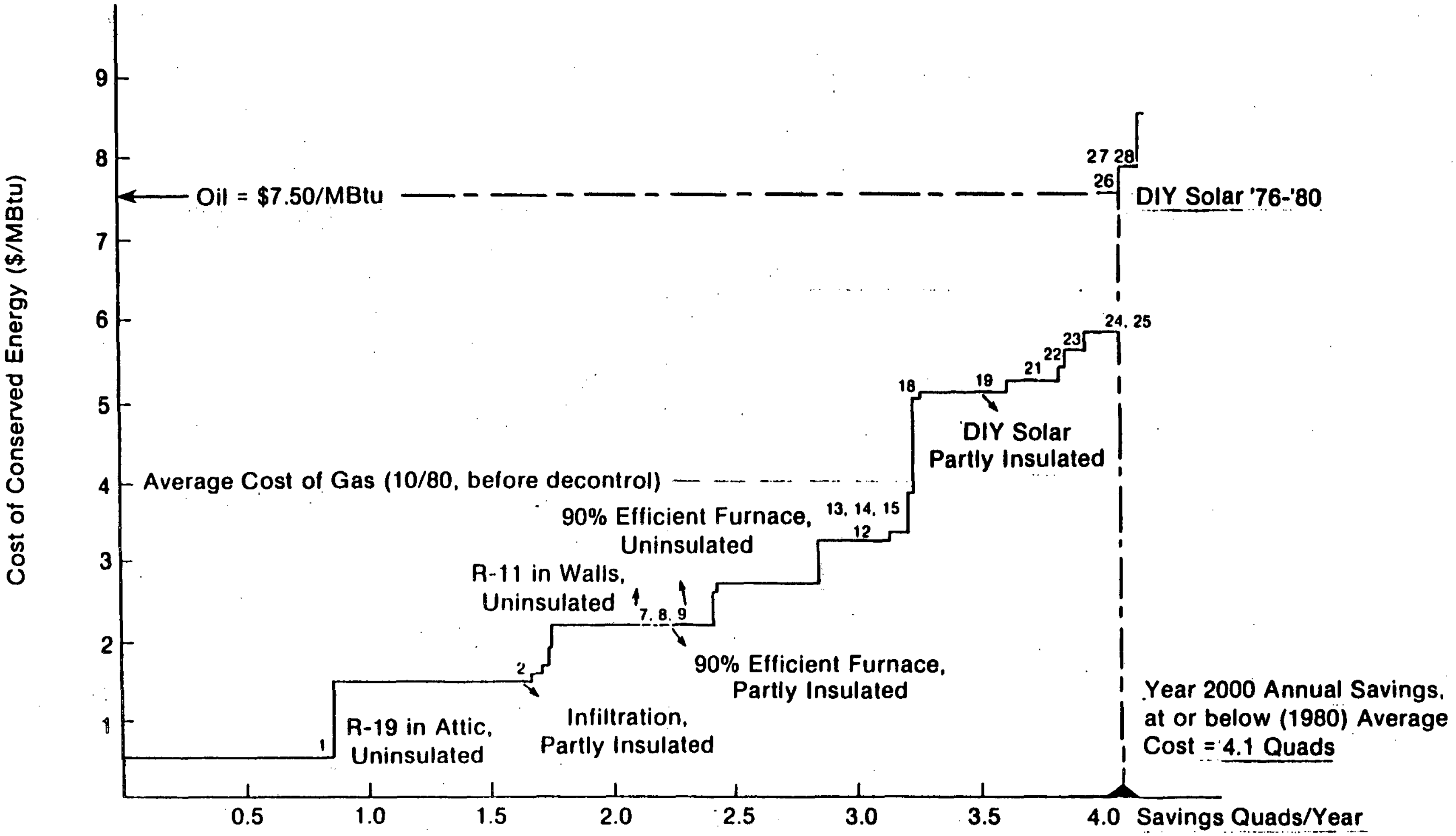


Figure C-1.Year 2000 Supply Curve of Conserved Energy (in quads/year) for Space Heat of Fuel Heated Dwellings Built Through 1980.

Year 2000 baseline annual use for this sector is 5.5 Quads, where "baseline" assumes continuation of 1980 average unit energy consumption for existing stock or new additions in that year. Unit cost of conserved energy (in constant 1980 $) assumes that all increased costs are amortized over the useful life of this measure, using a 3% (real-dollar) interest rate. Potential annual savings in 2000, at or below today's cost of oil (7.5 $/MBtu) is 4.1 quads, or 75% of the year 2000 baseline.

Source: SERI/LBL (1981)

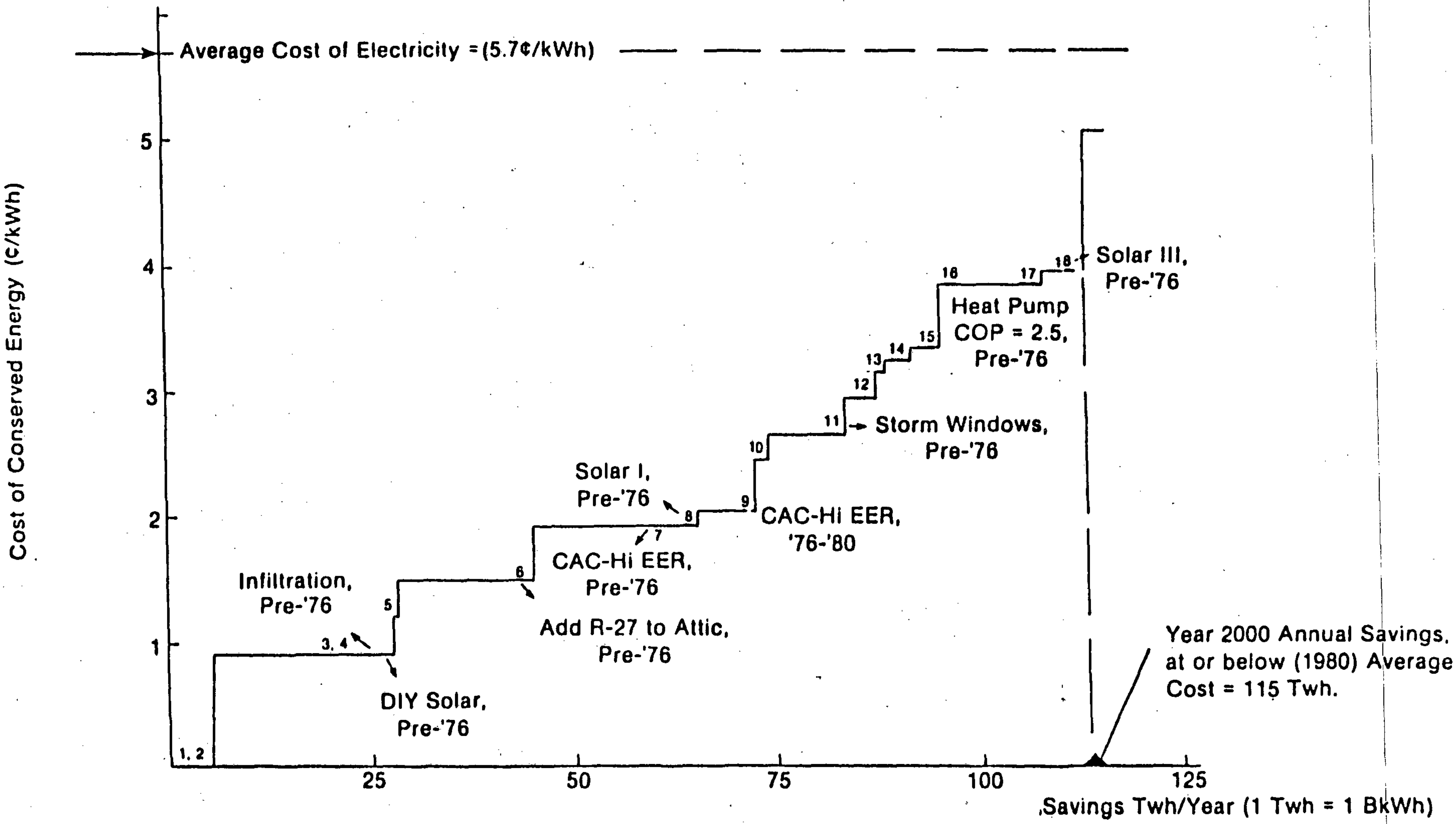


Figure C-2 **Year 2000 Supply Curve of Conserved Energy (In Twh/year) for Space Heat In Electric-Heated Dwellings Built Through 1980 and All Central Airconditioning In Dwellings Built Through 1980.**

Year 2000 baseline annual use for this sector is 172 Twh, where "baseline" assumes continuation of 1980 average unit energy consumptions for existing stock or new additions in that year. Unit cost of conserved energy (in constant 1980 $) assumes that all increased costs are amortized over the useful life of the measure, using a 3% (real dollar) interest rate. Potential annual savings in 2000, at or below today's average cost (5.7¢/kWh) is 115 Twh, or 67% of the year 2000 baseline.

Source: SERI/LBL (1981)

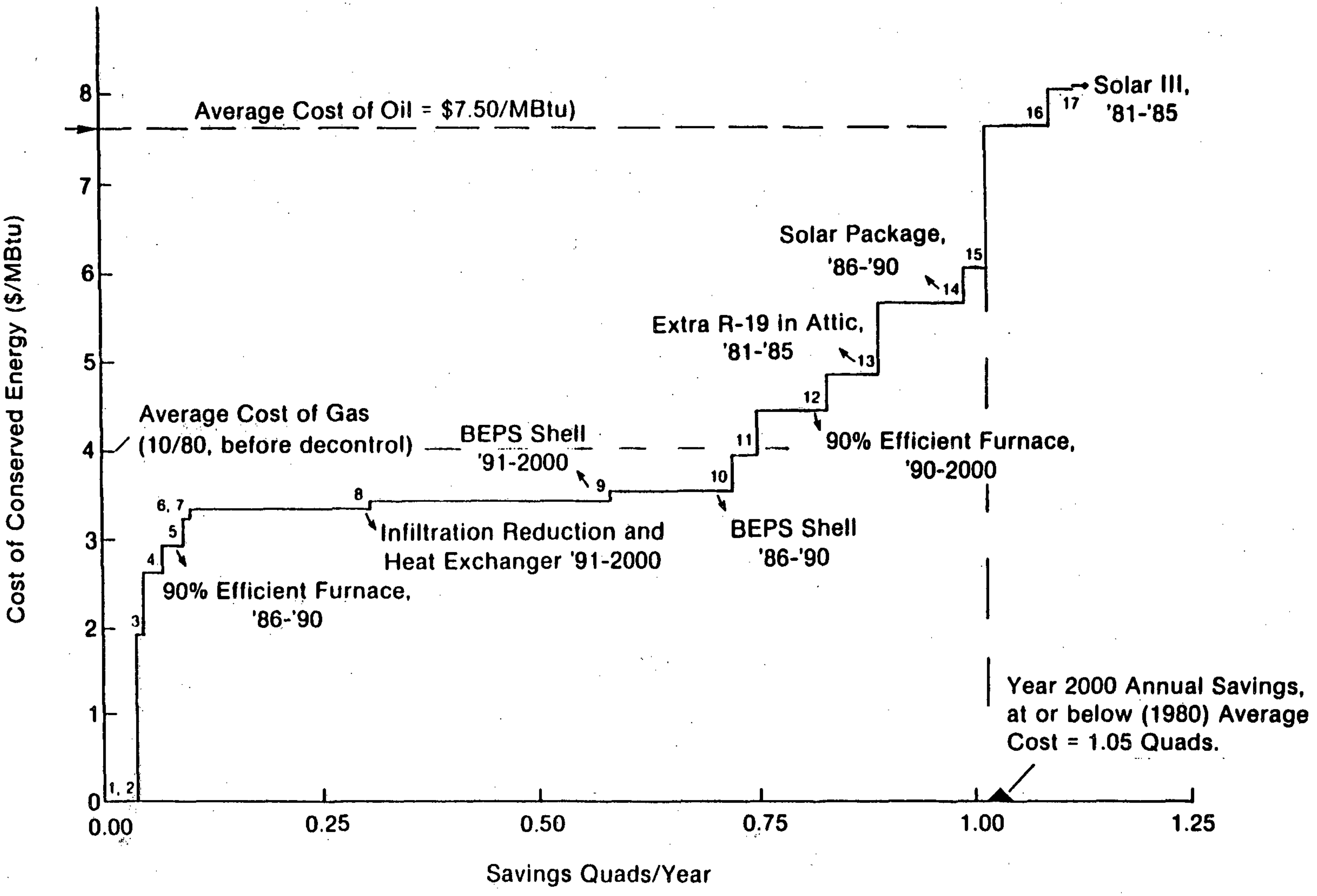


Figure C-3. Year 2000 Supply Curve of Conserved Energy (in quads/year) for Space Heat of New Fuel-Heated Dwellings.

Year 2000 baseline annual use for this sector is 1.59 quads, where "baseline" assumes continuation of 1980 average unit energy consumption for existing stock or new additions in that year. Unit cost of conserved energy (in constant 1980 $) assumes that all increased costs are amortized over the useful life of the measure, using a 3% (real-dollar) interest rate. Potential annual savings in 2000, at or below today's average cost ($7.50/MBtu) is 1.05 quads, or 66% of the year 2000 baseline.

Source: SERI/LBL (1981)

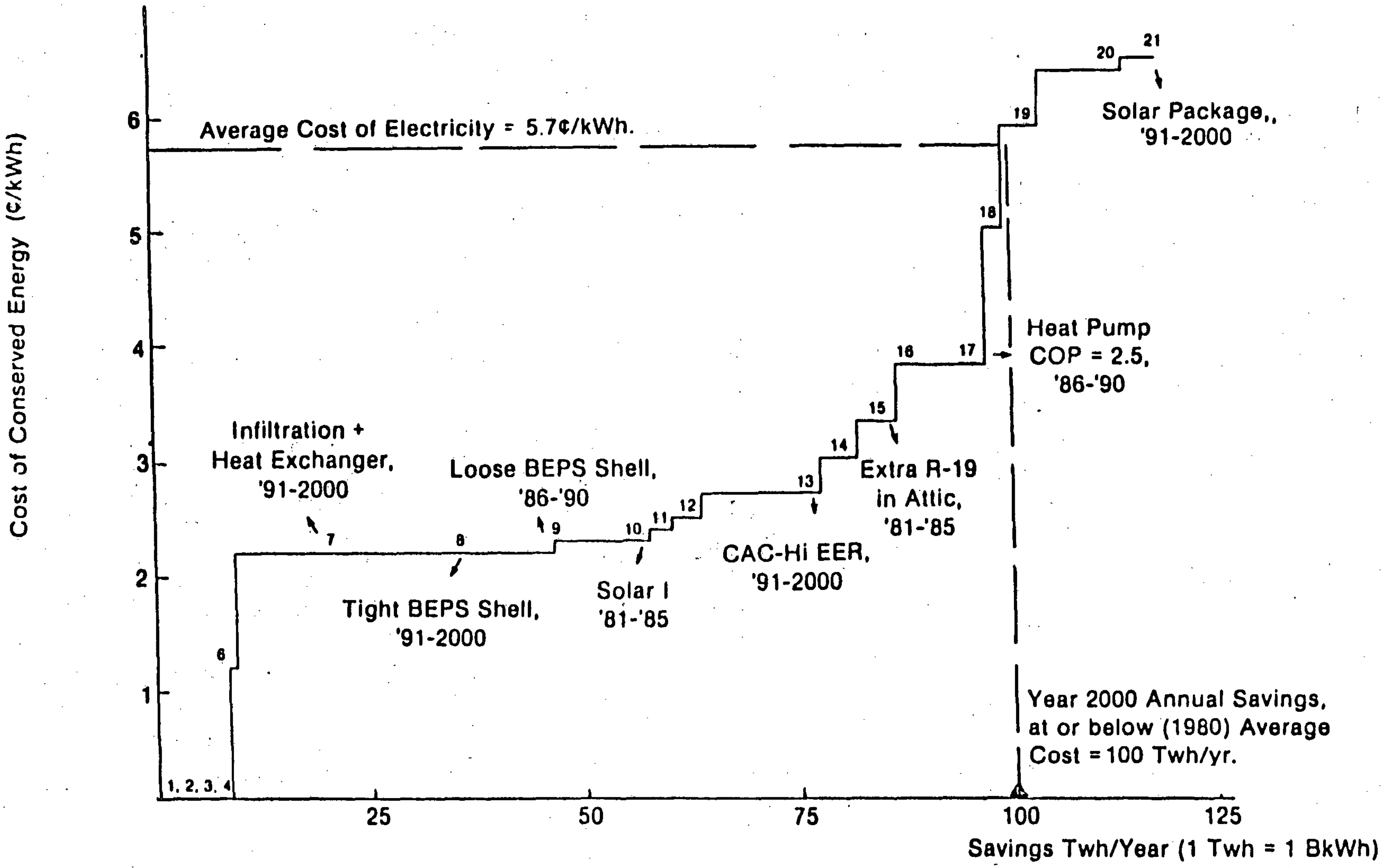


Figure C-4. Year 2000 Supply Curve of Conserved Energy (In Twh/year) for Space Heat In Electrically-Heated New Homes and All Central Airconditioning In New Homes.

Year 2000 baseline annual use for this sector is 170 Twh, where "baseline" assumes continuation of 1980 average unit energy consumptions for existing stock or new additions in that year. Unit cost of conserved energy (in constant 1980 $) assumes that all increased costs are amortized over the useful life of the measure, using a 3% (real-dollar) interest rate. Potential annual savings in 2000, at or below today's average cost (5.7¢/kWh) is 100 Twh, or 59% of the year 2000 baseline.

Source: SERI/LBL (1981)

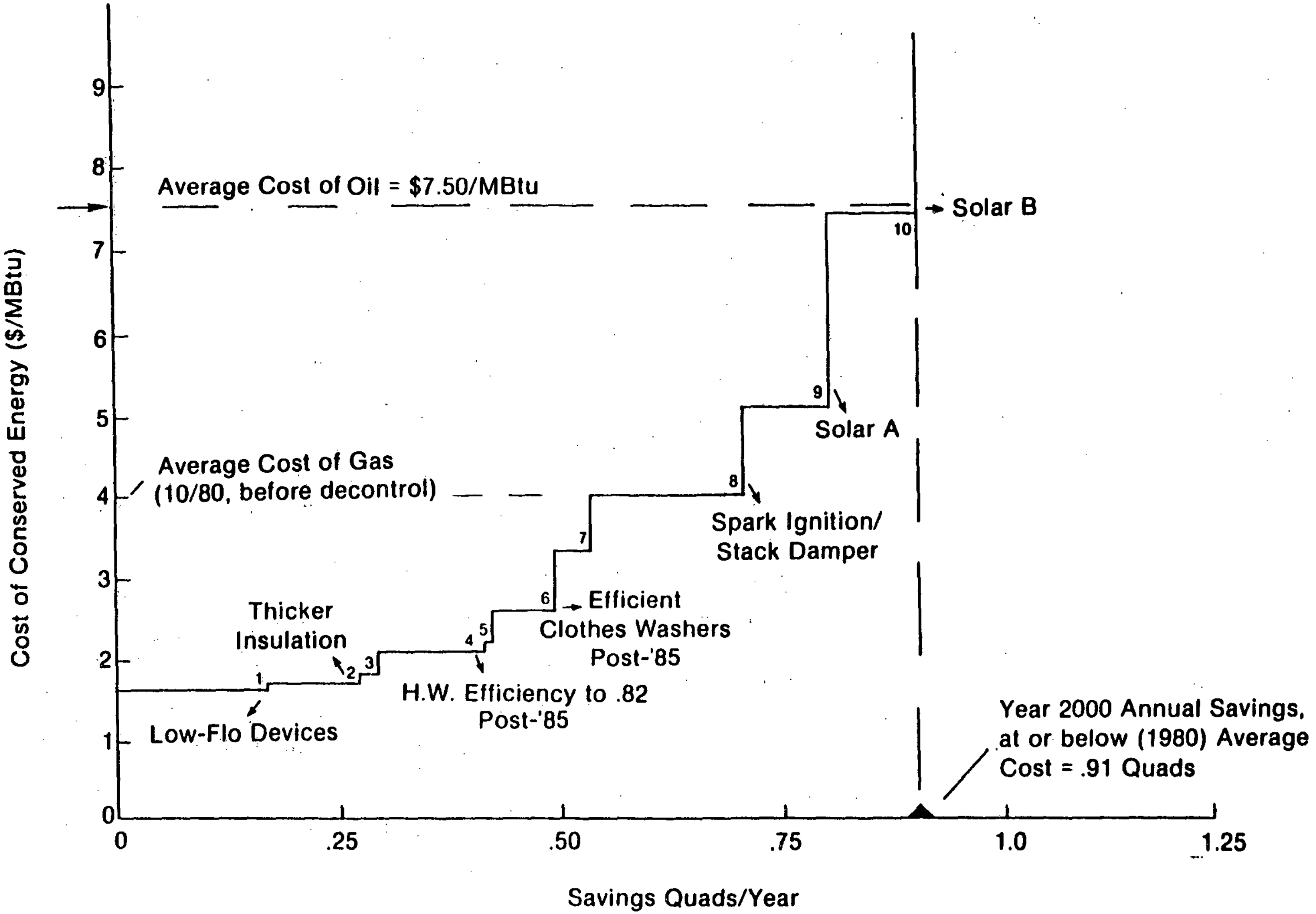


Figure C-5 **Year 2000 Supply Curve of Conserved Energy (in quads/year) for Fuel-Heated Water Heaters.**

Year 2000 baseline annual use for this sector is 1.46 quads, where "baseline" assumes continuation of 1980 average unit energy consumption for existing stock or new additions in that year. Unit cost of conserved energy (in constant 1980 $) assumes that all increased costs are amortized over the useful life of the measure, using a 3% (real-dollar) interest rate. Potential annual savings in 2000, at or below today's cost of oil ($7.50/MBtu) is 0.91 quads, or 62% of the year 2000 baseline.

Source: SERI/LBL (1981)

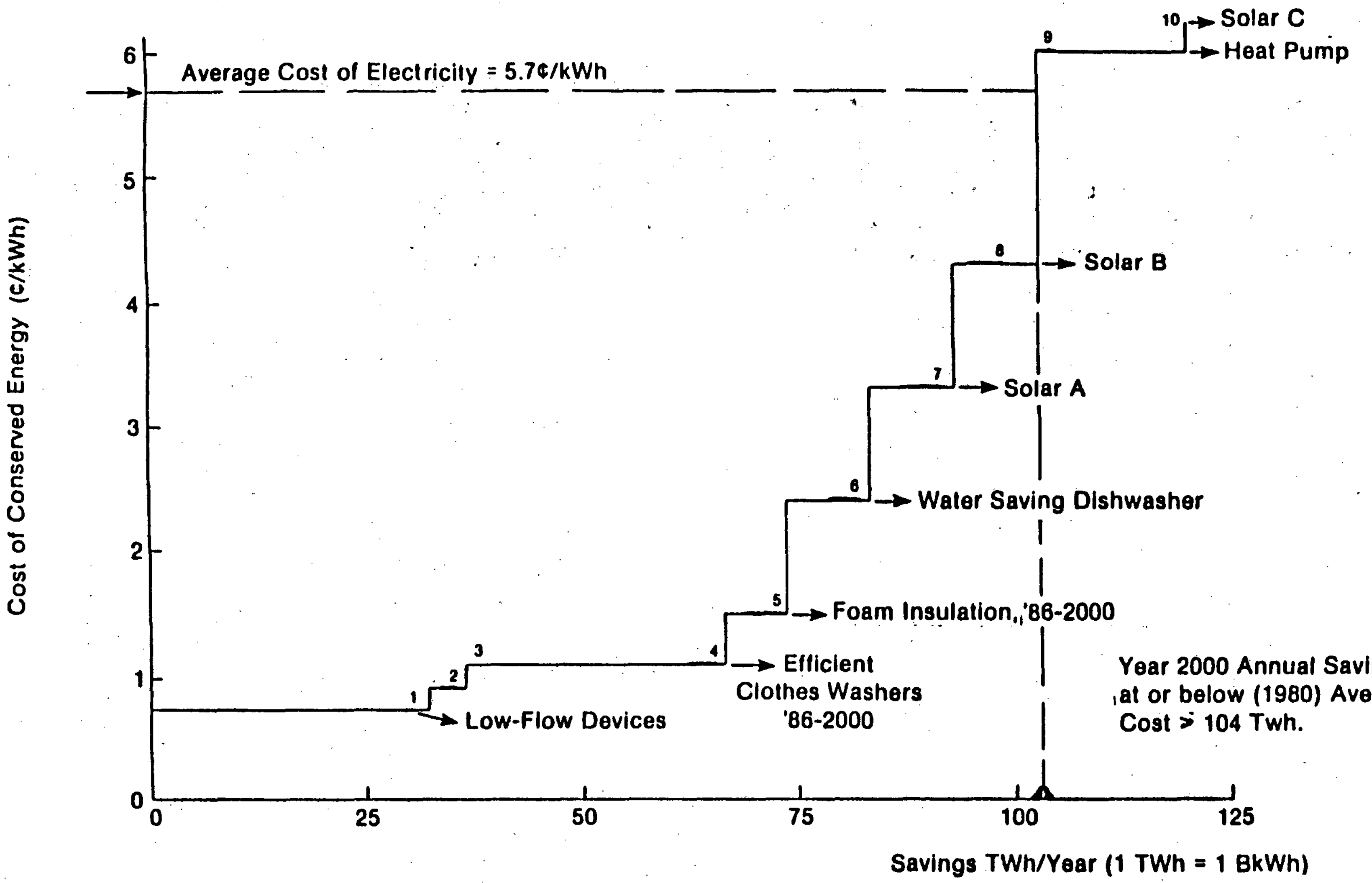


Figure C-6.**Year 2000 Supply Curve of Conserved Energy (in Twh/year) for Electric Water Heaters.**

Year 2000 baseline annual use for this sector is173 Twh,where "baseline" assumes continuation of 1980 average unit energy consumption for existing stock or new additions in that year. Unit cost of conserved energy (in constant 1980 $) assumes that all increased costs are amortized, over the useful life of the measure, using a 3% (real-dollar) interest rate. Potential annual savings in 2000, at or below today's average cost of 5.7¢/kWh, is 104 Twh, or 60% of the year 2000 baseline.

Source: SERI/LBL (1981)

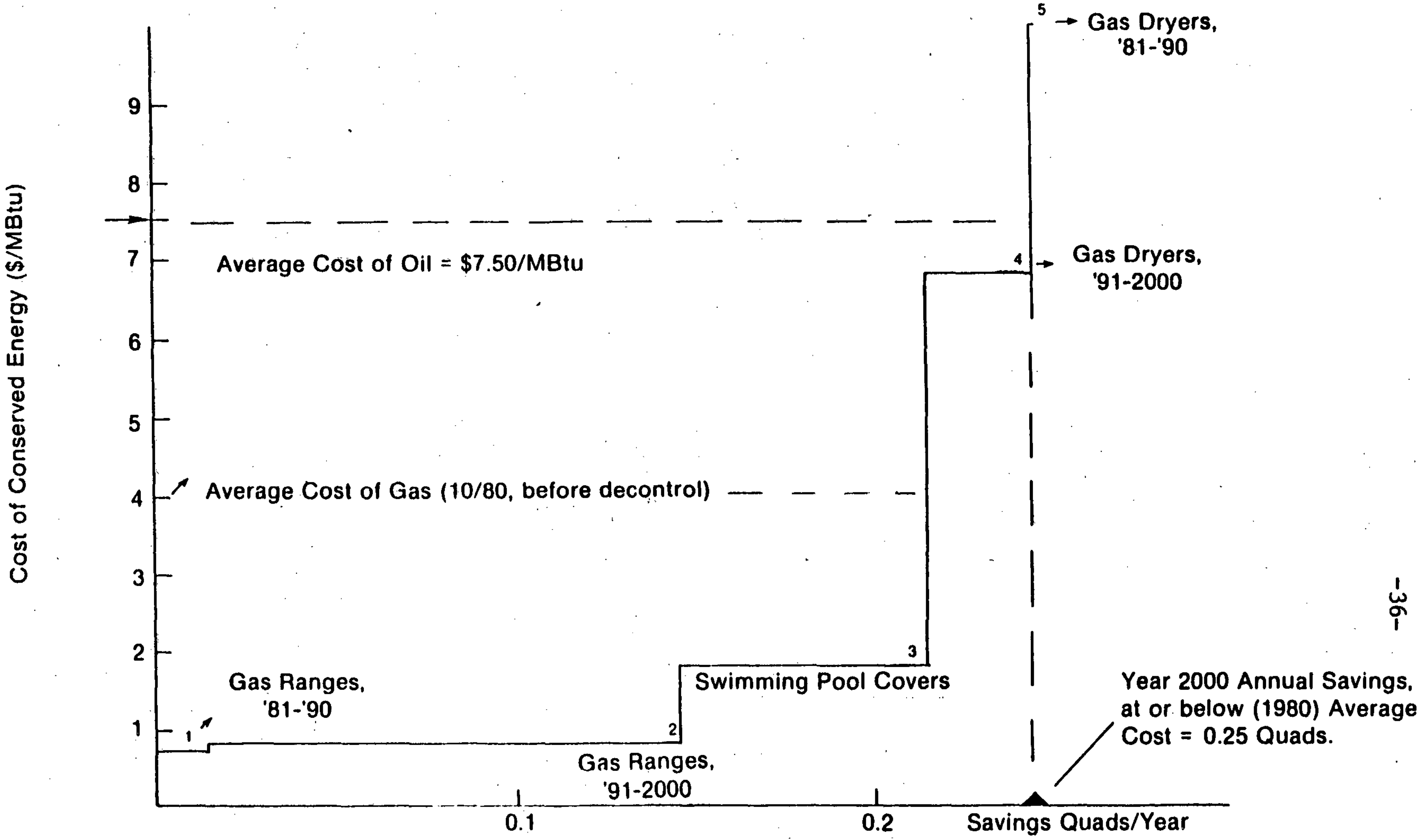


Figure C-7.**Year 2000 Supply Curve of Conserved Energy (in quads/year) for Fuel Appliances.**
Year 2000 baseline annual use for this sector is 0.68 Quads, where "baseline" assumes continuation of 1980 average unit energy consumptions for existing stock or new additions in that year. Unit cost of conserved energy (in constatnt 1980 $) assumes that all increased costs are amortized over the useful life of the measure, using a 3% (real-dollar) interest rate. Potential annual savings in 2000, at or below today's cost of oil ($7.50/MBtu) is .25 quads, or 37% of the year 2000 baseline.
Source: SERI/LBL (1981)

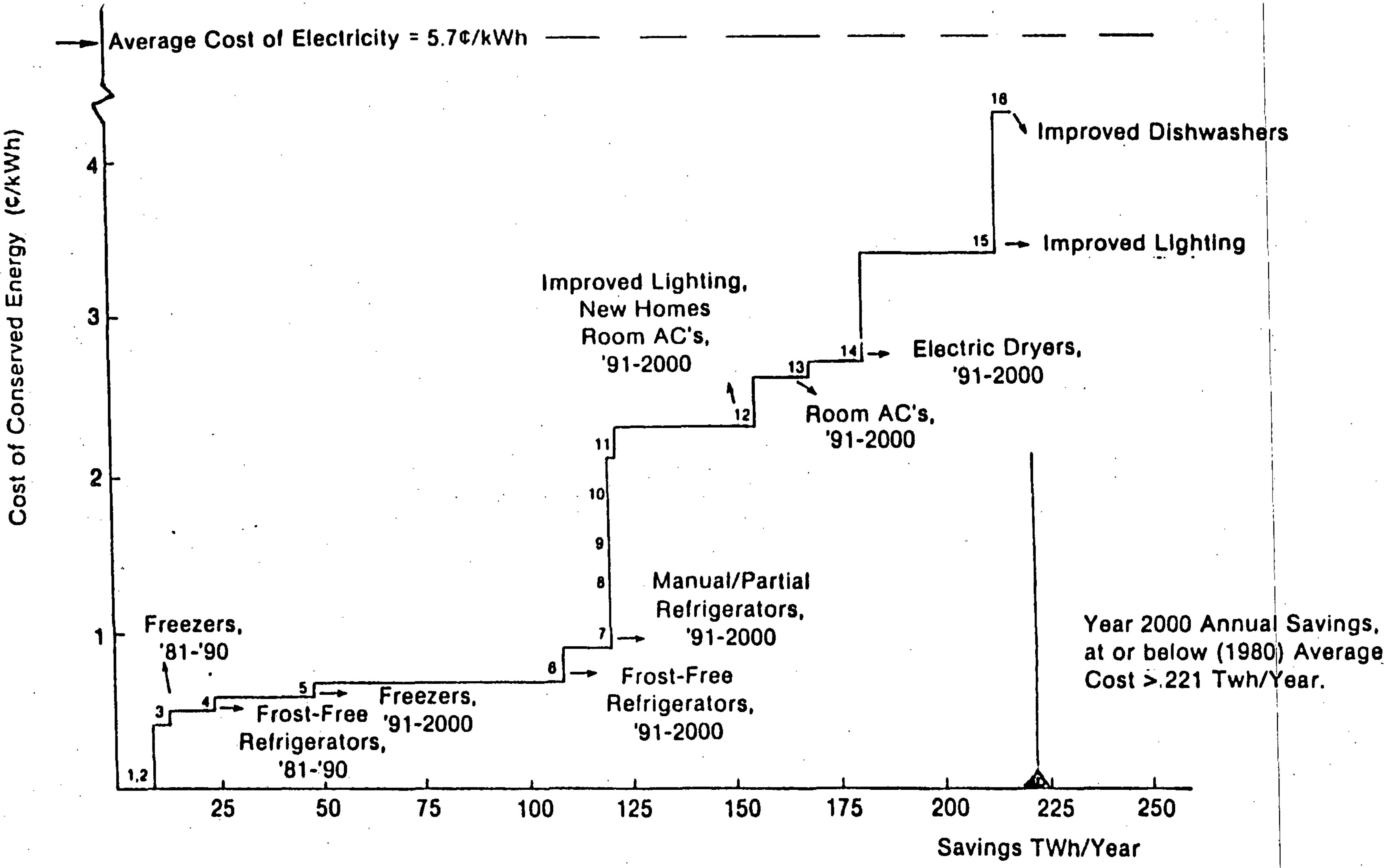
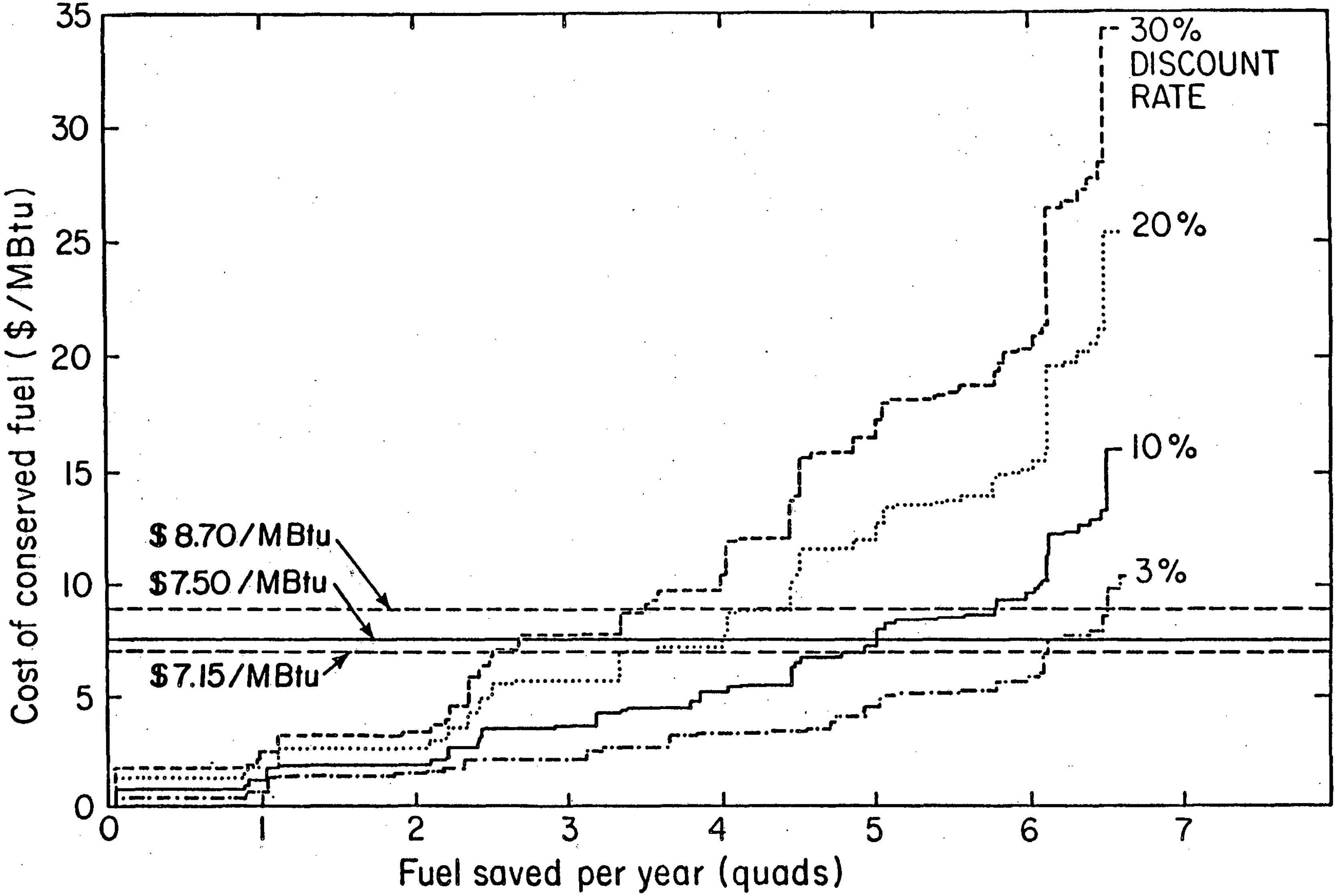


Figure C-8. **Year 2000 Supply Curve of Conserved Energy (in Twh/year) for Electric Appliances.** Year 2000 baseline annual use for this sector is 581 Twh, where 'baseline" assumes continuation of 1980 average unit energy consumption for existing stock or new additions in that year. Unit cost of conserved energy (in constant 1980 $) assumes that all increased costs are amortized over the useful life of the measure, using a 3% (real-dollar) interest rate. Potential saviangs in 2000, at or below today's average cost of 5.7¢/kWh is 221 Twh, or 38% of the year 2000 baseline.
Source: SERI/LBL (1981)



XBL 816-3085

Figure C-9.Grand supply curve of conserved fuel (gas + heating oil) for all U.S. residences as of the year 2000, showing sensitivity to discount rate assumptions and value placed on each unit of saved energy. The baseline residential fuel use forecast for 2000 is 9.23 quads (10^{15} Btu). Potential annual savings available at less than $7.50/MBtu is 6.34 quads, or 69% of the baseline projection (using a 3% real discount rate) The price level of $7.50/MBtu represents the assumed current value of conserved residential heating oil or gas (under deregulation). As a sensitivity test, the other two horizontal lines show a fuel-mix-weighted average residential fuel cost without assuming that deregulated gas approaches heating oil prices (projected to reach $7.15 in 1990 and $8.70 in 2000). Dollars are in constant 1980 $. Source: SERI/LBL (1981).

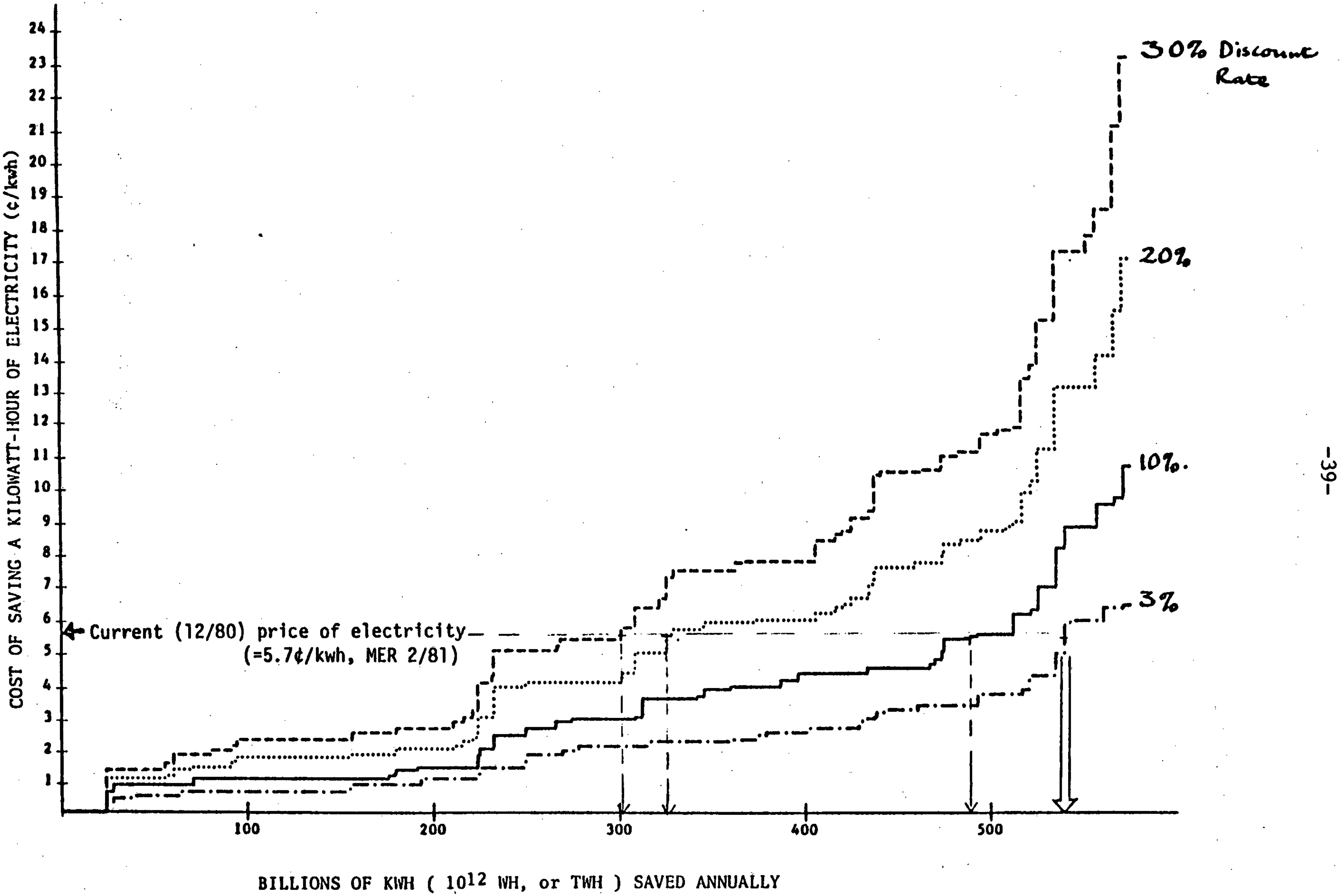


Figure C-10 Grand supply curve of conserved electricity for all U.S. residences as of the year 2000, showing sensitivity to discount rate assumptions. The baseline residential electricity forecast for 2000 is 1,106 TWh. Potential annual savings available at less than 5.7¢/kwh is 539 TWh, or 49% of the baseline projection (using a 3% discount rate). Dollars are in constant 1980 $. Source: SERI/LBL (1981).

D. SELECTED RESULTS AND CONSERVATION SUPPLY CURVES FOR CALIFORNIA

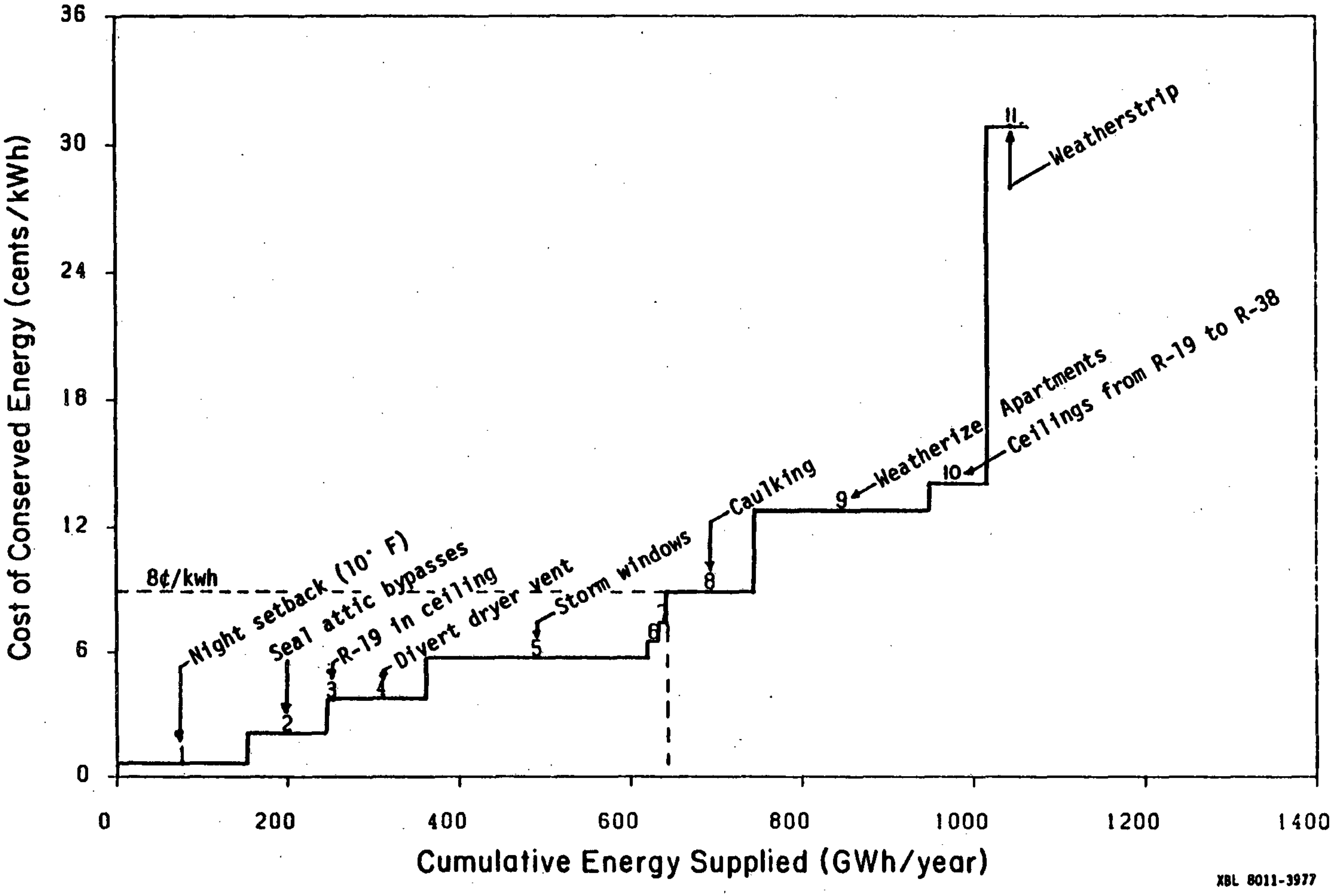
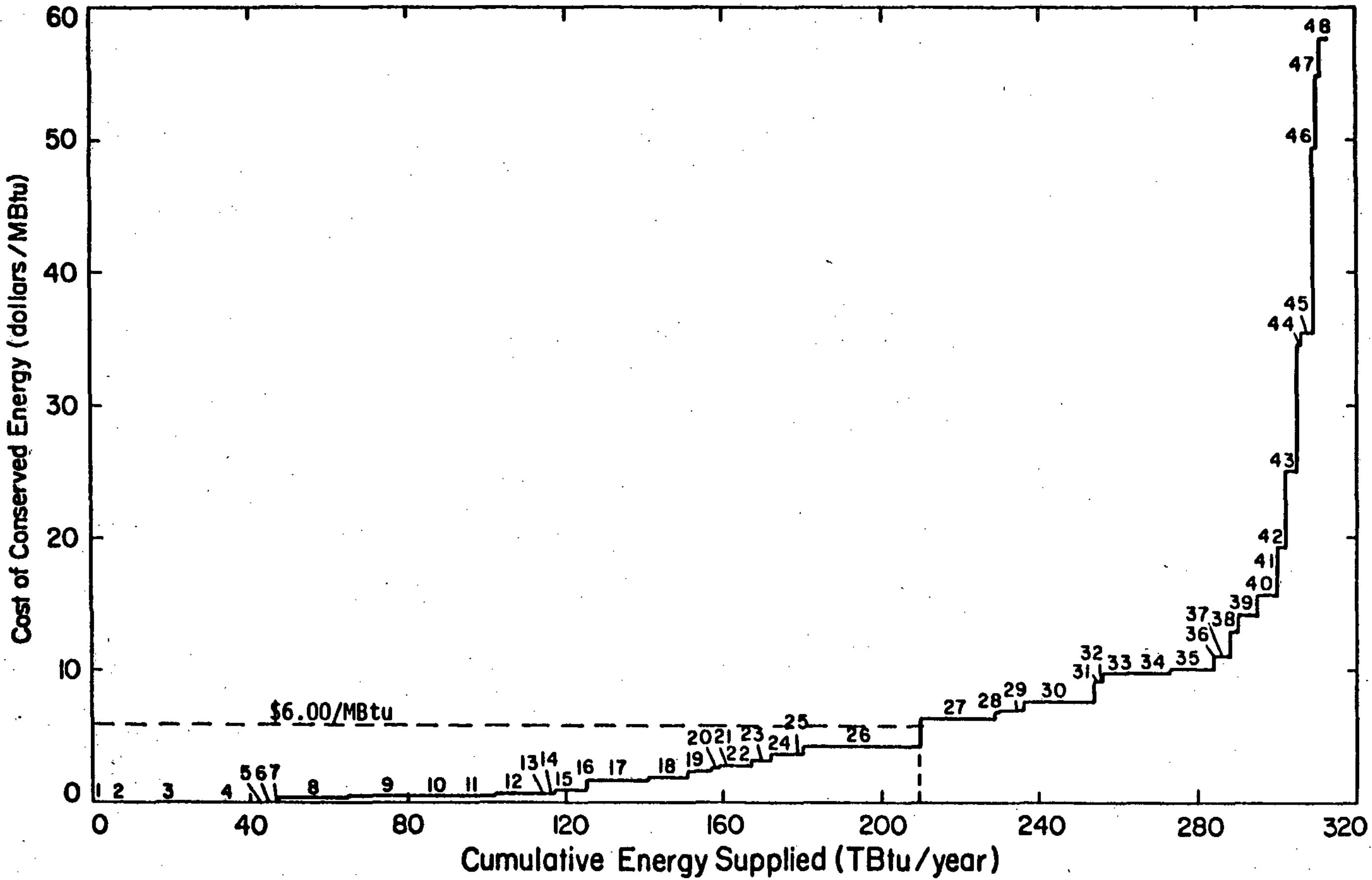


Figure D-1. Supply curve for conserved electricity used in space heating of existing (1978) California homes. Electricity consumption for residential space heating in California was 3,600 GWh in 1978. The potential annual savings available at less than 8¢/kwh is 641 GWh, or 18% of the baseline usage. The supply curve is calculated using a 5% constant-dollar discount rate, and a time horizon of 10 years for equipment replacement (at normal turnover rates). No new construction is considered. Dollars are in constant 1978 $. Source: Wright, et al (LBL 10738).



XBL 8011-3985

Figure D-2. Grand supply curve for conserved natural gas, all residential end-uses, in existing (1978) California homes. Total natural gas consumption in California homes was 612 TBtu in 1978. The potential annual savings available at less than $6.00/MBtu is 211 TBtu, or 34% of the baseline usage. The supply curve is calculated using a 5% constant-dollar discount rate, and a time horizon of 10 years for equipment replacement (at normal turnover rates). No new construction is considered. Dollars are in constant 1978 $. Source: Wright, et al (LBL 10738).

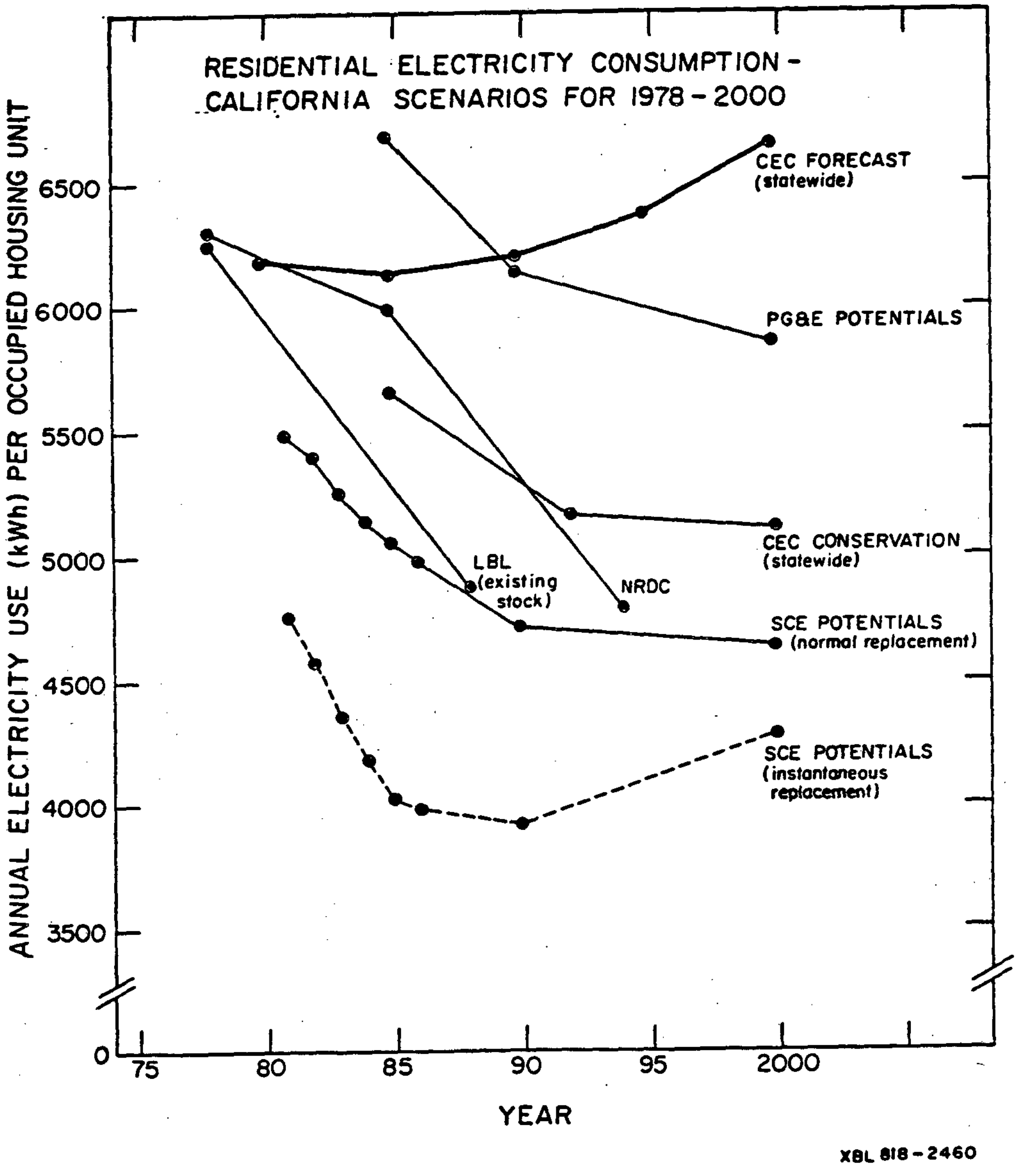


Figure D-3.Comparison of electricity demand scenarios for California residences, statewide and for two major utility service areas, from 1978 to 2000. Vertical scale is average annual electricity use (kwh) per occupied household, based on standardized weather. Average usage combines all-electric and gas-heated homes. The twenty-year trends reflect not only efficiency gains, but regional weather differences and future changes in stock characteristics, including fuel mix. All the entries except the one labelled "CEC Forecast" are estimates of conservation potential rather than expected demand; the NRDC scenario is intended to be "achievable" while the others are statements of technical potentials. Sources: CEC (1980, as revised 11/80), CEC (1981b), PG&E (1980), SCE (1981), Wright/LBL (1981), and King/NRDC (1980).

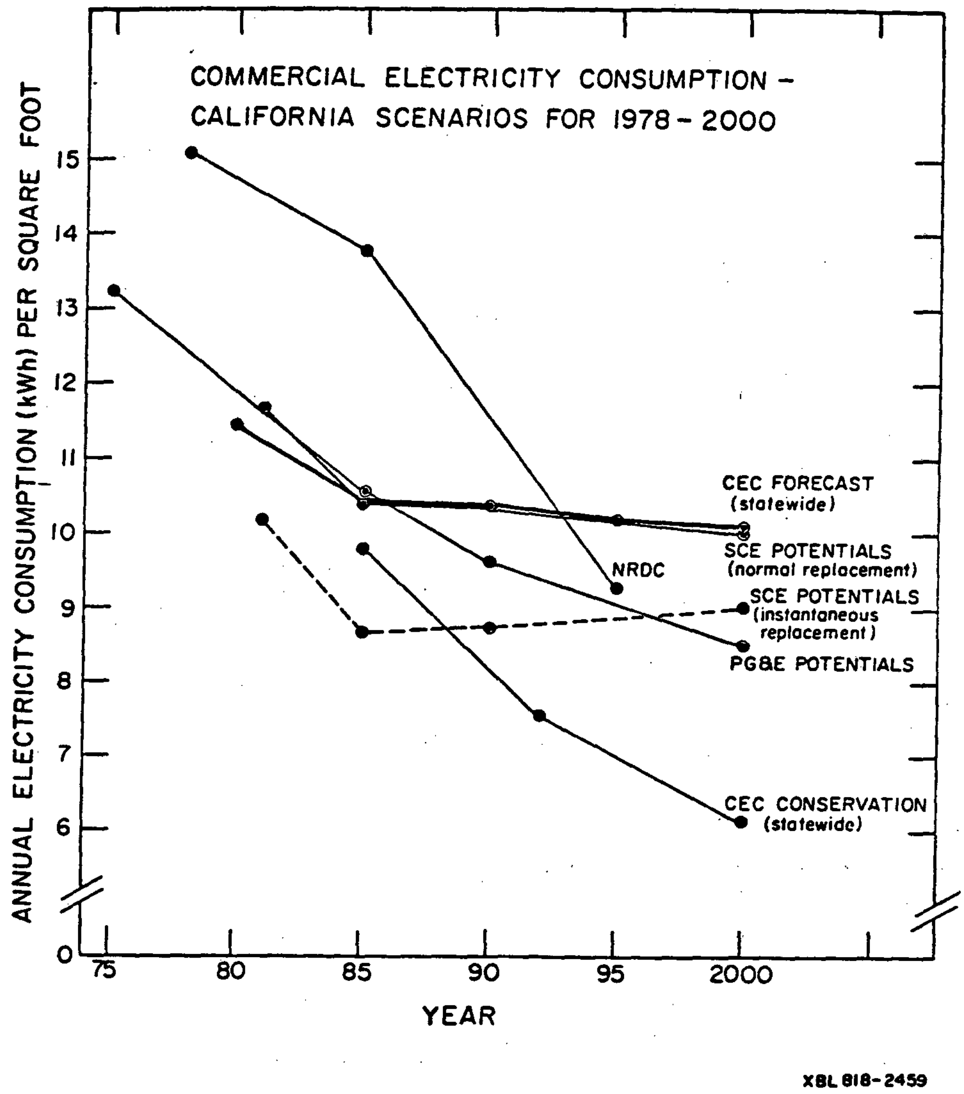


Figure D-4. Comparison of electricity demand scenarios for California commercial buildings, statewide and for two major utility service areas, from 1978 to 2000. Vertical scale is average annual electricity consumption (kwh) per square foot. Average usage includes all building types, and fuel-heated or -cooled as well as all-electric buildings. All the entries except the one labelled "CEC Forecast" are estimates of conservation potential rather than expected demand; the NRDC scenario is intended to be "achievable" while the others are statements of technical potentials. Sources: CEC (1980, as revised 11/80), CEC (1981b), PG&E (1980), SCE (1981), and King/NRDC (1980).

E. EXAMPLES OF DATA SOURCES

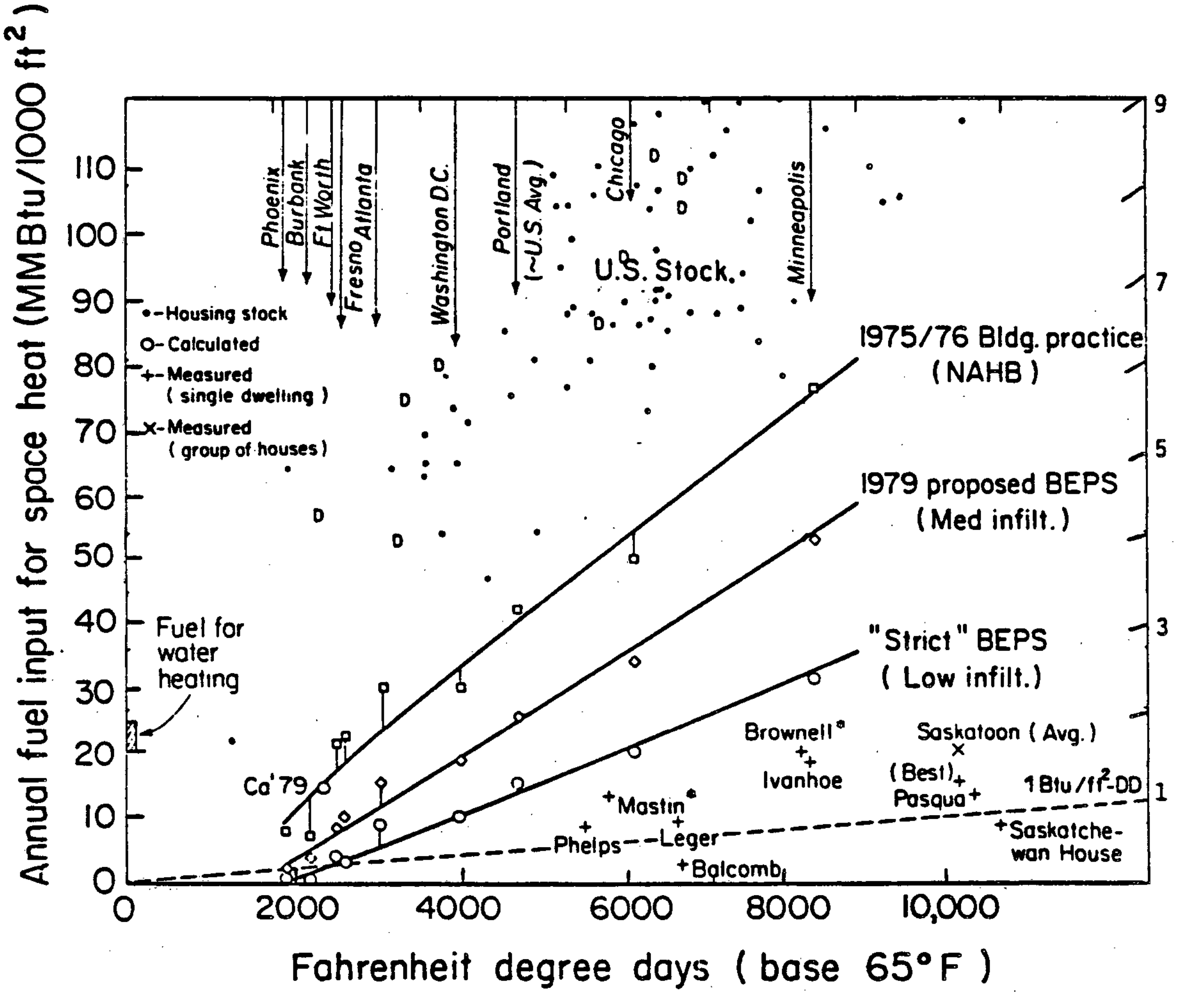


Fig. E-1. Annual fuel input for space heat in single-family US homes. Dots are actual gas sendout to residential customers for space heat for calendar 1978. 1979 proposed BEPS leaves infiltration at current practice levels of 0.6 air changes/hour (ach); strict BEPS reduces infiltration to 0.2 ach but 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: A. H. Rosenfeld et al., BECA-A: Building Energy Use Compilation and Analysis, LBL 8912, submitted to Energy and Buildings, 1980.

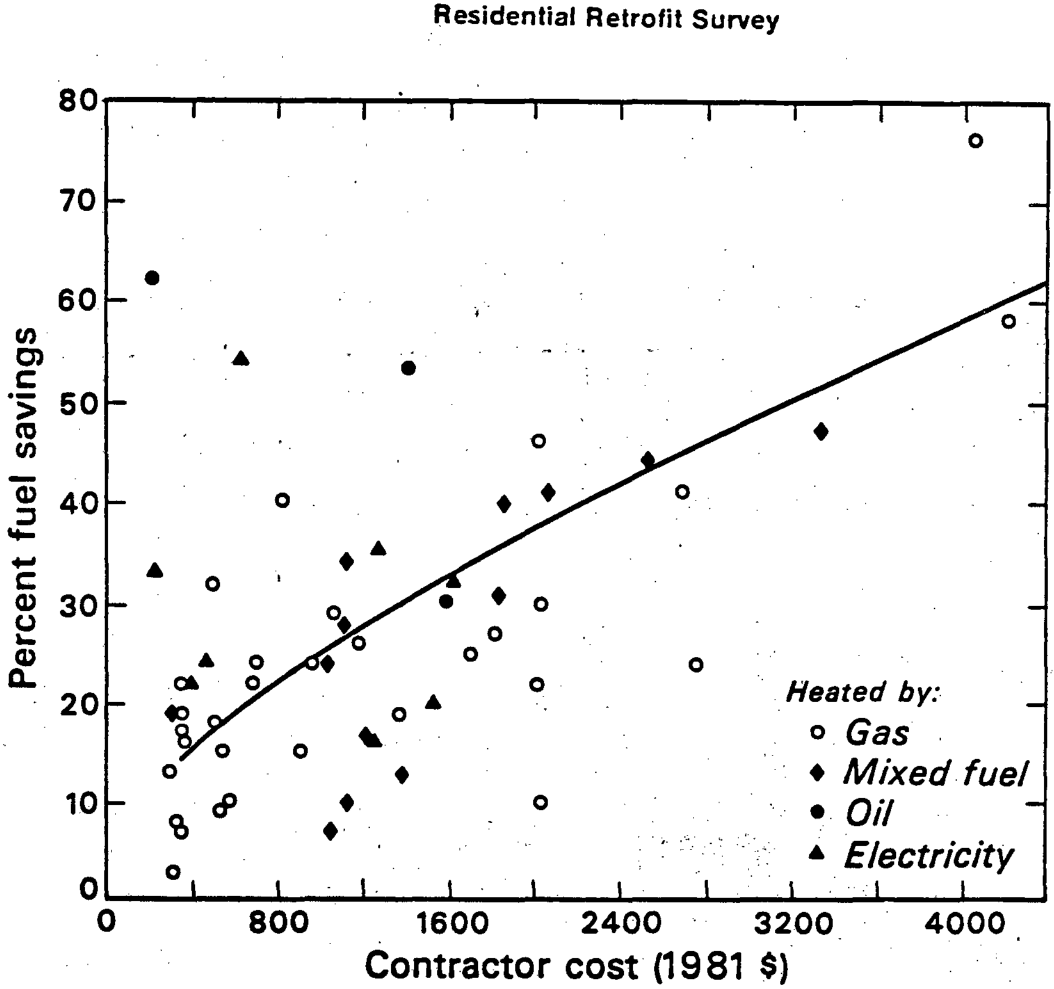


Figure E-2. Preliminary survey of residential retrofit energy savings vs. costs, from selected research and demonstration projects in the U.S. and Canada. Data points range from a single home to average values for several hundred thousand homes (CHIP, for "Canadian Home Improvement Program"). Some of these points represent preliminary estimates rather than measured savings from on-site instrumentation or from analysis of utility/fuel bills; measured data, as they become available, will replace the estimated values. Source: SERI/LBL (1981), as updated.

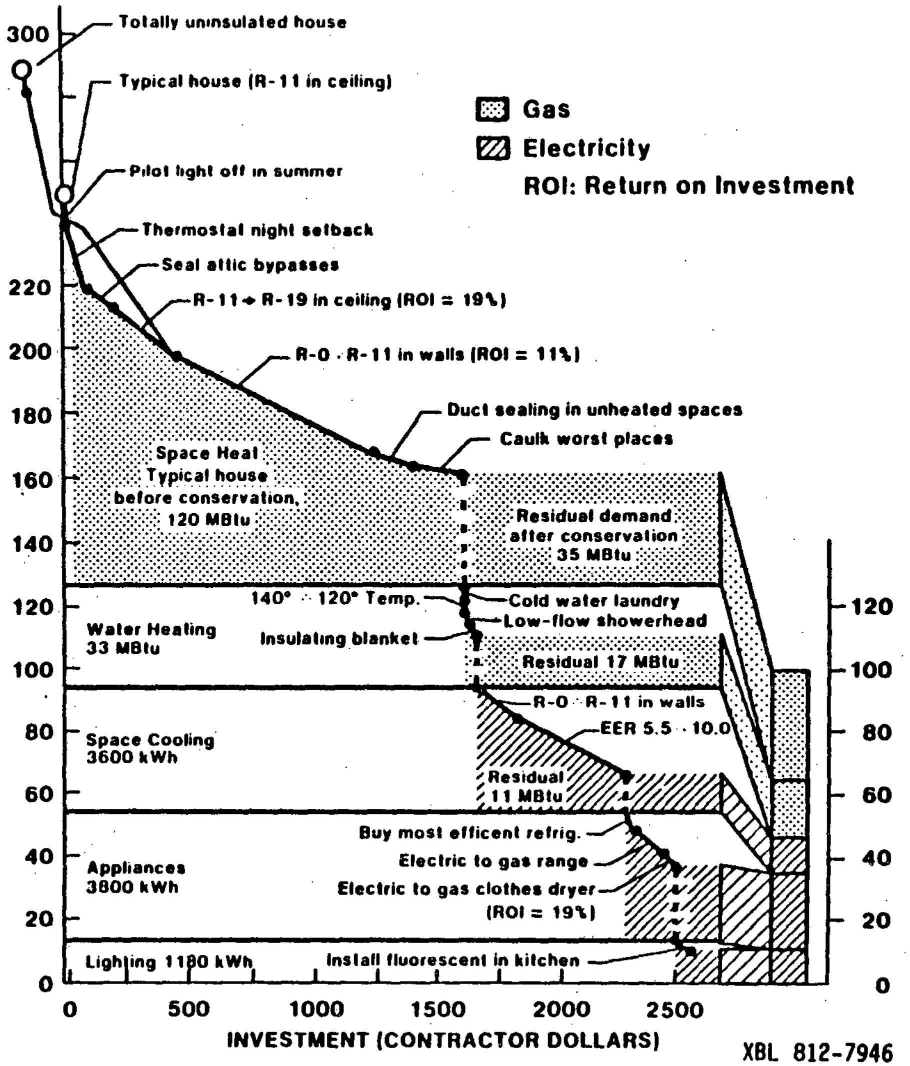


FIG. E-3 CONSERVATION POTENTIAL IN A NORTHERN CALIFORNIA SINGLE FAMILY HOME, GAS HEAT.

(1200 ft.², 3000 HEATING DEGREE DAYS)

XBL 812-7946
BBC 803-8788

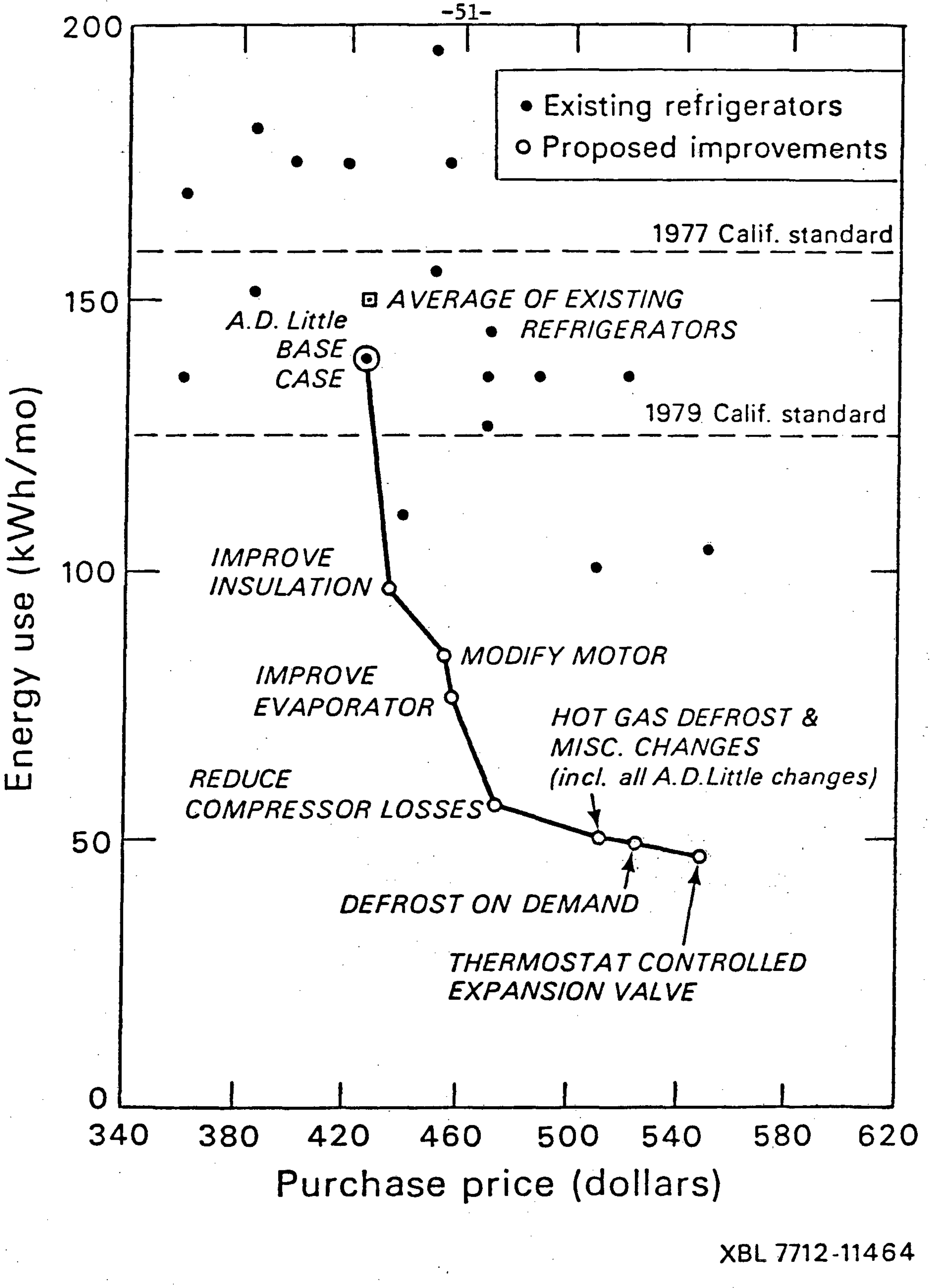
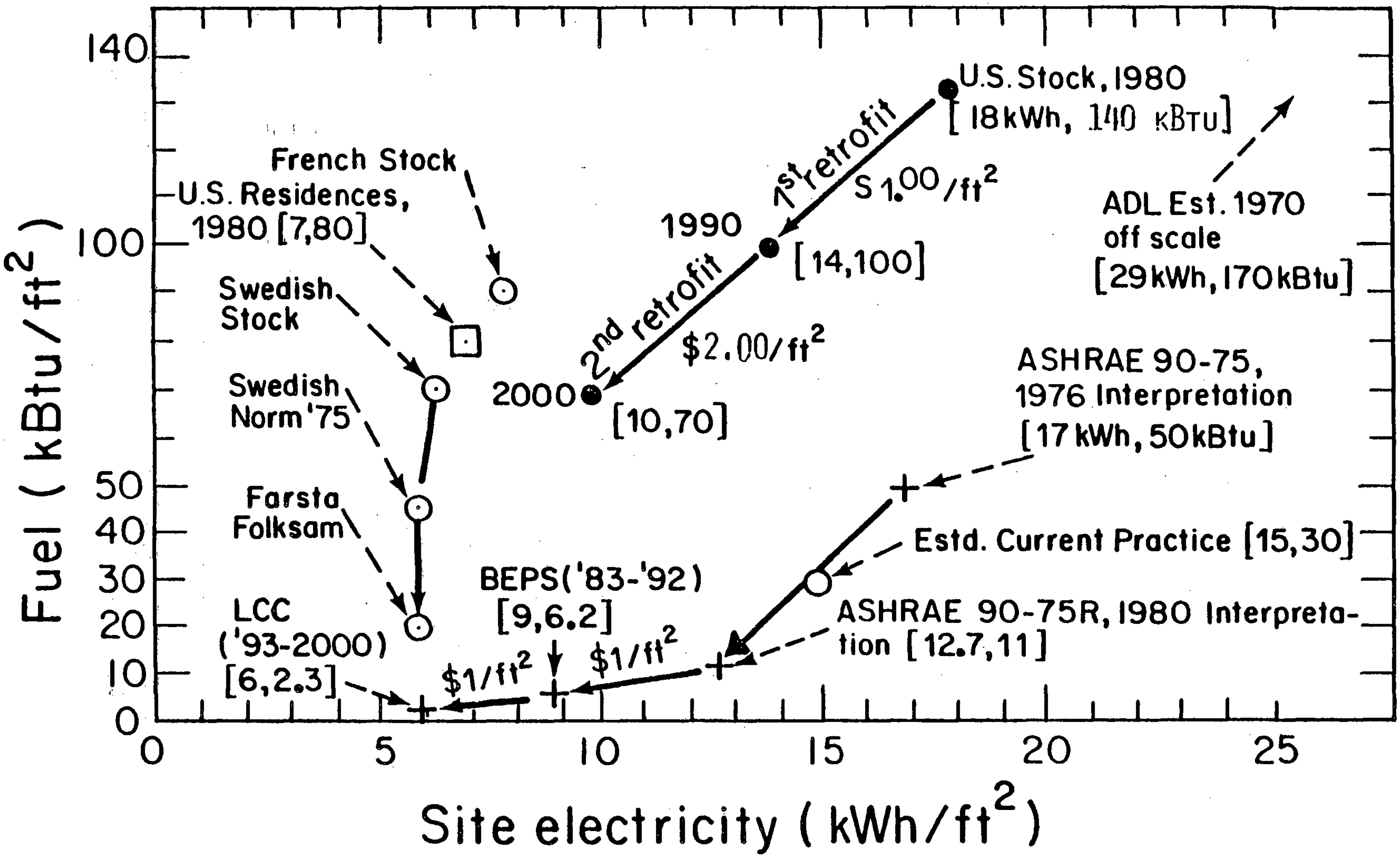


Fig. E-4. Electricity use vs. purchase price for existing and proposed refrigerators. The closed circles in the upper half of the figure represent 16-17.5 cu. ft. top-freezer, automatic defrost models sold in California in 1976. The open circles joined by a heavy line are improved design steps proposed by A.D. Little (May 1977). All U.S. refrigerators plus freezers in 1980 used about 140 BkWh, so the vertical scale can also be read in BkWh, for the U.S. The potential savings of 85 BkWh is the output of 17 1000-MW baseload power plants. Source: Rosenfeld/Goldstein et al (LBL 6865).



XBL 809-1848

Fig . E-5 Energy use of existing U.S. office buildings and new fuel-heated office buildings. Progress in Swedish building efficiency is shown for comparison. Swedish buildings already use considerable daylighting, and electricity is not decreasing, but space heat has dropped from 70 kBtu/ft^2 for stock to 50 kBtu for Stockholm buildings conforming to the 1975 "Swedish Building Norm", to 20 kBtu/ft^2 for the Farsta Folksam building which used thermal storage over nights and weekends. The "U.S. Stock" point comes from the 1980 energy use in the DOE/EIA 1979 Report to Congress divided by 32.5 Bft^2 of commercial space (from the ORNL model) with electricity scaled up by 10% to convert from "commercial sector" to "offices only". Source: SERI/LBL (1981).

F. ACHIEVING THE ENERGY CONSERVATION POTENTIALS

Figure F-1

HOW TO ACHIEVE THE TECHNICAL POTENTIAL--KEY INGREDIENTS:

(1) PROPER SIGNALS FROM ENERGY PRICES

- O INCREASING-BLOCK RATES (LAST BLOCK ≅ REPLACEMENT COSTS)
- O IMPROVED CUSTOMER AWARENESS OF COST OF THE "MARGINAL KWH" (THERM)
- O DEAL WITH IMPACTS ON LOW/FIXED INCOME GROUPS
- O PRICE-RESPONSE IS POTENT, BUT UNAIDED MARKET HAS 10-20 YEAR LAGS (FIG. 18)

(2) STRENGTHEN "TECHNICAL INFRASTRUCTURE" (INFORMATION, SKILLS, AVAILABILITY OF NEW PRODUCTS/SERVICES)

- O REQUIRES CONTINUED RESEARCH, TRAINING, TECHNOLOGY-TRANSFER
- O COLLABORATIVE EFFORTS BY UTILITIES, INDUSTRY, GOVERNMENT
- O INDUSTRY-ENFORCED QUALITY STANDARDS/QUALITY CONTROL

(3) LACK OF CONSUMER AWARENESS AND CONFIDENCE IN MEASURES TO IMPROVE EFFICIENCY

- O ACCESS TO ACCURATE, CONSISTENT TECHNICAL INFORMATION
- O CONSUMER PROTECTION (INDEPENDENT PRODUCT TESTING, PERFORMANCE WARRANTIES)
- O EMPIRICALLY PROVEN RESULTS
- O ENERGY LABELS FOR BUILDINGS/APPLIANCES (LIKE CARS)

(4) ADDRESS SPECIFIC MARKET BARRIERS

- O RENTAL HOUSING
- O LEASED COMMERCIAL SPACE
- O APPLIANCES NOT PURCHASED BY FINAL USER (OVER 50%)

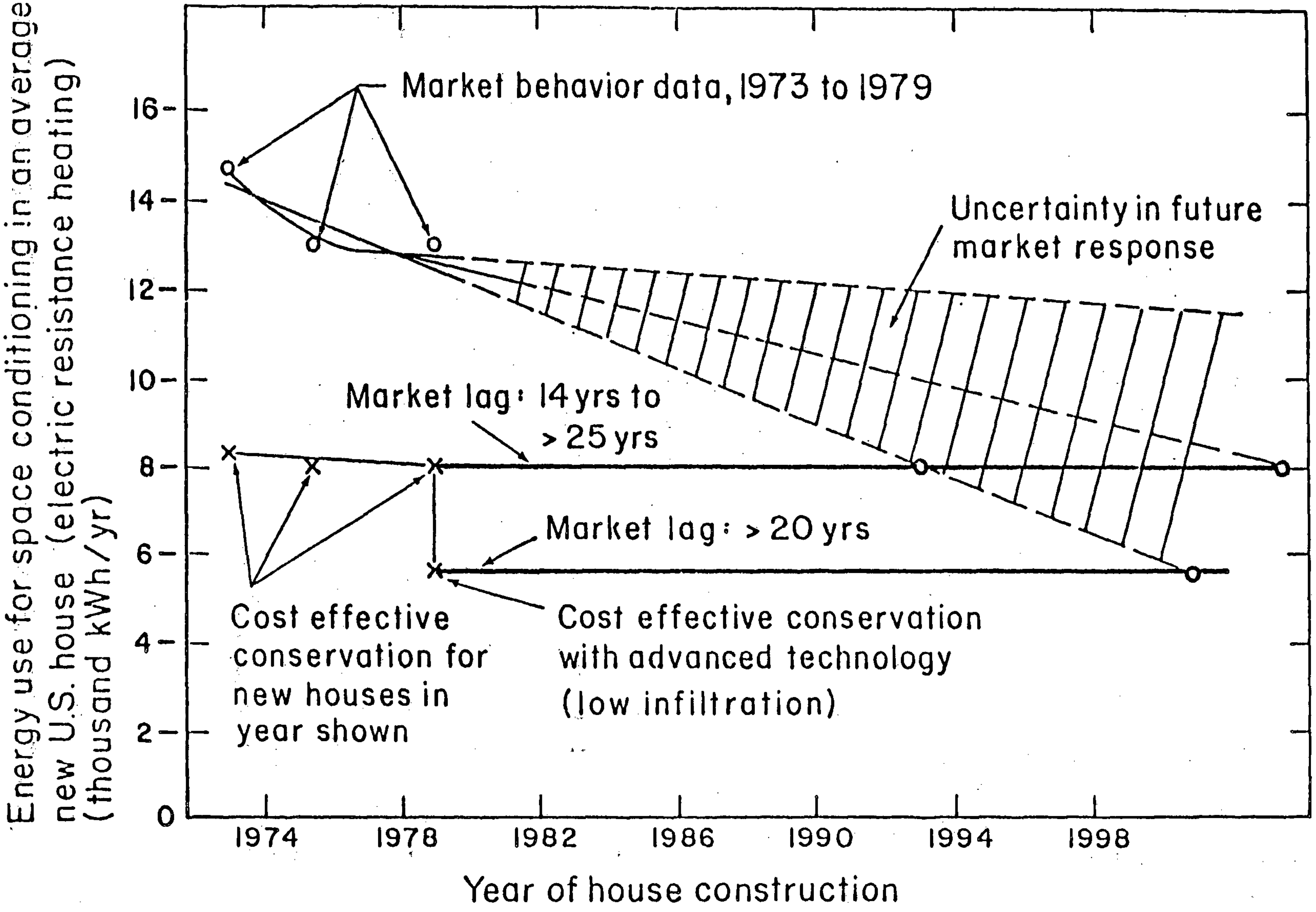
Figure F-1 (con't.)

(5) EMPHASIS OF GOVERNMENT CONSERVATION PROGRAMS SHOULD CHANGE

- O NOT TO GET PEOPLE TO CONSERVE, BUT HELP THEM USE ENERGY EFFICIENCY IN RESPONSE TO RISING PRICES
- O FEDERAL ROLE IN SUPPORTING:
  - --BASIC/APPLIED RESEARCH
  - --"WHOLESALE" DISSEMINATION TO INDUSTRY, PROFESSIONS, "INTERMEDIARIES"
  - --INNOVATIVE LOCAL PROGRAMS AIMED AT MARKET BARRIERS

(6) "BOLD NEW PROGRAMS" LESS IMPORTANT THAN GOOD IMPLEMENTATION:

- O REDUCING COSTS OF PROGRAMS AND CONSERVATION MEASURES
- O BROADER COVERAGE; EQUITABLE TARGETING OF PROGRAMS
- O TECHNICAL TRAINING AND QUALITY CONTROL
- O EVALUATION/DOCUMENTATION OF RESULTS + FEEDBACK TO PROGRAMS



XBL 813-507

Figure F-2. Observed market behavior vs. life cycle cost-minima for electric space conditioning energy in average new U.S. residences built in 1973-79, with projections of both least-cost and market trends to 2000. Market behavior data are based on LBL analysis of new home characteristics, as determined in the NAHB survey of 300,000 new housing units. Source: Rosenfeld/Levine (LBL 12739).

Figure F-3

BUILDING ENERGY PERFORMANCE LABELS

PURPOSES:

- O PROVIDE AN OVERALL "YARDSTICK" OF BUILDING ENERGY PERFORMANCE FOR COMPARISON SHOPPING BY BUYERS (OR RENTERS)
- O CREDIBLE MARKETING TOOL FOR BUILDERS
- O BASIS FOR LENDERS TO ESTIMATE MONTHLY OBLIGATIONS FOR UTILITY COSTS
- O ASSURANCE TO OWNERS THAT CONSERVATION INVESTMENTS WILL BE RECOVERED ON RESALE
- O FLEXIBLE COMPLIANCE METHOD FOR STATE/LOCAL BUILDING EFFICIENCY REQUIREMENTS (NEW OR RETROFIT)
- O CRITERIA FOR BASING CONSERVATION INCENTIVES ON PERFORMANCE (NOT COSTS)

APPLICABILITY:

- O NEW + EXISTING BUILDINGS
- O RESIDENTIAL + (SOME) COMMERCIAL
- O OWNER-OCCUPIED + RENTED/LEASED

EACH LABEL CONTAINS:

- O OVERALL ENERGY RATING (LIKE EPA MILEAGE)
  - --"STANDARDIZED" FOR AVERAGE OCCUPANCY, OPERATIONS, LOCAL WEATHER...
- O ACTUAL USAGE HISTORY (IF AVAILABLE)
- O KEY FEATURES THAT HELP OR HURT EFFICIENCY (OR ARE MISSING)

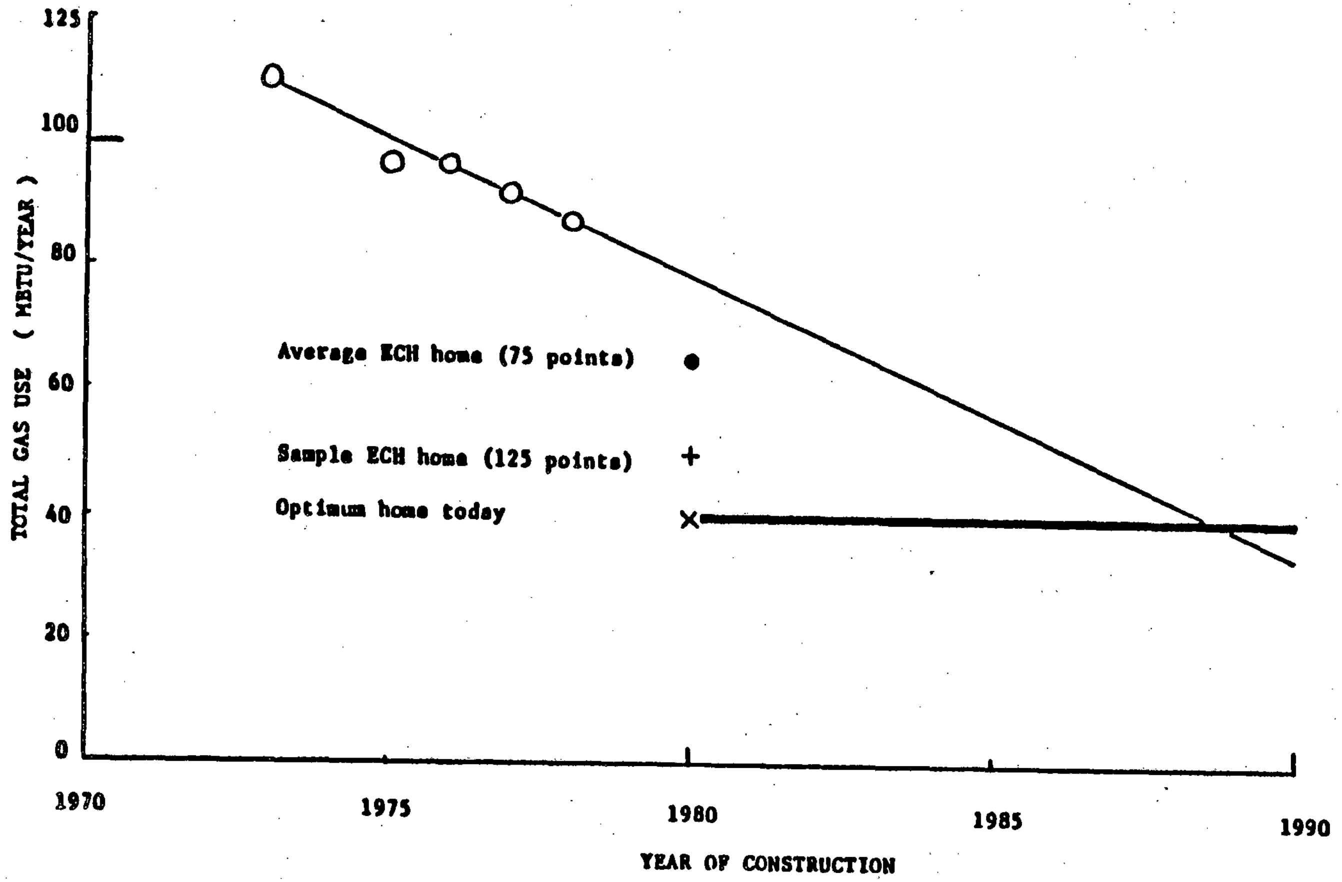


Figure F-4. Market behavior vs. impact of a new home energy-conservation incentive and labelling program by Pacific Gas and Electric Company in Northern California. Open circles are average billed use of gas for homes built from 1973 through 1978. The solid dot is the calculated gas use of the average new home qualifying in 1980 as an Energy Conservation Home; 60% of all new homes qualified. The "+" is a sample Energy Conservation Home that would qualify for 125 points (i.e., 375 therms) for about $175. The "x" is the estimated use for a home built today in Fresno's climate that minimizes its lifetime costs. Presley Homes currently advertises that its homes are as good as this "least-cost optimum." The thick horizontal line projects the economic optimum energy use, using the extremely conservative assumption that gas and gas-conservation costs remain constant in real dollars. This figure is in the same format as Figure 18, except that the open circles are based on actual metered gas use, instead of estimates based on building plans. Source: Rosenfeld/Levine (LBL-12739).

Figure F-5

HIGH-FREQUENCY SOLID-STATE BALLAST FOR FLUORESCENT LAMPS

There are two ways in which the efficacy of fluorescent lamps can be improved. First, it has been known since 1950 that if the lamps are driven at high-frequency instead of 60 HZ power from the utility, their lumen output per watt (efficacy) improves 15%.

Secondly, for every 100 watts input into a typical conventional fluorescent fixture, 16 watts goes to heating the steel and iron "ballast" and never gets to the lamp.

By the late 1970's, advanced electronic technology made it possible to design a solid-state high-frequency oscillator which could power the lamps and have internal losses of only a few watts instead of the typical 16 watts. The lamp becomes more efficient because it does not turn off every half a cycle at the high frequencies (no flicker) and the ballasting is done at high frequencies which use smaller components that have less heat losses. The combined savings for a typical 100-watt fixture are then 10 watts from the ballast and 15 watts from the lamps, totaling 25 watts. As to price, the normal ballasts cost about $6.00 wholesale, and tend to be noisy; the new ballasts will sell for about $20.00; both sorts last about 15 years.

The favorable economics for each lamp are as follows: over 15 years, the extra $14 investment will save 1300 KWH, worth about $65.00. Using a 10% real interest rate (in constant 1980 dollars) the cost of conserved electricity is 2.1 ¢/KWH, much cheaper than the average commercial-sector price of 6¢/KWH. In addition, the new ballasts are capable fo continuous dimming, both to take advantage of daylight, and to keep a constant light level on the task below as the lamps degrade with time.

If economics (2.1 ¢/KWH) are so favorable, one wonders why the lighting industry waited for a federal incentive program, or how much this program advanced the inevitable development.

The ballast industry is very similar in structure to other sectors of the lighting industry, namely a very stable industry dominated by four to six large companies with many small companies comprising a very small percentage of sales. Because of the structure of the industry and the relative stability of the market share, it is very difficult for small companies to infiltrate the marketplace and be competitive. There is also little incentive for the large companies to rapidly innovate new technologies, especially when the innovation will require substantial investment on their part, since the results will probably be duplicated by the other companies at less cost, and market shares will not change drastically.

Box continued on next page

Figure F-5, (cont'd.)

Looking for cooperation with industry, LBL issued a competitive request for proposals four years ago to develop a solid-state ballast that would improve efficiency by 25%, offer continuous dimming capability, and be lighter/smaller in size. The large ballast companies not only refused to respond to the request for proposals, but published many statements that solid state ballasts would never make it due to first cost, technical problems, adverse affect on lamps, consumer acceptance, etc., etc. The LBL program worked with two small contractors to develop and test solid state ballasts. As a result of the successful tests, a large corporation, Beatrice Foods, purchased the rights to one of the ballast designs, conducted a large demonstration (cost-shared with DOE) of the ballasts, constructed a manufacturing plant, and is now taking orders for solid state ballasts. Since Beatrice Foods has the funds to impact market shares in the ballast industry, all companies were forced to reevaluate their position. Recently, seven manufacturers have announced the development of an energy saving solid state electronic ballast. At least two of these seven are large ballast manufacturers that did not respond to the original request for proposals. Total expenditure of public funds in this area has been less than $1.5M and the results have been the availability on the commercial market of a solid state ballast for fluorescent lamps and the acceptance by the ballast industry of this new energy saving technology.

In 1980 the electronic ballast systems were assessed for total performance; that is, we considered all of the improved attributes of the electronically ballasted system--the tighter system control brought about by improved voltage regulation, the regulation of light output, and the ability to dim lamps, in addition to the 25% "intrinsic" improvement in system efficiency. Among our findings, now being compiled for publication as an LBL report, we demonstrated that total energy savings can be as high as 40-70%.

Finally, we note that at present the U.S. consumes annually about 220 x 10^9 KWH in fluorescent lighting.* A market penetration of 25% with a 35% improvement in efficiency at .05 per KWH results in annual savings to consumers of $1 billion--not bad for a total DOE catalytic investment of $1.5 million!

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* At 5¢/kWh, this costs more than $10 billion a year, or twice the entire non-military, non-strategic petroleum reserve budget of DOE.

Source: Rosenfeld and Levine (1981), LBL-12739

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