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RESIDENTIAL ENERGY CONSTRUCTION:
STANDARDS, SUBSIDIES AND PUBLIC PROGRAMS

BY

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RESIDENTIAL ENERGY CONSERVATION:
Standards, Subsidies and Public Programs

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Abstract

This paper reviews federal standards and tax credit programs designed to encourage residential energy conservation. It also reviews the ambitious tax credit, subsidy, and mandatory standards programs adopted by the State of California, the California Energy Commission, and the California Public Utility Commission.

The paper presents new evidence on the distribution of subsidies under these programs and summarizes the available evidence on effectiveness.

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I. INTRODUCTION

The dramatic increase in world energy prices in the early 1970's led to a variety of painful market adjustments and to the imposition of regulatory policies intended to stabilize domestic prices, to allocate energy resources on more equitable grounds, and to improve the technical engineering efficiency of energy utilization. Fuel prices were controlled, energy was allocated regionally and was rationed by queues, and "conservation" took on patriotic significance.

An important object of conservation was the energy used in residences -- fully one fifth of total U.S. energy demand arises from the requirements to heat, cool, light, or to provide hot water in residential dwellings. Thus, to an important extent, the overall impact on the economy of substantial increases in the level and variation in world energy prices depends upon the potential for energy conservation in the residential sector of the U.S. economy. Even modest relative savings in energy consumption can lead to large absolute savings in energy and can increase its availability for industry or for the commercial sectors of the economy.

This essay reviews government policies designed to promote conservation of energy in the residential sector of the economy. By "conservation" we mean reductions in energy consumption from the levels which would otherwise be observed in the market, given prices and incomes, production processes and forecasts of future conditions. The counterfactual is based on expectations about the actual operation of the market, not necessarily the idealized market of the economics textbook or the engineering caricature obtained by neglecting the possibilities for substitution in production and consumption.

The analysis provides a parallel treatment of Federal tax credit and regulatory policies and those adopted by the state of California. The Federal-state comparison is especially fruitful. The California programs of residential tax credits and building standards have been similar, but they were much more ambitious than those of the Federal government. We begin with a discussion of government grant and tax credit policies designed to encourage the direct substitution of capital for energy in the construction or retrofit of dwellings. Section II below discusses policies of the Federal government and of the State of California. Section III expands the discussion to include a variety of incentive programs authorized, directed, or mandated by state regulatory agencies, but undertaken and implemented by public utilities themselves.

Section IV considers a variety of mandated standards for residential construction, regulations which require compliance with specific mandates governing inputs or energy usage. Section V summarizes the expectations about future energy prices which may have motivated some of these policies, at least ex ante.

II. RESIDENTIAL WEATHERIZATION AND ALTERNATIVE ENERGY PROGRAMS

The oil crisis resulting from the OPEC oil embargo of 1973-1974 led to a shift in emphasis of Federal energy policy towards the recognition of conservation as an explicit policy goal. This change can be seen in the language of Project Independence, proposed in November of 1973 by the Nixon Administration, and in the content of laws passed in the mid-1970's to promote conversion to alternative energy sources.[1]

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[1] See, for example, the Solar Heating and Cooling Demonstration Act of 1974 (PL93-409) and the Solar Energy Research Development and Demonstration Act of 1974 (PL93-473). The Energy Reorganization Act of 1974 (PL93-438) cre-

The zenith of this change in Federal energy policy was the National Energy Act of 1978 (PL95-618). In the act, a Federal policy of energy conservation was explicitly introduced. Indeed, the articulation of this policy was a principal goal of the act itself, and the residential sector of the economy was the principal object of the policy. It was contended that substantial waste and inefficiency existed in the use of energy in residential buildings, and thus there was considerable scope for reducing energy use by increased conservation in the residential sector. The National Energy Act introduced a federal system of income tax credits (subsequently amended by the Crude Oil Windfall Profits Act of 1980, PL96-223). The Energy Act of 1978 contained a variety of energy conserving provisions: the "gas guzzler" tax, incentives for van pooling, and a variety of business energy tax credits. The principal tool of Federal policy introduced by the act, however, was a system of personal income tax credits.

A. Direct Federal Subsidies

Prior to the introduction of these tax credits, however, the Federal government had undertaken a direct program to increase the insulation in dwellings occupied by low income households. The Energy Conservation in Existing Buildings Act of 1976 authorized the Department of Energy (DOE) to develop and

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ated an agency to develop conservation measures, and the Energy Policy and Conservation Act of 1975 (PL94-163) authorized the Federal Energy Administrator to provide financial as well as technical assistance to states which instituted energy conservation programs. (The more important part of the law, however, was the provision to reduce fuel consumption in automobiles by mandated fuel economy standards). In 1976, the Energy Conservation and Production Act (PL94-385) provided a much broader range of energy conservation incentives including: mandatory energy standards for new buildings under Title III; the labeling of energy efficiency in appliances; the availability of $200 million for weatherization grants under Title IV; and the setting aside of $300 million for the demonstration of energy conserving home improvements. Finally, the act provided for $12 billion in loan guarantees for the conversion to renewable energy resources (e.g., solar and geothermal) in the non-residential sector.

implement a Weatherization Assistance Program to assist in achieving a prescribed level of insulation in the dwellings of low-income persons. DOE's program regulations allow up to a maximum of $1,600 per dwelling for numerous weatherization measures, including caulking, weatherstripping, and repair, insulating attics, exterior walls, floors, and water heaters, modifying furnaces for greater efficiency, and installing storm windows and doors. Under this program, funds are distributed to the states for implementation and dispersal. In California, for example, program funds are allocated to the Community Action Committee of the California Department of Economic Opportunity. The committee evaluates grant proposals from local groups, subject to DOE eligibility guidelines. About 60 community action programs are currently funded in California.

To date, about $1.4 Billion in Federal funds has been allocated under this program. Through 1984, weatherization has been completed for about 1.4 million of the estimated 14.4 million dwelling units occupied by eligible low-income persons. In the same period for California, 66,000 of the estimated 1.35 million eligible units were weatherized.

After the second shock in energy prices in the late 1970's, the Low Income Home Energy Assistance (LIHEA) block grant was established. The act encourages the states to use the block grant to facilitate "low cost weatherization" by low income households. Federal requirements regarding the use of LIHEAP weatherization funds are minimal, and neither the act nor the regulations define "low-cost weatherization." Therfore, the program provides substantial flexibility for states in designing their programs, including the establishment of cost and income eligibility within the limit set in the act.

Table 1 summarizes Federal funding of these weatherization programs during recent years. Direct Federal expenditures for weatherization rose from $279 M in 1982 to $398 M in 1985; expenditures in California increased form $7 M to almost $14 M during the period.[2] Section 155 of the 1983 Further Continuing Appropriations Act, provided for the disbursement of up to $200 million in petroleum violation escrow funds to each of the states. The states could use these funds to supplement the DOE Weatherization Program and LIHEAP.

On March 6, 1986, the DOE released nearly $2.1 billion to the states, reflecting the settlement of oil overcharge litigation with the Exxon Corporation. California received $194.7 million from the escrow account, or 9.4 percent of the available funds.

In addition to these weatherization programs, the Federal government has provided modest subsidies to encourage solar energy investment through the Solar Energy and Energy Conservation Bank which authorized the Energy Security Act of 1980. A total of $81.9 million has been appropriated to the Bank for fiscal years 1982 through 1985.

B. Government Tax Credits

Compared to these direct subsidy programs, aimed at low income households, programs of tax credit, aimed at upper income households, have been quite large.

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[2] These figures increased substantially in a one shot increase in fiscal year 1987.

TABLE 1

Direct Expenditures for Weatherization under the
Weatherization Assistance Program (WAP) and the
Low Income Home Energy Assistance Program (LIHEAP)
(millions of dollars)

	1982	1983	1984	1985
A. Total Federal Expenditures				
WAP	$143.0	$242.3	$187.0	$187.0
LIHEAP	136.2	195.5	195.9	211.1
B. Federal Grants to California				
WAP	3.7	6.3	4.8	4.7
LIHEAP	3.3	7.8	12.0	9.8

Source: U.S. General Accounting Office, Human Resources Division, *Low Income Energy Assistance*, (GAO/HRD-86-92), May 1986.

U.S. General Accounting Office, Resources, Community, and Economic Development Division, *Low Income Weatherization*, (GAO/RCED-86-19), October 31, 1985.

National Regulatory Research Institute, *Trends Report of Energy Assistance Programs in the Fifty States, 1979-1984*, (85-18), December 1985.

i. Federal

The system of residential energy tax credits authorized by the National Energy Act of 1980 included the following features:

First, a credit of 15 percent against Federal income tax liability was permitted for up to $2,000 of qualifying expenditures on particular insulation and energy conserving devices, including caulking, weather stripping, storm windows, furnace replacement burners, and so forth. The maximum credit allowed was $300, and the minimum which could be claimed was $10.

Second, legislation provided a credit for investment in equipment which uses renewable inexhaustible sources such as solar, wind, and geothermal energy. The 1978 act provided for a 30 percent credit for the first $2,000 in expenditures and a 20 percent credit for the next $8,000 of investment up to a maximum of $2,200 in tax credit for investments in renewable resources. When amended in 1980, the credit was increased to 40 percent of the first $10,000 in expenditures, up to a $4,000 maximum.

Third, these credits were nonrefundable, and they were subject to particular limitations. Certain alternative government energy subsidies did reduce the amount of the tax credit available in any year, but the energy credit could be carried forward until exhausted or until 1987. Significantly, the credit applied only to principal residences; hence it excluded vacation homes, second homes, and so forth. Renters as well as homeowners could qualify.

Fourth, it was required that investments be in new devices having useful lives of at least five years. A number of potential conservation devices were excluded from the credit, for example, wood burning stoves and passive solar systems.

This extensive program of tax credits expired on December 31, 1985. Table 2 provides a summary of the provisions of the Federal acts.

ii. State

The system of California state energy tax credits was introduced two years before the Federal program; since 1976, the state of California has enacted eight laws which authorize tax credits for investments in certain classes of energy saving capital equipment in residential dwellings. Between 1976 and 1980, the state enacted four bills providing tax credits for solar and wind energy systems for dwelling units. The first of these, the so-called Alquist Bill (SB0218) adopted in 1976, provided solar energy tax credits for individual and corporate taxpayers. Taxpayers were permitted to claim a tax credit equal to ten percent of the cost of acquiring and installing solar energy equipment for heating, cooling, or producing electricity in residential dwellings, up to a maximum credit of $1,000. The bill specified that the credit could be claimed only once between January 1, 1976 and December 31, 1980. This ten percent tax credit remained in effect until September 1977 when new legislation (AB1558) established a 55 percent tax credit, up to a limit of $3,000, for solar systems for single family dwellings (including condominiums). This bill also extended eligibility to specific conservation measures installed in conjunction with a solar heating or cooling system.

For multi-family dwellings, and for commercial or industrial buildings, the 55 percent credit applied to investments up to $12,000 in total costs. In ex-

TABLE 2
Solar and Energy Conservation Tax Credits
for Residential Properties: Federal Income Tax

BILL:	Energy Tax Act of 1978
CREDIT:	15% of first $2,000 up to $300 for conservation items, and 30% of first $2,000 and 20% of next $8,000 up to cumulative maximum of $2,200 for renewable resources expenditures.
ELIGIBILITY:	Nonrefundable tax credits to households investing in energy conservation equipment or in residential hot water heaters powered by renewable energy sources (i.e., solar, geothermal, or wind-powered heaters).
EXPIRATION:	12/31/85
BILL:	Crude Oil Windfall Profit Tax Act of 1980
CREDIT:	40% of first $10,000 up to $4,000 maximum for renewable resource credit.
ELIGIBILITY:	Expanded credits to include electricity generation as well as water heating. Retroactive to 1/1/80.
EXPIRATION:	12/31/85

Source: U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress: 1981*.

cess of $12,000, the credit was set at 25 percent of the cost without an upper limit. The bill specified that this credit would expire on December 31, 1980.

In 1978, the solar credit program was amended again (by AB3623) to allow the builder or the developer of a new dwelling to claim the credit at the time of construction, or to pass on the tax credit to the original purchaser of a new dwelling. Wind energy systems and the cost of acquiring a solar easement were also made expressly eligible for the tax credit by the 1978 bill.

During the 1980 legislative session, the California code was amended again to extend the expiration date of the credit to December 31, 1983 and to expand the 55 percent credit to include all residential applications rather than simply single-family dwellings. This bill also provided for successive reductions in the credits available for recreational or therapeutic solar energy water heating systems, from 55 percent in 1980 to 45 percent in 1981, to 35 percent in 1982, and to 25 percent in 1983.

Also in 1980, the California Legislature passed California's first conservation tax credit (AB2030). This bill permitted a taxpayer to claim a 40 percent credit for investments in conservation measures installed in dwellings or in other premises, up to $1,500 in credit. For conservation investments exceeding $6,000 and installed on premises other than dwellings, a credit of 25 percent was provided, again without an upper limit. The conservation tax credit became effective on January 1, 1981, and AB2030 specified sunset dates varying from December 31, 1983 to December 31, 1986, depending upon the type of measure and the property affected.

In 1983, Governor George Deukmejian proposed the elimination of both the solar energy credit and the energy conservation tax credit programs. The Legislature held separate hearings to consider the Governor's proposal and ultimately included amendments in the State budget's "Trailer Bill," extending the credits for several years while at the same time reducing the credit level and eliminating the eligibility of certain measures. The solar and wind energy tax credits were extended through December 31, 1986, but the 55 percent solar tax credit was reduced to 50 percent beginning August 1, 1983. All tax credits for solar heating of pools and spas were eliminated as of August 1983. The measure also reduced California's 40 percent conservation tax credit to 35 percent, but extended eligibility for these tax credits until December 31, 1985. Finally, the bill provided that only one half of available credits for certain measures could be claimed against 1983 tax liability, with the remainder carried forward against future tax liabilities.

Also in 1983, two additional bills, SB0298 and AB2158, were enacted to revise the solar and conservation tax credit program. The former made three changes to the solar tax credit, retroactive to January 1, 1983. First, the amount of the tax credit for builders and developers who elected to claim the state tax credit (instead of passing it on to the original purchaser) was reduced from 25 to 15 percent. For solar energy systems which were also eligible for Federal credit, the state credit was also reduced to 15 percent. The solar credit was simplified by removing a $12,000 minimum cost threshold for solar systems installed in premises other than dwellings. Under the revision, all solar and wind systems in non-residential properties were eligible for the 25 percent state tax credit. Third, the eligibility for tax credit of leased solar systems was expanded. The latter bill (AB2158) removed the requirement that a taxpayer have a home energy audit provided and paid for by the local utility company as a condition of eligibility for certain categories of conservation measures: wall insulation, floor insulation, cooling fans, and heat pumps.

Finally, in 1985 two bills were enacted which reduced substantially the total amount of credit which could be claimed by taxpayers. These bills deleted provisions which link state tax credits to eligibility for Federal credits. They also reduced the allowable credit as a fraction of total investment. Under the new law, solar credits for single-family residential dwellings were limited to 10 percent of the system cost regardless of the availability of Federal credit, up to a maximum credit of $1,000. For multi-family residential construction, credits were limited to five percent of the total cost, with no maximum credit per unit. For commercial and industrial properties, solar credits were limited to 25 percent of the total system costs. Credits for wind energy were changed to be generally similar to solar credits. Solar and wind energy tax credits expired on December 31, 1985.

These bills also revised and reduced the state energy conservation tax credit program. For single-family residential dwellings, the credit was reduced to 10 percent of the cost of all qualifying systems, regardless of the availability of the Federal credit. The maximum credit was reduced to $750. Eligibility for many of the qualifying items expired December 31, 1985; all others expired at the end of 1986. For multi-family dwellings, the state credit was reduced to 25 percent of total cost effective September 1, 1985 through December 31, 1985 and to 20 percent of total cost during calendar year 1986. All state tax credits under these programs expired on December 31, 1986.

Table 3 provides a summary of state programs for tax credits for solar, wind and conservation investments.

TABLE 3

Solar Energy and Conservation Tax Credits for Residential Properties:
California State Income Tax

Year	Bill	Credit	Eligibility/Limitations	Expiration
1976	SB0218	10% up to $1,000	Solar energy equipment for heating, cooling, and producing electricity (one time claim).	12/31/80
1977	AB1558	55% up to $3,000 net of federal credits	Solar energy systems for single family dwellings Includes conservation measures installed in conjunction with a solar system. (For multi-family, 55% credit applied to systems costing less than $12,000).	12/31/80
1978	AB3623	55% up to $3,000 net of federal credits	Wind energy systems and the cost of acquiring a solar easement made eligible for 55% credit. Builder of a new single family dwelling could claim 25% credit or pass it on to original buyer.	12/31/80
1980	AB2036	55% up to $3,000 net of federal credits	Expanded 55% credit to include all residential applications. Reduced credits for recreational or therapeutic solar energy water heating systems from 55% in 1980 to 25% in 1983).	12/31/83
1980	AB2030	40% up to $1,500 net of federal credits	Tax credit for residential energy conservation measures including insulation, weatherizing, duct wrap, heater blankets, etc. (State plus federal credit not to exceed 40%).	12/31/83-12/31/86 varies
1983	State Budget	50% for solar systems up to $3,000 net of of federal credits	Eliminated all credits for solar heating of pools and spas. Required carryforward of some credits.	12/31/86 for solar wind energy 12/31/85 for energy conservation credits

TABLE 3 Continued

Solar Energy and Conservation Tax Credits for Residential Properties:
California State Income Tax

Year	Bill	Credit	Eligibility/Limitations	Expiration
1983	SB0298 AB2158S		Lowered 25% state tax credit to 15% for builders of single family dwellings who claim credits (instead of passing them on) for a solar system that is also eligible for the federal credit. Expanded eligibility of leased solar systems. Removed audit requirement for four categories of conservation measures: a) floor insulation in dwellings with electrical resistance heating; b) wall insulation; c) ventilation cooling fans, attic ventilation, and economizer systems; and d) heat pumps and water heating heat pumps.	
1985	SB0125 SB1079	Gross of federal credit	Broke link between federal state credits. Prohibited certain carryovers.	
		10% single family 25% multi-family up to $1,000	Solar Tax Credits.	12/31/86
		10% all dwelling structures up to $1,000	Credits for Wind Energy	12/31/86
		10% single family 25% multi-family (effective 8/1/85-12/31/85) 20% multi-family (effective 1/1/86-12/31/86) up to $750 single family, no maximum for multi-family	Energy Conservation Tax Credits	12/31/86 for ceiling insulation and other specific lost cost measures 12/31/85 for all other measures

Source: Extracted from public laws.

B. Program Impacts

Individuals avail themselves of tax credits under these programs by including the relevant information on their personal income tax returns. U.S. taxpayers submit form 5695 to the Internal Revenue Service; California taxpayers submit form FTB3514 to the state's Franchise Tax Board. Thus a wealth of descriptive information about these tax expenditure programs is compiled, but not published, by agencies administering the tax code.

Tables 4 and 5 summarize unpublished data on the impact of Federal credits for renewable energy sources and for energy conservation during the period 1978-1982. As reported in Table 4, qualifying investments in solar, geothermal or wind energy sources increased from $115 M to $805 M from 1978 to 1982, and total tax expenditures under this program increased from $29 M to $322 M. Since 1980, about 80 percent of these tax expenditures were made to households earning more than $25,000 a year. The average tax credit per household varies directly with income, and is 15 to 20 times as large for households earning $100,000 than for households earning $10,000 a year. Part D of the table indicates that the fraction of households claiming these credits is quite small. Only for the highest income households does it approach one percent.

The average investment in renewable energy sources made by those claiming the credit increased from $1,750 in 1978 to $3,500 in 1982; investments increase moderately with income. The average credit claimed by investors increased form $450 to $1,400. Credits per investor increase moderately with income.

Table 5 provides similar information for energy conservation tax credits. Qualifying investments under this program declined from $3.6 B in 1978 to under

TABLE 4

Distribution of Federal Renewable Energy Source Tax Credits 1978-1982

Income Class	1978	1979	1980	1981	1982
A. Value of Qualifying Investment ($ millions)					
$0-5,000	$ 0.2	$ 1.6	$ 5.9	$ 8.5	$ 7.4
5-10,000	1.6	6.6	28.1	4.4	8.9
10-15,000	6.3	6.6	14.0	41.9	35.9
15-20,000	7.9	13.5	39.9	32.9	47.3
20-25,000	24.0	17.7	31.4	72.4	58.0
25-30,000	8.4	32.7	58.6	107.3	185.8
30-40,000	46.1	42.1	98.6	144.5	180.2
40-50,000	0.0	14.2	44.7	85.4	109.4
50-100,000	15.6	27.7	71.2	129.5	146.6
100,000+	5.3	8.8	21.8	34.2	25.1
Total:	$115.3	$171.6	$414.3	$661.0	$804.6
B. Total Tax Credit ($ millions)					
$0-5,000	$ 0.0	$ 0.4	$ 2.4	$ 3.4	$ 3.0
5-10,000	0.5	1.8	11.2	1.7	3.6
10-15,000	1.7	1.9	5.6	16.8	14.4
15-20,000	2.2	3.6	15.9	13.1	18.9
20-25,000	6.4	4.6	12.6	28.9	23.2
25-30,000	2.2	8.0	23.4	42.9	74.3
30-40,000	11.8	10.7	29.5	57.8	72.1
40-50,000	0.0	3.7	17.9	34.2	43.8
50-100,000	3.7	6.9	28.5	51.8	58.6
100,000+	1.2	2.1	8.7	13.7	10.0
Total:	$ 28.6	$ 43.8	$165.6	$264.3	$321.8
C. Average Tax Credit Per Household					
$0-5,000		$ 0.02	$ 0.12	$ 0.18	$ 0.17
5-10,000	$ 0.01	0.09	0.61	0.10	0.21
10-15,000		0.13	0.39	0.18	1.00
15-20,000	0.15	0.31	1.43	1.19	1.79
20-25,000	0.75	0.51	1.37	3.18	2.64
25-30,000		1.26	3.45	5.95	9.75
30-40,000	0.42	1.67	4.96	6.28	7.31
40-50,000		1.66	5.86	8.17	9.28
50-100,000	2.49	3.66	11.09	15.05	15.60
100,000+	3.26	4.74	15.56	20.92	13.54
Average:	$ 0.33	$ 0.47	$ 1.76	$ 2.77	$ 3.38

TABLE 4 Continued

Distribution of Federal Renewable Energy Tax Source Credits 1978-1982

Income Class	1978	1979	1980	1981	1982
D. Percent of Households Claiming Credit					
$0-5,000		0.00%	0.01%	0.02%	0.04%
5-10,000	1.01%	0.02	0.06	0.03	0.04
10-15,000		0.06	0.06	0.14	0.08
15-20,000	0.03	0.07	0.14	0.18	0.21
20-25,000	0.18	0.11	0.19	0.30	0.15
25-30,000	0.17	0.15	0.37	0.43	0.64
30-40,000		0.26	0.40	0.50	0.55
40-50,000	0.34	0.25	0.66	0.72	0.53
50-100,000	0.31	0.54	0.86	1.02	0.95
100,000+	0.40	0.52	0.97	1.22	0.76
Average:	0.07%	0.08%	0.17%	0.24%	0.24%
E. Average Qualifying Investment					
$0-5,000	$2667	$1818	$4039	$2920	$1108
5-10,000	370	1316	2628	7775	1246
10-15,000	2050	756	2275	2182	3102
15-20,000	1419	1653	2662	1629	2153
20-25,000	1594	1755	1807	2607	4455
25-30,000		3566	2340	3429	3831
30-40,000	894	2551	3106	3151	3343
40-50,000		2507	2209	2827	4341
50-100,000	3446	2721	3223	3671	4123
100,000+	3709	3763	3996	4275	4465
Average:	$1757	$2241	$2668	$2920	$3511
F. Average Credit Per Investor					
$0-5,000	$ 681	$ 464	$1615	$1168	$ 442
5-10,000	109	383	1050	310	498
10-15,000	556	221	909	873	1241
15-20,000	388	437	1061	651	861
20-25,000	424	459	723	1042	1782
25-30,000		868	936	1371	1532
30-40,000	239	650	1242	1260	1337
40-50,000		654	884	1131	1736
50-100,000	811	678	1289	1468	1649
100,000+	806	914	1598	1710	1786
Average:	$ 451	$ 573	$1067	$1168	$1404

Source: U.S. Department of the Treasury, Internal Revenue Service, Statistics of Income Division, "Individual Income Tax Returns, Analytical Table A" (unpublished), 1978-82.

TABLE 5

Distribution of Federal Energy Conservation Tax Credits 1978-1982

Income Class	1978	1979	1980	1981	1982
A. Value of Qualifying Investment ($ millions)					
$0-5,000	$ 21.3	$ 33.9	$ 33.4	$ 25.9	$ 46.9
5-10,000	138.8	195.2	152.4	103.1	105.0
10-15,000	424.5	303.5	251.9	179.3	142.2
15-20,000	503.0	453.1	328.9	244.3	186.1
20-25,000	797.9	468.2	425.8	311.1	220.8
25-30,000	564.6	452.4	406.6	322.8	261.6
30-40,000	885.6	560.3	582.0	593.8	453.5
40-50,000	0.0	205.7	301.1	327.8	247.4
50-100,000	226.7	195.6	260.1	274.0	246.3
100,000+	61.2	49.1	54.7	55.8	45.7
Total:	$3623.5	$2916.9	$2796.8	$2437.8	$1955.6
B. Total Tax Credit ($ millions)					
$0-5,000	$ 2.4	$ 5.1	$ 5.0	$ 3.9	$ 7.0
5-10,000	19.3	29.2	22.8	15.4	15.7
10-15,000	58.7	45.4	37.7	26.8	21.3
15-20,000	70.4	67.9	49.3	36.5	27.8
20-25,000	110.1	70.1	62.8	46.5	33.0
25-30,000	78.1	67.7	60.9	48.2	39.1
30-40,000	119.2	83.9	87.2	88.7	67.7
40-50,000	0.0	40.8	45.1	49.0	37.0
50-100,000	28.8	29.3	39.0	41.0	36.8
100,000+	6.8	7.4	8.2	8.4	6.8
Total:	$ 493.9	$ 436.8	$ 418.8	$ 364.2	$ 292.2
C. Average Tax Credit Per Household					
$0-5,000		$ 0.24	$ 0.25	$ 0.21	$ 0.39
5-10,000	$ 0.52	1.49	1.24	0.87	0.92
10-15,000		3.15	2.64	1.89	1.49
15-20,000	5.03	5.96	4.44	3.32	2.64
20-25,000	12.88	7.77	6.96	5.10	3.75
25-30,000	14.50	10.74	8.98	6.69	5.13
30-40,000		13.02	10.96	9.64	6.87
40-50,000	18.24	13.83	14.76	11.71	7.83
50-100,000	19.57	15.50	15.17	11.89	9.79
100,000+	19.14	16.29	14.61	12.76	9.24
Average:	$ 5.50	$ 4.71	$ 4.46	$ 3.82	$ 3.07

TABLE 5 Continued

Distribution of Federal Energy Conservation Tax Credits 1978-1982

Income Class	1978	1979	1980	1981	1982
D. Percent of Households Claiming Credit					
$0-5,000		0.26%	0.22%	0.17%	0.28%
5-10,000	0.63%	1.49	1.41	0.97	0.91
10-15,000		3.64	2.95	1.94	1.46
15-20,000	5.63	6.58	5.25	3.61	2.62
20-25,000	13.80	9.26	7.94	5.81	4.37
25-30,000		12.30	10.23	7.36	5.47
30-40,000	15.86	14.15	12.43	10.06	7.31
40-50,000		13.99	14.78	10.49	8.36
50-100,000	16.00	14.28	13.79	11.30	8.86
100,000+	12.54	11.89	10.98	9.15	6.92
Average:	5.79%	5.16%	4.88%	3.93%	3.14%
E. Average Qualifying Investment					
$0-5,000	$ 747	$ 617	$ 756	$ 802	$ 936
5-10,000	589	665	587	602	676
10-15,000	677	578	596	652	683
15-20,000	616	605	564	615	675
20-25,000	676	561	586	588	574
25-30,000		583	586	609	628
30-40,000	661	614	589	641	629
40-50,000		660	667	747	627
50-100,000	963	725	734	704	740
100,000+	1378	914	889	932	892
Average:	$ 697	$ 610	$ 610	$ 650	$ 654
F. Average Credit Per Investor					
$0-5,000	$ 84	$ 92	$ 113	$ 120	$ 140
5-10,000	82	100	88	90	101
10-15,000	94	87	89	97	102
15-20,000	86	91	85	92	101
20-25,000	93	84	88	88	86
25-30,000		87	88	91	94
30-40,000	91	92	88	96	94
40-50,000		99	100	112	94
50-100,000	122	109	110	105	111
100,000+	153	137	133	139	134
Average:	$ 95	$ 91	$ 91	$ 97	$ 98

Source: U.S. Department of the Treasury, Internal Revenue Service, Statistics of Income Division, "Individual Income Tax Returns, Analytical Table A" (unpublished), 1978-82.

$2.0 B in 1982, and federal tax expenditures declined from $493 M to $292 M during this period.

The distribution of average tax credits by income class, reported in part C of the table, is regressive, but much less so than the credits for renewable energy sources. A much larger fraction of households claim credits under this program, but neither the average qualifying investment nor the average credit per investor varies much by income class.

For both the federal renewable energy and the conservation tax credit programs, the regressivity of benefits arises more from variations in the proportion of households claiming credits by income class than from variations in credits claimed per investor.

Similar information is available on the California tax credit programs for wind and solar energy investments and for energy conservation investments. Tables 6 and 7 provide information on the kinds of investments undertaken by households claiming these credits. Table 6 refers to the California Wind and Solar Energy Investment program. As Part A of the table indicates, total claims for tax credits under this program increased from 16,800 household returns in 1978 to a high of 85,100 returns in 1980. In the most recent year for which data are available, 1983, over 57,000 state personal income tax returns claimed credit for investment in wind and solar energy. Part B of the table indicates the reported amount of wind and solar investment qualifying for the tax credit. The reported investment has steadily increased from $31.4 million in 1978 to over a half billion dollars in tax year 1983. During the first three years of the program, qualifying investments were heavily concentrated in the heating of swimming pools and recreational spas. About half of the investments claimed

TABLE 6
Distribution by Type of California Wind and Solar Energy Investments Qualifying for Tax Credits 1978-1983

	1978	1979	1980	1981	1982	1983
A. Number of Claims (thousands)						
Pool, Spa	10.9	32.9	60.6	16.9	8.5	4.2
Water	1.7	4.4	17.3	30.9	28.3	36.2
Heat/AC	2.3	1.0	2.8	3.1	4.0	6.5
Wind	0.0	0.8	0.0	0.1	1.9	6.4
MF/Solar	1.9	1.8	4.3	10.0	8.3	4.0
Total	16.8	41.0	85.1	61.0	51.0	57.3
B. Value of Qualifying Investment ($ millions)						
Pool, Spa	$ 16.2	$ 46.2	$ 92.8	$ 48.4	$ 18.5	$ 8.0
Water	6.2	17.5	60.1	117.0	110.1	192.2
Heat/AC	3.9	5.4	14.6	6.6	47.4	71.3
Wind	0.0	2.9	0.1	8.3	101.5	253.5
MF/Solar	5.2	10.5	23.7	56.5	52.3	28.1
Total:	$ 31.4	$ 82.6	$191.4	$236.8	$329.8	$553.1
C. Distribution of Qualifying Investments (%)						
Pool, Spa	51.6%	56.0%	48.5%	20.4%	5.6%	1.5%
Water	19.6	21.3	31.4	49.4	33.4	33.4
Heat/AC	12.2	6.4	7.6	2.7	14.4	12.8
Wind	0.0	3.5	0.1	3.5	30.8	45.8
MF/Solar	16.7	12.7	12.4	23.9	15.8	5.1
Total:	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Notes: AC, air conditioner
MF, multi-family dwelling

Source: Unpublished tabulations provided by the State of California, Franchise Tax Board, FTB/SSB, 3/8/83.

during the years 1978-1980 were in those categories. When the law was amended to phase out the eligibility of these investments, the mix shifted rather rapidly. During the 1981-1983 period, qualifying investments in solar hot water systems more than tripled to $192 million, and investments in solar heating and air conditioning systems increased to $71.3 million. The most substantial increase, however, was in wind systems. The distribution of investments is noted in Panel C of the table. It indicates that about a third of the qualifying investments during the latter period have been made in hot water systems, and an eighth in heating and air conditioning. In 1983, almost forty-six percent of qualifying investment was made in wind systems.

Table 7 presents similar information for California Energy Conservation Tax Credits which went into effect in 1981. The table indicates the number of claims, the value of the qualifying investments and the distribution of those investments. As the table indicates, the number of households claiming the credit has been substantial, between 190,000 households and 240,000 households, or more than four times the number claiming wind and solar energy tax credits. The value of the qualifying investments is substantially less, however, varying between $195 million and $230 million. As the table indicates, insulation expenditures have made up about half of the total qualifying investments. Storm windows have increased from six to fifteen percent of total investment and heating and cooling devices have increased from a smaller base. A little less than one third of the total qualifying investment is claimed in multi-family dwellings (where it is not possible to identify the particular system which has been installed).

TABLE 7

Distribution by Type of California Energy Conservation Investments Qualifying for Tax Credit 1981-1983

	Number of Claims (thousands)			Value of Qualifying Investments ($ millions)			Distribution of Qualifying Investments (%)		
	1981	1982	1983	1981	1982	1983	1981	1982	1983
Pool Cover	22.7	15.8	10.4	$16.7	$4.8	$4.9	8.6%	2.1%	2.5%
Insulation	131.1	135.3	99.2	93.7	135.8	88.1	48.0	59.0	45.3
Caulking, Vent Dampers, etc.	11.7	8.6	11.8	2.6	6.0	3.3	1.4	2.7	2.0
Storm Windows	10.7	15.6	16.0	11.5	18.3	28.3	5.9	7.9	14.6
Heat/Cooling Devices	2.4	4.1	8.7	2.2	3.7	11.6	1.2	1.6	5.8
Multifamily	35.0	44.1	44.8	48.2	60.3	56.9	24.7	26.2	29.2
Other	10.5	0.6	1.1	20.5	1.3	0.8	10.5	0.6	0.4
Total:	239.7	229.7	191.9	$195.4	$230.2	$194.6	100.0%	100.0%	100.0%

Source: Unpublished Tabulations Provided by State of California, Franchise Tax Board, FTB/SSB, 8/15/84.

Tables 8 and 9 present information on these two state programs by income class. They are thus directly comparable to tables 4 and 5 for the federal programs.

Table 8 refers to the distribution of solar and wind energy tax credits by income class. Part A of the table shows the distribution of qualifying investments made by households of varying income categories. Households of higher incomes tend, on average, to claim more in qualifying investments. Households of the lowest income class also report larger investments. In part, of course, this reflects the peculiar economic circumstances of those who report tax losses for state income purposes. Over time, it appears that the concentration of qualifying investments among households of the highest income classes has increased. By 1983, for example, $235 million of the $554 million in qualifying investments was made by households whose adjusted gross income was greater than $100,000. Similarly, over time the total tax credit has become both larger and more concentrated among households of higher incomes. Part B notes these trends; the total tax credit increased from $6.5 million in 1978 to $126 million in 1983. By 1983, $98 million of the $126 million aggregate credit was claimed by households whose incomes exceeded $50,000 per year. In fact, the tax credits generated by households with incomes greater than $100,000 per year exceeded all the credits distributed through the entire program two years previously. Part C of the table indicates that the average tax credit for households in the state has been relatively small, at least until 1983. The tax credit increases with the income of the households, and only for the highest income households is it a large number. By comparison, though, it should be noted that in 1985 the renters' tax credit for joint filers was $137 per year and the credit for an additional personal exemption on California income taxes was $13 per year.

TABLE 8
Distribution of California Wind and Solar Energy Tax Credits by Income Class 1978-1983

Income Class	1978	1979	1980	1981	1982	1983
A. Value of Qualifying Investment ($ millions)						
$0-5,000	$ 1.7	$ 0.9	$ 9.7	$ 7.5	$ 2.9	$ 15.3
5-10,000	0.1	0.3	3.6	5.0	0.4	2.5
10-15,000	0.4	4.7	6.2	1.6	3.4	2.6
15-20,000	1.4	2.6	12.0	5.1	4.5	15.7
20-25,000	4.1	4.6	11.5	22.6	5.1	12.3
25-30,000	3.4	11.5	11.1	11.0	22.0	15.1
30-40,000	6.5	11.6	34.4	51.5	41.6	41.9
40-50,000	3.8	15.1	20.7	23.7	36.3	47.9
50-100,000	7.3	22.3	61.6	76.2	91.2	165.1
100,000+	2.5	9.0	20.7	32.7	122.4	235.5
Total:	$ 31.4	$ 82.6	$191.4	$236.8	$329.7	$554.0
B. Total Tax Credit ($ millions)						
$0-5,000	$ 0.0	$ 0.0	$ 2.7	$ 2.1	$ 0.7	$ 2.4
5-10,000	0.0	0.0	0.7	0.9	0.1	0.5
10-15,000	0.0	0.3	1.1	0.1	0.5	0.5
15-20,000	0.1	0.6	2.6	1.1	0.9	3.3
20-25,000	0.3	0.9	3.3	4.6	0.6	1.7
25-30,000	0.3	2.3	2.7	2.5	4.8	2.4
30-40,000	1.7	3.1	10.6	10.3	8.8	8.4
40-50,000	0.9	6.1	6.5	5.2	7.1	9.0
50-100,000	2.2	7.9	21.1	18.8	21.5	36.6
100,000+	0.9	3.5	6.7	8.8	31.3	61.2
Total:	$ 6.5	$ 24.8	$ 58.0	$ 54.5	$ 76.4	$125.7
C. Average Tax Credit Per Household						
$0-5,000	$ 0.00	$ 0.00	$ 1.19	$ 0.93	$ 0.34	$ 1.12
5-10,000	0.00	0.01	0.42	0.46	0.08	0.29
10-15,000	0.02	0.21	0.72	0.09	0.37	0.29
15-20,000	0.08	0.55	2.23	1.00	0.73	2.70
20-25,000	0.37	0.97	3.43	4.82	0.68	1.72
25-30,000	0.52	3.48	3.68	3.26	5.87	2.92
30-40,000	2.79	3.90	11.50	9.94	8.08	7.43
40-50,000	4.20	19.39	14.49	9.09	11.66	13.44
50-100,000	10.79	28.86	56.35	37.33	34.63	47.19
100,000+	18.62	54.48	80.89	90.20	275.44	446.47
Average:	$ 0.69	$ 2.43	$ 5.61	$ 5.11	$ 7.13	$ 11.48

TABLE 8 Continued

Distribution of California Wind and Solar Energy Tax Credits by Income Class 1978-1983

Income Class	1978	1979	1980	1981	1982	1983
D. Percent of Households Claiming Credit						
$0-5,000	0.02%	0.01%	0.09%	0.08%	0.03%	0.03%
5-10,000	0.00	0.01	0.10	0.10	0.01	0.06
10-1,0000	0.06	0.07	0.17	0.07	0.08	0.13
15-20,000	0.14	0.19	0.59	0.19	0.14	0.22
20-25,000	0.30	0.41	0.74	0.62	0.19	0.36
25-30,000	0.27	0.92	1.05	0.46	0.46	0.47
30-40,000	0.57	1.11	1.85	1.54	0.92	0.83
40-50,000	1.15	2.49	2.85	1.31	1.44	1.43
50-100,000	1.28	3.07	5.76	3.25	2.50	2.18
100,000+	1.15	3.65	6.70	4.96	6.57	5.87
Average:	0.18%	0.40%	0.82%	0.57%	0.48%	0.52%
E. Average Qualifying Investment						
$0-5,000	$3412	$3600	$4463	$4153	$ 5091	23049
5-10,000	2494	2766	2054	2936	1450	2520
10-15,000	538	4486	2283	1527	3102	1473
15-20,000	843	1160	1744	2259	2548	5819
20-25,000	1545	1221	1627	3829	2852	3464
25-30,000	2018	1869	1456	3089	5943	3981
30-40,000	1841	1312	2030	3240	4144	4500
40-50,000	1478	1933	1614	3135	4146	5012
50-100,000	2843	2658	2858	4640	5876	9779
100,000+	3510	3752	3711	6743	16379	29257
Average:	$1870	$2014	$2250	$3884	$ 6471	$ 9675
F. Average Tax Credit Per Investor						
$0-5,000	$ -0-	$ -0-	$1252	$1163	$1298	3581
5-10,000	-0-	136	428	487	508	490
10-15,000	44	305	420	129	489	233
15-20,000	61	293	379	526	504	1206
20-25,000	125	236	464	782	360	471
25-30,000	189	379	349	710	1285	628
30-40,000	492	350	623	646	878	900
40-50,000	364	777	508	693	810	937
50-100,000	844	941	978	1148	1386	2168
100,000+	1243	1491	1206	1818	4190	7604
Average:	$ 390	$ 606	$ 682	$ 894	$1500	$2196

Source: Unpublished tabulation provided by State of California, Franchise Tax Board, FTB/SSB, 8/15/84.

The fraction of households claiming the tax credit clearly increases with income, and for the highest income categories it is on the order of two to six percent. In 1982, about 2-1/2 percent of households earning between $50,000 and $100,000 claimed the tax credit; 2.18 percent claimed it in 1983. 6-1/2 percent of households earning greater than $100,000 claimed a credit in 1982, and 5.9 percent claimed it in 1983. Part F of the table indicates the average qualifying investment made by households of different income classes. Again, the table reveals that for households which have made investments in solar and wind systems, the average level of the investment is rather high, until recently ranging between $1,500 and $6,000 per year; it also increases with income. During the last two years, the level of investment by the highest income households has increased substantially. The concentration of the credit in the highest income classes and the very large qualifying investments reflect the surge in investment in "wind farms" during the past few years. Finally part F of the table shows the average credit claimed by those who claim tax credits. The credit varies between $350 and $1,000 for middle income households, but increases to $2,200 to $7,600 for the highest income categories.

Table 9 provides similar information for the California Energy Conservation Tax Credit program introduced in 1981. Part A of the table indicates the value of the qualifying investments in millions of dollars. In contrast to solar and wind energy tax credits, conservation investments do not increase as markedly with income. Neither, in fact, does the total tax credit, which has varied between $50 and $61 million during the period 1981-1983. Because the number of households claiming energy conservation credits is so much larger than those claiming solar and wind energy credits (as noted in Part D of the table), the average credit per household in the California population is not too different by income class. Middle income households are five to ten times more likely

TABLE 9
Distribution of California Energy Conservation Tax Credits by Income Class
1981-1983

Income Class	1981	1982	1983
A. Value of Qualifying Investment ($ millions)			
$0-5,000	$ 6.5	$ 3.1	$ 2.5
5-10,000	5.1	5.9	6.8
10-15,000	12.0	10.6	4.4
15-20,000	19.7	10.4	10.8
20-25,000	19.2	19.8	12.2
25-30,000	21.6	24.0	24.7
30-40,000	44.2	37.8	39.4
40-50,000	26.7	30.9	28.8
50-100,000	31.7	71.4	47.3
100,000+	8.5	16.4	17.7
Total:	$195.4	$230.4	$194.6
B. Total Tax Credit ($ millions)			
$0-5,000	$ 2.2	$ .1	$ .8
5-10,000	1.4	1.6	1.7
10-15,000	3.2	2.9	1.2
15-20,000	4.0	2.8	2.6
20-25,000	5.2	5.3	3.1
25-30,000	5.8	6.4	5.9
30-40,000	12.2	10.2	10.2
40-50,000	7.5	8.1	7.2
50-100,000	9.0	18.7	12.2
100,000+	2.4	4.1	4.5
Total:	$ 52.8	$ 61.1	$ 49.5
C. Average Tax Credit Per Household			
$0-5,000	$ 0.97	$ 0.42	$ 0.36
5-10,000	0.78	0.96	1.00
10-15,000	2.12	2.05	0.87
15-20,000	3.41	2.30	2.13
20-25,000	5.40	5.57	3.14
25-30,000	7.56	7.96	7.29
30-40,000	11.83	9.34	9.01
40-50,000	12.97	13.41	10.85
50-100,000	17.74	30.08	15.79
100,000+	24.59	35.88	33.22
Average:	$ 4.96	$ 5.70	$ 4.52

TABLE 9 Continued

Distribution of California Energy Conservation Tax Credits by Income Class
1981-1983

Income Class	1981	1982	1983
D. Percent of Households Claiming Credit			
$0-5,000	0.21%	0.11%	0.07%
5-10,000	0.38	0.36	0.29
10-15,000	1.05	0.90	0.41
15-20,000	2.02	1.22	1.21
20-25,000	2.82	2.63	1.77
25-30,000	3.80	3.34	3.16
30-40,000	4.14	4.64	3.63
40-50,000	6.35	6.56	4.30
50-100,000	7.30	7.09	5.87
100,000+	5.74	6.04	5.16
Average:	2.25%	2.14%	1.75%
E. Average Qualifying Investment			
$0-5,000	$1337	$1228	$1791
5-10,000	750	977	1372
10-15,000	763	822	777
15-20,000	825	699	740
20-25,000	711	794	709
25-30,000	737	889	958
30-40,000	833	745	963
40-50,000	732	776	1006
50-100,000	881	1622	1038
100,000+	1523	2385	2496
Average:	$ 815	$1003	$1014
F. Average Tax Credit Per Investor			
$0-5,000	$454	$385	$548
5-10,000	202	269	345
10-15,000	202	228	212
15-20,000	169	188	176
20-25,000	191	212	178
25-30,000	199	238	231
30-40,000	230	201	248
40-50,000	204	204	252
50-100,000	243	424	269
100,000+	429	594	643
Average:	$220	$266	$258

Source: Unpublished tabulation provided by State of California, Franchise Tax Board, FTB/SSB, August 15, 1984.

to claim energy conservation tax credits than to claim wind and solar energy tax credits. As part E of the table indicates, the average qualifying investment is substantially lower for energy conservation than for wind and solar, averaging on the order of $1,000 per qualifying investment. There is some tendency for investments increase with income.

Finally, the average tax credit claimed per investor is also substantially lower than for solar and wind credits; it averages about $250 per claim. Again, there is a rather pronounced tendency for tax credits to increase with the income of households (again, with the exception of the very lowest adjusted gross income category, which includes some very wealthy households). At the highest income classes, the average credit claimed per investing household is between $270 and $650.

C. Evaluation

An economic rationale for these expensive and regressive subsidy programs may be based upon one of two arguments. First, consumers may be unable to evaluate appropriately the savings arising from investments in retrofit activities or to act upon that evaluation. A variety of engineering standards are routinely set to protect consumers from the consequences of their own ignorance, and these subsidy programs could be seen as a less draconian regulatory device. If consumers are in fact capable of calculating their self-interest, liquidity constraints could still prevent them from investing in appropriate in retrofit technologies. In this latter circumstance, however, tax credit programs are likely to be inferior to revolving funds offering consumers market rate loans for conservation investments.

Secondly, if consumers are neither ignorant nor capital constrained, their optimizing decisions regarding conservation investment may be based upon energy prices which do not represent scarcity or societal costs. In particular, if energy prices are controlled or regulated by other policies, then even informed consumer choices would lead in general to underinvestment in energy saving residential capital.

Other economic arguments are sometimes made to justify investments in alternative energy sources, such as solar heating systems and wind farms. These rationalizations are typically based upon some variant of the infant industry argument: public investments will facilitate scale economies which will reduce investment costs and hence energy costs to consumers over some longer run. With efficient energy prices, of course, there is no more reason to subsidize the exploitation of these scale economies using public funds than to subsidize the exploitation of scale economies in the auto industry.

These basic economic issues relevant to the evaluation of tax credit programs are not well represented in those studies purporting to measure the effectiveness of these federal and state tax credit programs.

To date, nine studies purporting to determine the effectiveness of federal residential energy tax credits have been completed.[3] None of these studies conclusively determines the overall effectiveness of the system of energy tax credits for renewable energy sources or for conservation. Some of the studies noted below provide only indirect evidence or implications consistent with ef-

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[3] We have been unable to locate any studies purporting to evaluate the California tax credit programs.

fectiveness or ineffectiveness. Others measure effectiveness by the growth of the market for alternative energy devices or by the market penetration of these devices. In general the evidence is weak, and the empirical testing is inadequate or inconsistent.

Two studies commissioned by the Department of Energy (DOE), Office of Conservation and Renewable Energy, examined the impact of the residential energy tax credit on the development of solar technology. Arthur D. Little (1981), examined the market development of solar technologies, projected energy savings, and estimated the net cost to the government of providing investment tax credits. The study concludes that the value of energy savings outweighs the cost of the tax credit to the federal government. This conclusion is apparently based on the assumption that tax credits result in a net increase in total investment in the U.S. economy, not merely a shift in resources from one type of investment to another. No evidence is presented to support this.[4] If tax credits do not stimulate aggregate investment, then the result of the study would be very different.

The second DOE study, conducted by the Urban Systems Research Corporation (1981), concluded that the profitability and competitiveness of solar energy equipment are both highly sensitive to the level of tax credit, but also to interest rates and the real rate of increase of energy prices in the economy. The authors compute internal rate of return (IRR) and the profitability of a variety of new technologies. Included in the calculations the IRR are:

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[4] In contrast, past studies on the investment tax credit (ITC) have suggested that the ITC changes the composition of investment but has little effect on the aggregate level of investment in the economy.

renewable energy tax credits, investment tax credits and the then current business depreciation schedule. The profitability and competitiveness of solar equipment is quite sensitive to the level of tax credits available, the method of financing and the real rate of inflation in energy prices. The calculations suggest that with a 2.8 percent per year real increase in energy prices, no solar equipment would be attractive before the year 2,000.[5] The analysis also indicates that if the real energy prices rise by 4.3 percent during 1980-2000, virtually all technologies would achieve the required internal rate of return under the existing law with a 25 percent business energy investment tax credit. However, the authors conclude that even if the current business investment tax credits were extended through 1990, rapid substitution of solar for conventional equipment would not occur.

Two studies also sponsored indirectly by the U.S. Department of Energy have addressed Federal energy conservation credits. The ICF-Mathematica (1981) study develops an econometric model to evaluate the various factors influencing household decisions to invest in energy conservation equipment. The model relates the decision to invest in energy saving equipment to household demographic considerations, incomes, relative prices, and estimated fuel savings from these conservation measures.[6] The statistical results suggest that households are more than likely to respond to the expected savings and fuel bills than to the cost of the conservation equipment in their decisions about investment. This

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[5] The only exception is so-called "solar ponds" which could achieve a target 20 percent internal rate of return by 1990.

[6] The study is based upon data on individual households gathered by the Department of Energy's, National Interim Consumption Survey 1980, and the Annual Housing Survey of the U.S. Census for 1975, 1976 and 1977.

could imply that government money would be spent more effectively in developing efficient technologies to increase energy savings. The findings also suggest that: households headed by older individuals are less likely to invest; most conservation efforts are concentrated among households in single family detached units; and that conservation expenditures increase substantially with income.

The Charles Rivers (CRA) study identifies social benefits, energy savings, and the cost to the federal government of household investments in insulation, storm windows, and doors (categories which accounted for 87 percent of total energy conservation expenditures in 1978). The report also analyzes investment in solar hot water heaters. CRA develop an econometric model of household purchases to estimate the probability of investment in energy saving equipment. From this the market demand for energy saving investment is derived. Finally, the market penetration of these technologies is estimated by postulating an investment supply schedule and equating supply to demand. These calculations are then used to estimate social benefits and revenue losses as a result of tax credits. The authors conclude that the benefits from energy tax credits are highest for wall insulation, storm windows and roof insulation. (That is, the tax loss per barrel of oil saved is the lowest for these categories). In contrast, storm doors and solar hot water heaters result in high tax losses per barrel of oil saved.[7]

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[7] A key assumption in the model is that household energy consumption behavior does not change after an investment is made. For example, the model assumes that households leave the thermostat position unchanged after purchasing insulation. However, given the effect of insulation on energy bills, individuals may set the thermostat at higher comfort levels and still pay less than without insulation.

Lazzari (1982) also provides an econometric investigation of the effect of residential energy and conservation tax credits on consumer energy expenditures. His econometric model relates energy expenditures per household to measures of the relative price of energy, household income, and a dummy variable representing the availability of federal tax credits. The regressions are estimated for the period 1960-1979 using aggregate national data on average residential energy expenditures per household, energy prices, income, and a dummy variable equal to one during the years 1977, 1978 and 1979 when the tax credit was available. The dummy variables for the years in which the tax credits are available are small in magnitude and by and large insignificantly different from zero, although they often have the correct sign.[8]

The recent analysis of the production of housing and the derived demand for residential energy by Quigley (1984) provides some information on the effectiveness of conservation tax credit programs. Estimates of the production function relating energy inputs, land, and real estate to housing output and estimates of consumer demand for output can be combined to indicate the relationship between investment subsidies and energy savings. This analysis suggests that if society valued each dollar's worth of energy at $1.19 then the federal program of conservation tax credits would be fully justified. In contrast, it would require a substantially larger mispricing of energy to justify the California conservation tax credit program on these terms; one dollar's

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[8] The author notes that in 12 of the 40 specifications of the model presented (that is 30 percent of the time) the tax credit variable is statistically significant at the .90 level and is inversely related to energy use per household, The variable is never significant in regression equations which include the price of energy and the recent change in the price of energy, that is, the contemporaneous and the lagged energy price change.

worth of energy at market prices would have to be worth about $1.65 to justify the program on economic grounds.[9]

All in all, this evidence about the economic effectiveness of tax credits is quite weak indeed. This should be particularly distressing, given the pronounced regressivity of these subsidies.

III. CONSERVATION PROGRAMS OF PUBLIC UTILITIES

All eight of the large investor owned public utilities in California encourage residential energy conservation by providing services and subsidies financed by general rate payers. These programs include low interest financing, residential audits, hardware rebates, and information programs. Some of these programs are mandated by the State Legislature, the California Energy Commission, or the Public Utilities Commission. Others have been initiated by the utilities themselves. In this section, we describe nine such programs undertaken in California. The discussion places more emphasis on the solar financing program merely because more is known about this activity.

Solar Financing

In 1978, the California State Legislature instructed the California Public Utilities Commission (PUC) to "investigate the feasibility of alternative methods of providing low interest, long-term financing of solar energy systems

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[9] These numerical results are subject to a variety of qualifications: the empirical results are based upon data for newly constructed FHA insured single detached housing; they refer exclusively to owner occupants; they assume that consumers and producers act competitively, given the prices of energy and other goods which they face, etc.

for utility customers." (Hausker and Bardach, 1983). This directive was consistent with the state's strong commitment to develop renewable energy sources reflected in the massive tax subsidies noted earlier. It arose from concerns over the slow rate of market penetration by solar energy systems. In addition, it was apparently motivated by the perceived inequities in the existing solar income tax credit. Recall, at this time more than half of state tax expenditures for energy were used to subsidize the heating of swimming pools and spas.

In 1980, the PUC directed the four major investor-owned utilities (PG&E, SCG, SCE and SDGE) to assist in financing the installation of up to 200,000 solar water heaters in 375,000 existing residences. Under the resulting program, consumers who replaced their electric, gas, propane or butane water heating system with a certified solar heated system were eligible to receive quarterly rebate payments. The program also offered low-interest loans for the retrofit of solar water heating systems in existing residences. Table 10 summarizes the types and the levels of subsidies ordered by the PUC as well as the goals for market penetration. It also notes the utility savings estimated by the PUC. In addition to the goals of increasing the market penetration of solar heating systems, the Public Utilities Commission had its own equity goals clearly in mind -- the PUC ordered public utilities to supply almost 1,800 solar water heating systems free to low-income families at a net cost of $6.2 million. In this way the PUC hoped to avoid the major criticism leveled at the solar tax credit, namely that it benefited upper-income households at the expense of general taxpayers. The PUC program also included 20 year loans at six percent interest rates to gas customers in two of the four utility service areas covered by the demonstration program.

TABLE 10

California Demonstration Solar Financing Program Subsidies

Target Market	Type of Subsidy	Subsidy per Dwelling	Market Penetration Target	Target Percent of Total Market	Estimated Utility Savings ($thousand)
Single-family, electric	Credit	$720[a]	70,940	15	$ 48,050[d]
Single-family, gas	Credit	$960[b]	21,000	0.5	-10,770
Single-family, gas	Low interest loan	6%, 20-year loan	18,500	0.5	-10,670
Multifamily, gas	Credit	$288 per apartment[c]	266,600	10	-20,310
Low-income families	Free solar system	100% of cost	1,780		- 6,260
Total			378,820		$ 40

Source: Compiled from Karl Hausker and Eugene Bardach, "Encouraging Solar Water Heating: Some Implmentation Issues," in The Social Constraints on Energy-Policy Implementation, Lexington, MA, DC Heath & Co., 1983, pp. 63-89. See also, PUC Decision 92251, September 16, 1980.

[a] Twenty dollars per month for thirty-six months (present value at 10 percent: $615).

[b] Twenty dollars per month for forty-eight months (present value at 10 percent: $783).

[c] Eight dollars per month per apartment unit for thirty-six months (present value at 10 percent: $246).

[d] Calculated according to the PUC's own methodology. PUC Decision 92251, September 16, 1980, table III. Estimate ignores administrative costs.

This program had several objectives. One was to assist low and moderate income households, who may have neither the resources nor the access to credit, to purchase a system. A second was to buffer swings in commercial lenders' policies towards loans for solar hot water systems. A third objective was to ascertain the extent of consumer interest in subsidy programs, using cash payments. The desire to reach low-income households was also undoubtedly part of the commission's motivation in extending cash credits.

Residential Conservation Audits

The Residential Conservation Service (RCS) program, monitored by the California Energy Commission, was mandated in 1978 by the National Energy Conservation Policy Act. Residents of single-family dwellings and small apartments (multi-family dwellings with no more than four units) are eligible to receive a free conservation audit. This audit involves the inspection of the dwelling by a utility representative who, with the help of a computer analysis, then recommends specific conservation measures. The utilities focus on the so-called "Big Six" measures which are known to save energy -- ceiling insulation, caulking, weatherstripping, water heater blankets, duct wrap, and low-flow showerheads. The firms also provide information about the availability of Federal and state tax credits and financing under other programs.

Weatherization Financing

All eight of California's investor owned utilities offer financing incentives to encourage customers to install selected conservation measures. Each firm has arranged its own subsidy program; the range of plans includes zero interest rate loans, loans at 8 percent interest, monthly or lump sum rebates for the installation of specific measures, and installations provided to the consumer "at cost." Under each program, the Big Six measures are eligible for subsidized finance. Other measures may also be financed, however, contingent upon installation of the six most important measures and on their efficacy, as determined by the RCS audit.

One specific program is the so-called Zero Interest Program (ZIP) sponsored by the Pacific Gas and Electric Company through its subsidiary, Pacific Conservation Services. Through this program, PG&E offers loans to eligible Californians for the financing of certain energy conservation measures.[10] Conservation measures may be installed by the individual or by a California contractor licensed to participate in the program. Under this program, consumers can receive a loan for up to $1,000 for ceiling insulation, caulking, weatherstripping, duct wrap, low-flow showerhead and water heater blankets. In addition, a loan of up to $2,500 may be obtained if recommended by the RCS audit for other measures such as floor insulation, storm or thermal windows or doors, set-back thermostats, lighting conversion, intermittent ignition devices, or common area lighting. Under this program, the amount eligible for zero interest rate financing is paid back in 48 equal installments without interest. At a market interest rate of 10 percent, the present value of the subsidy in a $3,500 loan of this type is about $650.

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[10] To be eligible for the program, the individual or the household must meet several criteria. The individual must have been a customer of PG&E for 12 of the previous 24 months with an adequate payment record. (A new PG&E customer may be accepted upon written verification of credit from the previous utility.) The residence served must be a single-family home, mobile home, or a mulish-family complex built prior to January 28, 1981 and located within the PG&E service area. A single-family or a mobile home must be occupied at least six months of the year; in a multi-family complex, all units must be occupied nine months of the year. The minimum amount which can be financed is $85 with a minimum monthly payment of $5.

Direct Weatherization

The direct weatherization program provides matching grants (rebates) or free installation of weatherization measures and selected structural repairs for housing designated by community action groups. The program subsidizes weatherization in low income housing in an attempt to ensure that the proportion of low income households participating in weatherization programs equals the proportion in the overall consumer population. Five of the eight major California utilities are involved in this program of direct cash payment or in kind provision.

Conservation Hardware

Several of the utility companies offer direct payments (rebates) to households installing water heater blankets and low-flow showerheads. All utilities provide some financial encouragement to residential customers to purchase energy saving devices such as setback thermostats and swimming pool covers. The utility may sell these devices itself, offer rebates for commercially available devices, or work with appliance dealers on sales promotion via rebates.

Seasonal Pilot Light

Utilities advertise to encourage and to educate customers to turn off furnace pilot lights during the summer months. Service personnel will relight pilots in the fall for customers who, for any reason, request the service.

Builder Conservation

In contrast to those residential energy conservation programs directed towards improving energy efficiency in existing homes, builder conservation programs encourage energy efficiency in the design and construction of new homes. Promotional measures enhance design standards which exceed local, state, and Federal building standards.

Master Meter Conversions

Conversion from a master to individual gas or electric meters in multi-unit complexes presumably enhances conservation by facilitating pricing at the dwelling unit level. Several utilities subsidize these conversions.

Other Residential Conservation

In addition to the preceding programs, the utilities are involved in a variety of other conservation activities, generally informational in nature. They include educational programs, community volunteer training, conservation awards and others.

Table 11 summarizes ratepayer expenditures on these programs for the past three years. For each program, the table presents annual costs, the number of affected dwellings, and the gross subsidy per affected dwelling. The table also reports the PUC estimate of the annual savings in oil associated with each program and the program cost per barrel of oil saved in the first year.[11]

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[11] We have been unable to review the methodology underlying all these estimates of energy savings. For RCS audits, the estimates are based on empirical evidence, at least for the data reported by the Pacific Gas & Electric Company. PG&E compared energy consumption at two points in time by audited households with the energy consumption at the same points by a sample of non audited rate payers. See Pacific Gas & Electric Company (1963).

TABLE 11

Summary of Utility Financed Residential Conservation Programs in California 1983-1985

Year	Program Cost ($thousands)	Dwellings Affected	Gross Subsidy Per Dwelling	Annual Barrels of Oil Saved (thousands)	Pgm. Cost Per Barrel Saved in First Year	Present Value of Pgm. Cost Per Barrel@
RCS Audits						
1983	$ 31,226	476,794	$ 65	456	$ 68.48	$ 20.53
1984	28,492	504,192	57	324	87.94	26.38
1985	16,981	417,453	41	256	66.33	19.90
Weatherization Finance						
1983	94,879	501,334	189	797	119.04	35.71
1984	112,916	467,509	242	724	155.96	46.79
1985	129,764	523,826	248	1,637	79.27	23.77
Direct Weatherization						
1983	27,920	42,840	652	99	282.02	84.61
1984	42,313	81,791	517	188	225.07	67.53
1985	44,631	120,983	369	214	208.56	62.57
Solar Financing						
1983	24,513	72,243	339	152	161.27	48.39
1984	33,212	88,202	377	173	191.98	57.60
1985	27,940	None+		None+		
Conservation Hardware						
1983	13,288	N/A	N/A	310		
1984	3,988	42,092	210	209	43.00	12.90
1985	7,999	41,509	193	128	62.49	18.77
Seasonal Pilot Light						
1983	1,399	3,767,000*	N/A	1,989	0.70	0.70
1984	1,299	3,414,988*	N/A	1,512	0.86	0.86
1985	1,106	3,584.952*	N/A	1,720	0.64	0.64
Builder Conservation						
1983	1,898	N/A	N/A	50	37.96	11.40
1984	2,214	N/A	N/A	63	35.14	10.55
1985	2.203	14,579	151	28	78.68	23.63
Meter Conservation						
1983	813	N/A		15	54.20	16.28
1984	932	14,061#	66	13	71.69	21.53
1985	833	10,998#	76	6	138.83	41.69

Notes: N/A Not available
* Number of pilot lights affected
# Number of master meters converted
@ Assuming 20 percent depreciation in effectiveness of investment, 40 year useful life, 10 percent discount rate and constant fuel prices.
+ Program closeout phase

Source: State of California Public Utilities Commission, Energy Branch, Energy Conservation Program Summary, 1983, 1984, 1985

The table also presents a crude estimate of the implicit value of a barrel of oil as a measure of the effectiveness of each program. These calculations assume that the investments made under these programs last for forty years, and their effectiveness in saving energy declines at 20 percent per year. At constant energy prices, the present value of expenditures per barrel of oil saved (at a 10 percent rate of interest) is shown in the last column for each program. These calculations of program effectiveness are hardly very accurate. Nevertheless, they do suggest that, at least some of these programs are rather ineffective. For example, under the solar financing program general ratepayers are observed to pay $50-$60 per barrel of oil saved. Under the direct weatherization program, the implicit payments are even higher -- $60-$85 per barrel.

IV. MANDATED STANDARDS FOR NEW CONSTRUCTION

A. Federal Policy

ASHRAE 90-75

In 1973, the National Conference of States on Building Codes and Standards (NCSBCS) requested the National Bureau of Standards (NBS) to develop a standard for energy conservation in buildings. The objective of the proposed standard was to bring consideration of energy conservation into the design process for building shapes, orientation, insulation, and mechanical and electrical systems. The standard was envisioned as the first step in improved conservation through voluntary building codes.

The standard, "Design and Evaluation Criteria for Energy Conservation in New Buildings" (NBSIR-74-452), was promulgated in February 1974. It outlined criteria for heat transfer through building walls and roofs, for heating, ventilation, and air conditioning (HVAC) systems, service water heating, electrical distribution and power factors, and lighting.

The performance budget approach of the document came under much criticism. Because some provisions were written in performance language rather than in prescriptive form, it was argued that small builders, designers, and code enforcement officials would be unable to verify compliance.

The NBS document was intended to provide a foundation for improved standards under normal voluntary codes. After some controversy, the American Society of Heating, Refrigeration, and Air Conditioning Engineers accepted and sponsored the new standard: ASHRAE Standard (90-75) "Energy Conservation in Building Design." When compared with the original NBS document, ASHRAE claimed to have used more responsive and flexible thermal response factors. These factors differentiated standards by building type, latitude, heating degree days, and shading coefficients. While calling the draft "an excellent compendium of engineering considerations and recommended practices", the American Institute of Architects (AIA) found fault with the document, claiming that the greater potential for energy conservation lay in exploring an array of alternative strategies, not in adopting a "perspective standards" approach.

Despite heavy AIA criticism, ASHRAE stood by its prescriptive code. Initially, the International Conference of Building Officials (ICBO), the Southern Building Code Congress (SBCC), the Building Officials and Code Administrators International (BOCA) and the American Insurance Association opposed the controversial prescriptive standard.

At the same time, Arthur D. Little conducted a federally funded study of ASHRAE 90-75. Their findings were "astounding." The study suggested that "... it appears that the ASHRAE 90 modified buildings should cost no more to build and will have significantly less annual energy costs. Furthermore, even if the total initial cost did increase, the savings in operating cost (over those of conventionally-designed buildings) would more than recover such costs in a couple of months. If instituted by all states, ASHRAE 90 could reduce the annual energy consumed in new construction by about 27%."[12]

Ultimately, the ASHRAE standard received strong federal support. Under the 1976 Energy Policy and Conservation Act (EPCA), states were offered federal subsidies for implementing energy conservation programs on the condition that they meet several mandatory requirements, including thermal standards for buildings. Federal guidelines issued called on the states to adopt thermal insulation standards consistent with ASHRAE 90-75 or with the HUD Minimum Property Standards. To obtain EPCA funds, many states incorporated some form of ASHRAE 90-75 by reference as a supplement to existing building codes. Ultimately, the major building code groups, ICBO, SBCC and BOCA, accepted the standard as part of their own codes.

Building Energy Performance Standards

The 1976 Energy Conservation and Production Act mandated the development of Building Energy Performance Standards (BEPS). The responsibility for developing the standard was given to the Department of Housing and Urban Development,

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[12] See Lee and Rehr (1977) and Sherat (1981).

and later transferred to DOE which sponsored an elaborate research program investigating the thermal properties of structures. When the proposed mandatory standards were presented to the Senate in 1981, however, they faced considerable opposition. Builders were opposed to the performance nature of the standard, and the electric utility industry apparently believed that BEPS favored gas heating. Due to this strong opposition BEPS became a national voluntary program; nevertheless these standards are mandatory for federally owned new construction. Subsequent efforts have been made to encourage the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) to use DOE research results to update their standards. Table 12 highlights the inglorious history of BEPS.

Minimum Property Standards

The Department of Housing and Urban Development (HUD) has responsibility for design and construction standards for low rent public housing as well as all other housing approved for mortgage insurance under HUD sponsored programs. In 1977, the Minimum Property Standards (MPS) promulgated by HUD were revised to strengthen requirements for insulation and other thermal properties. The MPS were revised again in 1981 to incorporate the BEPS rejected by the Senate. Finally, in 1985, the MPS were relaxed in favor of local building regulations for one and two family dwellings, but the MPS regulations remain in force for multi-family buildings. Table 12 also summarizes this activity.

TABLE 12

Federal Energy Conservation Initiatives for Residential Construction

A. Building Energy Performance Standards (BEPS)

YEAR	REGULATION	DESCRIPTION
1976	Energy Conservation Standards for New Buildings Act (PL 94-385)	Mandated the development, promulgation, implementation and administration of building energy performance standards for new construction. Directed HUD to conduct the necessary studies to assist development of the standards. Deadline for implementation: 8/14/80.
1979	Notice of Proposed Rolemaking (NOPR)	Outlined the background of the act, highlighted the research effort in developing technical background, set forth proposed hot water and space conditioning budgets, and explained implementation of proposed building energy performance standards.
1980	Withdrawal of NOPR	Proposed building energy performance standards withdrawn. Converted to a voluntary standard for private construction, but a mandatory standard for new federal buildings.

B. Minimum Property Standards (MPS)

YEAR	REGULATION	DESCRIPTION
1977	HUD handbook 4900.1 Revised	Mandated types of building insulation, maximum thermal transmittance of building components (ceilings, walls, doors, windows), performance levels for heating and hot water systems. Relied heavily on ASHRAE standards.
1981	HUD handbook 4900.1 Revised	Strengthened the standards, based upon HUD DOE studies for BEPS. Lowered maximum transmittance and introduced alternative performance criteria for the overall structure.
1985	HUD MPS: Final Rule R-85-1183:FR-1655	Eliminated the HUD handbook 4900.1. HUD now relies on local building codes or the Council of American Building Officials' (CABO) One and Two Family Building Code.

Source: Extracted from laws and regulations.

B. State Policy

The State of California acted more quickly than the federal government to adopt energy conservation standards and to modify building design by state mandate. As early as November 1972, Governor Ronald Reagan signed into law a measure (SB 277) requiring all California communities to adopt minimum energy conservation standards for all new residential structures that are heated and mechanically cooled.

The law provided that the State of California Commission on Housing and Community Development (HCD) adopt rules and regulations prescribing minimum energy insulation standards for single-family homes, apartment houses, motels and hotels. The legislation also required that an advisory committee be appointed to assist in the development of these standards. The composition of the committee was mandated by law to include architects, builders and speciality contractors, and state and local building officials.

After extensive research and hearings, the advisory committee recommended thermal-design standards for walls, ceilings and floors that exceeded the Minimum Property Standards of the Department of Housing and Urban Development.

The recommendations were adopted by HCD in February 1974, and one year later the energy insulation standards for new residential building standards became effective throughout the state.

Before these new standards could be fully implemented, California enacted sweeping new energy conservation measures. The Warren-Alquist State Energy Resources and Development Act of 1974 created the State Energy Resources Conservation and Development Commission (ERCDC) with authority to develop and administer residential energy conservation standards. The 1974 legislation also required the ERCDC:

- To develop and promulgate lighting, insulation, climate control, and other building design and construction standards for new residential buildings that are "cost effective, when taken in their entirety, and when amortized over the economic life of the structure when compared with historic practice;"

- To establish energy conservation performance standards for residential buildings, and to base these standards on energy consumption per gross square foot of floor space;

- To prescribe standards for minimum levels of operating efficiency for all residential appliances requiring a significant amount of energy.

- To develop a public domain computer program to assist architects, engineerings, contractors, builders, and government officials in estimating the energy consumed by buildings; and

- To provide training, technical assistance, and other services to local building officials.

Other provisions for the implementation and enforcement of this legislation specified that commission standards and regulations were to be enforced by city and county building departments and that no permits were to be issued until a building department had determined that a proposed building satisfied state energy conservation standards.

1978 Title 24 Standards

The original energy conservation legislation mandated only that insulation requirements be set for new residential buildings. Amendments to the Code called for energy conservation standards beyond that of building envelope insulation, and also required the application of the standards to nonresidential buildings. Thus, the Energy Commission promulgated a revised energy conservation code for new buildings, effective July 1, 1978.

Given the legislative mandate to develop both component-oriented standards and energy-budget or performance standards, and to make the standards cost-effective over the economic life of the structure, the 1978 revised code for residential buildings represented a major departure. The most significant differences were in the specification of alternative paths for compliance with the code, and in the number and complexity of calculations required for review in the building permit process.

Under the 1978 code, the alternative ways of complying with design standards were:

- The component standards method, in which prescriptive requirements for the building envelope and subsystems could be met; or

- An alternative method, in which certain deficiencies in the building envelope could be offset by the use of environmental systems relying upon nondepletable energy sources.

Alternative designs required supporting calculations showing that energy consumption would be no more than consumption under the standard prescriptive design. Within the component standards method, there were some opportunities for justifying deviations from the prescriptive standards by a designated life-cycle-cost calculation.

1981 Title 24 Regulation Changes

In 1978, the California Energy Commission initiated hearings to revise building standards to be cost-effective when measured by 1980 fuel prices. The Commission adopted revised energy standards for new residential buildings on June 30, 1981. These revisions were approved by the State Building Standards Commission on September 24, 1981, to take effect on July 13, 1982. Subsequent legislation (AB1843) delayed the effective date until June 15, 1983 for single family homes and until December 31, 1983 for all other residential applications.

The new standards established separate "energy budgets" for single and multi-family buildings for 16 climate zones throughout the state. This budget, expressed in Btu per square foot per year, has two components: space conditioning and water heating. The standards allow for trade-offs between the space conditioning and water heating components. The space conditioning budget includes the energy used both for heating and cooling.

The standards include a set of "mandatory minimum" requirements: wall and ceiling insulation, infiltration control measures, vapor barriers, duct insulation, setback thermostats, and efficiency levels for some lighting. The standards also specify minimum levels of efficiency for space conditioning and water heating equipment.

Compliance with the "energy budget" can be determined by using an approved set of calculations to estimate annual energy use. One available calculation method is the "CALPAS 1" computer program used by the Commission staff in the development of the budgets. Alternatively, a simple point system can be used; points are assigned to various conservation measures and design strategies according to the estimated effect of a particular measure when installed in a building.

In the absence of detailed calculations, compliance with the energy budget may be demonstrated by installing one of several prescribed packages of "alternative components" in the building. For each climate zone, these packages list specific conservation measures; if these measures are installed, no calculation is required to demonstrate compliance. There are three optional packages of components for each climate zone:

- Package A, a set of measures for a passive solar building. Such a building would require proper solar distribution, appropriate levels of thermal mass, and moderate insulation levels;

- Package B, a set of those measures to be installed when the builder/designer does not use passive solar design in the building. Such a package generally requires higher insulation than Package A to make up for deficient solar distribution;

- Package C, a set of measures required for a building without passive solar design but with active solar water heating. The design would be appropriate for buildings lacking appropriate solar orientation but with adequate solar access.

The Commission appointed an Implementation Advisory Committee to assist the staff in its development of an implementation program. The staff published Energy Conservation Manuals which describe methods of compliance, and initiated a statewide "train the trainers" program for builders, architects, designers, and building officials.

1983 Changes Due to Assembly Bill 163

AB 163 (Goggin), which became law on July 28, 1983, provides builders with new options and additional flexibility in complying with the existing energy conservation standard for new residential buildings.

Builders may comply with the standards by averaging the performance of groups of buildings or units in a multi-family building. Each building or unit in an averaged group must be in the same subdivision, and each must be of the same model type. A builder demonstrates compliance by using the point system or any other approved calculation method to show that a simple arithmetic average of the energy performance of all buildings or units in the group meets the prescribed energy budget. When the dwellings are offered for sale, builders must notify potential buyers that compliance with the energy standards used averaging and that the performance of a particular home relative to the performance standard is available upon request.

In addition to the three prescriptive packages noted above, AB 163 created two additional options to allow more flexibility for builder/designers -- there are now five packages for single family and multi-family housing in each of the 16 climate zones.

A 1985 survey by the CEC indicated that the new options authorized by AB 163 are the primary methods by which builders comply with the state's energy building standards. In general, builders believe that AB 163 compliance options are more flexible and less costly than those available under the standards adopted in 1981. After conducting public workshops and surveying members of the building industry, the CEC has concluded that these new compliance approaches have complicated enforcement by the local building departments and that the net energy saving to the state has been reduced. A significant reduction in energy savings occurred through the "custom budget" approach allowed by AB 163. This reduction apparently arises because the custom budget approach requires significantly more rigorous compliance and enforcement procedures than the fixed energy budget.[13]

The CEC has therefore recommended to the California legislature that the statutory provisions of AB 163 be allowed to lapse on January 1, 1987, while work proceeds to correct the perceived defects in the legislation.

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[13] California Energy Commission *Legislatively Enacted Alternative Provisions for the Energy Conservation Standards for New Residential Buildings*, (86-RBS-1), May 1986.

Table 13 summarizes the course of building regulation in the state.

C. Cost Effectiveness of California Residential Building Standards

As noted above, since 1974 California law has required that regulatory standards for new residential construction be "cost effective, when taken in their entirety and when amortized over the life of the structure when compared with historic practice." Current regulations vary for each of three building types in 16 different climate zones in the state. The climate zones themselves were established for the commission during the process of developing the standards.

The standards specify an aggregate energy budget and permit a trade-off between energy used in water heating and in space conditioning. As noted above, the standards prescribe alternative methods by which compliance may be demonstrated.

The CEC staff itself determined that its proposed standards met the legally mandated cost-effectiveness test. In making this determination, the CEC compared the life-cycle costs of conservation measures in residences built before 1975 to the life-cycle costs of conservation measures in new residences designed to meet the standards. The analysis was performed for each of the three building types in each of the 16 climate zones.

The CEC estimated the characteristics typical of pre-1975 construction in each zone for each of the three "base case" building types through the assistance of local building departments (by questionnaires, interviews, etc.). It then used the Department of Energy's computer simulation program ("DOE2.0A") to estimate energy consumption in the base case buildings in each climate zone.

TABLE 13

California Energy Conservation Initiatives for Residential Construction

YEAR	PROGRAM	AFFECTED GROUP	EFFECTIVE DATE(S)	TECHNICAL SPECIFICATIONS
1974	The Warren-Alquist Act (SB277) required the Commission on Housing and Community Development to establish minimum standards for energy insulation in new residential dwellings, regulating thermal transmittance, glazing, insulation and weatherstripping. Enforcement by city and county building departments.	All new hotels, motels, apartments, lodging houses, single family dwellings and other residential buildings, for which a building permit was issued between 2/22/75 and 6/30/78.	From 2/22/75 to 6/30/78	Refer to: Energy Manual for Residential Buildings, Department of Housing and Community Development, State of California, February 1975.
1977	The California Title 24 Residential Building Standards incorporated into the California Administrative Code, establishing guidelines and minimum requirements for building envelope, climate control systems and water heating.	Any residential building including additions to existing structures less than 4 stories for which a building permit was issued between 7/1/78 and 6/30/81.	From 7/1/78 to 7/12/82	See: Energy Conservation Standard for New Residential Buildings Except Apartment Houses with four or more habitable stories and houses, CEC (P400-81-005)
1981	Title 24 Standards amended, establishing 16 distinct climate zone <u>budgets</u>. The standards also feature 3 <u>compliance</u> options: 1) alternative component packages, 2) simplified calculation method (point system), 3) compliance performance method. The standards also include a list of mandatory conservation requirements regardless of the approach used.	Any building of an occupancy Type R as defined in the Uniform Building Code, 1979 edition. This covers all residential buildings including additions that are 3 stories or less.	The CEC adopted the standards in 7/81 and the State Building Standards Commission approved them in 9/81 to take effect on 7/13/82. AB1846 exempted most implementations until 7/13/83.	See: Energy Conservation Standard for New Residential Buildings Except apartment houses with four or more habitable stories and houses, CEC (P400-81-005) and Manual for Respective Climate Zones.
1983	Title 24 standards modified by AB163 (Goggin), providing a group averaging method for compliance, as well as 2 additional prescriptive packages. Builders/developers can design their own "custom budget" provided designs result in the same energy performance in packages D or E.	Any building of occupancy Type R.	CEC adopted the changes into its fall 1984 manual. Expires 1/1/87.	

The commission identified a variety of conservation and solar measures and applied them in combination to each of the building types in each climate zone using the same computer program. Basic parameters for weather, ground temperature, internal loads, and thermostat settings were unchanged; only the physical and thermal properties of the buildings and energy utilization rates were varied according to conservation technologies. For water heating, the CEC used another computer simulation program ("f-CHART") to estimate the energy that could be supplied by "typical" solar water heaters systems.[14] Estimates of the quantities of energy saved by various conservation investments were converted to dollars using a 30-year series of unit energy prices projected by the CEC staff.[15] These price projections assume an increase in real energy prices of about 250 percent over a 29 year period.

Life cycle costs were estimated using another computer simulation "SOLFIN2". This program compares the life-cycle costs of dwellings built in conformance with the standards with the costs of base case dwellings built according to "historic practice." The costs of owning and operating a building are calculated using specific assumptions about the initial downpayment, mortgage payments, the resale value (if any), natural gas costs, electricity costs, maintenance costs, insurance costs, the costs of replacing HVAC, water heating, and energy conservation systems, Federal taxes, Federal tax credits for solar

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[14] Data on 33 different systems were collected from solar installers throughout the states. From these data the CEC staff identified a typical system. Even in the least sunny areas where the proposed standards menu contains solar water heating, 60% of the energy required for weather heating in California residences can be provided by the "typical system."

[15] California Energy Commission, *Fuel Price and Supply Projections: 1980-2000*, November 1979.

measures, Federal tax credits, and miscellaneous costs. The program calculates annual costs for each of the 30 years, and determines the present value of the life-cycle costs using a 4 percent real rate of interest.

The inclusion of federal taxes and credits in the calculation and comparison of social costs is an elementary error and may indicate more serious problems in the logic of these computer programs. In any case, however, with expectations of large increases in fuel prices and low discount rates, stringent standards were justified.

Very little information is available which would permit an independent evaluation of this regulatory program. Public reports of the CEC claim that the standards save substantial quantities of energy and also that the net monetary savings are large. For example, a recent report claims that the energy savings in 1996 attributable to current residential building standards in California will amount to 3,854 MW of peak electrical demand, 436 M cubic feet per day of natural gas, and 10,697 CWh of electricity sales.[16] The report continues:

> The standards adopted in 1975, 1978, and revised in 1983 have reduced the amount of energy new homes used by 50 percent compared to pre-1975 homes. With the new standards, a house designed today will consume only half the energy for space heating and cooling and water heating that would have been used in homes built to the 1978 standards.

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[16] California Energy Commission *Preliminary Conservation Report, (P400-85-010), November 1985, p 2-7.*

A report issued five months earlier claimed that the standards save both energy and money (though the estimate of thermal efficiency differs by one half):

> The Commission's residential building standards result in new home construction that is 75 percent more energy efficient than homes built in the 1970's. Over a 30-year period a typical homeowner in Los Angeles will save $25,000.[17]

Apparently these claims are not based upon empirical evidence, but rather upon the computer simulation described above.

A somewhat different perspective on California's regional residential energy standards is provided in a paper by Quigley (1985). This analysis estimates a production function for housing -- with energy, real estate and land as inputs, using data on FHA financed new single family construction in California in the 1970's. Under a variety of assumptions,[18] the results can be used to estimate the efficiency of building regulations.

The analysis suggests that the California standards are quite efficient if energy prices are expected to increase by about 10 percent per year, but are quite costly indeed if energy prices are expected to appreciate less rapidly.

V. EXPECTATIONS ABOUT ENERGY PRICE INCREASES

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17 California Energy Commission, *The 1985 California Energy Plan, Technical Version* (P106-85-002A), May 1985.

18 These are spelled out more fully in the analysis. The most important maintained hypothesis is that residential construction is undertaken in an efficient manner.

Expectations about the future course of energy prices are crucial to the design of energy policy for buildings and for any evaluation of policies. At the time of construction, there may indeed be considerable scope for substitution between initial capital investments and the quantities of energy required for the operation of residential or industrial real estate. Once constructed, however, durable structures are typically quite expensive to modify. The cost of "retrofit" required to reduce the annual energy utilization of a given residential or commercial configuration is quite high relative to the additional costs of designing increased energy efficiency into the initial construction.

Not only is the production process characterized by a more limited scope for the substitution of capital for operating expenditures in existing buildings, but also the life span of existing buildings, particularly residential dwellings, is quite long. It is not unusual for structures aged 100 years or more to be fully occupied as residential properties. Together, these characteristics suggest that producers of housing or other buildings must consider the expected course of energy prices throughout the life of the building in order to choose appropriately between higher quantities of initial capital investment -- insulation, glazing or the siting of a dwelling on a parcel -- and the subsequent quantities of energy to provide heat, light, air-conditioning and so forth. If builders and residents anticipated very large increases in energy prices during the lifetime of a cohort of buildings, then efficient production would lead to larger initial expenditures on durable capital with better thermal properties. Conversely, if energy prices were expected to decline in real terms during the lifetime of the building, we would expect the producers and consumers to prefer lower initial expenditures on capital and higher subsequent expenditures on the presumed cheaper variable inputs. In evaluating policies which have been explicitly designed to promote additional residential capital investment, it is therefore important to understand expectations about the course of prices for energy. In this section, we review the forecasts of energy price increase which were made during the decade of the 1970's and 1980's; we compare these forecasts with the actual course of relative price change.

We have uncovered about a dozen studies undertaken between 1972 and 1983 which, by one means or another, projected estimates of the average annual growth in real energy prices. These estimates were made under a variety of circumstances, based upon particular assumptions about the parameters of supply and demand conditions and about the level of inter-fuel competition among countries and regions.

Table 14 presents a summary of the projections of real price increases associated with these forecasting efforts. For each study, the table presents the predicted rate of price increase projected between the date of the study and 1985, 1990, and 1995, where available.[19] The table also presents the actual course of price increase realized from the date the study was published through 1985. For comparison, all results have been converted to rates of price increase compounded annually.

The initial study of energy demand in California was conducted by the Rand Corporation and published a year before the first oil embargo. The Rand study

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[19] It should be noted that several of these studies did not forecast the course of energy prices. Rather, they used assumptions about the future course of prices to forecast other aspects of the energy market (e.g., demand). The studies discussed in this section are either forecasts of energy prices (EIA, CEC) or the assumptions about the course of future prices which condition other forecasts (RAND, FEA).

TABLE 14

Forecasts of Average Annual Rate of Energy Price Increase Through 1995

Source	Year of Forecast		Actual Compound Rate Thru 1985	Predicted Compound Rate of Price Increase Through 1985	1990	1995	Remarks
RAND	1972	A	10.66%	3.80%	3.53%	3.30%	Electricity
		B		7.60	7.18	6.65	Gas
		C		4.73	4.69	4.49	Fuels
FEA Project Indep.	1974	A	9.34	-8.90			Low
		B		-4.20			Base
		C		-0.20			High
Ford	1974	A	9.34	4.80	4.40	4.40	Historical Growth
Foundation		B		3.80	4.60	4.40	Tech. Fix Growth
		C		3.80	4.60	4.40	Zero Energy Growth
MIT Energy Lab	1976		9.45	-1.76		-0.58	Most Likely
Foster Assoc.	1976		9.45	-10.70	-4.30	-1.70	Low
				-1.20	-0.07	0.83	Base*
				3.40	3.10	2.90	High
EIA	1978	A	9.89	0.68	0.94	1.84	HG/HS
		B		6.00	4.23	4.76	HG/LS
		C		0.68	2.17	2.97	AG/AS*
		D		0.68	0.40	0.85	LG/HS
		E		2.50	3.25	3.46	LG/LS
MEFS	1978	A	9.89	3.80			HD/HS
		B		9.20			HD/LS
		C		3.80			MD/MS*
		D		3.00			LD/HS
		E		5.70			LD/LS
		C-high		9.30			MD/MS
EIA	1979	A	7.53	10.90	6.90	6.00	HG/LS/HD
		B		7.90	5.00	3.90	MP/MS/MD
		C		3.80	2.10	1.40	LP/HS/LD
CEC	1980	A	3.39	8.30	5.20	3.90	Low Price
		B		12.70	8.50	6.50	Most Likely*
		C		16.10	11.20	8.80	Worst Case

TABLE 14 Continued

Source	Year of Forecast		Actual Compound Rate Thru 1985	Predicted Compound Rate of Price Increase Through 1985	1990	1995	Remarks
EIA	1981	A	0.99	-6.50	0.30	2.60	Low Price
		B		-0.70	4.10	5.00	Mid Price*
		C		2.80	6.50	7.00	High Price
Stobaugh and Yergin	1982	A	0.83	2.04	2.00	2.00	Most Likely
				4.50	4.50	4.50	Most Likely
CEC	1981	A	0.99	3.00	5.90	2.00	Most Likely
CEC	1983	A	0.85	1.00	2.10	2.74	Most Likely

HG=High Growth HS=High Supply HD=High Demand BC=Base Case
AG=Average Growth AS=Average Supply MD=Medium Demand WC=Worst Case
LG=Low Growth LS=Low Supply LD=Low Demand PIC=Price Increase Case

* Preferred Forecast

Sources:

- California Energy Commission, *Energy Tomorrow: Challenges and Opportunities for California*, 1981 Biennial Report.
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provided estimates of energy demand through the 1980's and 90's under the assumption that energy prices remain constant. The study also provided forecasts of demand and interfuel substitution under the assumption that fuel prices increased by 4.7 percent per year through 1985; real energy prices have actually increased by 11.5 per year since the Rand report was released. The 1974 report of the Federal Energy Agency investigated the domestic energy market under the "base case" of energy price declines of 4.2 percent from 1974-1984, while prices actually increased by 10.3 percent. In 1976, the MIT energy lab forecast a 1.8 percent annual decline in real energy prices and Foster associates forecast a 1.2 percent annual decline to 1985. During the 1976-1985 period, energy prices increased by 10.7 percent per year.

The Mid-Range Energy Forecasting System (MEFS), a large scale interdisciplinary model of the U.S. energy system maintained by the Department of Energy, has been used to provide forecasts on a regional basis, and for the long run, of delivered prices of various kinds of energy. As noted in the table, the model produces price forecasts conditional upon several sets of supply and demand parameters. The most likely forecast for 1985, produced in 1978, estimated price increases of 3.8 percent per year. The actual course of price increase, 1978-1985, was 9.9 percent per year.

The Energy Information Administration (EIA) is charged with producing projections of energy outcomes in an annual report to Congress. These projections are based upon the OMS model noted above and the International Energy Evaluation System (IEES) which estimates energy supplies, demands, and interfuel competition for world regions. The 1978 EIA price projections were rather low, and the preferred forecast was less than 0.7 percent per year through 1985. The preferred forecast in 1979 was 7.9 percent per year, while in 1981 it was -0.7 percent. The realized price changes, through 1984, for these three periods were 9.9 percent, 7.5 percent and 1.0 percent respectively.

The 1980 energy price estimates of the California Energy Commission (CEC) have been quite influential in state policy and standard setting. These projections were based upon a variety of qualitative factors. The most likely rate of price increase through 1985 was estimated to be 12.7 percent. The actual rate of price increase has been 3.4 percent.

More recent comparative information on forecasts of energy price increases is available through the International Energy Workshop (IEW). The IEW has compiled "poll results" from the projections of a variety of analysts in various countries using many different forecasting techniques for projecting energy supply and demand. A set of "poll results" is available for the international price of crude oil, based upon forecasts published in 1984-1985.

Figure 1 summarizes the price forecasts made in 1984-85 by the 36 members of the IEW for 1990, 2000 and 2010, compared with the actual course of world crude oil prices since 1980. Compared to a base of 100 for 1980, the median forecast for 1990 is 89.5, and for 2000 it is 109.00. The latter figure represents a projected increase of 0.4 percent per year during the 1980-2000 period. The mean projections for 1990 and 2000 are 89.1 and 116.4 respectively. These summaries however mask a great deal of variation -- the standard deviation of the forecasts in 21.6 for 1990 and 40.6 for the year 2000.

Figure 2 puts these forecasts into some perspective. It compares the median poll responses with those poll responses, reported at two previous dates, December 1981 and July 1983. As the figure indicates, the median projection of

FIGURE 1

Price forecasts from 36 models, 1984

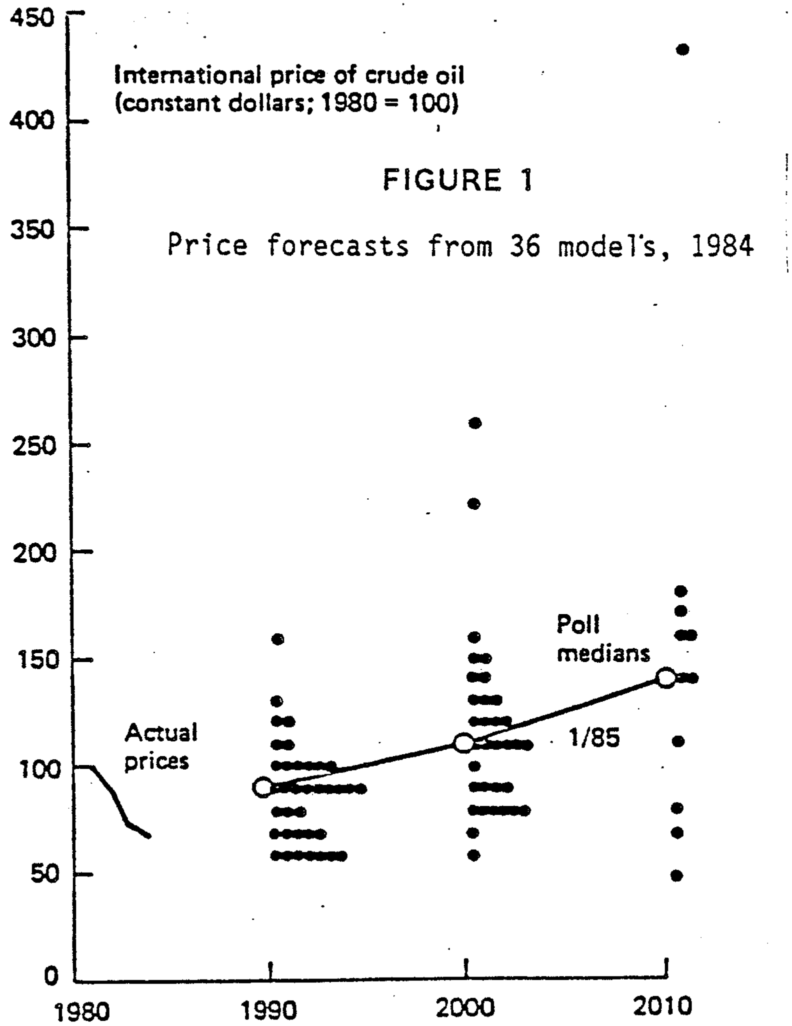
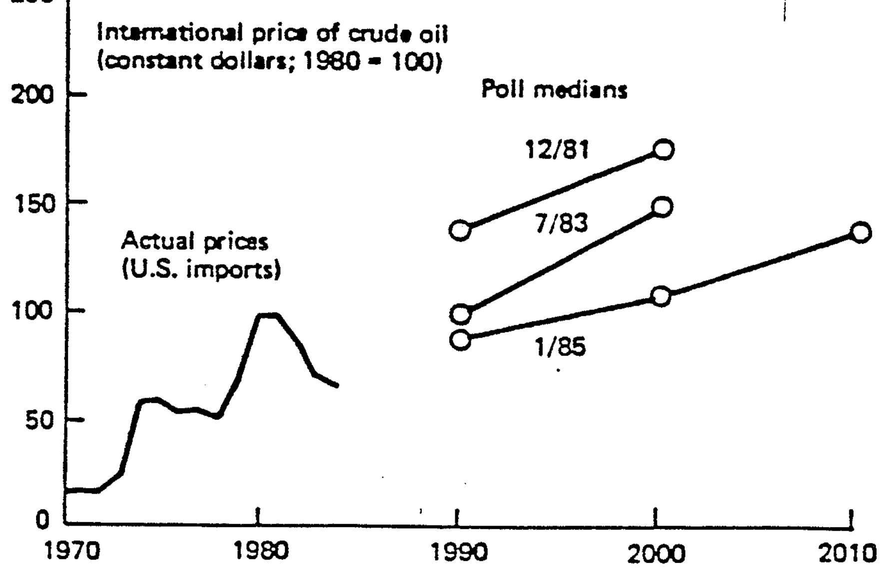


FIGURE 2

Price forecasts made in 1981, 1983, 1985



Source for Figures 1 and 2:

Alan S. Manne, et al., "International Energy Workshop: A Progress Report," Energy Modelling Forum, Stanford University, mimeo, June 1985.

energy prices in the year 2000 has dropped by almost 40 percent in a little over three years. (This is not far from the 33 percent decline in the real price of crude oil during the same period).

VI. CONCLUSIONS

This paper has reviewed government programs encouraging energy conservation in residential buildings, including tax credit programs to encourage retrofits of dwellings, standards for new construction, and a variety of outreach programs.

The impact of tax credit subsidies under both the Federal and California income tax laws has been sharply regressive, more so for California laws than for federal tax provisions. This regressivity is most pronounced for California solar and wind energy tax credits; by 1983 49 percent of these credits ($61.2 M) were claimed by households with annual incomes in excess of $100,000.

There is little hard evidence on the effects of these tax subsidy programs, and no empirical evidence at all on the effects of the expensive California tax credits.

A variety of residential conservation programs have been undertaken by investor owned public utilities in California. Some of these programs have been undertaken at the initiative of the utilities, while others have been mandated by the Public Utilities Commission. These programs are financed by general ratepayers and provide specific benefits to particular dwellings and their occupants. Given the rate structure in California, the incidence of program costs is roughly proportional to income. Estimates of energy saved by these programs are not based upon direct observation. Available estimates do suggest, however, that many of these programs are quite expensive per BTU saved.

The mandatory standards for new construction developed by the California Energy Commission are quite innovative, and were designed to comply with legislation requiring the regulations to be "cost effective." The design and evaluation of these standards has been based upon computer simulation methods, and there is no empirical evidence on the quantity of energy saved by these regulations.

The savings from these mandatory standards depend crucially upon the expected course of energy prices in the future. Thus, the cost-effectiveness of government standards, or of tax credit programs for that matter, depends upon the expected course of prices during the lifetime of the investment. An analysis of available energy price forecasts gives little confidence in their reliability. Further, it appears that the specific forecast of future energy prices which underlies California residential building standards is much too high. This suggests that the standards are much too stringent to satisfy the cost effectiveness criterion mandated by California law.

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