ELECTRICITY CONSERVATION: POTENTIAL VS. ACHIEVEMENT

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I. Introduction

The organizers of the conference asked us to address the questions of "How much electricity conservation potential is out there"? and "How much does it cost"? The answers to these questions are of obvious value to utilities and their regulators, and they will be covered in this paper. But it is a big step from identifying cost-effective conservation opportunities to achieving savings. We believe it is just as important to ask "How much of the potential is being achieved"? and "How can utilities and regulators maximize the amount of electricity conservation being achieved"? In this paper, we also examine the extent of electricity and peak demand reduction achieved by various utilities that are recognized as leaders in the field.

II. Electricity Conservation Potential in New York State

ACEEE has conducted a number of studies of electricity conservation potential and cost effectiveness in recent years [1, 2]. The latest in-depth study considered the potential for electricity savings and peak demand reductions in the current equipment and building stock in New York State [3]. The objective was to identify and characterize the electricity conservation resource that currently exists in New York as well as in the individual service areas of the seven major private utilities. Consequently, conservation and load management measures were analyzed without considering utility program costs, implementation rates, or limits to full adoption.

A. Methodology

The analysis is based on electricity consumption and peak demand in the state as of 1986, the most recent year for which comprehensive end-use data are available. First, electricity use, summer peak demand, and winter peak demand are disaggregated by sector, building type, and end use for the entire state as well as for each of the major private utilities. Second, end-use technologies are defined which are representative of the building and equipment stock as of 1986.

The conservation analysis then evaluates the savings of electricity and peak demand that would result from the implementation of 62 efficiency measures. Most of the measures are commercially available; a few are expected to become available by the early 1990's. The cost effectiveness of each measure is evaluated in terms of "cost of saved energy" (CSE) and "cost of reduced peak demand" (CRD). CSE is the cost of reducing electricity consumption over the lifetime of the efficiency measure. CRD is the capital cost for saving a kW of peak demand over a standard 20-year time period. Cost effectiveness is evaluated from the utility perspective using a 10% real discount rate, consumer perspective using a 6% real discount rate, and societal perspective using a 3% real discount rate. The conservation analyses for individual end uses and building types are combined into "conservation supply curves."

In order to present estimates of the overall cost-effective potential for electricity savings and peak demand reductions, cost-effectiveness thresholds are needed. For the consumer perspective, the thresholds are the average electricity rates in 1986. For the utility and societal perspectives, the thresholds are based on long-range marginal costs for each utility as developed by the New York Public Service Commission.

Since the analysis applies to the building and equipment stock as of 1986, no attempt is made to evaluate new sources of electricity demand that have been added since then or that might be added in the future. Also, the analysis does not address the issues of fuel switching or increasing electrification through technologies such as heat pumps. It is reasonable to ignore these issues because the objective is to determine the technical and economic potential for electricity and peak demand savings in the current equipment and building stock, not to forecast future electricity demand.

B. Results

Table 1 presents the ranking of conservation measures by cost effectiveness (from the consumer perspective) along with the statewide electricity savings potential. In some cases, specific conservation measures are aggregated into broader categories (e.g., HVAC retrofits in commercial buildings) in order to keep the list short. Also, some less consequential measures are not included in Table 1. Full adoption of all measures analyzed in this study would reduce statewide electricity consumption by 37,000 GWh (38%). The savings potential is highest in the commercial sector (50%), followed by the residential sector (37%), and the industrial sector (22%). The average cost of saved energy associated with the measures is approximately $0.025/kWh. For comparison, it typically costs $0.045-0.065 to produce a kWh from a new coal or gas-fired power plant, and about $0.055-0.08 to supply a kWh of demand taking into account the necessary reserve margin and T&D losses [4].

Figures 1 and 2 present the statewide conservation supply curves evaluated from the consumer perspective. Figure 1 shows that over 30,000 GWh/yr of electricity savings (over 30% of 1986 use) are potentially available at a cost of up to five cents per kWh saved. Figure 2 shows that a peak demand reduction of 5,000 MW (25% of 1986 peak demand) is available at a cost of up to $1000 per kW saved.

Table 2 presents the total electricity and peak demand savings potential below the cost-effectiveness thresholds. From the consumer perspective, the potential cost-effective electricity savings are 34,300 GWh/yr or 35% of statewide consumption in 1986. The potential cost-effective reduction in summer peak demand is 6,850 MW (33% of the 1986 summer peak), while the cost-effective reduction with respect to the winter peak is 4,800 MW (27% of the 1986 winter peak).

The potential for cost-effective savings from the utility perspective is considerably lower than from the consumer perspective. Economical electricity savings decline to 23% of 1986 usage, and economical peak reductions decline to 30% and 21% in the summer and winter, respectively. This result is due to an average CSE threshold of approximately 4 cents/kWh from the utility perspective compared to 5-10 cents/kWh from the consumer perspective. The lower utility threshold results from the capacity surpluses and low marginal costs for some of the utilities. Also, the CSE values are higher from the utility perspective because of the higher discount rate assumption. The potential for cost-effective electricity savings from the societal perspective is similar to that from the consumer perspective.

Measures which offer a particularly large potential for cost-effective electricity savings include more-efficient residential refrigerators and freezers (4,370 GWh/yr), the installation of reflectors in fluorescent light fixtures (4,140 GWh/yr), the installation of variable-speed drives on fan and pump motors in commercial buildings (3,470 GWh/yr), conversion of commercial HVAC systems to variable air volume (2,780 GWh/yr), industrial variable speed drives (2,550 GWh/yr), energy-efficient fluorescent lamps and ballasts (2,190 GWh/yr), and compact fluorescent lamps (2,020 GWh/yr).

The measures which offer the largest potential for cost-effective reductions in summer peak demand include reflectors (1,130 MW), more-efficient refrigerators and freezers (880 MW), and conversion to variable air volume systems in commercial buildings (550 MW). These same measures offer the largest potential for cost-effective reductions in winter peak demand. In addition, residential load controllers, more-efficient air conditioning, and commercial cool storage offer substantial cost-effective peak demand reductions from the societal perspective.

Part of the cost-effective savings potential will be realized as a result of state or federal efficiency standards. In particular, standards on residential refrigerators and freezers will have a significant impact on future electricity use. If we exclude efficiency measures that will be adopted in response to these efficiency standards, the potential for cost-effective savings from the consumer perspective drops to 29,400 GWh/yr, 5,650 MW of summer peak demand, and 4,300 MW of winter peak demand. Thus, existing efficiency standards will induce about 15% of the cost-effective savings potential in the state.

To put the total cost-effective savings potential in perspective, a recent forecast by New York State energy authorities predicts electricity demand growth of 1.6-2.1%/yr during 1988-2008 [5]. This implies that electricity demand in the service areas of the seven major private utilities will increase by about 26,000 GWh/yr between 1988 and 2000. Based on our analysis, all of this new demand could be displaced if approximately 80% of the cost-effective electricity savings potential in existing buildings and equipment (based on the consumer or societal perspectives) is realized. Very little of the savings potential in existing buildings and equipment is incorporated into the state's forecast.

C. Comparison to Other Studies

Detailed studies of electricity conservation potential have been completed for other regions of the country. Some show less savings potential, some show more savings potential than the New York study. For example, the 1986 Northwest Conservation and Electric Power Plan indicates a savings potential of 28,000 GWh/yr in the Northwest region by 2005 below a cost effectiveness threshold of $0.02/kWh [6]. The savings potential reaches 40,000 GWh/yr with a cost effectiveness threshold of $0.05/kWh. The latter represents 20–25% of projected electricity demand in the region in 2005.

An analysis of electricity conservation potential in buildings in Texas indicates a potential cost-effective savings of 50,000 GWh by the year 2000 [7]. This is approximately one-third of projected electricity demand in 2000 without the efficiency measures. In making this estimate, conservation measures up to a cost-effectiveness threshold of $0.08/kWh are included. The average cost for all conservation measures in this study is approximately $0.027/kWh.

Estimates of electricity conservation potential by Amory Lovins are considerably greater and less costly than those cited above. Lovins issued a national electricity conservation supply curve that shows a 75% savings potential up to a cost-effectiveness threshold of about $0.03/kWh [8]. The average cost of saved energy in this case is only about $0.006/kWh. Similar to other studies, the end uses offering the largest savings are lighting, drivepower, and cooling.

Clearly there is wide variation in the savings potential and average cost of saved energy among different studies. Each study is affected by end-use characteristics, the number and type of measures considered, methodology, and performance assumptions. For example, some studies include only commercially available technologies, others include commercially available and advanced technologies. Some studies base their estimates on "optimal" performance, others on "typical" performance. In spite of the differences in methodology and results, the expanding literature on electricity conservation potential supports two important conclusions:

1) There is large electricity conservation potential throughout the country.

2) The conservation resource is quite inexpensive compared to supply-side alternatives (excluding any costs to promote adoption).

The questions of whether the savings potential in a particular region is 25%, 50%, or 75% and whether savings cost 1, 2, or 3 cents per kWh are not of primary importance, in our opinion. The most critical issues are how can utilities and their regulators develop policies and programs that will facilitate implementation of a significant portion of this resource (however large it is).

III. Examples of Implementation

Given the large, cost-effective potential for electricity savings, how are utilities doing in fostering adoption of this resource among their customers? To address this question, we examined data on conservation and load management (C&LM) programs and overall load growth for seven utilities (Austin, Texas Electric Dept., Central Maine Power Co., New England Electric System, Pacific Gas and Electric Co., Seattle City Light, Southern California Edison Co., and Wisconsin Electric Power Co.). These utilities are recognized as leaders in terms of their financial and institutional commitment to electricity conservation. Although other utilities could be added to the list, the utilities covered have had (or now have) relatively large programs.

Table 3 shows C&LM program budget levels for the seven utilities during their period of heavy activity. In general, the West Coast utilities began major efforts around 1981, while the other utilities started major programs much more recently. A few of the utilities (CMP and NEES, for example) are rapidly expanding their C&LM programs as of 1989.

Table 3 shows that in the last year covered (usually 1988 or 1989), these utilities are spending 0.6%–4.1% of their gross revenues on their conservation programs. Weighting each utility equally, the average expenditure is 2.5% of gross revenues. It should be noted that the California utilities have significantly reduced the size of their C&LM programs in recent years [9]. At their peak during 1984–5, PG&E and SCE spent 1.5–2.1% of revenues on C&LM. Overall, these two utilities spent nearly $1 billion on C&LM during 1981–88. Based on peak year expenditures rather than final year expenditures, the average peak expenditure for the seven utilities equals 3.4% of revenues.

Table 4 shows the estimated electricity and peak demand savings as a result of the C&LM programs. For most utilities (as noted at the bottom of Table 4), peak demand reduction is at the time of the utilities' summer peak. For a few utilities, estimates of coincident peak demand savings are not available, so total demand savings (the sum of non-coincident demand savings for individual measures) are reported.

The savings estimates were determined by the utilities themselves. To the extent possible, we used consistent savings estimates by excluding savings for so-called free riders. For a few utilities, including the two California utilities, detailed free rider estimates were not available so the results include free riders. According to their own analyses, the two large California utilities have cut peak demand by 840–1250 MW as a result of their programs since 1981. However, studies commissioned by these utilities indicate that approximately half of the savings may be due to free riders [10, 11]. The cumulative peak reduction for the other utilities is around 100–200 MW.

Table 5 shows the reductions as a fraction of total sales and peak demand in 1987. Cumulatively, C&LM programs run by the two California utilities have reduced electricity use and peak demand by approximately 6–14%, according to the utilities' estimates (without adjusting for free riders). Elsewhere, cumulative reductions are less than 5% of total electricity demand or peak load. Based on program data for the last year covered, these C&LM programs are typically reducing electricity use by 0.4–1.0% per year, with slightly higher percentage reductions in peak demand in most cases. Once again, the "last year" values for the West Coast utilities are much less than the reductions achieved when the programs were at their peak during the mid-1980s.

PG&E and SCE are claiming that their C&LM programs cumulatively have lowered electricity sales and peak demand by on the order of 10%. If such reductions are indeed occurring, then they should be observable in the overall growth rates experienced by these utilities. In particular, PG&E and SCE should have experienced lower demand growth than other utilities in their region which were not aggressively promoting C&LM. The data in fact support this hypothesis. Figure 3 shows the average growth in electricity sales and summer peak demand during 1981-1987 for PG&E, SCE, and Seattle City Light along with the growth rates for all other utilities in the Western Region (i.e., Pacific and Mountain states). These three utilities experienced growth rates of 0.5-1.2% per year, while other utilities in the region grew at 1.5-2.0% per year. Of course, other factors besides utility programs affected these growth rates. Policies such as state efficiency standards and high (or rapidly increasing) electricity prices helped to limit demand growth in California and the Northwest.

Given the fact that the three Western utilities with major conservation programs did experience significantly lower growth than other utilities in their region, it is interesting to examine the annual trends. Figure 4 shows year-by-year electricity sales for the utilities and the region, using 1981 sales as an index. In general, the growth rate for the three utilities lagged growth in the rest of the region during 1984-86 when the utilities' C&LM programs were at their peak. Since 1986, the three utilities cut back their C&LM programs and they experienced significant demand growth along with other utilities in the region. As of 1988, electricity demand for the three utilities was around 10% less than what it would have been had these utilities experienced the same growth rate as the rest of the region during 1981-88.

IV. Conclusion

Studies such as ACEEE's New York study show that there is enormous potential for cost-effective electricity savings and peak demand reduction within the existing stock of buildings and equipment. Developing a significant portion of this resource could save households and businesses tens of billions of dollars and eliminate the need to build many new power plants.

A few utilities are spending on the order of 1-4% of their gross revenues on C&LM programs and are beginning to foster the implementation of a sizable fraction of the overall savings potential. Major utilities in California estimate that they have reduced electricity demand and peak load on the order of 6-14% through C&LM programs conducted during the past eight years. Trends in electricity sales and peak load support these claims. Other utilities that have more recently undertaken major C&LM programs have had a small impact on total electricity sales and peak load so far. However, utilities such as NEES and WEPCo expect to significantly reduce their load growth during the 1990s due to C&LM programs now underway or planned [12].

Most utilities have barely begun to tap the potential for cost-effective electricity savings in their service area. A survey of utility activities conducted in 1985 found that seven utilities accounted for about 70% of total conservation program expenditures reported by 76 utilities [13]. Concerning load management, the top seven utilities accounted for about 75% of reported expenditures by 50 utilities. Concentration of C&LM activities among a handful of utilities appears to be continuing, although the group of leading utilities has changed as C&LM programs diminish in some places (e.g., TVA) and expand in others (e.g., the Northeast).

There are some encouraging trends that could "narrow the gap" between electricity conservation potential and implementation. Recent pilot and small-scale programs have achieved participation rates as high as 85% of eligible customers and energy savings of up to 30% among participating customers. These results are considerably in excess of the participation rates and savings achieved by conventional C&LM programs [14]. These programs identify, finance, and install C&LM measures at little or no cost to the customer.

Second, the proliferation of least-cost utility planning (LCUP) leads utilities and regulators to directly compare demand-side and supply-side resource options. C&LM options almost always look attractive, and regulators encourage or require utilities to make C&LM investments a top priority. By the end of 1988, 17 states required LCUP and many other states and utilities were establishing similar planning procedures [15].

Third, there is growing recognition that utilities lose money when they effectively promote electricity conservation -- cutting electricity demand reduces revenues and profits in the short run [16]. A few states (e.g., New York, Maine, and Wisconsin) are starting to take steps to overcome this barrier. Making the least-cost strategy for society also the "most-profit" strategy for the utility could go a long way towards convincing utilities to vigorously promote and finance C&LM.

Finally, it should be recognized that large amounts of "conservation resources" cannot be acquired overnight. It takes many years to establish vendors and markets for new energy-efficient technologies, as well as to implement these technologies in a sizable fraction of the building and equipment stock. Sustained and complementary efforts by utilities, regulatory and state energy officials, and the private sector are required in order to implement a significant portion of the cost-effective conservation potential. Such efforts can pay off in billions of dollars of savings for consumers and businesses, as demonstrated in California [17].

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17. "1988 Conservation Report", California Energy Commission, Sacramento, CA, Oct. 1988.

Table 1

COST-EFFECTIVE CONSERVATION POTENTIAL IN NEW YORK STATE

Major Conservation Measures	Savings Potential (GWh/yr)	Cost of Energy ($/KWh)
Reflectors for fluorescent fixtures	4140	0.010
High eff. refrigerators and freezers	5280	0.011
Residential infiltration reduction	590	0.017
HVAC retrofits in commercial buildings	6850	0.020
Commercial bldg. variable speed drives	3473	0.024
Energy saving incandescent lamps	880	0.028
High eff. industrial lighting	470	0.028
Occupancy sensors in comm. buildings	500	0.033
High eff. commercial fluor. lighting	2190	0.036
Industrial variable speed drives	2550	0.040
Compact fluorescent lamps	2020	0.040
Infrared reflecting lamps	810	0.044
Daylighting in commercial buildings	1660	0.047
Heat pump clothes dryer	860	0.065
All major measures	32,270	0.025

Notes

1. Savings potential excludes measures already implemented.

2. Total electricity use in 1986 - 99,000 GWh.

3. Cost of saved energy is based on a 6% real discount rate.

Source: Miller, Eto, and Geller, "The Potential for Electricity Conservation in New York State, ACEEE and NYSERDA, Sept. 1989.

Table 2

COST-EFFECTIVE ELECTRICITY AND PEAK DEMAND SAVINGS
NEW YORK STATE
Savings and percent of total

CONSUMER PERSPECTIVE

Sector	Electricity consumption (GWh/yr)	(%)	Summer peak demand (MW)	(%)	Winter peak demand (MW)	(%)
Residential	12,297	35.6%	1,951	27.0%	1,859	27.6%
Commercial	19,399	48.4%	4,463	44.3%	2,517	31.8%
Industrial	2,646	13.0%	438	13.4%	411	13.2%
Total	34,342	34.7%	6,852	33.3%	4,787	26.9%

UTILITY PERSPECTIVE

Sector	Electricity consumption (GWh/yr)	(%)	Summer peak demand (MW)	(%)	Winter peak demand (MW)	(%)
Residential	8,222	23.8%	2,943	40.7%	1,962	29.1%
Commercial	13,691	34.2%	3,075	30.5%	1,698	21.4%
Industrial	413	2.0%	67	2.1%	63	2.0%
Total	22,326	22.5%	6,085	29.6%	3,723	20.9%

SOCIETAL PERSPECTIVE

Sector	Electricity consumption (GWh/yr)	(%)	Summer peak demand (MW)	(%)	Winter peak demand (MW)	(%)
Residential	12,599	36.4%	3,258	45.1%	3,197	47.4%
Commercial	19,402	48.4%	5,181	51.5%	2,512	31.7%
Industrial	3,466	17.0%	554	17.0%	531	17.0%
Total	35,467	35.8%	8,993	43.7%	6,240	35.1%

*Discount rates for each perspective are: 6% - consumer, 10% - utility, 3% - societal

Table 3

EXPENDITURES FOR C&LM PROGRAMS BY SELECTED MAJOR UTILITIES

		In Last Year		Cumulative
Utility	Period Covered	Dollars (million)	% of '87 Revenues	Dollars (million)
Austin	1985-8	$9.03	2.3%	$38.95
CMP	1987-9	$20.78	3.7%	$35.46
NEES	1987-9	$37.02	2.7%	$73.27
PG&E	1981-8	$34.68	0.7%	$530.57
Seattle	1981-7	$9.99	4.1%	$74.24
SCE	1981-8	$29.98	0.6%	$441.41
WEPCo	1987-9	$38.76	3.5%	$115.01

Note:

All figures in 1987 dollars.

Sources: C&LM expenditure figures were obtained from published reports and from personnal communications with staff at the individual utilities. Utility revenue figures for 1987 are from Energy Information Administration, Financial Statistics of Selected Electric Utilities 1987, Washington, D.C., U.S. Government Printing Office.

Table 4

ENERGY AND POWER SAVINGS FROM SELECTED MAJOR UTILITY C&LM PROGRAMS

Utility	Period Covered	Cumulative GWh	Cumulative MW	In Last Yr GWh	In Last Yr MW
Austin	1984–8	101.1	163.3	21.1	12.6
CMP	1984–8	236.0	NA	83.6	NA
NEES	1987–9	268.1	126.8	142.6	53.6
PG&E	1981–8	5303.4	841.3	388.7	28.5
Seattle	1981–7	172.6	NA	16.7	NA
SCE	1981–8	8993.2	1251.2	375.4	96.2
WEPCo	1987–9	404.8	94.0	126.7	31.6

Notes:

1. Austin, CMP, PG&E and SCE figures include free riders. Other utilities exclude free riders from their figures.

2. MW savings are for coincident peak for Austin, NEES and WEPCo. For the other utilities, MW savings are not adjusted for coincidence with the peak.

3. Seattle and SCE figures exclude measures which have passed their useful life. PG&E figures include many low and no cost measures which are probably no longer in place.

Source: Figures were obtained from published reports and from personnal communications with staff at the individual utilities.

Table 5

ENERGY AND POWER SAVINGS AS A PERCENT OF 1987 GWH SALES AND PEAK DEMAND FROM SELECTED MAJOR UTILITY C&LM PROGRAMS

Utility	Period Covered	Cumulative GWh	Cumulative MW	In Last Yr GWh	In Last Yr MW
Austin	1984-8	1.8%	4.5%	0.4%	0.9%
CMP	1984-8	2.6%	NA	0.9%	NA
NEES	1987-9	1.4%	3.3%	0.7%	1.4%
PG&E	1981-8	8.0%	5.9%	0.6%	0.2%
Seattle	1981-7	2.1%	NA	0.2%	NA
SCE	1981-8	13.7%	8.5%	0.6%	0.7%
WEPCo	1987-9	2.0%	2.5%	0.6%	0.8%

Note:

Based on data in Table 3 and 1987 sales and peak demand data from Electrical World Directory of Electric Utilities, 1989, 97th Edition, New York, McGraw Hill.

Figure 1

ELECTRICITY CONSERVATION SUPPLY CURVE
New York State – 6% Discount Rate

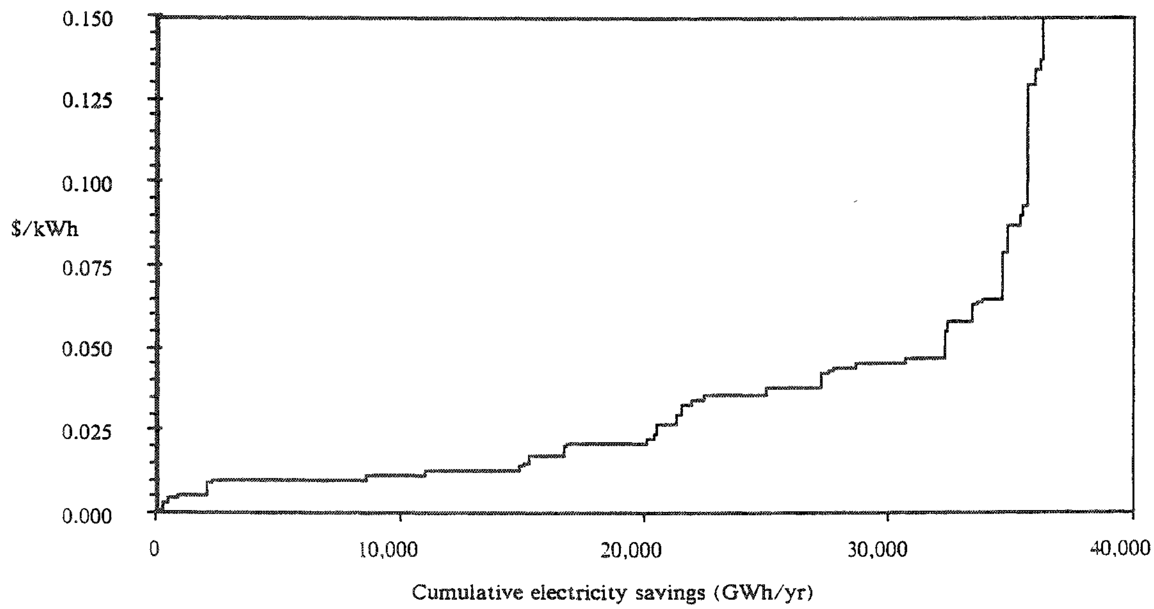


Figure 2

SUMMER PEAK DEMAND REDUCTION SUPPLY CURVE
New York State – 6% Discount Rate

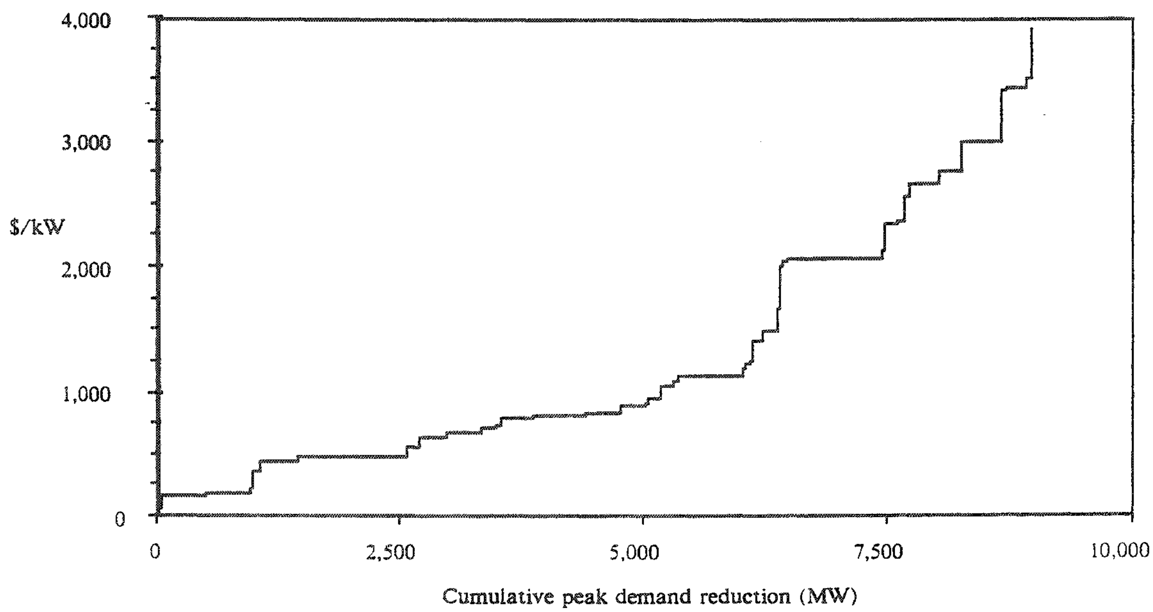
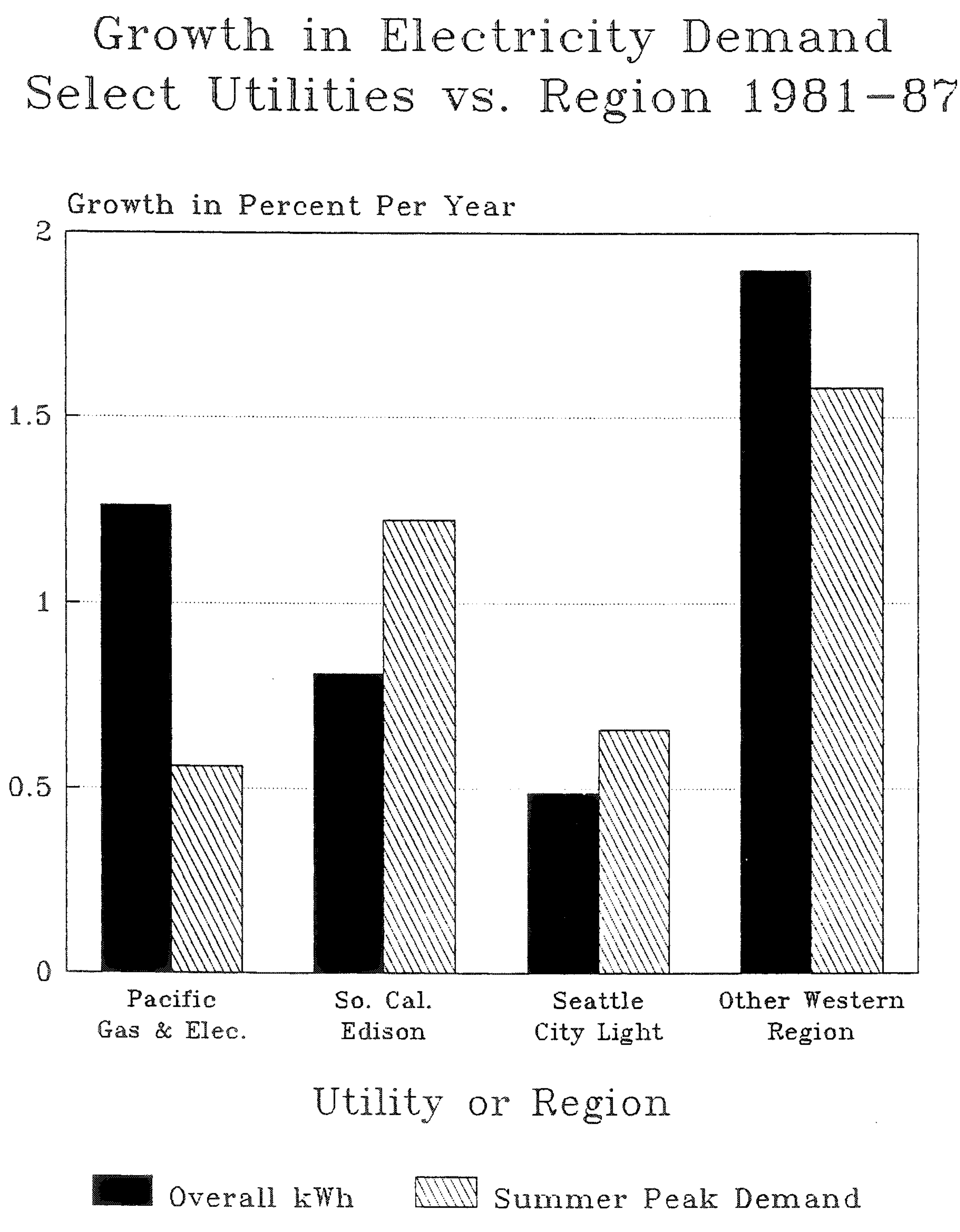
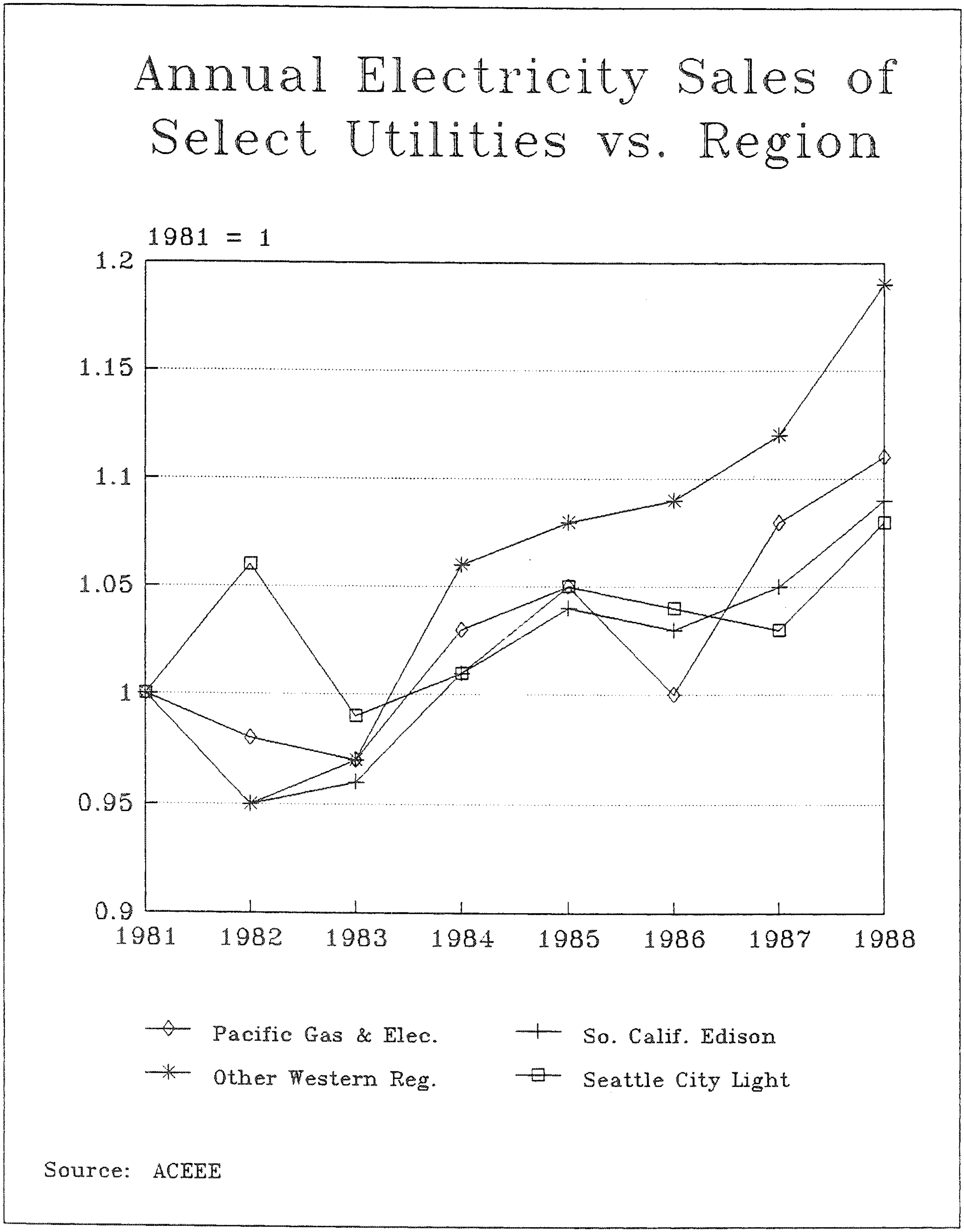


Figure 3



Source: ACEEE

Figure 4


Annual Electricity Sales of
Select Utilities vs. Region
1981 = 1
1.2
1.15
1.1
1.05
1
0.95
0.9
1981
1982
1983
1984
1985
1986
1987
1988
Pacific Gas & Elec.
So. Calif. Edison
Other Western Reg.
Seattle City Light
Source: ACEEE