THE POTENTIAL FOR ELECTRICITY CONSERVATION IN THE STATE OF NEW YORK, USA

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ABSTRACT

Traditional utility planning relies on new plant construction to meet future electrical demands. Recently, the assumptions underlying this approach have been questioned and an alternative planning approach, called least-cost planning, has been proposed.
The least-cost planning approach requires planners to consider all practical means for meeting customer's demands for energy services including options that use energy more efficiently. The approach requires determination of the costs of both supply- and demand-side options and selection of the least expensive option. Advocates of least-cost planning have argued that significant opportunities exist to save energy at costs lower than the marginal cost of new supplies.

In this paper, we investigate this claim for a particular situation in the United States. We examine the potential for electricity conservation in the residential, commercial, and industrial sectors of the state of New York. These sectors account for 35%, 40%, and 21% of electrical sales in the state, which in 1986 were nearly 100 TWh. We quantify the energy savings that would result from implementation of 62 energy conservation measures. The measures are ranked according to their cost and aggregate energy savings. Costs include the direct capital and labor costs of installating the measures, but they do not include the costs of stimulating the market to adopt them (such as utility program costs).

We find that substantial electricity savings are available at costs less than the marginal cost of new supplies. If all measures costing less than the marginal cost of new supply were implemented, we estimate that statewide electricity demand could be reduced by 34%. These potential savings result from reductions of 34%, 47%, and 16% in the electricity consumed by the residential, commercial, and industrial sectors. The magnitude of these savings suggests that the potential for electricity conservation in the state of New York is a significant and largely un-tapped resource. The findings also suggest that consumer's demands for energy services will be served at lower cost by aggressive implementation of electricity conservation programs rather than by additional electricity generation.

KEYWORDS: ENERGY POLICY, ECONOMICS, ENERGY CONSERVATION, ELECTRIC UTILITIES, RESIDENTIAL, COMMERCIAL, INDUSTRIAL, UNITED STATES

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INTRODUCTION

Traditional utility planning approaches rely on new plant construction to meet future electrical demands. This planning approach is based on the assumption that the markets for energy services are perfectly competitive. By this assumption, consumers invest in and utilize economically efficient energy-using goods of their own accord, motivated by self-interest. Consumers act based on comparisons of the returns from alternative activities and selection of those activities that provide equal or better returns than those available from alternatives. According to this model, future electricity demands are immutable (and new plant construction by utilities is unavoidable) because additional demand-side activities by consumers (such as increased energy efficiency) would exceed the economically justified limit. In other words, demand- side inefficiencies (and therefore demand-side resources) can only exist, if price signals are incorrect. Thus, the appropriate policy response to perceived inefficiencies in electricity markets is rate reform based on marginal cost principles.

While improved pricing is without question an important component of electricity policy, additional assumptions underlying the conventional model have also been called into question (Krause and Eto 1988). Foremost among these is the assumption that market imperfections or barriers are neglible or affect only a small number of consumers. Advocates of least-cost planning argue that, to the contrary, market imperfections are pervasive and require significant intervention to correct. Their arguments rest on three empirical observations:

1. The efficiency gap between the average efficiency of, say, new buildings and current equipment as currently built and purchased is large compared to the most energy-efficient, cost-effective available designs and models;

2. The payback gap between the investment time horizons used by consumers (either implicitly or explicitly) when they purchase or use energy-using goods and that used by utilities investing in new supplies is large; and

3. Significant market and institutional barriers, distinct from price, prevent economically efficient investments from being made by consumers. These barriers include split incentives (e.g., between landlords and tenants), limited access to capital and protection from risk, and high information and transaction costs, among others.

In this paper, we report on a recent study that quantifies the first of these observations for the residential, commercial, and industrial electriciy consuming sectors of state of New York, USA (Miller, Eto, Geller 1989). The objective of the study was to determine the potential for electricity and peak demand reductions in the current equipment and building stock in New York state.

It is important to be very precise about this objective: The study was one of the potential for electricity conservation. We determined only the magnitude and direct costs of the demand-side or conservation resource that exists in the state. These costs included only the capital and labor costs of the resource; they did not include the costs associated with stimulating the market to adopt the resource nor did we consider the rate of adoption.

Rather, we posed the following thought experiment: What would be the electricity and peak demand savings resulting from 100% implementation of available cost-effective conservation measures in current buildings? This framework placed important qualifications on the scope of our analysis. We did not, for example, examine the potential for conservation in buildings not yet built nor did we examine opportunities to substitute non-electrical energy sources as a means for electricity. Finally, our examination focussed on a unique location, the state of New York, generalizations to other regions would require additional detailed comparisons on a fairly disaggregated level.

The paper is organized in four sections following this introduction. We begin by briefly reviewing electricity use in the state of New York. This discussion is followed by a desription of the method of study employed to determine the conservation potential in the state. Presentation of the results of our study focusses primarily on findings from the buildings sectors (residential and commercial). Finally, we conclude with comments on the significance of the study for future energy policies for the state.

ELECTRICITY CONSUMPTION IN NEW YORK STATE

In 1986, the seven major private utilities in New York (Consolidat- ed Edison Company of New York, Inc., Niagara Mohawk Power Corpora- tion, Long Island Lighting Company, New York State Electric and Gas Corporation, Rochester Gas and Electric Corporation, Orange and Rockland Utilities, Inc., and Central Hudson Gas and Electric Corporation) recorded electricity sales of 99,035 GWh. The commercial sector accounted for the largest percentage of sales (40%) followed by the residential (35%) and industrial (21%) sectors.

Statewide peak demand in the summer of 1986 was 20,558 MW. Of this total, the commercial sector accounted for 49%, while the residential sector accounted for 35%. Winter peak demand in 1986 was 15% lower than the summer peak demand (17,768 MW).

The commercial sector consists of approximately 330 million square meters of floor space. Office buildings account for the largest fraction (28%), followed by small buildings (21%), educational buildings (14%), retail stores (12%), hospitals (5%), hotels (3%), and supermarkets (2%). We did not analyze conservation opportunities for the remaining 16% of commercial floor area.

The residential sector consists of approximately 5.9 million households of which 50% are single-family dwellings. The remainder of the housing stock is divided among large (5 or more units) multi-family buildings (29%), small multi-family buildings (18%), and mobile homes (2%).

The industrial sector is difficult to characterize succinctly due to its heterogenous composition. The two largest sectors, chemicals and allied products, and electric and electronic machinery, each accounted for 15% of 1986 industrial electricity sales. The remaining major sectors (primary metal; machinery (except electrical); transportation equipment; stone, clay, glass, and concrete; paper and allied products; and food and kindred products) each accounted for between 6% to 10% of industrial sales.

METHOD OF STUDY

The conservation analysis consists of determining the aggregate electricity and peak demand savings that would result from implementation of a total of 62 conservation measures in the commercial, residential, and industrial sectors. Most of the measures are commercially available; a few are expected to be available by the early 1990's. For the most part, the conservation measures reduce electricity consumption and peak demand without adversely affecting the energy services delivered. n other words, energy savings for say, lighting, are not achieved through reductions in lighting below recommended levels, rather they are achieved through provision of recommended lighting levels with greater efficiency.

Each conservation measures is analyzed with respect to:

1. total electricity and peak demand savings; and

2. cost-effectiveness. Cost-effectiveness is measured by expressing cost of each measure in terms of both a "cost of saved energy" and a "cost of reduced peak demand". For both of these indicators, the total capital and installation costs of a conservation measure are first annualized using an assumed real discount rate and the average life of the measure. The annualized quantity is then normalized by estimated annual energy or peak demand savings. The result is an annualized cost for each measure expressed on a per kWh or per kW basis.

The conservation analyses of the measures are then aggregated separately for each sector. Measures are ordered by increasing cost, which along with associated total energy or peak demand savings forms a "supply curve of conserved energy" or "supply curve of reduced peak demand." Specification of an appropriate opportunity cost then determines the threshold for cost- effectiveness. All measures costing less than the threshold are cost-effective and the sum of the energy savings from these measures is the cost-effective conservation potential. See Meier, Wright, and Rosenfeld (1983) for a description of the concepts underlying and formal definitions for calculating "costs of conserved energy" and "supply curves of conserved energy."

We examined cost-effectiveness from three perspectives, the consumer, the utility, and society. For all three perspectives, the costs consist of the capital and labor costs of installing the energy efficiency measures. The perspectives differ in the definition of the benefits from the energy efficiency measures and in choice of discount rate applied to these benefits. For the consumer perspective, we used a 6% real discount rate; for the utility perspective, we used a 10% real discount rate; and for the societal perspective, we used a 3% real discount rate. For the consumer perspective, the benefit consists of reduced electricity bills. In this case, the appropriate cost effectiveness threshold is the average cost of electricity (which, in 1987$ is $0.096/kWh, $0.106/kWh, and $0.053/kWh for the residential, commercial, and industrial sectors, respectively).

For the utility and societal perspectives, the benefit consists of avoided utility investments and operating expenses for electricity generation. In this case, the relevant threshold for cost-effectiveness is the utilities' long-run marginal cost of electricity generation. Our estimate of the long-run marginal cost of electricity supply is taken from a ruling by the New York State Public Service Commission that sets rates for utilities' purchases of power produced by non-utility genearators. The ruling considers the long-run avoided costs of both energy and capacity. Long-run avoided energy costs were estimated using a utility production cost simulation model that considers both changing fuel and purchase power costs, and diurnal and seasonal fluctuations in hourly loads.

Capacity costs were based on an analysis of the incremental capital and amortization costs of a hypothetical new generation plant. The energy and capacity costs are then combined and levelized for comparison to the costs of conserved energy ($0.037/kWh for the utility perspective using a real discount rate of 10% and $0.072/kWh for the societal perspective using a real discount rate of 3%).

See Krause and Eto (1988) for a detailed discussion of the three benefit-cost perspectives, their application in least-cost utility planning, and on procedures used to calculate utility avoided costs.

The estimation of savings from each conservation measure was based on the relative cost-effectiveness of the measures. That is, the electricity and peak demand impacts of more cost-effective measures were subtracted from total energy use before estimating the impacts of less cost-effective measures. This procedure is essential to avoid double-counting savings within and across end-uses. An example of double-counting savings within an end-use occurs when the difference in energy use between a base case and a policy case of, say, a commercial lighting measure such as replacement of existing lighting with very high efficiency fluorescent lamps is attributed entirely to the very high efficiency fluorescent lamps.

In fact, only the incremental energy savings that result from installing these lamps after first installing a more cost-effective measure, such as high efficiency fluorescent ballasts, can be attributed to the very high efficiency fluorescent lamps. An example of double-counting savings across end-uses occurs when the full savings from an efficiency upgrade for air-conditioning equipment are attributed to this equipment without first accounting for the reduced cooling loads that are being met by this equipment due to the prior introduction of an even more cost-effective retrofit that reduced lighting energy use (and hence cooling loads).

To provide a consistent framework for analyzing these interactions, we used the DOE-2 building energy simulation program for our analysis of the energy and peak demand savings of conservation measures in residential and commercial buildings. The DOE-2 program was developed by the Lawrence Berkeley and Los Alamos National Laboratories for the US Department of Energy to provide architects, engineers, and building researchers with a state-of-the-art tool for estimating building energy performance (BESG 1984). Separate simulations were carried-out for two residential building prototypes (a single family residence and a high-rise multifamily building) and seven commercial building prototypes (office, retail, hotel, hospital, supermarket, school, and small building).

THE POTENTIAL FOR ELECTRICITY CONSERVATION

Tables 1 and 2 present, from the consumer perspective (i.e., using a real discount rate of 6%) in order of increasing cost of saved energy, aggregate electricity savings for the commercial and residential sectors, respectively. These tables indicate that the overall technical potential for electricity savings (ignoring cost- effectiveness) is 50% in the commercial sector and 37% in the residential sector. When combined with the estimated technical potential for the industrial sector of 22% (not shown), we find that the full adoption of the measure analyzed by this study would reduce statewide electricity consumption by 38%. Full adoption of the measures would also reduce statewide summer peak demands by 45% (the sectoral savings in summer peak demand would be as follows: commercial - 53%; residential - 44%; and industrial - 22%) and winter peak demands by 35%.

Table 3 presents the cost-effective electricity and peak demand savings potentials for each benefit-cost perspective (consumer, utility, and society). From the consumer perspective, the cost- effective electricity savings potential is 34,300 GWh/yr or 35% of statewide consumption in 1986. From the utility perspective, the cost-effective potential is somewhat lower (about 27% of 1986 consumption) due to the high discount rate (10% real), which lowers the value of future energy savings (i.e., the value of avoided utility generation). From the societal perspective, the cost- effective potential is slightly lower than that found from the consumer perspective (about 34% of 1986 consumption). While the societal perspective relies on the same long-run marginal cost used to determine cost-effectiveness for the utility perspective, use of a lower discount rate (3% real) increases the size of the cost- effective potential.

Considering only the consumer perspective for the moment, we find that the largest potential for cost-effective electricity savings lies with more efficient refrigerators and freezers in the residential sector. In the commercial sector, the greatest savings result from installation of reflectors in fluorescent light fixtures and the use of variable speed drives for pumps and fans. From the standpoint of saving summer peak demand, the largest savings result from more efficient residential refrigerators and freezers, reflectors for commercial fluorescent lights, and conversion of commerical HVAC systems to variable air volume systems. These three measures also offer the largest savings in winter peak demand.

SIGNIFICANCE OF THE RESULTS

Our analysis shows that there is an enormous potential for cost-effective electricity savings and peak demand reductions within the existing stock of buildings and equipment of the state of New York.

Developing a significant portion of this resource could save households and businesses in the state billions of dollars and eliminate the need to build a number of new power plants.

For example, a recent forecast by the New York State Energy Office predicts electricity demand growth of 1.75%/yr for the period 1985- 2002. This growth rate, if realized, would mean that electricity demands for the utilities examined by this study would increase by about 27,000 GWh/yr over this period. Based on our analysis, the entire forecasted increase in demand could be displaced by developing 80% of the cost-effective electricity savings identified for existing buildings and equipment.

It is important to remember that our estimates of potential savings do not take into account any limitations on implementation. In reality, only a portion of the full technical or cost-effective potential savings can be achieved. In order to obtain these savings, additional expenditures may be required to stimulate adoption of the measures by consumers (such as advertising, provision of information, rebates, or loans). On the other hand the adoption of conservation measures provides other benefits not included in the economic calculation of cost-effectiveness (e.g., air pollution and the emission of greenhouse gasses are reduced by the electricity generation offset by conservation).

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Table I. New York State Electricity Conservation Potential
Commercial Sector (1986 sales = 40,087 GWh)
Consumer Perspective - real discount rate = 6%

End Use	Option	Cost of Saved Energy (87$/kWh)	Energy Savings (GWh/yr)	Cum. % of Sector (%)
LIT	Delamping	0.001	141	0.4
REF	Floating Head Pressure Control	0.001	172	0.8
REF	High Efficiency Compressor	0.003	214	1.3
HVAC	Reset Supply Air Temperature	0.005	1182	4.3
LIT	Reflectors	0.010	4142	14.6
HVAC	High Efficiency Fan Motor	0.011	309	15.4
LIT	High Efficiency Ballast	0.013	513	16.6
HVAC	VAV Conversion	0.017	2776	23.6
HVAC	Economizer	0.017	301	24.3
LIT	Energy-Saving Fluorescent	0.017	593	25.8
HVAC	High Efficiency Pump Motor	0.018	23	25.9
HVAC	Variable Speed Fan Drives	0.021	3261	34.0
LIT	Occupancy Sensors	0.033	500	35.2
HVAC	Re-Size Chiller	0.038	2260	40.9
REF	Refrigerated Case Covers	0.044	54	41.0
LIT	Daylighting Controls	0.047	1660	45.2
LIT	Very High Eff. Lamps and Ballasts	0.058	1085	47.9
HVAC	Variable Speed Pump Motor	0.063	212	48.4
HVAC	Window Film (South and West, only)	0.134	196	48.9
HVAC	Low-Emissivity Windows (North, only)	0.215	85	49.1
HVAC	Low-Emissivity Windows (All)	0.236	319	49.9
HVAC	Roof Insulation	0.603	16	49.9

Table 2. New York State Electricity Conservation Potential
Residential Sector (1986 sales = 34,577 GWh)
Consumer Perspective - real discount rate = 6%

End Use	Option	Cost of Saved Energy (87$/kWh)	Cum. Energy Savings (GWh/yr)	% of Sector (%)
FRZ	Current Sales Average (1986)	0.004	373	1.1
REF	Current Sales Average (1986)	0.010	1876	6.5
REF	Best Current (1988)	0.011	1865	11.9
REF	Near-Term Advanced	0.013	781	14.2
DHW	Traps & Blanket (EF=0.9)	0.013	265	14.9
FRZ	Best Current (1988)	0.014	259	15.7
FRZ	Near-Term Advanced	0.015	129	16.0
SHS	Infiltration Reduction	0.017	593	17.8
COK	Improved Oven	0.022	212	18.4
SHM	Storm Windows	0.022	112	18.7
SHM	Low-Emissivity Film	0.024	35	18.8
COK	Improved Cooktop	0.025	74	19.0
LIT	Tungsten Halogen Lamp - 300 hr/yr	0.027	697	21.0
LIT	Energy Saving Lamp - 620 hr/yr	0.030	82	21.3
LIT	Energy Saving Lamp - 1,240 hr/yr	0.030	98	21.5
DHW	Front Loading Clothes Washer	0.034	447	22.8
LIT	Compact Fluorescent - 1,240 hr/yr	0.036	1102	26.0
SHS	Heat Pump (HSPF=7)	0.042	236	26.7
LIT	IRF Lamps - 300 hr/yr	0.044	813	29.1
LIT	Compact Fluorescent - 620 hr/yr	0.045	918	31.7
SHS	Heat Pump (HSPF=8)	0.055	23	31.8
CDR	Heat Pump Clothes Dryer	0.065	858	34.3
SHS	Low-Emissivity Film	0.079	163	34.7
RAC	High Efficiency RAC (EER=8.5)	0.093	144	35.2
CAC	Window Film	0.137	76	35.4
RAC	High Efficiency RAC (EER=10)	0.152	87	35.6
CAC	High Efficiency CAC (SEER=10)	0.161	79	35.9
RAC	High Efficiency RAC (EER=12)	0.195	91	36.1
CAC	Variable Speed Drive	0.221	55	36.3
CAC	High Efficiency CAC (SEER=12)	0.316	47	36.4
SHS	Roof/Ceiling Insulation	0.455	25	36.5
CAC	High Efficiency CAC (SEER=14)	0.463	37	36.6

Table 3. Cost-Effective Electricity and Peak Demand Savings

	Consumption (GWh/yr)	(%)	Summer Peak (MW)	(%)	Winter Peak (MW)	(%)
Consumer Perspective						
Residential	12297	36	1951	27	1859	28
Commercial	19399	48	4463	44	2517	32
Industrial	2646	13	438	13	411	13
Total	**34342**	**35**	**6852**	**33**	**4787**	**27**
Utility Perspective						
Residential	9823	28	2442	34	1604	24
Commercial	15606	39	3450	34	1970	25
Industrial	1859	9	293	9	290	9
Total	**27288**	**23**	**6185**	**30**	**3864**	**22**
Societal Perspective						
Residential	11856	34	3083	43	2988	45
Commercial	18901	47	5062	50	2506	32
Industrial	3303	16	529	16	507	16
Total	**34060**	**34**	**8674**	**42**	**6011**	**34**

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