Title
ANALYSIS OF MICHIGAN'S DEMAND-SIDE ELECTRICITY RESOURCES IN THE RESIDENTIAL SECTOR, VOLUME 1. EXECUTIVE SUMMARY

Authors
Krause, F.
Brown, J.
Connell, D.

Publication Date
1988-04-01

LBL-23025
UC-95d

Lawrence Berkeley Laboratory

UNIVERSITY OF CALIFORNIA

APPLIED SCIENCE DIVISION

Final Report: Analysis of Michigan's Demand-Side Electricity Resources in the Residential Sector

Volume I. Executive Summary

F. Krause, J. Brown, D. Connell, P. DuPont, K. Greely,
M. Meal, A. Meier, E. Mills, and B. Nordman

April 1988

APPLIED SCIENCE DIVISION

Prepared for the U.S. Department of Energy under Contract Number DE-AC03-76SF00098.

DISCLAIMER

LBL-#23025

ANALYSIS OF MICHIGAN'S DEMAND-SIDE ELECTRICITY RESOURCES IN THE RESIDENTIAL SECTOR*

Volume I

Executive Summary

by

Florentin Krause
Project Leader

John Brown, Deb Connell, Peter DuPont,
Kathy Greely, Meg Meal,
Alan Meier, Evan Mills, Bruce Nordman,
Contributing Staff

Lawrence Berkeley Laboratory
Applied Science Division
One Cyclotron Road
Berkeley, California 94720

Revised Final Report
April 1988

*This work was funded by the MERRA Research Corporation under Contract 2C through the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

CONTENTS OF REPORT

VOLUME ONE: EXECUTIVE SUMMARY

VOLUME TWO: METHODOLOGY AND RESULTS

APPENDICES

VOLUME THREE: END-USE STUDIES

APPENDICES

ACKNOWLEDGMENTS

Funding for this project was provided by the MERRA Research Corporation under Contract 2C through the U.S. Department of Energy under Contract No. DE-AC03-76SF00098. We would also like to thank the many individuals who provided us with valuable help on this project, including: Charles Millar and Sharon Ehlke, of the Michigan Department of Commerce, Public Service Commission, Office of Energy Programs; Ved Agrwal, Larry Bailey, and Lisa Heldmeyer-Molner, of the Michigan Department of Commerce, Public Service Commission; Ken Linder of ICF, Inc.; Ronald Fryzel and Hank Schwab of Detroit Edison; Teri Boertman and Curt Puckett of Consumers Power Company; Joan Smith, Leo Soorus, and Andrew Takacs, of Whirlpool Corporation; Howard Geller of the American Council for an Energy-Efficient Economy; and Bill Colburne, Jean Ferrari, Jeff Harris, Chris Pignone, John Randolph, and Jacques Roturier, of the Lawrence Berkeley Laboratory.

EXECUTIVE SUMMARY

This report assesses the technical and economic potential for electricity conservation in Michigan's residential sector. We have investigated a wide range of technologies to reduce energy use and estimated the statewide impact of their implementation with respect to energy savings and costs. We present the results in terms of the ''cost of conserved electricity,'' which permits simple, consistent comparisons among demand-side measures and between demand- and supply-side options. The results of this report, while important in themselves because they demonstrate large potential electricity savings , are designed to serve as part of a larger, integrated assessment of Michigan's electricity resource options. For this reason, we make no recommendations regarding the selection of demand-side measures over supply-side measures or the optimal mix. However, we present typical electricity costs to provide readers a reference point for judging the measures themselves. We also discuss the merits of one demand-side measure relative to another.

This report builds on the rapidly increasing experience in demand-side management in Michigan and the United States. At the same time, it has several features that are unique. We assessed the *programs* to deliver the energy efficiency technologies as well as the technologies themselves. This permits a much more realistic assessment of the measures, including the costs to administer a program, and the rates at which the electricity savings will become available. We also investigated the impact of these demand-side measures on the major utilities' load shapes. Thus, we show the expected peak and off-peak power savings, in addition to annual electricity savings. We developed an indicator of cost-effectiveness, the ''cost of conserved power'' to permit a simple comparison with the cost of supplying power. Again, however, the selection of the optimal mix of demand and supply-side options is left to the integrated analysis.

Data Sources

We obtained our baseline assumptions from other MEOS working groups. They provided projections of population, housing stock, appliance saturations, and levels of services. The MEOS working groups developed ''business-as-usual'' energy use forecasts, from which we calculated potential energy savings. We also gathered considerable stock and load shape data from the two major Michigan utilities. To simplify the analysis, we confined our analysis to the service areas of Michigan's two largest utilities. This represents about 85% of the total residential energy use.

We investigated the energy and power saving potential in thirteen end-uses, including refrigeration, lighting, water heating, and space heating. These end uses consumed about two-thirds of all electricity purchased by the residential sector in 1985. Over one hundred demand-side technologies and programs were considered. We assumed that the levels of end-use services were maintained or even increased. Thus, these measures do not imply any sacrifice or reduction in lifestyle: room temperatures remain constant, showers just as pleasant, clothes as clean, etc.

Much of demand-side management experience gathered in other regions of the U.S. can be applied to Michigan. We therefore drew extensively on studies conducted outside the state. These studies included direct monitoring of in-place conservation technologies, assessments of new measures, and results from specific demand-side programs. This report is unique in its extensive reliance on *documented* energy savings. For each technology or retrofit, we compiled its cost, energy and power savings, lifetime, and special features. Engineering estimates were used only when no measured data were available or inappropriate for Michigan. We sought to benchmark all engineering estimates to known Michigan data and we adjusted the results to Michigan conditions when appropriate.

Methodology

We used the agreed-upon MEOS baseline assumptions and our conservation measure data to calculate the *technical potential* for electricity and peak power conservation. We first calculated the cost of conserved electricity (CCE) for each measure when implemented individually. Interactive effects between measures are described in the sections on End Use Studies, in Volume III. Next we calculated the statewide potential savings. Additional assumptions related to timing, penetration, and technical feasibility are used in this calculation. (Again, these are described in the End Use Studies sections, in Volume III.)

The technical potential represents an upper limit to the savings that can be achieved through demand-side management, and serves as a starting point for estimating the energy savings that can be realistically achieved. Demand-side programs, such as incentives, consumer information, technical assistance and standards, must be used to implement these measures: Our projections reflect the expected net change in penetration rates due to an "aggressive" set of programs -- but still less than 100% of the technical potential. Penetration rates of demand-side programs are just now entering the least-cost literature; nearly all of our information comes from reports issued in the last three years. Our projected implementation and penetration rates include a substantial period -- often up to five years -- for pilot programs to be field-tested and refined. In other cases, the programs are not assumed to start for several years. We also estimated the added costs to administer the programs. Costs of conserved energy and power were recalculated to reflect the adjusted costs and energy savings. The result is a second estimate, the *program-based achievable conservation.* This is a realistic assessment of the energy and peak power that can be saved through installation of off-the-shelf technologies and delivered through field-tested programs.

Results

We summarize the major findings of our analysis below. The reader should consult the results section in Volume II or the End Use Studies in Volume III for details.

Baseload equivalent demand in 1995 and 2005 for the MEOS baseline, our estimate of program achievable potential, and our estimate of technical potential are shown in the table below.

Comparison of Projected Residential Sector Baseload Equivalent Demand (MW), 1995 and 2005: Program Achievable Potential and Technical Potential

	MEOS Baseline	Program Achievable	Technical Potential
1995	2410	1910	1390
2005	2360	1680	1040

We first estimated the technical potential for energy and power savings through demand-side measures. Figure 1 summarizes the projections. By 2005, demand-side measures can save about 6590 Gigawatt-hours (GWh) per year, or 56%, of electricity predicted by the MEOS business-as-usual forecast. This corresponds to 1320 Megawatts (MW) of equivalent baseload.[1] Most of the savings are captured in the

[1] The electricity savings are converted to baseload equivalent by assuming a 60.4% capacity factor and 6% transmission losses, for an overall 57% conversion factor.

first decade; by 1995, the technical potential savings are 5100 GWh, or 42% of the MEOS forecast. These conservation options relied on off-the-shelf technologies that can already be ordered by the thousands or even millions. In a few cases, we relied on laboratory-proven prototypes to provide higher efficiencies for technologies introduced in the second decade of the scenario. We are confident that the prototypes are feasible, but there remains considerable work in converting them into commercially acceptable, mass-produced equipment.

We used the technical potentials to calculate the *achievable* potential through demand-side programs. The MEOS working group instructed us to assume *aggressive* conservation programs when estimating the potential. The achievable savings employ off-the-shelf technologies and proven demand-side programs. Program costs include the costs of administering the demand-side programs. We relied on documented results of similar programs. However, many assumptions regarding penetration rates of the technologies were still needed. We assumed very aggressive financial incentives so as to eliminate all extra first costs to participants. We also assumed that programs would need up to three years to develop and field-test the most effective subsidy and delivery mechanisms. We derived an achievable potential by reducing savings to account for non-participants and "free-riders."

We estimate that about 3400 GWh/year, or 680 MW of baseload equivalent, can be reliably saved by 2005. This represents about 29% of the MEOS' "business-as-usual" forecasted residential electricity use in 2005. Figure 1 shows our projection of achievable savings relative to the MEOS forecast and the technical potential. Almost three-quarters of these savings, that is, 500 MW, could be achieved by 1995. When aggressively pursued, the program-based savings equal about two-thirds of the technical potential. To achieve energy savings beyond these levels would require much higher administrative costs and would entail substantially greater implementation problems. Again, most of the savings (21% of the MEOS forecast) are obtained before 1995. Implementation of the achievable potential scenario would result in steady decline of about 1% per year in overall residential electricity demand over the next twenty years.

The residential electricity savings can be obtained, on average, at a low cost of conserved energy. 75% of the achievable savings can be "purchased" at a CCE of less than 3 ¢/kWh, and almost ninety percent of the achievable conservation can be obtained for less than 4 ¢/kWh, assuming that utility incentives cover the full extra first costs of consumer investments. The *average* cost for the first 75% of savings is about 1.1 ¢/kWh. In contrast, the short-run marginal cost of electricity from the average Michigan baseload plant is about 3 ¢/kWh, while actual electricity prices are more than twice as high. The above calculations assumed a 3% discount rate; however, the savings decrease (and the CCEs increase) only slightly when a 7% rate is used. The greatest potential savings lie in upgrading the efficiency of lighting, water heating, and refrigerators. Figures 2 and 3 are "supply curves of conserved energy" showing the achievable potential, based on 3% and 7% discount rates. These estimates include program administration costs and rebates of 100% of incremental costs to customers. (Rebates are higher than 100% of the incremental costs in some cases.)

The net present value of cumulative ratepayer program costs over the 20-year period for implementing these savings would be $759 million (1985) at a 3 percent discount rate, and $545 million (1985) at a seven percent discount rate.

Peak load reductions can be an important additional benefit of the energy savings, especially when they coincide with the utility system annual peak. The efficiency investments studied in this report bring with them a 26 percent reduction in summer peak by the year 2005, and a 40 percent reduction in winter peak. The seasonal difference is largely related to the limited economic potential for air conditioning improvements, given Michigan's short cooling season. In so far as the summer peak reduction of 26 percent is slightly lower than the percentage reduction in energy sales, the system annual load factor would decrease somewhat if no load management programs were pursued and the load curves from other customer classes stayed the same. This impact could be counteracted, if necessary, by implementing the load management options studied in our report, which allow significant peak load reductions. An adequate assessment of the final load shape impacts can, of course, only be made in the course of an integrated planning exercise covering all demand-side activities in all sectors.

We considered, but did not include in the final results, the impact of fuel switching and load management programs. (One difficulty is that the savings overlap.) Many Michigan homes have natural gas service but use electricity for water heating, clothes drying, and cooking. We calculated the costs and potential electricity savings from converting these electric appliances to gas. Fuel switching (for homes that already have gas service) appears to be relatively inexpensive, especially for water heaters. Even if the rate-payers paid for both the purchase and installation of a new water heater, the saved energy costs less than the short-run marginal cost of electricity. The statewide savings from water heater fuel switching are large: 1500 GWh/year, including 310 MW of summer peak. Conversion to gas clothes dryers and gas stoves could yield additional savings, but estimates of both energy savings and cost have greater uncertainties. There are cases where switching to electricity may be cost-effective. New, super-insulated homes may be cheaper to heat with electric resistance heating. Analysis of these aspects was beyond the scope of our study.

We estimate that 600 MW of demand at system peak could be shed through "demand subscription" programs. These programs would cost $270 per peak kW saved at a 3% discount rate. Summer peak demand can also be reduced through dedicated air conditioner and water heater load-shedding programs. The cost-effectiveness of load shedding depends on the end-use efficiency of electricity use. The savings for all types of load management programs would be smaller and more expensive if energy efficiency improvements are implemented first. We did not attempt to determine the optimal combination of conservation and load management measures.

The greatest possible uncertainty in our results arises from estimates of original energy use and the expected penetrations of conservation options. We relied as much as possible on monitored data to establish baseline energy use, but some studies were not statistically representative. We assumed aggressive implementation of conservation options which would permit high penetration. The high penetration potential cannot be confirmed until further pilot projects have been implemented. Uncertainties in our estimates of the costs of the options and the programs do not significantly affect the cost-effective potentials.

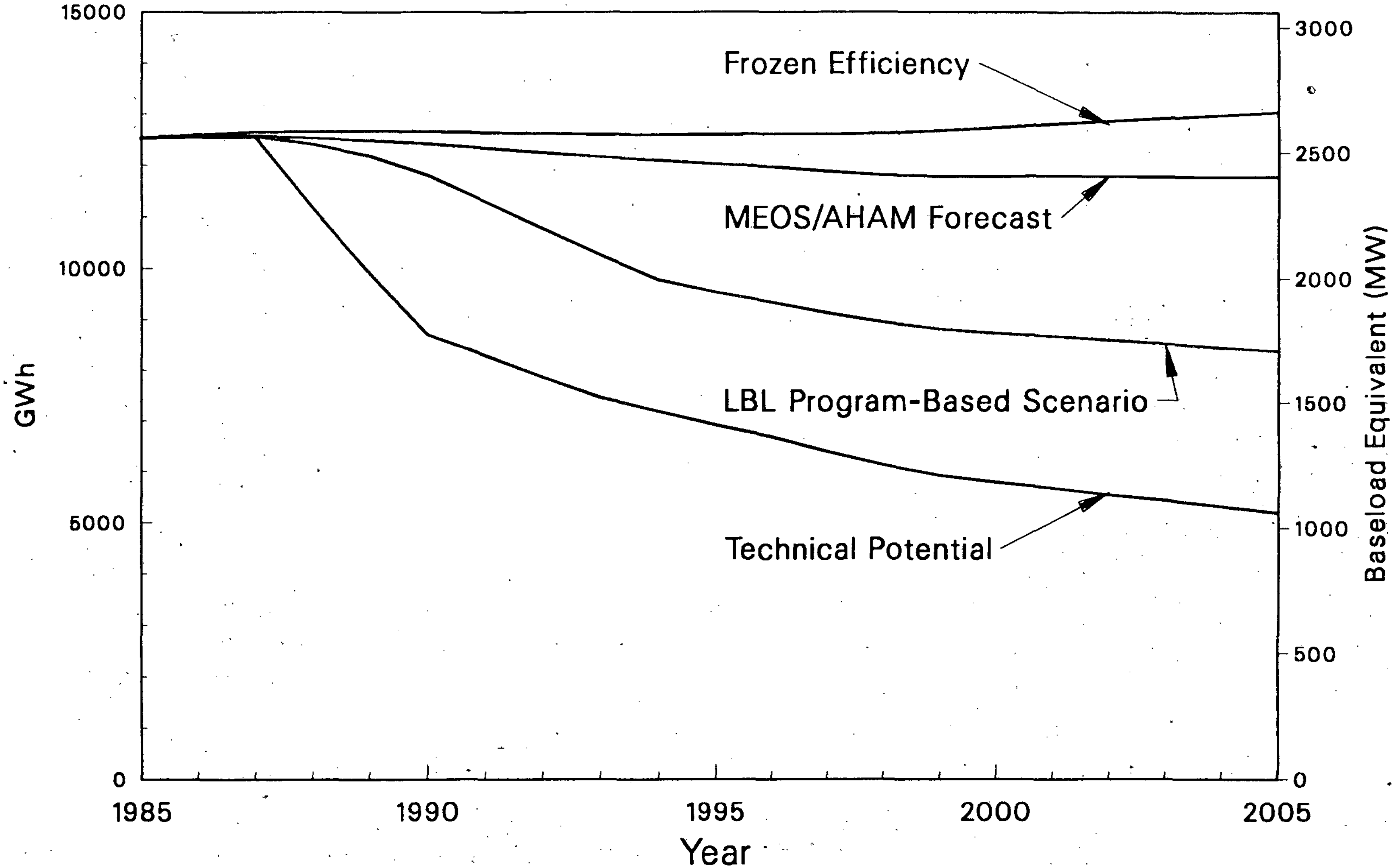
The key to reducing uncertainty is *feedback*. Results from surveys, monitoring, and pilot projects must be fed back into the estimates of the potential for conservation. Moreover, the feedback must continue as full-scale programs are implemented so as to assure that the savings are fully realized. Each program must track achieved savings, actual costs, and actual penetration rates. Monitoring and evaluation are essential elements of quality assurance.

We studied several issues related to an aggressive demand-side program, including the impacts on the environment, employment, and health. We found no significant obstacles; indeed, an aggressive energy efficiency appeared to improve the environment, create jobs, and, in some instances, increase the quality of life.

Figure 1

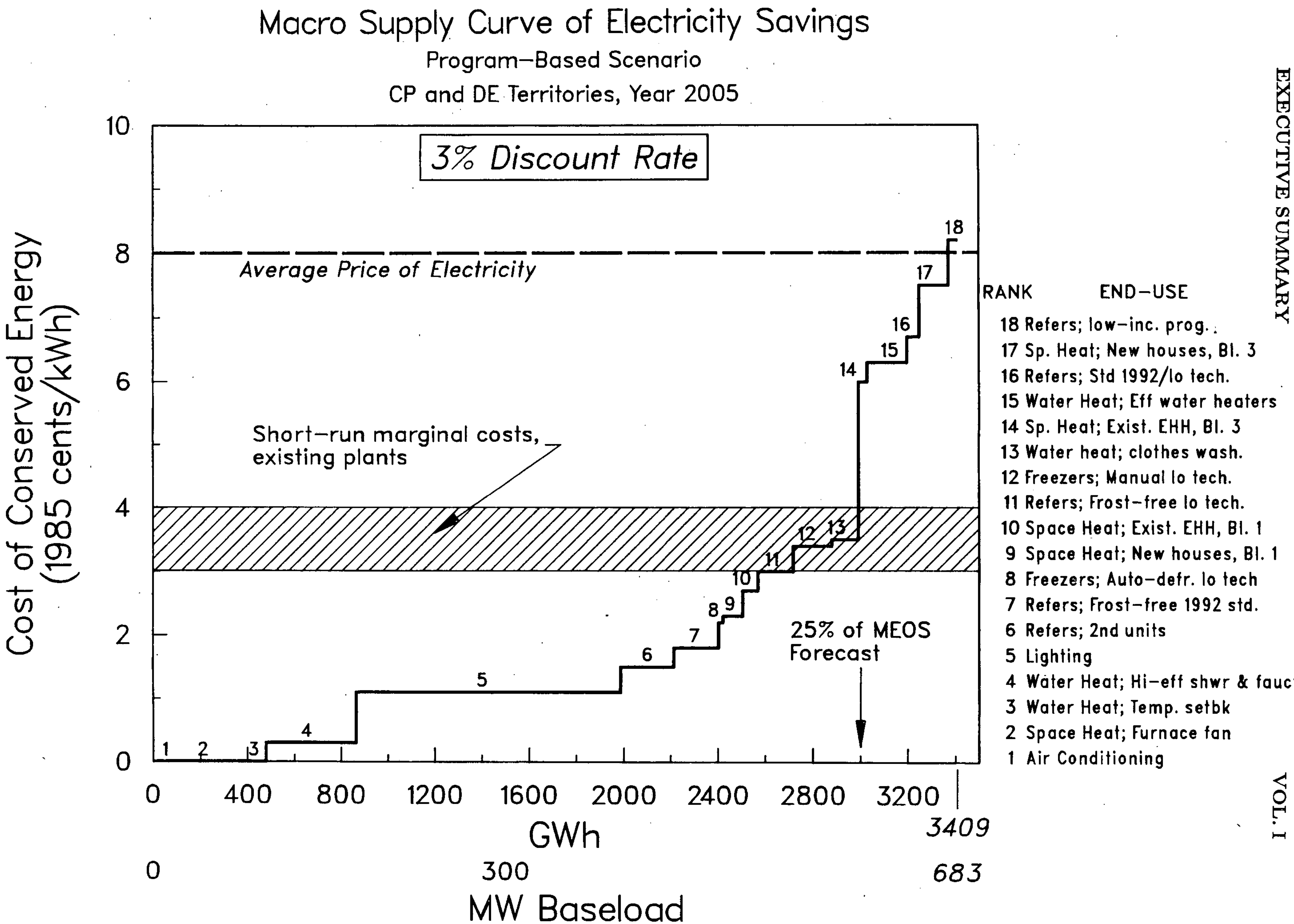
Change in Residential Electricity Use, 1985-2005

End-uses Studied by LBL, CP and DE Territories, no fuel switching



XCG 8612-12327

Figure 2



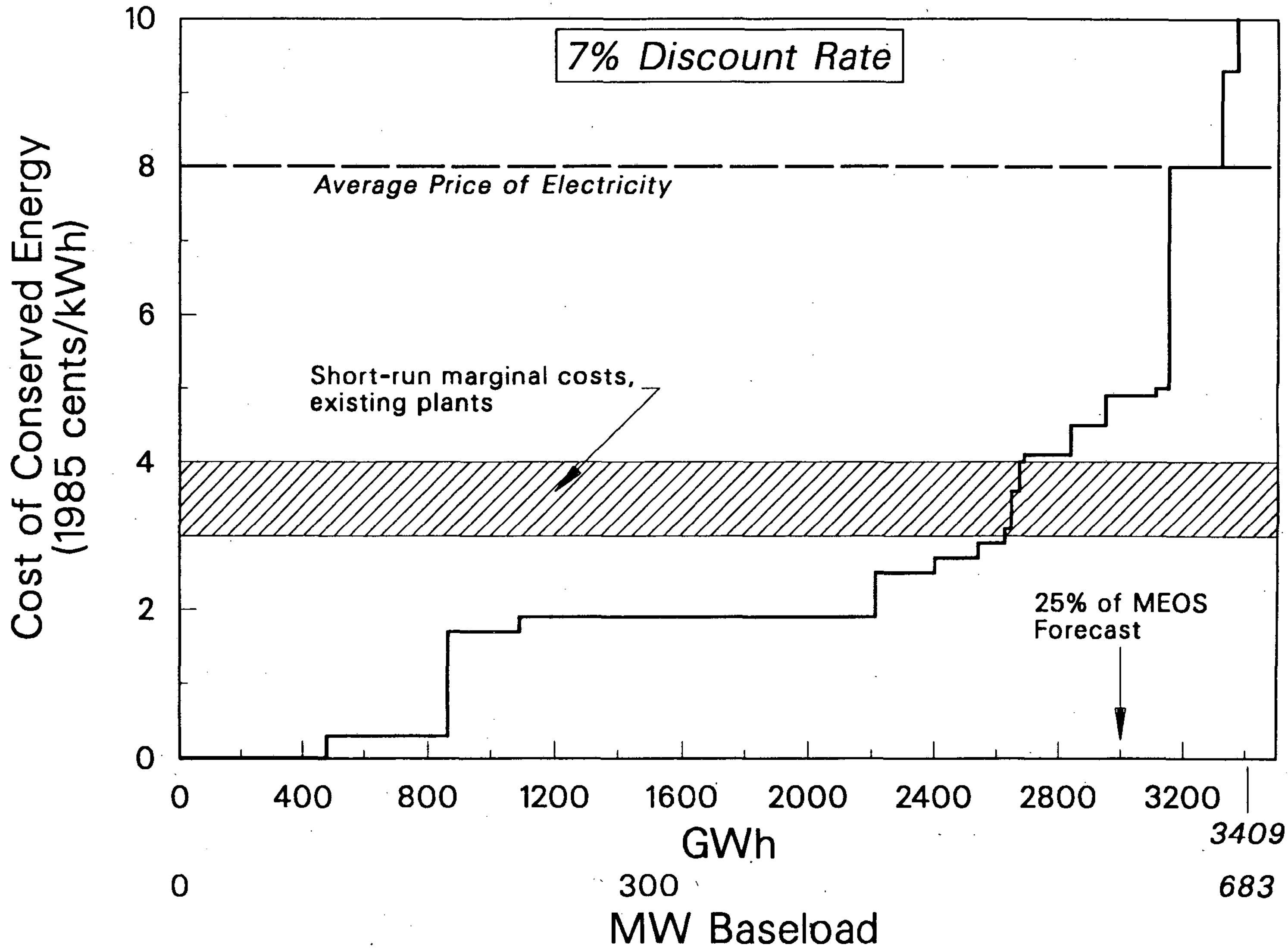
XCG 8612–12328 B

Figure 3

Macro Supply Curve of Electricity Savings

Program-Based Scenario

CP and DE Territories, Year 2005



XCG 8612–12329

LAWRENCE BERKELEY LABORATORY
TECHNICAL INFORMATION DEPARTMENT
1 CYCLOTRON ROAD
BERKELEY, CALIFORNIA 94720