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

Volume II. Methodology and Results

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DISCLAIMER

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

Volume II

Methodology and Results

by

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1. INTRODUCTION AND SCOPE

This study investigates the potential for demand-side management of Michigan's residential electricity use. This investigation is part of an integrated least-cost utility planning effort known as the Michigan Electricity Options Study (MEOS). We make no recommendations concerning the cost-effectiveness of the demand-side resource compared to other supply-side options; this integrated analysis will be undertaken by another work group. All analyses in this study are based on a set of scenarios covering the years 1985-2005.

Scope of MEOS Demand-Side Analyses

Four scenarios are distinguished on the demand-side:

- a frozen efficiency forecast,
- a business-as-usual forecast,
- a program-based scenario, and
- a technical potential/best available technology scenario.

All four are disaggregated, end-use based accounts of electricity use (rather than econometric). For each end-use, MEOS Work Group 5 developed a forecast of saturations and of other demographic and behavioral factors that influence the consumption of *energy services* in Michigan. Energy services are measured in physical units, such as gallons of hot water consumption per capita, and are the basis of all energy consumption. Behavior functions are time series of indices that express changes in the level of energy service within a particular end-use, such as changes in hot water consumption that result from reduced household sizes. The same MEOS WG 5 household numbers, saturations, and behavior functions were used for all four scenarios and forecasts.

The *frozen efficiency forecast* is based on the assumption that all existing equipment will remain at its 1985 stock-weighted energy efficiency until replaced (no efficiency retrofits). Further, all new equipment and buildings will be no more efficient than 1985 sales-weighted averages (no efficiency improvements in available equipment). Behavior functions, population and household growth, turnover of old capital stocks, and saturation changes occur as in the other scenarios. In so far as the unit energy consumptions of buildings and equipment *sold* in 1985 were lower than the stock-weighted averages, the frozen efficiency forecast can itself project reductions in stock-average unit energy consumptions as old equipment is replaced by new stocks over time.

The *business-as-usual forecast* combines the same demographic, saturation, and behavioral data with business-as-usual trends in appliance, lighting, and building efficiency. These trends are based, in part, on data supplied by the Association of Home Appliance Manufacturers (AHAM). This forecast is henceforth called MEOS/AHAM or, abbreviated, MEOS baseline forecast.

The task given to Lawrence Berkeley Laboratory consisted of preparing two additional scenarios. The *technical potential/best available technology scenario* is the hypothetical upper-limit case. This scenario estimates the electricity savings and load shifts that could be achieved if the most efficient conservation and load management technologies available were deployed, and if all eligible households were to participate in such a hypothetical demand-side management program. This scenario does not consider the lag times and associated problems with converting lab prototypes to commercially acceptable products. The level of service provided is kept constant.

The *program-based scenario*, or *achievable* potential, investigates the extent to which incentives programs and efficiency standards could be used to motivate customers to invest in more energy-efficient buildings, lighting, and appliances, and to participate in load management programs. Again, the level of service provided is kept constant.

We analyzed both scenarios in terms of the cost of conserved energy and peak power, and developed supply curves to show the various demand-side electricity resources in terms of their economic ranking and relative size.

Scope of the LBL Study

Our study investigates electricity use in the service territories of Consumers Power and Detroit Edison only. These two territories account for about 85 percent of all electricity use in Michigan. Key data on the two utilities are summarized in Table 1-1.

Table 1-1. Michigan Utility Profiles.

	Detroit Edison		Consumers Power	
	1984	1985	1984	1985
Total Sales (10^9 kWh)	35.887	36.695	25.230	25.483
Residential Sales (10^9 kWh)	10.150	10.077	8.181	8.178
% of Total Sales	28.28	27.46	32.43	32.09
Residential Customers	1,630,000	1,643,000	1,210,000	1,220,000
Avg Ann Use Per Customer (kWh)	6253	6165	6789	6720
System Peak Demand (summer MW)	7350	7171	4840	4700
Heating Degree Days (base 65°F) *	6869	6846	6869	6846
Cooling Degree Days (base 65°F) *	603	507	603	507
Normal HDD (30yrs) (65°F) *	6802	6802	6802	6802
Normal CDD (30yrs) (65°F) *	604	604	604	604

* Degree-day data reflect average Michigan temperatures. All our findings are reported for each company separately and for both companies combined. We have not extrapolated to the state-wide potentials in our figures.

We investigated the following demand-side measures:

Demand-side measures with impact on energy use and peak demand:

- More efficient refrigerators
- More efficient freezers
- More efficient air conditioners
- More efficient building shells
- More efficient electric space heating equipment (heat pumps)
- More efficient hot water use
- More efficient electric water heaters
- Fuel switching from electricity to gas in water heaters, clothes dryers, and ranges
- Solar water heaters

Load control measures:

- Air conditioner cycling
- Air conditioner load shedding
- Water heater cycling
- Thermal storage
- Demand subscription

The total conservation resource across all end-uses and measures as calculated and reported in this study excludes the savings from fuel switching. Fuel switching potentials were analyzed mainly to draw attention to a conceptual gap in the MEOS least-cost approach. To do justice to the fuel switching issue, a broadened approach must be devised to account for fuel switching in all sectors and in both directions (see Volume III, Section 8).

Special Features of the LBL MEOS Study

The present report differs from early conservation potential/supply curve studies in the following respects:

- The report covers not only conservation technologies, but also load management programs.
- The report investigates not only the electricity savings of efficiency investments, but also their impact on system peak demand. Load profiles are developed for different day types and seasons that allow an hourly valuation of the conservation resource.
- The study not only develops an upper limit for the demand-side electricity resource (technical potential/best technology scenario), but also estimates what amount of that resource can actually be deployed, and at what rate and over what periods of time.
- Annual savings in the period 1985-2005 are calculated on the basis of historical saturations and efficiencies dating back to 1967. The size and availability of demand-side potentials over time is thus mapped in close correlation with the actual vintage and efficiency composition of Michigan's equipment stocks.
- The study not only calculates the cost of conserved electricity (CCE), but also the cost of conserved peak power at system peak, based on a 20-year amortization period ($CCPP_{20}$).
- In addition to the technology-based cost of conserved energy, the study also provides estimates of the program-based cost of conserved energy. The program-based CCE is calculated from the program administration costs and the incentives paid to customers. It is the cost of the demand-side resource from the all-ratepayer perspective.
- The study also provides information on the social cost of the demand-side resource. This social cost is the sum of technology costs and program administration costs.
- We calculate the annual investment costs and net present value of all program administration and incentives costs.
- The results of the analysis are made directly useful for the MEOS integrated demand-side and supply-side analysis, by aggregating the demand-side resources into cost bins that reflect, respectively, the short-run marginal costs and long-run marginal costs of generating electricity and peak power from conventional supply sources.

The following sections describe our methodology, present our findings on the size of the demand-side resource and its cost-effectiveness, and highlights important uncertainties in these findings. Recommendations for future research are also developed.

2. BASELINE DATA AND METHODS USED IN THE ANALYSIS

In this section, we describe baseline data and forecasts used in our analysis, and explain our methodology and assumptions used to quantify the size of the demand-side resource. Our methodology is described in three parts:

- Calculation of cost of conserved energy and power for individual technologies,
- Analysis of incentive and standards programs to deploy these technologies, and
- Development of supply curves of conserved energy and power to evaluate the cost-effectiveness of the entire demand-side resource.

This last part allows for incorporating our analysis into an integrated least-cost resource plan.

Baseline Data

The baseline year for our study was 1985, though some baseline data were only available from earlier years. In general, we based our calculations on historical and baseline data supplied by MEOS WG 5. The MEOS frozen efficiency and business-as-usual forecasts relied on historical saturation, efficiency, and consumption data that reached back to 1967. These data were used to calculate the energy impacts of replacements of old equipment, based on fixed lifetimes for each category of equipment. The method captures the effect of past variations in saturations and sales-weighted efficiencies much more accurately than the common practice of treating existing stocks as if they were of homogeneous vintage and efficiency.

The LBL study reproduced the MEOS WG 5 forecasts with minor changes. In the case of refrigerators, freezers, and air conditioners, we used average historical efficiency data reported by manufacturers' associations for *national* sales, since the utility estimates of Michigan efficiencies, which differed from the national figures, were less well documented. A better understanding of Michigan-specific purchasing patterns should be developed through future surveys.

Another area of slight deviation is the use of normal year central air conditioning and space heating consumption rather than actual consumption for 1985. The resulting baseline data for the two companies, individually and combined, are given in Appendix A, Tables A-1 through A-3.

The end-uses studied by LBL (excluding fuel switching) cover 67 percent of combined 1985 sales. The tables show that more than 90 percent of total electricity sales can be attributed to specific end-uses. Less than 8.7 percent of combined 1985 sales fall into the miscellaneous category for which saturations, unit energy consumptions, and physical characteristics are not known. Figure 2-1 shows graphically how the major end-uses contribute to total combined 1985 sales.

We also estimated the baseline and system peak demand contributions of the major end-uses. These end-uses consumed the output of two and a half large (1000) MW central stations. To convert savings into equivalent baseload capacity, we used a 60.4 percent capacity factor (5300 full-load hours per year) and a six percent transmission and distribution loss. This figure is representative of a nuclear plant and also approximates the average capacity factor of all current Michigan generation capacity. For a baseload coal plant, the capacity factors would be larger. The equivalent baseload values do not imply that so much baseload could be replaced; rather, they are used to give the reader a reference order of magnitude.

On average, the end-uses studied by LBL make up 21 percent of the total system peak. Both utilities are summer peaking. The end-uses we studied are collectively summer peaking only for Detroit Edison, which has much larger air conditioning loads than Consumers Power.

Measuring Cost Effectiveness: Cost of Conserved Energy and Cost of Conserved Peak Power

Definitions. The *cost of conserved energy (CCE)* is the annual cost of implementing an efficiency or peak demand reduction measure, divided by the annual energy savings. It is defined by the following formula:

$$\text{cost of conserved energy} = \frac{\text{investment rate} \times \text{capital recovery} + O/M \text{ incremental cost}}{\text{annual energy saved}} \quad (1)$$

The capital recovery rate (CRR) annualizes the investment. In terms of the real annual discount rate d and the lifetime n, it is given by the expression:

$$f = \frac{d}{1-(1+d)^{-n}} \quad (2)$$

The Cost of conserved peak power ($CCPP_{20}$). While the CCE is annualized over the life of the hardware (e.g. ten years for a room air conditioner), the CCPP is present-valued over the life of the avoided peak power plant, which we take to be 20 years. The formula is:

$$\text{cost of conserved peak power} = \frac{\text{net present value of (investments} + O/M \text{ incremental cost)}}{\text{diversified peak demand saved}} \quad (3)$$

For hardware that is replaced sooner than 20 years, we add the present value of all replacement costs.

Sensitivity of the CCE to variations in parameters. Four variables affect the CCE: the measure's cost, the annual energy savings, the amortization time, and the discount rate. As technologies improve or new information on their durability and effectiveness emerge, initial estimates of costs, savings, and lifetimes may change. Likewise, real discount rates vary depending on the class of investors and their economic perspective. It is necessary to understand the procedures that we used to estimate the parameters.

Selection of cost data. The cost data reflected in our supply curves include materials, labor, and maintenance costs other than replacement of the measure. The sources for our cost data include manufacturer's retail prices, monitored construction experience, price lists from audit and conservation programs, and engineering-economic calculations.

For building shell measures, we distinguish between retrofit costs and new construction costs, since these can be very different. In retrofit situations, existing mechanical, electrical or structural systems are often in the way, or building walls have to be refinished after installation.

Lifetimes and discount rates. Amortization of investments is done over the useful life of the measure, i.e., the period during which it will continue to provide the calculated energy or peak power savings. Note the special procedure for calculating annualized costs for peak power savings, as described above. The discount rates for the the analysis are those uniformly set by MEOS, i.e., 3 percent and 7 percent in constant dollars.

Average and marginal CCEs and $CCPP_{20}$s. The savings from a particular measure often depend on what other measures, if any, have been already implemented. For the same reason, the cost of conserved energy or peak power is also a function of that sequence. The *total savings* from a package of measures is not dependent on that sequence.

We use two calculations. One is to calculate the cost of conserved energy that would result for each option if it were the only measure implemented. This CCE is called the *average* cost of conserved energy or peak power. The other is to calculate the *marginal cost of conserved energy or peak power*. It is based on the last increment of investment and savings. Where the number of interdependent measures is large, as in building shell efficiency improvements, we use an iterative procedure that reorders measures and recalculates savings until the total cost of implementing the entire set of measures is minimized. More important, it avoids "double-counting" energy savings. This ordering results in an investment schedule for the different measures. The options are ordered by increasing marginal cost of conserved energy or peak power.

Incentive Program Analysis

We have assessed the *programs* to deliver the energy efficient technologies as well as the technologies themselves. To estimate the energy savings that can be achieved through demand-side programs, our program-based scenario, or achievable potential, takes account of the current data situation and lessons learned from past experience, to permit a more realistic assessment of the measures, including costs to administer a program, and the rates at which the electricity savings will become available. We summarize the key parameters and assumptions used in our program analysis below.

- In each program, incentives are sufficiently high to eliminate all extra first costs for participants. The incentive is thus equal to the technology cost of the additional savings. The impact of increasing incentives on penetration fractions is schematically illustrated in Figure 2-2, which shows the social cost of conserved energy or peak power (i.e. the sum of technology costs and program implementation costs) for a simple two-step macro supply curve. (For 100 percent incentive levels, the social cost and the all-ratepayer costs of the demand-side resource become the same). Note that program administration costs are a relatively small fraction of total costs at this level of incentive. This approach is more aggressive than virtually all large-scale programs and most pilot programs to date. It has precedents in some highly successful pilot projects that were able to penetrate into customer groups that do not usually participate in utility programs. The choice of full incentives makes high participation rates and penetration fractions likely.

- For each end-use, the program scenario foresees a *two- to five year pilot project phase* in which possible design weaknesses are detected and eliminated before full-scale implementation begins. The onset of major savings is thus conservatively projected. Figure 2-3 shows schematically how various program phases and the customer response might evolve over time.

- Incentives are provided continuously until all existing stocks have been turned over, and for periods of up to 17 years. This long-term intervention is likely to bring about significant and persistent changes in customer purchasing patterns and manufacturer product development over the years, and makes high penetration fractions likely.

- To be conservative, we do not assume efficiency standards beyond those proposed as federal "consensus" standards for 1990-93, though tighter standards for the mid-1990s would be feasible and economically justified for a number of end-uses. The savings we calculate could be augmented and made more predictable by implementing state-wide efficiency standards for Michigan. This could also reduce program costs, and, to a lesser extent, social costs. (However, we did not assume implementation of state-wide standards.)

- We assume speeds of implementation (participation rates) that correspond to best large-scale program results so far, but are significantly lower than participation rates obtained in smaller-scale or pilot projects.

The last point is illustrated by our scenario assumptions for participation rates in a rebate-based RCS retrofit program for electrically heated homes (see Vol. 3 for details). The basic approach is illustrated in Figure 2-4. The traditional large-scale programs achieved participation rates of typically 5 percent per year. The best-designed large-scale efforts achieved 8-12 percent per year. The most successful medium-scale project, run in the city of Santa Monica, California, achieved a 33 percent annual participation rate, and the Bonneville Power Administration's project in the small community of Hood River, Oregon achieved more than 50 percent participation per year (with a 95 percent final penetration fraction).

In spite of these documented high participation rates, we limit our participation rates to 8-11 percent per year. It can be argued that if the lessons of past program experience are heeded, this level of participation could be achieved with about the same level of confidence as the more modest results of traditional programs. As higher participation is sought on a large scale, the confidence level drops off significantly. In our scenario assumptions we strove to define the range of participation rates that corresponds to the shaded area of high confidence level in Figure 2-4. The numerical values for this range vary, of course, as a function of the demand-side measure being studied. In many instances, participation rate data equivalent to those from RCS program evaluations are not available at this time.

Incentives programs buy behavioral change—often a more fickle commodity than hardware. The design of rebate and other incentives programs is more comparable to the design of electricity rates based on load-shaping objectives than to technology costing. A badly designed program may require large amounts of incentives without producing much conservation, whereas a well-designed program may produce the same conservation result at a fraction of the costs of the ineffective program. For the purpose of resource planning it is thus necessary to define a level of program costs that will be an upper bound.

In accordance with this requirement, the costs in our scenario were chosen to represent an *upper limit* of expected program costs for achieving the calculated savings. Uncertainties in estimating program costs should therefore point toward lower costs than assumed here. Specifically, we have incorporated the following assumptions:

- The technology costs (and therefore the incentive levels) used in this study are based in most cases on current retail prices. These retail prices usually reflect currently small markets with high dealer mark-ups. Experience with rebate programs has shown that well-designed programs tend to reduce the price differential between efficient and standard technologies. As this price differential drops, incentive levels can also be lowered.
- In almost all cases, our implementation scenario relies exclusively on comparatively expensive rebate programs rather than on state-promulgated standards or combinations of both. Standards are one to two orders of magnitude cheaper than incentives when evaluated in terms of the costs to the ratepayer. Optimizing the mix of standards and incentives is an important aspect of least cost planning. We made no attempt to define the kind of balance between standards and rebates that would deliver an optimal amount of conservation at minimum cost to the ratepayers. Whatever that optimal mix might be, it would entail a reduction in the all-ratepayer costs of demand-side resources. Our approach thus sets an upper limit for program costs on that basis alone.

- This study assumes *maximum incentive levels,* equal to the full incremental technology cost, and even higher levels for certain low-income programs. In other words, consumers are freed from all economic risks in participating in conservation programs. This choice of incentive levels partly reflects the MEOS directive to base the size of achievable demand-side contributions on an aggressive implementation approach. It also reflects a strong further conservatism in the program cost calculations. Much lower incentive levels might suffice to bring about the same level of participation, and the cost of conserved energy to all ratepayers would be correspondingly lower.

Summary of program assumptions. Our program assumptions for the various end-uses are compiled for quick overview in a set of summary sheets as Appendix B to this volume. These sheets also give estimated ranges for the maximum penetration fractions which the programs would achieve. Detailed discussions and references can be found in Volume III.

Evaluating the Cost Effectiveness of Michigan's Demand-Side Resource

Cost-effectiveness criteria for integrated planning. In the context of a least-cost planning exercise, the cost-effectiveness of demand-side resources must be evaluated from three perspectives: the societal perspective, the all-ratepayer perspective, and the utility perspective. Also, the time horizon of the evaluation is important, particularly if significant excess capacity exists in the short-to-medium term as in Michigan. In the following discussion, we mainly follow the all-rate payer perspective. We compare the cost of conservation savings to the short-run marginal costs of Michigan electricity production, and compare the cost of peak load savings from load management and conservation to that of a gas-fired peaking turbine. This permits the reader to make a rough assessment of cost-effectiveness.

It should be noted that this comparison can only provide a preliminary "sorting" of the demand-side resource, for two reasons. First, conservation resources, once put into place, continue to provide savings for a considerable period of time, up to 30 years or more in the case of building measures. Such long-lived measures thus save not only operating and fuel costs of existing plants in the short run but also capital costs for new capacities along with their operating and fuel costs in the long run. Similarly, peak demand savings from load management or conservation may have no capacity value in the short-run, but could have increasing capacity value in the longer run, as existing capacities are more intensively utilized and loss-of-load probabilities rise.

Second, supply-side options such as cogeneration, renewables, and reconditioning of old plants may be cost-competitive with, or cost-effective against, demand-side options. An integrated least-cost resource plan will be prepared by MEOS Work Group 6. In this report, we limit ourselves to establishing the cost-effectiveness of the demand-side resource relative to *existing* capacities. We assign the demand-side resource to three specific cost-bins or blocks:

1. Costs of conserved energy below the short-run marginal cost of producing more electricity from existing plants and costs of conserved peak power below the cost of extra peaking capacity (<3¢/kWh).

2. Costs of conserved energy and peak power that are competitive with short-run marginal costs and peaking turbines (3-4¢/kWh).

3. Costs of conserved energy and peak power that are larger than short-run marginal costs and peaking turbines (>4¢/kWh).

In the latter cost block, a further distinction can be made between conservation resources that are cost-effective against the *long-run* marginal costs of producing electricity and those that are not.

This allocation allows a preliminary assessment of the role demand-side options could play in a least-cost resource plan. The three cost blocks can be interpreted as follows:

1. *Electricity resources with costs lower than short-run marginal costs.* From the all-ratepayer perspective, it may be cheaper to buy this resource than to operate existing capacities. (This will be more accurately determined by MEOS WG6.) The resource moves ahead of existing plants in the dispatch order.

2. *Electricity resources with costs comparable to short-run marginal costs* are cost-competitive with existing capacities but their dispatch priority needs to be evaluated on the basis of additional analyses. Both short-run fuel cycle, operating and maintenance savings and long-run baseload capacity and fuel-cycle investment savings need to be taken into account. On the basis of such a life-cycle-cost analysis, conservation resources will tend to be economically more advantageous if the lifetime of the conservation measure extends into the period where new capacities or more expensive fuels will be needed.

3. *Electricity resources with costs higher than current short-run marginal costs but lower than the cost of power from new power plants.* These may or may not be cost-effective on a life-cycle basis. Theoretically, one would defer such resources until additional capacities are needed, and then dispatch them. In practice, conservation resources cannot be switched on and off like a power plant. Suppose an appliance has a 20 year life and efficiency improvements fall into this cost block. Not investing in a more efficient appliance now foregoes savings in that application for 20 years. Extra costs incurred in early years when marginal costs are low must therefore be balanced on a net present value basis with benefits in later years when marginal costs are high.

For load management options the evaluation is somewhat different. The common reference point is the peaking turbine on the supply-side. All load management options have approximately zero capacity value so long as existing capacities are sufficient to keep loss-of-load probabilities low. The cost bins for load management options can be interpreted as follows:

1. *Load management and conservation resources with costs of conserved peak power ($CCPP_{20}$) less than, or comparable to, that of a peaking turbine.* These options may or may not be cost-effective. A more detailed investigation is needed to determine the point in time when such peak load savings begin to have capacity value in the utility system. Direct control type programs usually can be simply deferred until such time when they become cost-effective.

2. *Load management and conservation resources with $CCPP_{20}$s greater than that of a peaking turbine.* As load control programs, these are clearly not economical. On the other hand, many conservation resources with comparatively high $CCPP_{20}$s would still be cost-effective on energy grounds alone, and would thus be dispatched irrespective of their capacity value.

MEOS Work Group 5 has developed a table of short-run marginal costs in 1986 mills/kWh from existing power plants (Table 2-1).

Table 2-1. Short-run marginal electricity costs from existing capacities (1986 mills/kWh)

Load Segment	Segment Number	Annual-Average Marginal Cost
peak	1 oil-fired peaking	60.4
peak	2	35.7
peak	3	33.7
peak	4	33.3
peak	5	33.0
peak	6	32.7
peak	7	32.3
mid-peak	8	31.5
off-peak	9	29.5
off-peak	10	28.1
base-load	11 coal, nuclear	27.4

The table distinguishes 11 load segments and three seasons. On average, baseload power costs 27.4 mills/kWh, and power in the mid-range of the load duration curve costs up to 35.7 mills/kWh. The last load segment, corresponding to peak load power production from small oil-fired peaking plants, costs 60.4 mills/kWh. These figures need to be corrected to account for transmission and distribution losses, which we take to be 6 percent. Figures for long-run marginal costs from conventional power plants were not provided, but are generally expected, under most favorable assumptions, to be at least as high or higher than current average electricity rates, i.e. at least 8 cents/kWh or more. For peaking turbines, capital costs are commonly estimated as $500-700/kW.

This overview of costs and cost-effectiveness criteria suggests that the supply curve of residential conservation resources should be aggregated into three major segments or blocks:

1. Programs and measures with CCEs of 3.0 cents/kWh or less (Block 1);
2. Programs and measures with CCEs of 3.0 to 4.0 cents/kWh (Block 2); and
3. Programs and measures with CCEs of more than 4.0 cents/kWh but less than 8.8 cents/kWh (Block 3).

Similarly, load management programs can be sorted in terms of their cost-effectiveness against the gas-turbine investment:

1. Programs and measures with $CCPP_{20}$s of less than $500/kW (Block 1);
2. Programs and measures with $CCPP_{20}$s of $500-700/kW (Block 2);
3. Programs and measures with $CCPP_{20}$s of more than $700/kW (Block 3).

This allocation does not consider environmental and other social costs associated with the use of electrical energy services. If such externalities are taken into account, demand-side resources often improve their competitiveness with supply-side resources. The importance of social benefits and costs will be analyzed by MEOS Work Group 6.

Technology Costs versus Program Costs

Taking the perspective of consumers, all ratepayers, or society can lead to very different cost-effectiveness assessments. In the absence of conservation programs, economically rational consumers will use a *technology cost* perspective, i.e. they will ask what incremental first cost and operating and maintenance cost is associated with the hardware and information they need to buy to save electricity. When the life-cycle cost of the conservation option is less than that of buying the saved electricity at current or anticipated *average* electricity rates, the least-cost oriented consumer will make a demand-side investment. In reality, consumers' investment decisions will not only reflect standard economic discounting based on the consumer cost of capital, but also many externalities and risks that are important to consumers, such as exposure to debt, fear of loss of comfort, confrontation with uncertainty or lack of information, etc. The consumer's risks and perceived externalities will be reflected in the implicit discount rate of his or her investment decision.

This consumer least-cost perspective is different from an all-ratepayer's and societal least-cost perspective in at least three important respects:

1. For ratepayers, the decisive cost is not the investment cost of buying the technology, but the program cost of *getting the consumer to buy* the technology. This cost can be much lower or higher than the technology cost. In terms of the expenditures associated with a demand-side program, this ratepayer cost is simply the rebate cost including free-rider effects, plus the cost of administering the incentive program including promotion, audits, information campaigns, etc. The actual technology cost, or the fraction paid by the consumer versus the ratepayer, is immaterial from that perspective, though it is, of course, relevant to the social perspective.

2. The all-ratepayer perspective evaluates conservation options on the basis of specific economic criteria that vary over time, i.e. short-run marginal and long-run marginal electricity costs instead of average rates. As discussed above, these two costs may be less than half as high or as much as twice as high as average rates.

3. The consumer and all-ratepayer perspectives differ with respect to the risks and externalities considered in each. The all-ratepayer perspective takes into account risks related to utility system reliability and financial stability, such as the risk of fuel shortages or environmental impacts that could potentially drive up the cost of electricity production, etc. Both the explicit discount rate and the non-economic decision-making criteria are different from those of consumers.

4. The all-ratepayer perspective, in turn, does not fully reflect the societal cost of a demand-side measure. This societal cost, which is the primary basis of all economically rational capital allocation, must take into account the expenditures borne by the consumer in addition to those borne by the utility. It also may be based on different discount rates and takes account of a wide range of externalities. In first approximation, societal and all-ratepayer criteria converge if utility incentives fully cover the incremental first cost of demand-side measures, as assumed in this report.

In a least-cost utility planning exercise it is thus necessary to estimate the *cost to all ratepayers* of demand-side resources, based on the risks and externalities relevant to that perspective. The costs to the utility and to society must also be developed, so that regulatory policies can build a bridge between the three perspectives.

Even without considering externalities, defining the all-ratepayer cost of demand-side resources in simple terms that would make them directly comparable to supply options is not without methodological problems. Ideally, one would want to calculate *all-ratepayer costs of conserved energy or peak power*. These costs could then be correlated with the kWh cost of producing power. The main problem is that for a strict least-cost comparison, these program-based CCEs would have to be calculated as a function of the hour (segment in the load duration curve) and year in which the saving occurs. Incentives and administration costs are likely to be different in early and mature phases of the program. This task is made more complex by the fact that the time periods in which program expenses are incurred do not coincide with the periods over which electricity savings are achieved. Savings may persist after the program has ceased. Also, program-based savings can only be meaningfully defined with reference to a business-as-usual forecast. The MEOS forecast stops in 2005, while savings from program investments do not.

It is possible to make a meaningful upper-limit approximation that circumvents this problem. Most of the conservation programs in our scenario envision paying customers the full incremental cost of the efficiency improvement. We therefore approximate the program-based CCE by the technology CCE, plus a percentage correction equivalent to the ratio of administration and incentive costs per customer in a mature program.

This can be expressed as:

$$\textit{Program based CCE} = \textit{technology CCE}\ (1 + \frac{\textit{administration costs}}{\textit{incentive costs}})$$

With full incremental cost incentives, this ratio is generally of the order of ten percent. Where applicable, free-rider corrections are also added (see the individual end-use sections and program summary sheets for administration costs and free rider factors). This procedure results in an upper limit cost because all programs terminate before 2005. Some of the efficiency investments in the latter part of the 1985-2005 scenario period are assumed to be achieved with reduced incentives or without incentives, as an after effect of the customer reorientation that the program brought about.

Figure 2-1

1985 Residential Electricity Sales

CP and DE Territories

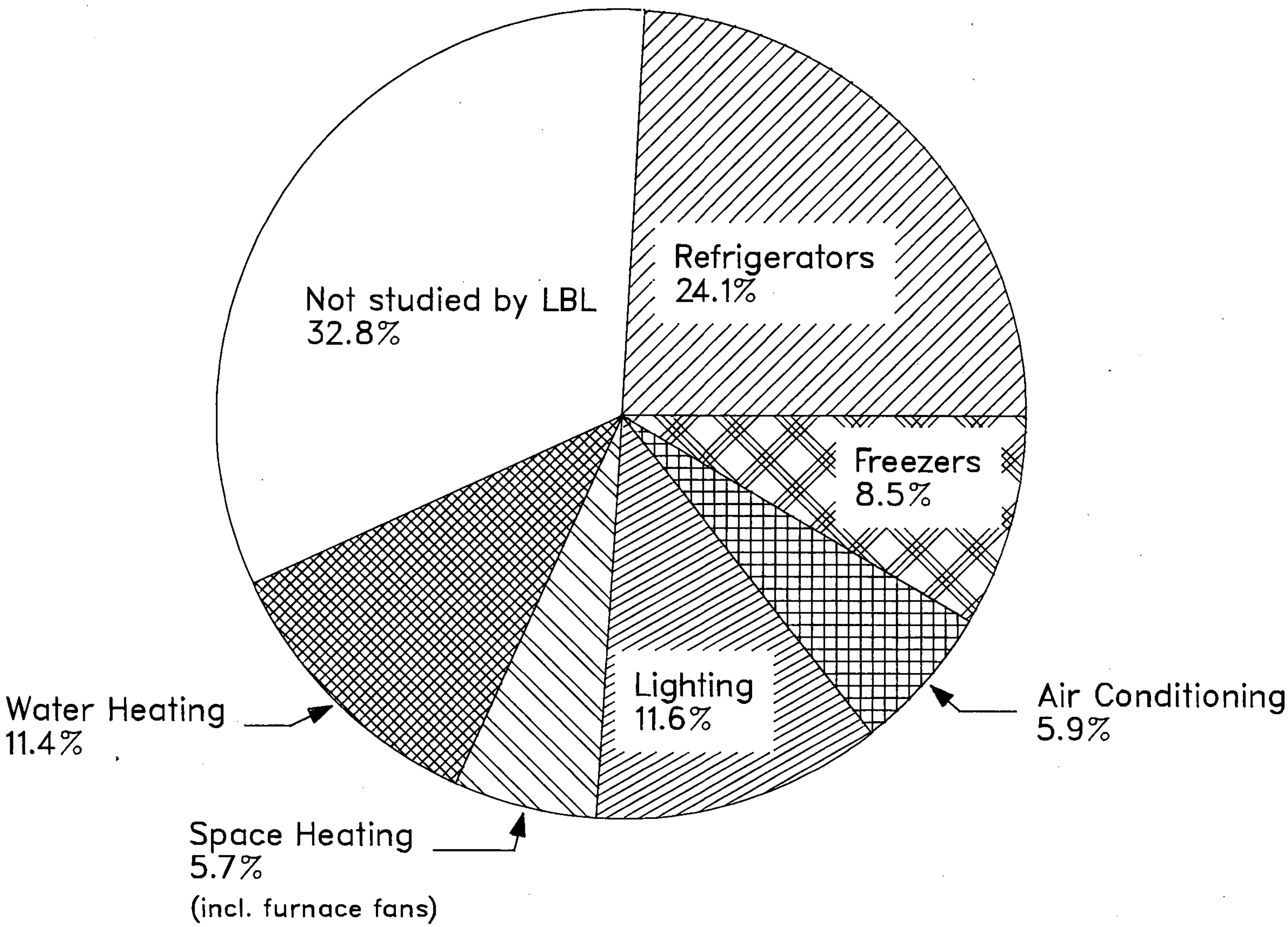

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Figure 2-2

TECHNICAL POTENTIAL AND PROGRAM-BASED SCENARIOS: COSTS OF SAVINGS TO SOCIETY

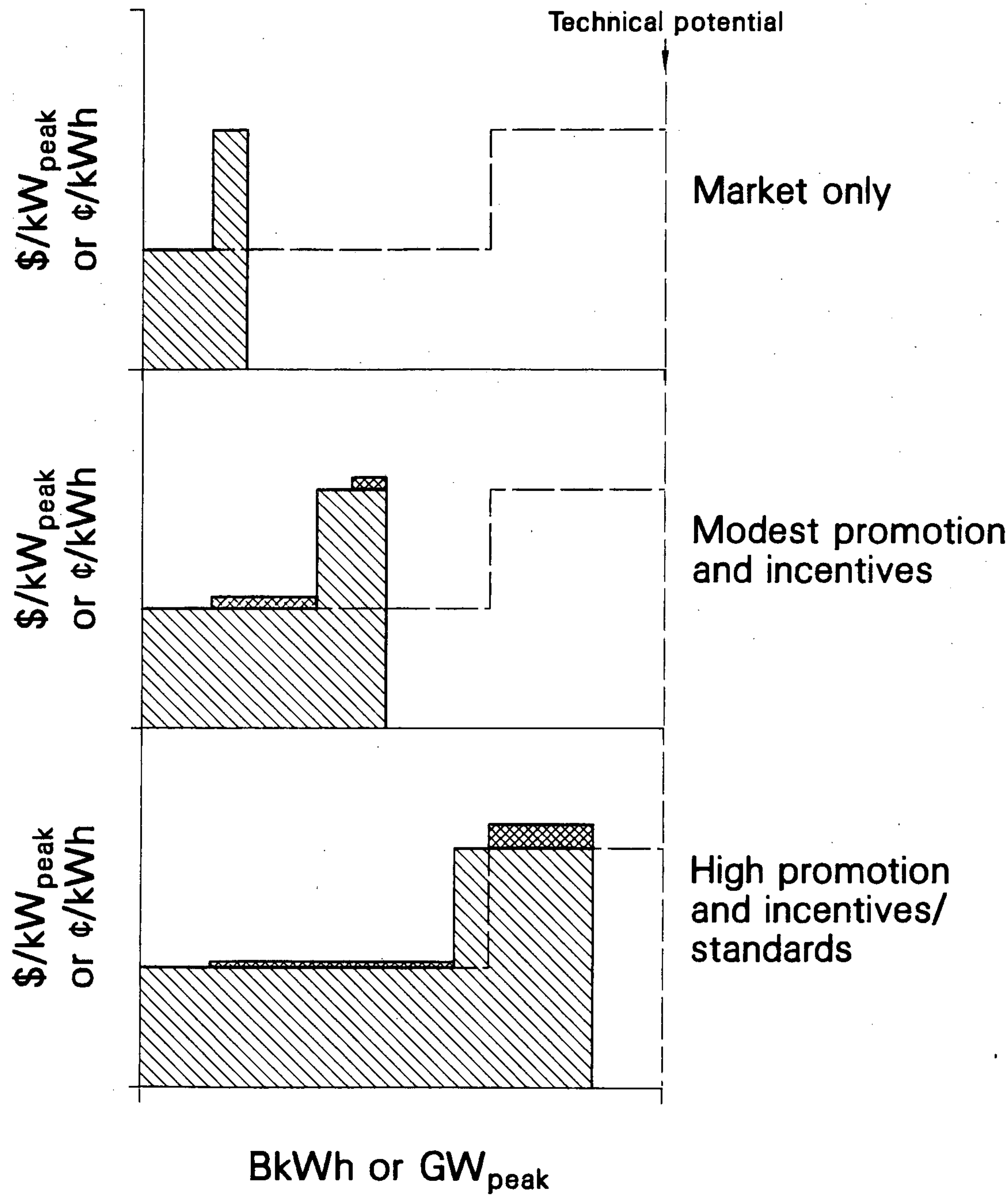

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Figure 2-3

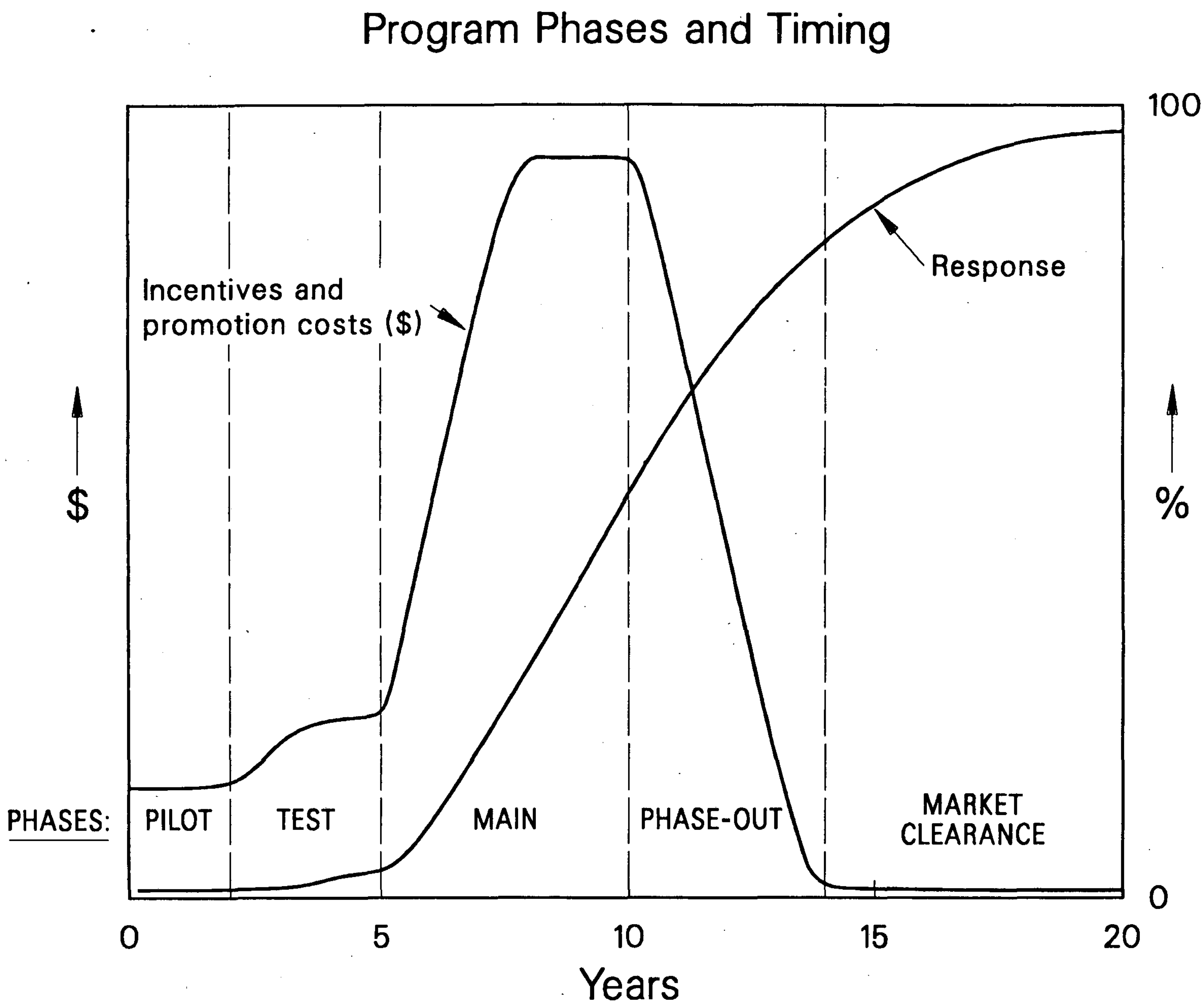

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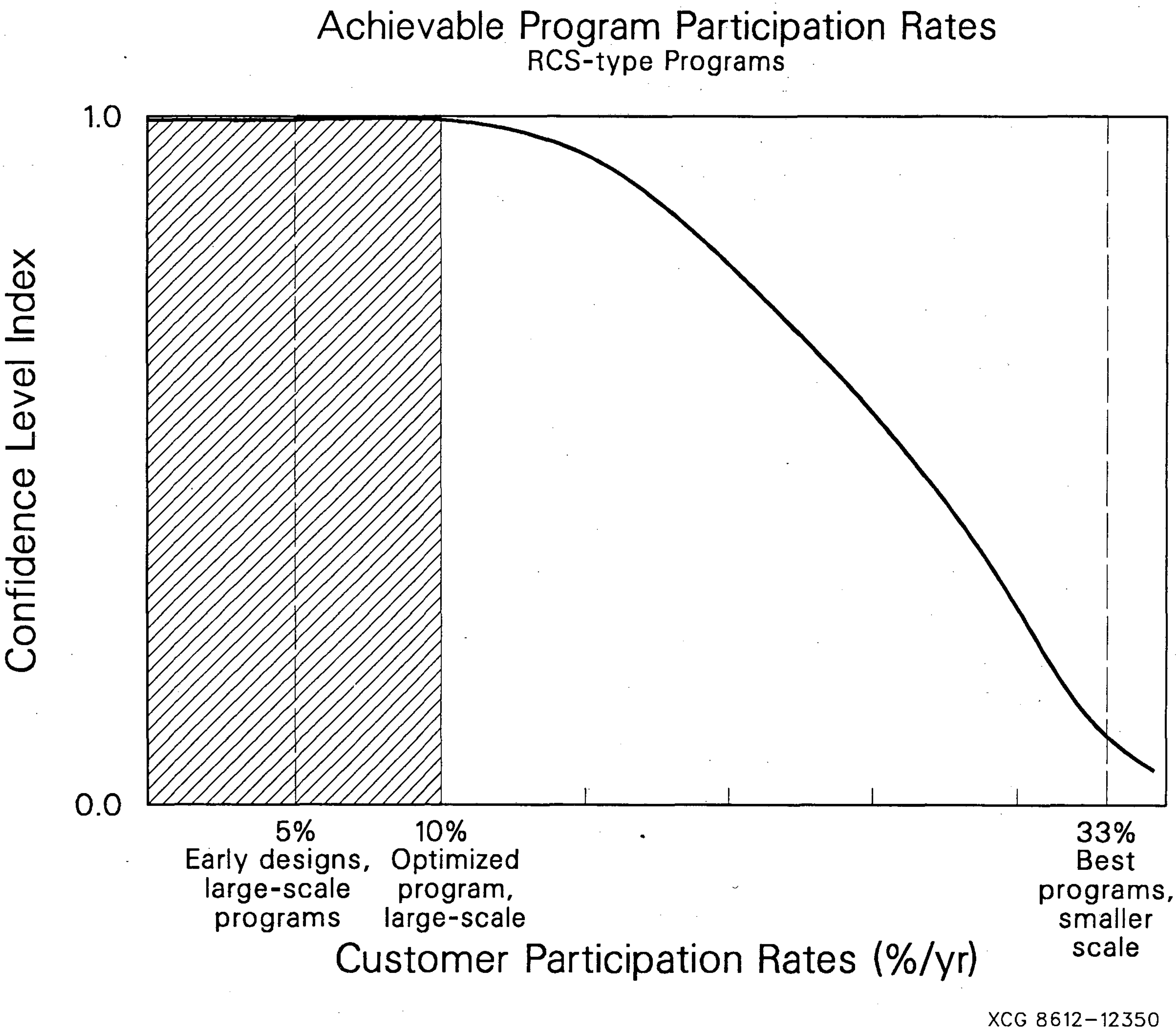
Figure 2-4



Achievable Program Participation Rates
RCS-type Programs
1.0
0.0
Confidence Level Index
5%
Early designs, large-scale programs
10%
Optimized program, large-scale
33%
Best programs, smaller scale
Customer Participation Rates (%/yr)
XCG 8612–12350

3. RESULTS: THE SIZE OF MICHIGAN'S RESIDENTIAL DEMAND-SIDE RESOURCE

We summarize the major findings of our analysis below. These results are based on assumptions described in detail in Volume 3, End Use Studies. 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

The Conservation Resource: Technical-Potential/Best-Available Technology Scenario

Electricity savings:

For the combined territories, technical potential savings are 42 percent (5110 GWh) in 1995 and 56 percent (6590 GWh) in 2005 compared to the MEOS forecast. Total savings are equivalent to 1020 and 1320 MW baseload capacity, respectively (Tables A-4 through A-9).

Peak demand savings:

1995 combined peak load savings are 1100 MW in the winter and 800 MW in the summer, or 46 percent and 35 percent. The corresponding figures in 2005 are 1380 MW and 1110 MW, or 56 and 49 percent (Tables A-10 through A-15). These savings do not include those available from direct load control strategies.

The Conservation Resource: Program-Based Scenario

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. Detailed assumptions are given in Volume III, End Use Studies.

Electricity use:

The 1995 and 2005 electricity and peak power savings from conservation measures, with respect to the MEOS business-as-usual forecast, are shown in Appendix A, Tables A-4 through A-9 (electricity and baseload equivalent) and Tables A-10 through A-15 (peak power savings). Figure 3-1 shows the relationship of these savings to the MEOS forecasts. Compared to the MEOS business-as-usual forecast, conservation programs achieve a 21 percent saving by 1995 (2500 GWh), and a 29 percent saving by 2005 (3410 GWh). The baseload equivalent MW savings for the two companies combined are 500 MW in 1995 and 680 MW in 2005.

The largest contributor to the total savings is improvement in lighting efficiency (45 percent in 1995 and 33 percent in 2005), followed by hot water and water heating savings (24 percent and 25 percent), refrigerator and freezer savings (18 and 25 percent), space heating savings (10 percent and 14 percent), and finally savings from air conditioning (3 percent and 3 percent). The differences in 1995 and 2005 contributions are in large part a reflection of differences in turnover rates among the various end-use devices. Figure 3-2 shows a pie chart of the savings by end-use for 2005.

Peak demand:

In 2005, the demand reduction for the combined territories at summer system peak is 20 percent (450 MW), and 34 percent during winter peak (835 MW). The corresponding figures for 1995 are 14 percent (320 MW) and 26 percent (620 MW). While the MEOS forecast would invert the winter to summer peaking situation in the *combined* territories for the end-uses studied, the program-scenario maintains the summer peaking. Within each company's territory, the qualitative winter/summer peak relationship remains unchanged.

Comparison of Technical Potential and Program-Based Scenarios

The program-based scenario achieves 50 percent of the technical potential savings in 1995, and 52 percent of the savings in 2005. This penetration into the technical potential is an average over all end-uses and varies somewhat from end-use to end-use. Space heating and lighting approach the technical potential most closely, while the refrigerator and freezer programs and the air conditioning programs lag furthest behind. The relationship of the program and technical potential scenarios is summarized for each end-use in the program summary sheets (Appendix B), and in Vol. 3.

Generally speaking, the technical potential is larger than the program scenario due to four factors:

- It is assumed that all eligible households (i.e. all households that have not yet installed the measure and can physically do so) will implement the demand-side measure.
- The transition to best available technologies in new purchases and retrofits is generally achieved between 1988-90.
- It is assumed that in each application the most efficient available technology or model is used rather than a mix of models that have high efficiency and satisfy the customer's need for non-energy related features the most efficient model might not have.
- Highest available efficiencies are assumed even when these are not cost-effective.

We illustrate these features with two examples. First, in the case of top-mounted auto-defrost refrigerators, the technical-potential efficiency is based on purchase of the prototype developed for commercialization by the California Public Utilities Commission and two California utilities (see Vol. III). All households would buy that model. In the program scenario, only 30 percent of customers choose high efficiency models, and the rebated units they buy have a higher unit energy consumption than the prototype. For this example, the technical potential technology is easily cost-effective for the consumer. In the second example, the case of air conditioners, the technical potential assumes the best commercially available central air conditioner efficiency ratios of SEER 16. At present usage rates and equipment and electricity prices, these units are not cost-effective for most Michigan consumers.

Load Management Options: Technical Potential

The analysis of load management options is qualitatively different from that of conservation measures with both energy and peak-demand impact. The Michigan utilities had themselves done a considerable amount of analysis on air conditioner cycling, water heater interruption, and even space heating thermal storage. However, no integration of these options and their trade-offs with other conservation measures had been attempted by either utility. We reviewed the Michigan studies and translated their and other utilities' findings into independent technical potentials and costs per kW peak demand.

We also calculated technical potentials for control programs that had not been analyzed in Michigan utility reports, i.e., demand subscription and air conditioner load shedding. These technical potentials are not additive, for reasons explained below.

We did not develop program-based scenarios for implementing the technically feasible load shifts, because:

- The size and cost-effectiveness of shiftable peak loads depends on the efficiency of end-use devices. This efficiency is a moving target. The analysis of conservation options had shown that considerable improvements are cost-effective and can be implemented over time. The Integrated Planning Model will determine the level of efficiency that should be assumed for each year. Only after this analysis will it be possible to integrate load management options into the supply-curve framework.

- Several of the options studied overlap in complex ways that are not well understood at this time. For example, demand subscription is in effect similar to air conditioner shedding, but could also displace some of the peak load savings that would be realized in a water heater interruption program.

- While summer peak load savings can be assumed to be relevant in a summer-peaking system, the usefulness of winter peak savings from such options as thermal storage is less clear. It will depend, among other factors, on the relative proportions of winter and summer peaks after the various cost-effective conservation options have been tallied for all sectors.

In absence of the necessary data for scenario building and integration, we simply calculate the maximum load shift that could be achieved with particular load management techniques, based on an analysis of the system load curve at system peak, and an optimization between peak savings at the peak hour and the subsequent peak when load control is ended ("payback spike"). The technical potentials we calculate are maximum potentials based on 1985 end-use efficiencies and diversified loads. Our costs of conserved peak power calculated for these potentials are incorporate typical equipment costs and rebate levels but exclude administrative costs.

Peak demand savings:

The technical potentials are shown in Appendix A, Table A-16. We estimate that the largest savings could be obtained from a demand subscription program: 639 MW for Consumers Power and Detroit Edison combined. The potential savings from air conditioner controls increases with the duration of the interruption period, reaching a maximum of 308 for the two utilities for load shedding. Savings for thermal storage are 148 MW. Water heater interruption has a summer peak potential of 86 MW.

It should be noted that these results are less well-delineated than the corresponding potentials for conservation measures. They are highly sensitive to system hourly load curves, the assumptions about acceptable load control periods, and the rate at which customers come back on line. We recommend that more work be done on load control scenarios in future iterations of the MEOS analysis.

Investment Requirements

The net present values of annual program administration and incentives costs for the program-based scenario and the technical potential scenario are shown in Appendix A, Tables A-17 through A-19. Total expenditures between 1988 and 2005 are $760 million (3 percent discount rate, 1985 $) and $545 million (7 percent discount rate).

Supply Curves of All-Ratepayer Costs of Conserved Energy

We calculated the program-based savings (from the MEOS baseline). Appendix A, Tables A-20 and A-21 show how the 2005 savings distributed over three cost blocks, for 3 percent and 7 percent real discount rates, respectively. The corresponding supply curves are shown in Figures 3-3 and 3-4. The residential demand-side resource in each cost block can thus be sized and compared to conventional supply sources in a meaningful way.

The scenario introduces in some instances continuous efficiency gains representing, e.g. in the case of refrigerators and freezers, interpolations between consecutive levels of technology improvements with discontinuous, point value CCEs. Here, we apportion savings from all years in which the first efficiency level is exceeded to the CCE of the second technology level. This procedure again reflects an upper-limit approximation.

The procedure for performing this aggregation is illustrated below, using the 2005 savings and a 3 percent discount rate.

For the seven percent discount rate, the ratio of the 3 percent and seven percent annualization factors is applied. These ratios are a function of the respective lifetimes of the measures.

Refrigerators. Manual refrigerators show relatively high costs of conserved energy due to their lower baseline consumption. We conservatively assign the CCEs for manual units to the entire standard (manual plus partial automatic) refrigerator savings, though the CCEs for partial-automatic defrost units should be about half-way between those for manual and auto-defrost units. With a 100 percent rebate and including program administration costs (see the refrigerator section, Tables 8 and 13), these CCEs are

$$5.1\ cents/kWh\ x\ (free\ rider\ correction + administration\ costs) =$$

$$5.1\ x \left[\frac{10}{9} + \frac{\$7}{\$120}\right] = 6.0\ cents/kWh$$

for the efficiency level equivalent to the 1992 California standard, and 6.7 cents/kWh for the low technology level. The program reward level UEC is somewhat higher than the low technology level, with a correspondingly lower CCE. We use the 6.7 cents/kWh figure for all standard refrigerator savings. The savings therefore fall into Block 3.

For auto-defrost units, we segment total GWh savings into those achieved by the low-income program, those achieved with the 1992 California standard efficiency level, and those achieved with higher efficiency levels.

For the low-income frost-free program, which is assumed to contribute 10 percent of the total GWh savings in the frost-free category, the program-based cost of conserved energy is 8.2 cents/kWh (see Volume III, Section 1).

CCEs increase significantly between the 1992 California standard efficiency level and the low technology level. Based on the proportions of savings over the 1990 standards, more than half the program scenario savings for auto-defrost refrigerators are available at the CCE of the 1992 California standard. This CCE, including program administration costs and free rider corrections, is 1.8 cents/kWh on a sales-weighted basis (Block 1). Low CCEs of about 1 cent/kWh are also achieved in second refrigerator bounty programs, and we assign these savings to Block 1 as well.

We then calculate the CCE of all program savings from higher efficiencies in the auto-defrost category on the basis of the "low technology" level of efficiency improvements. The low technology program-based CCE comes to 3.7 cents/kWh including administration costs and free rider correction. Since only 80 percent of this efficiency level is actually achieved at the reward level set by the program, we linearly interpolate to 3.0 cents/kWh for the average CCE of this savings increment.

Freezers. Here, we again distinguish between savings for standard and frost-free units. Since in the case of freezers the 1992 California standards are not significantly different from the MEOS forecast assumptions, we assign all savings to the "best-available technology" cost increment. The CCE for the "best-available technology" manual units is 3.7 cents/kWh. After correction for the 80 percent program reward level and administration and free rider costs, the figure becomes 3.4 cents/kWh (Block 2). For auto-defrost units, the corresponding figure is 2.2 cents/kWh (Block 1).

Air conditioning. We do not show any program costs for air conditioning savings. Equipment efficiency is increased by the national consensus appliance standards at no program incentive or administration cost to Michigan ratepayers or to the state of Michigan. Savings from building shell improvements do bring program costs with them, though these program costs would be assigned to gas and electric space heating savings and would likely be economically justified on the basis of these savings alone. We therefore assign a zero program CCE to air conditioning savings (Block 1).

Lighting. The CCE for outdoor and indoor lighting savings is almost the same. Including program administration costs and free-rider correction, the weighted average CCE is 1.1 cents/kWh (Block 1).

Space heating. We show CCEs separately for existing and new buildings and add program administration costs as specified in the summary sheets, Appendix B. Using the Tables 6-7 to 6-9, we apportion the total savings from all measures into each cost block.

Savings in existing buildings have program-based CCEs from 1.2-6.7 cents/kWh. Block 1 savings are 64 percent, with weighted average program-based CCEs of 2.7 cents/kWh. The remainder falls into Block 3 with an average program-based cost of 6.0¢/kWh.

In new buildings, 40 percent of total GWh savings fall into Block 1, with a weighted average CCE of 2.3 cents/kWh. The remaining savings fall into Block 3 with an average cost of 7.5 ¢/kWh.

Furnace fans. We treat furnace fan savings from improvements in gas-heated building shells in a manner analogous to air conditioning savings and assign them a zero program cost (Block 1).

Water heating. We separately show savings and CCEs (including program administration costs) for water heating demand reduction and for water heater improvements. Roughly 67 percent of the total water heater savings (showerheads, faucets, and temperature setback) are available at program-based CCEs of 0.3 cents/kWh or less (Block 1), while another 13 percent (improved clothes washers) cost 3.5 cents/kWh (Block 2). The remaining 20 percent (conversion to efficient resistance water heaters) costs 6.3 cents/kWh (Block 3). Free rider corrections do not apply.

Conclusions. Figure 3-3 shows that using a 3% discount rate, 75 percent of the total program-based savings can be bought for less than the short-run marginal cost of electricity production, and another 12 percent of the resource is cost-competitive with existing supplies. For reference, only 13 percent of the achievable savings cost more than the operation of current capacity, but even these savings cost less than the typical marginal cost of power from adding new capacity to the ratebase. Of course, the Integrated Planning Model will make the final allocation of resources.

Costs of Conserved Peak Power from Load Management Options

Table A-16 shows the costs per kW peak savings for the load-control measures. Air conditioner cycling, water heater interruption, and space heating thermal storage are more expensive than the reference peaking turbine ($500-$700/kW). Extending the air conditioner cycling period leads predictably to greater cost-effectiveness of that option, but makes that measure simultaneously less distinguishable from load shedding.

It is important to note that if the energy savings of the program scenario are implemented, the size of shiftable loads, and therefore the number of people with sufficiently large loads to be eligible for the program, will also decrease. For example, the central air conditioning loads will have decreased by 25 percent on account of improved building shells in gas-heated homes, and by a further (multiplicative) 18 percent on account of air conditioner standards. The combined 38.5 percent reduction in peak loads will increase the average $CCPP_{20}$ of air conditioner load shedding from $219/kW (diversified) in the case of DE to $356/kW. The peak power cost of demand subscription, now estimated to be $266 for high use customers, will rise to $433/kW.

Successful Program Planning and Implementation

Our results are based on aggressive demand-side programs. Successful programs will be the key to realizing the demand-side potential we have identified. Available evaluation studies and utility experience provide a wealth of findings on how to optimize demand-side programs. With these "lessons learned" it is now possible to design a second generation of programs that should be much more successful and predictable than past efforts. A detailed documentation of this emerging know-how lies beyond the framework of this study, and is proposed as a follow-up study to the current MEOS project. We briefly summarize a few key points:

- Large-scale programs should be preceded by well-designed and thoroughly evaluated pilot and demonstration projects.
- Monitoring, feedback, and quality control functions should be built into all aspects of the implementation process.
- Programs should make use of market segmentation techniques and other methods to flexibly target different consumer groups and local conditions.

- Community groups can be one of the most effective agents in the implementation process.
- Promotion of demand-side measures should emphasize how such measures contribute to the broad values sought by customers, such as increased comfort, safety, reliability, environmental health, and productivity.
- Incentives equal to or greater than the full additional first costs of demand-side measures may be a necessary condition for removing significant participation barriers, particularly among low-income groups. However, large incentives alone are not sufficient to ensure high participation rates and penetration fractions.
- Information and incentives strategies should build upon market forces wherever possible, and reward savings rather than expenditures.
- Efficiency standards can be one of the most effective complements to incentives-based programs. They can greatly increase the size certainty of demand-side resources while reducing their costs to all ratepayers.

Figure 3-1

Change in Residential Electricity Use, 1985-2005

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

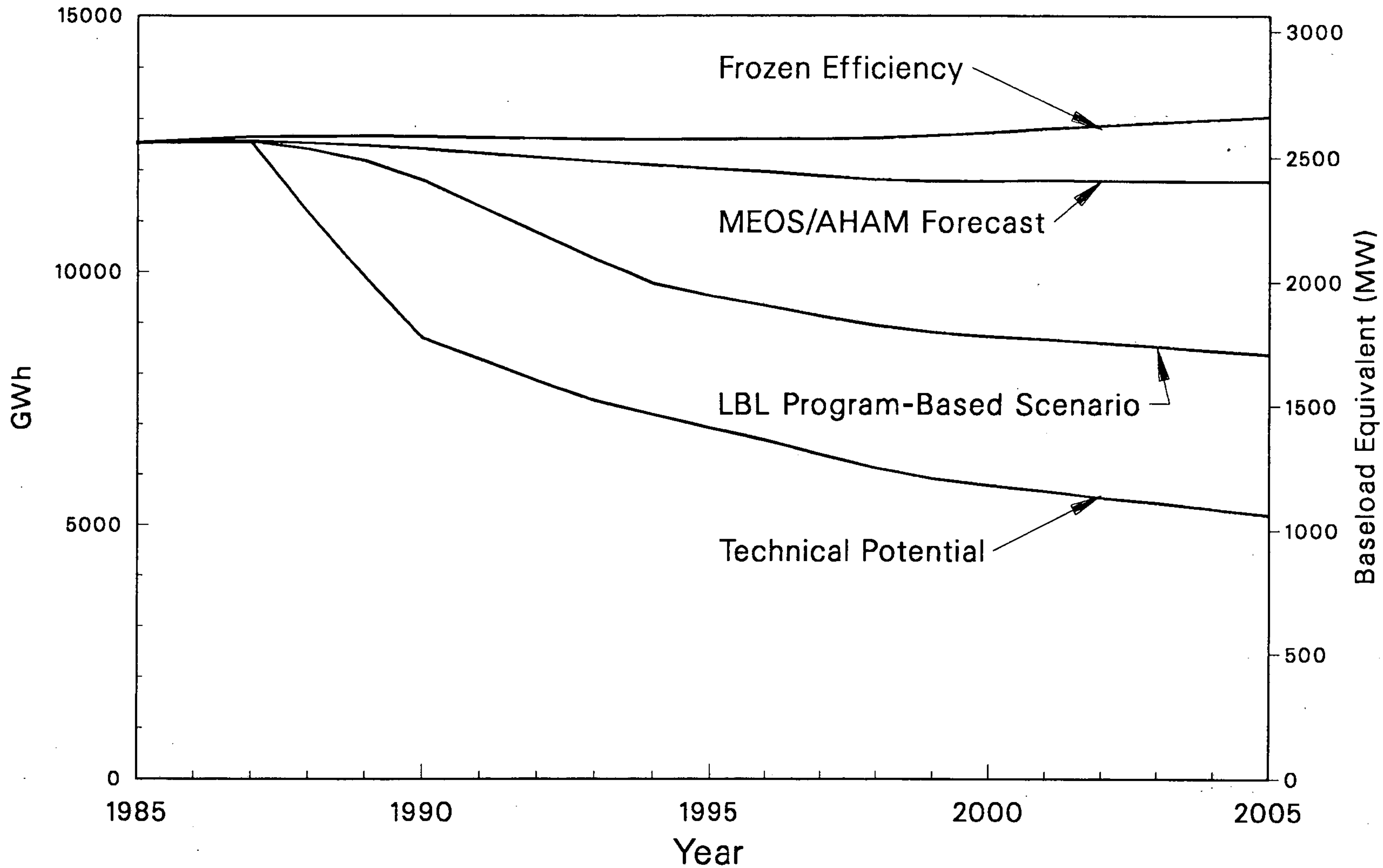


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Figure 3-2

Annual Program-Based Electricity Savings Over MEOS Forecast in Year 2005

Breakdown by End-use, CP and DE Territories

Total Savings = 3408 GWh

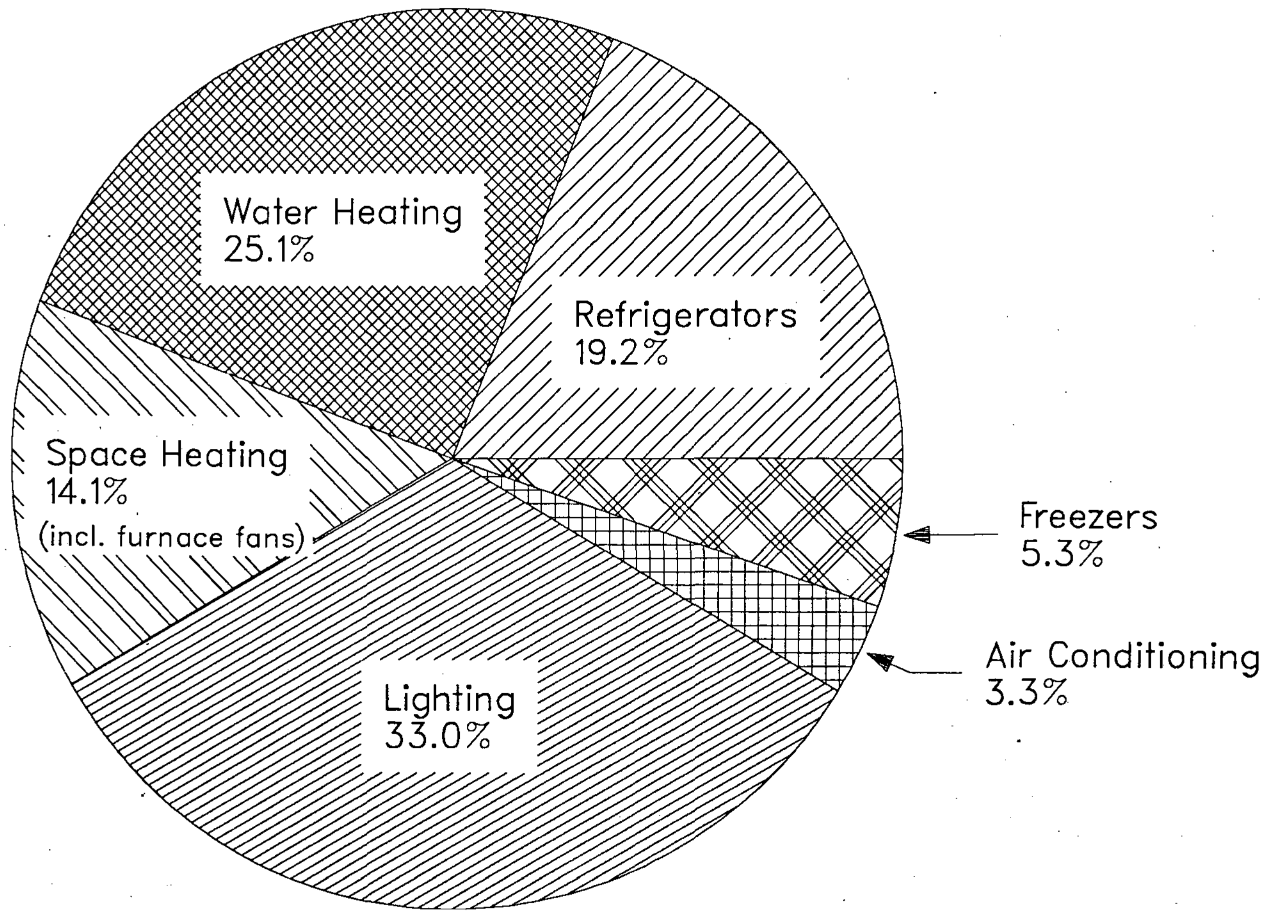

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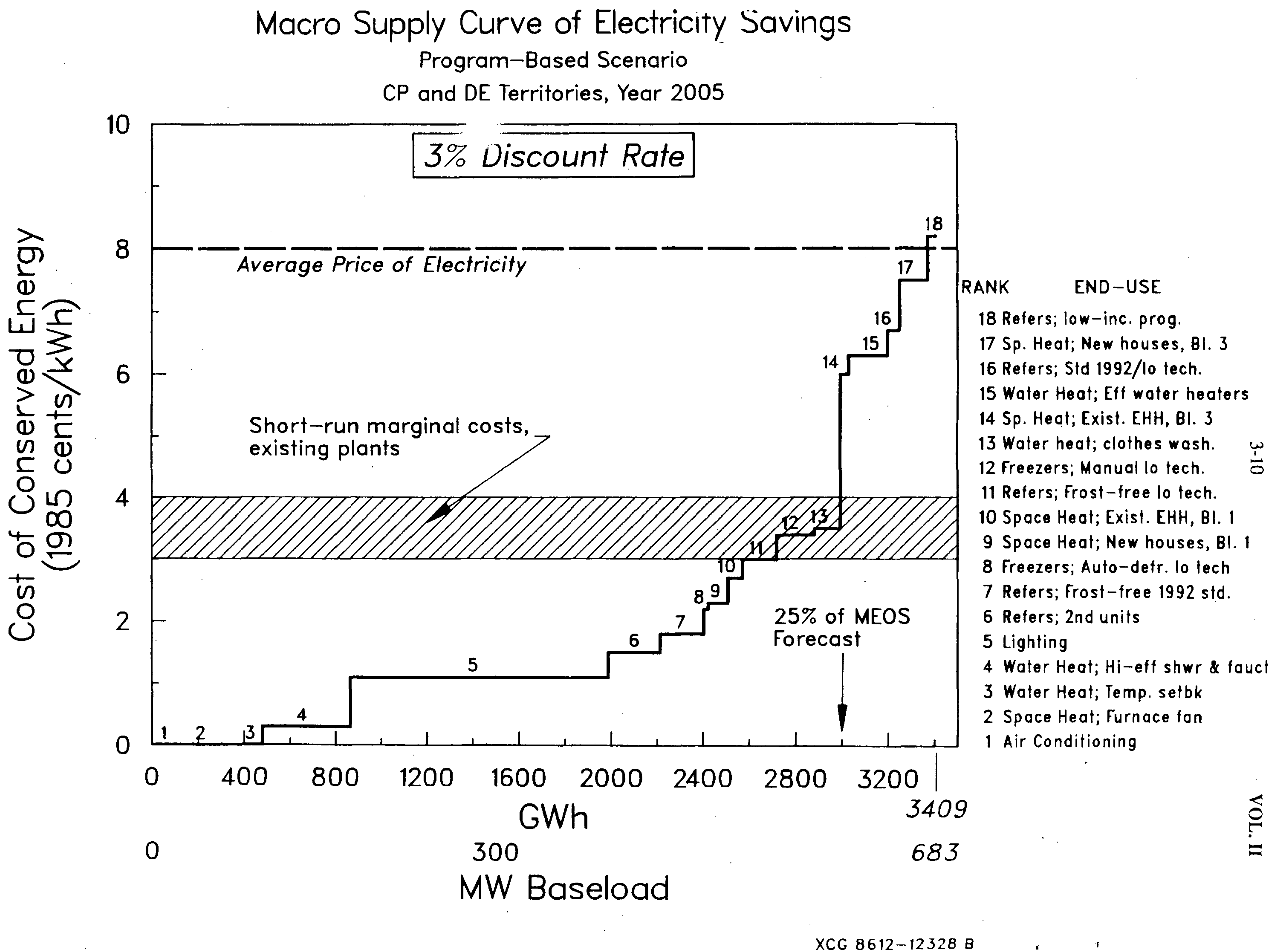
Figure 3-3

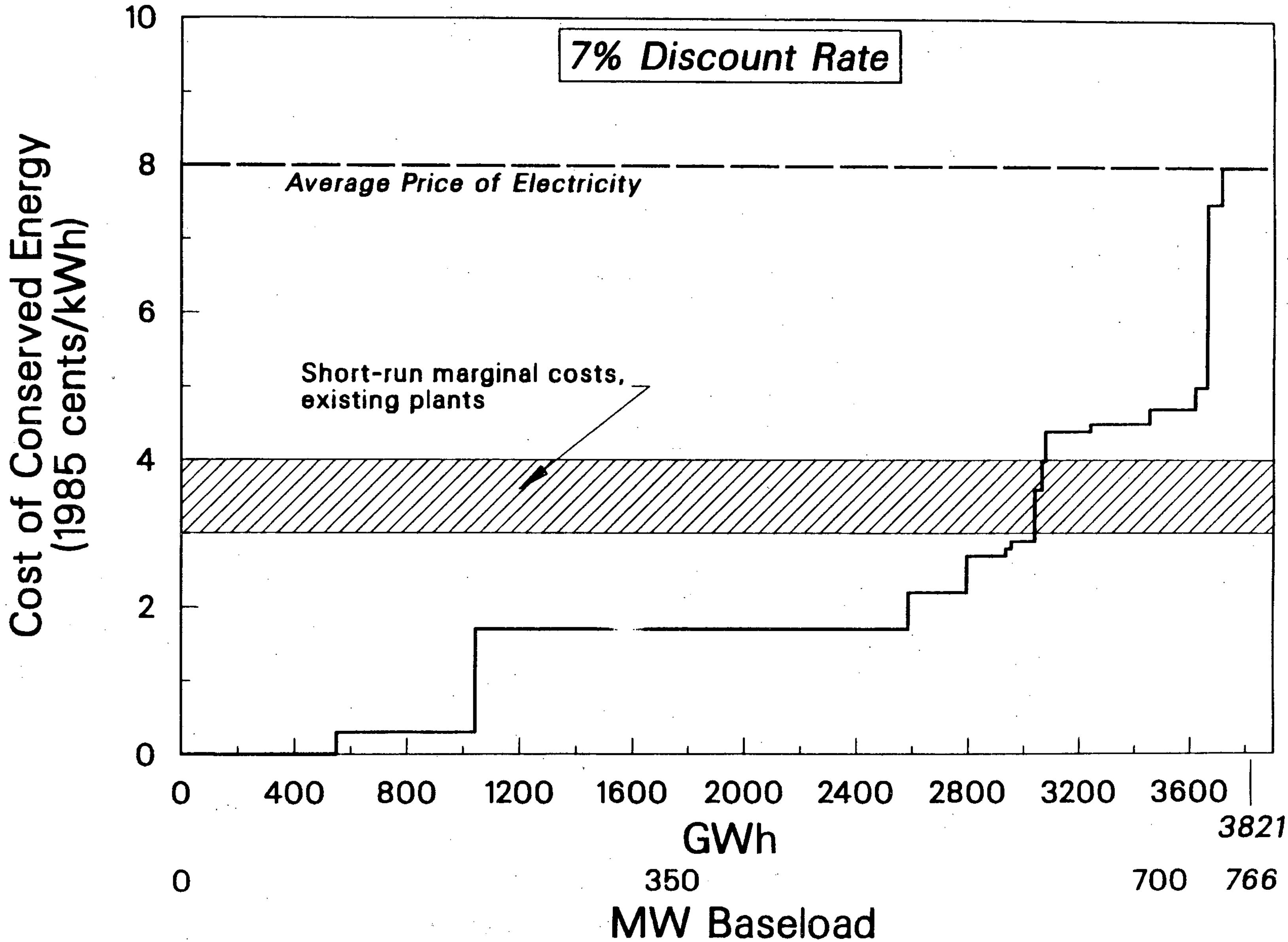


Macro Supply Curve of Electricity Savings
Program–Based Scenario
CP and DE Territories, Year 2005
3% Discount Rate
Average Price of Electricity
Short–run marginal costs, existing plants
25% of MEOS Forecast
Cost of Conserved Energy (1985 cents/kWh)
0
2
4
6
8
10
0
400
800
1200
1600
2000
2400
2800
3200
3409
GWh
0
300
683
MW Baseload
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
RANK END–USE
18 Refers; low–inc. prog.
17 Sp. Heat; New houses, Bl. 3
16 Refers; Std 1992/lo tech.
15 Water Heat; Eff water heaters
14 Sp. Heat; Exist. EHH, Bl. 3
13 Water heat; clothes wash.
12 Freezers; Manual lo tech.
11 Refers; Frost–free lo tech.
10 Space Heat; Exist. EHH, Bl. 1
9 Space Heat; New houses, Bl. 1
8 Freezers; Auto–defr. lo tech
7 Refers; Frost–free 1992 std.
6 Refers; 2nd units
5 Lighting
4 Water Heat; Hi–eff shwr & fauct
3 Water Heat; Temp. setbk
2 Space Heat; Furnace fan
1 Air Conditioning
XCG 8612–12328 B

Figure 3-4

Macro Supply Curve of Electricity Savings

CP and DE Territories, Year 2005



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4. UNCERTAINTIES IN ESTIMATES OF THE DEMAND-SIDE RESOURCE

Each step in our estimate of the energy savings has involved many assumptions. Each assumption potentially adds uncertainty in the final estimate of the demand-side resource. We tried to minimize the uncertainty by relying more than any previous study on monitored energy savings and documented conservation programs. At the same time, we described the *range* of savings, penetrations, and costs that were found in the literature. In this section, we discuss the sources of uncertainty, and the impact these could have on our estimates of the demand-side resource. The uncertainties can be reduced, however, through regular surveys, monitoring, and pilot projects.

Issues affecting uncertainty can be divided into those related to the individual household, or "micro" level, and those related to the region-wide implementation, or "macro" level.

Uncertainties at the Micro Level

At the micro level, each of the inputs to the cost-of-conserved-energy calculation (that is, the measure's cost, energy savings, lifetime, and discount rate) have associated uncertainties that affect the final estimate of the CCE. Meier discusses the impact of uncertainty at the micro level in his dissertation.* He derived estimates for uncertainties in the CCE as a result of uncertainties in the CCE inputs. Examples these are listed below, for a 5% discount rate.

A 20% error in estimate of the...	leads to an error in the CCE of:
cost of the measure	20%
energy savings	20%
lifetime (originally 5 years)	18%
lifetime (originally 10 years)	16%
lifetime (originally 20 years)	12%
discount rate (corresponding to a shift from 5% to 6%, 10 years)	35%

For example, if the energy savings for high-efficiency refrigerators were 20% less, then the CCE would be 20% higher. If a particular compact fluorescent light turns out to have an four-year lifetime (instead of five), the CCE would be about 16% higher. Clearly the CCE is most sensitive to the selection of the discount rate. A single percentage point change at 3% -- that is, shifting to 2% or 4% -- implies at 30% relative change in the interest rate, and close to 60% change in the CCE.

* Meier, Alan K. "Supply Curves of Conserved Energy", PhD dissertation, University of California, Berkeley. 1982.

Even large re-adjustments in the costs or energy savings will cause relatively small changes compared to using a slightly larger (or smaller) discount rate.** Since the 3% discount rate was selected by MEOS, the greatest source of uncertainty in the CCE is outside our control.

Meier also investigated the impact of errors in estimates of energy savings from a change in the *sequence* of conservation measures applied to a single unit. This is important because, at the micro level, the estimates of energy savings are the least certain input. This sequence included demand reduction measures (such as reduced hot water use), efficiency improvements, and reductions in standby losses. In addition, it is crucial to understand how an error in the assumptions for one measure will affect other, related measures. He found that:

1. *An error in the estimation of the initial energy use will lead to underestimates of the subsequent energy savings and an increase in their CCEs.* It may also lead to the re-ordering of the conservation measures.
2. *The absolute size of an error will diminish as it propagates through a sequence.* Once an error has occurred, subsequent conservation measures offset small portions of the error. The error can diminish rapidly if there are efficiency improvements in the sequence. This results in a mild "self-correcting" behavior in conservation supply curves as one moves up the curve.
3. *Removing a measure from a sequence allows subsequent measures to save more energy and have lower CCEs.* In effect, the subsequent measures have the opportunity to save energy that would have originally been saved by the deleted measure. Thus, the impact of deleting a measure tends to be less than the savings listed for it. This property of a conservation supply curve increases the robustness of the savings estimates.

The baseline consumption for each end use remains a source of great uncertainty. We relied as much as possible on monitored data to benchmark our estimates, but the available measured data still require considerable interpretation and extrapolation. Our water heating estimates are probably the most accurate -- perhaps within 15% -- and lighting is probably the least accurate -- perhaps within 30%. The errors are, to a limited extent, self-correcting because an overestimate in one end use implies an underestimate in another end use. Thus, savings in the second end use will be greater than we estimated. (However, the additional energy use could have been in the miscellaneous end uses that we did not cover, in which case our overall estimates do not get corrected.)

Our estimates of peak energy savings have greater uncertainties since the coincidence data were derived from submetering experiments with only 30-100 participants. Extrapolation to all Michigan residences results in large uncertainty.

There are additional uncertainties that occur at the micro level. In some end uses, consumers have the opportunity to convert some of the conserved energy to increased amenity. (This is sometimes called "take-back".) This is most likely to occur in the space heating, water heating, and lighting end uses. There have been no careful studies of this phenomenon, but we think that it would have been detected if it were greater than 30%. In those measures susceptible to take-back, we allowed 20% less savings than engineering estimates or measured savings to allow for the possibility that consumers will take longer showers, enjoy warmer homes, etc.

** The *cost-effective* potential does not increase appreciably if the original CCE is much lower than the energy price (the cut-off price) to begin with. For this reason, the statewide potential does not significantly change when a 7% discount rate was used. In supply curve terms, this corresponds to a conservation supply curve so far below the cut-off price that a doubling or tripling of the curve's height still keeps it under the cut-off price.

Uncertainties at the Macro Level

The MEOS project stipulated that all program-based scenarios should use an aggressive implementation approach and whenever possible rely on demonstrated implementation rates from actual program experience. Demand-side management programs oriented toward conservation have rarely been implemented aggressively on a large scale, however, and data from past or existing programs are not widely available. The availability and reliability of program-experience data vary from end-use to end-use. In general, data are better for annual participation rates (i.e. the percentage of eligible customers that participate in a given year) than for maximum penetration fractions (i.e. the maximum fraction of customers that will have adopted the demand-side measure once the program runs out or achieves its steady-state maintenance mode). Large-scale programs have only been in operation for a few years and have generally not been pursued in an aggressive manner. Further, many of the program experience data are derived from relatively small-scale, pilot projects. The participation rates and maximum penetration fractions from these may not necessarily be applicable on a state-wide scale.

Program costs were our best estimates based on documentation of other demand-side programs. While there may be considerable uncertainty in these costs, it is important to realize that they constitute a relatively small fraction of the total cost of the demand-side resource. For example, the refrigerator program administrative costs represented only about 10% of the total cost (incremental efficiency cost plus program cost).

In a few cases there are multiple paths to achieve the energy savings. These redundant approaches add reliability to the demand-side resource. In the short run, water heater standby losses will be reduced with insulation blankets. If this program does not achieve the projected saturation, then the missed savings will be eventually recovered as the old water heaters are replaced with high-efficiency (well-insulated) units.

Reducing Uncertainty

Michigan can reduce the uncertainty of its demand-side resource by establishing a regular series of surveys, monitoring programs, and pilot projects. Surveys would improve the quality of baseline information and energy-related characteristics. As indicated above, errors in the baseline lead to uncertainty in almost all proposed conservation measures. Surveys would include an expanded residential appliance saturation survey, plus status of insulation, and other characteristics related to the thermal performance of the house.

Monitoring programs would provide crucial data on energy use of appliances and the time at which they are used. Additional information regarding in-situ efficiency and efficiency degradation also deserve close scrutiny. Retrofits could be monitored and evaluated for energy savings, cost-effectiveness and consumer acceptance. In this way, one can reduce the uncertainty around the energy savings, fraction of eligible units, and costs. A monitoring program designed to provide reliable information would require that at least several hundred homes are being monitored at any time.

Pilot projects could test the efficacy of the rebates and incentives discussed in this report. Of course, it is hazardous to extrapolate from pilot projects to full-scale programs but more reliable estimates of participation rates and program costs could be obtained in this way. Pilot projects also permit a variety of different approaches to be tested in parallel; the most successful (and economic) could be then scaled-up to all of Michigan.

The key to reducing uncertainty is *feedback*. Results from the surveys, monitoring, and pilot projects must be fed back into the estimates of 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 is an essential element of any quality assurance.

APPENDIX A

AGGREGATE RESULTS: COMBINED AND UTILITY-SPECIFIC

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Table A-1. Summary of Baseline Energy Use and Loads
Consumers Power and Detroit Edison Service Territories.

End-Use Equipment	Saturation 1985 (%)	Stock 1985 (x1000)	UEC (kWh)	UPD Summer (W)	UPD Winter (W)	Total Use (GWh)	Baseline Demand (MW)	Peak Summer Demand (MW)	Peak Winter Demand (MW)
Refrigerators & Refrig./Freezers									
Frost-free	71.57	2041	1563	210	168	3191	639	428	342
Standard	28.06	800	821	110	88	657	131	88	70
Second	18.89	538	1079	145	115	582	116	78	62
ALL						**4430**	**886**	**594**	**474**
Freezers									
Frost-free	10.60	302	1632	221	175	495	99	67	53
Standard	33.60	958	1119	150	119	1073	215	144	114
ALL						**1568**	**314**	**211**	**167**
Air Conditioners									
Central	17.66	504	1419	1982	0	717	144	1001	0
Room	28.51	813	446	357	0	363	72	291	0
ALL						**1080**	**216**	**1292**	**0**
Lighting									
General	100.00	2852	679	56	211	1938	388	158	603
Outdoor	15.96	455	434	0	99	198	39	0	45
ALL						**2136**	**427**	**158**	**648**
Space Heating									
Existing EHH	2.51	72	5603	0	2657	407	81	0	193
New EHH	0.10	3	4128	0	2064	16	4	0	8
Furnace	74.57	2126	359	0	253	764	153	0	538
ALL						**1187**	**238**	**0**	**739**
Water Heating									
Water	20.27	578	3674	460	586	2127	426	266	339
ALL						**2127**	**426**	**266**	**339**
SUBTOTAL						**12528**	**2507**	**2521**	**2367**
End-uses not covered by LBL									
Ranges						1264	254		
Humid.&Dehumid.						208	42		
TVs						1287	258		
Water Pumps						226	45		
Electric Drives						607	122		
Clothes Dryers						979	196		
Miscellaneous						1620	323		
ALL						**6191**	**1239**		
TOTAL						**18719**	**3748**		

Table A-2. Summary of Baseline Energy Use and Loads
Consumers Power.

End-Use Equipment	Saturation 1985 (%)	Stock 1985 (x1000)	UEC (kWh)	UPD Summer (W)	UPD Winter (W)	Total Use (GWh)	Baseline Demand (MW)	Peak Summer Demand (MW)	Peak Winter Demand (MW)
Refrigerators & Refrig./Freezers									
Frost-free	69.92	851	1609	216	173	1370	274	184	147
Standard	29.75	362	803	108	86	291	58	39	31
Second	17.12	208	939	125	101	196	39	26	21
ALL						**1857**	**371**	**249**	**199**
Freezers									
Frost-free	13.42	163	1624	220	171	266	53	36	28
Standard	40.57	494	1143	154	121	565	113	76	60
ALL						**831**	**166**	**112**	**88**
Air Conditioners									
Central	9.58	117	1434	1673	0	168	34	196	0
Room	25.70	313	421	326	0	132	26	102	0
ALL						**300**	**60**	**298**	**0**
Lighting									
General	100.00	1217	685	55	212	834	167	67	258
Outdoor	18.60	226	295	0	66	67	13	0	15
ALL						**901**	**180**	**67**	**273**
Space Heating									
Existing EHH	4.02	49	4490	0	2265	222	44	0	112
New EHH	0.15	2	3529	0	1764	8	2	0	4
Furnace	72.65	884	359	0	253	318	64	0	224
ALL						**548**	**110**	**0**	**340**
Water Heating									
Water	33.92	413	3431	477	583	1418	284	197	241
ALL						**1418**	**284**	**197**	**241**
SUBTOTAL						**5855**	**1171**	**923**	**1141**
End-uses not covered by LBL									
Ranges						417	84		
Humid.&Dehumid.						208	42		
TVs						424	85		
Water Pumps						226	45		
Electric Drives						199	40		
Clothes Dryers						509	102		
Miscellaneous						379	75		
ALL						**2362**	**473**		
TOTAL						**8217**	**1645**		

Table A-3. Summary of Baseline Energy Use and Loads
Detroit Edison.

End-Use Equipment	Saturation 1985 (%)	Stock 1985 (x1000)	UEC (kWh)	UPD Summer (W)	UPD Winter (W)	Total Use (GWh)	Baseline Demand (MW)	Peak Summer Demand (MW)	Peak Winter Demand (MW)
Refrigerators & Refrig./Freezers									
Frost-free	72.80	1190	1530	205	164	1821	365	244	195
Standard	26.80	438	835	112	89	366	73	49	39
Second	20.20	330	1167	157	124	386	77	52	41
ALL						**2573**	**515**	**345**	**275**
Freezers									
Frost-free	8.50	139	1642	222	179	229	46	31	25
Standard	28.40	464	1093	146	116	508	102	68	54
ALL						**737**	**148**	**99**	**79**
Air Conditioners									
Central	23.70	387	1415	2075	0	549	110	805	0
Room	30.60	500	461	377	0	231	46	189	0
ALL						**780**	**156**	**994**	**0**
Lighting									
General	100.00	1635	675	56	211	1104	221	91	345
Outdoor	14.00	229	571	0	131	131	26	0	30
ALL						**1235**	**247**	**91**	**375**
Space Heating									
Existing EHH	1.39	23	7974	0	3491	185	37	0	81
New EHH	0.06	1	5326	0	2663	8	2	0	4
Furnace	76.00	1242	359	0	253	446	89	0	314
ALL						**639**	**128**	**0**	**399**
Water Heating									
Water	10.10	165	4282	417	592	709	142	69	98
ALL						**709**	**142**	**69**	**98**
SUBTOTAL						**6673**	**1336**	**1598**	**1226**
End-uses not covered by LBL									
Ranges						847	170		
Humid.&Dehumid.						0	0		
TVs						843	173		
Water Pumps						0	0		
Electric Drives						408	82		
Clothes Dryers						470	94		
Miscellaneous						1241	248		
ALL						**3829**	**766**		
TOTAL						**10502**	**2103**		

Table A-4. Summary of Electricity Savings and Baseload Equivalent results,
Consumers Power and Detroit Edison Service Territories, 1995 *(totals may not add due to rounding)*

End-Use	Frozen Efficiency		MEOS Forecast		Program Scenario		Technical Potential		Yearly Savings Over MEOS: Program		Yearly Savings Over MEOS: Technical	
	GWh	*MW*	*GWh*	*MW*	*GWh*	*MW*	*GWh*	*MW*	*GWh*	*MW*	*GWh*	*MW*
Refrigerators & Refrig./Freezers												
Frost-free	2989	599	2717	544	2634	528	2390	479	83	17	328	66
Standard	566	113	495	99	480	96	435	87	15	3	60	12
Second	798	160	798	160	553	111	159	32	245	49	638	128
ALL	**4353**	**872**	**4010**	**803**	**3667**	**735**	**2984**	**598**	**343**	**69**	**1026**	206
Indices	*100*	*100*	*92*	*92*	*84*	*84*	*69*	*69*				
Freezers												
Frost-free	515	103	472	95	466	93	436	87	6	1	36	7
Standard	925	185	887	178	780	156	701	140	107	21	186	37
ALL	**1440**	**288**	**1359**	**273**	**1246**	**249**	**1137**	**227**	**113**	**22**	**222**	**44**
Indices	*100*	*100*	*94*	*95*	*87*	*86*	*79*	*79*				
Air Conditioners												
Central	638	128	632	127	574	115	444	89	57	11	187	37
Room	386	77	376	75	355	71	301	60	22	4	75	15
ALL	**1024**	**205**	**1008**	**202**	**929**	**186**	**745**	**149**	**79**	**15**	**262**	**52**
Indices	*100*	*100*	*98*	*99*	*91*	*91*	*73*	*73*				
Lighting												
General	2163	433	2081	417	1074	215	528	106	1007	202	1553	311
Outdoor	234	47	234	47	129	26	47	9	106	21	187	37
ALL	**2397**	**480**	**2315**	**464**	**1203**	**241**	**575**	**115**	**1113**	**223**	**1740**	348
Indices	*100*	*100*	*97*	*97*	*50*	*50*	*24*	*24*				
Space Heating												
Existing EHH	359	72	359	72	280	56	201	40	79	16	156	31
New EHH	110	22	183	37	82	16	73	15	101	20	109	22
Furnace Fans	867	174	785	157	706	141	668	134	80	16	116	23
ALL	**1336**	**268**	**1327**	**266**	**1068**	**213**	**942**	**189**	**260**	**52**	**381**	76
Indices	*100*	*100*	*99*	*99*	*80*	*79*	*71*	*71*				
Water Heating												
Water	2054	411	2013	403	1416	284	539	108	596	119	1474	295
ALL	**2054**	**411**	**2013**	**403**	**1416**	**284**	**539**	**108**	**596**	**119**	**1474**	295
Indices	*100*	*100*	*98*	*98*	*69*	*69*	*26*	*26*				
TOTAL	**12604**	**2524**	**12032**	**2411**	**9529**	**1908**	**6922**	**1386**	**2504**	**500**	**5105**	**1021**
Indices	*100*	*100*	*95*	*96*	*76*	*76*	*55*	*55*				

Table A-5. Summary of Electricity Savings and Baseload Equivalent results, Consumers Power, 1995 *(totals may not add due to rounding)*

End-Use	Frozen Efficiency GWh	Frozen Efficiency MW	MEOS Forecast GWh	MEOS Forecast MW	Program Scenario GWh	Program Scenario MW	Technical Potential GWh	Technical Potential MW	Yearly Savings Over MEOS: Program GWh	Yearly Savings Over MEOS: Program MW	Yearly Savings Over MEOS: Technical GWh	Yearly Savings Over MEOS: Technical MW
Refrigerators & Refrig./Freezers												
Frost-free	1231	247	1107	222	1067	214	955	191	39	8	152	30
Standard	281	56	251	50	245	49	226	45	6	1	25	5
Second	317	63	317	63	219	44	63	13	98	20	254	51
ALL	**1829**	**366**	**1675**	**335**	**1531**	**307**	**1244**	**249**	**143**	**29**	**431**	**86**
Indices	*100*	*100*	*92*	*92*	*84*	*84*	*68*	*68*				
Freezers												
Frost-free	283	57	259	52	256	51	239	48	3	1	20	4
Standard	480	96	459	92	403	81	360	72	57	11	99	20
ALL	**763**	**153**	**718**	**144**	**659**	**132**	**599**	**120**	**60**	**12**	**119**	**24**
Indices	*100*	*100*	*94*	*94*	*86*	*86*	*79*	*78*				
Air Conditioners												
Central	177	35	175	35	160	32	125	25	15	3	50	10
Room	133	27	130	26	124	25	108	22	6	1	22	4
ALL	**310**	**62**	**305**	**61**	**284**	**57**	**233**	**47**	**21**	**4**	**72**	**14**
Indices	*100*	*100*	*98*	*98*	*92*	*92*	*75*	*76*				
Lighting												
General	942	189	906	181	468	94	229	46	438	88	677	136
Outdoor	79	16	79	16	44	9	16	3	36	7	63	13
ALL	**1021**	**205**	**985**	**197**	**512**	**103**	**245**	**49**	**474**	**95**	**740**	**149**
Indices	*100*	*100*	*96*	*96*	*50*	*50*	*24*	*24*				
Space Heating												
Existing EHH	200	40	200	40	157	31	114	23	43	9	85	17
New EHH	63	13	105	21	49	10	44	9	56	11	61	12
Furnace Fans	371	74	336	67	311	62	291	58	25	5	44	9
ALL	**634**	**127**	**641**	**128**	**517**	**103**	**449**	**90**	**124**	**25**	**190**	**38**
Indices	*100*	*100*	*101*	*101*	*82*	*81*	*71*	*71*				
Water Heating												
Water	1405	281	1377	276	982	197	374	75	394	79	1003	201
ALL	**1405**	**281**	**1377**	**276**	**982**	**197**	**374**	**75**	**394**	**79**	**1003**	**201**
Indices	*100*	*100*	*98*	*98*	*70*	*70*	*27*	*27*				
TOTAL	**5962**	**1194**	**5701**	**1141**	**4485**	**899**	**3144**	**630**	**1216**	**244**	**2555**	**512**
Indices	*100*	*100*	*96*	*96*	*75*	*75*	*53*	*53*				

Table A-6. Summary of Electricity Savings and Baseload Equivalent results, Detroit Edison, 1995 *(totals may not add due to rounding)*

End-Use	Frozen Efficiency		MEOS Forecast		Program Scenario		Technical Potential		Yearly Savings Over MEOS Program		Yearly Savings Over MEOS Technical	
	GWh	*MW*	*GWh*	*MW*	*GWh*	*MW*	*GWh*	*MW*	*GWh*	*MW*	*GWh*	*MW*
Refrigerators & Refrig./Freezers												
Frost-free	1758	352	1610	322	1567	314	1435	287	44	9	176	35
Standard	285	57	244	49	235	47	209	42	9	2	35	7
Second	481	96	481	96	334	67	96	19	147	29	384	77
ALL	**2524**	**505**	**2335**	**467**	**2136**	**428**	**1740**	**348**	**200**	**40**	**595**	**119**
Indices	*100*	*100*	*93*	*92*	*85*	*85*	*69*	*69*				
Freezers												
Frost-free	232	46	213	43	210	42	197	39	3	1	16	3
Standard	445	89	428	86	377	76	341	68	50	10	87	17
ALL	**677**	**135**	**641**	**129**	**587**	**118**	**538**	**107**	**53**	**11**	**103**	**20**
Indices	*100*	*100*	*95*	*96*	*87*	*87*	*79*	*79*				
Air Conditioners												
Central	461	92	457	92	414	83	319	64	42	8	137	27
Room	253	51	246	49	231	46	193	39	16	3	53	11
ALL	**714**	**143**	**703**	**141**	**645**	**129**	**512**	**103**	**58**	**11**	**190**	**38**
Indices	*100*	*100*	*98*	*99*	*90*	*90*	*72*	*72*				
Lighting												
General	1221	245	1175	235	606	121	299	60	569	114	876	175
Outdoor	155	31	155	31	85	17	31	6	70	14	124	25
ALL	**1376**	**276**	**1330**	**266**	**691**	**138**	**330**	**66**	**639**	**128**	**1000**	**200**
Indices	*100*	*100*	*97*	*96*	*50*	*50*	*24*	*24*				
Space Heating												
Existing EHH	159	32	159	32	123	25	87	17	36	7	71	14
New EHH	47	9	78	16	33	7	29	6	45	9	48	10
Furnace Fans	496	99	449	90	395	79	377	76	55	11	72	14
ALL	**702**	**140**	**686**	**138**	**551**	**111**	**493**	**99**	**136**	**27**	**191**	**38**
Indices	*100*	*100*	*98*	*99*	*78*	*79*	*70*	*71*				
Water Heating												
Water	649	130	636	127	434	87	165	33	202	40	471	94
ALL	**649**	**130**	**636**	**127**	**434**	**87**	**165**	**33**	**202**	**40**	**471**	**94**
Indices	*100*	*100*	*98*	*98*	*67*	*67*	*25*	*25*				
TOTAL	**6642**	**1329**	**6331**	**1268**	**5044**	**1011**	**3778**	**756**	**1288**	**257**	**2550**	**509**
Indices	*100*	*100*	*95*	*95*	*76*	*76*	*57*	*57*				

Table A-7. Summary of Electricity Savings and Baseload Equivalent results, Consumers Power and Detroit Edison Service Territories, 2005 *(totals may not add due to rounding)*

End-Use	Frozen Efficiency		MEOS Forecast		Program Scenario		Technical Potential		Yearly Savings Over MEOS			
									Program		Technical	
	GWh	*MW*	*GWh*	*MW*	*GWh*	*MW*	*GWh*	*MW*	*GWh*	*MW*	*GWh*	*MW*
Refrigerators & Refrig./Freezers												
Frost-free	3138	628	2531	507	2155	432	1475	295	376	75	1056	211
Standard	558	112	449	90	398	80	312	62	51	10	137	27
Second	716	143	707	142	481	96	142	28	226	45	565	113
ALL	**4412**	**883**	**3687**	**739**	**3034**	**608**	**1929**	**385**	**653**	**130**	**1758**	**351**
Indices	*100*	*100*	*84*	*84*	*69*	*69*	*44*	*44*				
Freezers												
Frost-free	541	108	421	84	401	80	327	65	20	4	93	19
Standard	960	192	871	174	708	142	558	112	162	32	313	63
ALL	**1501**	**300**	**1292**	**258**	**1109**	**222**	**885**	**177**	**182**	**36**	**406**	**82**
Indices	*100*	*100*	*86*	*86*	*74*	*74*	*59*	*59*				
Air Conditioners												
Central	646	129	630	126	534	107	339	68	96	19	291	58
Room	405	81	370	74	352	70	264	53	18	4	107	21
ALL	**1051**	**210**	**1000**	**200**	**886**	**177**	**603**	**121**	**114**	**23**	**398**	**79**
Indices	*100*	*100*	*95*	*95*	*84*	*84*	*57*	*58*				
Lighting												
General	2335	468	2166	434	1158	232	571	114	1008	202	1595	319
Outdoor	257	51	257	51	141	28	52	10	115	23	206	41
ALL	**2592**	**519**	**2423**	**485**	**1299**	**260**	**623**	**124**	**1123**	**225**	**1801**	**360**
Indices	*100*	*100*	*93*	*93*	*50*	*50*	*24*	*24*				
Space Heating												
Existing EHH	309	62	309	62	208	42	153	31	101	20	156	31
New EHH	208	42	347	69	141	28	132	26	207	41	214	43
Furnace Fans	939	188	778	156	605	121	529	106	173	35	249	50
ALL	**1456**	**292**	**1434**	**287**	**954**	**191**	**814**	**163**	**481**	**96**	**619**	**124**
Indices	*100*	*100*	*98*	*98*	*66*	*65*	*56*	*56*				
Water Heating												
Water	2032	407	1945	390	1091	219	341	68	855	171	1605	321
ALL	**2032**	**407**	**1945**	**390**	**1091**	**219**	**341**	**68**	**855**	**171**	**1605**	**321**
Indices	*100*	*100*	*96*	*96*	*54*	*54*	*17*	*17*				
TOTAL	**13044**	**2611**	**11781**	**2359**	**8373**	**1677**	**5195**	**1038**	**3408**	**681**	**6587**	**1317**
Indices	*100*	*100*	*90*	*90*	*64*	*64*	*40*	*40*				

Table A-8. Summary of Electricity Savings and Baseload Equivalent results, Consumers Power, 2005 *(totals may not add due to rounding)*												
End-Use	Frozen Efficiency		MEOS Forecast		Program Scenario		Technical Potential		Yearly Savings Over MEOS			
									Program		Technical	
	GWh	*MW*	*GWh*	*MW*	*GWh*	*MW*	*GWh*	*MW*	*GWh*	*MW*	*GWh*	*MW*
Refrigerators & Refrig./Freezers												
Frost-free	1308	262	1056	211	903	181	622	125	153	31	434	87
Standard	274	55	220	44	193	39	150	30	27	5	70	14
Second	298	60	294	59	200	40	59	12	94	19	235	47
ALL	**1880**	**377**	**1570**	**314**	**1296**	**260**	**831**	**167**	**274**	**55**	**739**	**148**
Indices	*100*	*100*	*84*	*83*	*69*	*69*	*44*	*44*				
Freezers												
Frost-free	304	61	237	47	226	45	184	37	11	2	52	10
Standard	485	97	441	88	358	72	283	57	82	16	158	32
ALL	**789**	**158**	**678**	**135**	**584**	**117**	**467**	**94**	**93**	**18**	**210**	**42**
Indices	*100*	*100*	*86*	*85*	*74*	*74*	*59*	*59*				
Air Conditioners												
Central	187	37	182	36	154	31	98	20	28	6	84	17
Room	139	28	127	25	121	24	91	18	6	1	37	7
ALL	**326**	**65**	**309**	**61**	**275**	**55**	**189**	**38**	**34**	**7**	**121**	**24**
Indices	*100*	*100*	*95*	*94*	*84*	*85*	*58*	*58*				
Lighting												
General	1018	204	944	189	505	101	248	50	439	88	696	139
Outdoor	90	18	90	18	49	10	18	4	40	8	72	14
ALL	**1108**	**222**	**1034**	**207**	**554**	**111**	**266**	**54**	**479**	**96**	**768**	**153**
Indices	*100*	*100*	*93*	*93*	*50*	*50*	*24*	*24*				
Space Heating												
Existing EHH	177	35	177	35	122	24	92	18	55	11	85	17
New EHH	123	25	206	41	85	17	80	16	121	24	125	25
Furnace Fans	404	81	335	67	279	56	239	48	56	11	96	19
ALL	**704**	**141**	**718**	**143**	**486**	**97**	**411**	**82**	**232**	**46**	**306**	**61**
Indices	*100*	*100*	*102*	*101*	*69*	*69*	*58*	*58*				
Water Heating												
Water	1382	277	1323	265	760	152	238	48	564	113	1086	218
ALL	**1382**	**277**	**1323**	**265**	**760**	**152**	**238**	**48**	**564**	**113**	**1086**	**218**
Indices	*100*	*100*	*96*	*96*	*55*	*55*	*17*	*17*				
TOTAL	**6189**	**1240**	**5632**	**1125**	**3955**	**792**	**2402**	**483**	**1676**	**335**	**3230**	**646**
Indices	*100*	*100*	*91*	*91*	*64*	*64*	*39*	*39*				

Table A-9. Summary of Electricity Savings and Baseload Equivalent results, Detroit Edison, 2005 *(totals may not add due to rounding)*

End-Use	Frozen Efficiency		MEOS Forecast		Program Scenario		Technical Potential		Yearly Savings Over MEOS Program		Technical	
	GWh	*MW*	*GWh*	*MW*	*GWh*	*MW*	*GWh*	*MW*	*GWh*	*MW*	*GWh*	*MW*
Refrigerators & Refrig./Freezers												
Frost-free	1830	367	1475	295	1252	251	853	171	223	45	622	125
Standard	284	57	229	46	205	41	162	32	24	5	67	13
Second	418	84	413	83	281	56	83	17	132	26	330	66
ALL	**2532**	**508**	**2117**	**424**	**1738**	**348**	**1098**	**220**	**379**	**76**	**1019**	**204**
Indices	*100*	*100*	*84*	*83*	*69*	*69*	*43*	*43*				
Freezers												
Frost-free	237	47	184	37	175	35	143	29	9	2	41	8
Standard	475	95	430	86	350	70	275	55	80	16	155	31
ALL	**712**	**142**	**614**	**123**	**525**	**105**	**418**	**84**	**89**	**18**	**196**	**39**
Indices	*100*	*100*	*86*	*87*	*74*	*74*	*59*	*59*				
Air Conditioners												
Central	459	92	448	90	380	76	241	48	68	14	207	41
Room	266	53	243	49	231	46	173	35	12	2	70	14
ALL	**725**	**145**	**691**	**139**	**611**	**122**	**414**	**83**	**80**	**16**	**277**	**55**
Indices	*100*	*100*	*95*	*96*	*84*	*84*	*57*	*57*				
Lighting												
General	1317	264	1222	245	653	131	323	65	569	114	899	180
Outdoor	167	33	167	33	92	18	34	7	75	15	134	27
ALL	**1484**	**297**	**1389**	**278**	**745**	**149**	**357**	**72**	**644**	**129**	**1033**	**207**
Indices	*100*	*100*	*94*	*94*	*50*	*50*	*24*	*24*				
Space Heating												
Existing EHH	132	26	132	26	86	17	61	12	46	9	71	14
New EHH	85	17	141	28	56	11	52	10	86	17	89	18
Furnace Fans	535	107	443	89	326	65	290	58	117	23	153	31
ALL	**752**	**150**	**716**	**143**	**468**	**93**	**403**	**80**	**249**	**49**	**313**	**63**
Indices	*100*	*100*	*95*	*95*	*62*	*62*	*54*	*53*				
Water Heating												
Water	650	130	622	125	331	66	103	21	291	58	519	104
ALL	**650**	**130**	**622**	**125**	**331**	**66**	**103**	**21**	**291**	**58**	**519**	**104**
Indices	*100*	*100*	*96*	*96*	*51*	*51*	*16*	*16*				
TOTAL	**6855**	**1372**	**6149**	**1232**	**4418**	**883**	**2793**	**560**	**1732**	**346**	**3357**	**672**
Indices	*100*	*100*	*90*	*90*	*64*	*64*	*41*	*41*				

Table A-10. Summary of Peak Power results, Consumers Power and Detroit Edison Service Territories, 1995 *(totals may not add due to rounding)*														
End-Use	Frozen Efficiency		MEOS Forecast		Program Scenario		Technical Potential		Yearly Savings Over MEOS			
									Program		Technical	
	Winter MW	*Summer MW*	*Winter MW*	*Summer MW*	*Winter MW*	*Summer MW*	*Winter MW*	*Summer MW*	*Winter MW*	*Summer MW*	*Winter MW*	*Summer MW*
Refrigerators & Refrig./Freezers												
Frost-free	320	401	290	364	282	353	256	320	9	11	35	44
Standard	60	76	53	67	51	64	46	58	2	2	7	8
Second	85	107	85	107	59	74	17	22	26	33	68	86
ALL	**465**	**584**	**428**	**538**	**392**	**491**	**319**	**400**	**37**	**46**	**110**	**138**
Indices	*100*	*100*	*92*	*92*	*84*	*84*	*69*	*68*				
Freezers												
Frost-free	55	69	51	64	49	62	47	58	0	0	4	5
Standard	99	124	95	119	83	105	75	94	11	15	20	25
ALL	**154**	**193**	**146**	**183**	**132**	**167**	**122**	**152**	**11**	**15**	**24**	**30**
Indices	*100*	*100*	*95*	*95*	*86*	*87*	*79*	*79*				
Air Conditioners												
Central	0	882	0	874	0	794	0	614	0	80	0	259
Room	0	309	0	301	0	283	0	241	0	18	0	61
ALL	**0**	**1191**	**0**	**1175**	**0**	**1077**	**0**	**855**	**0**	**98**	**0**	**320**
Indices	*100*	*100*	*0*	*99*	*0*	*90*	*0*	*72*				
Lighting												
General	674	175	649	168	335	87	164	42	314	82	484	126
Outdoor	53	0	53	0	29	0	11	0	24	0	43	0
ALL	**727**	**175**	**702**	**168**	**364**	**87**	**175**	**42**	**338**	**82**	**527**	**126**
Indices	*100*	*100*	*97*	*96*	*50*	*50*	*24*	*24*				
Space Heating												
Existing EHH	171	0	171	0	133	0	96	0	38	0	74	0
New EHH	53	0	87	0	39	0	35	0	48	0	52	0
Furnace Fans	610	0	552	0	497	0	471	0	57	0	82	0
ALL	**834**	**0**	**810**	**0**	**669**	**0**	**602**	**0**	**143**	**0**	**208**	**0**
Indices	*100*	*100*	*97*	*0*	*80*	*0*	*72*	*0*				
Water Heating												
Water	329	258	322	253	227	179	87	68	95	75	236	185
ALL	**329**	**258**	**322**	**253**	**227**	**179**	**87**	**68**	**95**	**75**	**236**	**185**
Indices	*100*	*100*	*98*	*98*	*69*	*69*	*26*	*26*				
TOTAL	**2509**	**2401**	**2408**	**2317**	**1784**	**2001**	**1305**	**1517**	**624**	**316**	**1105**	**799**
Indices	*100*	*100*	*96*	*97*	*71*	*83*	*52*	*63*				

Table A-11. Summary of Peak Power results, Consumers Power, 1995 *(totals may not add due to rounding)*

End-Use	Frozen Efficiency		MEOS Forecast		Program Scenario		Technical Potential		Yearly Savings Over MEOS: Program		Yearly Savings Over MEOS: Technical	
	Winter MW	*Summer MW*	*Winter MW*	*Summer MW*	*Winter MW*	*Summer MW*	*Winter MW*	*Summer MW*	*Winter MW*	*Summer MW*	*Winter MW*	*Summer MW*
Refrigerators & Refrig./Freezers												
Frost-free	132	165	118	148	114	143	102	128	4	5	16	20
Standard	30	38	27	34	26	33	24	30	1	1	3	3
Second	34	43	34	43	23	29	7	9	10	13	27	34
ALL	**196**	**246**	**179**	**225**	**163**	**205**	**133**	**167**	**15**	**19**	**46**	**57**
Indices	*100*	*100*	*91*	*91*	*83*	*83*	*68*	*68*				
Freezers												
Frost-free	30	38	28	35	27	34	26	32	0	0	2	3
Standard	51	64	49	62	43	54	39	48	6	8	11	13
ALL	**81**	**102**	**77**	**97**	**70**	**88**	**65**	**80**	**6**	**8**	**13**	**16**
Indices	*100*	*100*	*95*	*95*	*86*	*86*	*80*	*78*				
Air Conditioners												
Central	0	206	0	204	0	186	0	146	0	18	0	58
Room	0	102	0	100	0	95	0	84	0	5	0	17
ALL	**0**	**308**	**0**	**304**	**0**	**281**	**0**	**230**	**0**	**23**	**0**	**75**
Indices	*100*	*100*	*0*	*99*	*0*	*91*	*0*	*75*				
Lighting												
General	292	75	281	72	145	37	71	18	136	35	210	54
Outdoor	18	0	18	0	10	0	4	0	8	0	15	0
ALL	**310**	**75**	**299**	**72**	**155**	**37**	**75**	**18**	**144**	**35**	**225**	**54**
Indices	*100*	*100*	*96*	*96*	*50*	*49*	*24*	*24*				
Space Heating												
Existing EHH	101	0	101	0	79	0	58	0	22	0	43	0
New EHH	32	0	53	0	25	0	22	0	28	0	31	0
Furnace Fans	261	0	236	0	219	0	205	0	18	0	31	0
ALL	**394**	**0**	**390**	**0**	**323**	**0**	**285**	**0**	**68**	**0**	**105**	**0**
Indices	*100*	*100*	*99*	*0*	*82*	*0*	*72*	*0*				
Water Heating												
Water	239	195	234	191	167	137	64	52	67	55	171	139
ALL	**239**	**195**	**234**	**191**	**167**	**137**	**64**	**52**	**67**	**55**	**171**	**139**
Indices	*100*	*100*	*98*	*98*	*70*	*70*	*27*	*27*				
TOTAL	**1220**	**926**	**1179**	**889**	**878**	**748**	**622**	**547**	**300**	**140**	**560**	**341**
Indices	*100*	*100*	*97*	*96*	*72*	*81*	*51*	*59*				

Table A-12. Summary of Peak Power results,
Detroit Edison, 1995 *(totals may not add due to rounding)*

End-Use	Frozen Efficiency		MEOS Forecast		Program Scenario		Technical Potential		Yearly Savings Over MEOS Program		Yearly Savings Over MEOS Technical	
	Winter MW	*Summer MW*	*Winter MW*	*Summer MW*	*Winter MW*	*Summer MW*	*Winter MW*	*Summer MW*	*Winter MW*	*Summer MW*	*Winter MW*	*Summer MW*
Refrigerators & Refrig./Freezers												
Frost-free	188	236	172	216	168	210	154	192	5	6	19	24
Standard	30	38	26	33	25	31	22	28	1	1	4	5
Second	51	64	51	64	36	45	10	13	16	20	41	52
ALL	**269**	**338**	**249**	**313**	**229**	**286**	**186**	**233**	**22**	**27**	**64**	**81**
Indices	*100*	*100*	*93*	*93*	*85*	*85*	*69*	*69*				
Freezers												
Frost-free	25	31	23	29	22	28	21	26	0	0	2	2
Standard	48	60	46	57	40	51	36	46	5	7	9	12
ALL	**73**	**91**	**69**	**86**	**62**	**79**	**57**	**72**	**5**	**7**	**11**	**14**
Indices	*100*	*100*	*95*	*95*	*85*	*87*	*78*	*79*				
Air Conditioners												
Central	0	676	0	670	0	608	0	468	0	62	0	201
Room	0	207	0	201	0	188	0	157	0	13	0	44
ALL	**0**	**883**	**0**	**871**	**0**	**796**	**0**	**625**	**0**	**75**	**0**	**245**
Indices	*100*	*100*	*0*	*99*	*0*	*90*	*0*	*71*				
Lighting												
General	382	100	368	96	190	50	93	24	178	47	274	72
Outdoor	35	0	35	0	19	0	7	0	16	0	28	0
ALL	**417**	**100**	**403**	**96**	**209**	**50**	**100**	**24**	**194**	**47**	**302**	**72**
Indices	*100*	*100*	*97*	*96*	*50*	*50*	*24*	*24*				
Space Heating												
Existing EHH	70	0	70	0	54	0	38	0	16	0	31	0
New EHH	21	0	34	0	14	0	13	0	20	0	21	0
Furnace Fans	349	0	316	0	278	0	266	0	39	0	51	0
ALL	**440**	**0**	**420**	**0**	**346**	**0**	**317**	**0**	**75**	**0**	**103**	**0**
Indices	*100*	*100*	*95*	*0*	*79*	*0*	*72*	*0*				
Water Heating												
Water	90	63	88	62	60	42	23	16	28	20	65	46
ALL	**90**	**63**	**88**	**62**	**60**	**42**	**23**	**16**	**28**	**20**	**65**	**46**
Indices	*100*	*100*	*98*	*98*	*67*	*67*	*26*	*25*				
TOTAL	**1289**	**1475**	**1229**	**1428**	**906**	**1253**	**683**	**970**	**324**	**176**	**545**	**458**
Indices	*100*	*100*	*95*	*97*	*70*	*85*	*53*	*66*				

Table A-13. Summary of Peak Power results,
Consumers Power and Detroit Edison Service Territories, 2005 *(totals may not add due to rounding)*

End-Use	Frozen Efficiency Winter MW	Frozen Efficiency Summer MW	MEOS Forecast Winter MW	MEOS Forecast Summer MW	Program Scenario Winter MW	Program Scenario Summer MW	Technical Potential Winter MW	Technical Potential Summer MW	Yearly Savings Over MEOS: Program Winter MW	Yearly Savings Over MEOS: Program Summer MW	Yearly Savings Over MEOS: Technical Winter MW	Yearly Savings Over MEOS: Technical Summer MW
Refrigerators & Refrig./Freezers												
Frost-free	336	420	271	340	231	289	158	197	40	50	113	141
Standard	59	75	48	61	43	53	33	42	6	7	15	18
Second	77	96	75	94	51	65	15	19	24	31	60	76
ALL	**472**	**591**	**394**	**495**	**325**	**407**	**206**	**258**	**70**	**88**	**188**	**235**
Indices	*100*	*100*	*83*	*84*	*69*	*69*	*44*	*44*				
Freezers												
Frost-free	58	73	45	57	43	53	35	44	2	2	10	12
Standard	103	129	93	117	75	95	59	75	18	22	34	42
ALL	**161**	**202**	**138**	**174**	**118**	**148**	**94**	**119**	**20**	**24**	**44**	**54**
Indices	*100*	*100*	*86*	*86*	*73*	*73*	*58*	*59*				
Air Conditioners												
Central	0	890	0	868	0	736	0	467	0	132	0	401
Room	0	324	0	297	0	282	0	211	0	15	0	85
ALL	**0**	**1214**	**0**	**1165**	**0**	**1018**	**0**	**678**	**0**	**147**	**0**	**486**
Indices	*100*	*100*	*0*	*96*	*0*	*84*	*0*	*56*				
Lighting												
General	727	189	676	176	361	94	178	46	314	82	498	130
Outdoor	59	0	59	0	32	0	12	0	26	0	48	0
ALL	**786**	**189**	**735**	**176**	**393**	**94**	**190**	**46**	**340**	**82**	**546**	**130**
Indices	*100*	*100*	*94*	*93*	*50*	*50*	*24*	*24*				
Space Heating												
Existing EHH	147	0	147	0	100	0	73	0	48	0	74	0
New EHH	99	0	166	0	67	0	63	0	99	0	102	0
Furnace Fans	662	0	548	0	426	0	372	0	121	0	176	0
ALL	**908**	**0**	**861**	**0**	**593**	**0**	**508**	**0**	**268**	**0**	**352**	**0**
Indices	*100*	*100*	*95*	*0*	*65*	*0*	*56*	*0*				
Water Heating												
Water	325	255	311	244	175	138	54	43	136	106	257	201
ALL	**325**	**255**	**311**	**244**	**175**	**138**	**54**	**43**	**136**	**106**	**257**	**201**
Indices	*100*	*100*	*96*	*96*	*54*	*54*	*17*	*17*				
TOTAL	**2652**	**2451**	**2439**	**2254**	**1604**	**1805**	**1052**	**1144**	**834**	**447**	**1307**	**1106**
Indices	*100*	*100*	*92*	*92*	*60*	*74*	*40*	*47*				

Table A-14. Summary of Peak Power results, Consumers Power, 2005 *(totals may not add due to rounding)*

End-Use	Frozen Efficiency		MEOS Forecast		Program Scenario		Technical Potential		Yearly Savings Over MEOS: Program		Yearly Savings Over MEOS: Technical	
	Winter MW	*Summer MW*	*Winter MW*	*Summer MW*	*Winter MW*	*Summer MW*	*Winter MW*	*Summer MW*	*Winter MW*	*Summer MW*	*Winter MW*	*Summer MW*
Refrigerators & Refrig./Freezers												
Frost-free	140	175	113	142	97	121	67	83	16	20	46	58
Standard	29	37	24	30	21	26	16	20	3	4	8	9
Second	32	40	31	39	21	27	6	8	10	13	25	32
ALL	**201**	**252**	**168**	**211**	**139**	**174**	**89**	**111**	**29**	**37**	**79**	**99**
Indices	*100*	*100*	*84*	*84*	*69*	*69*	*44*	*44*				
Freezers												
Frost-free	33	41	25	32	24	30	20	25	1	1	6	7
Standard	52	65	47	59	38	48	30	38	9	11	17	21
ALL	**85**	**106**	**72**	**91**	**62**	**78**	**50**	**63**	**10**	**12**	**23**	**28**
Indices	*100*	*100*	*85*	*86*	*73*	*74*	*59*	*59*				
Air Conditioners												
Central	0	217	0	212	0	180	0	114	0	32	0	98
Room	0	107	0	98	0	93	0	70	0	5	0	28
ALL	**0**	**324**	**0**	**310**	**0**	**273**	**0**	**184**	**0**	**37**	**0**	**126**
Indices	*100*	*100*	*0*	*96*	*0*	*84*	*0*	*57*				
Lighting												
General	315	81	293	76	157	40	77	20	136	35	216	56
Outdoor	21	0	21	0	11	0	4	0	9	0	17	0
ALL	**336**	**81**	**314**	**76**	**168**	**40**	**81**	**20**	**145**	**35**	**233**	**56**
Indices	*100*	*100*	*93*	*94*	*50*	*49*	*24*	*25*				
Space Heating												
Existing EHH	89	0	89	0	62	0	46	0	28	0	43	0
New EHH	62	0	104	0	43	0	40	0	61	0	63	0
Furnace Fans	285	0	236	0	196	0	168	0	39	0	68	0
ALL	**436**	**0**	**429**	**0**	**301**	**0**	**254**	**0**	**128**	**0**	**174**	**0**
Indices	*100*	*100*	*98*	*0*	*69*	*0*	*58*	*0*				
Water Heating												
Water	235	192	225	184	129	106	40	33	96	78	185	151
ALL	**235**	**192**	**225**	**184**	**129**	**106**	**40**	**33**	**96**	**78**	**185**	**151**
Indices	*100*	*100*	*96*	*96*	*55*	*55*	*17*	*17*				
TOTAL	**1293**	**955**	**1208**	**872**	**799**	**671**	**514**	**411**	**408**	**199**	**694**	**460**
Indices	*100*	*100*	*93*	*91*	*62*	*70*	*40*	*43*				

Table A-15. Summary of Peak Power results,
Detroit Edison, 2005 *(totals may not add due to rounding)*

End-Use	Frozen Efficiency		MEOS Forecast		Program Scenario		Technical Potential		Yearly Savings Over MEOS Program		Yearly Savings Over MEOS Technical	
	Winter MW	*Summer MW*	*Winter MW*	*Summer MW*	*Winter MW*	*Summer MW*	*Winter MW*	*Summer MW*	*Winter MW*	*Summer MW*	*Winter MW*	*Summer MW*
Refrigerators & Refrig./Freezers												
Frost-free	196	245	158	198	134	168	91	114	24	30	67	83
Standard	30	38	24	31	22	27	17	22	3	3	7	9
Second	45	56	44	55	30	38	9	11	14	18	35	44
ALL	**271**	**339**	**226**	**284**	**186**	**233**	**117**	**147**	**41**	**51**	**109**	**136**
Indices	*100*	*100*	*83*	*84*	*69*	*69*	*43*	*43*				
Freezers												
Frost-free	25	32	20	25	19	23	15	19	1	1	4	5
Standard	51	64	46	58	37	47	29	37	9	11	17	21
ALL	**76**	**96**	**66**	**83**	**56**	**70**	**44**	**56**	**10**	**12**	**21**	**26**
Indices	*100*	*100*	*87*	*86*	*74*	*73*	*58*	*58*				
Air Conditioners												
Central	0	673	0	656	0	556	0	353	0	100	0	303
Room	0	217	0	199	0	189	0	141	0	10	0	57
ALL	**0**	**890**	**0**	**855**	**0**	**745**	**0**	**494**	**0**	**110**	**0**	**360**
Indices	*100*	*100*	*0*	*96*	*0*	*84*	*0*	*56*				
Lighting												
General	412	108	383	100	204	54	101	26	178	47	282	74
Outdoor	38	0	38	0	21	0	8	0	17	0	31	0
ALL	**450**	**108**	**421**	**100**	**225**	**54**	**109**	**26**	**195**	**47**	**313**	**74**
Indices	*100*	*100*	*94*	*93*	*50*	*50*	*24*	*24*				
Space Heating												
Existing EHH	58	0	58	0	38	0	27	0	20	0	31	0
New EHH	37	0	62	0	24	0	23	0	38	0	39	0
Furnace Fans	377	0	312	0	230	0	204	0	82	0	108	0
ALL	**472**	**0**	**432**	**0**	**292**	**0**	**254**	**0**	**140**	**0**	**178**	**0**
Indices	*100*	*100*	*92*	*0*	*62*	*0*	*54*	*0*				
Water Heating												
Water	90	63	86	60	46	32	14	10	40	28	72	50
ALL	**90**	**63**	**86**	**60**	**46**	**32**	**14**	**10**	**40**	**28**	**72**	**50**
Indices	*100*	*100*	*96*	*95*	*51*	*51*	*16*	*16*				
TOTAL	**1359**	**1496**	**1231**	**1382**	**805**	**1134**	**538**	**733**	**426**	**248**	**693**	**646**
Indices	*100*	*100*	*91*	*92*	*59*	*76*	*40*	*49*				

Table A-16. Summary of Dispatchable Demand-Side Options: Technical Performance and Cost Effectiveness

STRATEGY	PARTICIPANTS	LOAD SHIFT (MW)	CAPITAL COST ($1985/kW)	$CCPP_{20}$,3% ($1985/kW)	$CCPP_{20}$,7% ($1985/kW)
Demand Subscription					
Consumers Power (base case)	78,261	216	51	**266**	203
Detroit Edison (base case)	153,541	423	51	**266**	203
Thermal Storage—SF homes only, 53%					
Consumers Power (base case)	27,030	134	815	**981**	933
Detroit Edison (base case)	13,780	68	815	**981**	933
Water Heater Interruption					
Consumers Power (base case)	59,619	34	151	**928**	704
Detroit Edison (base case)	89,897	52	151	**928**	704
Air Conditioner Load Shedding					
Consumers Power (base case)	64,799	128	44	**270**	203
Detroit Edison (base case)	73,943	180	36	**219**	164
Case I: 20 minute cycling periods					
Consumers Power	111,000	73	132	**809**	614
Detroit Edison	221,000	180	107	**656**	498
Case II: 40 minute cycling periods					
Consumers Power	97,198	128	66	**404**	307
Detroit Edison	110,970	180	54	**328**	249

Table A-17. Summary of Cumulative Program and Investment Costs, Consumers Power and Detroit Edison Service Territories, 1995 and 2005. *(totals may not add due to rounding)*

End-Use	Scenario Program Costs								Technical Potential	
	$million		Index		3% Discount		7% Discount		$million	
	1995	*2005*	*1995*	*2005*	*1995*	*2005*	*1995*	*2005*	*1995*	*2005*
Refrigerators & Refrig./Freezers										
Frost-free	33.55	89.04	5	9	26.31	63.99	19.3	42.26	118.9	421.29
Standard	9.47	13.43	1	1	7.52	10.17	5.59	7.17	40.28	103.27
Second	11.88	32.1	2	3	9.64	22.43	7.38	14.55	29.16	70.17
ALL	**54.9**	**134.57**	**8**	**14**	**43.47**	**96.59**	**32.27**	**63.98**	**188.34**	**594.73**
Freezers										
Frost-free	3.13	9.18	0	1	2.43	6.54	1.76	4.26	15.94	56.76
Standard	13.29	34.55	2	3	10.34	24.11	7.5	15.48	69.85	145.43
ALL	**16.42**	**43.73**	**2**	**4**	**12.77**	**30.65**	**9.26**	**19.74**	**85.79**	**202.19**
Air Conditioners										
Central	0	0	0	0	0	0	0	0	690.76	1504.21
Room	0	0	0	0	0	0	0	0	73.75	159.3
ALL	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**764.51**	**1663.51**
Lighting										
General	418.49	564.53	63	57	338.24	437.75	258.03	318.88	640.72	691.04
Outdoor	6.9	7.2	1	1	5.61	5.61	4.31	4.31	8.1	8.8
ALL	**425.39**	**571.73**	**64**	**58**	**343.85**	**443.36**	**262.34**	**323.19**	**648.82**	**699.84**
Space Heating										
Existing EHH	110.97	142.27	17	14	90.73	113.01	70.39	84.77	176.06	176.06
New EHH	2.6	3.6	0	0	2.26	2.89	1.89	2.25	80.87	173.64
Furnace Fans	0	0	0	0	0	0	0	0	0	0
ALL	**113.57**	**145.87**	**17**	**15**	**92.99**	**115.9**	**72.28**	**87.02**	**256.93**	**349.7**
Water Heating										
Water	56.44	96.58	8	10	45.85	72.7	35.27	51.33	433.26	695.61
ALL	**56.44**	**96.58**	**8**	**10**	**45.85**	**72.7**	**35.27**	**51.33**	**433.26**	**695.61**
TOTAL	**666.72**	**992.48**	**100**	**100**	**538.93**	**759.2**	**411.42**	**545.26**	**2377.65**	**4205.58**

Table A-18. Summary of Cumulative Program and Investment Costs, Consumers Power, 1995 and 2005 *(totals may not add due to rounding)*

End-Use	Scenario Program Costs $million 1995	$million 2005	Index 1995	Index 2005	3% Discount 1995	3% Discount 2005	7% Discount 1995	7% Discount 2005	Technical Potential $million 1995	Technical Potential $million 2005
Refrigerators & Refrig./Freezers										
Frost-free	15.72	36.75	5	7	12.31	26.65	9	17.79	55.13	172.17
Standard	3.76	6.28	1	1	2.99	4.66	2.22	3.21	16.52	53.72
Second	4.78	13.28	1	3	3.88	9.24	2.96	5.96	11.54	28.78
ALL	**24.26**	**56.31**	**7**	**11**	**19.18**	**40.55**	**14.18**	**26.96**	**83.19**	**254.67**
Freezers										
Frost-free	1.61	4.74	0	1	1.25	3.37	0.91	2.18	8.54	31.45
Standard	7.07	16.41	2	3	5.51	11.72	4	7.73	37.38	72.06
ALL	**8.68**	**21.15**	**3**	**4**	**6.76**	**15.09**	**4.91**	**9.91**	**45.92**	**103.51**
Air Conditioners										
Central	0.00	0.00	0	0	0	0	0	0	179.09	427.70
Room	0.00	0.00	0	0	0	0	0	0	22.16	55.12
ALL	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**201.25**	**482.82**
Lighting										
General	180.69	243.92	54	49	146.04	189.13	111.4	137.76	277.42	299.46
Outdoor	2.3	2.4	1	0	1.79	1.79	1.37	1.37	2.7	3.0
ALL	**182.99**	**246.32**	**55**	**50**	**147.83**	**190.92**	**112.77**	**139.13**	**280.12**	**302.46**
Space Heating										
Existing EHH	75.81	97.19	23	20	61.98	77.2	48.08	57.91	120.27	120.27
New EHH	1.30	1.80	0	0	1.13	1.45	0.94	1.12	53.71	122.46
Furnace Fans	0.00	0.00	0	0	0	0	0	0	0.00	0.00
ALL	**77.11**	**98.99**	**23**	**20**	**63.11**	**78.65**	**49.02**	**59.03**	**173.98**	**242.73**
Water Heating										
Water	40.92	70.05	12	14	33.24	52.73	25.57	37.23	314.04	504.24
ALL	**40.92**	**70.05**	**12**	**14**	**33.24**	**52.73**	**25.57**	**37.23**	**314.04**	**504.24**
TOTAL	**333.96**	**492.82**	**100**	**100**	**270.12**	**377.94**	**206.45**	**272.26**	**1098.5**	**1890.43**

Table A-19. Summary of Cumulative Program and Investment Costs, Detroit Edison, 1995 and 2005 *(totals may not add due to rounding)*

End-Use	Scenario Program Costs								Technical Potential $million	
	$million		Index		3% Discount		7% Discount			
	1995	*2005*	*1995*	*2005*	*1995*	*2005*	*1995*	*2005*	*1995*	*2005*
Refrigerators & Refrig./Freezers										
Frost-free	17.83	52.29	5	10	14.01	37.35	10.3	24.47	63.77	249.12
Standard	5.71	7.15	2	1	4.53	5.51	3.37	3.96	23.76	49.55
Second	7.10	18.82	2	4	5.76	13.19	4.41	8.59	17.62	41.39
ALL	**30.64**	**78.26**	**9**	**16**	**24.3**	**56.05**	**18.08**	**37.02**	**105.15**	**340.06**
Freezers										
Frost-free	1.52	4.44	0	1	1.18	3.18	0.85	2.07	7.40	25.31
Standard	6.22	18.14	2	4	4.83	12.39	3.5	7.75	32.47	73.37
ALL	**7.74**	**22.58**	**2**	**5**	**6.01**	**15.57**	**4.35**	**9.82**	**39.87**	**98.68**
Air Conditioners										
Central	0.00	0.00	0	0	0	0	0	0	511.67	1076.51
Room	0.00	0.00	0	0	0	0	0	0	51.59	104.18
ALL	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**563.26**	**1180.69**
Lighting										
General	237.80	320.61	71	64	192.2	248.62	146.63	181.12	363.30	391.58
Outdoor	4.6	4.8	1	1	3.82	3.82	2.94	2.94	5.4	5.8
ALL	**242.4**	**325.41**	**73**	**65**	**196.02**	**252.44**	**149.57**	**184.06**	**368.7**	**397.38**
Space Heating										
Existing EHH	35.16	45.08	11	9	28.75	35.81	22.31	26.87	55.79	55.79
New EHH	1.30	1.80	0	0	1.13	1.45	0.94	1.12	27.16	51.18
Furnace Fans	0.00	0.00	0	0	0	0	0	0	0.00	0.00
ALL	**36.46**	**46.88**	**11**	**9**	**29.88**	**37.26**	**23.25**	**27.99**	**82.95**	**106.97**
Water Heating										
Water	15.52	26.53	5	5	12.61	19.97	9.7	14.11	119.22	191.37
ALL	**15.52**	**26.53**	**5**	**5**	**12.61**	**19.97**	**9.7**	**14.11**	**119.22**	**191.37**
TOTAL	**332.76**	**499.66**	**100**	**100**	**268.82**	**381.29**	**204.95**	**273**	**1279.15**	**2315.15**

Table A-20 Macro Supply Curve of Annual Electricity Savings by Block, Consumer's Power and Detroit Edison Territories, Year 2005: 3% Discount Rate

End-Use/ DS-Measure	Annual Savings over MEOS (GWh) Block 1 0-3¢	Block 2 3-4¢	Block 3 >4¢	All-Ratepayer Cost of Conserved Energy ¢/kWh	Rank
1. Refrigerators					
a. Std. 1992/low tech.			51	6.7	16
b. Frost-free 1992 Std.	189			1.8	7
c. Frost-free low tech.		149		3.0	11
d. 2nd units	226			1.5	6
e. Low-income progr.			38	8.2	18
2.Freezers					
a. Manual low tech.		162		3.4	12
b. Auto-defrost low tech.	20			2.2	8
3. Air Cond.	114			0.0	1
4. Lighting	1123			1.1	5
5. Space Heating					
a. Exist. EHH, Block 1	64			2.7	10
b. Exist. EHH, Block 3			37	6.0	14
b. New Houses, Block 1	83			2.3	9
c. New Houses, Block 3		124		7.5	17
d. Furnace fans	173			0.0	2
6. Water Heating					
a. Temp. setback	191			0.0	3
b. Hi-eff. showers & faucets	385			0.3	4
c. Clothes washers		112		3.5	13
d. Eff. water heaters			168	6.3	15
Total	2568	423	418		
Percent of savings	75.3%	12.4%	12.3%		
Average CCE					
Block 1				1.1	
Block 2				3.3	
Block 3				6.8	
All Blocks				2.0	

Table A-21 Macro Supply Curve of Annual Electricity Savings by Block, Consumer's Power and Detroit Edison Territories, Year 2005: 7% Discount Rate

End-Use/ DS-Measure	Annual Savings over MEOS (GWh) Block 1 0-3¢	Block 2 3-4¢	Block 3 >4¢	All-Ratepayer Cost of Conserved Energy ¢/kWh	Rank
1. Refrigerators					
a. Std. 1992/low tech.			51	9.3	17
b. Frost-free 1992 Std.	189			2.5	8
c. Frost-free low tech.			149	4.1	12
d. 2nd units	226			1.7	5
e. Low-income progr.			38	11.3	19
2.Freezers					
a. Manual low tech.			162	4.9	14
b. Auto-defrost low tech.		20		3.1	9
3. Air Cond.	114			0.0	1
4. Lighting	1123			1.9	6
5. Space Heating					
a. Exist. EHH, Block 1	13			2.3	7
b. Exist. EHH, Block 2		52		4.0	11
c. Exist. EHH, Block 3			36	9.5	18
d. New EHH, Block 2		83		3.7	10
e. New EHH, Block 3			124	11.9	20
f. Furnace fans	173			0.0	2
6. Water Heating					
a. Temp. setback	191			0.0	3
b. Hi-eff. showers & faucets	385			0.3	4
c. Clothes washers			112	4.5	13
d. Eff. water heaters			168	8.0	16
Total	2414 70.8%	155 4.5%	840 24.7%		
Average CCE					
Block 1				1.4	
Block 2				3.7	
Block 3				7.1	
All Blocks				2.9	

APPENDIX B

INCENTIVES PROGRAM SUMMARY SHEETS

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INCENTIVES PROGRAM SUMMARY SHEET

More Efficient Refrigerators and Freezers

MEOS/AHAM forecast:
Efficiencies reach approximately the 1990 federal "consensus" standards level.

LBL Program-based scenario:

Program description:
Purchasers of new refrigerators and freezers are given rebates for buying units that significantly exceed the efficiency level of the 1990 federal "consensus" standards. Low income households are offered high efficiency refrigerators for the cost of inefficient used models usually purchased by these households.

Program impact:
New units sold under the program incorporate, on average, 80 percent of the efficiency improvement offered by best available models relative to the standard.

Program phases and timing:
Field tests and pilot programs are conducted in 1988-90. The program is operated at a moderate scale in 1991-94 to allow for 1990 standards to reach their full impact. A full-scale program begins in 1995 and goes to 2000. After 2000, new purchase patterns and related savings are maintained through an ongoing information and promotion campaign without further rebates.

Eligible fraction:
All new purchases could be shifted.

Annual program penetration:

high	40 percent of sales
low	20 percent of sales
point value	30 percent of sales

Incentive level:
Rebates increase over time, matching approximately 100 percent of the additional first cost of eligible models. Maximum rebates are:

auto defrost refrigerators	$130/unit
manual refrigerators	$120/unit
freezers	$150/unit

In the low-income program, which accounts for 10 percent of all participants, rebates average four times the level for the other 90 percent of participants. The weighted average rebate index is then 1.3.

Administration costs:
Program administration, promotion, etc. decreases over time, from $15 to $7 per unit.

Free riders:
We estimate that under the MEOS forecast, 3 percent of customers would buy models of very high efficiency, compared to the 30 percent of customers who do so under the program scenario. The free rider fraction is thus 10 percent.

Calculation of annual energy savings:
$= (\#\ of\ annual\ purchases)\,(penetration\ fraction)\,(savings\ per\ unit)$

Calculation of annual program costs:
$= (\#\ of\ annual\ purchases)\,(\frac{rebate + administration\ costs}{unit})\,(free\ rider\ correction)\,(low\ income\ correction)$
$= purchases\ (\frac{\$}{unit})\ \frac{10}{9}\cdot 1.3$

Technical potential/best available technology scenario:
This scenario assumes 100 percent shift of sales to the full best available technology level. Annual savings over the 1990-standard based UECs are up to $\frac{1}{0.3}\cdot\frac{1}{0.8} = 4.17$ times larger than in the program-based scenario.

INCENTIVES PROGRAM SUMMARY SHEET

Second Refrigerators

MEOS/AHAM forecast:
Second units have an average life of six years.

LBL Program-based scenario:

Program description:
A bounty is offered for second refrigerators through participating charities and dealers.

Program impact:
The program cuts the saturation of second refrigerators in half.

Program phases and timing:
The program is begun in 1988 and reaches full scale in 1991. It is operated in the same mode until 2005.

Eligible fraction:
All units that are not kept for regular use (an estimated 80-90 percent of all second refrigerators) are considered eligible for the program.

Annual program penetration:
The net effect is to eliminate:

high	50 percent of annual stock
low	30 percent of annual stock
point value	40 percent of annual stock

Assuming the point value, the program removes fifty percent of annual stocks, or about 56-63 percent of all eligible second units. Of these 50 percent of stocks, 80 percent are destroyed, the rest resold, with a net removal of 40 percent.

Rebate level:
A bounty of $25 is paid to the customer. The charity gets $5 for picking up the unit, and another $20 for destroying the unit. The average rebate, given that eighty percent are destroyed, is $46 per unit.

Administration costs:
Program administration, promotion, etc. costs $15 per unit in 1991, and $7 per unit in 1995.

Free riders:
We estimate that in absence of the program (MEOS forecast), only 5 percent of all customers or less would donate their second units to the charities, compared to 50 percent under the program. The free rider fraction is thus 10 percent.

Calculation of annual energy savings:

$$= (\textit{stock of second})(\textit{penetration rate})(\textit{average UEC per unit})$$

Calculation of annual program costs:

$$= (\textit{new second units})\left(\frac{\textit{rebate} + \textit{administration costs}}{\textit{unit}}\right)(\textit{free rider correction})$$

$$= (\textit{new stock})\left(\frac{\$}{\textit{unit}}\right)\frac{10}{9}$$

Technical potential/best technology scenario:
In this scenario, the saturation of second refrigerators is cut by 80 percent. Savings from going to this lower limit of eligible units are twice as large as those under the program scenario.

INCENTIVES PROGRAM SUMMARY SHEET

More Efficient General and Outdoor Lighting

MEOS/AHAM forecast:
Lighting efficiencies increase by 7.5 percent between 1985 and 2005, due to a ten percent penetration of fluorescent light bulbs.

Program-based scenario:

Program description:
Efficient light bulbs are aggressively promoted using several techniques: give-aways through door-to-door canvassing, trade-ins, and coupons offering efficient bulbs at the cost of incandescents. The average household receives 8 compact fluorescents and two to three heat mirror bulbs.

Program impact:
Indoor sockets operating more than 200 hours per year are fitted with compact fluorescents, saving 75 percent of consumption per socket, or 60% of indoor lighting consumption. Outdoor lighting and porch sockets are fitted with heat mirror bulbs saving 50 percent over incandescents.

Program phases and timing:
Field tests and pilot programs are conducted in 1988-89. The program is operated aggressively in 1991-94, with large penetrations achieved through both rebates and exchanges for new purchases and targeted retrofits through give-aways. Thereafter, a maintenance mode is achieved that focuses on maintaining the prevalence of efficient bulbs among existing and new households through promotion and customer information. No program is operated after the year 2000.

Eligible fraction:
Virtually 100 percent of all households are eligible for full high efficiency relamping.

Maximum penetration fraction:
The maximum fraction of households that can be reached by the program between 1988 and 2005 is assumed to be

high	100 percent
low	80 percent
point value	90 percent

Within each participating household, all outdoor sockets and about half of all indoor sockets are changed over. These indoor sockets currently use about 80% of indoor lighting consumption.

Annual program penetration rates:
In the program scenario, penetration rates rise from 1.8 percent per year in 1988 to 18 percent per year in 1991. Between 1991 and 1994, a steady state penetration rate of 18 percent is maintained. By 1995, the maximum penetration of 90 percent of all households has been reached. Subsequent program impacts maintain the 90 percent penetration for a slowly growing number of households.

Incentive level:
Rebates and other forms of incentives cover the full cost of efficient light bulbs. The incentive cost is \$105 for the initial set of general lighting (indoor plus porch light) bulbs, and \$5 (CP) to \$10 (DE) for the initial set of outdoor lighting bulbs. Annual maintenance costs are $(12\ months/7\ months)\ \$4 \approx \$7$ for porch lights, and \$7 (CP) and \$14 (DE) for outdoor sockets.

Administration costs:
Program administration, promotion, etc. cost \$10 per participating household.

Free riders:
In the MEOS forecast, about 5 percent of indoor lighting would be from efficient light bulbs in 1995. In the program-based scenario, 90 percent of households will have switched 80 percent of their incandescent consumption to efficient light bulbs by that year, equivalent to 72 percent of all lighting use. The free-rider fraction is thus 7 percent.

Calculation of annual energy savings:
For 1995 and after, the savings are calculated as follows:

$$= (\#\ of\ households)\ (penetration\ fraction)$$
$$\times ((UEC\ of\ porch\ lights)\ (savings) + (UEC\ of\ indoor\ lights)\ (consumption\ affected)\ (savings))$$
$$= (\#\ households)\ 0.9\ (0.5\ UEC_{porch} + UEC_{indoor}\ 0.8 \cdot 0.75)$$

Calculation of annual program costs:
For the core general lighting program in 1988-94, the calculation is:

$$= (\#\ of\ participating\ households)\ (\frac{rebate + administration\ costs}{household}) \times (free\ rider\ correction)$$
$$+ \$7 \times (number\ of\ households\ that\ participated\ up\ to\ the\ previous\ year)$$
$$= \$\,115 \times (\#\ households) \frac{100}{93} + \$\,7 \times (cumulative\ households)$$

Technical potential/best available technology scenario:
Between 1988 and 1990, all outdoor lighting is converted to high efficacy metal halide, and all indoor incandescent bulbs are converted to compact fluorescent bulbs, saving 75 percent of all electricity use for lighting. Participation among households is 100 percent.

INCENTIVES PROGRAM SUMMARY SHEET

Water-Efficient Dishwashers and Thermostat Setback

MEOS/AHAM forecast:
No thermostat setback is included in the MEOS forecast. The index of hot water consumption for new dishwashers declines by 22.8 percent between 1984 and 2005. A "behavior" function reflecting household size further reduces consumption by 10 percent between 1984 and 2005.

LBL Program-based scenario:

The same behavior function is used as in the MEOS forecast. The MEOS gains in hot water efficiency are interpreted as the product of two factors: lower temperatures and better designs. Lower hot water temperatures alone are assumed to reduce consumption by 12.5 percent to index 0.875. This index is further reduced by the effects of design changes, which add a multiplier of 0.882.

In LBL's scenario, the savings from lowered temperatures are calculated for all end-uses at once. To avoid double counting, only the 0.882 multiplier is applied in the scenario for dishwashers.

Program description:
The program promotes thermostat setback to 120°F. Among households without dishwashers, an informational campaign is coupled with inspections of participants in water heater retrofit and rebate programs.

Program impact:
No net savings over those forecast by MEOS are achieved in dishwashers, but savings do accrue in overall water heater system efficiency. The setback saves 12.5 percent of *total* water heating electricity use.

Program phases and timing:
Initially, only households without dishwashers participate. In time, dishwasher owners also set back by switching to better detergents and/or low-temperature or booster heater dishwashers.

Eligible fraction:
All households with electric water heating are eligible.

Participation rates:
Participation rates for setbacks follow those for the water heater program. By 1995, 50 percent of customers without dishwashers will have set back their thermostats. Full setback among all customers is achieved in 2005.

Incentive level:
No separate financial incentives are given for the setback, but free adjustment is offered by the utilities.

Administration costs:
No separate administration costs are calculated.

Calculation of energy savings:
For dishwashers, the hot water saving in 2005 is:

$= (\textit{\# of customers in } 2005)(\textit{penetration fraction})(\textit{MEOS hot water efficiency factor})$

$= (\textit{\# customers})\ 1.0 \cdot 0.882$

Technical potential/best available technology scenario:
This scenario assumes that all customers switch to the 120°F setback between 1988 and 1990. Savings in dishwasher hot water demand are of the same magnitude and timing as in the program scenario.

INCENTIVES PROGRAM SUMMARY SHEET

Water-Efficient Showerheads

MEOS/AHAM forecast:
Efficiency remains constant. Behavior function reflecting household size reduces consumption by 10 percent between 1984 and 2005.

LBL Program-based scenario:

The same behavior function is used as in the MEOS forecast.

Program description:
The program consists of two components. One is promulgating a modified version of the industry's ANSI norm for showerheads as a state standard. The modification requires all low-flow features to be permanent parts of the fixture. The other component is a retrofit program involving rebate coupons, canvassing and free installations and give-aways as part of an improved RCS and other programs.

Program impact:
New units sold under the standard have a maximum flow rate of 2.75 gal/min compared to 5.0 gal/min for standard units. Retrofit and coupon programs promote fixtures achieving 1.5 gal/min. On average, flow rates are reduced to 2.0 gal/min.

Program phases and timing:
Field tests and pilot programs are conducted in 1988-89. The standard becomes effective in 1990. A full-scale retrofit and rebate program begins in the same year and runs for 10 years. Maximum penetration is achieved in 2005.

Eligible fraction:
It is assumed that 10 percent of Michigan's households currently use 3.0 gal/min showerheads or flow restrictors. Savings-weighted eligibility is thus $1 - 0.1 \times \frac{2.0}{5.0} = 0.96$.

Maximum penetration fraction:
The estimated range of maximum penetration fractions is as follows:

high	100 percent of fixtures
low	80 percent of fixtures
point value	90 percent of fixtures

Penetration rates:
Annual penetration rates between 1990 and 1994 are 12 percent. By 1995, two thirds of all fixtures have been converted. These rates are achieved through both replacement sales and through retrofits in an improved and modified RCS program.

Incentive level:
The average incentive per household is assumed to be $20, equivalent to the full technology cost.

Administration costs:
The program is run as part of a larger water heater/RCS program. No separate administration costs are calculated.

Free riders:
Under the MEOS forecast, customers would buy no efficiency improvements. A free rider correction does therefore not apply.

Calculation of 2005 energy savings:

$$= (\#\ of\ \ customers)\,(eligible\ \ fraction)\,(maximum\ \ penetration\ \ fraction)\,(\frac{savings}{unit})$$

$$= (\#\ \ customers) \cdot 0.96 \cdot 0.9 \cdot 0.60$$

Calculation of annual program costs:

$$= (0.9 \times \#\ of\ \ customers)\,(annual\ \ penetration\ \ rate)\,(\frac{incentive\ \ costs}{unit})$$

Technical potential/best available technology scenario:
This scenario assumes a shift of showerhead flow rates to 1.5 gal/min in all households during 1988-1990. Savings are $= 0.96 \times 70\% = 67\%$.

INCENTIVES PROGRAM SUMMARY SHEET

Water-Efficient Faucets

MEOS/AHAM forecast:
There is no efficiency improvement in this miscellaneous category. The behavior function reflecting household size is suppressed, which implicitly increases the per capita consumption in these applications.

LBL Program-based scenario:

The same behavior function is used as in the MEOS forecast. Efficiency improvements from faucet aerators are introduced.

Program description:
The program consists of handing out and/or free installation of faucet aerators as part of the utilities' overall water heater retrofit and RCS programs.

Program impact:
The measure impacts 30 percent of miscellaneous hot water uses. Savings per household are 67 percent of these 30 percent, or 20 percent.

Eligible fraction:
It is assumed that one third of households already uses faucet aerators.

Maximum penetration fraction:
Under a mature program, the estimated range of penetration fractions is as follows:

high	90 percent of households
low	60 percent of households
point value	75 percent of households

Incentive level:
Free distribution at an estimated cost of $5 per household.

Administration costs:
The program is part of the overall water heater program. No separate administration costs are calculated.

Free riders:
Under the MEOS forecast, customers would buy no efficiency improvements. A free rider correction does therefore not apply.

Calculation of 2005 energy savings:
= (*# of customers in* 2005) (*eligible fraction*) (*maximum penetration rate*) (*savings per household*)
= (*# customers*) $0.67 \cdot 0.75 \cdot 0.20 = 10\%$

Calculation of annual program costs:
= (*# of customers*) (*annual penetration rate*) (*incentive costs per unit* ($ 5))

Technical potential/best available technology scenario:
This scenario assumes that all households retrofit aerators between 1988-90. The total savings are $67\% \times 20\% = 13.3$ percent.

INCENTIVES PROGRAM SUMMARY SHEET

Water-Efficient Clothes Washers

MEOS/AHAM forecast:
The index of electricity consumption for new machines declines by 12 percent between 1985 and 2005. A "behavior" function reflecting household size reduces consumption by about 10 percent between 1984 and 2005.

LBL Program-based scenario:

The same behavior function is used as in the MEOS forecast. The improved hot water efficiency as assumed by MEOS is attributed to better detergents. Additional savings are included from redesigned machines and cycles.

Program description:
The program promotes front-loading washing machines and improved top-loading machines and washing cycles offering comparable demand reductions. Incentives are thus not just given for one type of machine but for other designs and cycle improvements as well. Incentives take the form of rebates for new purchases that cover the full extra first cost of more efficient units. As in the refrigerator programs, special trade ally cooperation efforts generate additional dealer and manufacturer discounts that make water efficient machines cheaper than conventional units.

Program impact:
New units sold under the program save 50 percent of hot water demand over conventional units.

Program phases and timing:
Field tests and pilot programs are conducted in 1988-89. The full-scale program runs until 2002.

Eligible fraction:
All purchases of new washing machines are eligible.

Maximum penetration rate:
Under a mature program, the estimated range of penetration fractions is as follows:

high	75 percent of sales
low	30 percent of sales
point value	50 percent of 2005 stock

Annual penetration rates:
Annual penetration rates between 1990 and 2005 are based on linear interpolation.

Incentive level:
Incentives are $150, equivalent to the full technology cost of front-loading machines under current market conditions. As with refrigerators, the rebate program will move the more efficient top- and front-loading units out of their high mark-up brackets. This will reduce the required incentives, and so will manufacturer and dealer rebates. These reductions are not reflected here.

Administration costs:
The administration cost declines from initially $15 to $7 as the program matures. The average is $10/unit.

Free riders:
Under the MEOS forecast, customers would buy no efficiency improvements beyond the better detergents. A free rider correction therefore does not apply.

Calculation of annual energy savings:
For the mature program,

$$= \left(\frac{\#\ of\ customers}{washer\ lifetime}\right) (annual\ penetration\ rate) \left(\frac{savings}{unit}\right) (better\ detergent\ savings)$$

$$= (\#\ customers) \frac{1}{13}\ 0.5 \cdot 0.5\ (detergent\ savings)$$

In 2005, savings across the stock will be 50 percent.

Calculation of annual program costs:

$$= (\#\ of\ customers) (annual\ penetration\ rate) (rebate + administration\ costs\ per\ unit (\$\ 160))$$

Technical potential/best available technology scenario:
This scenario assumes a linear decrease of hot water efficiency for laundry to 20 percent of the initial value between 1988 and 2005. Savings are 80 percent in 2005.

INCENTIVES PROGRAM SUMMARY SHEET

Energy-Efficient Resistance Water Heaters

MEOS/AHAM forecast:
The forecast assumes no behavior function or efficiency improvement.

LBL Program-based scenario:

Water heater efficiencies improve due to reduced system stand-by losses from tanks and pipes.

Program description:
The program has two components. One is the introduction of the 1990 federal consensus standards (EF = 0.91). Another is a water heater retrofit and rebate program that rewards installation of best available new water heaters (EF = 0.96), i.e. units in excess of the standard's requirements. Water heater wraps of existing units are also rebated, and so are wraps of new units that do not meet the 0.96 energy factor target. Rebates cover the full increase in first costs for new units and the full cost of materials and installation for existing ones.

Program impact:
Efficiencies based on normal thermostat settings rise from 0.81 to 0.96. Energy savings under the program scenario are only 10.4 percent because thermostat setback is assumed to be done first.

Program phases and timing:
Field tests and pilot programs for the rebates on new water heaters are conducted in 1988-89. Meanwhile, past RCS-type water heater retrofit efforts, are continued with improved promotion and more aggressive outreach. The full-scale program runs until the year 2000, when all households that can be reached will have retrofitted and/or replaced their water heaters.

Eligible fraction:
The number of households with high efficiency water heaters is negligible at this time. All households with electric water heaters are eligible.

Maximum penetration rate:
Under an mature program, the estimated range of penetration fractions is as follows:

high	95 percent of households
low	70 percent of households
point value	90 percent of households

Annual penetration rates:
Annual penetration rates between 1988 and 2000 are of the order of 8-10 percent per year, based on linear interpolation with the maximum penetration fraction, which is reached at that time.

Incentive level:
Incentives are $50, equivalent to the full estimated technology cost of increasing the efficiency of units that meet the 1990 standard to 0.96.

Administration costs:
The administration cost is \$10/unit.

Free riders:
Under the MEOS forecast, customers would buy no efficiency improvements beyond the better detergents. A free rider correction does therefore not apply.

Calculation of year 2000 energy savings:
= (*# of customers*) (*maximum penetration fraction*) (*savings per unit*)
= (*#customers*) $0.90 \cdot 0.104$

Calculation of annual program costs:
= (*# of customers*) (*annual penetration rate*) (*rebate + administration costs per unit* ((\$ 60)

Technical potential/best available technology scenario:
This scenario assumes that resistance water heaters are replaced when they wear out with heat pump water heaters with efficiencies of 2.4. The savings over MEOS are thus $\frac{0.8}{2.40} = 33\%$.

INCENTIVES PROGRAM SUMMARY SHEET

Building Shell Retrofits, Existing Electrically-Heated Houses

MEOS/AHAM forecast:
No shell improvements are assumed and no behavioral changes occur.

LBL Program-based scenario:

Program description:
A special audits-plus-incentives program is conducted to promote retrofits. Average costs are about $3000 per eligible house. Building insulation levels are raised to significantly decrease the life-cycle costs of space heating. Customers receive free audits and incur no investment costs. A special outreach program is conducted among low-income customers, using such techniques as door-to-door canvassing. The entire program is led by community groups and institutions with high credibility among the customer constituents.

Program impact:
Program impacts are estimated on the basis of CIRA model runs. Runs are normalized to actual electricity consumption levels. The scenario assumes that only 80 percent of calculated electric space heating savings are achieved in practice, or 0.8 x 0.5 = 40 percent.

Program phases and timing:
Field tests and pilot programs are conducted in 1988-89. The program is operated at full scale in 1990-97 and ends thereafter.

Eligible fraction:
80 percent of existing households are eligible for retrofits.

Maximum penetration fraction:
We assume that only 80 percent of eligible customers will participate despite strong incentives.

Annual program penetration:
The range of observed participation rates in reasonably large-scale retrofit programs is given below, along with the point value used for the full-scale phase from 1990-97:

high	33 percent of eligible customers/year
low	5 percent of eligible customers/year
point value	9 percent of eligible customers/year

Incentive level:
Rebates average $2700 per house, equivalent to the full retrofit cost.

Administration costs:
Program administration, promotion, audits, etc. are $300 per house.

Free riders:
Under the MEOS forecast, no improvements are assumed in building shells. The program therefore has no free rider costs.

Calculation of annual energy savings:

$$= (\#\ of\ existing\ houses)\ (eligible\ fraction)\ (reachable\ fraction)\ (penetration\ rate)\ (\frac{savings}{unit})\ (correction\ factor)$$

$$= (\#\ existing\ houses)\ 0.8 \cdot 0.8\ (penetration\ rate)\ 0.5\ (consumption)\ 0.8$$

Calculation of annual program costs:

$$= (\#\ of\ retrofits)\ (rebate + administration\ costs\ per\ unit)$$

Technical potential/best available technology scenario:
This scenario assumes that 50 percent savings are achieved within 1988-1990 in 80 percent of existing houses.

INCENTIVES PROGRAM SUMMARY SHEET

Improved Building Shells, New Electrically-Heated Houses

MEOS/AHAM forecast:
No shell improvements are assumed and no behavioral changes occur.

LBL Program-based scenario:

Program description:
A new building standard is promulgated for new electrically heated houses. The standard implements building shell options with an average cost of less than 6 cents/kWh of conserved electricity. The standard includes ventilation systems with air-to-air heat exchangers to improve indoor air quality. Extra construction costs per home are about $3300. A mixture of prescriptive and point systems are used to implement the standard so as to allow maximum flexibility for builders. As part of the program, a house energy labeling system is established to facilitate the marketing of houses that exceed the standard.

Program impact:
Savings over current new construction practice, after accounting for deviations between engineering calculations and field practice, are 40 percent.

Program phases and timing:
The building standard is introduced in 1990.

Eligible fraction:
All new residential buildings are covered.

Maximum penetration fraction:

high	100 percent
low	90 percent
point value	95 percent

Annual program penetration:
The number of new houses is the sum of annual replacement of existing stocks plus the annual growth in the number of households. 95 percent of these residential buildings comply with the standard.

Incentive level:
No incentives are given.

Administration costs:
The cost of establishing a state-wide standard (both for electrically heated and gas-heated houses) is $2 million. Annual enforcement costs are $100,000.

Calculation of annual energy savings:
$= (\#\ of\ newly\ constructed\ houses)\,(compliance\ fraction)\,(savings\ per\ unit)$
$= (\#\ new\ houses)\, 0.95 \cdot 0.4(baselineconsumption)$

Technical potential/best available technology scenario:
This scenario assumes that the same 40 percent savings are achieved in all of newly constructed houses starting in 1988.

APPENDIX C

GLOSSARY OF TERMS

AAL. Annual average load. The unit energy consumption of an end-use device spread over 8766 hours.

UPD. Unit peak demand. The diversified demand contribution per end-use device at the hour of system peak.

UEC. Unit energy consumption. The number of kWh consumed per device per year.

Fraction-in-use. The ratio of the diversified demand per device for a specific hour, day type, and season and the average maximum non-coincident demand measured in submetering experiments, or the installed kW rating of the end-use device. Fractions-in-use are always less than one.

Hourly-to-average load ratio. The ratio of the diversified demand per device for a particular hour, day type, and season, and the average annual load of the device. This ratio can be smaller or larger than one. It is used where submetering data or rated power inputs for calculating fractions-in-use are not available.

SEER. Seasonal energy efficiency ratio. See the section on air conditioning baseload data.

CCE. Cost of conserved energy. See Vol. 2 for a definition.

CCPP20. Cost of conserved peak power, calculated over a 20-year time horizon. See Vol. 2 for a definition.

EF. Energy factor. An efficiency index used for refrigerators and water heaters. See the respective baseline sections for a definition.

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