COMPREHENSIVE ASSESSMENT OF CONSERVATION OPPORTUNITY FOR UTILITY LONG-RANGE PLANNING: CONPRO - A COMPUTER SIMULATION

Douglas L. Norland
Alliance to Save Energy

ABSTRACT

This paper presents preliminary results of a case-study with General Public Utilities to estimate the opportunity for conservation in its Pennsylvania Electric Company subsidiary. By conservation opporuntity we mean the maximum amount of electricity or capacity savings available from investment in electricity conservation and load management applications that are economic from the perspective of individual consumers or society. Over seventy-five electricity conservation alternatives (ECAs) for the residential, commercial and industrial classes were identified and evaluated across twenty-one end-uses. For the society viewpoint, the ECAs were evaluated at a single society discount rate and the utility's marginal costs. For the consumer point of view, ECAs were evaluated using customer class discount rate distributions and calculated savings in electric bills. Total conservation opportunity was estimated each year from 1985 to 2004 for each perspective and compared to the utility's energy and load forecasts. All calculations were performed using a micro-computer simulation program developed for the project called CONPRO.

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Demand Side Management (DSM) programs are increasingly being examined by utilities and state public service commissions as part of strategies to meet consumer electricity needs reliably and at least cost. Unfortunately, comprehensive analysis of conservation and load management opportunities in utility strategic planning is new to the industry and managers often lack the tools and data necessary to do the job. Some sophicated tools for such planning have been developed, but they typically require large amounts of detailed load data. The Alliance to Save Energy has developed a simple, easy-to-use computer program that is a DSM screening tool. As a screening tool, the program allows users to make basic analyses and judgements about the economics of DSM options and the impact of conservation programs.

The tool - called CONPRO for CONservation PROgram Impact Estimation Model - aids utility planners in determining how much resource expenditure on conservation and load management programs is "optimal" - or maximizes utility program goals. In a case study done by the Alliance with General Public Utilities (GPU), the goal was to find the level of expenditures on a generic rebate program targeted to all customer classes that resulted in the lowest present value of future revenue requirements over the next 20 years. CONPRO, however, can handle other specifications of utility DSM program objectives.

While CONPRO can do complete program revenue requirement impact analyses, it has many features that allow the analyst to do partial or specific subanalyses. These features include the ability to:

- Evaluate impacts of DSM programs on utility loads, revenues, costs, rates, and revenue requirements.
- Calculate the magnitude of economic DSM alternatives to society or individual consumers and display the resulting load curves along with the utility's load forecast.
- Calculate DSM option costs of conserved energy (CCE) or demand (CCD) [The CCE or CCD equals the levelized cost of each kWh or kW saved over the life of the option.]
- Calculate and print or graph DSM supply or resource curves for any time period.
- Calculate market penetration of DSM alternatives over time.

In this paper preliminary results form the GPU case-study will be used to illustrate the calculation of the magnitude of economic electricity conservation and load management alternatives (ECAs) from two different perspectives, comparing them to the utility's load forecasts. The paper is organized in two parts: (1) an overview of the definition and measurement of the opportunity for economic conservation, and (2) results from the GPU project.

CONSERVATION OPPORTUNITY: CONCEPT AND MEASUREMENT

Conservation Opportunity (CO) is defined as the maximum amount of conservation or load management that is economic from the perspective of the consumer or society. Consumers individually or as a whole (society viewpoint) evaluate the economics of conservation and load management investments. This methodology evaluates all ECAs using the net present value (NPV) method. By the NPV method, all investment benefits and costs are discounted by either society's or the consumer's discount rate. The present value of the costs are subtracted from the present value of the benefits. Positive results for an ECA indicate that the "yield" of the ECA is greater than the consumer's or society's discount rate and the ECA is economic.

While the ranking of ECAs by NPVs is useful when making investment decisions, in this paper we are only concerned with identifying the number of ECAs, and their corresponding kWh or kW savings, that qualify as economic investments. These ECAs could be viewed as an inventory of conservation and load management alternatives which at least meet minimum requirements for consumer or societal investment versus spending money on consuming more electricity.

Society Viewpoint

For society, ECAs are economic if the NPV of the investment is positive at society's discount rate. From this viewpoint, benefits equal the utility's avoided costs* due to the electricity savings from the ECA investment and costs equal the ECA's incremental purchase price.

Society is faced with many choices to meet its energy service needs, especially with regard to electric services. For example, in the area of lighting, commercial building owners may light a hallway using several 40 watt fluorescent lamps. An alternative might be to use new efficient 32 watt lamps. The cost savings resulting from the lower generation and consumption of electricity constitute the main benefits to society from the conservation investment. These cost savings are primarily fuel savings in the short term and, if the total savings from conservation and load management is large

* The benefits to society may be greater than just the utility's avoided costs where external benefits such as reduced environmental damage are included. For the most part such costs are difficult to quantify and are often ignored. CONPRO could include such benefits (if quantified by the user) by treating them as additions to the utility's marginal costs. They would be added because if electricity is generated these additional costs will be incurred by society.

enough, fuel and capacity savings in the form of delayed, down sized, or cancelled power plants in the long run. These are measurable costs avoided by the utility.

In our methodology, it is assumed that society uses a single discount rate. This discount rate reflects society's time value of money in making long-term collective investment decisions. In this study, we chose the yield on long-term government securities as a proxy for society's discount rate.

Individual Consumer Viewpoint

Individual consumers vary considerably in the benefits they identify with conservation investments and the discount rates they apply in investment evaluation. Even so, ECAs are still economic whenever their NPVs are positive where benefits equal the consumer's electric bill savings and costs equal the ECA's incremental purchase price.

When consumers make conservation investments they do not receive benefits in the form of the savings in utility costs; rather, they receive a reduction in their electric bills. Benefits to the consumer will almost always be different than the benefits to society because the utility's average rates are its average embedded costs while the utility's avoided costs equal its marginal costs. Depending upon the relationship between a utility's avoided costs and its average rates, the benefits to a consumer could be perceived to be higher (average rates > avoided costs) or lower (avoided costs > average rates) than those perceived by society.

Because there are a large number of individual consumers for any given utility applying many different discount rates, calculations of CO from the consumer's viewpoint require a representation of the variation in discount rates using a discount rate distribution for each customer class--residential, commercial, and industrial.

In our methodology, up to seven discount rate categories may be specified for each customer class. For the individual consumer's viewpoint, instead of applying one discount rate as in the society viewpoint, each ECA's economics are evaluated for each of the seven customer class discount rate categories. The conservation and load reductions are counted in calculating CO only for those customers segments who obtain a positive NPV result.

Conservation Opportunity Over Time

Conservation Opportunity, whether from the viewpoint of society or individual consumers, will change over time due to growth in the customer population and the economy and the rate of ECA investment. As new growth and the turnover of existing electricity-using devices takes place, CO will grow. This growth in CO is important to utility analysts and can be calculated each year given assumptions about ECA useful lives, replacement rates, and growth in number of customers.

In CONPRO, CO is calculated year-by-year for both the society (COs) and consumer (COc) viewpoints for 20 years. CONPRO also projects the current electricity consumption of the utility over 20 years assuming growth in the customer population (or floorspace for the commercial class and production output for the industrial class) occurs but that the stock of electricity-using devices remains constant in terms of efficiency and consumer utilization. This projection, called ULceu (Utility Load—constant efficiency and utilization), is used as a reference point to subtract and graph COs and COc.

Figure 1 shows what the plot of COs and COc over time might look like in comparison to ULceu. In Figure 1, COc and COs are subtracted from ULceu to produce the utility load in kWh or kW that would result if all economic ECAs were implemented. ULcco is the utility load that would result if all ECAs economic from the consumer viewpoint were undertaken and ULsco is the utility load that would result if all economic ECA investment from society's viewpoint were undertaken.

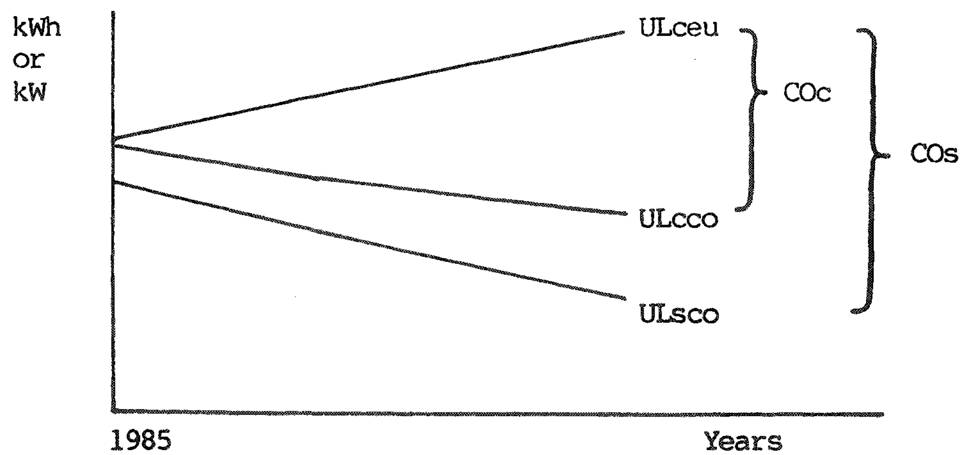

Figure 1
Conservation Opportunity Over Time
(Society and Consumer Viewpoints)

GPU PROJECT RESULTS

Conservation Opportunity in the case-study with GPU was calculated for annual energy, summer peak demand, and winter peak demand over a 20 year horizon. Preliminary results for GPU's Pennsylvania Electric subsidiary are used here for illustration.

Data Requirements

To make the CO estimates two data sets are required: (1) a common set of utility customer class rates, end-use characteristics, energy and demand forecasts, discount rate distributions and utility marginal costs and (2) an inventory of conservation and load management options by customer class and end-use. An example of the information required in the common data set for class end-use characteristics is shown in Table I. Here data for nine end-uses on number of customers with the end-use, growth rate in customers with the end-use, and summer and winter annual kWh and peak kW usage are displayed. This data is used to develop the ULceu reference load forecast. Similar data, including end-use load factors, was developed for eight end-uses in the commercial sector and six end-uses in the industrial sector.

Table I.
Pennsylvania Electric Company
End-Use Data: Residential Class

End-Use	Number of Customers w/End-Use	Growth Rate in Customers w/End-Use	Average Use Per Customer w/End-Use: Summer kWh	Winter kWh	Summer Peak kW	Winter Peak kW
Other & Light	463,000	0.6	750	750	0.27	0.41
Refrig.	540,043	0.6	680	580	0.15	0.10
Water Heat	180,107	1.4	1,700	1,850	0.70	1.00
Space Heat	41,670	1.6	-	8,316	-	3.89
Cooking	275,485	1.3	740	440	0.10	0.10
Dryer	265,762	1.5	275	665	-	-
Freezer	236,130	0.9	590	505	0.15	0.10
Window A/C	111,120	1.6	200	-	0.20	-
Central A/C	14,816	1.5	200	-	0.60	-

Data requirements for CONPRO require specification of ECA option characteristics. While many utilities have not as yet developed the necessary data, most utilities with the use of in-house and secondary data could develop it without a substantial investment in resources. For example, each ECA option for a given customer class requires information on applicable end-use; investment type (i.e., retrofit, normal replacement, etc.); units per customer; unit incremental costs; useful life; percent of customers for which the option is technically applicable; current level of market penetration; year of ECA option market introduction; total, seasonal, and on- and off-peak energy changes; and summer and winter peak diversified and non-diversified demand changes. For the GPU project, 76 ECAs were identified and specified. The breakdown of the ECAs by customer class was: 26 for residential, 28 for commercial, and 22 for industrial. One example of the ECA input data for each class is shown in Table II.

Conservation Opportunity Results

Given the ECA characteristics and discount rate information, each option can be evaluated as to its economics for each customer class or for society as a whole. As discussed, an ECA is considered economic if its net present value is positive for any given discount rate category. Alternatives that are economic enter the market based on their replacement characteristics. Figure 2 illustrates for Pennsylvania Electric the annual energy, summer peak demand, and winter peak demand load curves CONPRO produces and compares to the utility's load forecast.

The top curve in each case, labeled ULceu Utility Load (Constant Efficiency and Utilization), equals the load that would occur due to economic growth (i.e., population, new homes and appliances, etc.) with electric-using device efficiency and utilization held constant at 1985 levels. This curve is calculated and portrayed as a reference point.

Table II.
Pennsylvania Electric Co.
Example ECA Data
Residential, Commercial, and Industrial Classes

	Residential	Commercial	Industrial
ECA Description	High Efficiency Side-Door, Manual Defrost Refrigerator	Replace Standard F40 watt Lamp and Ballasts with High Efficiency Units	Replace Standard Efficiency Motors with High Efficiency Motors
End-Use	Refrigeration	Lighting	Motors
Investment Category	New + Normal Replacement	New + Normal Replacement	New + Normal Replacement
Unit	Refrigerator	Lamp	Hp
Units/Customer	1	68	64
Cost	$30	12.668 cents/Ft^2	$2,664,000 (Total)
Cost Basis	Incremental	Incremental	Incremental
Use Life (Years)	20	10	7
% of Customers w/End-Use	7	100	100
% of Market Penetration	1	25	20
Year of Product Introduction	1984	1977	1977
kWh Reduction:	per/unit	per/Ft^2	(1000's)
Winter On-Peak	69	0.238	13,468
Winter Off-Peak	69	0.119	13,468
Summer On-Peak	84	0.238	13,468
Summer Off-Peak	84	0.119	13,468
Total	306	0.716	53,872
Diversified kW Reduction:	per/unit	$(1x10^{-3})/Ft^2$	(TotalkW)
Winter Peak	0.087	0.190	19,111
Summer Peak	0.089	0.178	18,440
Non-Diversified kW Reduction:	per/unit	$(1x10^{-3})/Ft^2$	(TotalkW)
Winter Peak	n.a.	0.254	32,603
Summer Peak	n.a.	0.238	31,459
Facility Size (Sq. Ft.)	n.a.	2684	n.a.
Number of Facilities	n.a.	n.a.	4625

The second curve, ULcco (Customer Conservation Opportunity), is the load one would expect if GPU's customers made all ECA investments they found economic. The third curve, ULsco (Conservation Opportunity - society) is the load one would expect if society invested in all ECA options it found economic. The magnitude of the savings each year that is economic to customers (or society) is subtracted from ULceu to produce load forecast ULcco or (ULsco). In each case the customer economic load forecast is above the societial forecast because we have assumed, for some customer categories, much higher investment hurdle rates for ECA options. The fourth forecast displayed is the utility's forecast (ULfor). This forecast typically is derived by traditional econometric procedures.

Looking at Figure 2a, Annual Energy, we find the ULceu, ULfor, and ULcco curves for the year 1985 all start between 10,700 and 11,100 GWh (Note: the ULceu and ULfor curves start from a common point in 1984). The ULsco load forecast begins at 9,900 Gwh. Thus, while consumer opportunities are in line with the utility load forecast, potential conservation (due to immediate retrofit opportunities for some ECAs) shown a potential from society's viewpoint of approximately 1,200 GWh (or 10.8 percent)

Over time conservation potential increased compared to holding electricity usage constant at 1985 efficiency and utilization levels (ULceu). By the year 2004, projected utility sales would have risen to 14,000 GWh without efficiency changes. Conservation investment considered economic to individual consumers, if entirely undertaken, results in sales of about 12,800 GWh (or a 11.7 percent reduction from the ULceu level). If all of society's economic ECAs are undertaken the load reduction would be about 17.2 percent (or 2,500 GWh).

For Pennsylvania Electric, our preliminary results show that the utility's sales forecast produces in the year 2004 an almost identical forecast to the society Conservatioon Opportunity forecast. Essentially, Pennsylvania Electric is currently forecasting long-term sales to fully capture societal economic ECA opportunities, while we project the likely forecast based on consumer discount rate behavior to lead to a higher forecast. At this point it is conjective whether GPU is underforecasting total sales or we are understating the number of conservation opportunities (and their impact) or overstating consumer discount rates. What our analysis does shows is that GPU's annual sales forecast assumes an average customer discount rate of 7.5 percent (the proxy for the societal discount rate we used). This provides additional information to GPU to re-examine its sales forecast. If our view were considered the better of the two upon further analysis, it would tell GPU that to achieve its present sales forecast, conservation programs producing an 800 GWh reduction in energy by the year 2004 would be required.

Examination of the summer and winter peak forecasts presents a slightly different picture. In these cases, forecasted peak tends to fall near or slightly below the ULcco forecast (or individual consumer CO forecast). This indicates additional peak reduction opportunities are available through conservation and load management programs moving the forecast closer to the societal line.

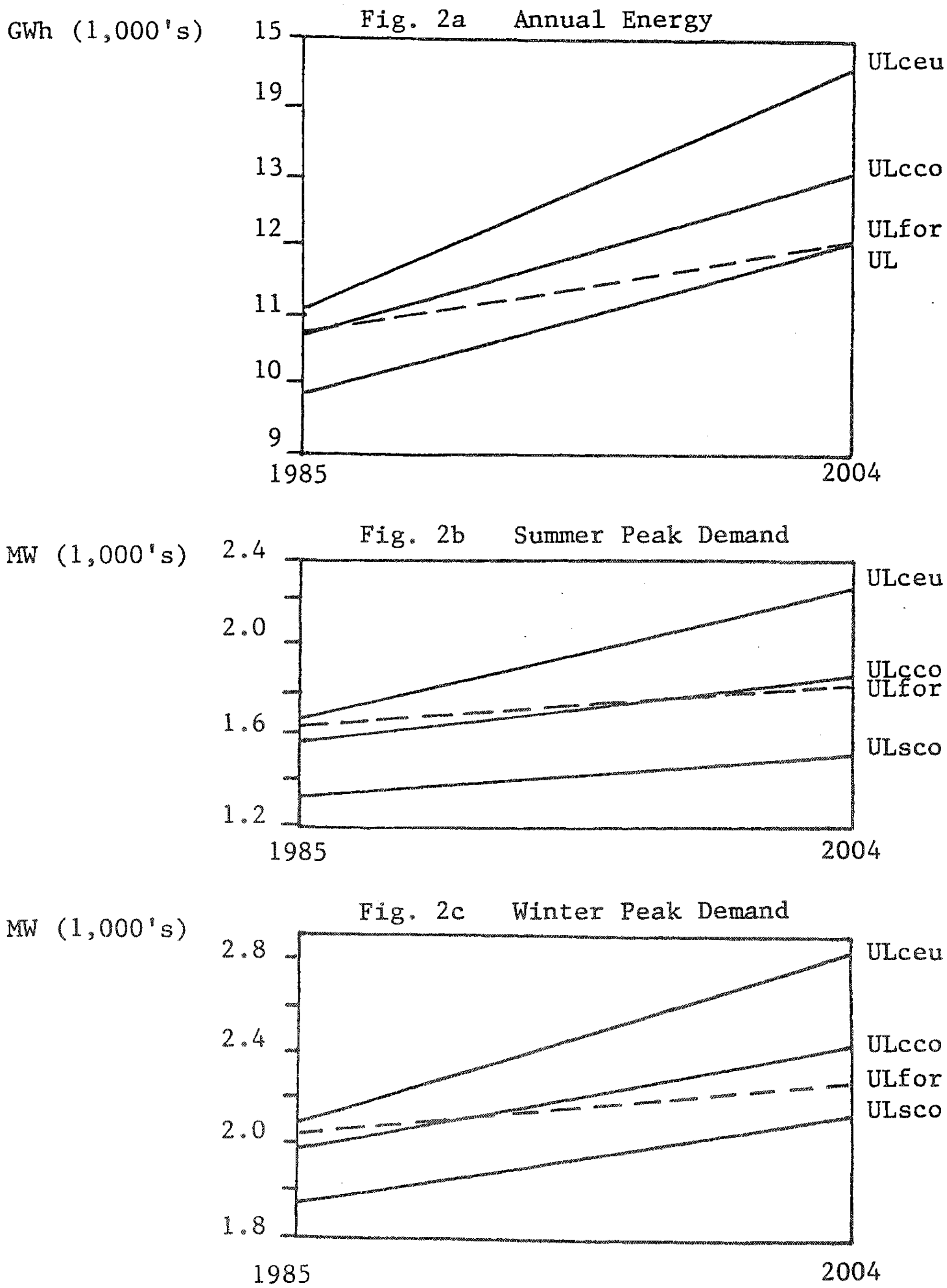

Figure 2. Conservation Opportunity: 1985 - 2004
Pennsylvania Electric Co.

CONCLUSION

The advantage of this analysis is that it provides explicit information about ECA option economics. Using CONPRO, assuming one has fully specified ECA options for the utility, a customer class, or end-use, the analyst can derive the average discount rate implicit in the utility's comparable forecast. Analyses with CONPRO can also be extended to estimate actual market penetration rates of ECA options and the impacts of any conservation program that can be quantified as having an effect on ECA option profitability or cost.

CONPRO provides utilities a simple, but comprehensive tool for screening conservation and load management options and programs. In addition, it provides information that can be used to check the implicit assumptions underlying utility energy and peak forecasts. Overall, CONPRO helps utility management utilize end-use and conservation and load management option data to improve their demand-side management decision-making.

CONRPO will be available in October, with an operators manual, from the Alliance to Save Energy, 1925 K Street, N.W., Suite 206, Washington, D.C. 20006. It's development was supported by General Public Utilities and the Pennsylvania Governor's Energy Council. A report describing the complete results of the project analysis done for GPU will also be available at that time.