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Abstract

Electric utility companies are increasingly using mainframe computer models as their central planning tools. Adoption of modelling represents a response to the complexities that have made planning increasingly difficult over the last few years. At the same time, the concept of least-cost utility planning is gaining acceptance as the guiding principle of planning. The interaction between these two significant changes in industry thinking and methods is described, and two of the leading planning models are evaluated for usefulness as tools in the least-cost planning process. It is argued that for better or worse computer modelling is de facto the industry's chosen road to least-cost planning. Further, regulators and policymakers must adopt comparable modelling capability if useful exchange is to continue in the industry.

1. INTRODUCTION

"Least-cost utility planning" (LCUP) is an integrated approach to demand-side and supply-side electric utility planning. LCUP results in a least-cost plan for the utility company consisting of a policy set that, if adopted in its entirety, will ensure that forecast demand for electricity services within the company's service territory will be met. The least-cost principle simply requires that the policy set that incurs the *least cost* be the one adopted. The problem then reduces to evenhandedly estimating and comparing the costs of policy scenarios that are different in nature, have uncertain outcomes, and are not independent in effects. In an electric utility nowadays, this problem would most likely be approached, at least initially, by use of a standard mainframe corporate planning model. In fact, mainframe models have emerged as *the* standard method of analysis for LCUP purposes.[1] The adoption of models reflects both the complexity of the analysis and the historical "accident" that the LCUP principle and the comprehensive models came into common currency at the same time, that is, over the last five years.

Developing a least-cost plan requires a sophisticated analysis of the company and the exogenous market conditions it faces. Further, the interaction between the company and its economic and regulatory environment is a simultaneous system and any analysis of it must recognize it as such. Since the LCUP principle requires that policies of several diverse types be traded off against each other, and, since an intervention anywhere in a simultaneous system can affect everything else, large scale computer modelling promises to be the most appropriate tool. Computer models allow the analyst to keep track of the numerous details that can have significant feedback effects under different policy options, to do sensitivity cases easily, and to replicate the results of other company departments or outside agencies. Regulators and policymakers are currently a step behind the industry in their appreciation of the models' value as LCUP tools, although their acceptance of LCUP principles is, arguably, ahead of the companies'.[2] The use of models by companies will undoubtedly expand, and regulators and policymakers should be accelerating their modelling efforts to keep pace with the historic changes in industry thinking and methods currently unfolding.

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[1] This is not to deny that great skepticism about the value of large models does exist in the industry.

[2] See Reference 20.

2. BACKGROUND

Until the mid-1970's, electric utility demand forecasting and generation planning were separate company functions. Electricity demand grew rapidly but consistently, and the role of the generation planner was perceived as one of commencing new construction in a timely manner to meet the forecast demand as cheaply as possible. Nonetheless, the inherent stability of the electricity supply industry, with consistently rising demand on the one side and falling costs on the other, was an environment in which this planning method was adequate. After the mid-1970's, however, great uncertainties entered both sides of the utility supply-demand balance, making utility forecasting suddenly complicated and traditional planning methods inadequate. The unfamiliar instability of the electricity market has had a double-barrelled consequence for utility planners. On the one hand, the potential for planning error has grown, and on the other, the costs of error have also grown. Two responses to this unfamiliar environment are the focus here. The first is the adoption of large scale computer models, and the second is the emergence of "demand-side" programs, that is, programs intended to limit or reshape demand so that it is more readily met by expected generating capacity.

Use of the expression "least-cost" was first popularized by Roger Sant and Amory Lovins in the late 1970's and it rapidly entered the everyday energy lexicon.[3] These authors claim a parallel exists between their original global terms of reference, the problem of meeting worldwide energy needs, and the point of view of an electric utility, which is usually the *only* supplier of electric power in its territory, and which is required by law to meet the demand of its customers.[4] Although this parallel in part contradicts Sant's earlier view that fostering greater competition in energy markets is desirable, the least-cost approach is being embraced by the industry.[5] To achieve the demand-supply harmony implied by LCUP, an integrated approach is necessary wherein the traditional supply-side planning methods are coordinated with the more recent methods of evaluating demand-side programs. Demand is to be no longer thought of as an exogenously determined output target but rather as a controllable parameter that utility policies should aim to set at the desirable level. This level is the one at which reducing demand by one kWh at any point in time costs exactly as much as delivering that kWh to the customer.[6] Clearly, the meaning of "cost" in LCUP as it is currently used is somewhat different from the "cost" originally refered to by Lovins and Sant, that is, the full cost, both direct and indirect. The current usage of "least-cost," and the one adopted here, is the limited company-level view in which "cost" refers to the company cost, with customer cost, externalities, etc., excluded. The LCUP problem, as it is addressed here, is, therefore, *given the business and regulatory environment in which an electric utility finds itself, what policy set, or least-cost plan, will ensure that it meets the forecast demand for electricity services within its service territory at minimum direct cost?*

When forecasting is conducted at a utility, the least-cost principle requires that all conceivable means and combinations of means of meeting forecast customer demand for the services electricity provides should be evenhandedly considered. This sounds both intuitively reasonable and analytically straightforward, but in practice it is a mammoth undertaking. First, adequately

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[3] See References 19 and 25.

[4] See Reference 21.

[5] See Reference 24, page 40.

[6] Note that as always with electricity, the instant of delivery has to be specified.

forming the problem requires large data sets. Second, advanced methods and considerable resources are required to adequately weigh the pros and cons of diverse policy sets, all of which involve great uncertainties. And third, the institutional difficulty of coordinating the work of formerly separate company departments is significant. And further, overcoming these problems is required of an industry whose forecasting ability was rudimentary until recent times. The challenge for computer modellers is to adequately represent this complex company problem in a comprehensible yet manageable model.

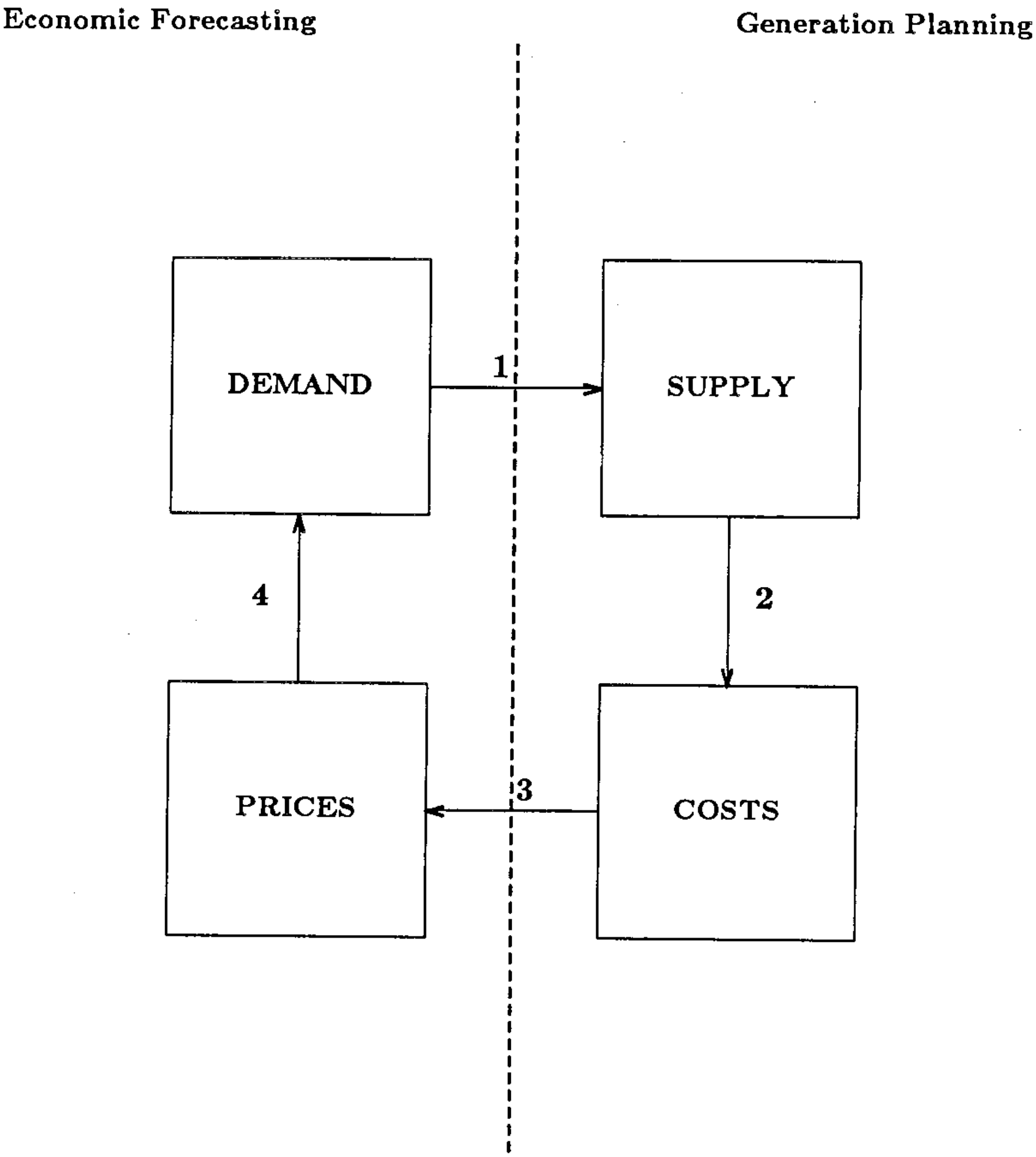

Figure 1

3. THE MODELLING PROBLEM

Figure 1 shows a simple schematic of an electricity system, or, indeed, any market. While Figure 1 appears trivial, several salient features of this particular industry contrive to make the modelling problem immensely complex, and the simple demand and supply diagram of economics a poor basis for modelling. The major complications are the following:

1. Since electricity cannot be stored at reasonable cost, a full characterization of demand must include an hour-by-hour load curve.
2. Being such a capital-intensive industry with long lead times for new plant construction, forecasting must have at least a ten-year time horizon.
3. Regulation produces a set of prices that do not reflect true time- and place-dependent electricity costs but derive from a formula that aims to just meet average costs and an allowable return on investment over the long run.
4. The "obligation to serve" principle requires an electric utility to operate unprofitably at certain times and in certain places.
5. The utility is usually a monopolist within its service territory.
6. Electricity rates are non-linear, and numerous rate schedules are in effect simultaneously, so changes in costs have diverse consequences for sales and revenues depending on which specific consumers' behavior is affected.[7]

Among the standard corporate planning models, two groups of models can be identified. The first are ones based on the traditional methods of production costing. Treatments of demand-side policies can be added to a standard supply-side algorithm to create a LCUP tool. The second group, now in their infancy, are full system models that attempt to solve the whole of the problem portrayed in Figure 1 in one integrated process. The two models reviewed below represent the state of the art for each of these two camps.

4. EGEAS

Description

The Electric Generation Expansion Analysis System (EGEAS) represents the state of the art traditional generation planning and production costing model.[8] It incorporates advanced optimization techniques based on load duration curve methods to obtain a cost minimizing use of plant capacity. Some of the EGEAS computer code is original and some is based on pre-existing models.

EGEAS is structured in five components. The first component is a pre-processor for user-supplied hourly loads. The second component creates a central data base used by the simulation. The third component performs the annual simulation of production costs and optimizes generation expansion. The fourth component generates output reports summarizing the results of the analysis. And the fifth component creates "reduced-form" summaries of the results.

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[7] "Non-linear" here means that price varies over levels of usage, usually in an increasing or decreasing block manner, with the added effect of a fixed customer charge or minimum bill requirement.

[8] EGEAS was developed by the Massachusetts Institute of Technology and Stone and Webster Engineering Corp. for EPRI. See Reference 6.

not so convincing a method for modelling the other sectors. Nowhere in the LMSTM manual is any specification of the industrial sector suggested other than as an amorphous single enduse mass. Here more than anywhere, the absence of business cycle and efficiency improvement inputs causes concern.

The problems involved in accurately recreating a full system load shape by enduse are daunting, and, further, getting it right once is no guarantee that the specification is correct and forecasts credible. Particularly, the exclusion of efficiency improvements from the industrial sector is worrisome. On the plus side, the breakdown of the year into 16 typical days permits sensible and manageable simplification, and LMSTM is wisely structured so the user can build his/her data sets from scanty beginnings. Also, it should be emphasized that for LCUP the horizon must necessarily be distant, given that ten years is the minimum time required to plan and build new baseload capacity, so the enduse approach is probably the most promising.

In general, load management through creative pricing should be a strategy at the top of the least-cost planner's tool box and, unfortunately, LMSTM's treatment of time-differentiated pricing is unconvincing. Neither the origin nor the application of the elasticities asked for in the input files is clear from the documentation.

Within the class of large planning models, LMSTM is relatively easy to use. It appears to be stable, and error messages are comprehensible. It could be run by staff at many levels of a company, adding greatly to its value as a filtering tool whose purpose is to select candidates from a large class of potential strategies. It also means that the user will become familiar with the general character of outcomes, and establishing credibility bounds is easier.

Finally, it should be restated that LMSTM is a rigid model. Certainly its authors have ingeniously written it so as to permit the adoption of numerous possible interventions such as direct load control, energy storage, time-differentiated pricing, etc., but any one strategy has to be evaluated one run at a time. That is, LMSTM does not derive an optimal strategy for a utility; it merely, as its name suggests, tests policy options input by the user. As such, it does not answer the real modelling challenge of least-cost planning and depends on the creativity of the user to develop potential strategies.

Other Models

EGEAS and LMSTM are the state of the art models used in the industry, but it would be a mistake to think that the choice of LCUP tools must be limited to these two. Numerous other models have been built by various modellers over recent years, including many developed by companies for in-house use. Many of these models can and will be used to provide primary and intermediate level inputs.

6. CONCLUSION

Returning to Figure 1, the complexity of developing a least-cost plan should now be apparent. A true least-cost plan would include a set of policy initiatives that might intervene at any of the corners. Consider, for example, the importance of being able to forecast the effect of a simultaneous innovative pricing policy and new plant construction. The optimal size of the new plant cannot be known until the effect on demand of the new pricing policy is known. Vice versa, the level of the new prices cannot be known until the size of the plant and its consequent costs are known. Given the complexity of this problem and the importance of solving it simultaneously, large scale computer modelling presents the only promising rigorous approach. However, the heavy data requirement of large models inhibits their rapid worthwhile application, the intra-company barriers to cooperation pose a difficult institutional problem, and since no ideal model exists, either current models must undergo improvement or groups of models must be run in shaky, hard-to-handle tandems.

Utility companies clearly recognize the importance of expanding their modelling capability and they are using large scale models increasingly. The models are *de facto* the currency of the industry. Policymakers and regulators must recognize the same currency if beneficial exchange is to continue. Fortunately, however, the models establish a stable and convenient standard in which all parties can enjoy confidence.

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