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A PRELIMINARY EVALUATION

OF

THE I.S.E.R. ELECTRICITY DEMAND FORECAST

(Working Paper #1)

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In October 1979, Energy Probe was asked by The House Power Alternatives Study Committee (HPASC) of the Alaska State Legislature to submit a proposal for a study that would evaluate the electricity demand forecasting method developed by the University of Alaska's Institute for Social and Economic Research (ISER). This report is the first of three to be prepared by Energy Probe, and presents an initial evaluation of the ISER forecasting model and the Man in the Arctic Project (MAP) model on which, in part, the electricity demand forecast is based.

The present report draws on information contained within the Detailed Work Plan submitted November 14, 1979 by Dr. Scott Goldsmith of ISER; May 1979 MAP model documentation; various publications relevant to the future social and economic activity in the state of Alaska; and personal discussions with ISER personnel.

Further reports in this series will deal with the sensitivity of electricity growth in the Railbelt region of Alaska to policy and market induced changes in the social, economic and physical factors which influence electricity growth; and with an analysis of the appropriate role and interpretation of electricity demand forecasts within the broader context of state energy policy development.

Because this report is a working document intended only for use by HPASC members and consultants, it is written in relatively technical language. Our final report, to be prepared by May 1980, will detail the three areas mentioned above in less technical language.

The views expressed herein are those of the authors, and not necessarily the House Power Alternatives Study Committee.

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1. INTRODUCTION

Electricity demand forecasting, like all quantitative forecasting, is an effort to view the past and present in a systematic way with a view towards making reasonable statements about the future. The basic problem is that the future is not known, and indeed cannot be known, even in a probabilistic sense. As a matter of fact, pretending to forecast the future is an indictable offence under the New York State criminal code. 1.
Similar provisions, we are certain, are in effect elsewhere.

However, analysts often find it necessary to fly in the face of strict legality when the viability of a large project hinges on the need for it in the future. Hence, forecasting has become an integral part of planning for investments in energy, transportation, housing and a myriad of other functional service delivery areas. Forecasting the demand for such services comprises a two-stage process. In the first stage, aggregate social and economic activity is projected into the future (using, for example, the ISER MAP model); the second stage translates this aggregate activity into a detailed forecast of the demand for the product or service in question.

Stage I models tend to be rather ubiquitous, finding application in a number of functional areas. MAP, for example, has been used in a variety of forecasting environments including energy impact analysis and fiscal forecasting. On the other hand, Stage II models are generally specialized and tailored to the problem at hand. In transportation planning, they are classified under the general heading of travel demand models. In energy demand forecasting, a number of different approaches have been developed, which have met with varying degrees of success. To the extent that a debate over appropriate forecasting methods exists, it is really a debate over the choice of a Stage II approach. In fact, as we argue below, the choice of a Stage II approach essentially dictates the output and hence the structure of the Stage I model to be used.

The argument over Stage II models centers on the extent to which the model should deal with two distinct but equally important aspects of the problem. Given an aggregate forecast from Stage I, should a Stage II model focus on the specific activity involved or should it focus on the decision of the consuming unit? In forecasting within a policy environment concerned with housing, for example, the latter dictates that we examine household budgets, prices and so on. However, a dwelling offers service far beyond simple shelter; amenity, proximity and opportunities for social interaction are but a few of these. Hence, the former approach would argue that the demand for housing is really a composite demand for the services offered by a structure. Transportation and energy are similar. Rarely are they required for their own sake; in reality they are crucial inputs into a number of satisfaction yielding activities.

In electricity demand forecasting it was once possible to do a reasonable job of prediction by looking at a historical rate of growth and simply plotting future levels of consumption against time. A draftsman with a French curve (or an engineer with semi-log paper) could make a reasonable guess at future demand by simple curve fitting and extrapolation. However, it is logically clear that the growth in the demand for electricity has little to do with the passage of time *per se*. Rather, it is related to individual *decisions* to engage in a growing number of electricity using *activities* over time.

2. STAGE II MODELLING APPROACHES

Attempts to deal seriously with this complexity became necessary in the early years of the 1970's when historical rates of electricity growth ceased to be realized by most electrical utilities in North America. The formation of OPEC and the 1973 Arab oil embargo, with its subsequent increases in petroleum prices, ended the era of cheap energy; and all fuels, including electricity, rose in price rather dramatically. Unfortunately, the econometric demand forecasting models in use at this time[2] were incapable of dealing with such rapid changes and continued to point to historic or near-historic rates of electricity growth. ISER's 1975 electricity demand forecast for the State of Alaska (with which, we might add, ISER itself was not comfortable) is a case in point. The most telling criticism of its strict time-series econometric approach is that potentially ludicrous <u>activity</u> forecasts result. In ISER's 1975 effort, initial results indicated a demand for electricity which implied 100% saturation of electric space heating in Fairbanks in the future. The point to be made here is that because individual activity levels are not explicitly identified in aggregate economic models, such models run the risk of implying physically unrealistic activity levels.

End use forecasting models in their pure form take the opposite approach by relying almost exclusively on <u>activities</u>, independent of the underlying economic conditions. The logic is simple: consuming units engage in various activities requiring energy. Energy growth can result from

(a) engaging in additional energy consuming activities;
(b) engaging in the same activities more intensively;
(c) engaging in the same activities less efficiently;
(d) any combination of the above.

The case of oral hygiene provides a humorous example. A household may switch from "manual" to electric toothbrushing, an additional energy using activity. Given an electric toothbrush, members of the household may wish to brush more regularly. When the toothbrush wears out it may be replaced with a model which delivers fewer brush strokes per unit of energy input. In any of these cases, electricity use increases. In principle, it is possible to examine all electricity use in this manner, noting that all energy is used in a final form such as heat, light, motion or sound, and that it is transformed from its input form to its final end use form by a "device".

Again, in principle, electricity demand can be projected by forecasting the characteristics of devices and activities. This has become known as the engineering or end use approach to demand forecasting. The most telling criticism of this method in its pure form is that it is not sensitive to changes in prices, incomes and preferences, i.e. the decision aspect of the process modelled in Stage II. This is a generally accurate criticism whose resolution requires an examination of policies affecting the decisions of the individual consuming unit. In further work for HPASC, we will be discussing this problem.

For functional forecasting purposes, an approach is emerging which seeks to overcome the inherent difficulties of both extremes of Stage II modelling methods. The econometric-end use approach (EEU) attempts to deal with electricity use at the level of the activity while recognizing that the decision to own and operate a device, i.e. to engage in an activity at some level of intensity, is inherently a problem of microeconomic choice and therefore sensitive to prices, incomes and the availability of alternatives.[3.]

In our opinion, an EEU approach is the only sensible way to forecast electricity demand and to justify a huge expenditure of public funds.

We are pleased that ISER agrees in principle with this general philosophy. The detailed work schedule circulated by ISER lays out a rather impressive plan. We anticipate problems arising because of the extensive data requirements of EEU, which will be intensified by the basic data problems of Alaska: short time-series and a small population. However, we fully support ISER's desire to cast the net widely at first, while recognizing that data, and more importantly time and financial constraints will require the net to be drawn in somewhat.

At this point we would like to comment on the allocation of resources for independent demand forecasting relative to the magnitude of potential capital investments. Given the magnitude of the stakes for a project such as Susitna, i.e. a potential investment of billions of dollars, we fell that far too little money is being spent on this crucial element of project feasibility. ISER will likely argue, and justifiably so, that data is simply not available to construct a full scale EEU model. The missing data, however, is not of the variety which is impossible to collect. With additional resources made available, it could be gathered and incorporated into the forecast model, resulting in a forecast method with which all could be reasonably comfortable.

In the following pages we will review the EEU approach to Stage II and the requirements of a Stage I model to provide requisite inputs into EEU. Our goal is two fold: first to analyze and suggest approaches to particular problems for the benefit of ISER, and secondly to lay out the logic of ISER's forecasting proposal for the benefit of all consultants involved in HPASC activities. It is our hope that this will facilitate discussion and understanding of ISER's methods and in the longer term, identify avenues for potential policy intervention.

3. THE ECONOMETRIC - END USE APPROACH

EEU begins with the simple proposition that all energy is used in capital items or devices, which perform a specific task, i.e. an end use. Each device, by virtue of its design, has a specific energy input requirement for each unit of useful output, a concept similar to "First Law Efficiency". Devices are owned or rented and operated by consuming units. However, not all consuming units own all types of devices, nor do devices operate at all times. Further, many devices may be powered by more than one fuel. The decisions to own or lease and operate a device are economic decisions made by the consuming unit in light of prices, incomes, preferences and available options. For a given period, say a year, the total energy required by a consuming unit to power a given device is by definition its hours of operation times its power requirement. If the device is electrically powered, this energy demand will contribute to an electricity demand estimate.

Any portion of the electric power consumed by the economic unit which it generates itself, does not contribute to this utility forecast.

There are, of course, many consuming units and many devices. We may translate from the device level at the consuming unit by simply summing over devices and consuming units yielding the following expression for utility electric demand over a period of one year:

$$TUD = \sum_{k=1}^{N} \sum_{j=1}^{M} [D_{kj} \cdot E_{kj} \cdot I_{kj} \cdot R_{kj} - S_{k}] \qquad (1)$$

where

TUD = total utility demand (kW.h)

D_{kj} = 1 if consuming unit k has device j
0 if otherwise

E_{kj} = 1 if device j is powered by electricity in consuming unit k
0 if otherwise

I_{kj} = intensity of use of device j by consuming unit k (hours)

R_{kj} = power requirement of device j by consuming unit k (kW)

S_{k} = amount of self supplied electricity by consuming unit k (kW.h)

N = total number of consuming units

M = number of distinct devices

This is an accounting framework for utility demand.[4.] To operationalize it for forecasting purposes, each of the components must be related to known or "knowable" variables. Engineering knowledge and economic theory suggest potential relationships. Econometric or other techniques are used to estimate their direction and strength.

For operational purposes it is necessary to group consuming units into classes on the basis of predominant activity within the unit (i.e. residential, commercial, etc.), similarity in patterns of device ownership or energy requirements, or some other appropriate criterion. Clearly, there are losses in precision due to this sort of aggregation. After grouping consuming units into classes, the demand for utility electricity is obtained by the following expression:

$$TUD = \sum_{i=1}^{Q} CUD_i = \sum_{i=1}^{Q} \sum_{j=1}^{M} [N_i \cdot PD_{ij} \cdot PE_{ij} \cdot I_{ij} \cdot R_{ij} - S_i] \quad (2)$$

where

CUD_i = demand for electricity by class i (kW.h)

N_i = number of consuming units in class i

PD_{ij} = proportion of class i consumers owning device j

PE_{ij} = proportion of devices j in class i that are electrically powered

I_{ij} = average intensity of use of device j by members of class i (hours)

R_{ij} = average power requirement of device j owned by members of class i (kW)

S_i = amount of electricity self supplied by class i members (kW.h)

Q = number of consuming classes

The advantage of examining end use demand in this manner is obvious. Not only is it less data intensive than Equation (1), but also, key parameters become easier to pinpoint. For example, in an analysis of a subclass comprised of mobile homes built before 1970, space heating requirements would be rather similar.

Time, of course, is also a crucial consideration which must enter the model in a forecasting environment. The advantage of an end use model is that the factors developed above exhaust the realm of demand factors, and each will change over time. As time passes, classes of consuming units grow or decline, devices become more or less prevalent and more or less "electrical", self - supplied electricity may become more widely used, devices may be used more or less intensively, and device efficiencies will undoubtedly change. The latter is particularly important since many devices will be replaced over the forecast period and those which are not may be "retrofitted" to improve their performance.

While the passage of time is itself not the reason for change, the argument above suggests that it may prove fruitful to view demand growth in a temporal sense. At a point in time we begin with a "stock" of consuming units equipped with devices. Over the ensuing year the consuming unit may disappear, change or modify its collection of devices or means of powering them. In addition, new consuming units may be formed complete with new devices. Presumably these new devices would have energy consumption characteristics different from "old" devices. At the end of the year we witness a revised "stock" of existing consuming units and devices comprised of the previous year's units plus net increases. This may be taken a year at a time for the entire forecast period yielding electricity requirements for specific annual points and annual increments in demand.

4. THE ISER MODEL AND SUGGESTED APPROACHES AND REVISIONS

In the context of the Railbelt region, EEU makes a great deal of sense for the residential and commercial sectors which, taken together, account for about 86% of Alaska's total electricity demand. Because industrial development in Alaska is largely of the major project variety, it is best to examine these in a case by case manner. Further, with the exception of block heating in vehicles, the transportation sector currently uses an insignificant amount of electricity. Again, this is best viewed as a special case.

ISER's EEU model, Figure 1 in their "Detailed Work Plan", incorporates most of the features of an ideal EEU discussed above. It is a stock/flow model which segregates consuming units into "new" and "old" and deals with four residential subclasses, and segregates devices into six categories including an"other" category for minor appliances.

The commercial sector should be divided into at least the following groups:

1) Public/Institutional Buildings;

2) Large shopping plazas/office buildings (say larger than 100,000 or 250,000 sq.ft.);

3) Other commerical buildings.

This would be fruitful for two reasons: within each group there are similar requirements for electricity, and policies/programs may be specifically tailored, at a later date, to this particular pattern of consumption and occupancy/ownership.

Missing in ISER's proposed model is a term to account for electricity or energy supplied by the consuming unit and hence not required from a central system. This should be added to the model even though it may not greatly affect the magnitude of the final forecast. A number of considerations warrant its inclusion, not the least of which is the possibility of co-generation of electricity and steam for space heating in large commercial establishments, schools, hospitals, and the like.

The present ISER formulation allows for the scrapping of dwelling units but not for the replacement of appliances within existing units. A number of appliances ISER intends to consider have useful lives of substantially fewer years than either the forecast period or the structure. In ISER's model, this problem could be solved by adjusting the average consumption of appliances on an annual basis. It is better, however, not to confound the effiency measure with the effect of new appliance stocks.

Given these structural refinements which we consider necessary, the ISER approach to residential and commercial electricity demand forecasting is methodologically sound. Since residential and commercial consumption in the railbelt are quite important, it is necessary to examine the components of the EEU model and to suggest possible approaches to modelling each component. In this case we refer initally to our formulation of EEU above, and explicitely to these elements pertaining to Stage II.

In Equation (2), total utility demand was expressed as the sum of class demands. Class demand is a function of the number of units in the class, the proportion owning various devices, the proportion of these devices powered by electricity, the average intensity of each device's use, the average power requirements of the various devices and the amount of self-supplied electricity. The number of consuming units in each class is essentially a modified form of the output of Stage I which we discuss below. The reamining factors are however, Stage II concerns which we deal with in turn.

PD_{ij}, the proportion of class i units owning device j, is obviously a variable whose value lies between 0 and 1. For certain end uses, i.e. space heating, its value equals unity and will continue to do so over the forecast period. In other cases like clothes drying and refrigeration, its value is a matter of choice, and while perhaps initially close to unity it is variable over the forecast period. In an ideal world we would hope to estimate this proportion on the basis of income level and distribution within the Railbelt Region, bearing in mind that the decision to own a "device" also <u>commits</u> the owner to operating expenses over its lifetime. Hence the general price level of all competing fuels may be important.

PE_{ij}, the proportion of device j owned by class i which are electrically powered is also a variable whose value ranges between 0 and 1. Again, for certain end uses, especially refrigeration, its value is close to unity and will likely remain so over the forecast period. However, a great deal of choice exists in this area. A useful way to look at this problem has been proposed by Fuss

who suggests the decision to engage in an activity with a specific fuel is essentially separable. In other words, given a decision to engage in an activity, the choice of fuel is essentially a separate question,[5] made on the basis of relative prices.

The question of the treatment of conservation arises in this instance. If conservation is factored into average energy requirements, then no more need be said. However, if we view each or any device as having a "base-line" energy requirement, then any effort to reduce it involves an explicit tradeoff of electricity for conservation. In this sense, conservation is self supply, and has an average supply price equal to the amortized annual cost of the conservation project divided by the number of kilowatt-hours displaced during a year. Marginal costs may be calculated by assuming, ideally, various levels of conservation and calculating, presumably, a step function for the fuel equivalent value of various conservation schemes. The same logic may be applied to renewable energy projects as well.

We feel it is useful to view conservation and renewables in this way when considering existing activities at a point in time. The major point is that given an existing activity, like space and water heating (the major ones) the consuming unit can choose not only to switch from one convential fuel to another but can also choose to supply a portion of its requirements with conservation. In an oil heated home, for example, the household may switch to gas, electricity, or conservation for all or part of its heating on the basis of relative prices. Considering conservation as an explicit fuel represents a useful modification of interfuel substitution analysis.

R_{ij}, the average power requirement of device j in class i, becomes basically an engineering design parameter when conservation is treated as a fuel. Consequently it is a function mainly of vintage, not confounded by retrofit. One item that should be examined is the trend in device efficiencies over time. This may well be an appropriate area for regulation.

I_{ij}, the average intensity of use of device j by class i members is also a consumer choice variable although to a limited extent in the major consumption categories. Actions like reducing inside temperatures and the like are evidence of the economizing behavior of households under this category; how much farther we can go in this area is certainly questionable. In this case, comfort and convenience bound choice from below. To the extnet that there is flexibility it is likely price and income related.

The final term in our formulation is S_i, the amount of self-supplied electricity by members of class i. In this instance we suggest that this term be kept pure in the sense that conservation not be viewed as self supply in this term. We include S_i in the model for the reasons stated above. There is a price at which self-generation or cogeneration becomes attractive whether by means of water power, wind, or conventional fuel. The model should be sensitive to this possibility.

The above relates to our formulation and also to ISER's model. The remaining terms in ISER's model relate to new household formation which we discuss below and the various "scrapping rates". Scrapping of a device involves not only physical deterioration but also economic considerations, one of which is the device's fuel requirements. Logically, the scrapping rate should increase with decreasing energy requirements for new models a particular device. This is extraordinarily difficult to measure and project over time; however, it is something to be kept in mind.

Generally speaking, we are impressed with ISER's proposed method for handling the Stage II modelling of the residential and commercial sectors. With the modifications suggested above we can wholeheartedly endorse ISER's approach and we look forward to working with ISER on further questions of approach and sensivity analysis. With respect to the ISER approach to non-residential and commercial use of electricity, we reserve judgement since the method has not yet been developed. We will, of course, comment at an appropriate time and we are confident that ISER will take a sound approach, based on their work to date.

5. STAGE I APPROACHES

We now turn to the merits of the MAP model of the Alaskan economy as a Stage I model for econometric end-use forecasting. Regional economic forecasting can take a variety of forms. Some approaches being considered in the "Detailed Work Plan" are input-output analysis, the economic base approach, Curtis Harris' locationally efficient model, and the Delphi technique. These all have strong and weak points but none is a serious contender to a moderately detailed econometric model like MAP.

What is required of the Stage I model? It must provide the number of consuming units in each class for the end use equation. That is, in the number of housing units of several types and the number of firms, employees, square footage, or business volume for commercial and institutional units. It must be sensitive to the scenarios of fast, likely, and slow growth mentioned in the "Detailed Work Plan". It must respond to changes in oil and gas pricing, energy and other major investment projects, national economic trends, and demographic realities including migration. Whiel the current MAP models incorporate most of the latter functions, the restriction of demographic projections to persons (not households or families), the introduction of housing only through the dollar volume of construction, and the lack of other physical measures of economic activity closely related to the number and type of consuming units <u>are major deficiencies</u>. As noted in the "Detailed Work Plan", data must be gathered and incorporated into new versions of MAP.

What regional techniques must be added? In our opinion none of the above mentioned techniques merit much effort.

Input - output analysis is appropriate when a region has a large industrial base which relies to a great extent on inter-industry sales. Alaska does not have such an economy yet, and the method's well-know data-intensity suggests that it need not be considered further. Shortcuts to true regional input-output data gathering -- such as the use of technical coefficients borrowed from other studies -- are inappropriate for an unusual state economy such as that of Alaska.

The strong points of economic base analysis -- a technique which is useful when the regional economy pivots on clearly defined basic industries -- are already contained within the MAP model. The simple economic base methods are too elementary; ISER is well beyond them already in its work. The same criticism holds for purely extrapolative methods. Just as ruler and graph paper are inappropriate for local forecasting, they are too simplistic for the economic part of econometric-end-use analysis.

Curtis C. Harris developed a regional forecasting model at the detailed industry level based on short time series changes in output by industry and state and incorporating transportation costs estimated by optimization techniques. Alaska clearly is not likely to exhibit consistent locational cost patterns of industrial development necessary to take Harris' approach.

Delphi, a technological and political forecasting technique developed first at the Rand Corporation is unlikely to yield the moderately detailed consuming unit forecasts needed here. However, it may always be considered for developing scenarios for energy projects, general ecomic growth levels, or energy policy decisions. Hence it is not a Stage I model but a source of exogenous and policy variable values for any forecasting method.

Among general methods for forecasting regional economic activity, one not yet mentioned is shift-share analysis. This method is based on statistical estimation of the contribution to a state's industrial growth of industry factors and regional factors. It is an excellent basic method which is sufficiently incorporated in a MAP-type econometric approach. While both input-output and shift-share methods are usually performed with a great deal of industry detail, such detail is not needed in our Stage I approach.

What is needed is more detail aimed at household characteristics and building stock characteristics. While data source end points for households are well-known and trusted, a region such as Alaska can have rapid and crucial post-Censal fluctuations in households and household size. As for buildings, only dwelling units are enumerated in the Census. Building stock estimates for non residential units are rare above the city level.[6.] Land use surveys and Civil Defense surveys give spotty data sets, but the building stock is basically an unknown quantity for regions such as states. For the current research, increased information on the building stock is important.

As an expedient it is suggested that housing be looked at in detail (so as to allow better end use forecasts for space and water, heating, lighting, and appliance loads); that large commercial and institutional uses be examined through enumeration of structures; and that the rest be treated by the use of employment or sales estimates.

Recent efforts by others in energy forecasting suggests two approches: 1) macroeconomic econometric models such as MAP, and 2) microeconomic simulations of consuming unit responses to changes in price, income and the availability of alternatives. The former is necessary to introduce national and major regional trends. The latter is used to discover what the distributional effects of new pricing and supply levels will be.

A study commissioned by a number of New York consumer groups and carried out at Cornell University was used in testimony before the New York State Energy Master Plan Meetings in September 1979.[7] In this approach, Green, Moung, and Saltzman utilized a four-sector economic/demographic state econometric model with a partially integrated energy sub-model. The four sectors were residential, industrial, commercial and transportation. All major energy types - electricity, oil, gas and coal - were forecasted simultaneously. This Cornell model as well as another model developed with end use detail by the New York State Energy Office, predicted significantly lower electricity requirements than had previous state plans. It should be noted that while the Cornell Model is not extremely complicated (57 economic equations, 150 demographic equations) it contains household formation functions for each age-sex cohort. Unfortunately the Cornell Model does not give explicit place in its structure to self-supply wood space heating, or conservation.

Furthermore, in the Cornell approach, a microeconomic simulation was linked to the macro model in order to relate income and price changes and restrictions on fuel supply to consumer demand for the different fuels.[8] This, of course, requires an extensive data base of individual households studied by survey research methods. In this case a sample of 7000 households was utilized.

While such microsimulation may be beyond current possibilities in evaluating Susitna (and we are not convinced that such further study should be considered extravagant) it suggests again the need to make the energy forecasting version of MAP more oriented to consuming units, <u>households</u>, and to the biggest devices of all, <u>buildings</u>.

Looking in more detail at MAP, based on the May 31, 1979 documentation, we note that it has more than enough economic detail, but not enough demographic information because of households not appearing explicitly. Finally a housing and/or buildings component is lacking; this is a critical shortcoming.

In the "Detailed Work Plan" we support most strongly Items A 7 - 9 on electricity consumption; Item 10 on households, houses, and appliances. These are more important, in our estimation, than the refinement of the MAP economic model <u>per se</u>. They should receive top priority.

Regional disaggregation (Task B) is important, but less so than getting on to EEU forecasting for the Railbelt region as a whole. Thus the Items in D are crucial -- interfuel substitution <u>plus</u> the addition of conservation.

A general evaluation of the MAP models serves to reveal several strengths in addition to the above shortcomings. First despite the limited length of the Alaska data series, the resulting equations are adequate by conventional statistical benchmarks, at least for forecasting use. The detailed fiscal and native/non-native/ military results, needed for earlier applications, are well developed, but may not be particularly helpful in the current application.

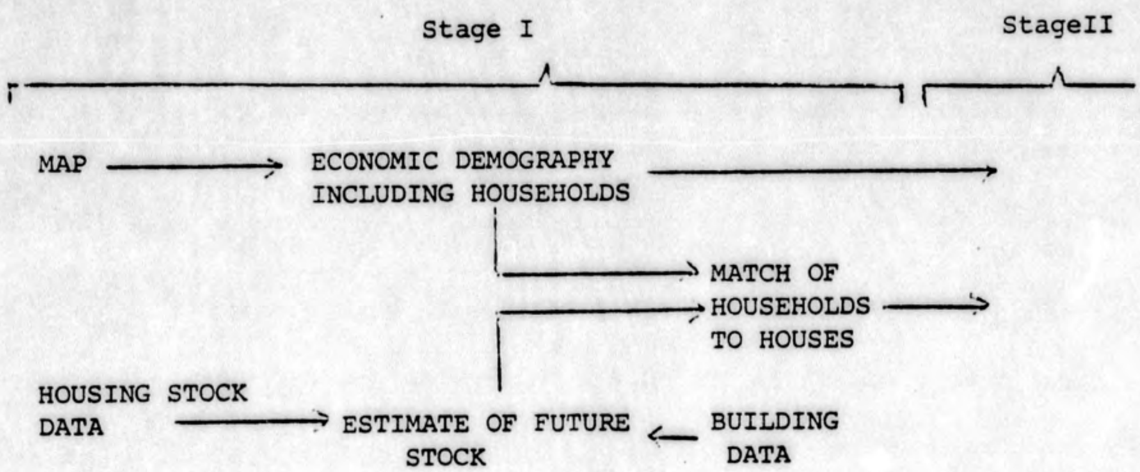
What is needed, more than any other modification, is a housing sub model. Whether the data can be gathered for such an addition remains to be seen. Lacking a formal housing model, some intermediate step is required based on the housing stock data from the decennial censuses. A brief outline of each alternative is in order.

A full-blown econometric sub model for housing would flow from the following modifications to MAP:

1) inclusion of household formation equations in the demographic sub model
2) a set of equations for the housing stock (or alternatively changes to that stock) by age and type of unit.

Some of the crucial right hand variables would be from the construction and investment functions of the economic model as well as the household formation results.

If the time series data are lacking for the housing modifications to MAP, then the available census benchmarks -- number of dwelling units by age and type -- should be combined with recent data on housing starts, mobile home sales, building permits, etc., to update the distribution of the housing stock. This results in the following structure:



6. CONCLUSIONS

Energy demand forecasting, the most crucial element of energy policy development, is difficult in the face of growing uncertainties. In order to maintain confidence in forecasting procedures, the analyst is faced with the need to develop what amount to relatively more sophisticated models and forecasts than has traditionally been the case.

Pure econometric and pure end use forecasts suffer inadequacies; hence, a blended approach combining the best elements of each is necessary. This blended EEU approach is difficult because of its data requirements and because modifications must be made to the structure of the underlying econometric and end use models on which it is based.

In the long run, an EEU forecasting system for Alaska can be developed with MAP, suitably modified, at its heart. Its data requirements are not yet attainable in a small region such as Alaska with a short data history. Therefore, in the short term, ad hoc forecasting must be carried out with the outputs of the current version of MAP. These outputs must be obtained by using a very wide range of input scenarios.

The most crucial shortcoming of the current version of MAP is the lack of a housing sector and this must be bridged by some reasonable if imperfect method of estimating Alaskan housing stock and characteristics in recent years.

7. FOOTNOTES

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1. Joan Robinson, "What are the Questions?", Journal of Economic Literature 15, December, 1977, p. 1322.

2. These are an extremely expensive and sophisticated version of semi-log paper. See Herman Daly,"Energy Demand Forecasting: Prediction of Planning?", Journal of the American Institute of Planners, January 1976.

3. Robert W. Shaw Jr., "New Factors in Utility Load Forecasting", Public Utilities Fortnightly, July 19, 1979, pp. 19 - 23.

4. Much as Dr. Goldsmith's is a stock/flow approach to accounting for demand.

5. M. A. Fuss, "The Demand for Energy in Canadian Manufacturing: An Example of the Estimation of Production Structures with Many Inputs", Journal of Econometrics 5, January 1977, pp. 89 - 116.

6. B. Jones, D. Manson, J. Mulford, M. Chain, The Estimation of Building Stocks and their Characteristics in Urban Areas, Program in Urban and Regional Studies, Cornell University, 1976.

7. W. Greene, T. Mount, and S. Saltzman, "Forecast of the Demand for Major Fuels in New York State 1980 - 1994", Technical Report, September 4, 1979.

8. S. Caldwell, W. Greene, T. Mount and S. Saltzman, "Forecasting Regional Energy Demand with Linked Macro/Micro Models", Working Paper in Planning #1, Department of City and Regional Planning, Cornell University, January 1979, forthcoming in Papers of the Regional Science Association 45.