THE NEMS CONFERENCE

BUILDINGS DEMAND PANEL

February 1, 1993 - 10:00 am

PANELISTS:

Mark E. Rodekohr, Moderator
Edward J. Flynn, Presenter
David Belzer, Reviewer
Howard Geller, Reviewer
Paul S. Komor, Reviewer

AUDIENCE PARTICIPANTS:

Lynda Carlson
David Porter
Walter Short
Jim McMahon
Frances Wood
Steve Burnow
David Chien

EIA

PROCEEDINGS

MR. RODEKOHR: I think it's about time we went ahead and got started now.

My name is Mark Rodekohr. I'm the Director of the Energy Demand and Integration Division at the Energy Information Administration.

I think we've got a very good panel today. Presenting our model structure will be Ed Flynn, here to my left. Ed is the Chief of EIA's Energy Demand Analysis Branch, and oversees the demand sector analysis and model development for the National Energy Modeling System.

Our three reviewers are Howard Geller, who is the Executive Director of the American Council for an Energy Efficient Economy, and has been with that organization since it was established in Washington. He's authored a number of books on energy efficiency, and it should be very interesting to hear his remarks.

In addition, furthest on my left is Paul Komor, a Senior Analyst at the Congressional Office of Technology Assessment. He's authored a book called "Building Energy Efficiency, 1992," and he used to work at the Electric Power Research Institute.

And, last, but not least, is David Belzer, a Senior Research Economist at the Pacific Northwest Laboratories in Richland, Washington.

Before we start, I have a couple of requests to make. First of all, I would appreciate it if you would hold your questions until the end. Then when you do have a question or a comment, we will pass around a microphone; please identify yourself, since we are making proceedings, and speak into the microphone.

So, with that, I'd like to introduce Edward Flynn, who will give you an overview of our modeling.

MR. FLYNN: Thanks.

The Building sector comprises all the buildings and appliances in the residential and commercial sectors. The composite sector of residential and commercial accounts for over 35 percent of all domestic energy consumption and 60 percent of electricity.

The NEMS system itself is made up of 13 component modules that represent the macroeconomic, international, integrating, energy supply, energy conversion and the energy demand components of energy markets.

Shown at the top right-hand side of the slide, the buildings sector is represented by two models, the residential sector energy demand module and the commercial sector demand module. The models and the integrating software are written in FORTRAN and run on the EIA mainframe.

The models obtain inputs of macroeconomic drivers and fuel prices via the integrating

Buildings Demand
in the
National Energy Modeling System

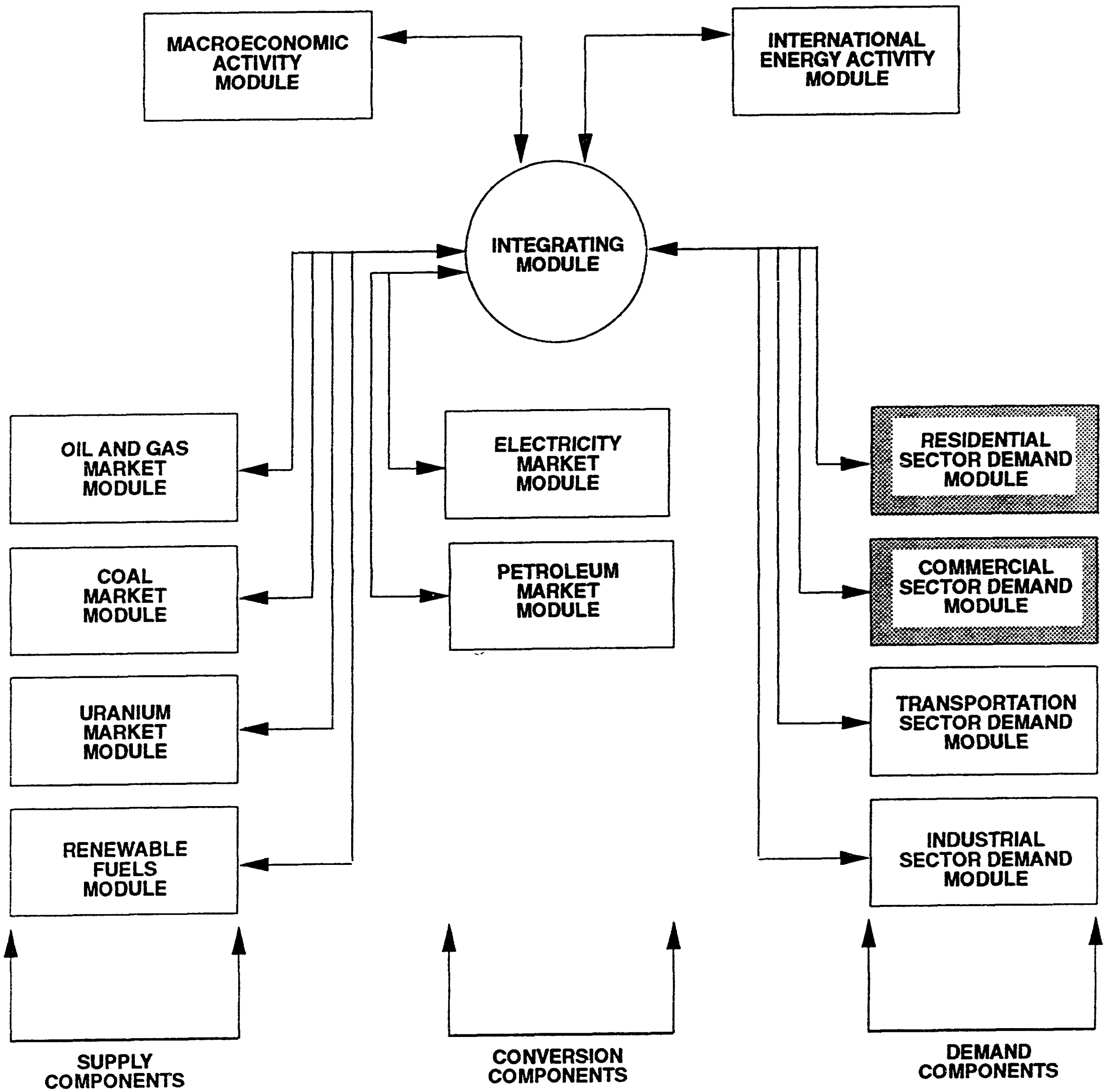
138

Edward J. Flynn
Energy Information Administration

EIA

February 1, 1993

Buildings Sector Demand in the NEMS



model, and respond with fuel demand estimates via the integrating model. This process takes place in each model, both the residential and commercial, on a yearly basis as the overall control program checks for market equilibrium.

Baseline data for the models will be provided by two EIA sectoral consumption surveys, the residential energy consumption survey and the commercial building energy consumption survey.

A technique called conditional demand analysis has been applied to regional data from these surveys, in order to derive consumption estimates for each end use, that is, heating, cooling, water heating, lighting and other services.

The primary objective of NEMS is to support energy policy analysis. Policy analysis is concerned with the several key subject areas. Energy requirements must be known in terms of supply, demand and prices on a year-by-year basis for a period of 25 years, through the year 2015.

Economic outcomes of any policy vary across energy sectors.

Expenditures for primary energy and electricity in the buildings sector exceeded $188 billion in 1990. Various analyses have concluded that energy consumption and expenditures can be reduced significantly through the adoption of cost-effective measures.

Environmental outcomes require a knowledge of fossil fuel emissions, carbon, carbon monoxide and carbon dioxide, as well as sulphur oxides, nitrogen oxides and volatile organic compounds.

The building models will calculate only the direct emissions that are associated with fossil fuel and renewables consumption. Emissions that are associated with the consumption of electricity are tracked by the electric utility models.

Energy security or vulnerability is often evaluated by policy analysts in terms of the level of energy imports. Currently, 40 percent of petroleum supply, and over ten percent of natural gas supply, come from imports. The share of imports is projected to increase substantially over the next 20 years. Policies directed at conservation and greater use of renewable energy offer two means of reducing import dependence.

Finally, legislation such as the recent Energy Policy Act of 1992, which we are calling EPACT, will change the path of energy consumption in the building sector. EPACT has provisions that are directed at building codes, DSM, and for the first time efficiency standards for the commercial sector.

Other legislative proposals concerning energy consumption taxes, carbon taxes, and import fees are under consideration.

One purpose for the building sector models is to project overall consumption trends and to develop business-as-usual baseline forecasts, against which policy measures can be evaluated.

Overall Objectives for Buildings Sector Models

- Support policy analysis in the areas of:
- Energy Requirements
- Economic Outcomes
- Environmental Outcomes
- Energy Security
- Effects of Energy Legislation

OIAF 1/93

Over time, energy consumption in the building sector grows at about one half the rate of GNP. Regional factors and increasing appliance saturation rates contribute to a somewhat higher growth rate for electricity. Policy measures seek to reduce the growth rate of energy demand and change the fuel mix.

It's important to determine the technical potential that conservation and new technology represent to reduce energy supply requirements. There have been a number of estimates that phasing in the implementation of cost-effective technologies could save 25 to 40 percent of energy consumed in the building sector.

A critical question concerns the allocation of scarce research and development funds among a set of candidate projects. R&D support can increase the extent of technical improvement and speed the rate of adoption of new technologies.

Government incentives can take the form of such measures as tax credits and energy efficient mortgages, or simply take the form of public recognition of conservation efforts, such as the EPA's Green Lights Program.

Information programs, such as facts sheets, public service messages, and appliance labels, all serve to alert consumers to the potential savings from energy efficiency. Although there is no direct way to incorporate these measures in a model, it may be appropriate to reflect such programs as adjustments to consumer discount rates.

There are numerous federal, state and local government programs in the form of standards or building codes, both mandatory and voluntary, that establish floors in energy efficiency. These will be implemented in the models in time blocks that correspond to the specific years that they take effect.

Demand-side management programs have grown in scope and number in the recent years. They are intended to encourage energy savings and peak load reductions via rebates, audits, low-interest loans and load control programs.

The use of dispersed renewable energy in the form of wood, solar and geothermal, offers important benefits in terms of oil displacement, supply diversification and pollution reduction.

The building models must respond to these policy analysis requirements. They provide a structural representation of their sector. They are designed to project, not only overall fuel consumption, but also the end uses to which the fuels are consumed.

In addition, the models keep track of the composition of the stock of buildings and appliances by vintage group, in order to provide a means of properly accounting for the effects of stock turnover. Federal appliance standards are incorporated in the technology menu as efficiency floors for each end use. As a result, it will be possible to estimate the likely effects of future revisions to the standards.

The initial implementation of the model will be designed to reflect aggregate rates of

Buildings Sector Policy Questions

- Consumption Trends
- Technical Potential for Conservation
- Research and Development Targets
- Role of Government Incentives
- Need for Information Programs
- Impacts of Building Codes and Appliance Efficiency Standards
- Demand-Side Management
- Renewable Energy

Building Sector Model Capabilities

- Structural representation of end-use demands
- Federal appliance efficiency standards and impact of improved thermal integrity
- Life-cycle cost decision-making
- Impact assessment of advanced technologies
- Demand-side management programs
- Dispersed renewables evaluation

improvement in thermal integrity. In subsequent versions of the model, we intend to make use of studies that are based on engineering models, such as DOE 2 and ASEAM, that are applied to prototype buildings.

The models use a form of life-cycle cost decision-making to reflect the method by which consumers choose among different energy saving technologies. In general, this methodology assumes that there will be a tradeoff made between incremental first costs and future energy savings, and that equipment purchase shares will reflect the relative life-cycle costs.

There are already a number of advanced new technologies that are on the market or assumed to be cost effective. As they are identified, the building sector models will be able to incorporate these technologies within the appropriate end-use sector.

The building sector models will communicate with the load-and-demand-side management sub-module of the electricity market module to incorporate estimated impacts of customer participation in demand-side management programs. The linkage will involve sharing or passing information between modules regarding technology characteristics, market size and participation rates.

Dispersed renewables will be included as technology options within specific service categories, and competed where appropriate with conventional technologies. It will be necessary to consider regional factors that relate to the technical performance and market size for these renewable technologies. Consumption of renewables will reduce the size of the market that will be shared among the fossil fuels and electricity.

Market share determination is a significant problem in the buildings models. Technology choice decisions determine the characteristics of future building and equipment stock and play a major role in determining the path of future energy demand.

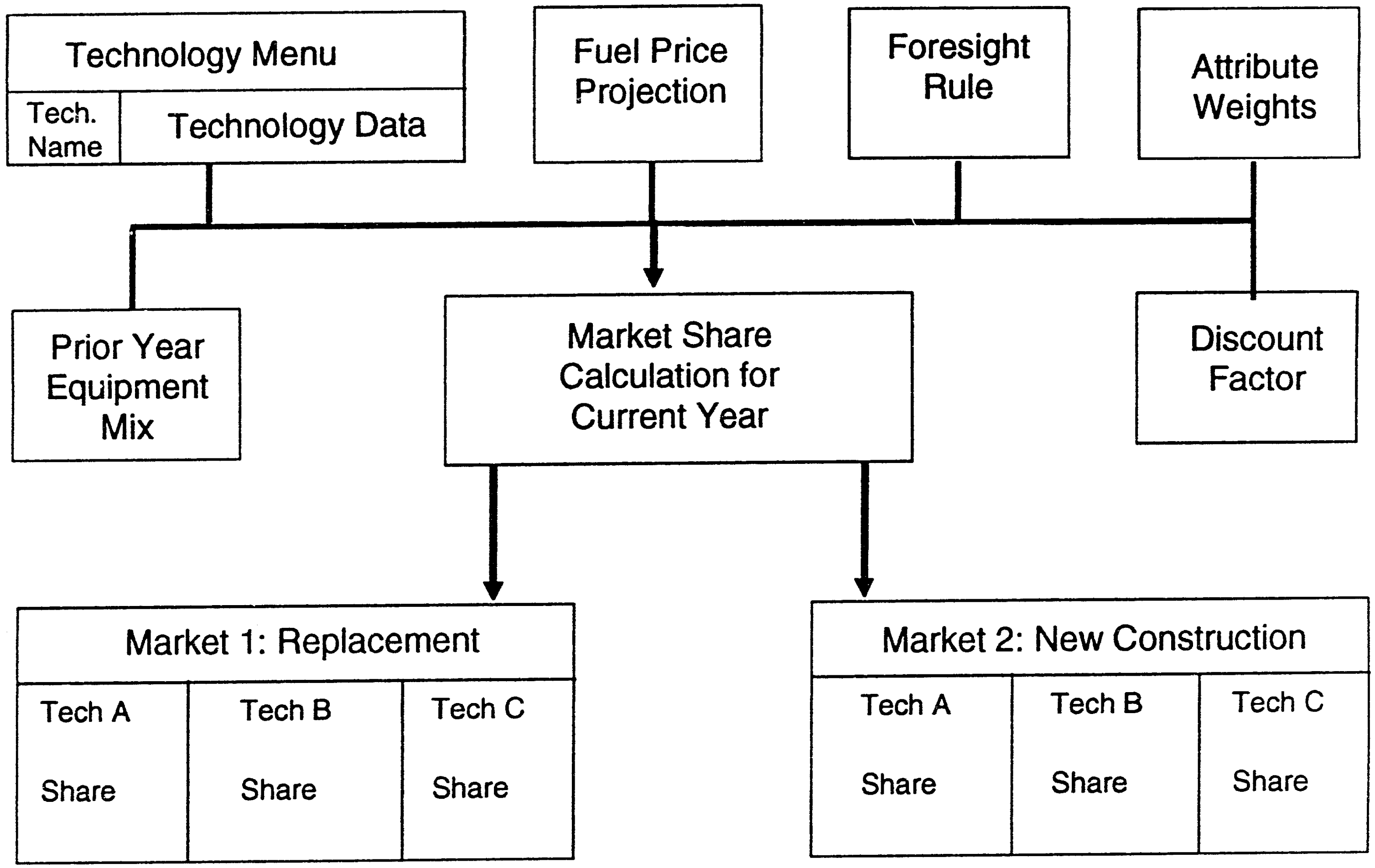
For this reason, the building sector models are structural and capture key activities and decisions that are made in each market in each year. Purchase decisions by consumers determine how stock efficiency characteristics change over time, and there are a number of programs and policies that are directed at influencing such decisions. Most notably these include, federal efficiency standards and utility DSM programs.

Each year, four types of events occur in the building sector that change the composition of the stock. There is replacement of equipment that fails, there is new construction, there is demolition of existing buildings, and retrofit of operational stock.

For convenience, this slide shows just two of these events, which constitute markets. Replacement and new construction are down at the bottom of the slide. Each situation represents a different market with different consumer priorities and different market shares.

Some of the factors that affect technology choice are shown at the top of the figure. Prior year equipment mix appears in the upper left-hand corner. Consumers often stay with proven and less-expensive technology. They are uncertain that advertised savings will be achieved. They are concerned about the operating reliability and are often resistant to change.

Market Share Determination



OIAF 2/93

Some sections of the model will use a partial adjustment formulation to reflect this tendency.

The technology menu provides a full description of the choices that are available, including the initial cost and efficiency.

Another factor in the technology choice are the fuel price projections, which are received from the integrating model. Associated with the fuel prices is a "foresight rule," which specifies the degree to which a market uses past and current information to form opinions about the future. If the foresight is myopic, then stock decisions are based, essentially, on current prices, a very conservative strategy. If they are adaptive, it assumes that decisions are based on trend extrapolation of current prices. In perfect foresight, the decision-maker acts to reflect foresight concerning future prices. If he believes that there will be definitely a price increase over time, he will react and, therefore, pick more efficient technology earlier in the game.

Attribute rankings describe the relative importance of technology attributes, such as first costs, reliability, warranties and so forth. A discount factor is used to reflect the time value of money.

Other factors that influence consumption will be things such as utility demand-side management programs. They are offered by electric and natural gas utilities, and they provide rebates and other incentives that affect technology choice. Consumers in a DSM-eligible market can face a different cost structure for certain technology decisions.

The modeling effort considers the interplay of all these factors in the determination of the market share for each of the competing technologies.

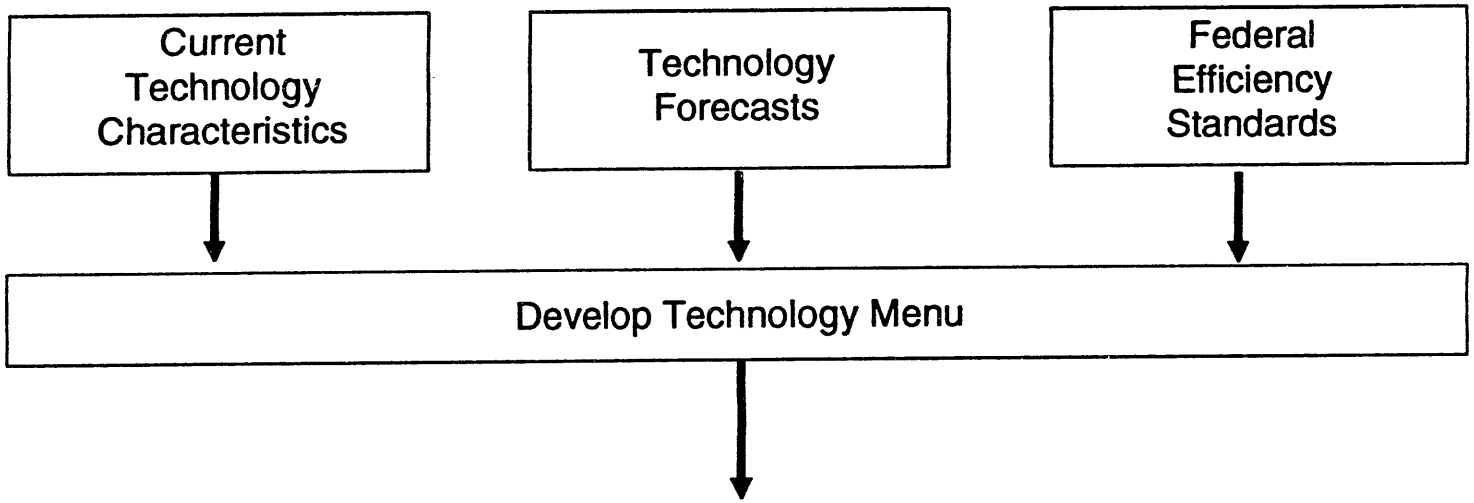
We use a technology menu in the overall models, in each model. The way these are developed is that current technologies represent a baseline set of choices that are initially available. Technology attributes and availability will change from base year values on a year-by-year basis. Technology forecasts will be developed exogenously and in concert with other offices in DOE and in the national laboratories, in order to project where efficiencies are heading in the out years. Federal efficiency standards will set floors for efficiency in the future years.

Since NEMS will produce forecasts through the year 2015, it's necessary that the technology menu (the array of possibilities) changes over time, reflecting internal judgment as to the pace of the technological progress and the future path of standards.

The building sector models have the capability to represent the phased introduction of new technologies. These technologies are directed at different energy services. The developer of any new technology faces the problem of identifying the market and building customer acceptance. It can take a long time for technology to sell itself.

Among the new technologies in the sector are compact fluorescent lamps, which will ultimately replace incandescent lamps that now dominate the residential sector. They use one fourth the electricity and have a lifetime that's ten times as great as incandescent bulbs. High first costs have slowed their market penetration, even though they are cost effective in many

Technology Menu Development



Technology Menu					
Technology A	Constant Data	Year by Year			
	Fuel				
	Availability	—	X	X	X
	Efficiency	—	.90		
	Cost	—	1000	900	800
Technology B					

Buildings Sector Model New Technologies

- Compact fluorescent lamps
- Ground-source heat pumps
- Solar water heaters
- Thermal shell improvement
- Heat pump water heaters
- Condensing furnaces

applications.

It is interesting that in Japan, where residential and commercial sector electricity prices are substantially higher than in the United States, compact fluorescents have already won a larger share of their markets than the share that incandescent bulbs hold.

Other new technologies include ground source heat pumps, which circulate working fluid through pipes that are buried in moist soil or near outside water, rather than exposed to outside air. These heat pumps have higher first costs, but energy savings can make them economic in many regions.

Solar water heating, a more established renewable energy technology, could have a resurgence with better technology, higher electricity prices in some regions, and emphasis on renewable energy.

Thermal shell improvements, in the form of advances and upgrades that are being made to windows, insulation and building codes, improve shell integrity. These improvements will not only reduce operating energy costs to provide the same level of service, and will often permit down-sizing of the capacity of heating and cooling units.

Other technologies of interest that are of an advanced nature are heat pump water heaters and natural gas condensing furnaces, which offer efficiency levels on the order of 97 percent compared to the current standard of 78 percent. The down side of considerably higher first costs has slowed market penetration for this technology as well.

I wanted to show you some of the items that are on the technology menu, which is designed to store about ten different elements for each technology. Some will be constant, such as technology type and fuel, and others will vary across time. To the extent that other attributes can have a significant impact on technology choice, they can be included in the menu.

The menu contains a basic set of identifiers for the technology, including the service, heating and cooling, fuel and technology, resistance heating or heat pumps. The identifiers are followed by a set of attributes, such as capital or first costs, which is expressed on a per unit or a per square foot basis.

Maintenance cost and reliability -- initially at least, some of the advanced technologies have higher maintenance costs than currently available technologies and these attributes must be factored into any kind of decision process.

Efficiency levels, along with energy prices, determine the cost of energy consumed to meet a given service level.

The year of availability is important because it is used to permit the introduction of new technology at a future date.

Equipment life determines the fraction of equipment that reaches the end of its useful life in each year. It is used in conjunction with vintage data to calculate the number of replacement

Technology Data Menu

End-use service

Technology type

Fuel

Capital cost

Maintenance cost

Reliability

Efficiency

Year of availability

Equipment life

Base year saturation

units of equipment that will be purchased.

And finally, base year saturation, which provides a jumping off point for the model, as well as data for partial adjustment purposes.

Just a word about the federal efficiency standards. Over a dozen types of equipment are already covered in the residential sector. The recent energy bill extends coverage to the commercial and industrial sectors, and includes lighting and electric motors. Given the extensive array of makes and models of appliances that are associated with each service, it is a significant analysis modeling task, to find a way of grouping these technologies into manageable bundles and project the effects of standards on overall efficiency levels.
as well as data for partial adjustment purposes.

The building sector models are now operating as prototypes within the integrating system to test the essential intermodule linkages. We are currently concentrating on final specification and coding of technology choice algorithms and the assembly of the initial database for the technology menu. The target date for completion of a fully operational version of both modules is April 30, 1993.

Thank you.

MR. RODEKOHR: Thanks very much, Ed.

Now that you've seen what we're going to do, we'll now have three reviewers tell us either how we are doing it wrong or how we can do it right.

And, with that, I'd like to start with Howard Geller from the American Council for an Energy Efficient Economy.

MR. GELLER: Thank you, Mark and Ed.

First, I'd like to just make the general comment that in reviewing the material, at least on the building module in this overall model, and looking at some of the other material, I'm quite impressed with the goals and the approach that's being taken and the general level of sophistication. It's clearly an impressive piece of work. If it will do everything that's being called for then I think we'll have a very valuable modeling tool, something that I think should have been done ten years ago. I certainly would have liked to have had this kind of a tool when the National Energy Strategy was developed. The proposals would have been a lot more tied to technical and economic merit and less tied to ideology, if we had this kind of a model.

I have about five or six specific comments on what I saw in the building module. First, I think there's clearly a high degree of sophistication with respect to technology choice in this module. But there is another part of the equation that I saw less attention devoted to, and that is the area of usage rates and service levels, how much space heat, how much space cooling, how much hot water is being demanded or is predicted to be demanded over time.

There are a range of technologies that can affect usage and service levels. For example,

National Appliance Energy Conservation Act

- Refrigerators and Freezers
- Room and Central Air Conditioners
- Water Heaters
- Furnaces
- Dishwashers, Clothes Washers, and Dryers
- Direct Heating Equipment and Pool Heaters
- Kitchen Ranges and Ovens
- Television Sets
- Fluorescent Light Ballasts

low-flow showerheads and faucets are part of the recent Energy Policy Act. There will be maximum flow rate standards taking effect in the future, which should limit hot water use and reduce hot water use over time as they work their way into the building stock.

Obviously, behavior affects service levels and usage levels and can be affected by policies as well as just social and cultural changes over time. Thermostat settings can change, air conditioning can be affected by things like time-of-use rates, or even technologies. In our house, we put in ceiling fans recently, and I think we use our air conditioner a lot less in the summer with the fans going in the bedrooms.

My second comment, kind of a detailed comment, in reviewing the commercial sector model I thought, perhaps, there needs to be a consideration of rehabilitation of commercial buildings. It's not just new construction as an option for bringing in efficiency, there's something in between new construction and retrofit when a new tenant takes over in a commercial building, or even an existing tenant wants a major rehab. There's an opportunity available in such situations to upgrade efficiency at fairly low additional cost.

My third comment pertains to the analysis of policy options. There's clearly a lot of attention being given to this, and I think that's a reasonable and correct priority. It is important to have a model like this that can come up with some kind of estimate of impacts of various policy proposals. I think a lot of attention is being given to the different kinds of policies. Ed talked about the ability to model DSM programs, and codes and standards, and also information programs such as the EPA Green Programs.

There are a couple of other categories of policies that I think will be important to build the capability to analyze into the model. First of all, I think incentives need to be generalized, that it's not only DSM programs run by utilities. I think there's a need to allow for a whole range of market incentives, whether it be higher energy prices or some other market policy. There's some discussion of variable fees and rebates which can be applied, of course, to automobiles, but possibly even to buildings. There has been very limited adoption so far but, perhaps, more adoption in the future of sliding scale hook-up fees depending on the efficiency of new buildings.

Likewise, in the area of education/ information/persuasion type programs, there are a whole range of programs in addition to the EPA Green Programs recognizing companies that adopt a high level of cost-effective efficiency measures. There are also home energy ratings and energy efficient mortgages, for example. I think what EIA has suggested, the idea of modifying the implicit discount rate in the model is a logical way to approach modeling of consumer response to these kinds of initiatives.

I think there ought to be a way to estimate the impacts of accelerated R&D. That is one of the policy options that exists, and there's obviously a lot of guess work involved in what kind of response you get from R&D, but in terms of advancing the technology options that come in through the technology menus, that would be one way to handle it.

And then finally, there needs to be a way to account for interactions among policies. If you are going to model an aggressive energy efficiency scenario, where you are simultaneously offering incentives, and education, and bringing in standards that improve over time, you need to be careful not to double count savings.

EPA will be accounting for all the energy efficient lighting being put in as a response to Green Lights, and DOE will be saying it's a response to national standards, and utilities will be saying it's a result of their rebate programs, and you can't give everybody credit.

More generally, in the area of consumer behavior and consumer choice, what I saw seems to be a highly economic approach to modeling consumer choice through implicit discount rates and minimization of life-cycle cost.

I thought, perhaps, there needs to be some further development and integration of non-economic approaches to consumer behavior and consumer response. There's a vast literature showing that very few consumers, if any consumers, go through calculations determining what their discount rate is and minimizing life-cycle costs. There are all kinds of other models that have been developed by sociologists and social scientists on consumer choice, EIA should consider using either initially or later down the road, a more sophisticated, perhaps, stochastic approach, where you have the market segmented into different types of consumers, the environmentalists, and the risk avoiders, and the hassle avoiders, and so forth.

I know a number of utilities have done this kind of a modeling, and it's a combination of the sociological view of the world and the economist's view of the world, possibly using different kinds of implicit discount rate assumptions and different categories of consumers.

And then finally, I was asked to think about uses for the model and what other possible applications there might be for this kind of a model. One thought I had was to consider allowing the model to be used to back out from certain assumed goals and to ask and then answer the question, what will it take to get there, in technical and economic terms -- technical actions and economic feasibility, and then policy requirements.

For example, I could see policymakers saying, okay, let's agree to freeze CO_2 emissions by the year 2000, and then begin to cut them back from, let's say, 1990 levels as we move into the next century. What would it take to get a 20 percent reduction in CO_2 emissions from fossil fuel combustion, say, by the year 2010 or 2015? The analyst could then push some buttons in a model and come up with a couple of paths for achieving that kind of an objective.

Another potential application that I see, which I think goes beyond the buildings module but I'll throw it out anyway, is to get into the area of employment and income impacts from different scenarios, to build into the macroeconomic side of the model either an input/output segment of the model or some other way of modeling employment levels over time.

Clearly from the news these days, there's a lot of interest in dealing with our persistent unemployment problem, and I think that that's an area that's going to get attention for many years. The ability to show what kind of effects you have on employment from different scenarios and different policy interventions, I think, would be very useful.

I appreciate the opportunity to comment, and I look forward to seeing this system out on the street, as I'm sure lots of other people do as well.

Thank you.

MR. RODEKOHR: Thank you, Howard.

Next, I'd like to ask Paul Komor to give his remarks. He's from the Congressional Office of Technological Assessment.

MR. KOMOR: Thank you, gentlemen. A few introductory comments. My name is Paul Komor. I'm with the Office of Technology Assessment.

OTA, usually known by its acronym, because Office of Technology Assessment takes too long to say, is a small, analytical support agency of the U.S. Congress, generally, with a pretty low profile. That's been spoiled in the last couple weeks as we lost our Director to the new Administration, but our general role is to support policy by doing analyses of new technologies and policy options related to those technologies.

We've been doing a fair bit of work in energy over the years. I think the reason I'm here is that we did a report last year called "Building Energy Efficiency," which was intended to provide some support for the negotiations which resulted in the Energy Policy Act of 1992.

Before I talk about the two substantive issues I want to raise, I wanted to echo some of Howard's comments. I was quite impressed with the documentation, as well as with the process that is being used. It seems to be a very open process, a lot of open discussion, meetings such as this, and I think that's a much better way to go then to close a bunch of modelers off in a room and tell them to come up with an ultimate model. So, I'd just basically like to thank DOE and EIA for allowing so much public and even congressional interaction in the process of coming up with the NEMS.

Okay, enough kind words.

There are two issues I want to bring up. One relates to behavioral modeling methods used by NEMS as described in the reports, and the other relates to how well NEMS will be able to answer policy questions, at least policy questions that we see on the congressional side.

I'll talk briefly about the first issue. If you have the handouts, I switched the order, so you'll have to go to, I think, the third page. Again, this is echoing some of Howard's comments. The question is, are the behavioral modeling methods used by NEMS descriptively accurate?

As Howard pointed out, the behavioral assumptions seem to be based on economic theory and econometrics. I'm trying to avoid a debate whether economists are good or bad people. The point I want to make is, in all the work that I've seen and some of the work I've done, the life-cycle cost minimization is not an accurate descriptive model. It doesn't well capture what people actually do. There's a lot of evidence on this, and I think this has all been discussed. There's evidence on some of the factors that influence choice, that is consumer choice, a

Modeling the Buildings Sector: The Congressional Perspective

Paul Komor
Office of Technology Assessment
U.S. Congress

February 1, 1993

Two issues of concern:

1. Will NEMS be able to help answer policy questions raised by the Congress?
2. Are the behavioral modeling methods used by NEMS descriptively accurate?

Issue 2. Are the behavioral modeling methods used by NEMS descriptively accurate?

<u>Inconvenient but true:</u>

-Life-cycle cost minimization is not an accurate descriptive model

-Many factors influence choice:
- -First cost
- -Perceived operating cost
- -Discounting method
- -Hassle Factor
- -Perceived time requirement
- -Familiarity
- -Ease of use
- -High tech. appeal
- -etc.

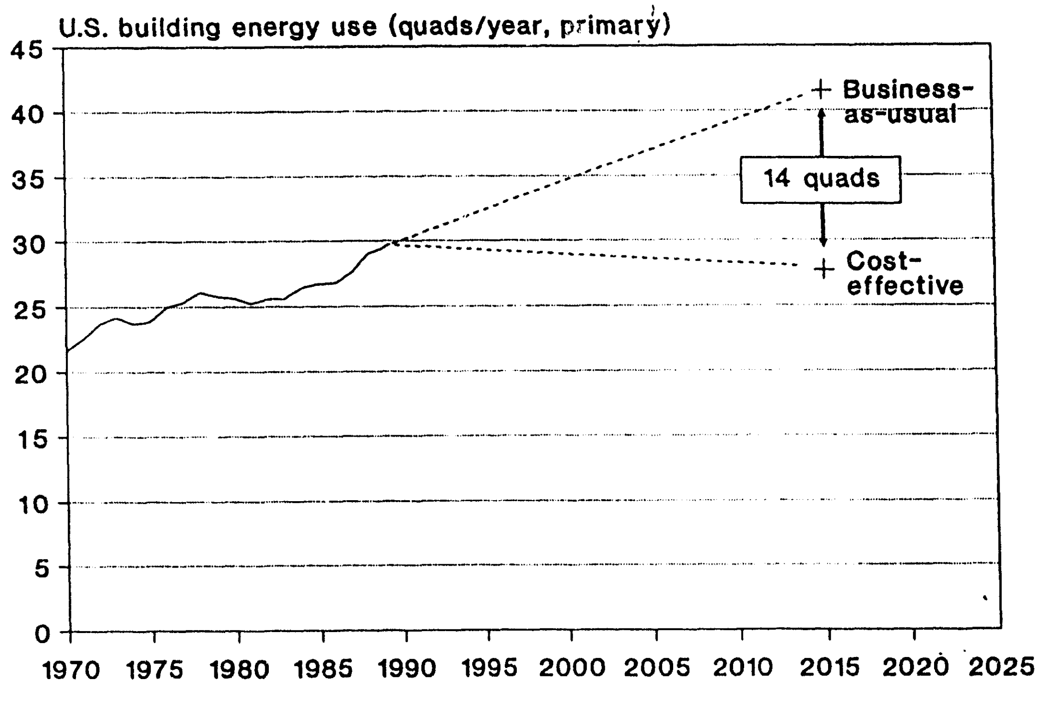


Fig1-14

consumer making a decision.

First cost matters; certainly operating cost matters as well; the discounting method matters. A lot of other things matter as well, such as the hassle factor, the time requirement, how long it takes to get it done, whether it is a familiar technology, how easy it is to use, whether it has some kind of high-tech appeal. There are a number of factors here that influence choice. It's not well understood how they interact, how people trade them off, but they certainly matter, and I think to ignore them is to have a model that won't be descriptively accurate, that is, won't predict or model well what people actually do.

Let me just mention some work we did that's in support of that point. These are some estimates we did last year on building energy use, and we had a couple of scenarios, a business as usual scenario and what we defined as a cost-effective scenario that basically said, if people were life-cycle cost minimizers, what would happen?

If you'd like to, we can argue about these numbers. They were estimated prior to the Energy Policy Act, so I know they are wrong.

The point I want to make is that there's a big gap between cost effective and business as usual. This, again, is in support of the point that people don't behave like life-cycle cost minimizers, and if they did we would be on a very different trajectory.

I just happened to notice that the exit signs here look to be incandescent, and for those of you who have done analyses of lighting, the paybacks on a conversion to a fluorescent or an LED system would probably be on the order of months. That's not to criticize the hotel, they have good reasons for doing what they do, but they are clearly not life-cycle cost minimizers either.

To get into more specifics about the behavioral assumptions behind the model, let me talk briefly about the commercial module model. My understanding of the way it will be modeling behavior is, it allows for three behavioral rules.

A decision-maker can minimize life-cycle costs, can use the same fuel, and then within that constraint minimize life-cycle costs, or could use the same technology regardless of costs.

Let me raise a few questions that one could consider to improve this. Again, the goal here is to come up with a model that's descriptively accurate, that well predicts what people actually do.

There could be additional behavioral rules. If you are going to pick one rule that would predict well, it would to be to minimize initial costs. I think that very often happens in commercial buildings, especially in rental buildings.

Another behavioral rule that might make more sense is to use the dominant technology in the region, especially if it's installed by a contractor. This is probably more true in the residential sector. They tend to put in what is normally put in, regardless of costs within bounds.

Another behavioral rule could be to use the same fuel and then minimize the initial costs.

I wanted to raise a few other points. It wasn't clear to me from the documentation, given that you have a set of behavioral rules, how you decide if a certain segment of the market uses one rule or another.

Is there a continuous range of efficiencies within a technology? If you look at the data, for example, for furnaces, it's fairly discrete where you have some clumped in the 80-85 percent efficiency, and then you have the very high 94-97 percent efficient units. Does the market assume a continuous range, or does it assume some kind of lumpy distribution of possible efficiencies?

The data source for actual costs is something we struggle with a lot. We ended up using the Sears Big Book, which as you probably know is being discontinued, so we are going to be in trouble, but it's very hard to get accurate data on actual retail true costs -- I mean, you can go to the store, but that's only a sample of one, so that's something to be concerned about.

The discounting method: along with life-cycle cost minimization being a lousy descriptive model, I suspect discount rate is as well. You could imagine people dealing with the problem of future cash flow in a lot of other ways. You could use a simple time horizon: I'm going to cut everything off at three years. You could use a payback model, which is basically the same thing. You could have a non-linear discounting. For example, everything in the first three years I'll discount 5 percent, after that I'm going to discount it 50 percent. I don't know what the best model is, but I think what someone needs to do, and some people have done a little bit already, is to get some data and try to figure out what the best model is, again, with the intent of predicting actual choice as opposed to optimal choice.

The general observation is, the goal is, to predict the actual choice, not the optimal or best choice as defined by someone else. The empirical calibration and evaluation is critical. What really has to happen is, if you come up with some ideas about discounting, about the behavioral rules, to get some data and see whether they predict people's actual behavior. If we can do that, I think the model would be that much stronger.

A few comments on the residential module. My understanding is that in phase one, the model assumes that consumer choice is a function of three attributes or factors: initial costs, operating costs, and a discount rate. The functional form of the model is a logit. I have the binomial one here. The multinominal basically looks the same, but it's an even uglier equation than this one.

I don't think the functional form is as important as the way it's estimated. In phase one, your relevant variables, as far as I understand, are the operating costs, initial costs and discount rate. The first question I would raise, why those things, why not other things? Do we have evidence suggesting that those things will predict actual choice, and will accurately model consumer behavior.

The A's and B's, that is, the coefficients -- are they empirically evaluated? What is the basis for the numbers in the equation? Do we have data on people's actual choices. Have we tried to model them, and have we both empirically estimated them and evaluated them? And, if the answer is yes, how well did it do?

This is a logit formulation; the commercial model uses decision rules. I don't know which one works better. I would hope that there is some evidence somewhere suggesting that these approaches are appropriate for those two sectors. Again, I'm making the same point, and I'll stop beating it into the ground--The goal is to predict the actual choice, that is, what people actually do, not an optimal choice, and more effort could be made on empirical calibration and evaluation of these models.

Let me jump to a totally different point here, away from the behavioral modeling, and to a Congressional perspective of the world.

This, I guess, is not a criticism of the model, it's kind of a warning, or I guess the way I'll put it is, if you are considering Congress and groups such as OTA as potential users, here are the types of questions we need to answer, or we are asked to answer and we struggle with. A real question that we've been asked is if the Energy Policy Act of 1992 will result in stabilized emissions in the building sector. The way Congress and OTA works is that OTA could be asked a question like that, and my first reaction as a modeler is, I don't know, but let me spend a few months. And then, someone says, no, we are either to going to write a bill or we are not, and we need to know by tomorrow. There's a real need to make policy decisions, often under very short time constraints. And, the people who are making those decisions don't have the time or interest to know the details, not due to ability or lack of, but they have a lot of issues to worry about and energy is a small part of that, and energy modeling is a minuscule part of that.

So, we, the modeling community, can say, "Well, we don't know, but let us build a model and run it and then tell you about the uncertainties," and I don't think we'll get much attention. It's a difficult tradeoff that I'm always trying to make between accuracy and usefulness, because if I don't say anything then, often a more political, or I think less appropriate, criteria makes the decision. This is a round about way of saying there's always this tension between being right and giving an answer.

There was a quote here. I can't remember who I heard it from, but it said, "Don't let the perfect be the enemy of the good." If we can come up with something useful that we have reasonable confidence in, I think we should make an effort to stick our necks out and offer it, because the alternatives are probably worse.

I have some more examples of the kind of questions we've been asked. What would be the energy and carbon savings resulting from, extending Green Lights to other end uses, requiring whole building consumption labels, increasing support for code compliance, changing the design of labels, extending code coverage?

I don't know if NEMS, as presently formulated, can answer these questions. These are the kinds of questions that we are asked to answer, and it would be great if NEMS could help us come up with reasonable responses.

Issue 2 (cont): Are the behavioral modeling methods used by NEMS descriptively accurate?

How does NEMS Commercial module model behavior?

-Three behavior rules currently allowed:
- -Minimize life-cycle cost
- -Use same fuel, then minimize life-cycle costs
- -Use same technology

What changes or questions could be considered?

-Add more behavior rules:
- -Minimize initial costs (especially in rented buildings)
- -Use dominant technology in region
- -Use same fuel, then minimize initial costs

-How are decision-makers assigned rules?
-Is there a continuous range of energy efficiencies within a technology?
-What is the data source for actual costs?
-Discounting method: is 'discount rate' best?
Alternatives:
Three year time horizon
Simple payback
Non-linear discounting
-General Observation:
Intent should be to predict actual choice, not optimal or best choice.
Empirical calibration and evaluation is critical.

Issue 2 (cont): Are the behavioral modeling methods used by NEMS descriptively accurate?

How does NEMS Residential module model behavior?

-Phase 1 model assumes consumer choice is a function of:
- -initial cost
- -operating cost
- -discount rate

-Functional form: $P(Y) = 1 / [1+e^{-(A+BX_i)}]$ (logit)

What changes or questions could be considered?

-Why these B's (i.e., costs and rate) and not others?
-Are A and B's empirically calibrated and evaluated?
-How well did model predict choice?
-Is this approach more descriptively accurate than decision rules used in cmrcl. sector?

-General Observation (again):

Intent should be to predict actual choice, not optimal or best choice.
Empirical calibration and evaluation is critical.

Issue 1: Will NEMS be able to help answer policy questions raised by the Congress?

Typical questions raised by Congressional members and staff:

1. Will the National Energy Policy Act (1992) result in stabilized emissions in the buildings sector?

2. What energy and carbon savings would result from:
   - -Extending the 'Green Lights' program to other end uses?
   - -Requiring whole-building consumption labels?
   - -Increasing support for building code compliance?
   - -Changing the design of appliance labels?
   - -Extending code coverage through changes in Federal mortgage programs?

3. What could be done to stabilize emissions in the buildings sector?

Characteristics of the ideal tool to help answer these questions:

1. Easy to use
2. Has appropriate policy hooks
3. Honest about assumptions and uncertainties

Characteristics often raised, but less important:

1. Transparent
2. Has explicit treatment of uncertainty

And, finally, similar to what Howard was saying, what could be done to stabilize emissions, coming at the question from the other side? What policies could be considered to reach this goal.

A few thoughts on characteristics of a tool trying to help answer these questions. Easy to use, obviously, has appropriate policy hooks, where you could hook in a policy and see what happens, and honest about the assumptions and uncertainties.

This is a difficult issue. How could we be both honest and useful? I'm not sure of the answer to this, but it's a problem. There are some other characteristics raised, but, perhaps, less important. One often hears that a model should be transparent. I suspect when you are talking about an integrated supply/demand model, if transparent means obvious in everything it does, I think that's asking too much.

An analogy is a telephone or an automatic transmission. Most people don't know how it works, and they don't care. They understand the relationship between inputs and outputs and can use it as a tool. I'm not sure that it's realistic for us to expect this model to be transparent to all the users. It should be transparent in relation, perhaps, to inputs and outputs, but the black box might have to remain a black box if we are dealing with a very complex and large problem.

The second characteristic I'm unclear about relates to uncertainty. I have mixed feelings about it. We should be honest about uncertainty in our results. On the other hand, policymakers don't want to know about ranges or distributions, they want to know answers. I'm not sure of the best way to deal with this.

At OTA, our client is the Congress. What we often do is talk about a range. We'll say we don't really know what this number is. We think it's probably between this and that. That's probably the most explicit treatment of uncertainty in the results that we can realistically provide and that will be useful. If we provide a distribution or some standard error or something like that, people won't take the time to sort out what we are trying to get at and we won't be relevant to the policy process.

One more brief point. Ed asked me to talk a little bit about my views on upcoming legislation. I don't really know anything that you probably haven't already read in the paper. There will probably not be major legislation along the lines of the Energy Policy Act. The feeling seems to be, "We did energy, let's do something else." There is a lot of discussion about taxes again. It was said this morning; you read it in the Times Sunday. It's unclear what's going to come out of that. There is some talk about a CAFE bill, but it's doubtful. Howard might have more information on that.

I think the biggest policy debate over energy in the next year or so will be over an energy tax, whether or not we want one, and, if so, what form it should take.

Thank you.

MR. RODEKOHR: Thank you, Paul.

Now, we are going to hear from David Belzer, from the Pacific Northwest Laboratory.

MR. BELZER: Let me introduce my comments this morning with a word of explanation about the title of my presentation. I think it's clear that the NEMS modules in the buildings sector, both residential and commercial, display high promise.

I think the key aspect is that they will assess the impacts of new end-use technologies and that they provide a long-run analysis and capability with vintaging and stock turnover effects, which really hasn't been available thus far with any of the DOE models. The models also incorporate greater detail for policy and program impacts studies, including demand-side management programs.

Pentium, the second part of my presentation's title, is the name that Intel has given to the next generation microprocessor, which will succeed the 486 with about 100 million instructions per second. It is claimed to be two or three times faster than the current fastest microcomputers.

The reason I use Pentium in the title is that it's clear that the proposed model design, at least in the commercial sector, suggests an enormous increase in computational requirements over the existing models that are being used within EIA. The additional requirements come about from more end uses, much greater degree of market segmentation, and a much higher level of regional detail.

With that brief introduction, let me turn to some of the topics I want to talk about this morning.

I want to spend a few minutes just talking about some examples within the Department of Energy, and, particularly, the Conservation and Renewable Energy organization, about what end uses have been included in such end-use models in the past.

I want to talk briefly on technology choice. Then I want to talk about the engineering framework that buttresses these models, particularly in the commercial sector.

Time permitting, I'll talk about building lifetimes, a little bit about historical validation, and then I'll conclude with some summary remarks and recommendations.

I didn't try to do any kind of exhaustive survey of all the people within our laboratory, or all the other national laboratories that have used end-use models from EIA or from elsewhere. I can just think of a few cases within PNL; I thought of several particular instances where we've used such models in the past. These include looking at the energy savings from the Research and Development Program within the Office of Building Technologies and looking at the impacts from more stringent building standards. A similar point was brought up by Howard Geller in his talk: that it clearly would have been desirable to have such a model when we were going through looking at the National Energy Strategy.

We've also done a couple of studies for the Office of Policy, looking at oil conservation by the year 2010 and trying to glean some insights from the existing EIA models about the turnover of oil-using equipment in the residential sector.

And then finally, we've also done some studies looking at the retrospective analysis of efficiency trends in the residential and commercial sectors.

Those are just a few examples of the types of uses that these models are put to within the Department of Energy.

Ed mentioned some new building technologies. There are some key Office of Building Technologies' research areas that are, essentially, on the drawing board, if you will, not really currently available. They cover, to mention a few, looking at envelope technologies, looking at windows and daylighting, selective glazings, electrochromic windows or smart windows. A lot of research is being done at Lawrence Berkeley Laboratory, for instance, in this area. Within HVAC technologies, there is still some work being done on advanced electric heat pumps, but even more so work being done on gas-fired heat pumps, which is a technology that may be coming into the market some time after the year 2000.

Obviously, in the commercial sector, lighting is a critical end-use technology, and there's a lot of research that's being done in terms of looking at the physics of very high frequency fluorescent lamps.

In terms of the technology choice, the key concerns which I think have somewhat been addressed by the prior speakers, are representation of specific technologies, modeling new, replacement and retrofit markets separately, and some discussion, at least in the commercial sector, of an attempt to treat end use and component interactions.

Now, as Paul pointed out, there is a difference in the approach in the residential and commercial models, in terms of the technology choice algorithm that's been put forward within the component design reports.

The residential model uses a logit function modeling technology choice, and I'll show my economics background here by saying that it has no clear optimization framework behind it. My understanding of that particular modeling methodology, is that it is difficult to add new technologies or simulate specific behavioral assumptions.

In the commercial model, there are explicit behavioral rules in a clearly defined market segmentation approach. It easily adds new technologies and improved efficiency levels, but it clearly, as Paul pointed out, requires some kind of mechanism to calibrate it to historical data, and that's its shortcoming.

But, I'd like to make the point that, clearly, you want the model not only to be a forecasting model, but you also want it to have some policy prescriptive power. You want it to say what a cost-effective level of technology would ultimately yield for a long-run forecast of energy consumption.

THE NEMS COMMERCIAL MODEL:

High Promise Requiring Pentium Power

David B. Belzer

Prepared for National Energy Modeling System Conference

February 1, 1993

Pacific Northwest Laboratory
Richland, WA

Introduction

High Promise ...

- Assesses impacts of new end-use technologies
- Provides a long-run analysis capability with vintaging and stock turnover effects
- Incorporates greater detail for policy and program impact studies, including DSM

Pentium Power ...

- Pentium - Intel's next generation micro processor
  - 100 million instructions/second
  - 2 or 3 times faster than 486

- Proposed model design suggests enormous increase in computational requirements
  - more end uses
  - market segmentation
  - regional detail

Overview of Presentation

- Examples of DOE/CE Uses
- Technology Choice
- Engineering Framework
- Building Lifetimes
- Historical Validation
- Conclusions

Prior Studies Involving End-Use Models or Analysis - PNL Experience

- Energy savings from DOE/CE R&D programs
- Impacts from more stringent building standards
- Oil conservation potential by 2010
- Retrospective analysis of efficiency trends in the residential and commercial sectors

Key OBT Building Technology Research Areas

- Advanced windows and daylighting
  - Selective glazing
  - Electrochromics
- HVAC Technologies
  - Advanced electric heat pump
  - Gas-fired heat pumps
- Improved Lighting
  - Very high frequency fluorescent lamps

Segmentation of technology demands, within the commercial sector model, includes three decision types -- new, replacement, retrofit; three types of behavioral rules -- least cost, same fuel, same technology; different types of HVAC systems -- heating only, cooling only, heating and cooling; and a time preference premium, which I think is another word for the discount rate. That obviously generates quite a number of market segments.

I had a couple of quibbles and, perhaps, misunderstanding about the documentation regarding the behavior rules. It seems somewhat confusing about same technology. Obviously, that's not relevant for new buildings, and it's not clear to me from the documentation how levels of efficiency within a particular class of technology are treated.

It seems to me also that the classification of the behavior rules is somewhat unnecessary. Accounting for the same fuel and same technology choice can be handled in a least-cost framework, simply by accounting for the capital costs that change the fuel or technology in an existing building, or change when you are replacing equipment. So, I think you can use the least-cost rule to handle all the cases, and, look at the distribution of discount rates to indicate what percentage of the market actually, in fact, has used initial first costs as their primary choice criteria.

I think in the Commercial Sector Component Design Report, there's a mention that there would be an attempt to estimate the shares of the market that are using each of these particular behavior rules, and I don't think there's any way from the empirical data to be able to do that.

My other recommendation is, essentially, to strive for a flexible segmentation. As the model is currently structured, this market segmentation is going to generate a lot of segments. There's the behavioral rule, times the decision type, times the time preference premium there might be five levels of the time preference premium. That will generate 45 segments right there, and that's not including the vintages, building types or regions in the model.

So, obviously, efficient coding is very important, and I think the model builders should look at some ways to code the models so that you can use different levels of segmentation and do sensitivity analysis to determine the tradeoff between accuracy and computer time.

Let me next turn to the engineering framework, and I think it's fairly clear that many key issues in the building sector require building simulation models at the specific building level. For instance, as I mentioned, advanced windows is one of the OBT technologies being developed. These advanced windows not only have their changes in heating and cooling requirements because of conductive properties, but also because of solar gains. It's almost required that you go do some kind of hourly type simulation model to determine what the effects on the heating and cooling loads in that building would be from those advanced windows.

There are obviously, a number of other situations where you need this kind of detailed engineering modeling, part load and temperature effects, end-use interactions, peak loads, HVAC system changes such as economizers, just to name a few.

My point here is that previous commercial sector modeling work has generally adapted what's been available in terms of these simulation models and results and conducted fairly

Technology Choice

Key Attributes

- Representation of Specific Technologies
- Decision Types Modeled Separately (New, Replacement, Retrofit)
- End-Use and Component Interactions Considered

Technology Choice

Approach in Residential vs. Commercial Model

- **Residential Model**
  - Logit functions model technology choice
  - No clear optimization framework
  - Difficult to add new technologies or simulate explicit behavioral assumptions

- **Commercial Model**
  - Explicit behavioral rules
  - Market segmentation approach
  - Easily adds new technologies and improved efficiency levels
  - Requires mechanism to calibrate to historical data

Segmentation of Technology Demands

- Decision Type
  - New
  - Replacement
  - Retrofit
- Behavior Rule
  - Least Cost
  - Same Fuel
  - Same Technology
- Type of HVAC Service
  - Heating Only
  - Cooling Only
  - Heating & Cooling
- Time Preference Premium (Discount Rate)

Behavior Rules

Least Cost - Same Fuel - Same Technology

- **Documentation is confusing about "same technology"**
  - Not relevant for new buildings
  - Same technology needn't suggest same efficiency, e.g., more efficient heat pump

- **Classification of behavior rules is unnecessary**
  - Account for capital costs to change fuel or technology
  - Use least cost rule, with distribution of discount rates
  - Will not be able to estimate these shares of each behavior type from historical data

limited studies in that regard.

I think the first point, and I think Ed mentioned this, and I just wanted to reinforce it, is that clearly you want to be up front and have as a clearly documented part of the model, at least in the long term, a well-defined engineering basis for the model. In one case, for prototypical buildings or models or buildings that would represent key aspects of the building stock, these would be statistically based in the CBECS and reflect the energy use intensities for large segments of the model, or large segments of the building population.

And, there is an effort underway within Conservation and Renewable Energy to select a common set of prototypical buildings in the commercial sector for various types of analyses.

ASEAM is one possible, fairly simplified, type of engineering model that doesn't use a full 8,760 hour annual simulation. There are other types of models as well that could be used for that portion of the model.

This slide is taken from a recent report that I looked at reviewing existing commercial sector models, although excluding the models being developed at EIA, and, basically, my point here again is just to reinforce that the sectoral energy forecasts which are being done are from an accounting model. But, clearly, it is almost as important to have a clearly defined set of building prototypes and simulation analyses that back up that model, and that's represented on the box on the right side of the slide.

Now, I want to go ahead and skip to the last slide of these pie charts at this point. We've done some analysis looking at the components of commercial cooling, or both residential and commercial cooling and heating loads with work that's being done at PNL and also at Lawrence Berkeley Laboratory. I'll just show the commercial cooling load pie chart, the main point is that, obviously, at least as represented in the office and retail buildings across the country, internal gains dominate the components for cooling loads, and that the roof, and walls and windows make up a very small percentage of the contribution of the cooling load.

With that in mind, I want to skip now about three more slides, to one entitled "Shell Efficiency." The relevance to this is to the Shell Efficiency Indexes, which are part of the proposed structure in the residential and commercial models.

My basic point here is that, at least for cooling, the representation of the engineering framework in the commercial model borrowed heavily from the residential model. I want to stress that, at least in the long term, you should try to move to more of a commercial sector model that is framed in terms of the loads from the building envelope. You need to look at the importance of systems, such as the air-type systems in buildings that involve central systems or package zone systems, which have a large impact on energy use, especially in office buildings and some retail buildings, as well as the plant, which usually involves the efficiencies of the conversion equipment, and boilers and heat pumps. My point is: Don't ignore systems from the commercial sector. These are important. The control strategies are also important in terms of

Strive for Flexible Segmentation

- As currently structured, model generates

    Behavior rule (3)

X Time Preference (3)

X Time Preference Premium (≥5?)

≥ 45 segments

- Implied in CDR - segmentation carries over to vintages
- Efficient coding is important
- Flexible segmentation would be desirable and can be tested for precision of results

Engineering Framework

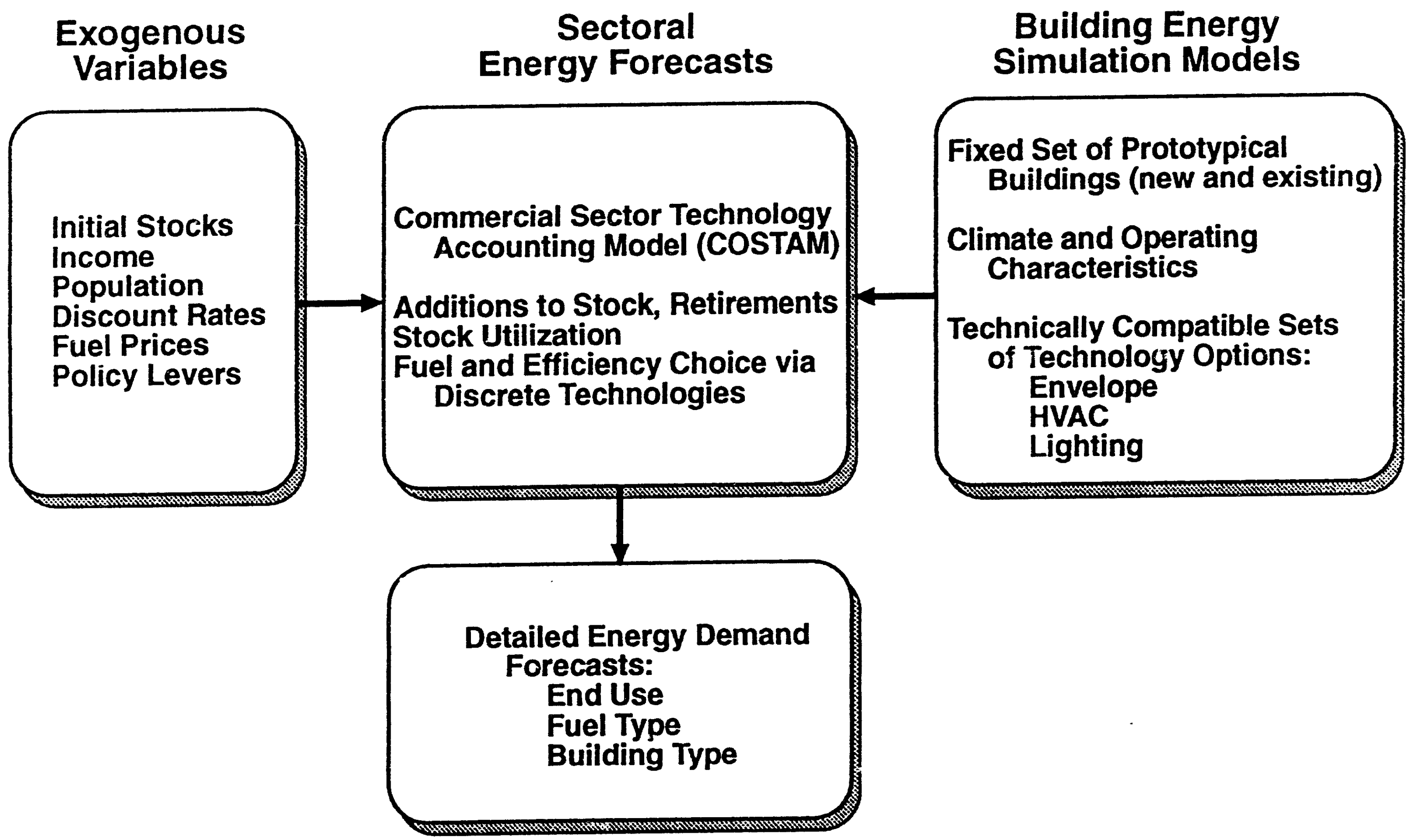
- Many key issues require engineering simulations
  - improved shell characteristics
  - part-load and temperature effects
  - end-use interactions
  - peak loads
  - HVAC system changes (e.g., economizer)

- Previous commercial modeling efforts have generally adapted available results or conducted limited studies

Prototypical Buildings

- Ideally, prototypical buildings would be defined to represent building stock and new buildings for each census division
  - statistically based on CBECS
  - reflect EUI's for larger sample of buildings
- Effort underway in DOE/CE to select/define common set of prototypes
- Buildings could likely use more simplified model than DOE-2
  - ASEAM (temperature bin method)
  - FEDS Level 2 (compact hourly method)

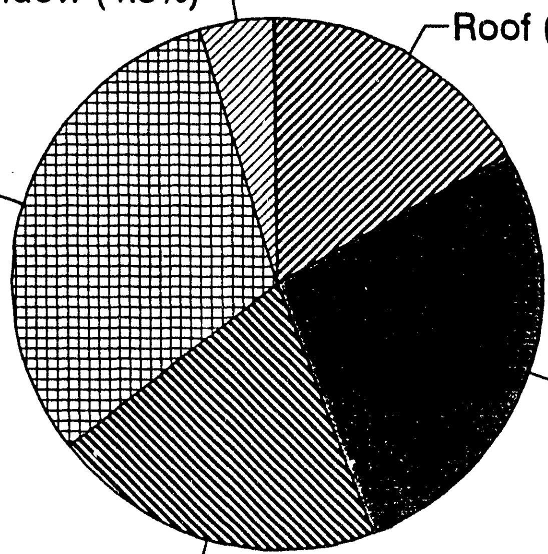
Overview of Commercial Sector Modeling System (COSEMS)



S9301034.1

Components of Residential Heating Loads
Stock Buildings

Weighted Average of building simulations for locations across U.S.

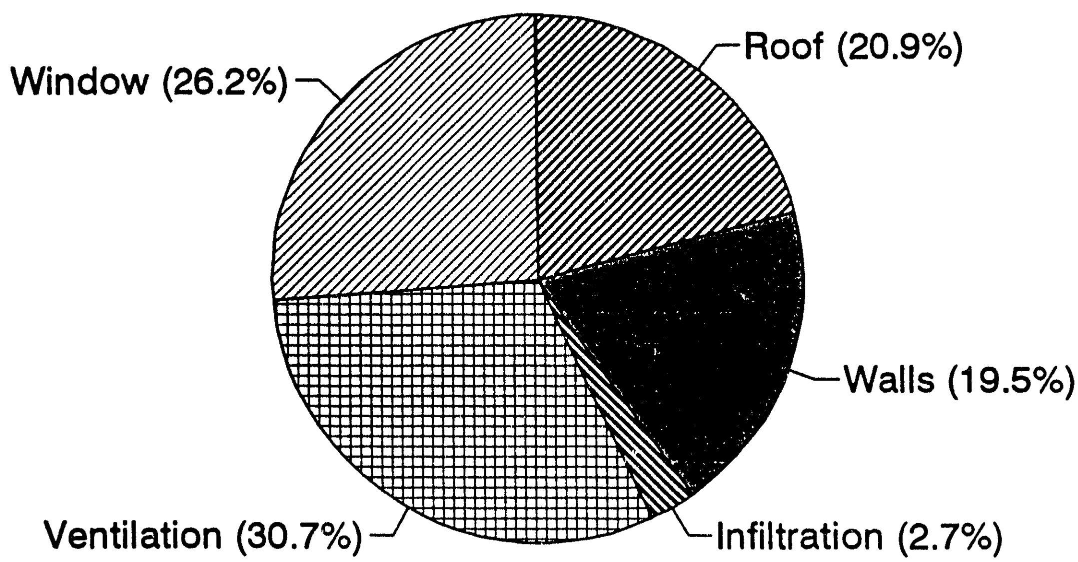


Source: Lawrence Berkeley Laboratory, 1992

Components of Commercial Heating Loads

Stock Buildings (Office and Retail)

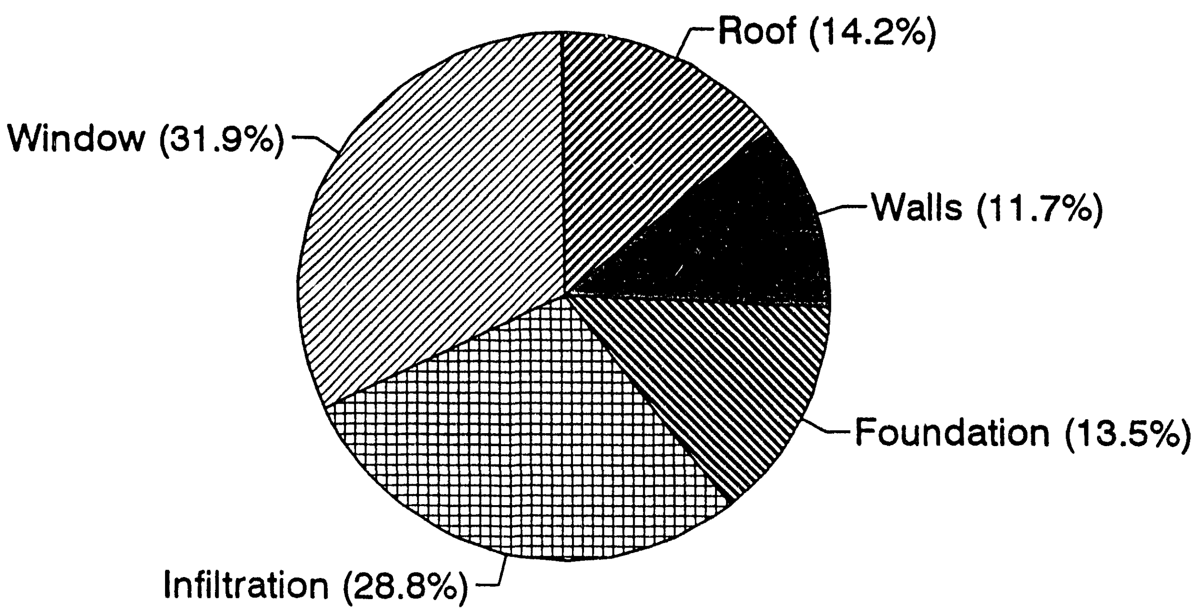
Weighted Average of DOE-2 Simulations for 5 U.S. Cities



Source: Pacific Northwest Laboratory, 1992

Components of Residential Cooling Loads
Stock Buildings

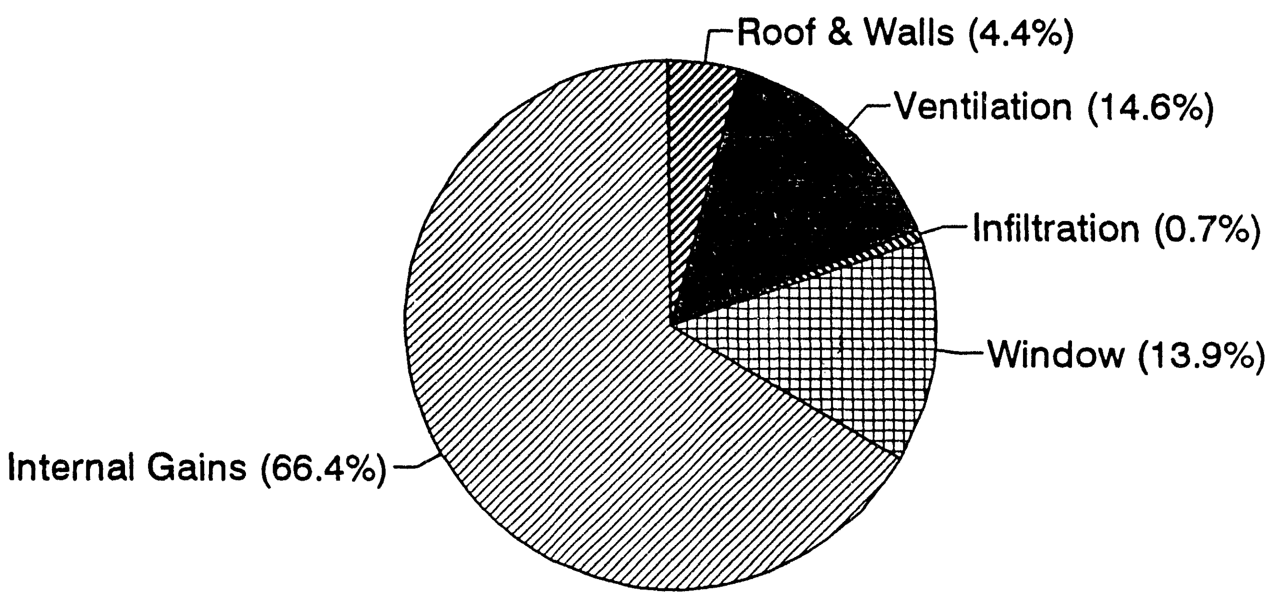
Weighted average of building simulations for locations across U.S.



Source: Lawrence Berkeley Laboratory, 1992

Components of Commercial Cooling Loads
Stock Buildings (Office and Retail)

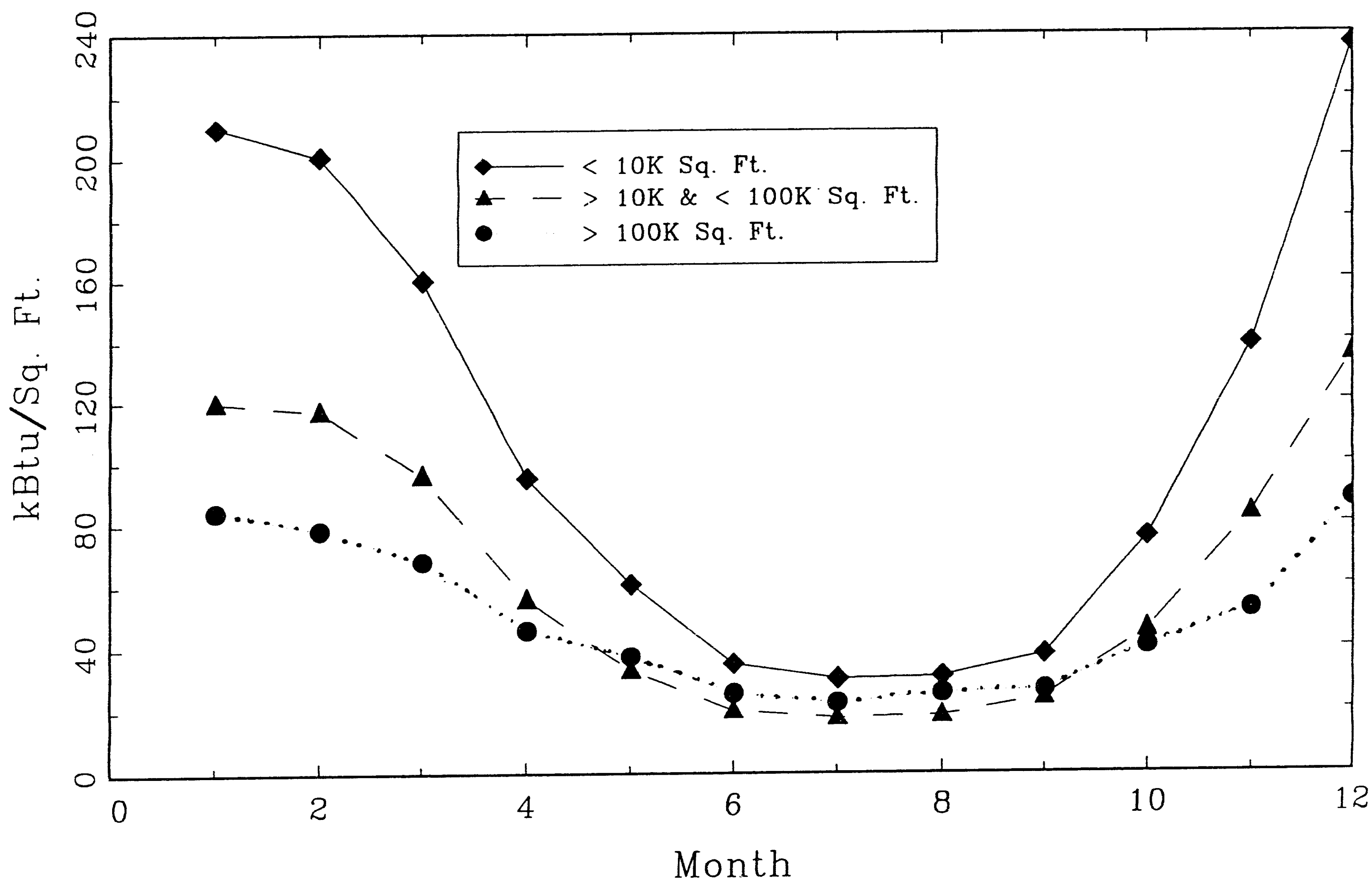
Weighted Average of DOE-2 Simulations for 5 U.S. Cities



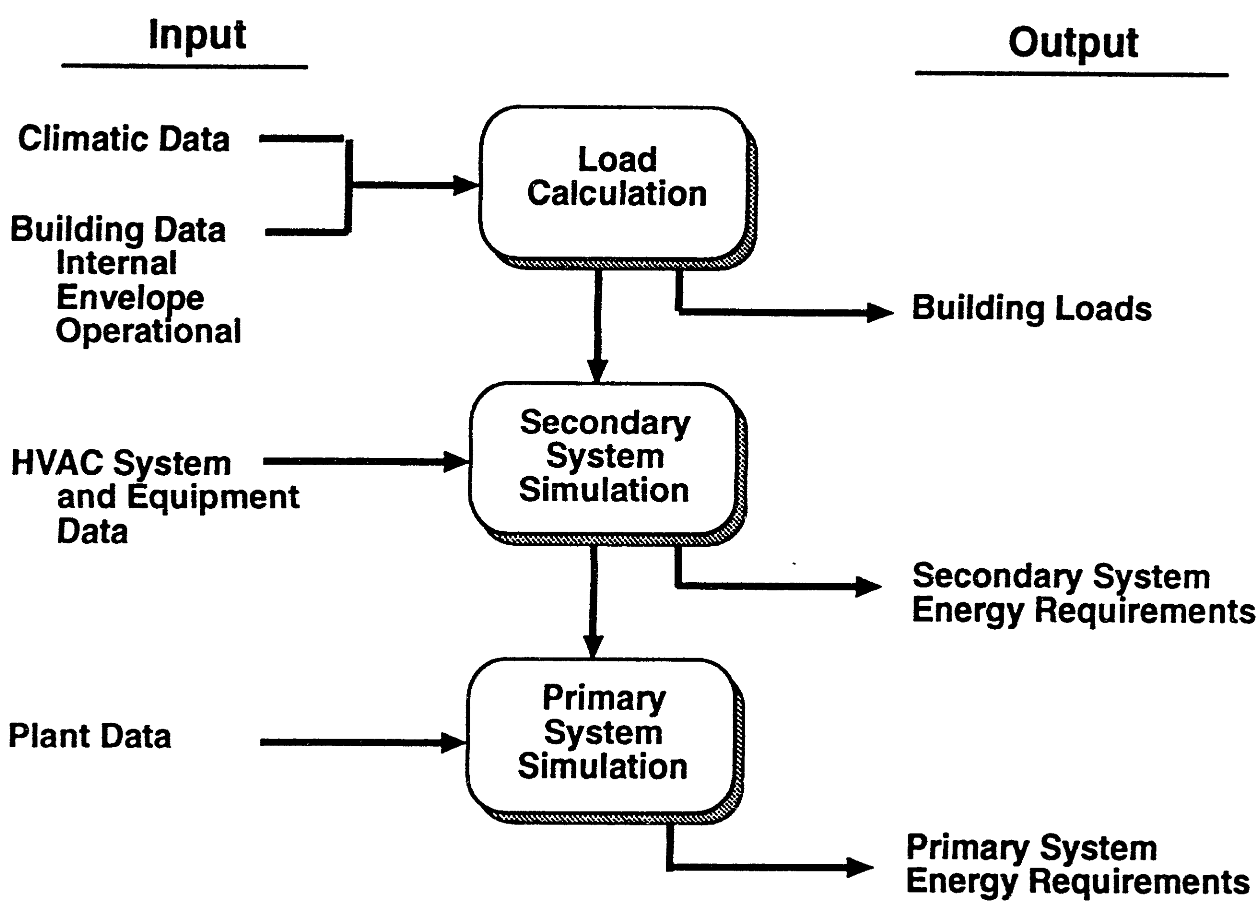
Source: Pacific Northwest Laboratory, 1992

Average Natural Gas Intensity for Small, Med, Lrg Bldgs

(kBtu/Sq. Ft)   Reported Heating and Water Heating

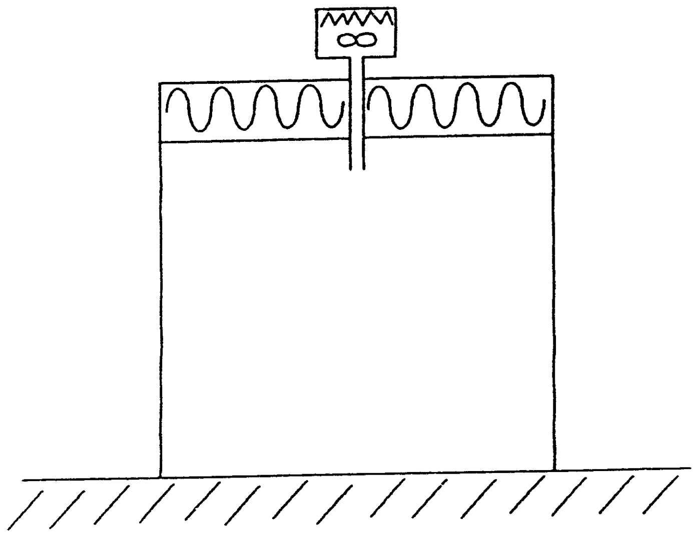


Major Steps in Estimating Building Energy Use

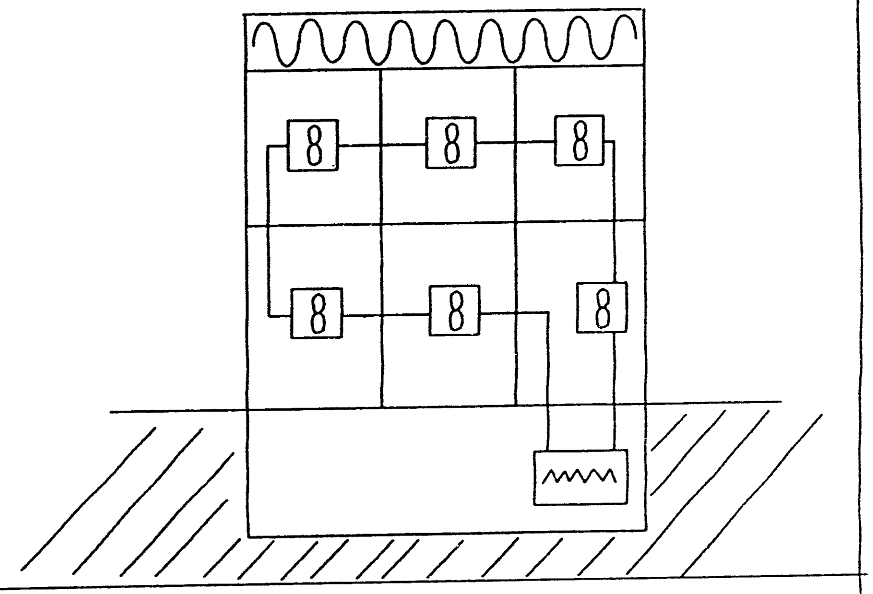


S9301034.2

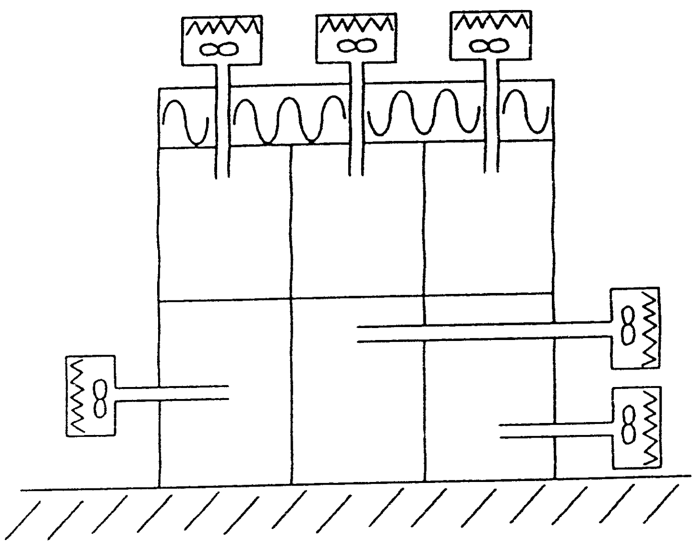
A) Single - Zone / Dedicated HVAC



C) Multi - Zone / Central HVAC



B) Multi - Zone / Dedicated HVAC



A - Same shell characteristics

B- Has more cooling than A

C - Adds reheat

For identical changes in shell or internal loads, changes in energy use are different

Shell Efficiency Indexes

- Frame in terms of loads-systems-plant breakdown in engineering model
- Don't Ignore Systems
  - control strategies - deadband, width setbacks
  - simultaneous heating and cooling
  - reheat
- Broaden definition of shell index or include separate index for systems
- Model separate indices for heating and cooling

Shell Characteristics

Interim Approach

- Start with simplified framework with few discrete levels of overall thermal integrity
- Let ASHRAE Standards be reference points (90A-1980, 90.1)
- Exploit ongoing standards development process
  - costing
  - climatic variation
- Add interaction effects in "Phase 3"
  - empirically may not as large as conventional wisdom
  - easier to handle with ex post adjustments

the width of dead band settings, night setbacks. There's the issue of simultaneous heating and cooling in commercial buildings, reheating in commercial buildings. None of these things are really addressed within the current documentation. I think it's something that should be looked at in the long term, and there's a possibility, at least for now, the definition of the Shell Efficiency Index should be broadened to include systems in the commercial sector, or possibly even in the future, try to provide a separate index for systems.

And then, I think it goes somewhat without saying here that there need to be, and I'm not sure if this is the case, it wasn't clear from the documentation, there do need to be separate indices for heating and cooling, because of this disparity of the impact of shell components on both those types of loads.

I want to skip one slide now and go to commercial building lifetimes, just spend a minute, hopefully, on that topic. It's somewhat out of the mainstream of some of the other topics, but we just wanted to mention it briefly. We've done some recent econometric analysis from the 1979 and 1983 NBECS, in which those building samples, essentially, were a longitudinal sample, where we were able to find out, basically, the number of buildings that disappeared from the stock in that four-year time frame. And so, you had some characteristics about what types of buildings disappeared from the stock.

And, our econometric analysis suggests that the buildings life spans at least in the commercial sector, may be much longer than 45 years, and that's been a normal assumption that's been used for quite some time, although I think the EIA current models do use something longer, a little bit longer than that.

The implications for the energy model, at least for the long-term energy model, are that, for a given stock there may be fewer new buildings in that stock than would otherwise be the case under a higher removal rate assumption, and that would, of course, increase the importance of policies and so forth that would look at building retrofits.

The next slide just basically demonstrates what those econometrically estimated survival curves look like from the '79 to '83 data, which look like a mean life of somewhere around 80 years in the building sector. It's quite a bit longer than the 45 year typical assumption.

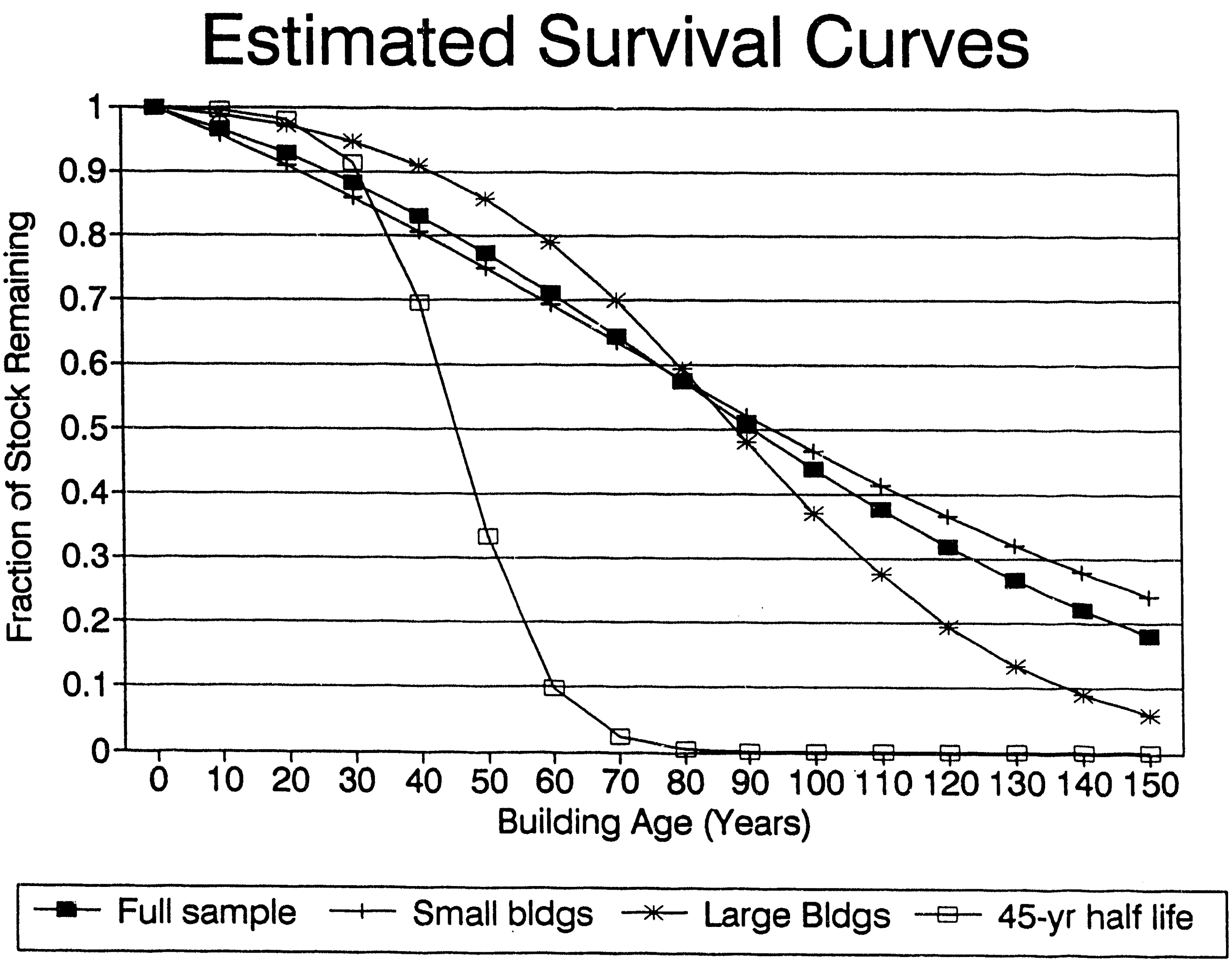
So, that's kind of a minor item that someone might want to at some point -- there was some discussion of looking at evidence in the component design report for the commercial sector, so I thought I'd bring that to bear.

My final topic has to do with historical validation, and, obviously, historical validation of the model provides a strenuous test of the model's forecasting capability. And, I think Jerry Jackson is really kind of the "Godfather" of all of these -- at least of the commercial sector end-use models and is a big proponent of that sort of exercise. In all of his work that he does for different utilities, he stresses that fact.

And, what he does is to use historical simulations, not only as a means of testing the model, but also as a means of calibrating the model and trying to determine where to modify these fairly rigid economic assumptions and trying to make them so that they replicate observed

Commercial Building Lifetimes

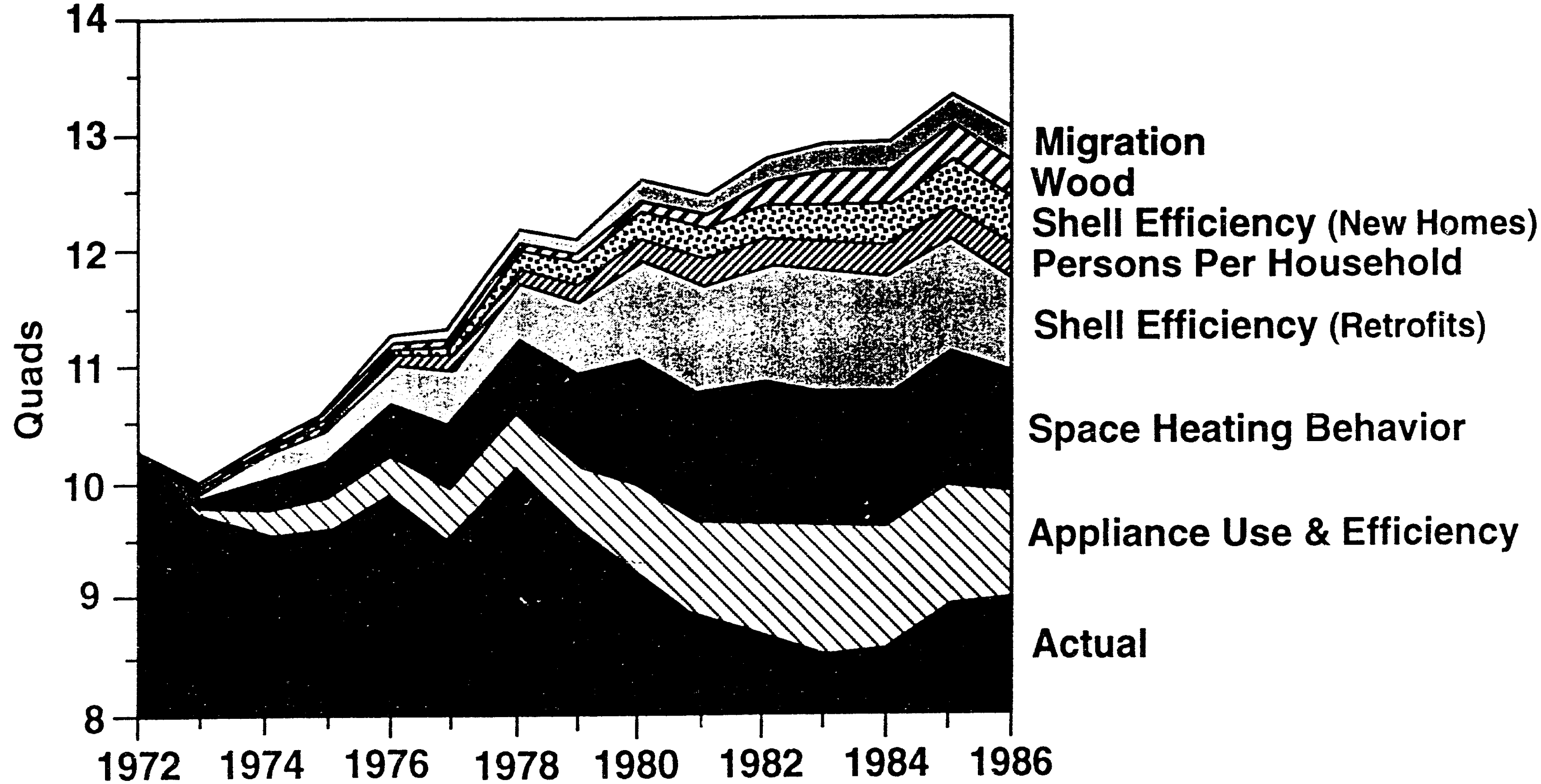
- Recent econometric analysis from 1979 and 1983 NBECS
- Building lives may be much longer than 45 years
- Survival patterns differ for small vs. large buildings
- Implications for energy model:
  - fewer new buildings in 2030 stock
  - retrofit behavior is more critical


Estimated Survival Curves
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Fraction of Stock Remaining
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
Building Age (Years)
Full sample
Small bldgs
Large Bldgs
45-yr half life

Historical Validation

- Provides strenuous test of model's forecasting capability
- Jerry Jackson uses historical simulations to calibrate key (CEDMS) model parameters
    - "non cost-based" preferences
    - short-run utilization elasticities
- Historical simulations could help to shed light on conservation potential in existing buildings
- Consider future validation studies as data are collected and model structure is coded

Components of Energy Savings Since 1972, Residential Sector



S9301019.1

behavior.

And so, he uses that historical validation work to change and look at non-cost-based preferences, so it moves you away somewhat from the strict optimization least-cost algorithm that's in the model proper.

And then, he also is able to use the historical validation exercises to look at short-run price utilization elasticities.

I think these historical simulations could also help shed light on what the conservation potential is in existing buildings.

So, my main point here is, though, that as the model building is undertaken, that we consider future validation studies as data are collected and the model structure is coded, so that one has the ability to go back to, say, the late 1970s and see how well the model would replicate the 1980s experience, and then learn from that and actually modify some of the model parameters.

I have a couple of other slides here that show our work for the Policy Office, in understanding what's happened in the 1980s in both the residential and commercial sectors. I won't go through the details of this, but it has relevance to the fact if a model exists that has a base year 10 or 15 years in the past, it would be very relevant for trying to untangle what's happened in the building sector. It's not very well known, in fact.

So, let me conclude with a couple of, I guess, fairly obvious points. Obviously the NEMS commercial and residential components are extremely ambitious modeling efforts, and I think the payoff to those efforts will be an ability to answer a variety of technical and policy questions that have been unable to be answered with the existing tools.

I just have a few recommendations. I suggest flexible segmentation in collapsing of the decision types. In the long term, build explicit linkages to the foundation of building level analytical tools, namely, prototypical models, and simulation tools. Develop the model with a view toward historical simulation capability, and then finally, there are many of us who are looking forward to obtaining the stand-alone version of those models as we put our orders in for the Pentium-based PCs, that is, if we can afford them.

And, I'm sure, access to the model will facilitate critical review and hopefully expedite future improvements.

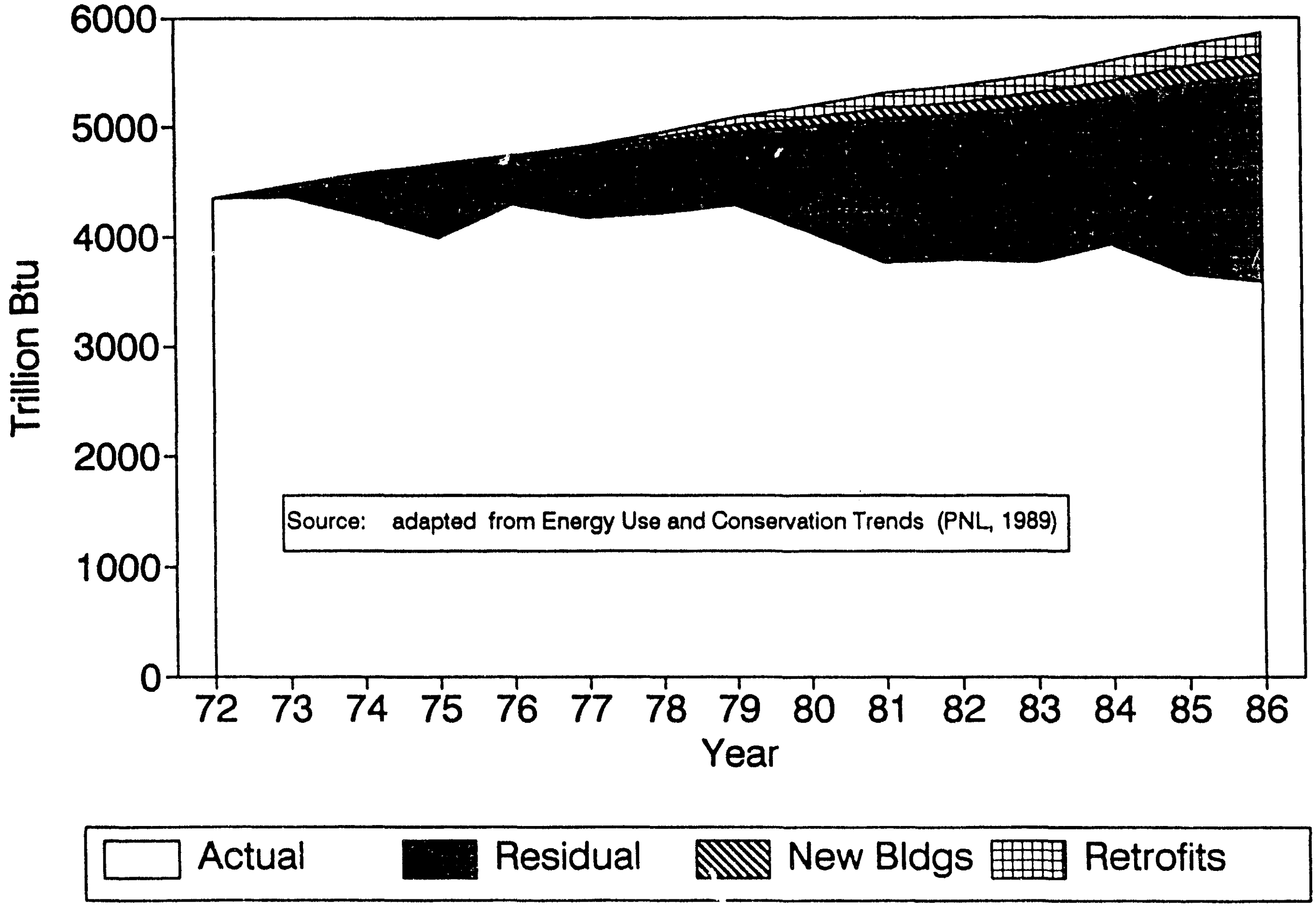
Thank you.

MR. RODEKOHR: At this point, I'd like to open the session up for questions to either ourselves or the reviewers.

Question in the back?

MS. CARLSON: Lynda Carlson, EIA. We've had continual pressure from the

Commercial Sector Fossil Fuel Savings
1972-1986



Conclusions/Recommendations

- NEMS component is most ambitious commercial end use modeling effort ever proposed
  - would answer variety of technical and policy issues
  - will undoubtedly become "industry" standard
- Suggest flexible segmentation and collapsing of decision types
- Build explicit linkages to foundation of building level analytical tools (models and prototypes)
- Develop with view toward historical simulation capability
- Stand-alone version could facilitate critical review and future improvements

Conservation and sometimes Policy Office to look at industrial buildings. Should that be a concern?

MR. RODEKOHR: Do any of our reviewers have any comments on that?

MR. GELLER: Somebody should look at industrial buildings. I think you have to sit down with the people doing the industrial module and figure out who is more appropriate.

MR. RODEKOHR: We do have a buildings component in the industrial module, so it is there. There is not as much detail as the components that you see here, for obvious reasons. It's quite a bit harder to disaggregate the data for industrial buildings from the process and other uses, but we're going to give it a try.

MR. PORTER: Thank you. David Porter, from Argonne National Laboratory.

I wanted to ask, does NEMS, in its research agenda, intend to model the energy consumption behavior of low-income households and minority households, and, if not, why not?

MR. RODEKOHR: Let me see if I can give you a fairly short answer. We did, several years ago, have a model called the "MATH CHRDS" model, which did break out the impact for low income, minority households and other income and classes.

Funding for that model ceased several years ago.

We do feel, however, we have the data to do just that kind of analysis from the person that's sitting right behind you. The Residential Energy Consumption Survey does have a lot of disaggregated data by income group and minority status, and I think that data probably gives you the best way of trying to answer that question in a cost-effective manner.

MR. PORTER: Under the sponsorship of the Office of Minority Economic Impact, some of that type of modeling is being done.

MR. RODEKOHR: Yes.

MR. PORTER: And what prompted me to ask the question is the fact that, you know, statistically there seems to be significant differences in the -- and behavior among these population groups.

Taking that information into consideration, of course, would improve the statistical performance of the model.

MR. RODEKOHR: Yes, I believe you are probably right about that. I don't know how I can cut the data quite that way, but it certainly is something worth considering. I was fortunate enough to be in the Forrestal yesterday looking at energy taxes and regressivity came up, and they are very regressive, no question about it. And, we were trying to look -- use some of Lynda's data to get it out.

MR. PORTER: But, there's certainly some policy relevancy to it.

MR. RODEKOHR: Oh, absolutely, yes.

MR. KOMOR: If you were to consider changes in the WAP and LINEAP programs, you would need to be able to separately model low-income households as well. So, there are several arguments for considering this.

MR. RODEKOHR: Oh, yes, that's true.

In the front here?

MR. SHORT: I'm Walter Short, with the National Renewable Energy Laboratory.

I heard no discussion so far this morning about how demand-side management activities on the part of utilities are going to impact building modeling.

I guess three things concern me. One, that we don't have double counting going on within NEMS between the utility and the buildings model; two, that the programs do have an impact; and three, how those are represented here in the building models isn't clear to me. I hope it's more than just through electricity prices.

MR. RODEKOHR: Do you want to answer it, Ed?

MR. FLYNN: We have a separate module in the Electricity Module called the "Load and Demand-Side Management Submodule (LDSM)." It's not one of the Buildings Sector modules.

Within the LDSM submodule is a parallel set of technology information to that maintained in the residential and commercial models. We send potential demand-side management participation information to the LDSM. They try different levels of programs and see what the consequences are and come back with, in effect, the estimated participation rates and the overall penetration levels for inclusion in our model.

It is a situation where we compute and pass information on the the number of decisions that are potentially to be made. On the basis of their knowledge of the DSM programs that are applicable in a given region, they come back with the consequences of it.

The non-DSM decisions are made within our own model; however, so we do avoid double counting in that manner.

MR. SHORT: The third part I just thought here, the third part of my question related to the fact that from what I could tell, everything was energy oriented, as opposed to impact on peak loads.

MR. FLYNN: The impact on peak loads will also be handled within the demand-side management modules. We will be giving them information on consumption requirements, which actually are by service, and to the extent they would alter the shape of the electricity demand patterns, they factor that in their own sub-module.

MR. SHORT: Will those patterns be time dependent?

MR. FLYNN: Heating would occur during a certain time pattern, lighting would tend to occur in a different time pattern. They have that information; they know what the likely pattern of load would be absent any DSM. To the extent that things like time of day rates would change the load pattern, they reflect that in the load shapes they are giving to the Electricity Module.

MR. RODEKOHR: Just to reinforce that, many DSM programs, you are right, might not do anything to total energy consumption, but they will shift load, and we do model it as a shift in that load.

MR. McMAHON: I'm Jim McMahon, from Lawrence Berkeley Lab, I have a question for Mr. Flynn. In your slide on the technology data menu, you have several items that I think are related--maintenance costs, reliability and equipment life. I'm interested in whether you are going to model the economic component of replacement decisions in your residential technology.

MR. FLYNN: The maintenance cost is included only to the extent that it is an offset to other costs. Manufacturer costs are another component of the annual costs of operation and would be weighed against the initial first costs.

The equipment life has a bearing on a number of appliances that would be coming up for replacement in a given year. If refrigerators have a life of 19 years, then approximately 1/19th of all the refrigerators in a given group would be eligible for replacement and would be subjected to the tech choice decision. This number would be added to any that would be coming in as a result of new construction.

MR. McMAHON: Well, it sounds as if there is no economic component in the replacement -- if a 19-year life is a physical life, irrespective of the cost of replacement or cost of maintaining that old product.

MR. FLYNN: We're not making any explicit decisions of pre-failure replacement. Is that the type of decision that you are referring to?

MR. McMAHON: I'm thinking both ways, pre-failure replacement, or if, for example, there were appliance standards that raised the price of a product, people might keep the old appliance rather than buy the new more expensive one, or might keep it longer than they would have otherwise.

MR. FLYNN: It is certainly an effect that we should consider. We could, if it were a real concern, make equipment life, a function of some other factors, rather than just a fixed number, but we haven't done that in our current formulation.

MR. RODEKOHR: That's a good point about a sort of unintended effect of a policy, but if they really were to make really binding standards and new equipment was very expensive, then it would pay to fix up the old stuff and run it, especially under conditions of relatively low prices.

So, I guess the bigger the differential between the standard and what people would tend to do without it, the more you are going to see that kind of effect. That's probably quite true.

MR. PORTER: From the modeling point of view, given proposals pertaining to this broad-based energy tax, how would NEMS handle assessing the impact on households, or considering the total energy costs associated with a broad-based energy tax which would both affect transportation and also residential energy expenditures? How would the model, essentially, integrate those components and come up with an overall impact on various households?

MR. RODEKOHR: What we'd have to do is, basically, do the calculations off line. We know what the impact would be on the household for heating and cooling residential fuels. We would have to go into the transportation sector. We do know how much gasoline use and how much diesel fuel use is associated with non-fleet driving. We can break that out. We'd have to break that out, add that back into the household budget, and then determine the overall impact.

It's currently not being broken out in the model that way. I think if there was a big policy push to look at those particular variables, we probably would break it out in the model and calculate it, but you can do it by hand. It takes a little bit of work.

Some more questions back in the back?

MS. WOOD: I'm Frances Wood from the AES Corporation. I had a question, several people on the panel talked about validity, and, perhaps, doing a historical backcast to see whether the algorithms used for consumer behavior, in fact, can predict the behavior we saw in the '70s and '80s.

I was just wondering what the plans are in terms of validating the buildings model, and, perhaps, the whole model together.

MR. RODEKOHR: Historical validation sounds good. I have some mixed feelings about it. Let me give you my mixed feelings.

If you build a model that was able to predict energy consumption, the regulatory environment that existed in the '70s and '80s, I'm not convinced that means you've built a good model for the '90s and beyond. So, that's why the mixed feelings.

We will not be able to historically simulate NEMS as a whole. Some of the component modules, and the buildings is not one of them, cannot simply do that. There are linear programming, cost minimization kinds of models. It would be extremely expensive, if not impossible, to try to simulate those components over history.

So, that limits our validation. We are going to try to run the model over broad ranges of what we would consider to be likely assumptions for the critical input parameters, to see if it gives reasonable answers. That's one approach to validation.

For better or for worse, we have a track record. Some physicists -- I was reading an article last week -- took our work, went out and recomputed or computed uncertainty bands around our scenario ranges, and then computed the probability of the ranges we had published actually happening or vice versa. They computed a 95 percent probability range. They, in general, determined it was probably two to three times wider than what we usually publish. Not that that really surprises me very much, but it's kind of a unique approach and we're considering using that.

Ed, do we have any plans to simulate the buildings models over history? I don't think we do. We have very few data points for most of the stuff we are looking at, quite frankly.

MR. FLYNN: OSS has certain requirements that we are reviewing.

MR. RODEKOHR: Yes, that's why I mentioned the simulation.

So, we are, basically, doing about all we can do in that area, given the fact that we don't have a 17-year history of residential surveys, it's a little bit difficult to go back and backcast in that sense.

MR. BURNOW: Steve Burnow, Tellus Institute. How much flexibility will users be afforded to vary some of the behavior relationships that are built into the model, sort of the counterpart to the validation question.

MR. RODEKOHR: We will make as many of those parameters input variables as we can, and so it should be pretty easy to vary them in that case. We'll try not to stick them in an equation buried 50 lines down in some code. We'll try to be a little bit better at it than that.

MR. CHIEN: I'm with EIA, my name is David Chien. The NEMS undertaking is a very large project and effort. And, due to the constraints of computational time and data availability, a lot of very interesting questions may have to be answered at a later date, when we have surveys or those kinds of data available.

I would agree that life-cycle cost is probably not the only factor that people base decisions on. First cost is certainly an important consideration, but modeling things such as the hassle factor, or perceived time requirement, ease of use or high-tech appeal would be very difficult because of lack of data.

MR. RODEKOHR: Thank you.

Any other questions?

MR. KOMOR: Can I respond?

MR. RODEKOHR: Sure can.

MR. KOMOR: I agree with the comment just made that while these things, hassle factor and ease of use, probably matter, we don't really know how to define them or how much they matter.

But, I think it's a mistake to say they don't matter. I think somehow the model has to incorporate and reflect what it doesn't know, as well as what it does, and not make assumptions that are analytically convenient, like life-cycle costs, when there is a lot of evidence suggesting that that's wrong.

I don't have a good alternative model, but I think the life-cycle cost model is not a very good one, and maybe there's a way to measure how bad it is and somehow carry that uncertainty through in the results.

MR. RODEKOHR: Well, I don't want to delay this too long, but I do have a couple of my own questions for the panel, if everybody else is done, and then we can move on from there.

I guess maybe when Paul talked about uncertainties he hit a sort of sensitive spot on me, because I kind of feel the same way he does, in that it's not entirely clear to me that policymakers want to know a lot about uncertainty. They want to know: "Well, what really is the effect of my policy."

Does anybody else on the panel or the audience have any feeling on this subject, because when you talk with statisticians about NEMS, they say, "Well, the only thing you should do is talk about uncertainty, and maybe I'm missing the point there." Anybody have comments on that? Okay. Go ahead.

MR. McMAHON: This is something that I've thought about lot. In our work, we've had a hard time getting our sponsors at DOE to put much effort into the source of treatment of uncertainty, and there are good reasons for that.

But, on the other hand, I agree with Paul's comment that people don't want to see a probability distribution of the impact of a policy, they want to know whether it's worth doing or not.

MR. RODEKOHR: Right.

MR. McMAHON: On the other hand, if you were to say there's a 50-percent probability that the policy will fail catastrophically, that would be information that they would be mad at you if they didn't have it when you knew it. Okay?

So, I don't know the full answer either, and this is something we are exploring. We are moving towards a selected treatment of uncertainty, where we at least internally generate the probability distributions, and then we worry about how to present that information.

If we find that in all possible future scenarios this policy is robust, then that's a significant finding, and we can report that. If we find there's a high probability that this policy will fail, we can make that statement, that qualitative statement as well. And, if the decision-makers want more information, we can then explain the pieces in that.

MR. RODEKOHR: That's a good point, and by determining if a policy fails, I think often times what you are doing is, you are measuring the unintended effects of the policy, and that's what makes it fail often times. That's true.

Paul, do you want to say anything?

MR. KOMOR: It's a conversation that I heard, and I'll alter the details so no one can guess who it is, between a staff member of Congress and a member of Congress, and the staff member was responsible for energy issues and there was a vote coming up on major legislation. And, the member of Congress called the staff person and said there's this major bill coming to the floor, I need to vote, should I vote yes or no? And, the staff person goes, well, it's a very complex issue. There are a number of considerations. You should probably have some background information.

And, of course, the member, in an impatient way, says, no, you don't understand, there's a vote, I've got to vote. And, the staffer says, oh, well, the no arguments are A, B, C and D, and the yes arguments, and then starts to go into the details.

And, the member again said, no, no, 15 seconds, I have to vote yes or no. And the staff person made a decision.

These policy decisions have to be made. I agree with what Jim said, you should tell people when you are uncertain, but sooner or later you are going to have to go yes or no on legislation or on policy decisions.

And, to the extent that our modeling efforts and our knowledge can help that, I think we should kind of push ourselves to go out on a limb.

MR. RODEKOHR: Thanks a lot, Paul.

I guess, does anybody have any insights about the interaction between efficiency and usage, and the reason I get to that, it's sort of a question of unintended policy.

If you force fairly high efficiency standards on households, do they do like they do in the automobile sector where they bring their usage back up because you've made the price so much lower to consume that energy. Does anybody have any insights on that?

MR. GELLER: I would comment that it's a nice relationship to put into your economic models, but I think you need to think real hard about what the real world is like and how decision are made, and how many consumers do you think know there are national efficiency standards on refrigerators when they go into the Sears or the appliance store and shop for a refrigerator. I think the answer is very few.

And, how many know that their appliances are using 20 percent less electricity than they would have had these standards not been put into effect.

I think that my reaction is that there's some economic theory that leads you to accounting for these effects, but if you get into the behavioral literature, behavioral research doesn't show that it's really there.

MR. RODEKOHR: Go ahead.

MR. FLYNN: One other aspect of it is in the whole issue of DSM program evaluation. This is becoming a very important consideration, because once these programs are implemented, there's a certain predicted response in terms of reduction in electricity loads.

And, to the extent that these are not quite as successful as one might expect, utilities are hoping to gather data along these lines. Therefore, we might be getting more information over time as to what really does happen.

MR. RODEKOHR: Go ahead, Jim.

MR. McMAHON: We probably have literature in the appliance standards, but let me make a couple of statements very briefly, and I can give you more detail later.

The concern seems to come from two areas, one is economic theory, if you change the operating costs there will be a response in usage. That's a general principle, but you have to look at the specifics to see whether it applies and how much it applies.

The other concern seems to come from electric utilities doing DSM programs, where they want to make sure they can count on the savings that they are estimating from engineering calculations.

I think those concerns are legitimate. If you look at the literature, we've been able to identify several in the buildings area that actually look at this in a clean way. There's a lot of work on price elasticities, where the usage is buried along with everything else. Those generally can't be interpreted in a way to answer this question.

Of the three studies I'm aware of, I'll cite one very quickly. Florida Power & Light some years ago went to several hundred homes and replaced the air conditioners with more efficient ones at no cost to the homeowner, and they had electrical bills for years before and years after. A team at Research Triangle Park analyzed that data on a monthly basis.

For air conditioning, what they found was that by and large, the take back over a year was on the order of 5 percent, and in any given month the biggest take back was 15 percent, and that was a spring month -- I believe it was April, when it got hot. You wouldn't otherwise turn on the air conditioner, but now it was so cheap to operate that they did for a day or two, where they otherwise wouldn't have.

All three studies that I have seen indicate that that's the level of impact, and it's only in space conditioning. As Howard indicated, for refrigerators, or for television sets, I wouldn't expect that people would change their usage because the thing was more efficient or less efficient.

MR. RODEKOHR: All right.

MR. McMAHON: The other comment that bears on this, I think, is David Green's work at Oak Ridge on transportation. For cars, where he's looked at the effect of CAFE standards, he finds the take-back effect is only between 5 and 15 percent. I think that has to be an upper bound for the things in buildings, because gasoline is the case where the consumer knows what they are paying, they buy the gas themselves and they drive the car. The connection is as clear and direct as it can possibly be, and it's not the case in buildings.

MR. RODEKOHR: Thanks very much.

Do any of the reviewers have any further comments? Okay.

MR. BELZER: Given that many of the space conditioning and ventilation loads are dictated by building codes related to health and safety issues, I would expect that take-back effect to be very small and minimal in the commercial sector, which is obviously a large component of building energy use.

MR. RODEKOHR: Well, thank you very much. Oh, wait, one more.

MR. KOOMEY: John Koomey, Lawrence Berkeley Lab, I just wanted to add a couple things to this. You have to separate the effects that you are talking about when you are talking about takeback. One is an economic effect, the other is the effect of this takeback on your energy savings.

From an economic perspective, if people are taking back savings by using more energy, they must value the services that they get from that more than the cost of the energy.

So, it's a wash from an economic perspective. It's not going to affect your cost effectiveness. It may affect, to the small level that Jim McMahon talked about, the amount of energy savings you'd get from 5, to 15 to 20 percent, but you do have to make that separation when you are talking about the effects on the policy analysis.

MR. RODEKOHR: Thank you very much.

Well, it's been a very good audience. I appreciate everybody's time and attention, and we'll see you at other sessions, I hope.

Thank you.