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Pacific Northwest National Laboratory

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ImBuild: Impact of Building Energy Efficiency Programs

M. J. Scott
D. J. Hostick
D. B. Belzer

April 1998

Prepared for the U.S. Department of Energy
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Summary

As part of measuring the impact of government programs on improving the energy efficiency of the Nation's building stock, the Department of Energy Office of Building Technology, State and Community Programs (BTS) is interested in assessing the economic impacts of its portfolio of programs, specifically the potential impact on national employment and income. This assessment is being made for the first time in FY99 as a supplement to the Government Performance and Results Act (GPRA, formerly Quality Metrics) estimates of primary energy savings and environmental and direct financial benefits of the BTS programs.

The programmatic needs of BTS suggest that a simple, flexible, user-friendly method is needed to derive national employment and income impacts of individual BTS programs. Therefore, BTS funded Pacific Northwest National Laboratory (PNNL) to develop a special-purpose version of the IMpact Analysis for PLANning (IMPLAN) national input-output model (Minnesota IMPLAN Group, Inc. 1997) specifically to estimate the employment and income effects of building energy technologies. IMPLAN was developed originally by the U.S. Forest Service in cooperation with the Federal Emergency Management Agency and the Bureau of Land Management to assist the Forest Service in land and resource management planning. It has been in use since 1979 by a wide variety of government and private agencies to assess economic impacts. The special-purpose version of the IMPLAN model used in this study is called ImBuild. In comparison with simple economic multiplier approaches, such as Department of Commerce RIMS II system, ImBuild allows for more complete and automated analysis of the economic impacts of energy efficiency investments in buildings. ImBuild is also easier to use than existing macroeconomic simulation models.

While ImBuild does not include the ability to model certain large-scale dynamic features of national markets for labor and other factors of production featured in more complex macroeconomic models, for most purposes these excluded features are not critical to the analysis. Individual energy efficiency investment programs can be managed well by an input-output model because the scale of these impacts is small enough (relative to the economy) that neither labor markets nor production cost relationships should significantly affect prices as the efficiency investments are made. The exact timing of impacts on gross product, employment, and output from energy efficiency investments is not well-enough understood that much special insight can be gained from the additional dynamic sophistication of a macroeconomic simulation model. Thus, ImBuild is a cost-effective compromise mid-range model.

We conducted an analysis of three sample BTS energy programs: the residential generator-absorber heat exchange gas heat pump (GAX heat pump), the low power sulfur lamp (LPSL) in residential and commercial applications, and the Building America program. The GAX heat pump would address the market for the high-efficiency residential combined heating and cooling systems. The LPSL would replace some highly efficient fluorescent commercial lighting. Building America seeks to improve the energy efficiency of new factory-built, modular, manufactured, and small-volume, site-built homes

through use of systems engineering concepts and early incorporation of new products and processes, and by increasing the demand for more energy-efficient homes. We analyze a scenario for market penetration of each of these technologies devised for BTS programs reported in the *BTS GPRA Metrics Estimates, FY99 Budget Request*, December 19, 1997.[1]

Energy efficient technology affects the activity level of the U.S. economy through three primary mechanisms. First, if the incremental capital costs of the new technology per installed unit are different than those of the conventional technology, changes in the level of purchases will occur in the sectors involved in manufacturing, distribution, and installation for both technologies, changing the level of overall economic activity. Second, depending on how the efficiency investment is financed, it may "crowd out" other domestic saving, investments, and consumer spending, offsetting some of the investment's positive impact on the economy. Third, energy and non-energy expenditures are reduced. On the one hand, this reduces final demand in the electric and gas utility sectors. as well as the trade and services sectors that provide related maintenance, parts, and services. On the other hand, it increases net disposable income of households and businesses and increases general consumer and business spending in all sectors (including some increases in expenditures for electric and gas utility services and retail trade and services). All three sample BTS programs show significant energy cost savings, as shown in Table S.1.

Notice, however, they differ significantly when the analysis includes the investment costs. The GAX gas-fired residential heat pump costs about $1000 (25%) more per household installation than does the competing technology. However, energy savings are high enough for a payback period of about 4.5 years and the GPRA scenario results in positive net impacts on potential national employment and wage income. The LPSL costs less per square foot of space than the competing lighting technology. In this case, there are actual savings of capital costs that add to the impact. Building America uses systems design principles and new products/processes to improve energy consumption of residential buildings, with a goal of no incremental capital cost relative to traditional technology after 2005. Therefore, if the program meets its goals, payback is instantaneous and the GPRA scenario shows only the positive effects on employment and wage income after 2005.

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(1) Investment costs (in 1994 dollars in the original document) and energy savings (in 1995 dollars) were updated to 1997 dollars for this report.

Table S.1. Economic Impact of Three Sample BTS Programs on the U.S. Economy

Program and Year	Incremental Capital Cost (Million 1997 Dollars)	Delivered Energy Saved (10^{12} Btu)	Potential Jobs Created	Impact on National Wage Income (Million 1997 Dollars)
GAX				
2005	$10.0	0.4	0	$0.0
2010	60.0	7.3	500	7.5
2020	190.0	44.9	3,700	57.7
LPSL				
2005	-$19.5	1.6	600	$6.9
2010	-58.4	9.8	3,100	41.3
2020	-128.9	49.0	14,200	207.6
Building America				
2005	$135.0	3.9	500	$7.1
2010	0	30.3	3,400	62.8
2020	0	92.9	10,500	193.4

Acronyms and Abbreviations

ACEEE	American Council for an Energy-Efficient Economy
ADL	Arthur D. Little, Inc.
AFUE	average fuel use efficiency
AMIGA	Argonne Multi-Sector Industry Growth Assessment Model
BTS	Building Technology, State and Community Programs
cfl	compact fluorescent lamps
CGE	Computable General Equilibrium
COP	coefficient of performance
FY	fiscal year
GAX	generator absorber heat exchange (heat pump)
GDP	Gross Domestic Product
GNP	Gross National Product
GPFI	gross private fixed investment
GPRA	Government Performance and Results Act
HVAC	heating, ventilation, and air conditioning (equipment)
I-O	input-output
ImBuild	Impact of Building Energy Efficiency Programs
IMPLAN	Impact Analysis for Planning Model
INFORUM	Inter Industry Forecasting Project (University of Maryland)
LPSL	low power sulfur lamps
LTSM	Lighting Technology Screening Matrix
PNNL	Pacific Northwest National Laboratory
R&D	research and development
RIMS	Regional Input-Output Modeling System
SEER	Seasonal Energy Efficiency Rating
SIC	Standard Industrial Classification
VHF	very high frequency

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The authors would like to acknowledge M. B. Ginsberg, Deputy Assistant Secretary, and W. J. Raup, Energy Technology Program Specialist, of the Department of Energy Office of Building Technology, State and Community Programs, for support of the work discussed in this report. We also would like to acknowledge the assistance of D. M. Anderson, who provided vital technical assistance in creating the ImBuild model used in this study, and several colleagues who reviewed and commented on the methodology and this report: A. K. Nicholls, S. C. McDonald, J. M. Roop, and D. B. Belzer.

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1.0 Introduction: A Method for Assessing Employment Impacts of Building Energy Efficiency

1.1 Current Situation

As part of measuring the impact of government programs in improving the energy efficiency of the nation's building stock, the Office of Building Technology, State and Community Programs (BTS) is interested in assessing the economic impacts of these programs, specifically upon national employment and wage income. As a consequence, BTS funded Pacific Northwest National Laboratory (PNNL) to develop a simple-to-use method that could be used in-house to estimate economic impacts of individual programs. Three fundamental methods are available to estimate employment and wage income impacts for selected energy efficiency improvements in the U.S. economy: multipliers, input-output (I-O) models, and macroeconomic simulation models. We will provide an overview of each.

1.2 Impact Multipliers

Multipliers are simple mathematical ratios that relate impacts on national or regional economic output, jobs, or income to some corresponding change in demand for goods and services in specific industries. To estimate the impact of improved energy efficiency, analysts have used multipliers for industries that supply energy services and energy saving technologies (one example is the U.S. Department of Commerce Regional Input-Output Modeling System (RIMS II).(1)

Multipliers have the advantage of being extremely simple, quick, and inexpensive to apply, as well as readily understandable. For estimating some aspects of energy efficiency improvements, such as the immediate economic impacts of small consumer investments in energy-saving equipment, multipliers may also produce adequate results. However, multipliers perform poorly when used for analyzing changes in the economy for which they were not intended. An example would be when a multiplier for building energy savings is intended to measure the impact of increased investment for energy-saving equipment in buildings, but is used when the actual impact comes mostly from the supply-side effect of energy and maintenance savings on the profitability of businesses that occupy these buildings. Multipliers, as ordinarily computed, are used to estimate the impacts of changes in final demand, whereas energy savings in industry affect the size of the multiplier itself by changing the pattern of interindustry purchases on which it is based. The change is not equivalent to a change in final demand for the industries in the commercial sector, as has been assumed at ACEEE(2) and elsewhere. These

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(1) Bureau of Economic Analysis, *Regional Multipliers: A User Handbook for the Regional Input-Output Modeling System (RIMS II)*, (Washington D.C.: U.S. Department of Commerce 1992).
(2) Howard Geller, John DeCicco, and Skip Laitner, *Energy Efficiency and Job Creation: The Employment and Income Benefits from Investing in Energy Conserving Technologies* (Washington, D.C.: The American Council for an Energy-Efficient Economy 1992).

previous analyses reach roughly plausible results because the major macroeconomic impacts of energy savings occur through the spending and investment of these savings in the economy, not from *changes in* the intensity of interindustry purchases. This result works because energy is a relatively small cost item for most industries.

1.3 Input-Output Models

Static input-output models, such as the IMPLAN model,[3] allow greater flexibility than do multipliers concerning the types of energy efficiency effects that can be accommodated. As previously noted, certain economic effects of energy efficiency improvements require an assessment of interindustry purchases. In the buildings example above, some "energy efficiency" investments will not only reduce the costs of energy but the costs of labor and other goods and services as well. In the language of economics, this represents an investment-specific increase in productivity and value-added[4] and a *change* in the multipliers, differing from a case in which constant multipliers are applied to a change in investment. Yet, this effect is at the heart of many investment decisions. Savings in the energy, labor, materials, and services from improved productivity are the source of subsequent rounds of investment and economic growth.

I-O models such as IMPLAN can be utilized to estimate the impact of changes in overall efficiency and productivity in the economic sectors that make energy-efficiency investments. An input-output model also can keep track of the potential increases in value added that result from the improvement in efficiency and can, with appropriate assumptions, calculate the macroeconomic effects associated with spending of this increased income.

While I-O models are more difficult to use than multipliers, a modest front-end investment in a user-friendly shell can make an I-O model nearly as easy to use, with the advantage that it provides more theoretically plausible and comprehensive results. The chief drawbacks of I-O models are that 1) they do not provide information on the *timing* of impacts (for example, they do not say how long an investment in efficiency will take to work its way through the economy), and 2) because no prices or explicit behavioral adjustment mechanisms are found in I-O models, such as IMPLAN, no internal market features are present, such as increasing prices for sector output or for factors of production that automatically limit the size of impacts. In an I-O model, it is assumed that inputs needed for production in each sector are available without limit in constant proportions at constant unit cost. Thus, when analyzed in an I-O model, even very large scale investments that increase the scale of an industry many

(3) For an explanation of IMPLAN, see Minnesota IMPLAN Group, Inc., *IMPLAN Professional: Social Accounting and Impact Analysis Software*, Minnesota IMPLAN Group, Inc., Stillwater, Minnesota 1997.

(4) Value-added is the difference between the value of the output of a sector and the costs of the purchased goods and services that go into the sector. It is mainly composed of labor and proprietor income, retained earnings of corporations, rents, and taxes.

times over would not encounter either labor or material shortages that might cause prices to rise in the real world and dampen the economic response.

1.4 Macroeconomic Simulation Models

Macroeconomic simulation models are systems of mathematical equations that depict the structure of an economy. They are generally developed through econometric derivation from time series data or an eclectic mix of techniques, including I-O. The flexible structures of these models alleviate both of the main drawbacks of I-O models to some extent, but generally either at the cost of less sectoral detail or of significantly increased computational time or cost. Macroeconomic simulation models explicitly portray the time profile of impacts. For example, a simulation model usually would be able to calculate the year 2000 impact of an investment that occurred in 1997. Macroeconomic simulation models usually include labor markets and production cost relationships for several industries. In macroeconomic simulation models, an expansion of an industry due to investment would encounter tighter labor and materials markets as the expansion proceeds, thus explicitly increasing labor and materials prices. The price increases would restrain the expansion. The most ambitious simulation models simultaneously track all the major markets for resources, intermediate investment goods, services, and final production in an economy and perform computations that derive an internally-consistent set of simultaneous solutions for each market. These models are called computable general equilibrium (CGE) models. Less ambitious simulation models solve only one or two important markets and deal with the others by simplifying assumptions.

One relevant example of a macroeconomic simulation model is the Argonne National Laboratory model, Argonne Multi-sector Industry Growth Assessment (AMIGA), a modeling framework designed to address the economic impacts, job creation, and other effects of technology-related policy such as R&D programs, advanced industrial processes, recycling, and energy and environmental policies. It is a simulation model written in C programming language that has a 246-sector I-O structure embedded in it. AMIGA has been used by the DOE Office of Budget Planning and Customer Service to assess the impacts of new technologies and programs on U.S. economic activity and employment. Based on documentation available on this model, AMIGA features labor markets (that is, limitations on labor supply), prices of materials, and dynamic effects of investment on overall economic activity.

Another relevant example is the INFORUM model developed by the Inter Industry Forecasting Project at the University of Maryland (McCarthy 1991) that features both a long-term econometric model of the U.S. economy to derive economic aggregates (such as Gross National Product or GNP) and an 83-sector I-O structure that translates overall GNP into industry-specific production rates and demand for factors of production (such as labor and capital). INFORUM has been used to evaluate the national economic impacts of energy efficiency programs (Moscovitch 1994).

Generally, the advantage of macroeconomic simulation models is they can directly handle at least some dynamic features of economic impact, such as supply-side constraints, on certain labor and materials markets. One difficulty is that INFORUM and some similar simulation models may be limited in their ability to handle certain kinds of efficiency changes. Also, information requirements for some simulation models are quite detailed. For example, the following information is needed for an AMIGA model run: year, type of scenario, change in consumption of final goods and services, estimate of GDP change from the base case, percentage changes to each technical coefficient file (materials, energy efficiency and fuel share equations, labor inputs, services inputs, and factor productivity). Finally, neither AMIGA nor INFORUM is a *turnkey* system. Substantial support is needed from the modeling groups at Argonne National Laboratory and University of Maryland to run their models.

None of the preceding examples exactly fit the need. BTS needed a relatively small, stand-alone, and simple-to-use model that could be used in-house to estimate the national employment and income impacts of investments that BTS has made in specific BTS technology-development programs. The model must be able to quickly evaluate individual programs and to help provide a check on the more comprehensive estimates of the energy efficiency program effects provided by others. The model needs to be fully compatible with information provided in response to the Government Performance and Results Act of 1993 (GPRA).

1.5 Solution

The programmatic needs of BTS suggest that a simple, flexible, user-friendly method is needed to derive national employment and income impacts of BTS programs. A special-purpose version of the IMPLAN national I-O model was designed specifically to estimate the employment and income effects of building energy technologies. This model is called Impact of Building Energy Efficiency Programs (ImBuild). In comparison with simple multipliers, ImBuild allows for more complete and automated analysis of the essential features of energy efficiency investments in buildings. ImBuild is also easier to use than extant macroeconomic simulation models. It does not include the ability to model certain dynamic features of markets for labor and other factors of production featured in the more complex models, but for most purposes these excluded features are not critical. The analysis should be credible as long as the assumption is made that relative prices in the economy would not be substantially affected by energy efficiency investments. In most cases, the expected scale of these investments is small enough that neither labor markets nor production cost relationships should seriously affect national prices as the investments are made. The exact timing of impacts on gross product, employment, and national wage income from energy efficiency investments is not well-enough understood that much special insight can be gained from the additional dynamic sophistication of a macroeconomic simulation model. Thus, we believe that ImBuild is a cost-effective, compromise mid-range model.

2.0 Approach

The macroeconomic impacts of BTS programs can be analyzed using the following 4-step process, illustrated in Figure 2.1. The first three steps are conducted as part of the normal GPRA Metrics process; however, the fourth step (calculating the economic impacts) has been automated. The process utilizes a version of the IMPLAN U.S. national I-O model incorporated in a Visual Basic program that controls processing in a series of Excel 7.0 spreadsheets. The goal of the model-building process was to create a computerized tool that required only a knowledge of spreadsheets to run. The model is called ImBuild, which stands for Impact of Building Energy Efficiency Programs. The national I-O model is a 35- x 35-sector version of the 528- x 528- sector IMPLAN model. The 35 sectors are those most important for analyzing economic impacts of residential and commercial buildings technologies. IMPLAN is a particularly easy model to use, and was made even easier by the creation of an inexpensive, user-friendly, menu-driven front end to facilitate user inputs. Dialog boxes and macros create this user-friendly *front end*. Thus, the project provides an analytical tool that BTS policy analysts can use.

2.1 Details of the Approach

Step 1. Identify Program Economic Characteristics

To analyze existing BTS programs, a set of assumptions must be developed concerning the effects in the marketplace when more efficient technologies are developed or adopted as a result of the programs. The relevant program information includes: size of the incremental investment in the technology over time compared with the conventional technology it replaces, corresponding extra energy savings by fuel type in physical and monetary terms (may include additional use of some fuels when one type of fuel replaces another), and non-energy operations savings (if any) in comparison with current (conventional) technology. Sufficient information of this type currently exists on many, if not most, of the BTS programs as a result of the GPRA Metrics process. Three technologies are used as examples in this report. They were chosen to demonstrate different types of BTS programs, as well as some related macroeconomic issues.

- *Residential Generator-Absorber Heat Exchange (GAX) Heat Pump*. The purpose of the DOE program in this area is to develop and commercialize highly efficient, thermally activated, gas-fired heat pumps for residential application. The GAX technology is expected to displace the next generation of already highly-efficient conventional natural gas furnaces and electric air conditioners.

- *Low Power Sulfur Lamp*. The DOE program is continuing the development of Very High Frequency (VHF) electronics and advanced light distribution systems. The report examines both residential and commercial application.

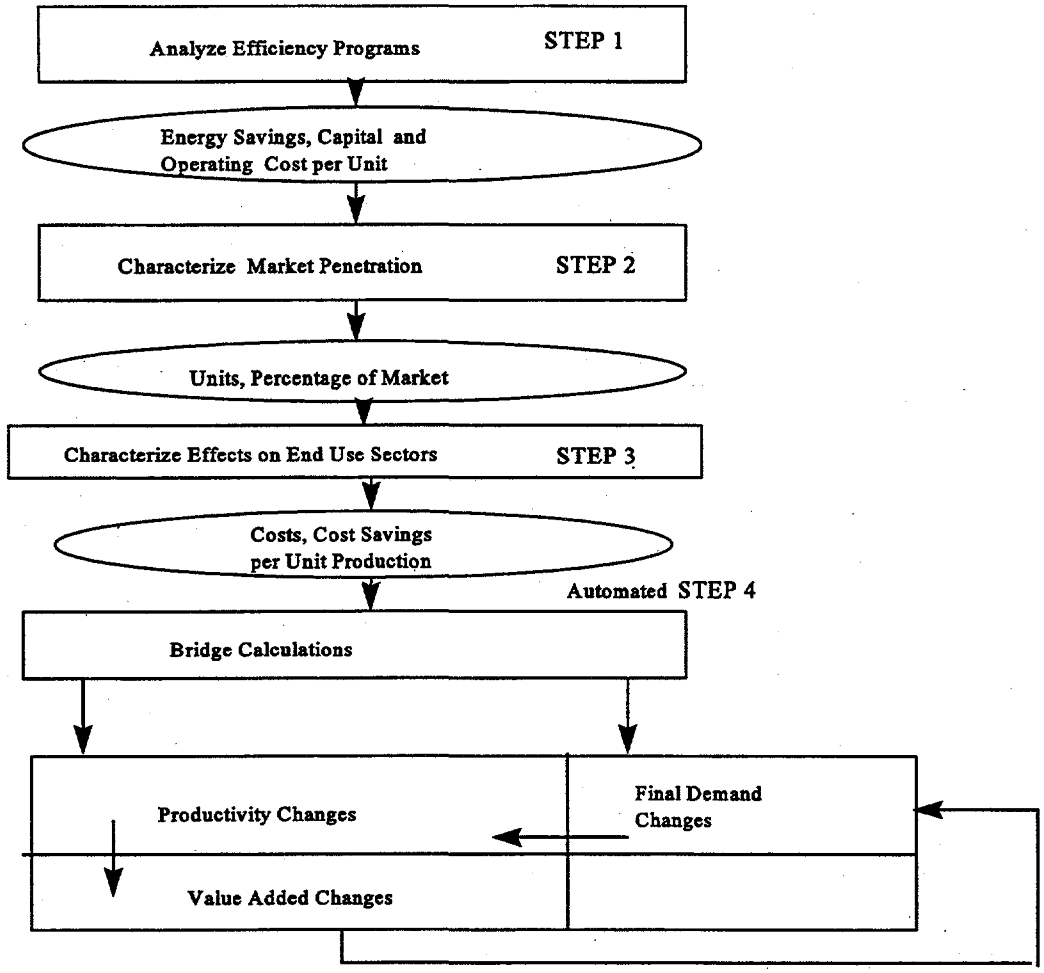

Figure 2.1. Process for Analyzing Economic Impacts of BTS Programs

- *Building America*. The final technology is Building America, a program that seeks to improve the energy efficiency of new factory-built, modular, manufactured, and small-volume site-built homes by use of systems engineering concepts, new products, and new processes.

Together, these examples demonstrate the impact of programs aimed at residential technology development, programs aimed at commercial technology development, and programs aimed at integration of energy efficiency knowledge and products into building systems.

Step 2. Characterize Market Penetration of the New Technologies

Existing research of the BTS market niche is used to characterize market penetration of the new technologies. Analysis depends on input from the GPRA Metrics program.

Step 3. Characterize Effects of the BTS Programs on End Use Sectors (Residential and Commercial Buildings)

Effects of the program on the end-use sectors, utilizing the technology or results of the program, must be characterized. This step combines analysis from Steps 1 and 2. A bridging matrix is used to match buildings and equipment investments in end-use sectors (for example, classes of commercial buildings) to the economic sectors that construct, operate or occupy these buildings. This process is necessary because, although the BTS programs are organized around buildings, equipment types and end uses, I-O models utilize economic sectors organized according to Standard Industrial Classification (SIC) codes. For purposes of the empirical analysis in this report, economic sectors occupying commercial buildings are assumed to experience savings in proportion to their baseline expenditures on energy and building maintenance goods and services.

Step 4. Calculate Economic Impacts

Given the data developed in Steps 1-3, the ImBuild model then calculates the impacts of energy efficiency programs on employment in the following three substeps.

Initial Investment Impacts

First, the model calculates the income and employment effects of initial spending on energy efficiency investments. (These impacts include the initial spending on plant and equipment by businesses and households that adopt the new energy-efficient equipment and practices. The impact of spending by the BTS programs on services provided in government, universities, and other contractors is not computed.) In an I-O model, this impact is estimated by changing expenditure levels in the government, household, and business investment columns of final demand and productivity in the last box of Figure 2.1. The left-hand side of Figure 2.2 illustrates the necessary calculations in more detail. The household and business investments are estimated, based on Step 2, then allocated to business sectors through the bridging calculations.

An important finding of this project is that the size and algebraic sign of the employment impacts of the initial investment process can depend critically on project financing. The investment typically must be paid for by diverting resources elsewhere in the economy. Therefore, the net employment impact of these energy-saving investments depends not only on the labor intensity of the investment process itself, but also on the relative labor intensities of those investment and consumption processes from which the necessary investment resources are diverted. As shown in Section 3.0, the positive impact of the initial capital investment is dampened considerably and may be reversed after the opportunity cost of the investment funds is taken into account.

Calculate Impact of Energy Savings on Value Added and Residential Savings

ImBuild calculates economic savings associated with changes in the use of energy, labor, and materials with the improved technologies and practices. In the case of residential applications this is

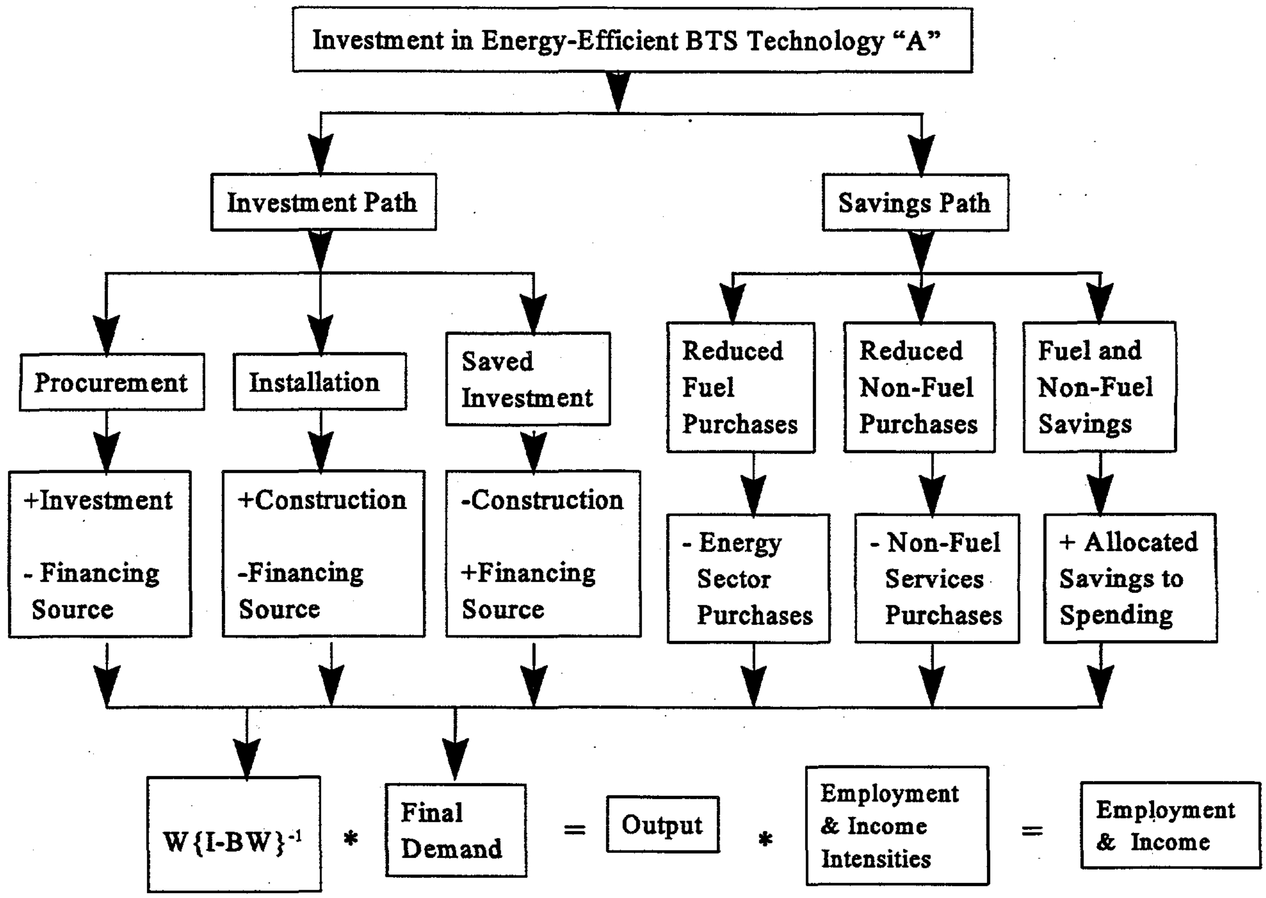

Figure 2.2. Detailed Calculations of the ImBuild Model

relatively straightforward, because residential savings are assumed to be recycled into final demand. For commercial building applications, the process is more complicated because the interindustry relationships between specific sectors are affected, not just final demand. For example, if the commercial building saves electricity, the business sectors operating/occupying these buildings would have lower purchases from the electric utility industry per dollar of output; thus, the coefficients in the utility industry row of the input/output structure of the economy must be reduced. Results from Step 3 are inserted into the ImBuild model in the interindustry portion of the I-O table (shown as Productivity Changes in the last box of Figure 2.1); then the model is run with the automatically recomputed table. Because the energy and maintenance intensity of the commercial sector changes, the coefficients of the I-O structure are automatically recalculated at each time step. This recomputation process requires less than 1 second on a Pentium 150 MHZ personal computer. The financial impacts of energy and non-energy savings (for example, savings in building maintenance) are computed by the model. These savings are treated as *free* income that is available to be saved or invested by the sector collecting the income.

The energy and non-energy savings do not affect employment in the national economy until they are reinvested or spent. For purposes of the analysis conducted for this report, the increments to value added (savings) are assumed to be allocated to compensation of labor and capital and to business taxes in the same proportion as all other value added in each sector. Then, the income of these sectors is assumed to be spent on final demand in the same proportion as existing compensation of labor, capital, and government. That is, if a given sector has 1% of all personal consumption expenditures in the economy and a 0.7% share of all business fixed investment, the sector will receive these same percentage shares of the efficiency-related increase in spending. Similarly, if labor compensation represents 70% of the baseline total value added in an industry, labor will receive 70% of any energy savings in that industry. Finally, labor compensation, business profits, and taxes are allocated to consumption, investment, and government spending according to current proportions.

Calculate Economic Impact of Value Added and Residential Savings

ImBuild accumulates the energy and non-energy savings in the residential buildings sector and the value-added changes associated with energy and non-energy savings within the commercial buildings sector. The model then calculates spending impacts associated with these savings by proportionately increasing final demand across all sectors as noted, while at the same time reducing final demand in the sectors that supplied the saved resources. This step accounts for the spending associated with the monetary savings and improvements in technological efficiency and for the associated shift from energy to non-energy spending. It also accounts for changes in the patterns of economic activity in the economy, due to technological changes caused by the BTS programs (for example, in retailing less electricity is used per dollar of output because of more efficient lighting).[1]

ImBuild collects the estimates of the initial investments, energy and non-energy savings, and economic activity associated with spending of the savings (increases in final demand in personal consumption, business investment, and government spending), and provides overall estimates of the increase in national output for each SIC sector using the adjusted I-O matrix. Finally, the model applies estimates of employment and wage income per dollar of economic output for each sector and calculates impacts on national employment and wage income.

When finished, the results of ImBuild model runs can be saved by running an imbedded dialog designed for this purpose.

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(1) ImBuild does not account for all of the long run impacts of technological change. The change in energy using capital in the commercial sector would alter the marginal value of all of the factors of production (including labor and capital) and would induce a rearrangement of capital and labor that ultimately results in an increase in output and in final demand. We show part of this effect, that of the initial spending associated with the savings, but not the effect of increased capital stock that would be created by the investment portion of the spending. Most economic models, including many dynamic simulation models, do not completely reflect the effect of capital accumulation and growth in capacity on final output and employment.

2.2 Components of Impacts: A Once-Only Investment

Energy conservation technology affects the activity level of the U.S. economy through three primary mechanisms. First, if the incremental capital costs of the new technology per installed unit are different than those of the conventional technology, changes in final demand will occur in the sectors involved in manufacturing, distribution, and installation for both technologies, changing the level of overall economic activity.[(2)] Second, depending on how the efficiency investment is financed, it may "crowd out" other domestic saving, investments, and consumer spending, somewhat reducing overall economic activity. Third, energy and non-energy expenditures are reduced. On the one hand, this reduction lowers final demand in the electric and gas utility sectors, as well as the trade and services sectors that provide maintenance, parts, and services. On the other hand, it increases net disposable income of households and businesses and increases general consumer and business spending in all sectors (including some increases in expenditures for electric and gas utility services and retail trade and services).

Figure 2.3 demonstrates how these mechanisms work by showing the effect of a hypothetical once-only investment in residential energy conservation technology in the ImBuild model. It is assumed that consumers spend a premium of $100 million on more-efficient residential appliances in the year 2000 that each year thereafter saves $15 million of electricity, $30 million in natural gas, and $5 million building maintenance expenditures, for annual savings of $50 million. This $50 million annual savings yields a simple payback period of 2 years. The first two cases in Figure 2.3 show only the employment effects of the $50 million savings. In the first case, the savings are confined to the residential sector. The second case shows how the impacts would change if these energy savings had instead been experienced in the commercial sector, where the savings are initially experienced as an increase in the profitability of those businesses saving the energy. These profits are assumed to be *recycled* in the economy as spending by workers, spending by the firms themselves, and by governments experiencing increases in tax collections. In the first case, the energy savings in the residential sector of $50 million have a net impact on the U.S. economy of about 520 jobs, or about 1.1 additional jobs per $100 thousand dollars of direct energy savings. The impact is somewhat greater if the energy savings occur in the commercial sector (570 jobs) because the employment intensity of the spending mix of businesses, their workers, and government associated with commercial savings is different from the spending intensity of the household sector alone, which is associated with residential savings.

Next, Figure 2.3 adds a third and fourth case to show the employment impacts of the $100 million investment itself. The third case shows the impact of the investment premium. In this case, even though investment in the technology itself generates employment, the short run net employment impact is negative (*minus* 580 jobs) because the opportunity cost of the investment premium is the dollar amount

(2) Frequently, a premium is present in the cost of appliance purchase and installation, over and above the cost of an alternative conventional system. We have assumed the premium attached to the new technology is due entirely to the differential cost of manufacturing the equipment. Distributor and dealer/installation costs are assumed to be unaffected.

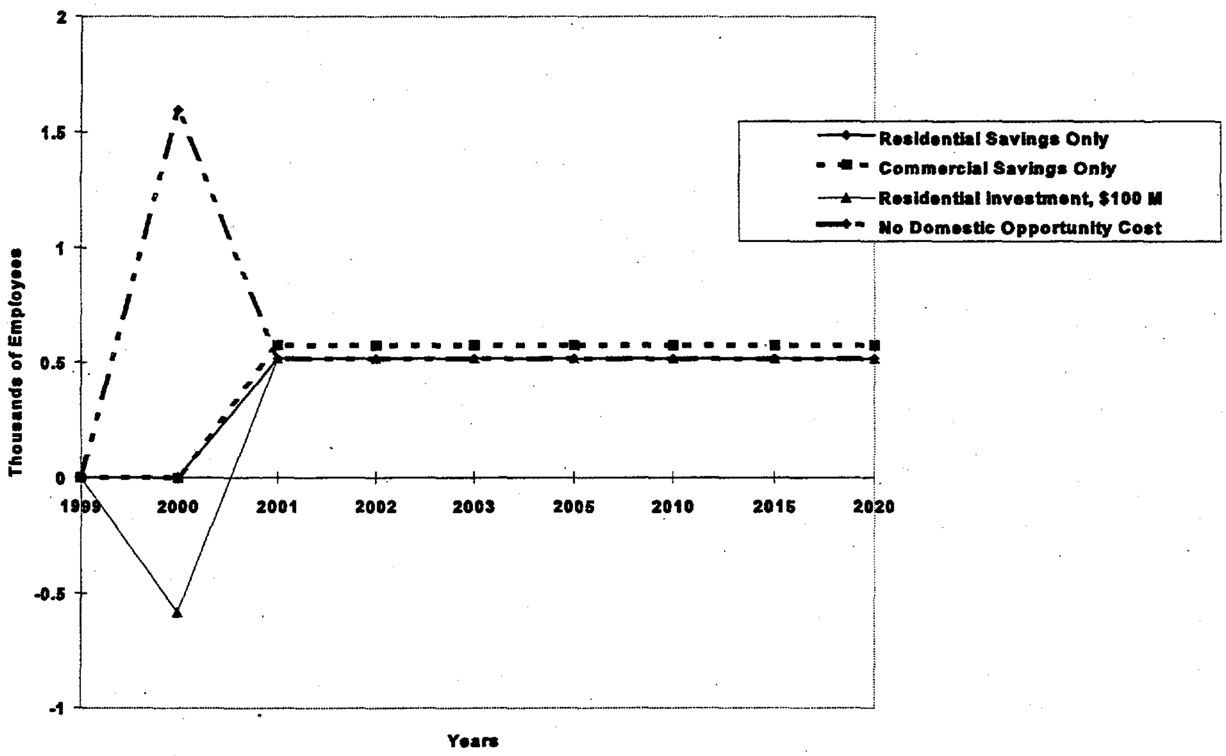

Figure 2.3. Impact of Hypothetical Once-Only $ 100 Million Investment in Heating and Air-Conditioning Equipment Efficiency on National Employment

the investment would have produced elsewhere in the U.S. economy, which on average is more labor-intensive than the manufacturing sector that makes the new technology.(3) Typically, efficiency programs are considered relatively labor-intensive, but this is not always the case. Heating and air conditioning manufacture, for example, is quite capital-intensive. The strength and direction of the investment effect depends on the size of the investment premium and its combined domestic U.S. direct and indirect labor intensity, relative to that of other domestic spending (the opportunity cost of the investment). For the employment impact of the investment to be positive, the sectors supplying the new technology must on average create more domestic jobs per dollar of spending than does other domestic spending. An extreme form of this positive investment effect would occur, if the investment were financed internationally (that is, no domestic opportunity cost is included). This is the fourth case in Figure 2.3, which shows a short-run jobs impact of 1600 and a long-run jobs impact of 520. The fourth case also corresponds to many regional analyses that have been made of energy conservation impacts, where the investment funds are assumed to come from *somewhere else* and have no opportunity cost in the region.

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(3) Strictly speaking, the labor intensity that counts is the employment, direct *and indirect*, that is created by each dollar of spending. Thus, it is theoretically possible for a capital-intensive industry to buy lots of labor-intensive inputs from other industries and the total effect to be labor intensive as a result.

3.0 ImBuild Model Results for Example BTS Programs

This section discusses the results obtained by using the ImBuild model to calculate the employment and income consequences of three specific building technologies as they are expected to be introduced into the U.S. residential and commercial buildings sectors. The three technologies were chosen because they represent a diversity of BTS program characteristics, are likely to affect the economy in different ways, and illustrate a number of issues concerning the economic impact of building technologies.

3.1 Comparison of Capital and Operating Cost Scenarios for Example BTS Technologies

The impact of BTS technologies on the national economy depends on the market penetration of these technologies and their associated investments and operating costs. This analysis is tied to the scenarios for market conditions, costs, and energy consumption of specific technologies and programs from the BTS GPRA Metrics, a product of significant work on technology performance, costs, and markets.(1) Appendix A shows the specific values of these savings and expenditures for the specific scenarios of market penetration. Figure 3.1 shows the premium in capital costs for the GPRA Metrics market penetration scenarios associated with three technologies, GAX heat pumps (GAX), low-power sulfur lamps (LPSL), and Building America.

- **Residential Generator-Absorber Heat Exchange Heat Pump**. The first technology is the gas-fired residential generator-absorber heat exchange heat pump or GAX technology. The purpose of this program is to commercialize highly efficient GAX heat pumps for new and existing manufactured and single-family residential buildings. Improved manufacturing techniques, assembly processes and increased rates of production for heat pumps and chillers are expected to lower manufacturing costs and expand the market. The technical, near-term objective of this program is to manufacture and commercialize an advanced absorption heat pump with an initial coefficient of performance (COP) of 1.6 for heating and 0.65 for cooling. The technical objective by the year 2000 is to raise efficiency to a COP of 1.8 for heating and 0.8 for cooling.

  Based on the Space Conditioning R&D: GAX Program Office Data Collection Survey (Fisksum 1997), the GAX unit is assumed to compete with a relatively efficient new residential gas furnace having an Average Fuel Use Efficiency (AFUE) of 92% and a central air conditioning unit with a COP of 2.93, rising to 3.9 in the year 2005. It is assumed the BTS technology competes only with new units and provides replacements of units that would have been retired regardless of the BTS program. Both new and existing buildings (those built before 1999) are affected. The start year for

(1) This report used BTS program data reported in the *BTS GPRA Metrics Estimates, FY99 Budget Request*, December 19, 1997, as well as program information from PNNL (1997) that PNNL updated by and with DOE/EE program managers to produce the descriptions shown here.

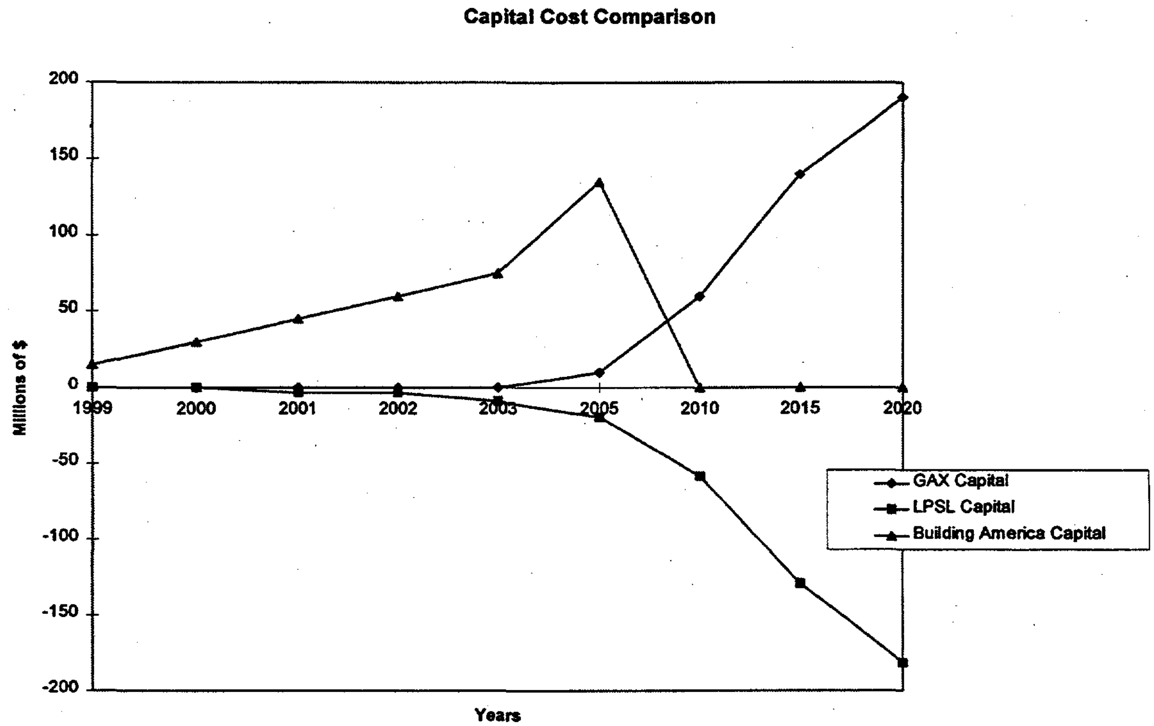

Figure 3.1. Incremental Capital Costs by Year for GPRA Metrics Market Scenarios of GAX Heat Pump, Low Power Sulfur Lamp, and Building America

market penetration was provided as 2002. The GAX heat pump program targets only new and existing manufactured and single family residential buildings located in the North region of the United States for income levels greater than $25,000. DOE's companion Hi-Cool Heat Pump program (not evaluated in this report) is assumed to target the same equipment, but is assumed to penetrate the market only in the South.

The Residential Absorption Heat Pump Program Office Data Collection Survey provided market penetration rates of 5% of all households by 2010 and 7% by 2020. These penetration rates were adjusted to provide a market penetration rate for residential households in the North heated with gas furnaces, a more restricted market. In order to simulate historical penetration rate patterns, penetration rates for all years prior to 2020 were calculated, based on a diffusion model for generic heating, ventilation, and air conditioning (HVAC) equipment. Non-energy cost savings were derived from the EIA Technology Forecast Updates (ADL 1995).

The Residential Absorption Heat Pump Program Office Data Collection Survey showed the incremental investment for GAX technology as $1000: the estimated retail cost of the GAX heat pump was given as $5000, while the estimated cost of the conventional system was given as $4000. The technology is cost-effective, eventually saving an estimated $223 per household per year in energy, compared with current technologies, despite improvement over time in the air conditioning portion of the competing standard technology. The simple payback period on the additional investment in a GAX installation is expected to be about 4.5 years.

- **Advanced Light Sources, Electronics, and New Concepts: Low Power Sulfur Lamp**. The second technology is the Advanced Light Sources, Electronics, & New Concepts: Low-Power Sulfur Lamp Program (the short name is LPSL or S Lamp). The DOE program is continuing the development of the VHF electronics and advanced light distribution systems that will make the technology commercially feasible. The LPSL technology is assumed to have a lighting efficacy of 75 lumens/watt, rising to 135 lumens/watt in the year 2005.

  The target market for the LPSL is the replacement of multiple incandescent lamps in commercial and residential, new and existing buildings. Both the residential and commercial market are expected to decline in size over time because of the market penetration of compact fluorescent lamps (CFL). The residential market is expected to remain constant in size. The increased baseline penetration of CFL by 2020, based on baseline market shares, was estimated at about 12.5% of the residential incandescent market and 43.5% of the commercial incandescent market. The LPSL technology was assumed to capture 20% of incandescent sales by 2020. The LPSL program penetration rates were developed from a generic lighting technology diffusion model.

  Costs were determined from the Lighting & Appliance R&D: Lighting R&D Program Office Data Collection Survey (Anderson 1997) and the Lighting Technology Screening Matrix 2.1 (LTSM) database (PNNL 1995). The cost of the baseline incandescent fixture was based on a 75 watt fixture with an installed cost of $25 per fixture. The cost of the LPSL fixture was assumed to be $25 through 2004, rising to $50 in 2005.

  The per fixture costs were translated to residential costs per household and commercial costs per square foot. A ratio of baseline lumens per fixture to LPSL technology lumens per fixture (0.21 before 2005, 0.11 afterwards) was used to translate the number of incandescent fixtures to the equivalent number of LPSL fixtures required to produce the same light output. The LPSL technology provides energy savings per household that begin at $71 per year in the year 2000 and rise to $109 per household by 2020. Energy savings in the commercial sector remain in a range of 28 to 44 cents per square foot from the year 2000 to the year 2020. Variation occurs because of changing electricity prices and changing LPSL efficiency. Because LPSL technology requires very few fixtures to light a large area, the capital cost of lighting actually is expected to fall, from a range of 9 to 16 cents per square foot with conventional technology to 2 to 3 cents per square foot with LPSL technology in commercial buildings, and from $200 to $225 per household with conventional technology to $46 to $52 per household with LPSL technology in residential buildings. Thus, the payback period on LPSL technology is projected to be instantaneous.

- **Building America**. The final technology is Building America, designed to improve the energy efficiency of new manufactured and single-family homes. The program seeks to improve and change current practices by emphasizing system engineered whole-building approaches that integrate component-based research and technology. The program will reduce energy use, construction time, and construction waste by incorporating new products and processes earlier, developing widespread demand for more energy efficient homes, and involving builders in improving home building design. The Building America performance objectives are a 25% reduction in energy requirements by 2005 and a 50% reduction in energy requirements by 2010.

The Building America program target market is new residential buildings for income levels greater than $25,000 or 54% of the total new residential building market. The market penetration rate in the year 2020 was calculated as 27.2% of the target market, which means that Building America practices and technologies would be included in 14.7% of all new residential buildings by the year 2020. Market penetration began in 1997.

According to the Residential Housing Program Office Data Collection Survey (Myers, James, and Stone 1997) conducted in 1997, the cost of designing and building more energy efficient homes eventually will be equal to the same costs for a conventional residential building, even though the techniques used currently are about $1500 more per household than conventional technology. Beginning in 2010, the baseline cost and the BTS technology cost are assumed the same. The annual energy savings are initially expected to average $117 per household, rising to $222 in 2010, and then declining slightly to $218 in 2020. Initially, the payback period on the incremental investment would be about 12.8 years, becoming instantaneous by 2010. No non-energy operations cost savings were calculated for this analysis.

Figure 3.2 shows the associated energy and non-energy savings (reduction in operating costs) compared with conventional technologies. All cost premiums and savings are measured relative to baseline conditions by the GPRA Metrics program. These figures represent total increases or decreases in cash outlays in the year shown and not the annualized savings or costs.[2] Cash outlays vary not only because of the characteristics of the technologies themselves, but also because the market penetration of each technology is expected to change over time as a result of BTS program success.

Capital expenditures shown in Figure 3.1 represent the premium of investment cost over the money that otherwise would have been spent to equip the same residential and commercial building stock with baseline technologies. The costs shown are dependent not only on the cost per unit of the new technology but on the costs of the technology with which it is assumed to compete. For example, the GAX heat pump technology is assumed to compete in the market for advanced residential furnace-air

(2) We do this because economic impacts, such as employment, will occur when the money is actually being spent, not when the economic entities incur the costs associated with the spending. Thus, for purposes of this analysis, if an investment is made in the year 2000, the jobs created are the same whether the money to pay the workers is accumulated cash or borrowed funds. The impact of the opportunity cost is more of a question, as financing theoretically could change the time distribution of the impact on the cost side. We have chosen to show the impact as if it all occurred in the same year as the investment in energy efficiency.

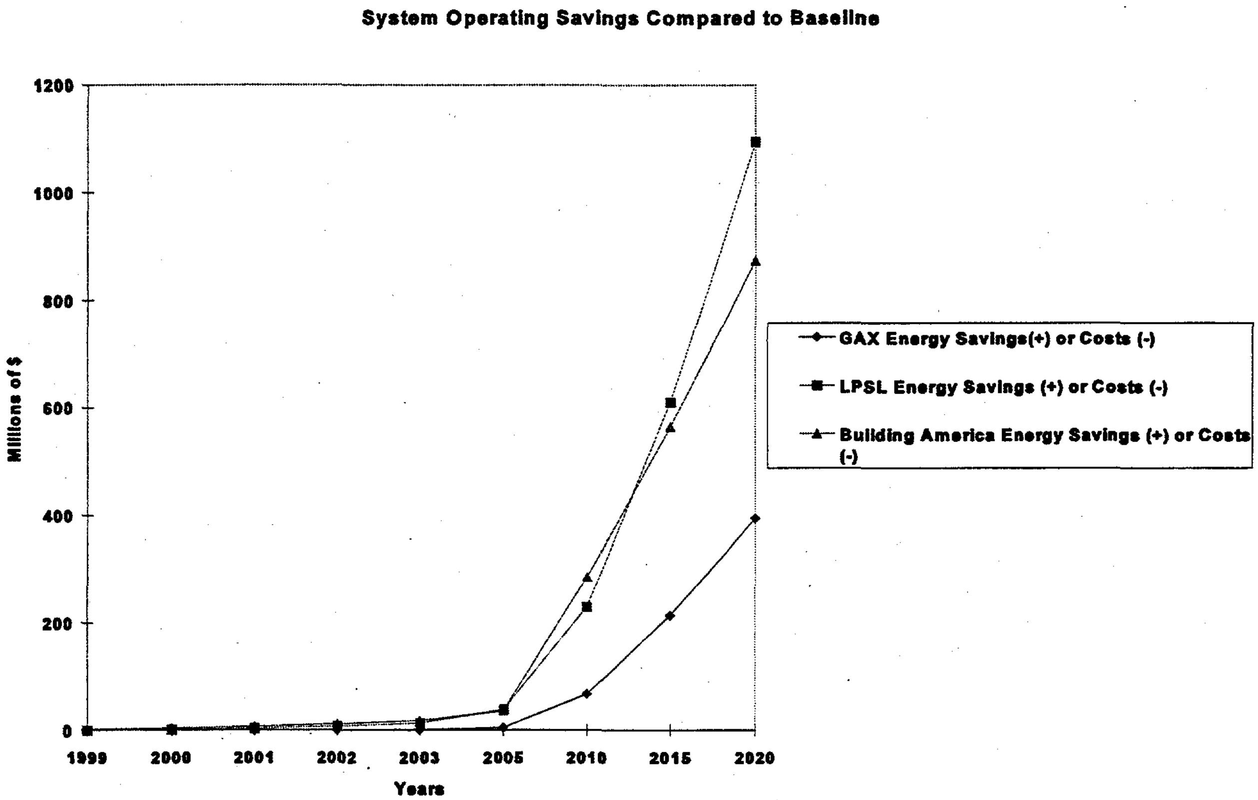

Figure 3.2. Level of Energy Savings by Year Relative to Baseline for GPRA Metrics Market Scenarios

conditioning combinations. The GAX heat pump is assumed to address only the high efficiency niche in this market, rather than the mass market. The alternative baseline technology in this case is assumed to be a gas furnace with an average fuel utilization efficiency (AFUE) of 92% and an air conditioning unit with a seasonal energy efficiency rating (SEER) of 12. This contrasts with an average AFUE of 78% and a SEER of 10 in current new installations, so the alternative technology is itself highly efficient. The alternative baseline 92 AFUE/12 SEER unit costs $4000 per household. The GAX unit is $1000 more expensive, at $5000. These costs result in rather slow market penetration

If the Building America program is successful, it is expected to save energy without adding to the initial investment in new buildings after the year 2005. Thus, no cost premium is shown for this program in Figure 3.1 beyond the year 2010. Because LPSL saves investment capital on each unit installed, the GPRA program scenario is projected to be saving investment capital at the rate of about $180 million per year by the year 2020.

All three programs show significant energy cost savings in Figure 3.2. These cost savings depend on the cumulative number of units installed compared with the same market developed with more conventional technology, the relative amount of energy used or saved, and any additional non-energy costs or savings.

The following three subsections describe the expected impacts of three individual technologies in more detail.

3.2 GAX Heat Pump

Figure 3.3 shows the employment impacts associated with variations of the GPRA Metrics GAX heat pump scenario. An essential feature of this scenario is the accelerating investment in GAX heat pumps throughout the forecast period out to 2020. This accelerating investment path means that in any time period, the economy is experiencing a mix of consequences from energy savings and new energy efficiency investment, with the prospect that negative investment consequences could dominate. In fact, however, the energy savings dominate. The line in Figure 3.3 marked Energy Savings Only demonstrates that eventually, the energy savings in the scenario could generate a considerable economic

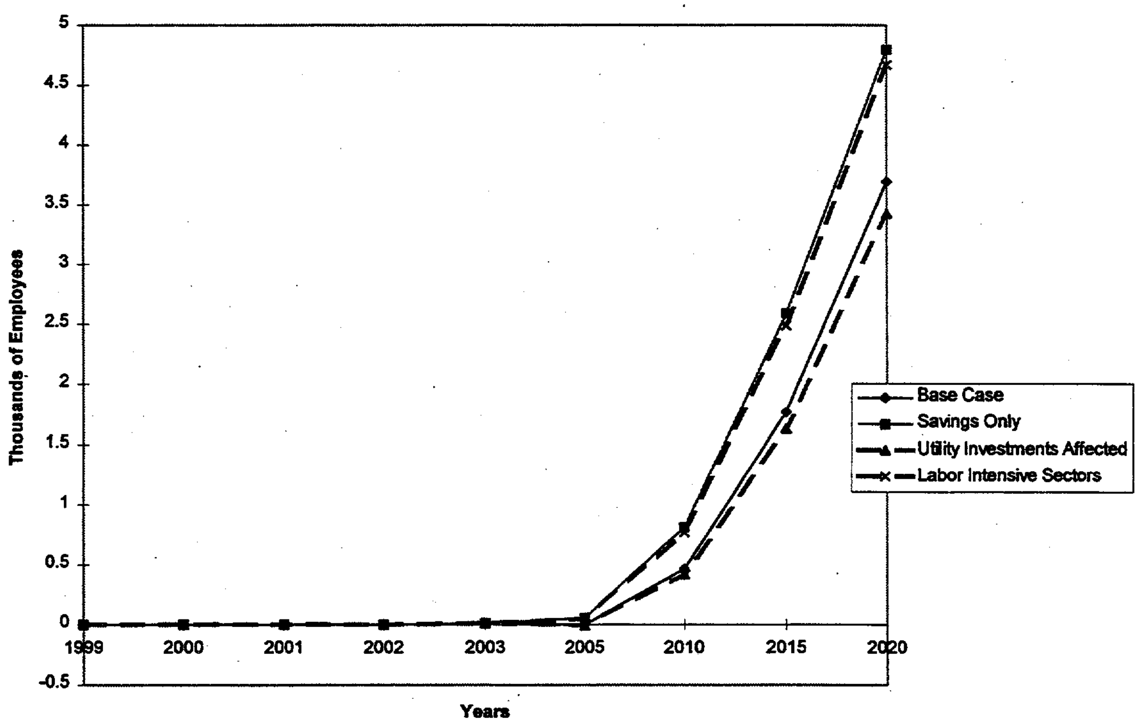

Figure 3.3. Employment Impacts of Investment in GAX Heat Pumps

surplus with the potential to create up to several thousand jobs.[3] The Base Case includes the negative net impact on jobs of the investment in heat pumps (spending is transferred from labor-intensive to capital-intensive sectors). Thus the Base Case lies below the Savings-Only Case. Next, we consider the effect of energy conservation on investment in capital by electric utilities and gas utilities. If energy consumption decreases, it may be possible for utilities to defer investments they otherwise would make in plant and equipment. To analyze this question, we assume that each reduction of 1 trillion Btu of annual electrical energy demand saves $32.9 million of electric utility investment (about $590 per MW of capacity) and every trillion Btu of natural gas saved in annual demand saves $5.29 million of gas utility investment.[4] Reduced investment by utilities releases resources from the utility construction sector, which is relatively labor-intensive, to the economy as a whole, which is slightly less so. The net effect is small – a reduction of just 300 jobs (the net employment impact is 3400 instead of 3700). Thus, saved utility investment, to the extent it occurs, has a slightly negative impact on employment.[5]

So far, this analysis has assumed the cost premium for GAX heat pumps is entirely due to their manufacture. The case in Figure 3.3 marked Labor-Intensive Sectors is a sensitivity case that shows if more labor-intensive appliance distribution sectors of the economy were affected by the initial investment (not just appliance manufacturing), the net employment effects of the investment premium would be near zero, and the overall net effects would largely mirror the energy savings alone.[6] However, we have no reason to believe that traditional percentage wholesale and retail trade markups would necessarily be maintained in the face of the higher manufacturing cost. It is more likely that distribution, marketing, and installation costs would be about the same for the GAX and the competitor unit.

Figure 3.4 shows that financing affects the size of the projected net employment effect. The net effect depends on the market penetration scenario itself (that is, how fast and at what cost the technologies enter the market) and on what activity in the U.S. economy is displaced by the investment

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(3) Whether the jobs actually would be created depends on future labor market supply conditions and macroeconomic policy. See, for example, Solow (1994) or Moscovitch (1994).

(4) For this report, we estimated electric power plant construction savings at about $590/kW of delivered electric energy, based on data in EIA (1997). The equivalent value for natural gas, is about $1.20/cubic foot/day capacity, based on EIA (1996).

(5) This analysis assumes that saved utility investment funds would be recycled in the economy, as are ordinary earnings. If these funds were used to make foreign investments, for example, the negative impact would be much greater.

(6) The differential employment impact of the GAX investment arises because the appliance manufacturing sector and its suppliers are more capital-intensive than the economy as a whole. Thus, diverting investment funds from the rest of the economy to appliance manufacturing tends to reduce employment. If the investment cost premium were spread among more labor intensive sectors, such as wholesale and retail trade, the average employment intensity of the GAX investment would be much closer to the national average. For the sensitivity case in the figure, we assumed that manufacturing took 46% of the investment premium; wholesale and retail trade, 37%; and construction, 17%. These proportions are normal industry averages.

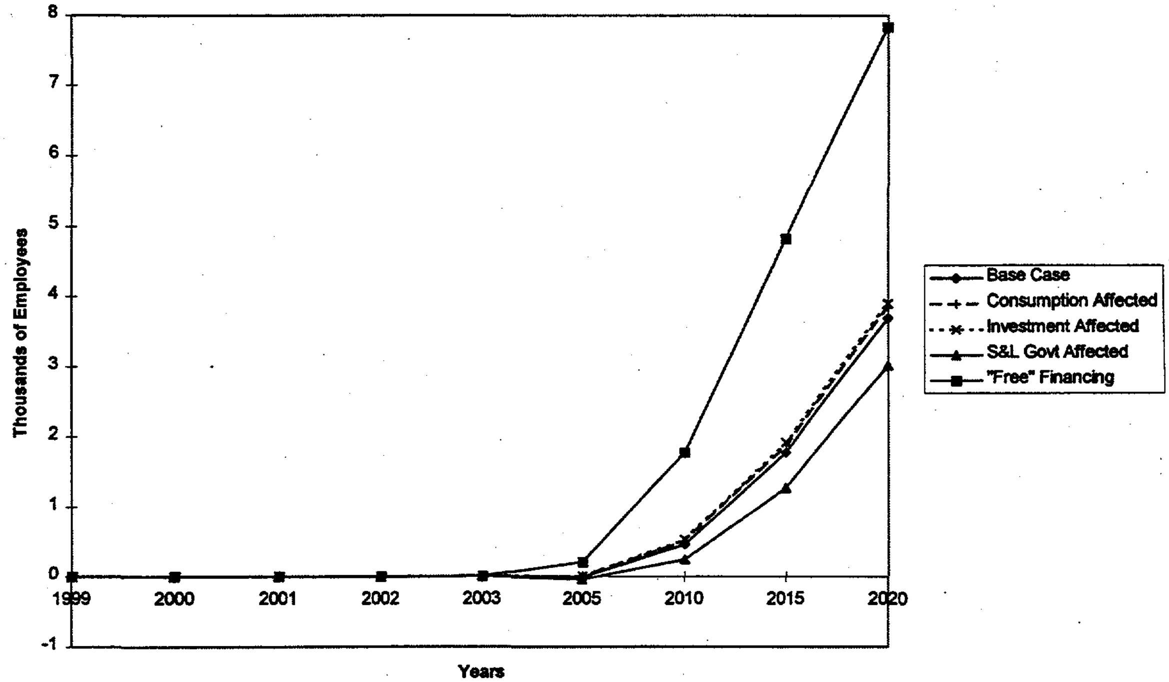

Figure 3.4. Impact of GAX Investment Financing on Employment

in heat pumps. Employment impacts are estimated for the GAX heat pump market penetration of the GPRA Metrics scenarios under differing scenarios concerning the financing of substantial up-front investment. For example, in the base case, the funds necessary to finance the heat pump investment are drawn proportionately from the all sectors of the economy.(7)

In the highest scenario in Figure 3.4 (Free Financing), the assumption is the investment does not impinge on U.S. economic activity, and thus, the entire incremental investment adds to U.S. final demand and domestic product. A number of reasons exist why this could happen. From a macroeconomic perspective, two plausible reasons are that consumers decide to spend previously accumulated savings or else the international financial markets judge the investment to be a cost-effective use of their lendable funds, so that investments in some other country are crowded out. This results in the maximum possible impact on U.S. employment from the investment, an impact large enough to dominate other macroeconomic effects of the technology.

The other scenarios in Figure 3.4 demonstrate to varying degrees that the employment impact would be temporary, if the new incremental investment in heat pumps displaces enough other consumer

(7) Personal (household) consumption is assumed to represent 70% of spending; gross private fixed investment, 10%; federal defense spending 2%; federal non-defense spending, 6%; and state and local government spending, about 12%. These percentages are close to the actual distribution of final demand among these sectors.

spending or business investment.[8] However, because the effects of energy savings are relatively large, the net effect on employment is positive. Similarly, although short-run employment is reduced even more if state and local government were to subsidize this investment (and reduce other spending to maintain a balanced budget), the net effect is positive because energy savings dominate. A major reason for the negative investment impact is, although the GAX technology is cost-effective, it is less employment-intensive than the general economy.[9]

Because the amount of the funds needed for investment in GAX heat pumps is the same in each scenario in Figure 3.4, the level of the offsetting impact depends on the relative employment intensity of economic activity in the various sectors from which the investment funds come. Overall, as government activity is particularly labor intensive, the largest drag on employment would occur if general government spending were reduced to make the GAX investments.

Of course, jobs are not the only metric by which we can measure the macroeconomic impact of energy efficiency programs. Because different industries pay different wages on average, it is theoretically possible to create a number of low-paying jobs while reducing the number of well-paying jobs and overall income. Thus, it is worth looking at the impact on wage incomes as well as employment. Figure 3.5 illustrates the effects on national wage income of the various scenarios, previously shown in Figure 3.4, with their different sources of investment capital.

Figure 3.5 illustrates that, as before with employment, the impact of the heat pump investments and savings on the national economic activity are positive when the investment does not crowd out domestic spending and investment. With the source of investment funds being the entire economy (Base Case), the net impact on national incomes is positive, as also was shown in Figure 3.4 for employment. As was true with employment, the impact on wage income is generally reduced (but not negative) if normal personal consumption or business investment are foreclosed by heat pump investments. On the other hand, if government activity is crowded out, the net impact on income is very slightly negative (but near zero) in the short run.[10]

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(8) The financing effects could be thought of in the following ways. If consumer spending is the only sector affected, it might be because consumers reduce their purchases of consumer durables like washing machines (or buy less expensive ones) to afford the additional heat pump investments. Business investments could be reduced instead because lenders provide loans to households to pay for heat pumps instead of loans to business to buy plant and equipment. Finally, state and local government spending could be reduced because tax credits are allowed on state and local income taxes for investments of this type.

(9) Although a GAX investment may be cost-effective in comparison with the alternative energy technology, these impact calculations do not address whether the GAX investment provides as many net economic benefits to the economy as other, non-energy investments with which it also competes.

(10) This situation is because state and local government is exceptionally labor-intensive; so much so that in the early years, the net negative impact of the investment more than offsets the positive effect of the savings.

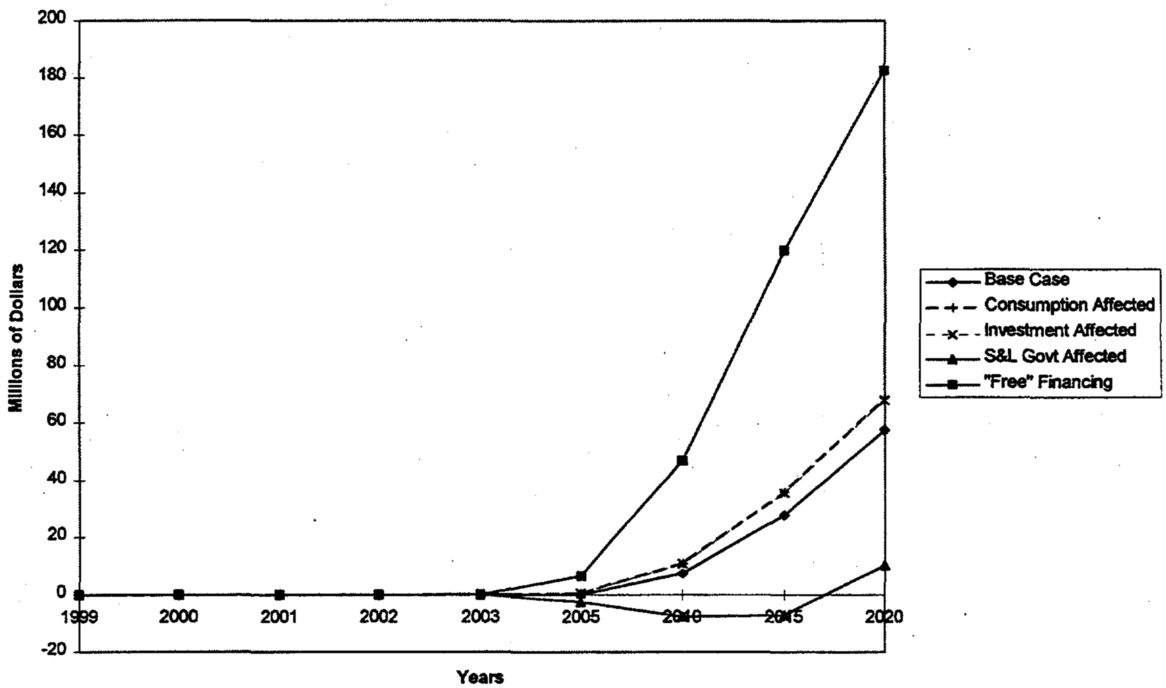

Figure 3.5. Impact of GAX Investment Financing on National Wage Income

Figure 3.6 is the wage income equivalent of Figure 3.3, and shows very similar results. As expected, the impact of the investment is initially negative (the Base Case lies below the Savings-Only case) because the activity created in heat pump manufacturing and its supplying industries employs fewer workers per dollar of activity than the national average. A slightly unexpected result occurs if energy savings defer utility investments. Energy savings, if they are large enough, could reduce utility investment in new plant and equipment (mostly construction). Should this occur, Figure 3.6 shows that reducing construction activity frees up dollars that tend to have a slightly more positive impact on national wage income when spent on personal consumption, business investment, and government programs than if they had been spent in construction.(11) Thus, the net impact on national wage income is very slight increase relative to the base case.

Finally, the figure shows that if the investment in heat pumps were distributed across more labor-intensive industries rather than just appliance manufacturing, then the net drag on national wage income

(11) In the case analyzed, this sign is the opposite of the comparable employment effect and is the combined result of intersector purchases and the wage rates in the affected sectors. The net effect is small, however, and could be of either sign, depending on exactly which sectors are affected. When relatively capital-intensive sectors spend the released investment funds, the effect is negative for both employment and income; when labor intensive sectors spend the money, the net effect is positive for both. The illustrated case involves a mix of sectors.

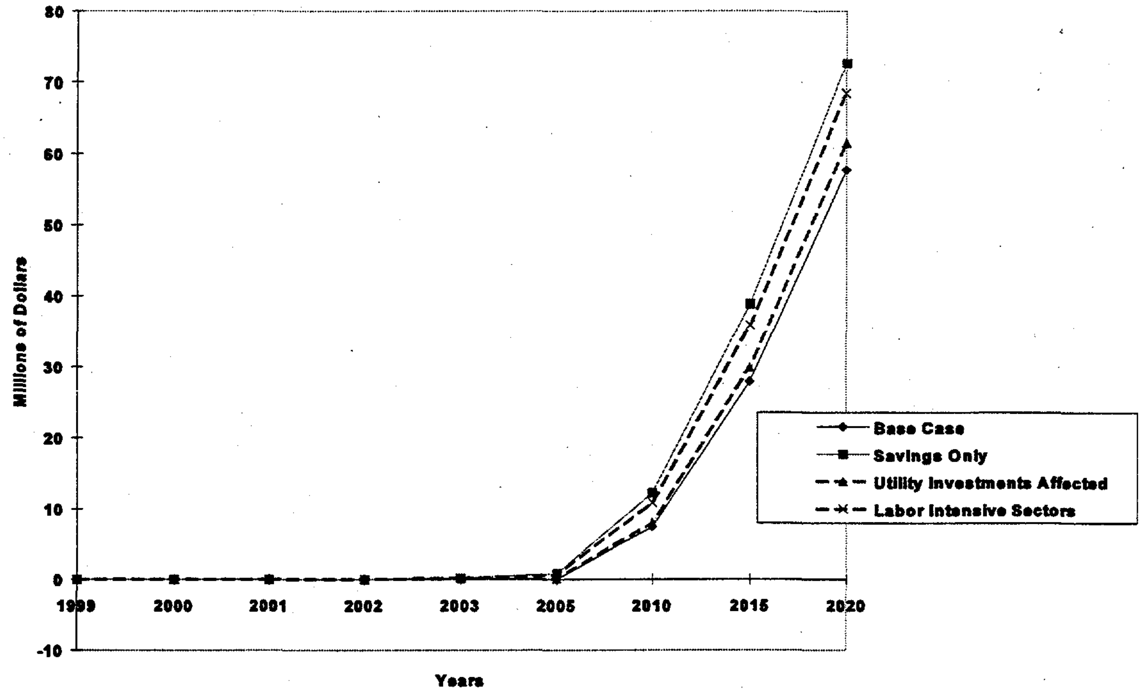

Figure 3.6. Sensitivity of Impacts on National Wage Income to GAX Investments

represented by diversion of investment dollars into capital-intensive manufacturing would decrease and the net impact would be similar to that created by the energy savings alone.(12) As before, however, it is likely that most of the premium in cost would be the additional cost of manufacturing.

3.3 Low Power Sulfur Lamps

Similar to GAX heat pumps, LPSL installed in residential and commercial buildings are expected to require an investment. The national economy is stimulated by additional final demand focused on the manufacturing sectors that make electric lights and related equipment. On the other hand, this investment requires capital the nation's households and businesses otherwise would have available to spend for other general investment and consumption purposes. The GAX and LPSL scenarios contain two significant differences. One of them is that LPSL are expected to *save investment,* when compared to conventional technology supplying the same level of lighting service (lumens per square foot). The investment savings release certain investment resources to the national markets, in the short term, potentially creating jobs beyond those created by energy savings alone. This potential is illustrated in Figure 3.7, in which the Base Case lies above the Savings Only Case.

(12) In this case, the investment premium was distributed 46% to appliance manufacturing, 37% to the wholesale and retail trade, and 17% to the construction sector for installation.

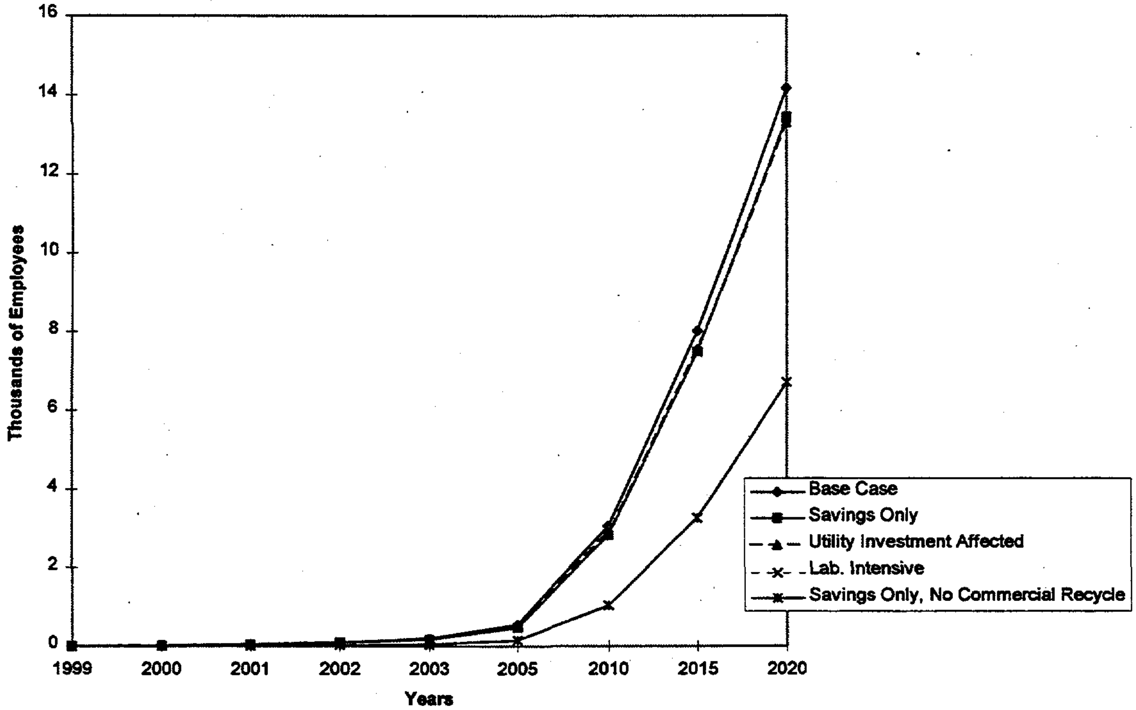

Figure 3.7. Sensitivity of National Employment to Low Power Sulfur Lamp Assumptions

A second difference is that one target market for LPSL is in commercial buildings. From a macroeconomic point of view, this difference is important because the destination for the energy/non-energy operational savings is not obvious. Potentially, energy savings would increase the profitability of firms that installed LPSL; however, the additional value-added per dollar of output could well be shared with the work force (in the form of higher wages due to higher productivity and effective bargaining by labor) and with the government (in the form of additional tax collections). With respect to business profits, it is not clear how much would be spent or invested, how much saved, and so on. However, even if a particular business had no immediate investment plans for the funds provided by energy savings, the economy as a whole would have abundant investment options available and the capital markets could readily absorb any savings. Therefore, we assume that energy savings by business (proportionately allocated to labor earnings, business profits, and taxes) are immediately recycled in the economy as consumer spending, business investment, and government spending. We test the sensitivity of the results to this assumption.

Figure 3.7 demonstrates the sensitivity of employment impacts to the manner in which cost savings are recycled. If the cost savings were not respent inside the U.S. economy as in the Savings Only, No Commercial Recycle case in the figure (for example, they were invested in telecommunications in Asia), then that portion of the energy savings would have no positive effect on the economy as a whole. Instead, the offsetting lost income of gas and electric utilities from commercial customers (about $323 million per year by the year 2020) would depress the economy and employment levels. Thus, in Figure 3.7, the case with no recycling of commercial savings lies below the Savings Only case, which does include this recycling of savings. In a fashion similar to the effects with the GAX example, the effect of saving utility investments, or of distributing the investment savings among more labor intensive sectors, moves the employment impacts in the direction of the Savings Only case.

Figure 3.8 illustrates the effects on national employment of introducing, with various financing assumptions, the LPSL in the U.S. residential and commercial buildings sectors. Because investment dollars are saved, the term *financing* means here that investment dollars are released to the named sectors, with the Base Case being a proportional allocation to all sectors. The order of the cases is reversed compared with order of the cases in Figure 3.4. In the lowest case, financing is *free* (that is, if no positive impact was made on other spending in the U.S. economy. The impact of the incremental investment spending could be subtracted from that of the energy savings, because total investment in the U.S. economy would decline by the amount of the saved investment. The mechanism is similar to the No Recycle case in Figure 3.7, but applies only to the savings on the initial investment. If the investment savings were applied to domestic spending, as is true of all of the other scenarios in the figure, the impact on employment is considerably increased. If the investment were to be applied to local government spending, the potential spending would be more labor-intensive than the economy as a whole, and the employment scenario would be more positive than in the Base Case.

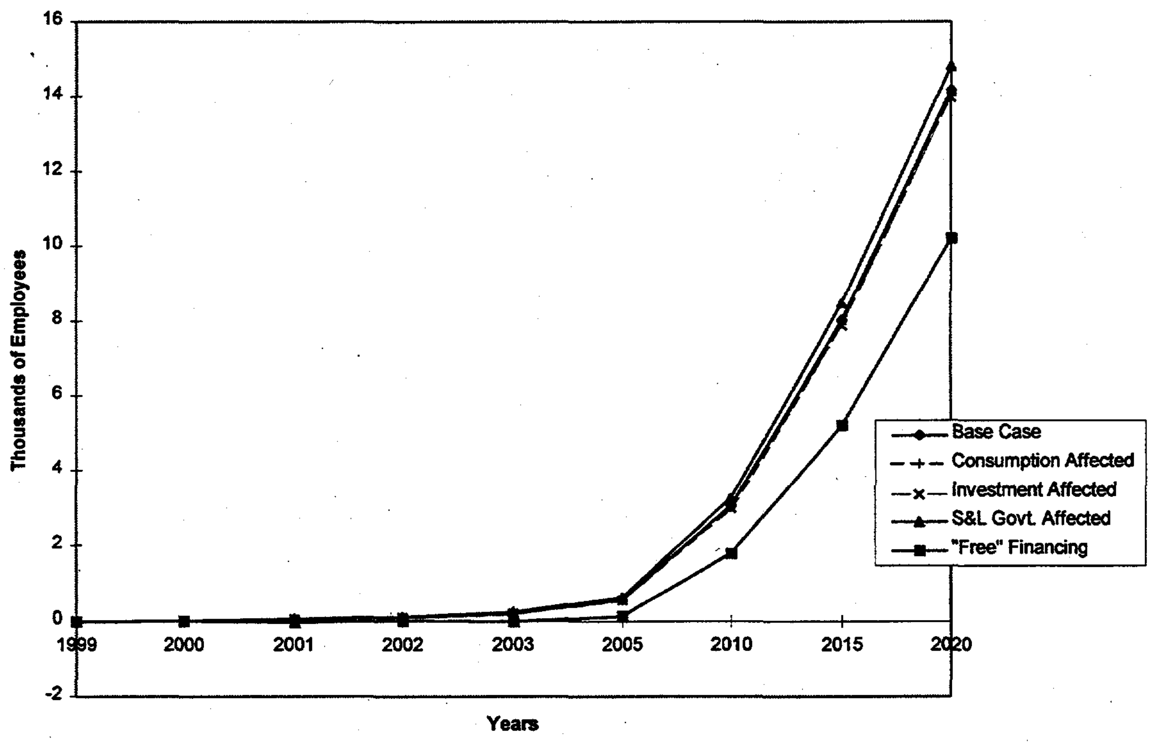

Figure 3.8. Impact of Low-Power Sulfur Lamp Investment Financing on National Employment

Figure 3.9 shows the net impact of the sulfur lamp investments on the wage economy is significant and also positive (due to both energy savings and investment savings). The Free Financing case illustrates the investment savings must be spent in the U.S. economy, however, for the net short-run impact to be positive. As was the case in Figure 3.8, if saved lighting investments are not spent domestically, the overall size of the economy would shrink, possibly more than offsetting the positive effects of energy savings on wage incomes in the short run. In addition, as in Figure 3.8, concentrating the investment savings on labor-intensive sectors tends to reinforce the wage effects of energy savings.

3.4 Building America

The final example technology in this report is Building America, a program designed to reduce energy consumption in new residential buildings by implementation of better building designs and better buildings products and processes. According to the program objectives, and based on several results from prototypical homes, the new products, procedures, and designs eventually will cost no more than their conventional competitors. Presumably, after 2005, no incremental investment cost will be associated with this program – it generates *free* energy savings. As a consequence, the source of funds for investment in these designs, technologies, and procedures would not matter because the investment is

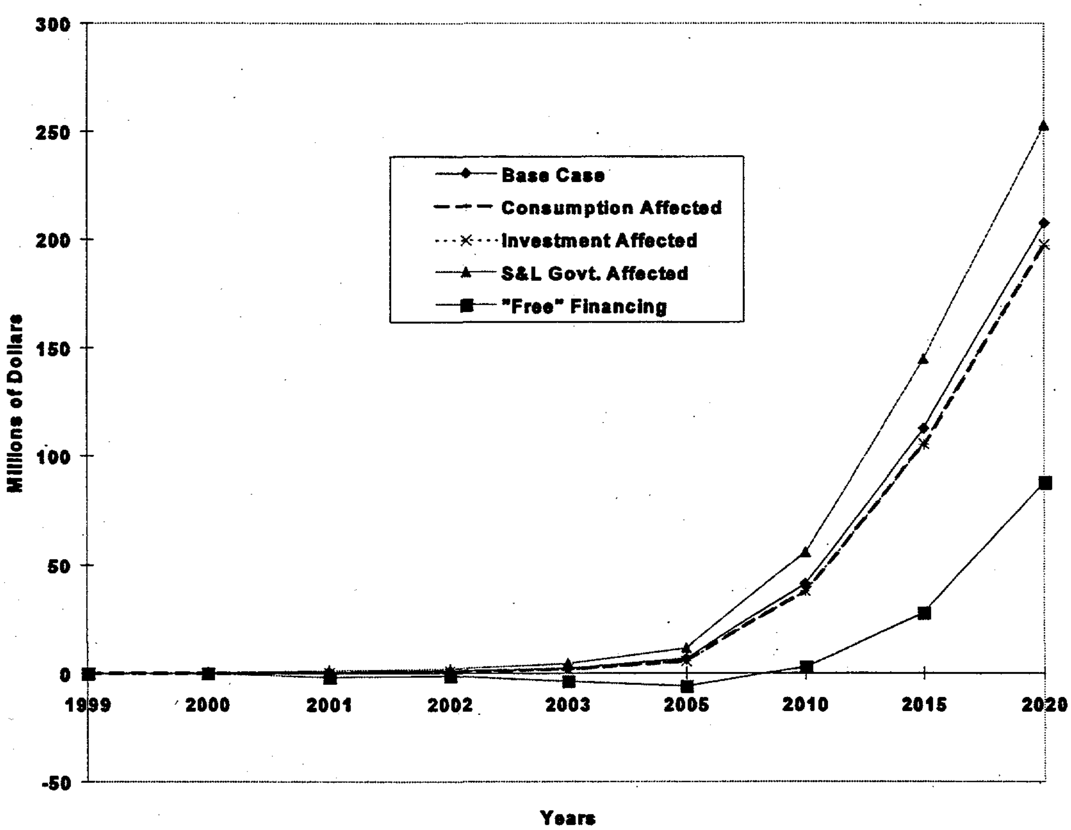

Figure 3.9. Effect of Low Power Sulfur Lamp Financing on National Wage Income

considered to be the same whether Building America or a conventional competitor is used. Figure 3.10 does not illustrate this situation, because all the finance option curves are almost the same in the Base Case and the Savings Only cases are almost identical. The short-term investment impacts would occur before the year 2005 in the construction sector that has an employment intensity very similar to that of the economy as a whole. Thus, diverting investment dollars into construction from the economy as a whole has almost no net employment consequences. The employment effects are entirely due to the energy savings, because no non-energy operations savings are projected. As before, if utility capital investment can be saved because of reduced energy demand, the employment impacts are slightly smaller.

The income consequences of Building America also arise strictly from the energy savings. The market penetration of energy efficient homes creates additional jobs by moving activity out of the capital-intensive utility sector into sectors that are generally more labor-intensive. Although these other sectors generally pay lower average wages, the overall impact on incomes is projected as positive. However, if the reduced energy demand also reduces utility capital expenditures, the income consequences are slightly more positive, for the same reasons as were found with the GAX technology. This impact is illustrated in Figure 3.11.

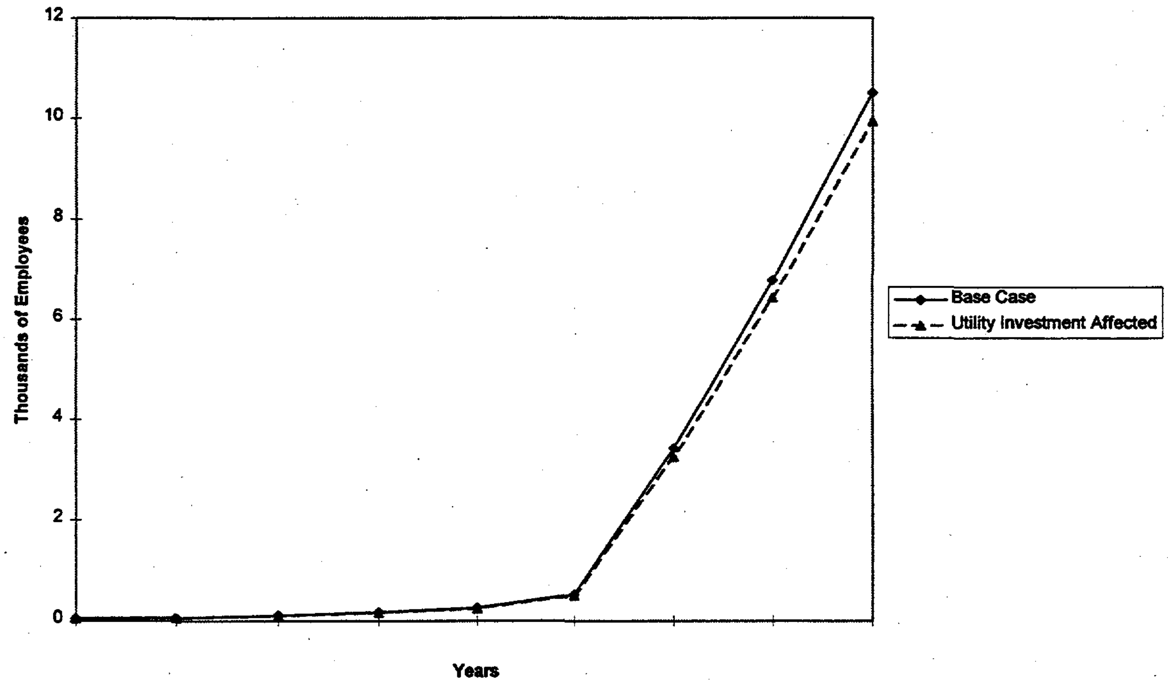

Figure 3.10. Impact of Building America Energy Savings on National Employment

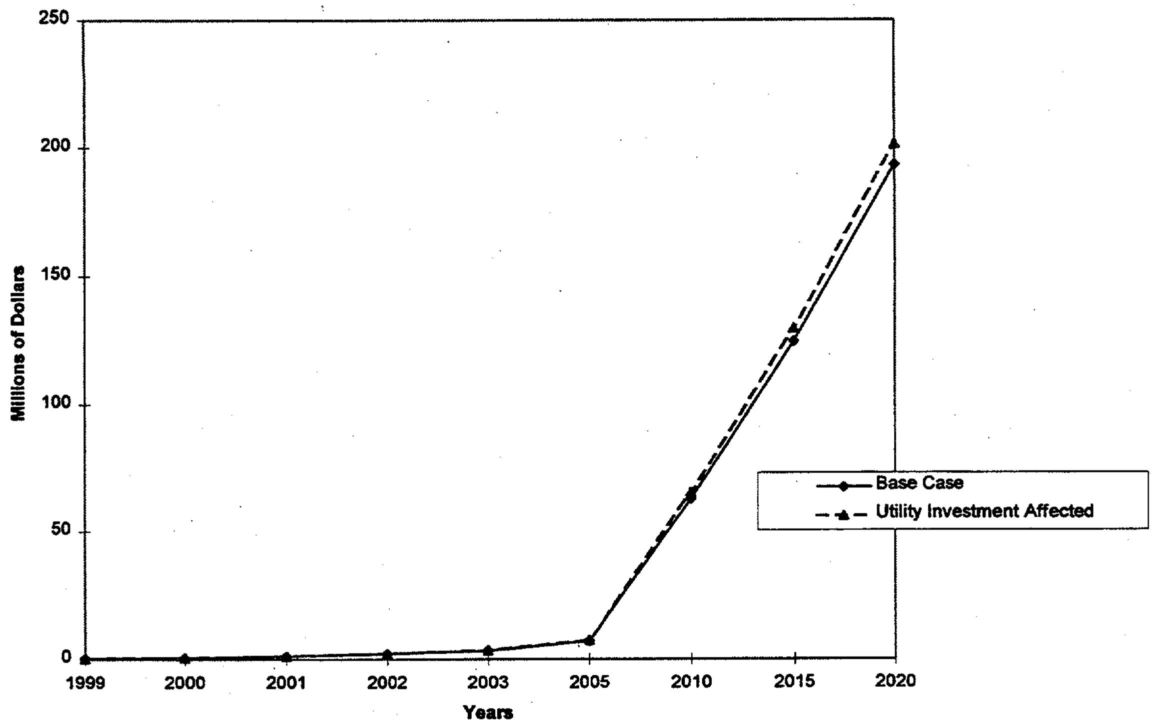

Figure 3.11. Impact of Building America on National Wage Income

4.0 Comparison with Other Studies

The results in this study are somewhat different than other previously published work. This difference is largely due to a few critical assumptions where honest disagreement is possible. In order to highlight these differences and to improve reader understanding of how building technologies may affect the U.S. macro economy, this section looks closely at differences between the studies.

4.1 Comparison to the 1992 ACEEE Study

One of the studies that is frequently cited to demonstrate the employment impacts of investments in conservation technologies is Geller, De Cicco, and Laitner, *Energy Efficiency and Job Creation: The Employment and Income Benefits from Investing in Energy Conserving Technologies,* published by the American Council for an Energy-Efficient Economy (ACEEE) in 1992. That study used the IMPLAN model to derive employment and income *multipliers* for a number of sectors that were then used to estimate the impacts of energy conservation investments and savings. One of the reasons our results differ may stem from the use of different economic sectors, resulting in different multipliers. The ImBuild model is designed specifically to analyze the results of building technologies and therefore has more detail in those manufacturing and trade sectors closely aligned with residential and commercial building equipment and operations, while summarizing those sectors of less direct importance. The ACEEE analysis was intended to be more general-purpose, including a wider variety of manufacturing sectors. Table 4.1 compares the Geller et al. (1992) gross output and employment multipliers with the most closely related gross output and employment multipliers in the ImBuild model.(1)

Because the ImBuild model and ACEEE (Geller et al. 1992) analysis have some different sectors, some differences in impacts are present due to these differences. More important, however, the Geller et al. (1992) analysis made different assumptions than we have concerning the economic treatment of new energy-efficient technologies, particularly the source of funds for investment. In their example of a new, more efficient electric motor, Geller et al. (1992) treat this investment in the pulp and paper industry as if it were a reduction in sales to consumers from that sector; in other words, a reduction in demand, not a change in supply technology. In the corrected treatment (the example that follows in Table 4.2), we recalculate the Geller et al. (1992) impact of an energy efficient investment in an electric motor. Note that in our re-analysis, the multiplier for the pulp and paper industry is not a factor because demand for pulp and paper is not directly affected by the energy efficient investment.(2)

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(1) Gross output is the total value of economic activity in the economy, unadjusted for costs of production. It sums the value of final output and the value of intermediate goods and services. The latter are a cost of business in producing the former. While gross output is useful as a basis for calculating employment and income effects, it is not an accurate measure of net creation of wealth.

(2) A very small indirect effect would be related to the change in the overall size of the economy.

Table 4.1. Comparison of Output and Employment Multipliers for the ACEEE and ImBuild Models Versions of IMPLAN

Industry	Output (Total $ Output per $ Final Demand)		Jobs (Total per Million $ Final Demand)	
	ACEEE	ImBuild	ACEEE	ImBuild
Agriculture	2.1198	2.3172	26.86	36.1588
Other Mining	1.8170	1.6867	13.51	8.3787
Coal Mining	1.8690	1.6053	12.88	Use "other Mining"
Oil and Gas Extraction	1.3438	1.6053	7.02	Use "other Mining
Stone and Clay Mining	Use "Other Mining"	1.6867	Use "Other Mining"	14.1125
Construction	1.9228	2.0469	20.97	23.3329
Wood Products	Use "Other Mfg."	2.4087	Use "Other Mfg."	25.7221
Paper	2.1011	Use "Other Mfg."	14.29	Use "Other Mfg."
Stone, Glass, Clay	1.9051	See Stone & Clay, or Glass & Glass Products	17.25	See Stone & Clay, or Glass & Glass Products
Glass & Glass Products	Use "Stone, Clay & Glass"	1.9545	Use "Stone, Clay & Glass"	18.7642
Stone and Clay Products	Use "Stone, Clay & Glass"	2.0014	Use "Stone, Clay & Glass"	19.1184
Metal Durables	1.9390	2.1701	17.28	18.7642
Food	2.4489	Use "Other Mfg."	19.77	Use "Other Mfg."
General Industrial Machines	Use "Other Mfg."	1.9413	Use "Other Mfg."	16.7117
Office & Computing Equip.	Use "Other Mfg."	2.0746	Use "Other Mfg."	15.9599
Service Industry Machines	Use "Other Mfg."	2.0753	Use "Other Mfg."	16.7130
Electric Industrial Equip.	Use "Other Mfg."	1.9631	Use "Other Mfg."	17.3147
Household Appliances	Use "Other Mfg."	2.1485	Use "Other Mfg."	17.3361

Table 4.1. (contd)

Industry	Output (Total $ Output per $ Final Demand)		Jobs (Total per Million $ Final Demand)	
	ACEEE	**ImBuild**	**ACEEE**	**ImBuild**
Electric Lighting & Wiring	Use "Other Mfg."	1.9674	Use "Other Mfg."	18.3309
Electronic Components & Access.	Use "Other Mfg."	1.8096	Use "Other Mfg."	14.8893
Other Mfg.	2.0310	2.2072	20.75	17.1678
Paper	2.1011	Use "Other Mfg."	14.29	Use "Other Mfg."
Chemicals	2.1282	Use "Other Mfg."	13.06	Use "Other Mfg."
Refining	2.0209	Use "Other Mfg."	7.14	Use "Other Mfg."
Primary Metals	2.0150	Use "Other Mfg."	13.05	Use "Other Mfg."
Motor Vehicles	2.1871	Use "Other Mfg."	13.70	Use "Other Mfg."
Transport./Communication	1.5777	1.8722	16.37	18.5466
Electric Utilities	1.7821	1.6874	9.54	8.9384
Gas Utilities	1.9921	2.0648	7.41	8.7375
Water/Sewer Utilities	1.5943	1.8722	14.00	18.5466
Wholesale Trade	1.4668	1.5379	20.43	28.1811
Retail Trade	1.5984	1.5379	32.24	28.1811
Finance/Insurance/Real estate	1.4220	See Below	10.10	See Below
Finance and Insurance	Use FIRE	1.9429	Use FIRE	21.0055
Real Estate	Use FIRE	1.3789	Use FIRE	7.7925
Hotels and Lodging Places	1.5815	1.3789	36.13	35.8844
Business & Prof. Services	Use "Other Svc."	1.7822	Use "Other Svc."	27.72
Other Services	1.3726	1.7822	26.45	38.08

Table 4.1. (contd)

Industry	Output (Total $ Output per $ Final Demand)		Jobs (Total per Million $ Final Demand)	
	ACEEE	ImBuild	ACEEE	ImBuild
Eating and Drinking Places	Use "Other Svc."	1.9429	Use "Other Svc."	44.73
Auto Repair & Service	Use "Other Svc."	2.0060	Use "Other Svc."	21.33
Amusements & Recreation Service	Use "Other Svc."	1.9717	Use "Other Svc."	31.83
Health Services	1.9766	1.6548	23.15	25.73
Education & Other Svcs.	Use "Other Svc."	1.9615	Use "Other Svc."	38.08
Federal Enterprises	Use "Other Svc."	1.4066	Use "Other Svc."	19.40
State & Local Govt. Enterprises	Use "Other Svc."	2.2598	Use "Other Svc."	21.18
Government Industry	Use "Other Svc."	1.0000	Use "Other Svc."	31.70
Miscellaneous Prod. & Svcs.	Use "Other Svc."	0.6493	Use "Other Svc."	0

Table 4.2. Comparison of the Impact on Gross Output of a Hypothetical $100 Investment in New Energy-Efficient Electric Motors Within the Pulp and Paper Industry (ACEEE Version of IMPLAN vs. ImBuild)

Component of Impact	ACEEE Multiplier	ImBuild Multiplier	ACEEE Impact on National Output	ImBuild Impact on National Output
Investment Impact $100 incremental motor purchase	2.0310 ("Other" Manufacturing)	1.9630 (Electrical Industrial Equipment)	+$203.10	+$196.30
Revenue Impact: -$100 required to finance the investment	2.1011 (treated like loss of current sales by pulp and paper)	1.8045 (reduced business investment)	-$210.11	-$180.45
Substitution impact: $50 of savings on utility bills	2.1011 (treated like increase in current sales by pulp and paper)	1.862 (average impact of commercial energy savings on output)	+$105.06	+$93.10
Displacement impact: -$50 revenue loss by utility sector	1.7821	1.6874	-$89.11	-$84.37
Net impact			+$8.94[a]	+$24.58
"Out Year" net impact (ignore investment effects on lines 1 and 2)			+$15.95[b]	+ $8.73

(a) Geller et al. would have shown a net impact of $38.90, had their investment been in the commercial sector, as their savings impact depends critically on which sector experiences the savings. Our calculation depends on the items purchased, both for investment and with the resulting savings, not which sector purchases them. Our estimate varies far less by sector.

(b) Taking an approximate average output multiplier of 1.6 for their commercial sector, Geller et al. would show a net impact of about -$9.10 for the commercial sector.

Geller et al. showed a net impact of $8.99 in this instance in the first year and $15.99 in subsequent years. Their impact multiplier for the original investment was *Other Manufacturing*, with a multiplier of 2.0310, for example, instead of the more narrowly defined *Electrical Industrial Equipment* used here. The major difference, however, was in their paper mill example, where the multiplier used in lines 2 and 3 above was the 2.1011 figure for pulp and paper. In contrast, we *finance* the motor investment here with a reduction of $100 that otherwise would have been made in gross private fixed investment (GPFI), distributed across all sectors. The multiplier is somewhat lower for GPFI taken as a whole than it is for a change in final demand for pulp and paper, but this is a more natural experiment than directly reducing the operating budget of a firm in the pulp and paper industry.(3) Also, our substitution impact (calculated in Table 4.2) assumes the savings in electricity are realized as 1) changes in the technology of the industry (a small reduction in the I-O matrix row coefficients pertaining to electric utility services and the commercial sector SIC codes) and 2) a corresponding increase in savings in the commercial sector industries. Such savings are distributed to labor, capital, and taxes according to historical patterns and then spent on consumption, investment, and government activity. Again, in this case, the average impact multiplier is somewhat lower than that for pulp and paper.

Although they account for opportunity cost by temporarily reducing sector activity (line 2 in Table 4.2), Geller et al. (1992) were not sensitive to the question of financing the investment in energy saving.(4) As our analysis of Building America in Chapter 3 shows, that issue is not very important when the investment is no larger for the energy-conserving technology than for the conventional one.(5) However, our analysis of the GAX heat pumps showed that, during the period when the energy efficiency investments are in progress, the size of the short-run macroeconomic impact can be strongly affected by the source of the investment funds(if the net difference in investment is large).

The central analysis of Geller et al. (1992) examined a high-energy efficiency scenario for all sectors in the U.S. economy to determine whether energy efficiency investments increased or decreased jobs and income. We have used ImBuild to re-analyze the residential and commercial building sectors in Geller et al. (1992) and have obtained broadly compatible results for a similar scenario.

Table 4.3 shows our estimates of the impact of energy efficiency investments in the residential and commercial buildings sectors on the U.S. economy in 1990 dollars (for consistency with Geller et al.1992). Impacts were calculated assuming that end-use savings were allocated to electricity, natural gas, and oil in the same proportions as in the original study (Alliance to Save Energy et al. 1991) on which Geller et al. (1992) is based. Because no data were available on how Geller et al. (1992) allocated incremental energy efficiency investments across sectors, we assumed the following distribution: construction, 20%; lighting and wiring, 30%; appliance manufacture, 30%; and heating and plumbing equipment manufacture, 20%. Financing was assumed to affect the whole economy in proportion to the amounts each sector historically represents: 70% personal consumption, 10% fixed investment, 2% federal defense spending, 6% federal non-defense spending, and 12% state and local government spending. Energy efficiency in the residential and commercial sectors generated roughly 46% of the

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(3) Geller et al. (1992) assume that the $100 premium on the motor was paid for by reducing the purchase of copier machines. If so, the proper way to have shown the impact on pulp and paper would have been to reduce final demand in the business machines manufacturing sector, not in pulp and paper.

(4) They show the financing as reduced final demand in the sector making the investment. A more correct procedure for financing is shown in the previous note. More generally, however, investment is often accomplished with borrowed funds, drawn from the economy as a whole. The corresponding multiplier may be quite different from that of the borrowing sector.

(5) A differential effect could result if the investments amounts were identical, but the processes that manufactured and installed the two technologies were very different.

Table 4.3. Economic Impact of High Efficiency Investments in the Residential and Commercial Buildings Sectors on the U.S. Economy

	ImBuild (Residential and Commercial Buildings Only)			Geller et al. 1992 (All End-Use Sectors)[a]		
	2000	2005	2010	2000	2005	2010
Investment (Billion 1990 $)	$14.5	$27.3	$27.7	$35.1	$59.0	$59.7
Energy Savings (10^{15} Btu)	1.9	4.2	6.6	7.5	14.1	20.8
Value of Energy Savings (Billion 1990 $)	Res. $15.4 Comm. $5.2	Res. $28.8 Comm. $15.4	Res. $42.5 Comm. $25.8			
Total	$20.6	$44.2	$68.3	$54.8	$109.9	$167.0
Net Impact on Employment (Thousand Jobs)	225	500	828	471	776	1087
Net Impact on Income (Billion 1990 $)	$3.2	$6.3	$9.8	$10.7	$20.2	$28.5

(a) Although Geller et al. 1992 provide some details on investments for residential and commercial end-use sector energy efficiency and resulting energy savings, insufficient data was presented on the allocation of these investments to each SIC sector or the impacts on output, employment and income attributed to each end use sector to permit a side-by-side comparison for the impacts of the residential and commercial sector investments alone.

investment and 66% of the total national energy savings by value in all sectors in the Geller et al. (1992) analysis. Not too surprisingly, we show energy efficiency in residential and commercial buildings alone generates about 70% of the employment and 36% of the total income impacts reported by Geller et al.(1992) for all end use sectors combined. (Besides residential and commercial buildings, Geller et al. include the transportation, utility, and industrial sectors.) The impacts would vary somewhat, depending on exactly which sectors are affected and to what degree. With the particular assumptions used, if utility sector capital investment can be saved as a result of improved energy efficiency, the employment impacts shown in Table 4.3 would be lower than shown by about 10% and the income effects about 9% higher.

4.2 Comparisons to Additional Studies

Geller et al. (1992) report on a number of other regional, state, and national studies that have attempted to estimate economic impacts of energy efficiency programs. For example, they report that in 1984 Charles River Associates evaluated the regional employment impacts of weatherization programs for the Bonneville Power Administration using an I-O model, contrasting one million kWh provided by weatherization versus one million kWh provided by nuclear power. The key finding of that study was that rate increases would lead to net regional job losses from nuclear power (-31 jobs per 1 million kWh), but that weatherization contributes slightly more jobs than it subtracts through rate increases (about +2 jobs per 1 million kWh). As with the findings of the current study, if by saving energy the utility industry can avoid increased energy costs that result from investment in new capacity, the impact on jobs is positive. This situation would be especially true for a relatively labor-intensive energy efficiency program such as weatherization. It would be particularly true at the regional level, where the funds for energy efficiency investment would not necessarily come from the regional economy. In that case, the region would, in effect, *import* capital and jobs from somewhere else and another region would bear the opportunity costs. In effect, this case would be one where "financing is costless" and "utility capital expenditures are saved." Relatively high positive employment impacts would be expected and were found. It is not clear which way the effects would go at the national level, as the model would be closed with respect to the capital investment funds on the one hand, but the multiplier effects should be larger on the other.

In a Canadian study, Jaccard and Sims (1991) looked at the employment effects of energy and hydropower in British Columbia. The cost of saving electricity in this case was estimated at 1.9 cents per kWh and the cost of new hydroelectric power was estimated at 5 cents per kWh. The net employment impact was positive (600 jobs per year), in large part because the direct cost of power was lower. Again, this study was regional, but the net effects would not necessarily have been smaller at a national level, because the source of regional funding for either weatherization or hydropower might have been the same. The ImBuild model shows positive employment impacts from energy cost savings of about 13 jobs per million dollars worth of residential electricity saved, before accounting for either positive or negative investment effects.

The Council on Economic Priorities of the State of New York looked at the effects of 32 residential energy and conservation options in 1979 (Buchsbaum et al.1979) using the Department of Commerce RIMS model and the National Economic Growth Model of the Bureau of Labor Statistics. The cost of the residential measures was estimated at $4.0 billion over 38 years. They found that conservation and solar technologies would create up to 1.4 times as much national employment as a nuclear power plant or about 10,000 to 13,000 jobs nationally. Running ImBuild for a $4.0 billion investment (in 1979 dollars) over 38 years ($105 million per year) in energy saving technology to save an average 1000 MW (5.7 billion kWh or 19.4 trillion Btu) at 5 cents per kWh (1979 dollars) generates an increase of about 5900 jobs nationally. At 10 cents per kWh saved, the net job creation is about 12,400[(6)], roughly the same as the Council on Economic Priorities figures.

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(6) We assumed $105 million in additional investment, adjusted to 1992 dollars from 1979 dollars, distributed as 20% construction, 20% plumbing and heating equipment, 30% appliance manufacture, and 30% lighting and wiring manufacture. Annual energy savings were based on an average load factor of 0.65.

A 1992 Missouri study found that cost-effective conservation resources could save about 100 trillion Btu per year (Laitner 1992). In the year 2000, an investment of $5 billion ($1 billion per year over 5 years) would create about 8000 to 13,000 new jobs for the state, increasing wages and salaries by $300 million. When ImBuild is run with a $1 billion per year investment (in 1992 dollars) for 5 years, in wages (in 1992 dollars) are created nationally by the energy savings associated with the initial national impact is about 13,200 jobs and $170 million (in 1992 dollars), allowing for the national opportunity costs of the invested funds. This solution is broadly consistent with the local Missouri figures, as some impacts would be out-of-state. In the longer term, about 16,900 jobs net and $193 million in wages (in 1992 dollars) are created nationally by the energy savings associated with the investments.[7]

In general, therefore, the ImBuild results are roughly comparable to those of other recent analyses.

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(7) A total of 100 trillion Btu were assumed divided 25% each for residential and commercial natural gas and electricity. Investment was distributed 20% construction, 20% heating and plumbing equipment, 30% appliance manufacturing, and 30% lighting and wiring manufacturing. Delivered energy prices were assumed to be $19-$21 (in 1992 dollars) per Mbtu for electricity and $5 per Mbtu for natural gas.

5.0 Operating the ImBuild Model

This document provides a brief introduction to operating the ImBuild model. The model is written in Visual Basic and Excel 7.0. The user needs a copy of Excel 7.0 operating in Windows 95 or higher and some familiarity with the use of spreadsheets, though not necessarily with macros. Because the current versions of the code and data are not write-protected, **the user is advised to make a backup copy of the model before using it.** The current version of the model uses slightly more than 1.6 MB of space on the hard drive. It is advisable to have at least 15 MB of storage space available in the same subdirectory for data handling and storage. **The model assumes that the main storage areas for output (named RUNLIB_1.XLS and OUT_1.XLS) are in the same subdirectory as the model (IMB98_1.XLS) and two required supplementary data-storage workbooks, TECHS_1.XLS and INLIB_1.XLS.**

The model was designed on a Gateway 2000 P5-150 personal computer running under Windows 95 and gives satisfactory operating speed in P5/150 environment. It takes slightly under 30 seconds for the model to execute 9 annual and five-year time steps (between 1999 and 2020). Much better speed can be obtained using a Pentium II-based machine running under Excel 97 and Windows 97. Right now, the reporting years match those of the GPRA Metrics program, but they can be changed easily.

5.1 Setting Up the Model

Copy the model (Excel workbook IMB98_1.XLS), supplementary workbooks (TECHS_1.XLS and INLIB_1.XLS), and output storage areas (Excel workbooks RUNLIB_1.XLS and OUT_1.XLS) to a subdirectory on your hard drive using any standard file handling or editing routine for Windows. Ideally, you should have about 15 MB of storage space available in the subdirectory.

The supplementary workbooks TECHS_1.XLS and INLIB_1.XLS serve a data-storage and record-keeping function. The main model workbook IMB98_1.XLS contains input data for only a few conservation technologies. The TECHS_1.XLS workbook contains additional technologies and is expandable. Every time you add a new technology, the input data for the technology is stored as a worksheet in TECHS_1.XLS.

The INLIB_1.XLS workbook stores the basic technology data for individual model runs, together with the other parameter settings of the model. This information makes it possible to trace back the results of a model run.

If you open the IMB98_1.XLS workbook, you will discover a number of individual worksheets. If a message states the model contains links and asks if you want to update them, reply *no*. Many of these sheets contain links to each other that will be automatically updated during the run.

It is important, if you switch directories after opening the IMB98_1.XLS worksheet, that you are in the same subdirectory as the RUNLIB_1.XLS worksheet when you try to save the model run. Otherwise the storage area will not open.

After opening IMB98_1.XLS in Excel, scroll to the worksheet called *Cover*.

5.2 Running the Model

Currently, the ImBuild model operates on a single technology or program at a time. It takes user-supplied input from the GPRA Metrics Program and estimates employment effects of these programs at national level. Built into the code are dialog screens and menus to facilitate user input on certain key economic assumptions. The following few pages guide you through a model run.

The first screen looks like Figure 5.1. To start running the model, use the mouse to press the start button, then follow the directions on subsequent screens.

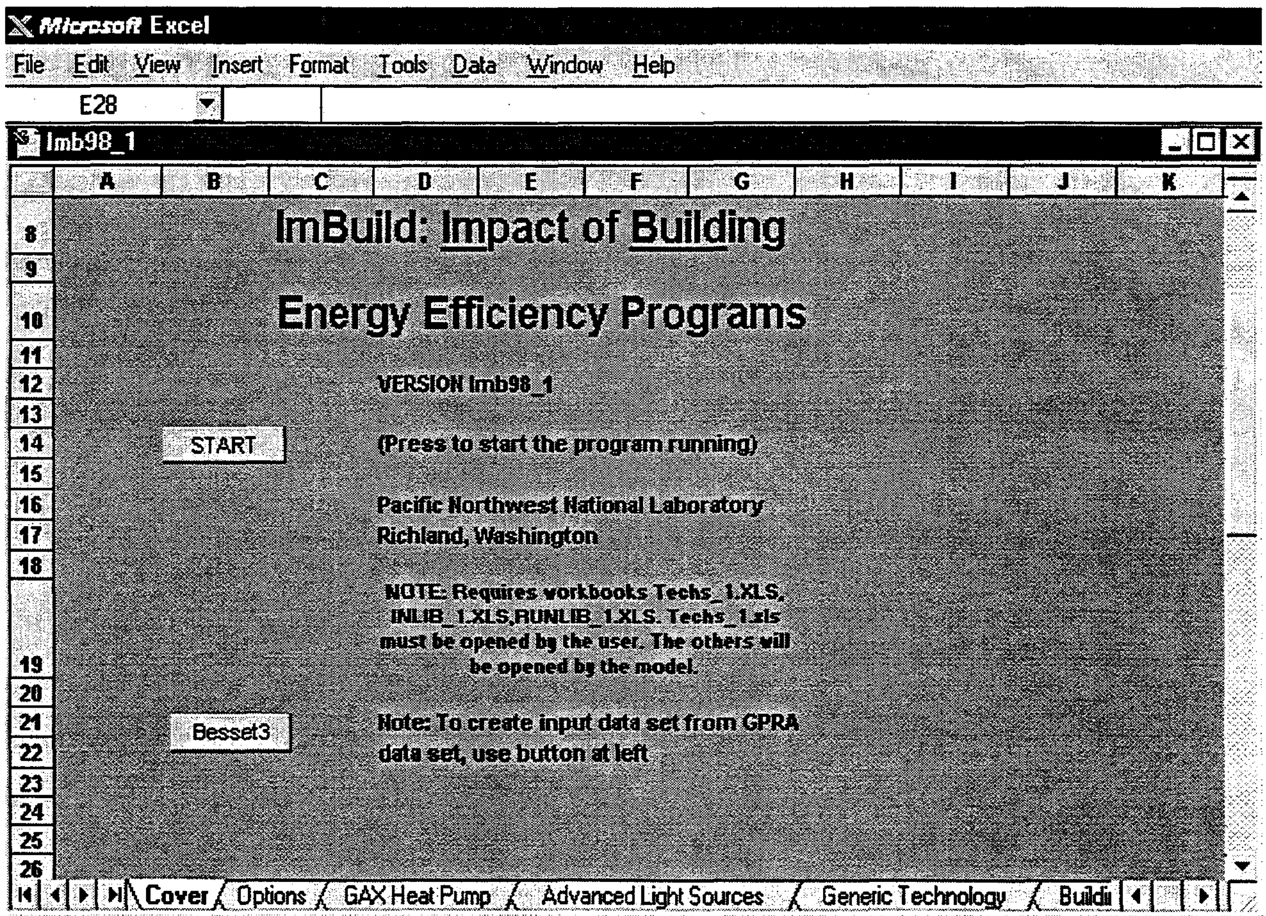

Figure 5.1. Initial Screen

The second screen you see will look like Figure 5.2. In the dialog box on the screen, you can pick the forecast years you wish to examine, as well as set inflation and cost escalation rates necessary to put all costs and benefits in the correct dollar year. For example, the original FY99 GPRA Metrics capital costs and value of energy saved are in 1994 and 1995 dollars, respectively, and the wage income values in IMB98_1 are in 1992 dollars. In Figure 5.2, it was necessary to escalate each set of values differently to obtain constant 1997 dollars used in this report.

The next screen is shown in Figure 5.3. It will ask you how you prefer to see the output of the model. The box can be dragged around the screen so that you can see any existing stored images. Choose one of the options. After you answer, and hit the *O.K.* button, the model will next ask if you are satisfied with the output that you see. (This question is prior to asking whether you want to delete any of it.) That message box looks like Figure 5.4. The message box *floats* on the screen and may be moved aside, so you can see the result. You should answer either *yes* or *no*.

If you press *yes*, the model will move to the next screen. If you press *no*, it will recycle and ask you which runs you want to delete, as shown in Figure 5.5. Currently, all of the boxes are checked in this supplementary screen (Figure 5.6) as a default to wipe out all previous results, but you can keep selected runs by un-checking some of the boxes on the appropriate sheet or by indicating you don't want to delete

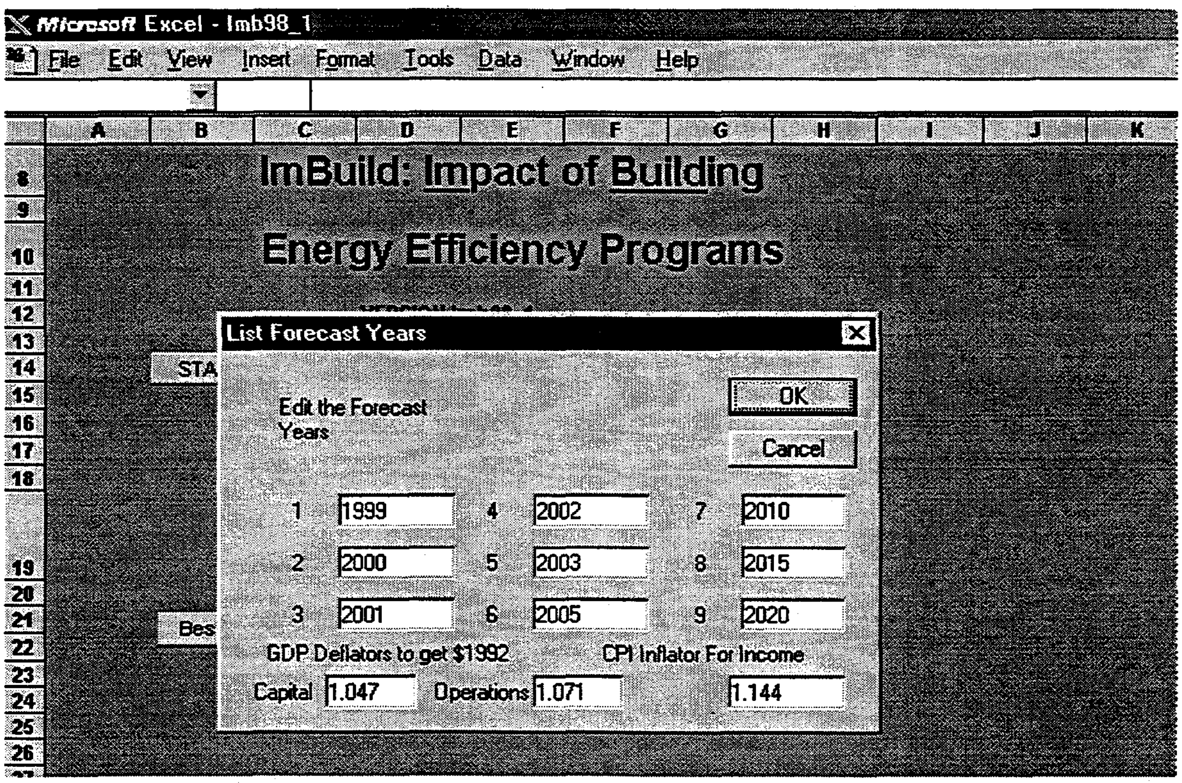

Figure 5.2. Setting Forecast Period and Inflation Rates

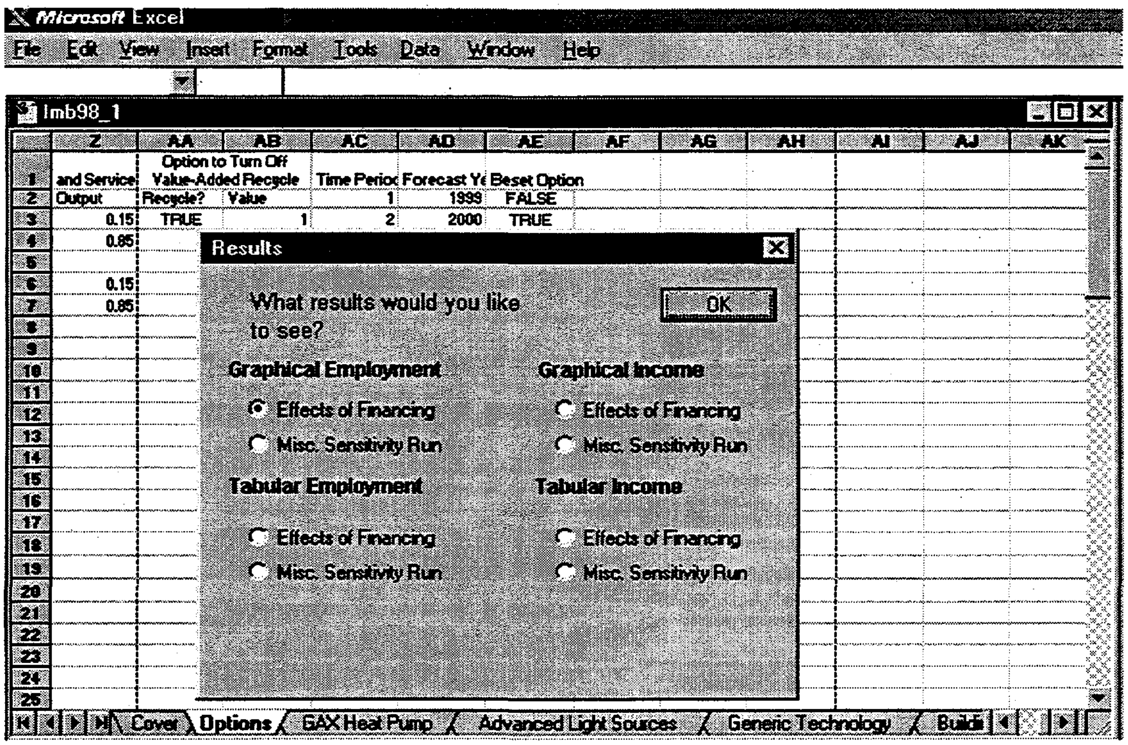

Figure 5.3. Dialog for Initial Display of Results

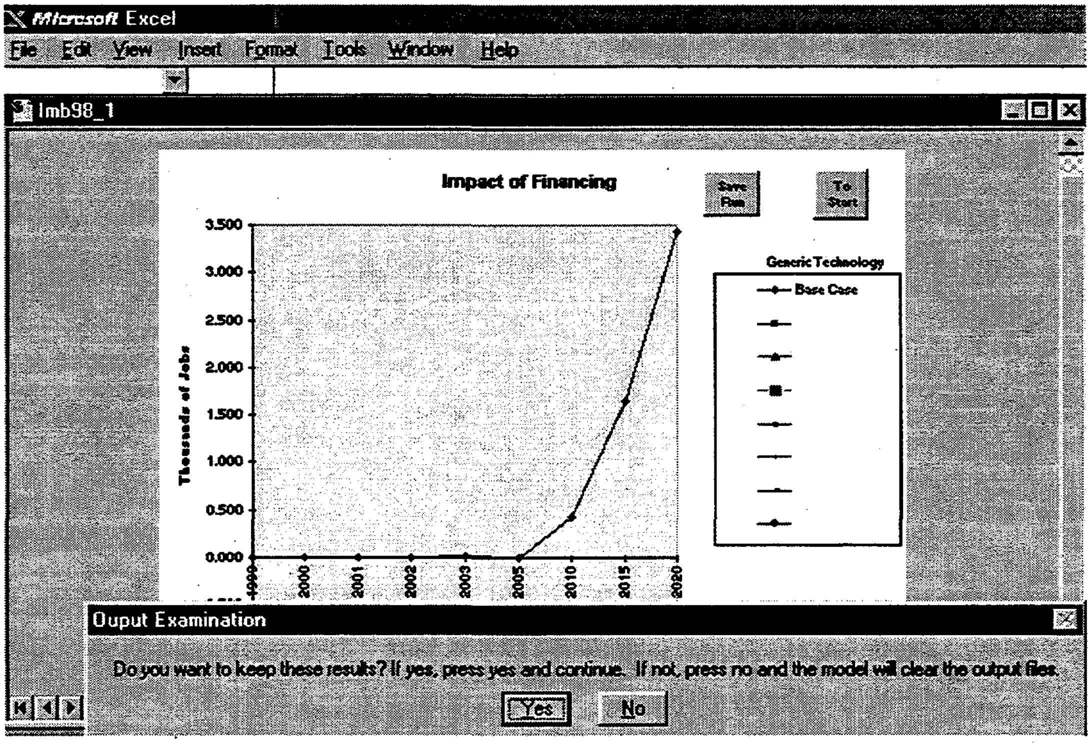

Figure 5.4. Confirming the Saving of Previous Runs

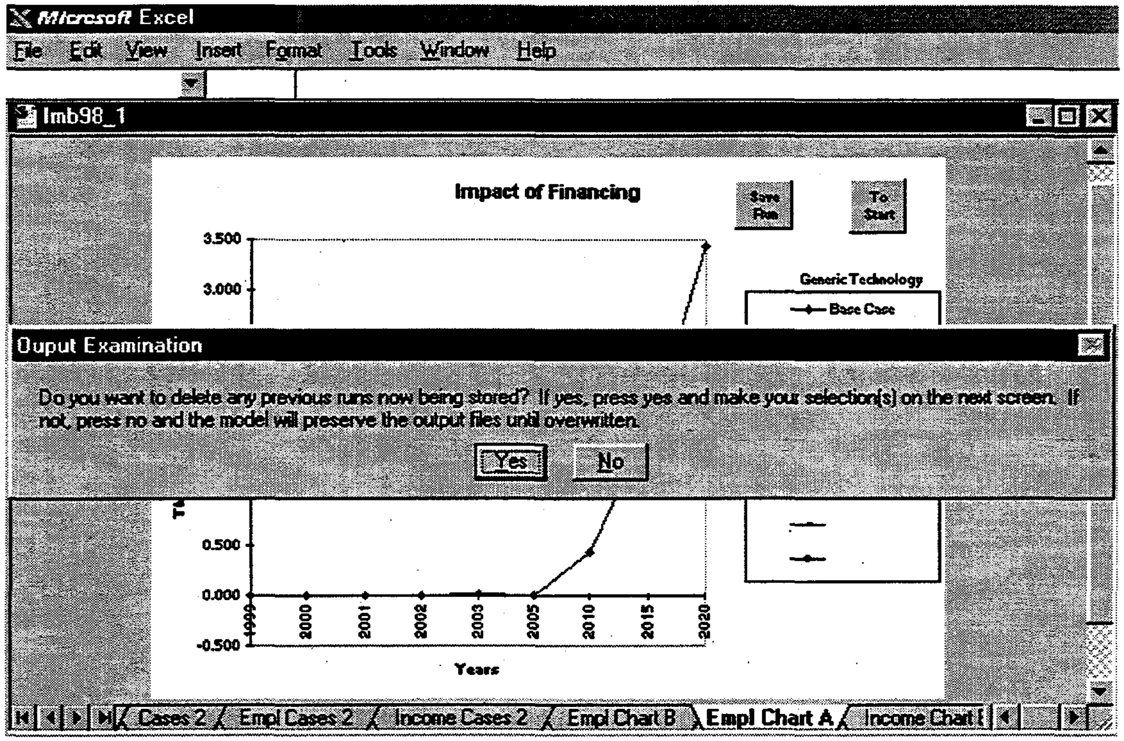

Figure 5.5. Choosing to Delete Previous Model Runs

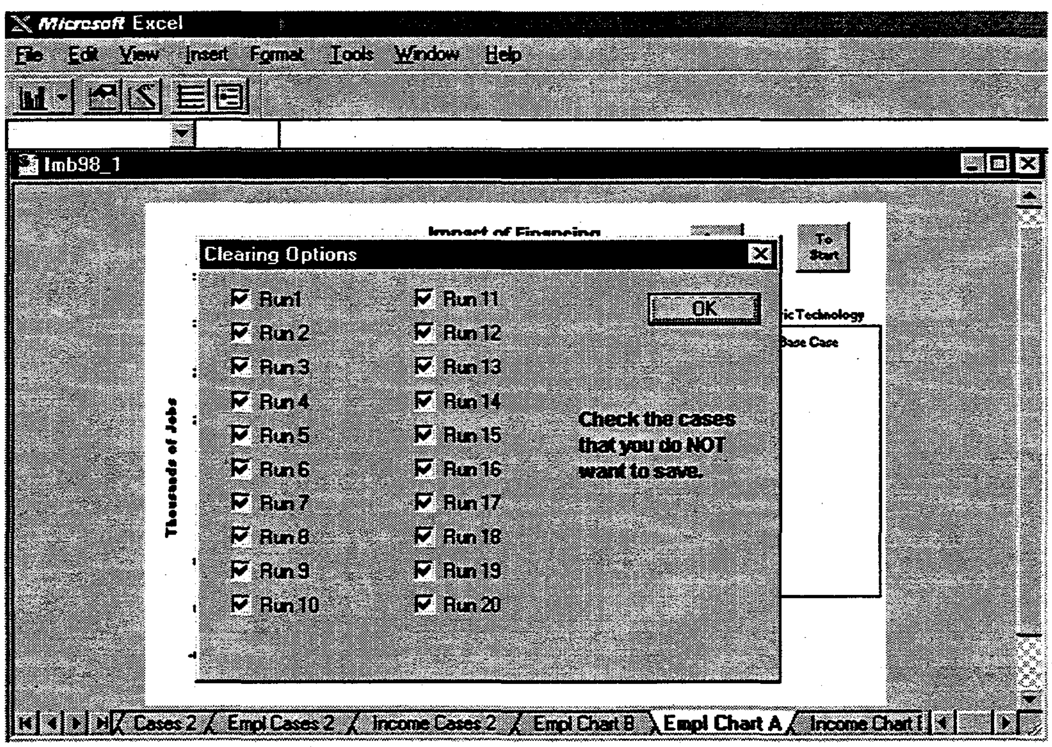

Figure 5.6. Deciding Which Previous Model Runs to Delete

any runs. Now that you have decided what to do with any previous model runs, the ImBuild model helps you to set up a new run by asking a series of questions on dialog screens. It begins with the number of the run (that determines where it appears in the output charts and tables) and a short descriptive name. The dialog screen appears in Figure 5.7.

In this case, we have answered that this run of the model will be numbered 1 and the incremental capital costs drawn from the entire economy on a proportional basis. You should keep track of the numbers you assign to your model runs. Runs 1 through 8 are assumed to be financing sensitivity runs and appear on the "A" results chart (more about this later). Numbers 9-20 are assumed the miscellaneous sensitivity runs and appear on the results chart *B*.

In the next screen, choose the technology or conservation program whose impact on the economy you will analyze. (See Figure 5.8.) You may choose one of the available technologies in the list, or go to *other* and either access the expanded list or edit the generic technology to create a new technology that you may then save. As information becomes available on more technologies, they can be added to the list . When you have made your choice, press *O.K.* This choice will bring up the next screen and load a copy of the economic assumptions concerning the technology you picked. The model will then ask you if this is actually the technology you want. If it is, answer *yes*. If not, the model will return to the screen shown in Figure 5.8 and let you pick another technology. In Figure 5.8, you initially choose *other* to go to the expanded technology list.

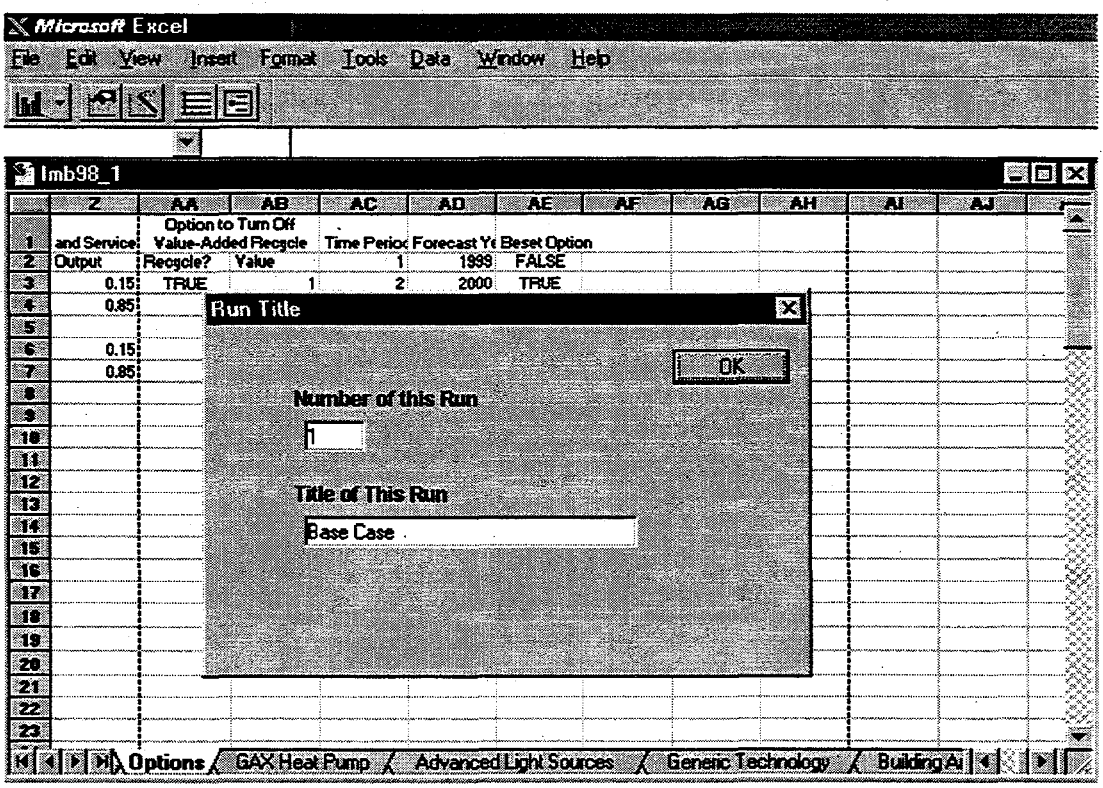

Figure 5.7. Dialog to Name a Model Run

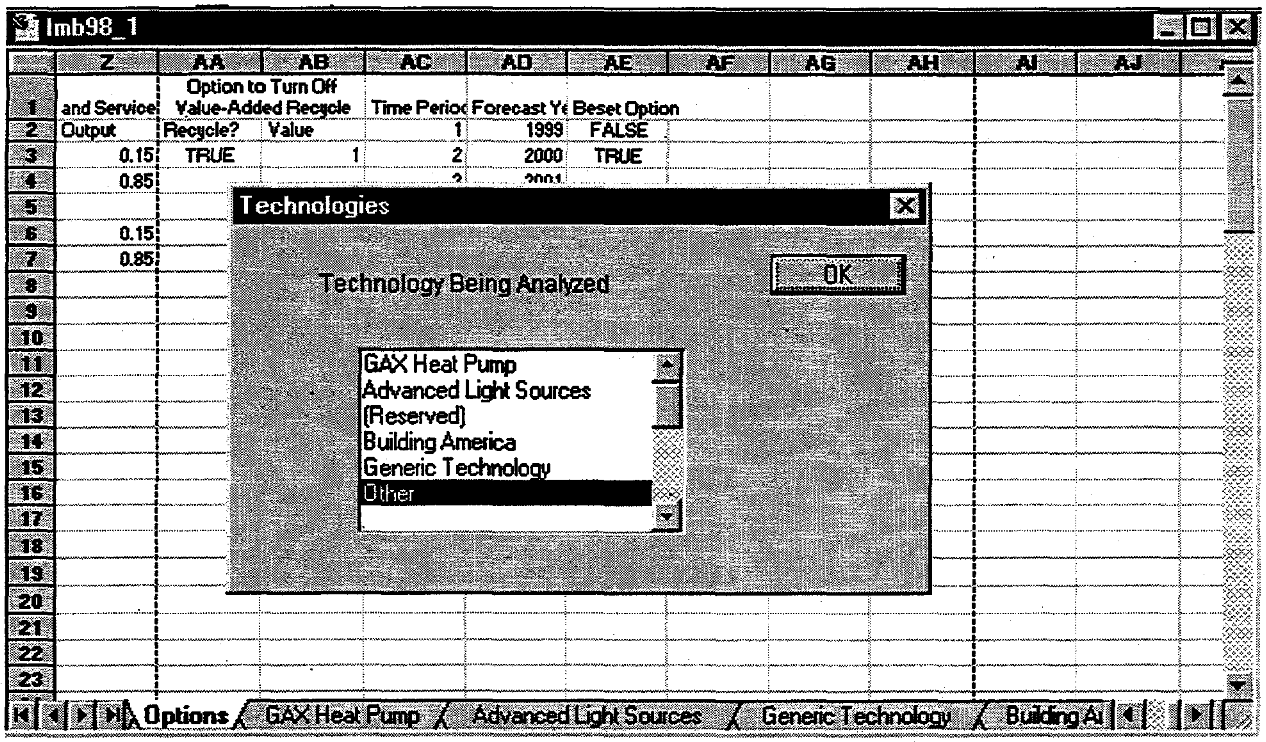

Figure 5.8. Initial Technology Selection

Now that you are in the expanded list of technology options, the model asks if you want to add a technology (Figure 5.9). If you are sure you want to add a new technology, answer *yes*; the model will bring up a generic technology sheet for you to edit and save under a new name. If you answer *no*, you can scroll through the choices currently available. You can also change your mind later if you want.

The model provides a screen in Figure 5.10 to name the new technology you have created. If you have given a name already in use, the model will sense the conflict and stop processing.

Figure 5.11 provides a check to confirm the technology you just selected. The box can be moved for a better view of the technology. If this not the correct technology, press *no* and the model will cycle back to technology choice. If you press *yes*, the model asks if the information displayed in the window on the screen is correct. (See Figure 5.12.) If it is not, and you want to edit the data, press *no* and the model will display the economic data on a technology screen that looks like Figure 5.13.

When you are satisfied with the data, press *O.K.* and the model will ask you to confirm the values are correct (Figure 5.14). You can then confirm the technology being analyzed (Figures 5.15 and 5.16), which may be different than the one you just edited. You then move to the next information input.

Next, the model will ask what sectors of the economy will account for the initial capital cost of the technology or technologies that are part of the option being evaluated. A sample input screen is shown as Figure 5.17. The capital costs accounted for by each selling sector are expressed as percentages of the

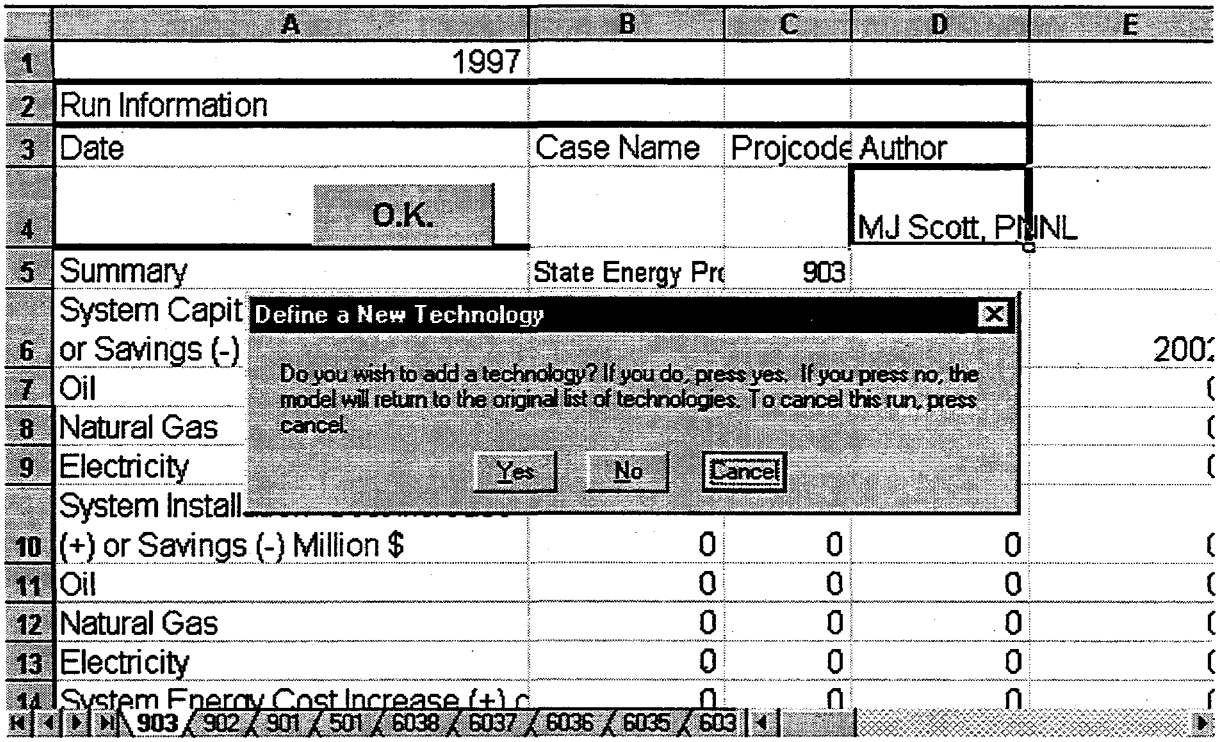

Figure 5.9. Choosing to Define a New Technology

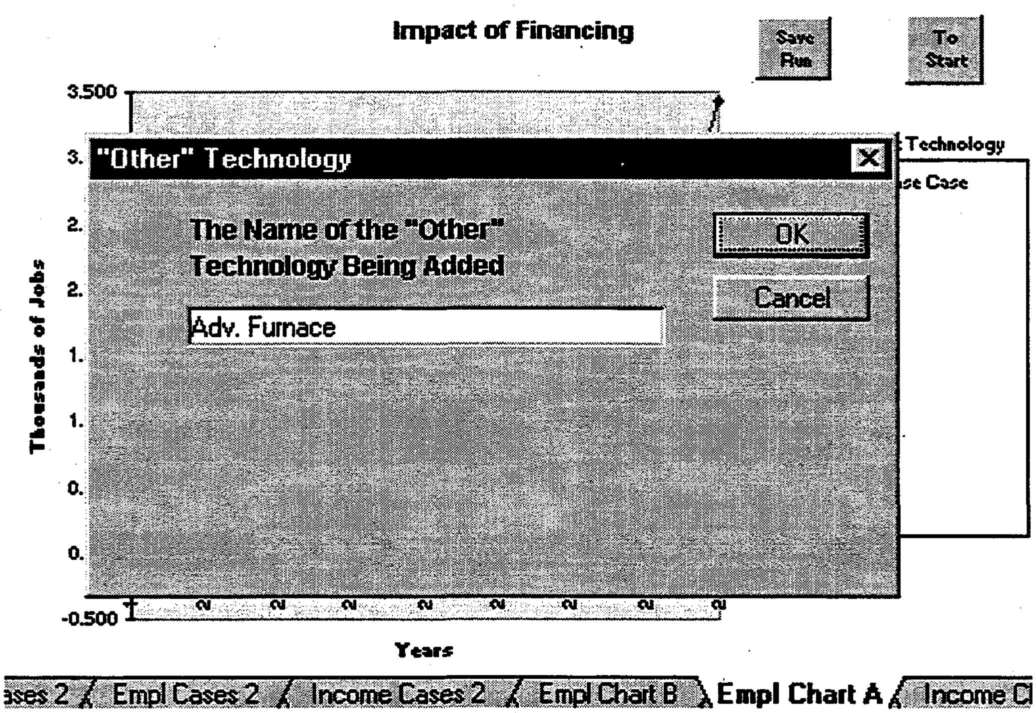

Figure 5.10. Naming the New Technology

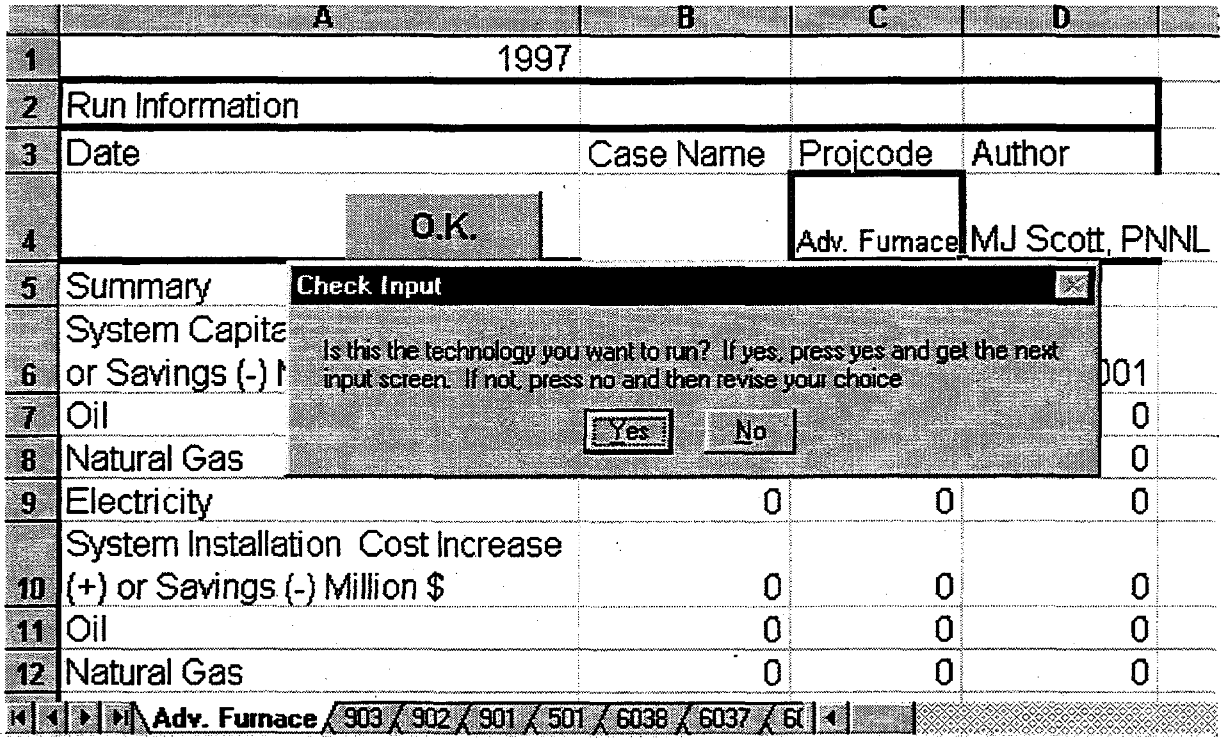

Figure 5.11. Confirming the Technology Selection

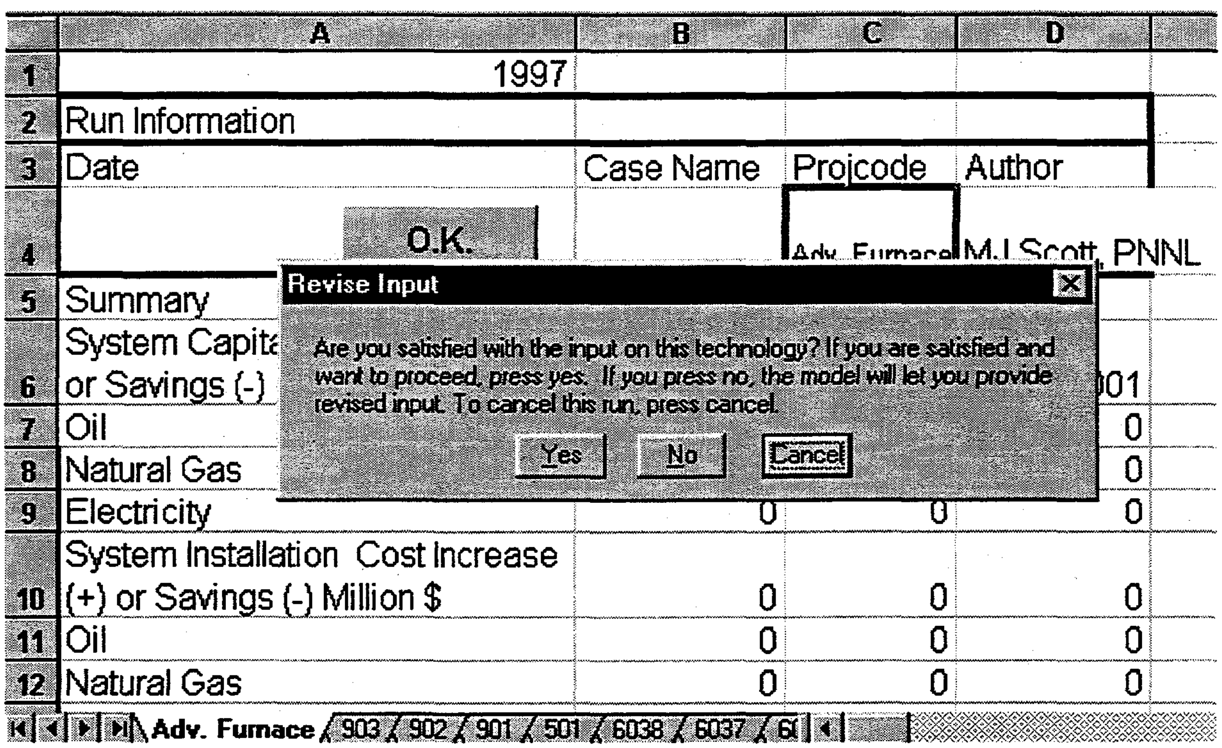

Figure 5.12. Choice to Edit Input Data for a Technology

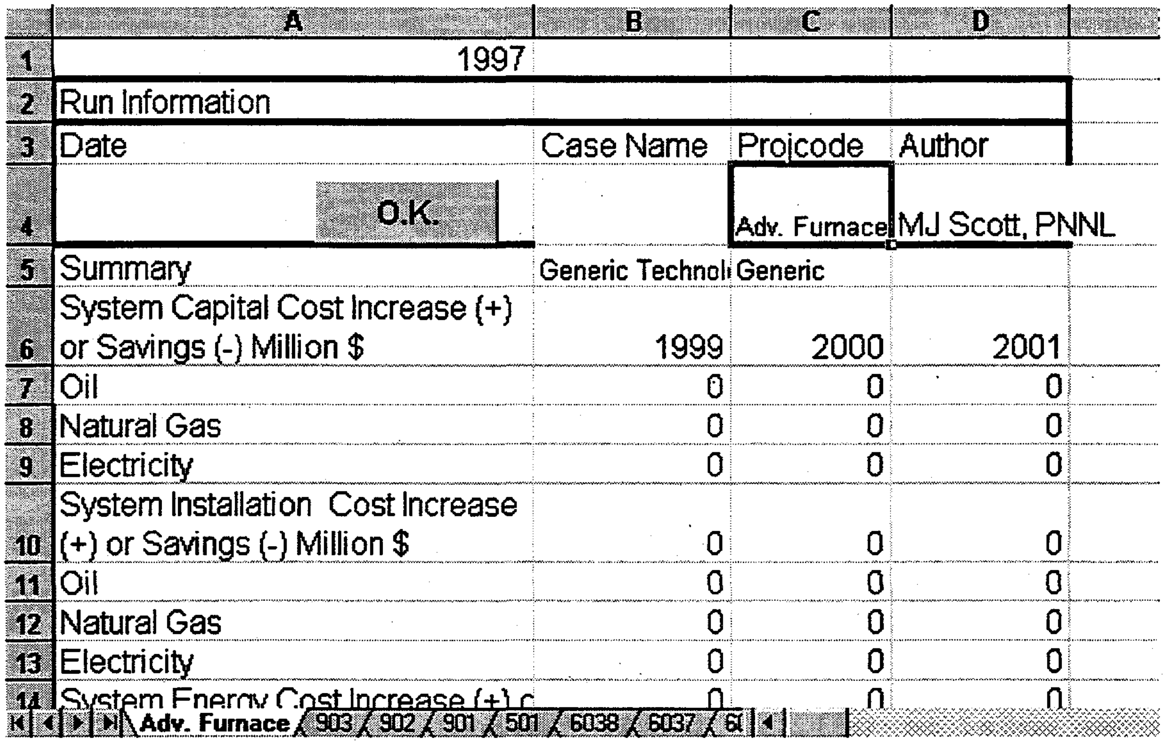

Figure 5.13. Editing Data for a Specific Technology (Note the O.K. Button)

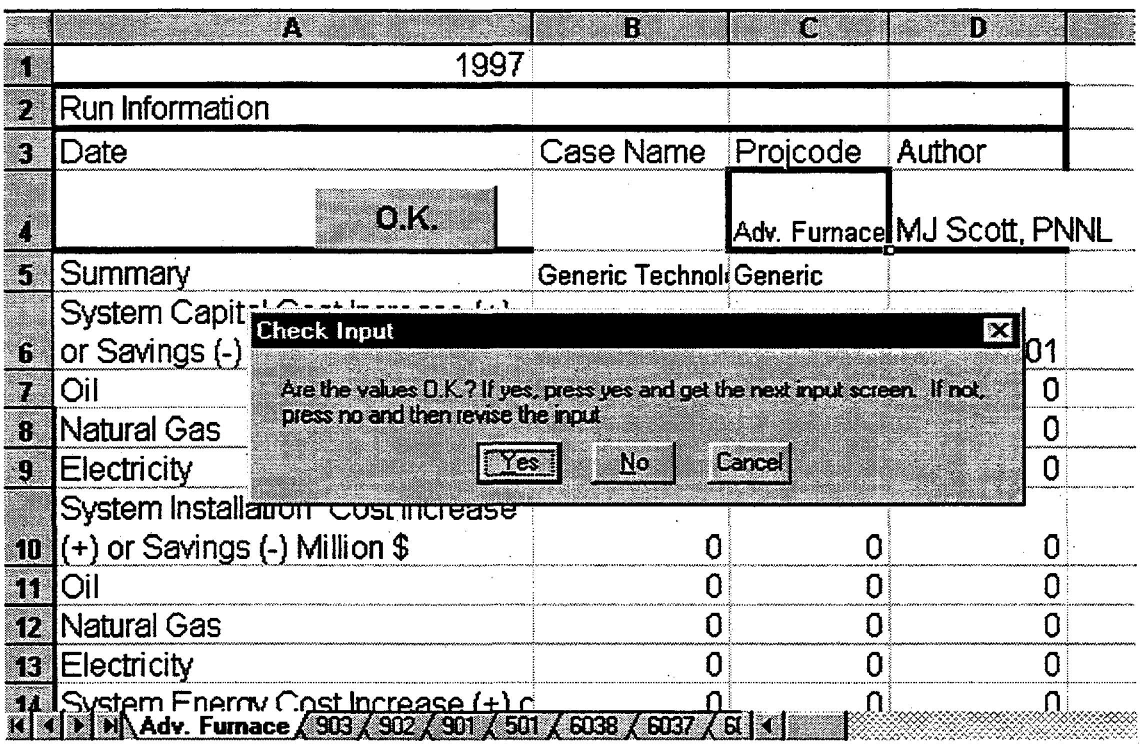

Figure 5.14. Confirming Input Values on a Technology

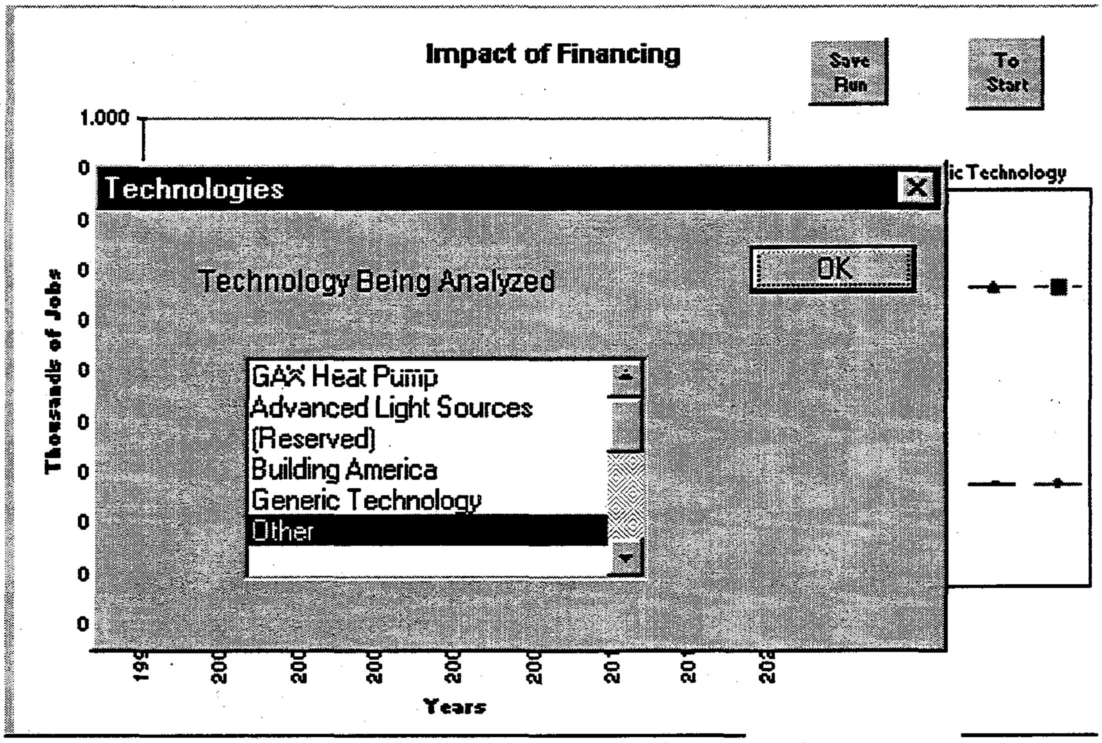

Figure 5.15. Confirming Which Technology is Being Run (Step 1)

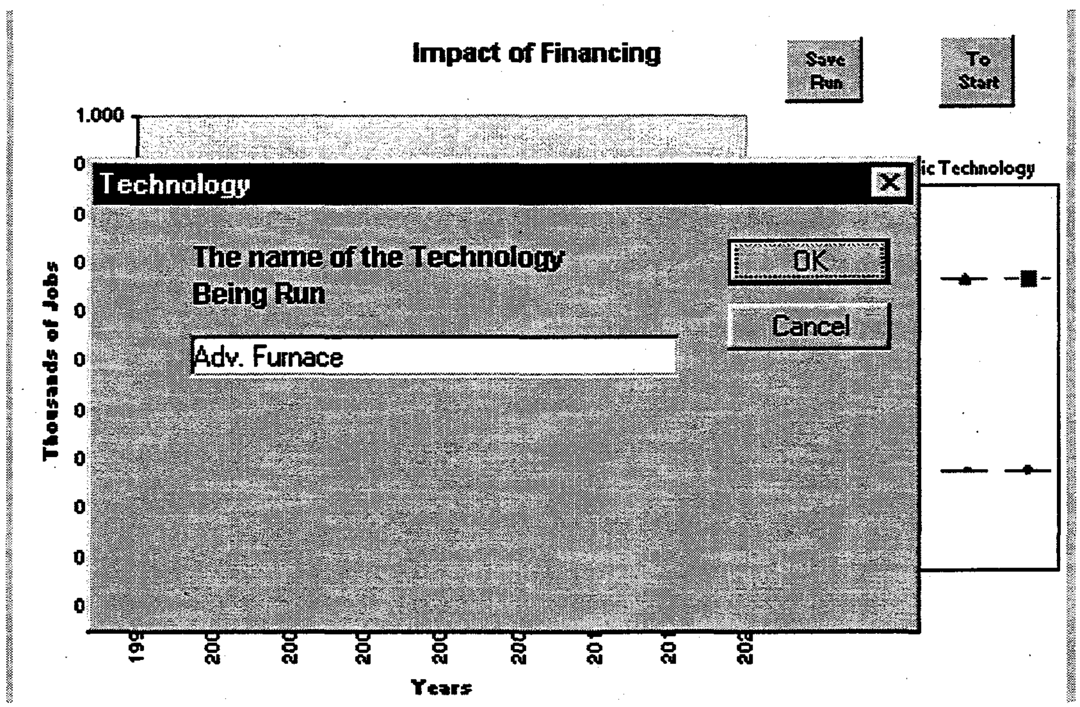

Figure 5.16. Confirming Which Technology is Being Run (Step 2)

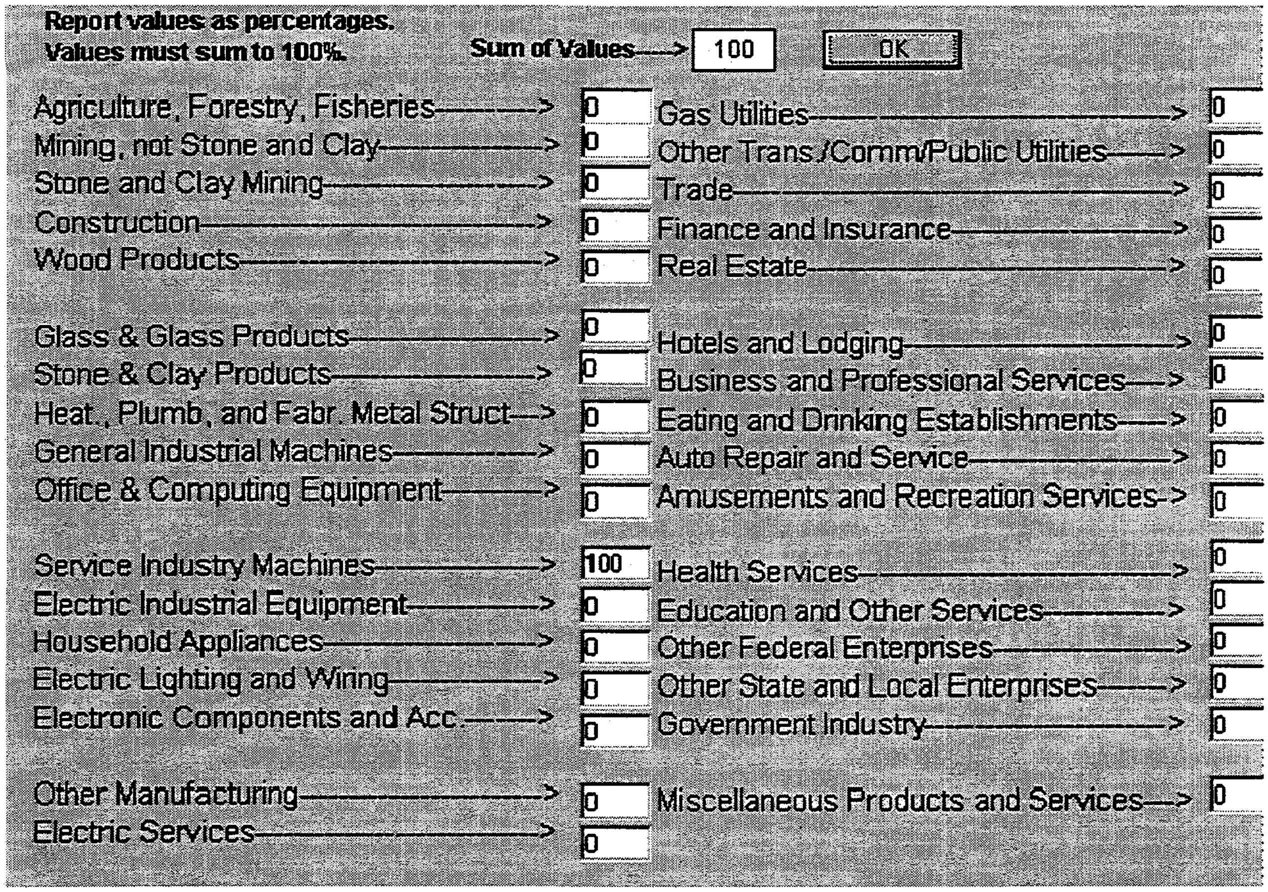

Figure 5.17. Distribution of Capital Cost Premium Among Sectors

initial capital costs (numbers between 0 and 100 express the percentages; for example, 15 = 15 percent and 0.15 = 0.15 percent). If you press *Yes*. the model will move to the next screen. If not, it will recycle until you are satisfied with the input.

In the example in Figure 5.17, 100% of the capital cost premium associated with the new technology is purchased directly from Service Industry Machines, the sector where heating and cooling equipment are manufactured. Energy savings automatically reduce purchases from the corresponding input-output sectors (such as electrical services), and non-energy savings on maintenance/operations are automatically assumed to be split between Trade and Services. Confirmation of the choices is made in Figure 5.18. As before, the dialog box *floats* and can be moved aside to view the input.

Next, the model allocates the non-energy operations costs of new technologies between sectors. The dialog box for this action appears as Figure 5.19. In the example shown, any differential in non-energy operations costs (such as, extra maintenance services or savings in maintenance) are allocated 15% to Trade and 85% to Services.

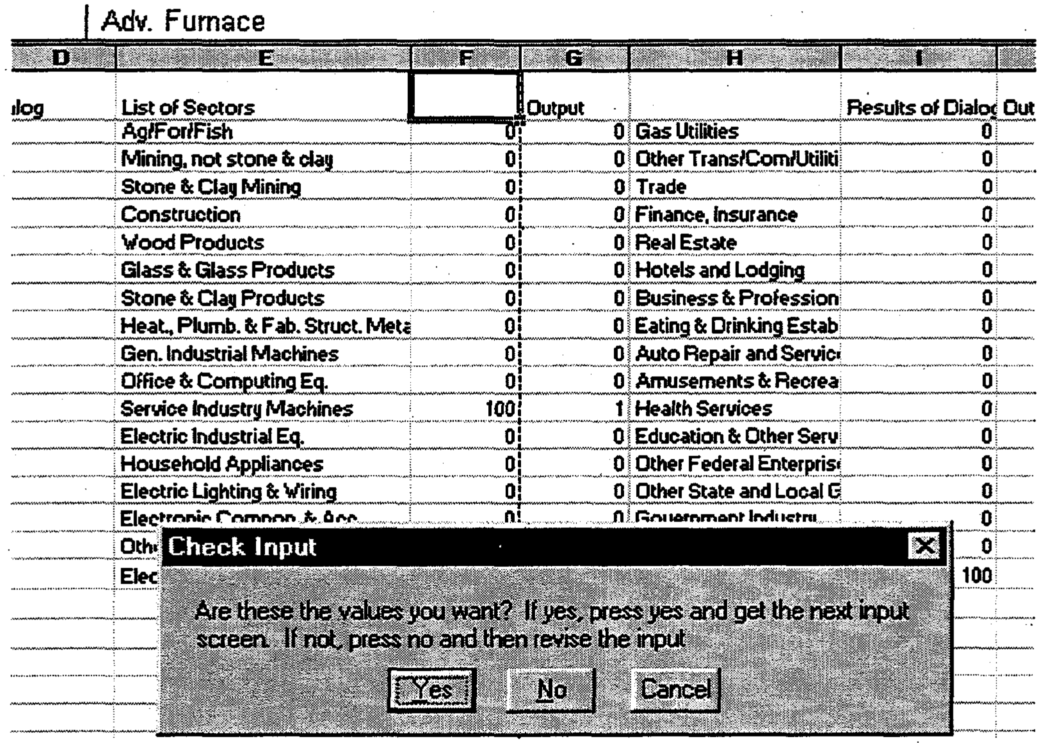

Figure 5.18. Confirming the Distribution of the Capital Cost Premium

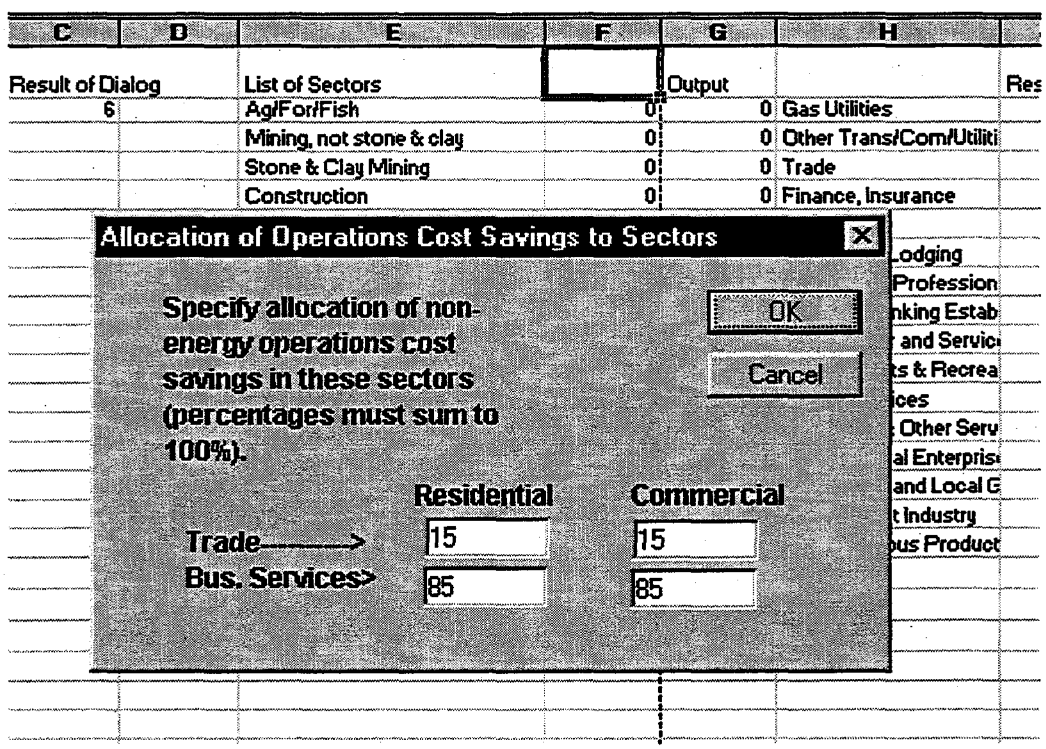

Figure 5.19. Dialog on Non-Energy Operations Cost Distribution Among Sectors

The model will confirm your choice with a dialog box that looks like Figure 5.20. If you are satisfied, press *yes*. If not, press *no* and reallocate the non-energy operations costs.

Next, the model turns to the question of financing the initial investment in the energy conservation technology. This financing could come from any number of sources: previously accumulated savings, lowered consumption, investment, or government spending, or reduced imports. It is likely that financing would affect a number of sectors in the U.S. economy. In the example in Figure 5.21, the financing for new investments is assumed to come from reduction in other domestic spending, allocated to components of final demand in approximately the proportion each source comprises of domestic final demand. Your choice is confirmed in Figure 5.22. In the example shown, the economy is considered *closed* and 100% of the investment has an opportunity cost in the U.S. economy's current activity, although this would not necessarily happen. These investments could be financed on international financial markets, for example, crowding out investments somewhere outside of the country. Thus, in alternative cases the percentages in Figure 5.21 would not necessarily sum to 100%.

Finally, the model asks whether the energy savings that result from reduced energy use have any induced investment effect. That is, do such savings reduce the amount of investment in electric and gas utility infrastructure that otherwise would have taken place? This choice is a simple *yes-no* choice in the model. If the answer is *yes* (the corresponding box is checked), then the model reduces investment in

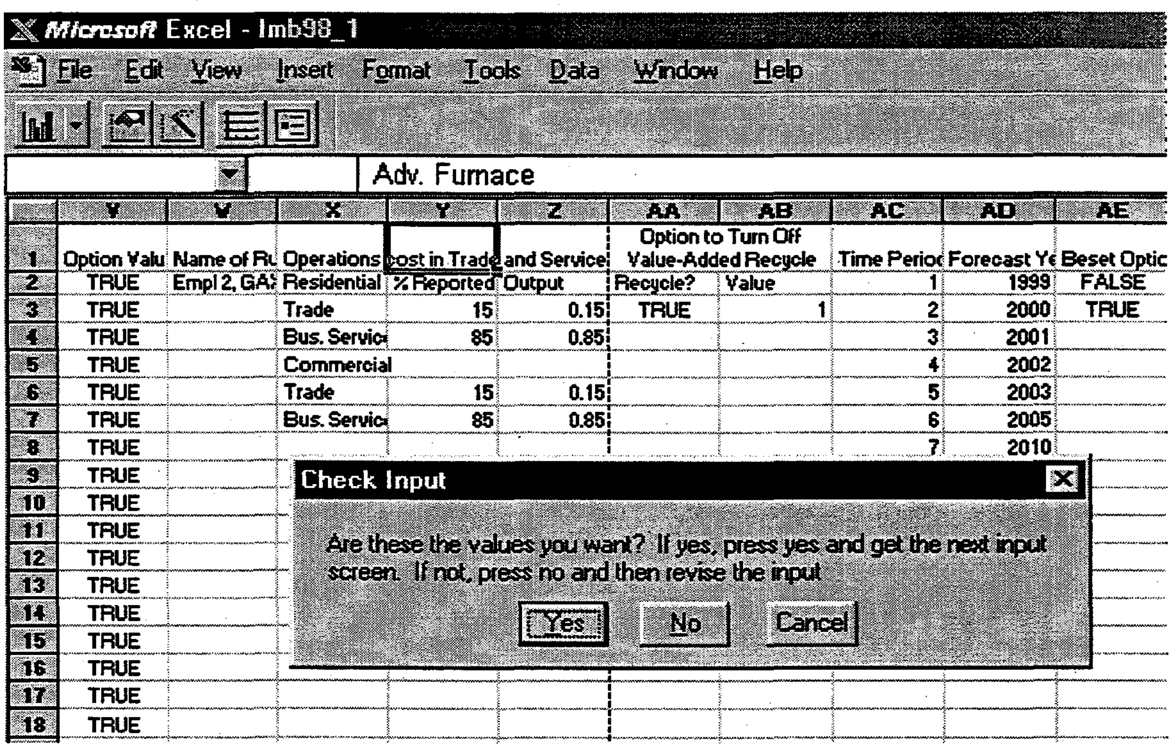

Figure 5.20. Confirming Distribution of Non-Energy Operating Costs

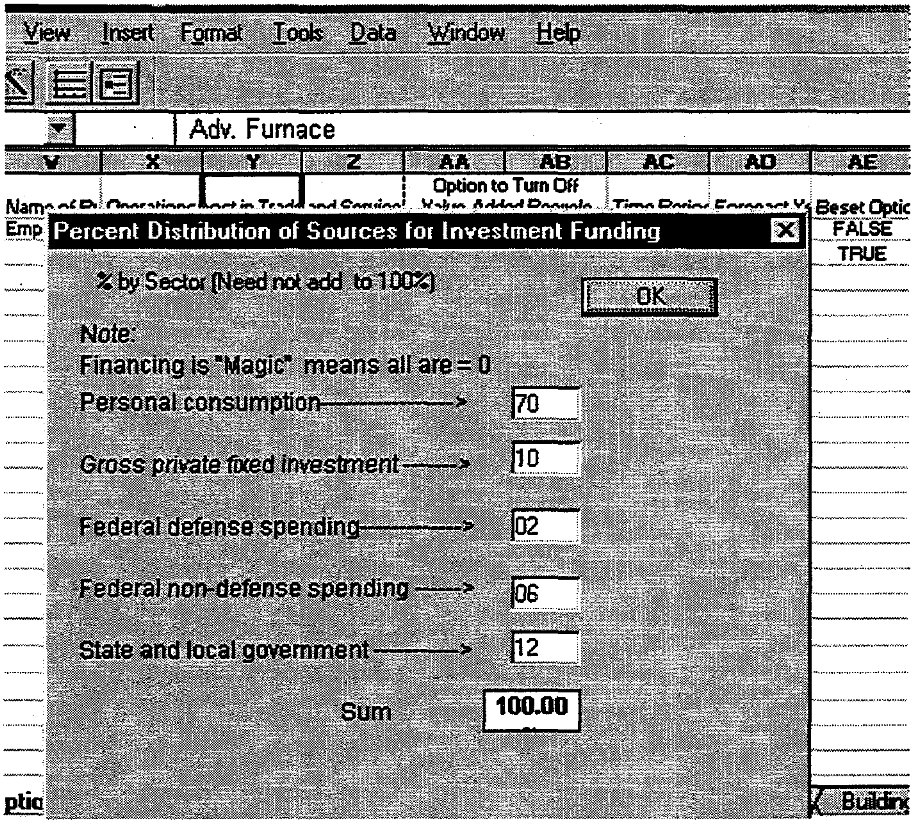

Figure 5.21. Opportunity Cost of Capital Investment (Source of Funds)

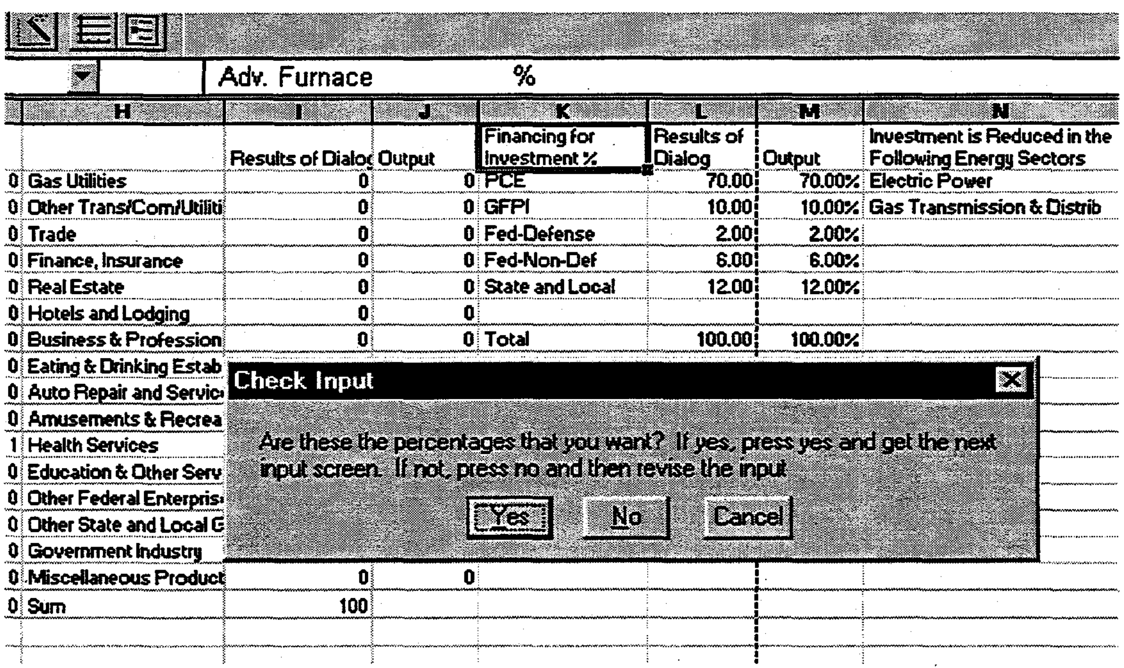

Figure 5.22. Confirming Opportunity Cost of Capital Investment

electric and gas utility plant and equipment through the construction industry at a rate that depends on the amount of energy saved. Figure 5.23 shows the input dialog box. In the example shown, both electric and gas utility investment is affected.

With the completion of the preceding dialogs, the model now has enough information to run. It loads the technology, financial, and investment information. It next loads the data and asks if you wish to change anything or run with the information given (see Figure 5.24).

If you answer *Yes* the model runs. If you answer *no*, the model asks again about input. If you answer *cancel*, the model goes back to the start. While it is running, the model displays the year of the analysis from one of its sheets in the upper left-hand corner of the screen. This cell changes value as the year of analysis changes.

After the model finishes running, it will ask how you want to save model input. If no cases with name conflicts appear in the previously saved input data sheets in INLIB_1.XLS, the model proceeds to save the input in INLIB_1.XLS. In those cases where a case is already resident with the same name in the INLIB_1.XLS file, the model will display an error message that you cannot rename a file with the same name as one that already exists. To recover, first press *End* to make the INLIB_1.XLS available to you. You then have three choices to resolve this conflict.

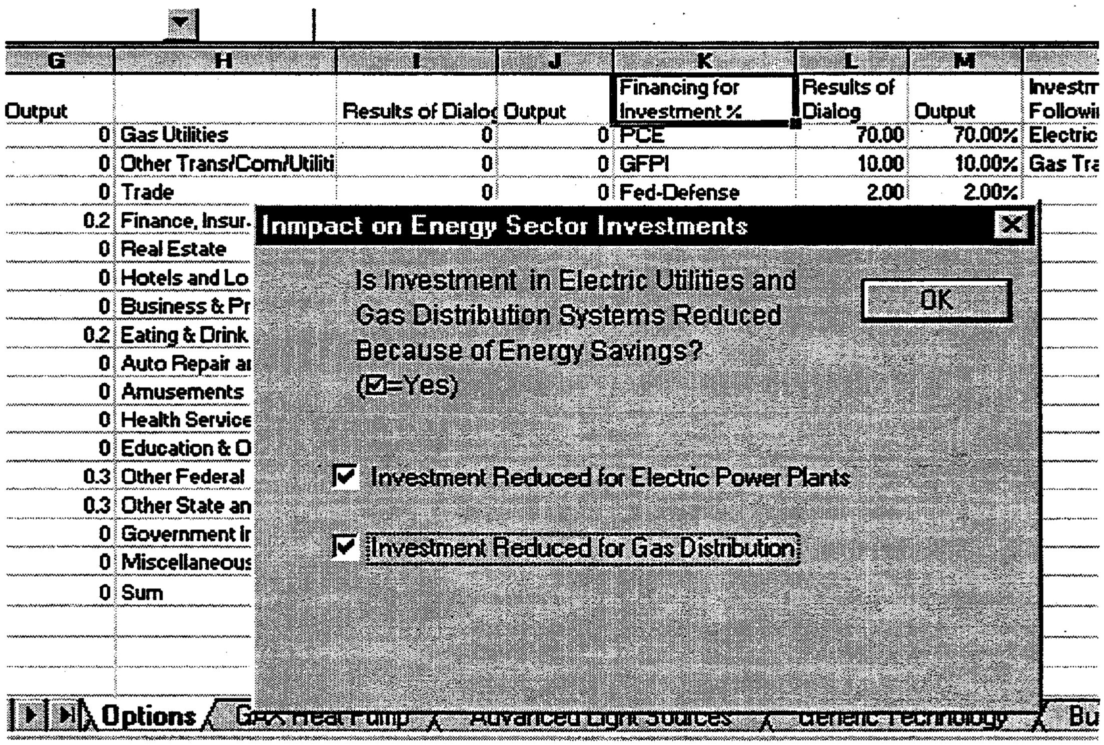

Figure 5.23. Dialog for Impact of Energy Savings on Utility Investments

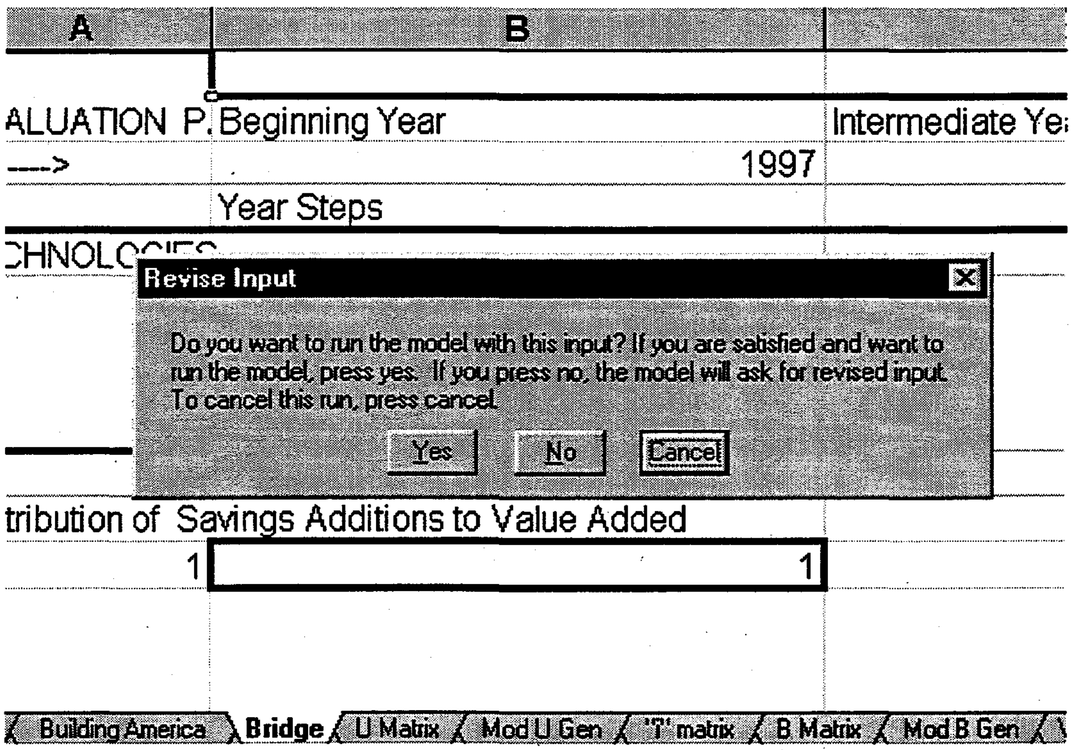

Figure 5.24. Confirmation to Begin Model Run

- If you want to keep both the old input file and the new one, you can rename *Sheet2* (the new duplicate sheet), then save INLIB_1.XLS and return to the IMB98_1.XLS window. Press the To End button to resume processing. ***Warning:*** if you rename an existing input file, bear in mind the output file library RUNLIB_1.XLS may also contain a copy of the file that you are renaming. In addition, output may be resident in the RUNLIB_1.XLS library that was created with the old input. You may wish to consider renaming or discarding this old output.

- If you want to save the old input file under its existing name and discard the new file, then close INLIB_1.XLS *without* saving it, then go to the IMB98_1.XLS window, and return to the *Cover* worksheet. You will have to rerun the new case under a new name.

- If you want to keep the new case but *not* the old file with the same name, discard the old file, rename the new file, save INLIB_1.XLS and return to the IMB98_1.XLS window. Press the *To End* button to resume processing. ***Warning:*** if you discard an existing input file, bear in mind the output file library RUNLIB_1.XLS may also contain another copy of the file that you are preparing to discard. In addition, there may be output in the RUNLIB_1.XLS library that was created with the old input. You may wish to consider renaming or discarding this old output.

The model next asks a series of questions concerning output. At this point, you may review the output in either graphical or tabular form. Figure 5.25 offers this choice. Because you may want to look at more than one result, this part of the model continues to recycle until you select *Move On* and press the *O.K.* button. (See Figure 5.26.)

You are now confronted with the question of what to do with the results. You may decide to return immediately to make another run of the model, store the results, or quit without saving anything (see Figure 5.27). To go to the beginning and make another run to add to the existing set of output, press the *no* button. The model goes back to the start and you can make another run to add to the results. If you are finished running the model for now, press *yes* and the model asks about saving output. If you answer *yes*, the model keeps all of the current model results and prepares to save them. If you press *no*, you get a screen like Figure 5.28, asking whether you want to store all of the current runs. If you answer *yes*, all of the runs will be saved. If you answer *no*, a screen like Figure 5.29 will ask if you wish to eliminate any runs before storing the remainder. Figure 5.30 provides a menu of model runs to eliminate. In the case shown in the figure, we have decided to save only the first run. When this process is complete, the model relinquishes control of the *Save Run* and *To Start* buttons; *To Start* takes you back to the initial page. This button appears in the upper right-hand corner of Figure 5.31. Depending on your decisions about saving or eliminating runs and which reviews you were doing when you decided to save runs, the screen may not be the same as the one in Figure 5.31. However, it will include a *Save Run* and a *To Start*.

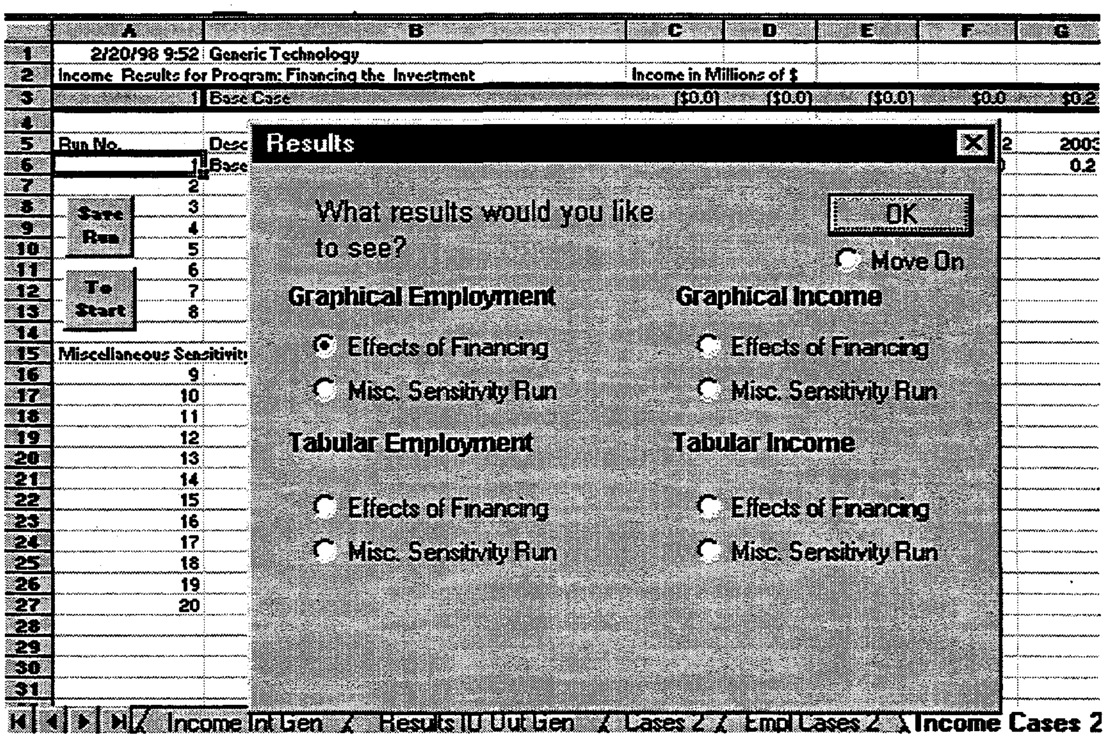

Figure 5.25. Initial Selection of Output

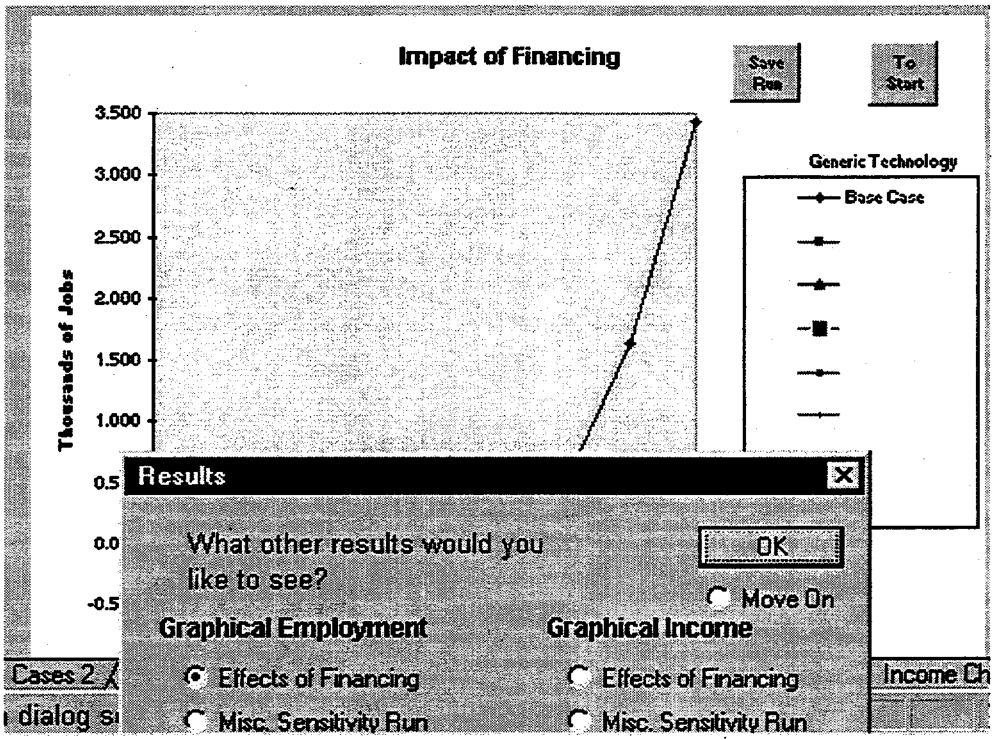

Figure 5.26. Reviewing Model Output

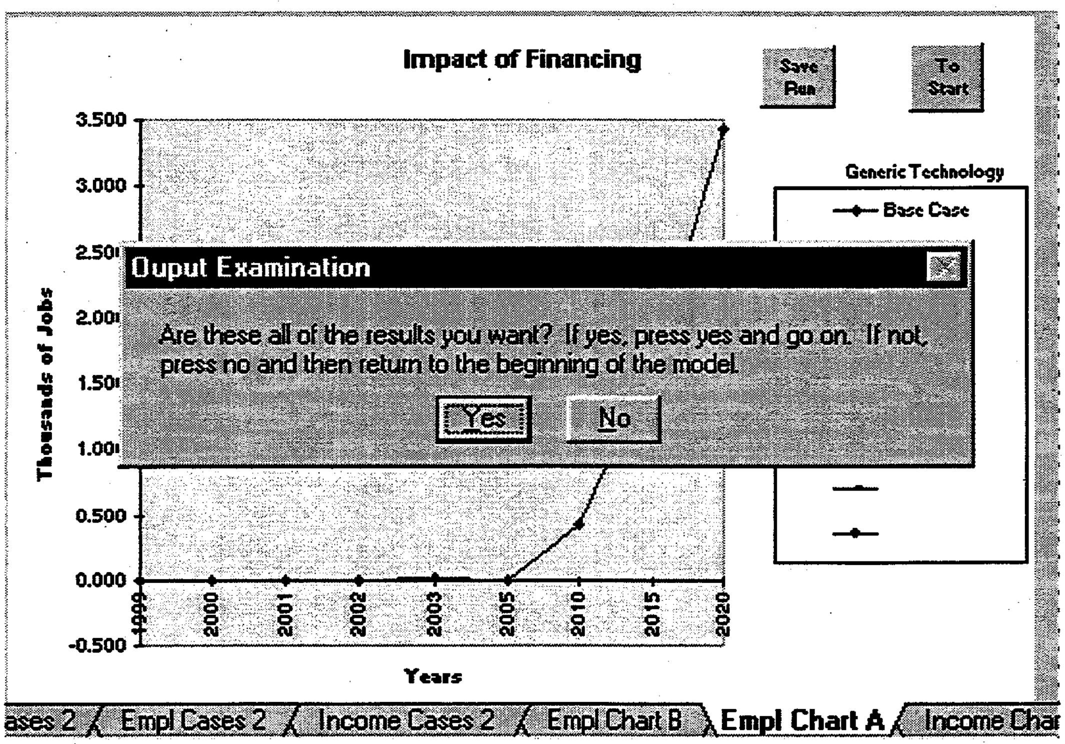

Figure 5.27. Dialog to Continue Running or Store Results

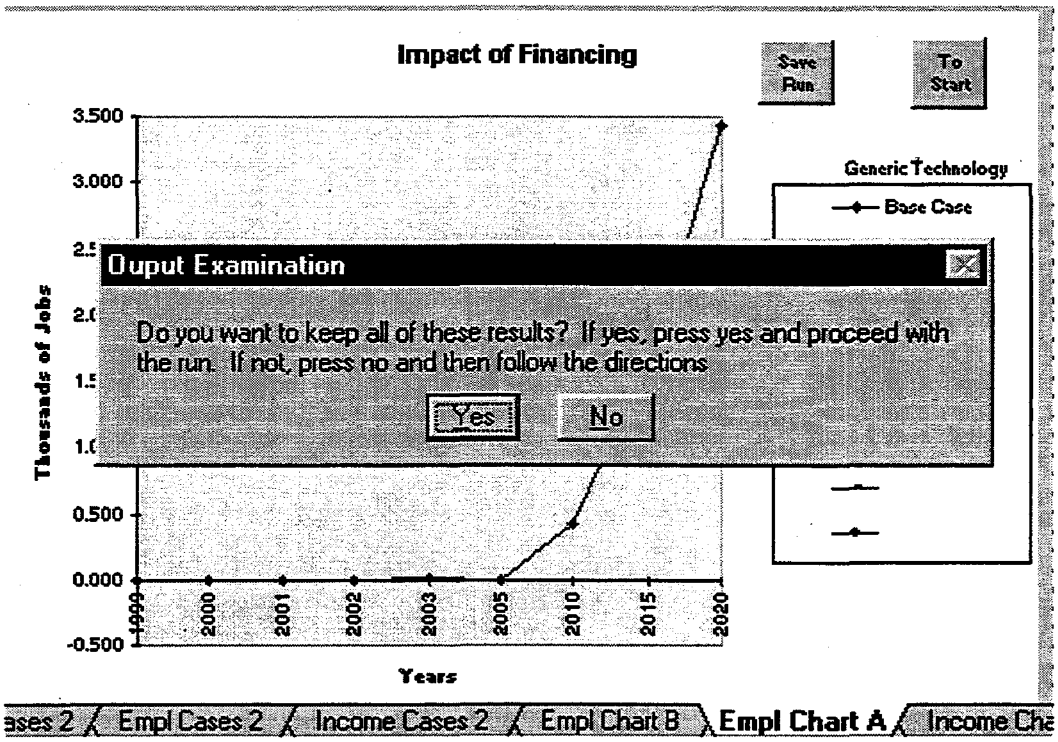

Figure 5.28. Dialog to Save All Current Model Runs

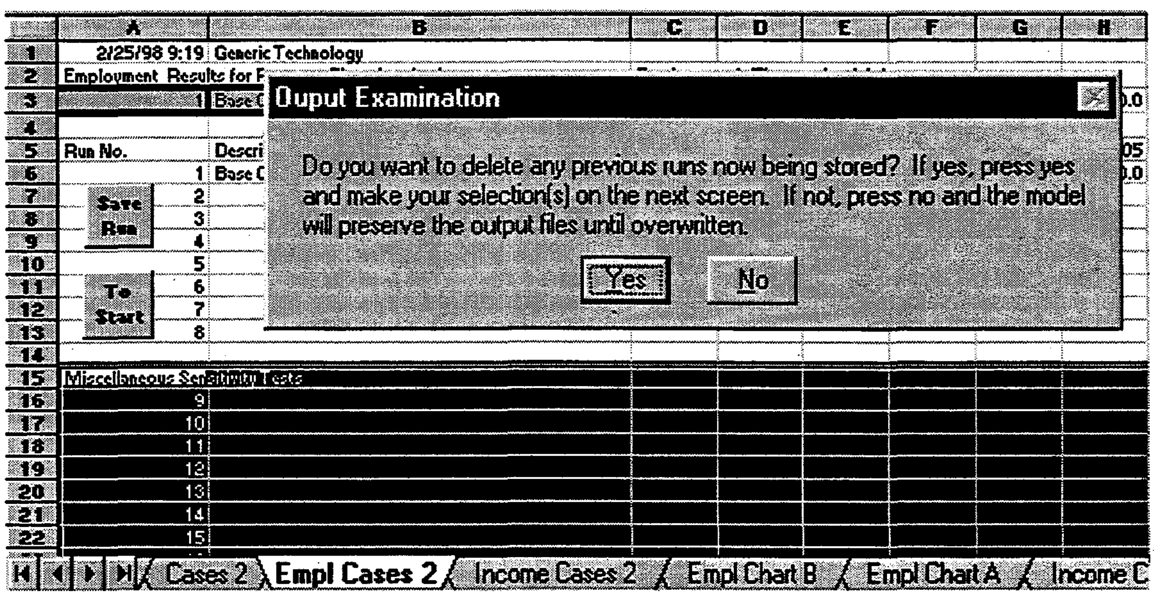

Figure 5.29. Dialog for Option to Eliminate Model Runs

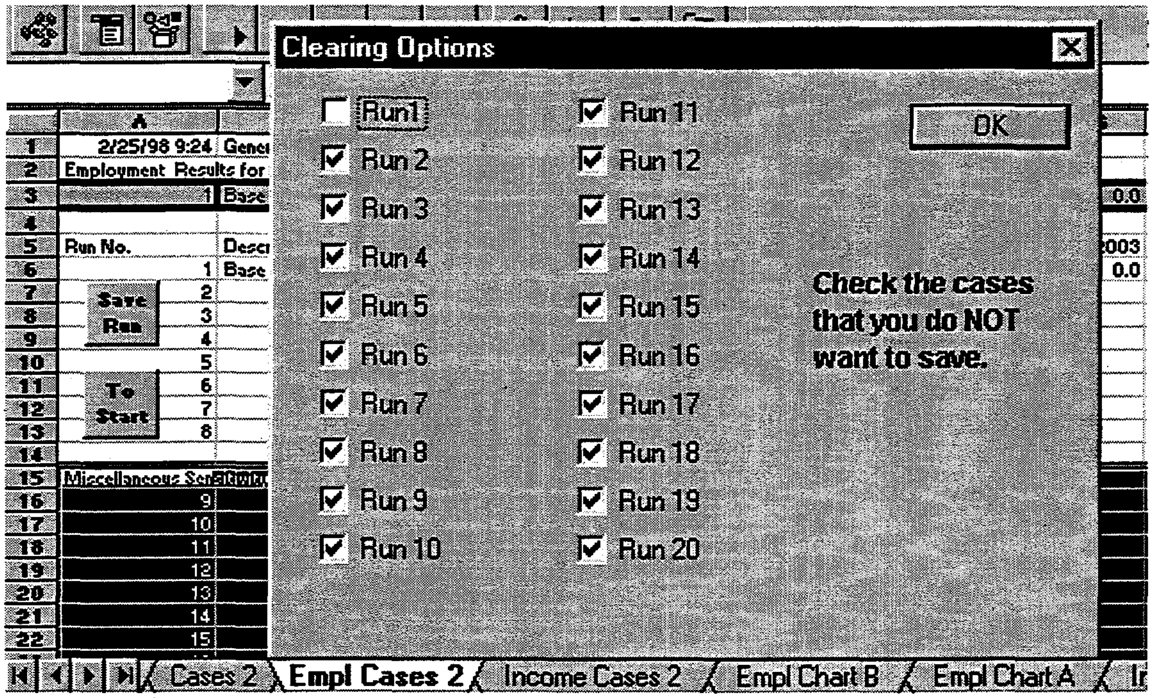

Figure 5.30. Choice of Model Runs to Eliminate

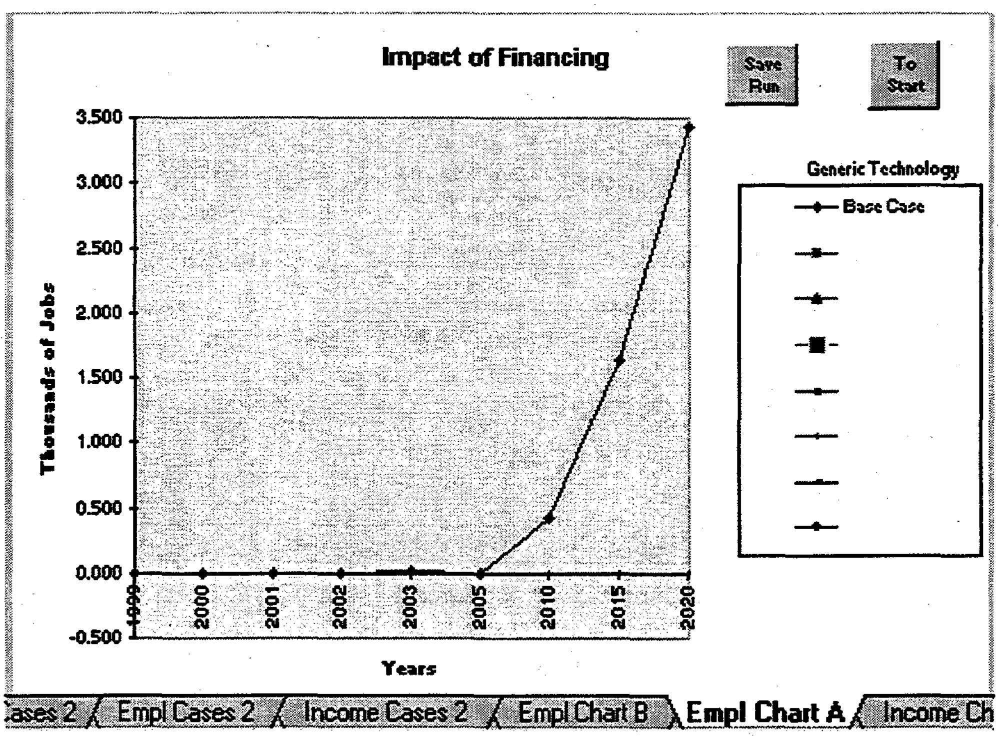

Figure 5.31. Option to Make Another Model Run or Save Results

To keep the file from being overwritten, save the output under a new name by pressing *Save Run* to activate the program that saves model runs to the RUNLIB_1.XLS run library. [Note: before pressing Save Run, make sure that RUNLIB_1.XLS is closed. You can do this by checking the open windows at *Window* at the top of your Excel Window.] Also in the library is a set of additional copies of the technology data sheets used by the model. If you want to quit without saving anything, just use the *File Close* or *File Exit* feature of Excel.

In the example shown, we decided to save the run and rename it to keep it from being accidentally overwritten. Pressing *Save Run* opens a dialog screen that looks like Figure 5.32.

Note the box that asks if you want to save the results as a BESET run. When this option is checked, ImBuild provides output to the OUT_1.XLS output file in a format that is easy for the BESET model to choose for other analysis purposes in the GPRA Metrics Program. In any case, the results are saved in RUNLIB_1.XLS.

By filling in the information in this screen, you can save the output data from any run of the ImBuild model for later use. It is important for the results to be saved under a name different from those already in use or previous files can be overwritten. Press *O.K.* when done.

You can use the Window button on the Excel toolbars to look at the RUNLIB_1 workbook.

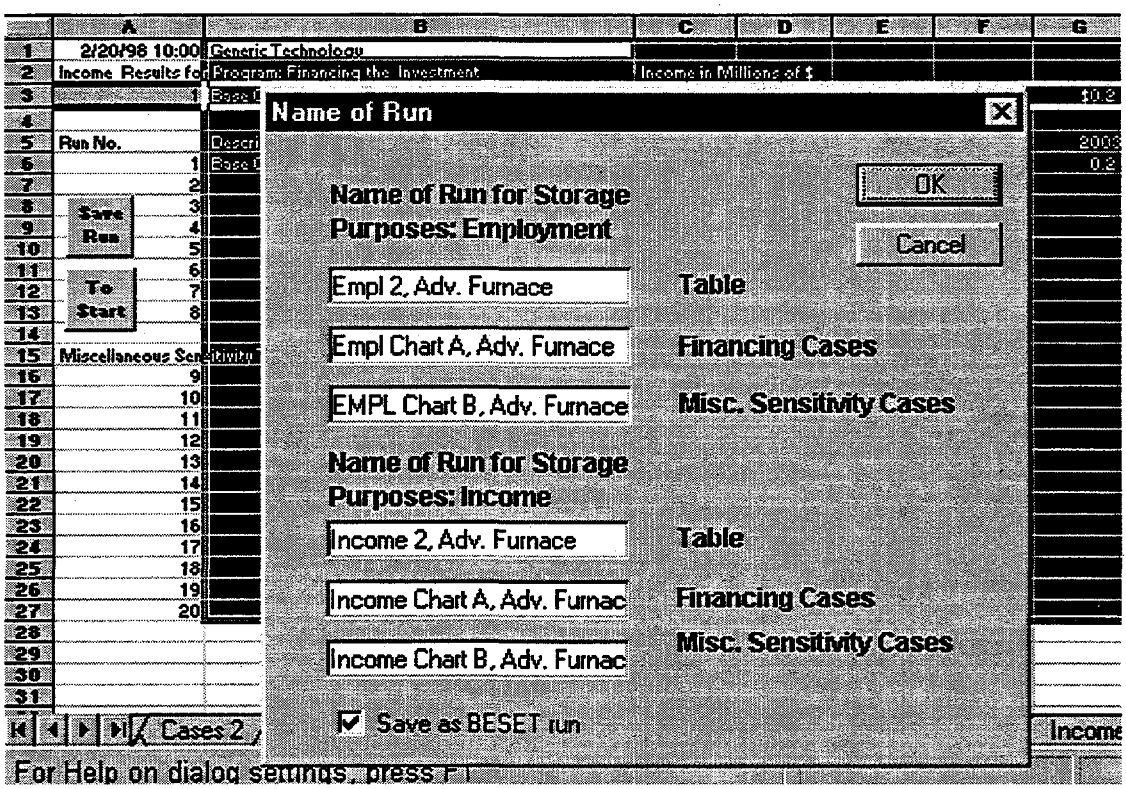

Figure 5.32. Saving Model Runs

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Appendix A

Base Cases for Building Energy Efficiency Technologies

Appendix A

Base Cases for Building Energy Efficiency Technologies

Gax Base Case

Base case	Residential Absorption Heat Pump GAX								
	1999	2000	2001	2002	2003	2005	2010	2015	2020
System Capital Cost Increase (+) or Savings (-) Million $									
Oil	0	0	0	0	0	0	0	0	0
Natural Gas	0	0	0	0	0	10	60	140	190
Electricity	0	0	0	0	0	0	0	0	0
System Installation Cost Increase (+) or Savings (-) Million $									
Oil	0	0	0	0	0	0	0	0	0
Natural Gas	0	0	0	0	0	0	0	0	0
Electricity	0	0	0	0	0	0	0	0	0
System Energy Cost Increase (+) or Savings (-) Million $									
Oil, Residential	0	0	0	0	0	0	0	0	0
Oil, Commercial	0	0	0	0	0	0	0	0	0
Natural Gas: Residential	0	0	0	-0.06	-0.33	-1.98	-29.3	-93.6	-175.69
Natural Gas: Commercial	0	0	0	0	0	0	0	0	0
Electricity: Residential	0	0	0	0	-0.24	-1.17	-17.16	-54.59	-101.29
Electricity: Commercial	0	0	0	0	-0.22	-1.28	-20.14	-62.88	-114.29
System Non-Energy Cost Increase (+) or Savings (-) Million $									
Residential	0	0	0	0	0	-0.22	-1.32	-3.08	-4.18
Commercial	0	0	0	0	0	0	0	0	0
System Energy Saved (-) or Used (For System Investment) 10^12 Btu									
Oil	0	0	0	0	0	0	0	0	0
Natural Gas	0	0	0	-0.01	-0.06	-0.36	-5.56	-18.07	-34.45
Electricity	0	0	0	0	-0.02	-0.11	-1.71	-5.54	-10.46

Low Power Sulfur Lamp Base Case

Base Case	Adv. Light Sources LPSL								
	1999	2000	2001	2002	2003	2005	2010	2015	2020
System Capital Cost Increase (+) or Savings (-) Million $									
Oil	0	0	0	0	0	0	0	0	0
Natural Gas	0	0	-3.58	-3.58	-8.95	-19.5	-58.36	-128.92	-181.58
Electricity	0	0	0	0	0	0	0	0	0
System Installation Cost Increase (+) or Savings (-) Million $									
Oil	0	0	0	0	0	0	0	0	0
Natural Gas	0	0	0	0	0	0	0	0	0
Electricity	0	0	0	0	0	0	0	0	0
System Energy Cost Increase (+) or Savings (-) Million $									
Oil, Residential	0	0	0	0	0	0	0.07	0.37	0.72
Oil, Commercial	0	0	0	0	0	0	0.11	0.27	0.47
Natural Gas: Residential	0	0	0	0.11	0.11	0.44	2.69	7.56	14.18
Natural Gas: Commercial	0	0	0	0	0.05	0.14	0.95	2.2	3.52
Electricity: Residential	0	-0.48	-1.93	-4.32	-7.87	-23.72	-147.58	-416.19	-789.52
Electricity: Commercial	0	-0.45	-1.33	-2.85	-5.46	-15.82	-86.02	-204.52	-323.93
System Non-Energy Cost Increase (+) or Savings (-) Million $									
Residential	0	0	0	0	0	0	0	0	0
Commercial	0	0	0	0	0	0	0	0	0
System Energy Saved (-) or Used (For System Investment) 10^12 Btu									
Oil	0	0	0	0	0	0	0.03	0.1	0.19
Natural Gas	0	0	0	0.02	0.03	0.11	0.72	1.95	3.57
Electricity	0	-0.04	-0.14	-0.31	-0.58	-1.75	-10.55	-28.73	-52.81

Building America Base Case

Base Case	Building America Build								
	1999	2000	2001	2002	2003	2005	2010	2015	2020
System Capital Cost Increase (+) or Savings (-) Million $									
Oil	0	0	0	0	0	0	0	0	0
Natural Gas	15	30	45	60	75	135	0	0	0
Electricity	0	0	0	0	0	0	0	0	0
System Installation Cost Increase (+) or Savings (-) Million $									
Oil	0	0	0	0	0	0	0	0	0
Natural Gas	0	0	0	0	0	0	0	0	0
Electricity	0	0	0	0	0	0	0	0	0
System Energy Cost Increase (+) or Savings (-) Million $									
Oil, Residential	0	-0.14	-0.21	-0.36	-0.5	-1.09	-8.57	-16.57	-25.13
Oil, Commercial	0	0	0	0	0	0	0	0	0
Natural Gas: Residential	-0.62	-1.63	-3.08	-5.09	-7.48	-15.87	-116.84	-223.72	-334.92
Natural Gas: Commercial	0	0	0	0	0	0	0	0	0
Electricity: Residential	-0.73	-1.93	-3.62	-6.23	-9.77	-19.97	-159.24	-324.4	-515.35
Electricity: Commercial	0	0	0	0	0	0	0	0	0
System Non-Energy Cost Increase (+) or Savings (-) Million $									
Residential	0	0	0	0	0	0	0	0	0
Commercial	0	0	0	0	0	0	0	0	0
System Energy Saved (-) or Used (For System Investment) 10^12 Btu									
Oil	0	-0.02	-0.03	-0.05	-0.07	-0.15	-1.15	-2.26	-3.48
Natural Gas	-0.11	-0.29	-0.55	-0.91	-1.34	-2.89	-22.17	-43.19	-65.67
Electricity	-0.03	-0.08	-0.15	-0.26	-0.41	-0.85	-6.96	-14.56	-23.76