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Pacific Northwest National Laboratory
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ImBuild II: Impact of Technologies on Energy Efficiency Programs

M.J. Scott
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Prepared for the U.S. Department of Energy
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Summary

This version of IMBUILD represents the "next generation" of the previously developed spreadsheet based IMBUILD version that was developed in the Excel 7 programming environment. More specifically, a special-purpose version of the Benchmark national I-O model was designed specifically to estimate the employment and income effects of building and other Office of Energy Efficiency and Renewable Energy (EE) developed energy-saving technologies. In comparison with the previous version of IMBUILD, this version allows for more complete and automated analysis of the essential features of energy efficiency investments in buildings, industry, and the electric power sectors. IMBUILD II is also easier to use than extant macroeconomic simulation models and incorporates information developed by each of the EE offices as part of the requirements of the Government Performance and Results Act. While 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, for most purposes these excluded features are not critical. The analysis is 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 this version of IMBUILD is a cost-effective solution to estimating the economic impacts of the development of energy-efficient technologies.

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1.0 Introduction: A Method for Assessing Economic Impacts of Energy-Efficient Technologies

1.1 Background and Current Situation

As part of measuring the impact of government programs in improving the energy efficiency of the nation's building stock, the U.S. Department of Energy's 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. After surveying three fundamental methods 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), the I-O approach was selected for the original version of ImBuild. (For an overview of each of these approaches, see the previous documentation in Scott, Hostick, and Belzer 1998).

This version of ImBuild uses essentially the same methodology as the previous version, but greatly expands the scope of the model to include more industrial sectors of the economy and thus covers a wider array of buildings technologies. By covering more industrial sectors, the model lends itself to assessing the impacts of evaluating technologies developed outside the BTS scope, including power technologies, industrial technologies and transportation technologies. The major differences between this version and the previous version of ImBuild are:

- The Visual Basic-EXCEL environment has been replaced with a Visual Basic (VB) program that assembles, accesses, and stores data in Access data files.
- The Input-Output structure is based on the 1992 Benchmark U.S. table,[a] specially aggregated for this project to 98 sectors rather than the previous 35-sector model.
- The manipulation of this larger I-O structure is done by a VB call to a FORTRAN program that returns the results to the VB program where the results are transformed into graphics and stored in Access files.

The model remains a static input-output model, which allows a great deal of flexibility concerning the types of energy efficiency effects that can be accommodated. Certain economic effects of energy efficiency improvements require an assessment of inter-industry purchases. As an example, 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

(a) Ann M. Lawson, "Benchmark Input-Output Accounts of the U. S. Economy, 1992: Make, Use and Supplementary Tables," *Survey of Current Business*, November, 1997, pp. 36-82.

in productivity and value-added[(a)] and a *change* to the input-output structure, differing from a case in which a constant I-O structure is 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 this one can be used to estimate the impact of changes in overall efficiency and productivity in the economic sectors that make energy-efficiency investments. In contrast to the previous version of ImBuild, which was designed only to estimate the impacts of energy efficiency in residential and commercial buildings, ImBuild II could apply to an investment by a paper mill in more energy-efficient equipment, the investment by an electric utility in more efficient plant, or improvements in transportation infrastructure. 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 this model has been greatly expanded in its capabilities, it retains its user-friendly shell that makes it easy to use, with the advantage that it provides more theoretically plausible and comprehensive results than alternative models.

The chief drawbacks of this, or any 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, 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 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.

While we acknowledge these drawbacks, the scale of most energy-efficiency improvements, relative to the overall economy, are small enough to make this an inconsequential effect.

1.2 Solution

The programmatic needs of BTS suggest that a simple, flexible, user-friendly method is needed to derive national employment income and output impacts of BTS programs. A special-purpose version of an I-O model was designed specifically to estimate the employment, income, and output effects of building and other EE energy technologies. This model retains its original name, Impact of Building Energy Efficiency Programs (ImBuild), though the new version (ImBuild II) can now handle energy efficiency improvements of almost any sort. In comparison with alternative models, ImBuild II allows for more complete and automated analysis of the essential features of energy efficiency investments.

(a) 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.

ImBuild II 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 II is a cost-effective solution to the problem at hand.

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 uses a version of the Benchmark U.S. national I-O table incorporated in a Visual Basic program that controls processing in a FORTRAN impacts calculator. The goal of the model-building process was to create a computerized tool that required only a knowledge of ImBuild II technologies to run. The national I-O model is a 98- x 98-sector version of the 498- x 498- sector benchmark U.S. Input-Output table for 1992. The 98 sectors are those most important for analyzing economic impacts of residential and commercial buildings technologies, but is comprehensive enough to cover other energy-efficient technologies as well. ImBuild II is a particularly easy model to use, and was made even easier by the creation of an inexpensive, user-friendly front end to facilitate user inputs. Dialog boxes and spreadsheet-like data entry screens create this user-friendly *front end*. Thus, the project provides an analytical tool that BTS policy analysts can use without having to be programming experts.

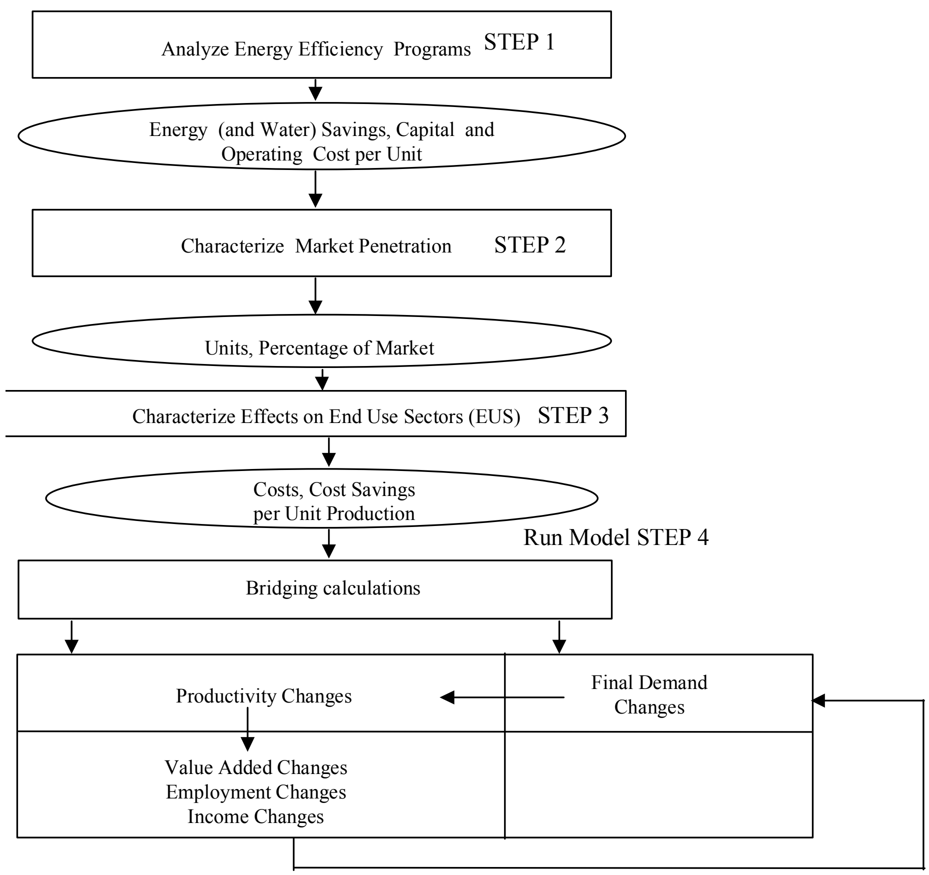

Figure 2.1. Process for Analyzing Economic Impact of Energy Efficiency Programs

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 Heat Pump Water Heater*. The purpose of the DOE program in this area is to develop and commercialize highly efficient water heaters. The technology is expected to displace the next generation of already highly-efficient conventional water heaters.

- *EPACT Commercial Building Standards—Air Conditioning*. The DOE program is continuing the development of efficiency standards for commercial air conditioning that will improve the comfort and reduce the cost of air conditioning commercial retail and office space.

- *Residential Buildings Integration R&D*. The final technology is Residential Buildings Integration R&D, 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 use 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 through 3, the ImBuild II 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.

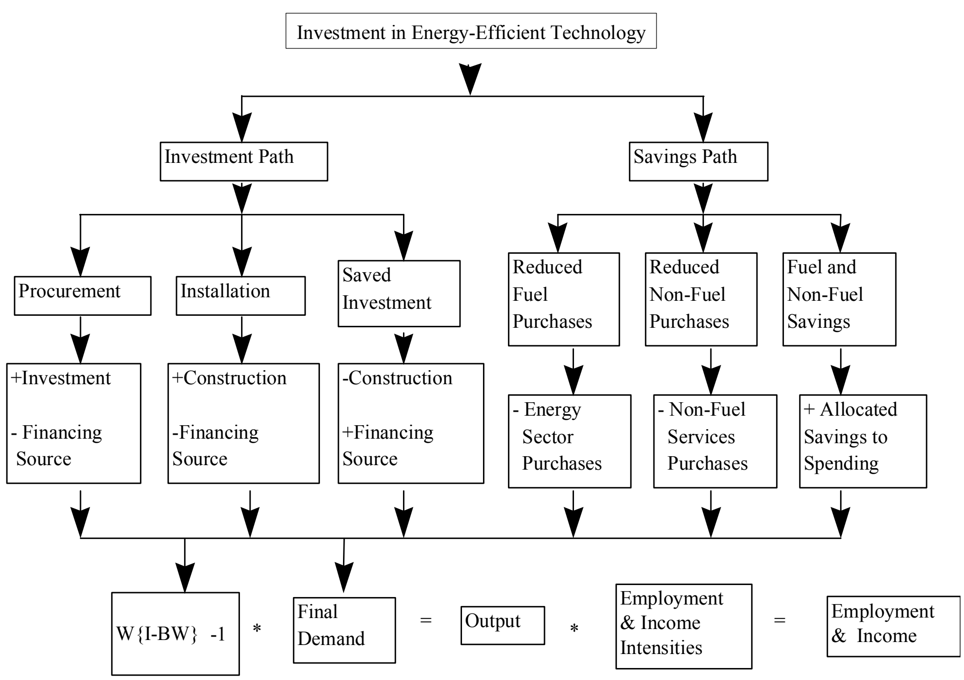

Figure 2.2. Detailed Calculations of the ImBuild II Model

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 II 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 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 II 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 re-computation process requires less than 1 second on a Pentium 500 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 II 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 (or industrial or transportation) 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).[a]

ImBuild II 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 II model runs can be saved by running an imbedded dialog designed for this purpose.

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.[b] 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

(a) ImBuild II 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.

(b) 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.

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 II 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 306 jobs, or about 0.6 additional jobs per $100 thousand dollars of direct energy savings. The impact is virtually identical if the energy savings occur in the commercial sector, because the employment intensity of the spending mix of businesses, their workers, and government associated with commercial savings is only slightly 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* 200 jobs) because the opportunity cost of the investment premium is the dollar amount 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.[a] 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 more than 1700 and a long-run jobs impact of 300. 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.

(a) 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.

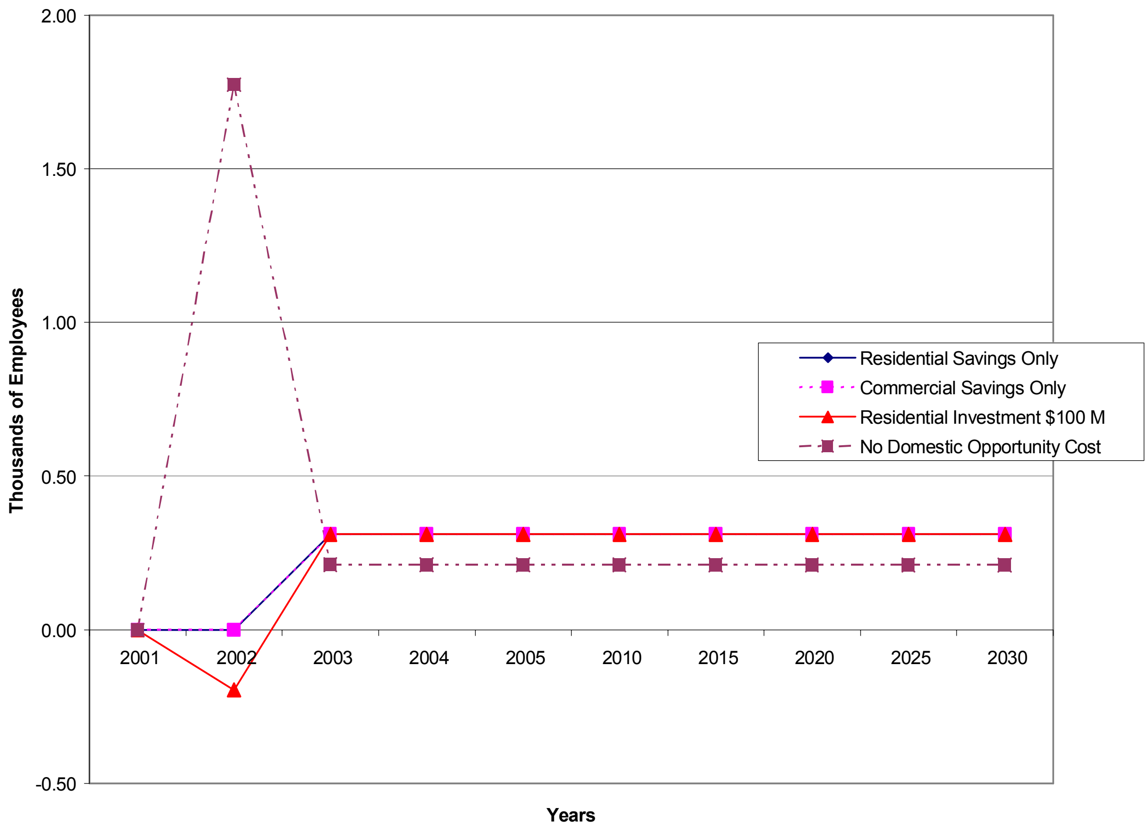

Figure 2.3. Impact on National Employment of a Hypothetical Once-Only Investment in Appliance Efficiency

3.0 ImBuild II Model Results for Example BTS Programs

This section discusses the results obtained by using the ImBuild II 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 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.[a] 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 programs: Emerging Technology R&D on heat pump water heaters, EPACT Energy Efficiency Standards, and Residential Buildings Integration R&D. These choices illustrate three basic types of BTS programs: an equipment R&D program (focused on the residential sector), an equipment efficiency standards program (focused on the commercial sector), and a systems and education program. Descriptions of these programs follow.

Heat Pump Water Heaters. The first program is Emerging Technology R&D on the heat pump water heater (HPWH) and other follow-on technologies. The purpose of this program is to commercialize highly efficient water heaters for new and existing manufactured and single-family residential buildings. The general program seeks comprehensive solutions for water heating consumption (low cost heat pump water heaters, condensing gas water heaters, waste heat recovery, and water conservation devices), and wants them well established in the market. Long-term goals include HPWHs being sold at a rate of 50,000/year in five years (currently, the volume is about 2,000/year). The program would like to see an increased likelihood of HPWH standards/building codes in the 2010 to 2020 timeframe, introduction of gas condensing residential gas water heaters, and increased likelihood of future standards. Near-term milestones include: market introduction of a low cost HPWH (less than $600) by the end of 2003, establishment of HPWH advocacy group with DOE funding for 3 to 5 years, and market introduction of residential gas condensing water heaters by 2005. Estimated markets are:

- HPWH: Target market of 13.6 million existing homes of the 36 million home potential with electric resistance water heaters, and approximately 40% of new homes. Limited but initial market for light commercial.

(a) This report used BTS program data reported in the *BTS GPRA Metrics Estimates, FY03 Budget Request*, December, 2001, as well as program information from PNNL (2002) that PNNL updated by and with DOE/EE program managers to produce the descriptions shown here.

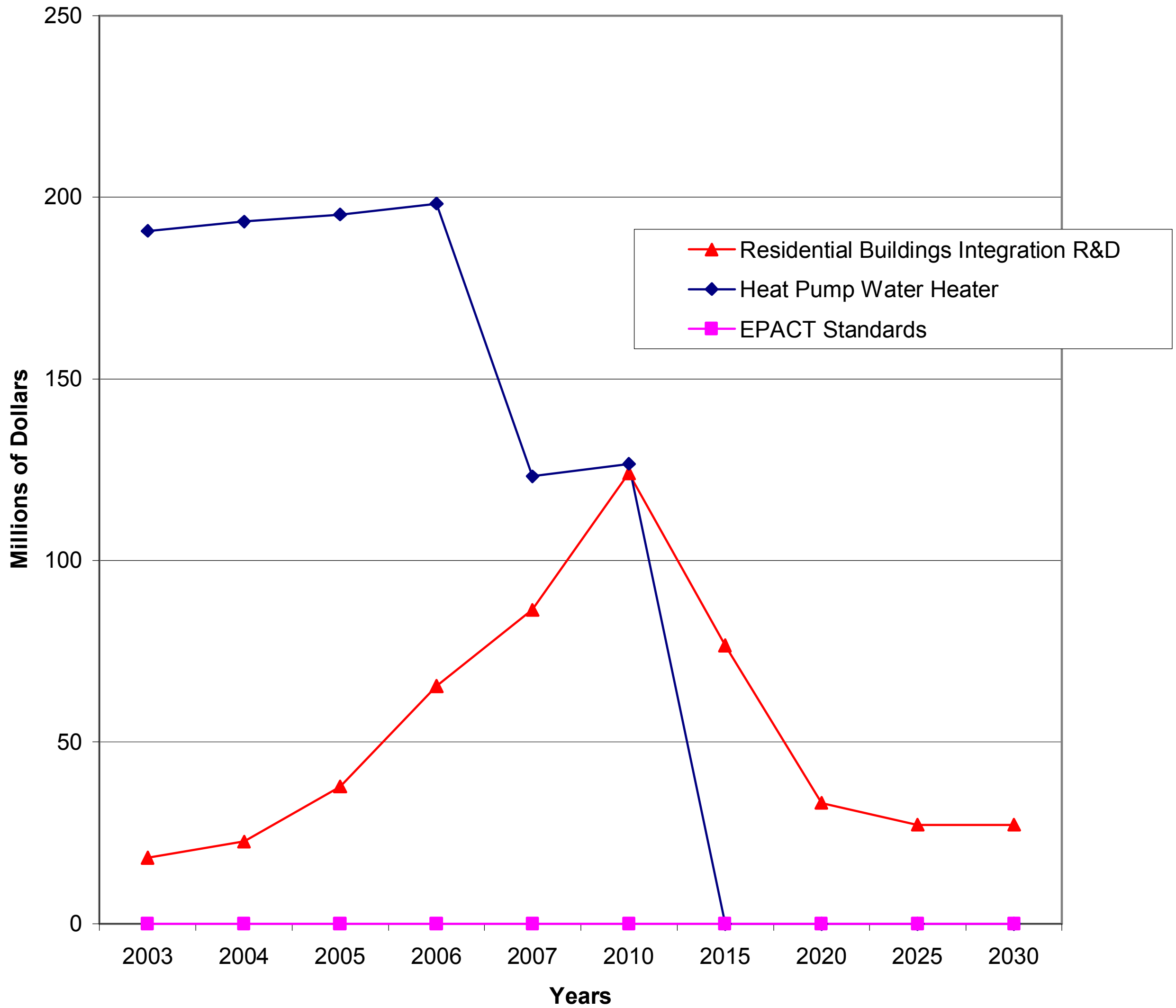

Figure 3.1. Incremental Capital Costs by Year for GPRA Metrics Market Scenarios of Heat Pump Water Heater, EPACT Efficiency Standards, and Residential Building Integration R&D

- Condensing Gas Water Heaters: Target market of approximately 20 million existing homes of the over 60 million homes potential, and about 40% of new homes.

About 50% of the program funds are spent on R&D, and about 50% on market transformation activities.

Heat Pump Water Heater

Market introduction:	2004
Performance Target:	2.00 Energy Factor (demonstrated)
Sales Target:	More aggressive sales target by 2015 (currently 6%) - perhaps 10% (building codes expected to help by excluding electrical resistance WH, as will be case in California)
Installed cost:	Initial installation cost of $700 dropping to $650 in 2010

Residential Gas Condensing Water Heater
Market introduction: 2005
Performance Target: Energy Factor of 0.80
Penetration Target: 9-10% by 2020
Installed Cost: Assume $350 base cost, new WH will have an incremental cost of $150-$200

EPACT Energy Efficiency Standards. The second program is EPACT Energy Efficiency Standards. The DOE program is continuing the development that will make a number of types of commercial space conditioning and other equipment commercially feasible. The mission of the overall lighting and appliance standards program is to achieve significant energy savings, consumer cost savings, and reduced air emissions through standards rulemaking.

The program also prescribes test procedures that measure energy efficiency and energy use and provide an estimate of the annual operating cost of each appliance.

The long-term goal of the program is the setting of efficiency standards that lead to substantial increases in the average efficiency of new building equipment. The assumption for GPRA is that work will continue in FY2003 for products for which cost-effective additional energy savings may be large. For this version of the GPRA process, these products include boilers, three-phase residential-size cooling equipment, PTAC and PTHP equipment, and large rooftop AC equipment. Major near-term milestones include publishing a Notice of Proposed Rulemaking for certain ASHRAE 90.1-1999 products (commercial HVAC and water heating equipment); for medium (1-200 hp) motors, residential furnaces and boilers, dishwashers, and fluorescent and reflector lamps; for residential central air and combination space and water heating appliances; and for plumbing products, pool heaters, and direct heating equipment.

Three basic kinds of commercial air conditioning equipment are considered, at various sizes. In general, the goal for these units is to increase their Seasonal Energy Efficiency Rating (SEER) from roughly 8-10 to around 10-12 by the year 2008:

	Efficiency (SEER,EER)			Energy Savings in Year (TBtu)			
Equipment Category	EPCA 92	New Std	Eff. Date	2010	2020	2030	Cum.
3-Phase S. Package, Air Source AC, <65 kBtu/h	9.7	12	2005	4.6	21.0	26.5	396.0
3-Phase Split, Air Source AC, <65 kBtu/h	9.7	11	2005	0.9	4.1	5.2	78.1
Central, Air Source AC, >=65, <135 kBtu/h	8.9	11	2008	5.5	25.0	31.6	471.6
Central, Air Source AC, >=135, <240 kBtu/h	8.5	11	2008	5.4	24.6	31.0	463.1
Packaged Terminal AC, 7-10 kBtu/h	8.6	10.8	2008	0.4	1.8	2.2	33.3
Packaged Terminal AC, 10-13 kBtu/h	8.1	10.2	2008	0.6	2.6	3.3	49.5
Packaged Terminal AC, >13 kBtu/h	7.8	9.5	2008	0.3	1.3	1.7	25.2

Residential Buildings Integration R&D. The final program is Residential Building Integration R&D, which seeks to consolidate the formerly separate systems engineering programs of Building America, Industrialized Housing, Passive Solar Buildings, indoor air quality, and existing building research into a comprehensive program to accelerate the introduction of highly-efficient building technologies and practices through research and development of advanced systems for production builders. The program seeks to improve and change current practices by emphasizing system engineered whole-building approaches that integrate component-based research and technology. Long term, the overall program wants to develop advanced systems to improve the energy performance of over 300,000 of the 1 million homes built in 2010. The performance increase will allow the homes to use 50 % less energy for space conditioning and water heating use than typical homes built in 1993.

The program targets new single family, multi-family, and manufactured housing units with over $25,000 annual income in all climate zones as well as new single family homes, multi-family infill, Housing and Urban Development (HUD) code homes, and small commercial buildings. Existing homes benefit from new technologies and improved construction practices developed for new homes.

About 1.2 million new housing units are built per year. This is the primary target of Building America. In addition, the program targets 31.1 million existing households with incomes from $25,000 to 50,000 per year. (DOE's Weatherization Program targets the lower-income households). The incremental investment is assumed to be about 2% above conventional construction costs.

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.[a] 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 also on the costs of the technology with which it is assumed to compete. Thus, no cost premium is shown at all for EPACT Standards, which are assumed to result in commercial equipment that is cost-competitive with current equipment, or for shown for the heat pump water heater in Figure 3.1 beyond the year 2010. Conversely, because of variation in the rate of building and relative reduction in costs for new technology over time, Residential Buildings Integration R&D at first peaks and then declines. The peak occurs as program-related investment grows in size relative to current technology, then declines as program-related investment is overtaken by the advanced technology installation that would have occurred anyway in the absence of the program.

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.

(a) 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.

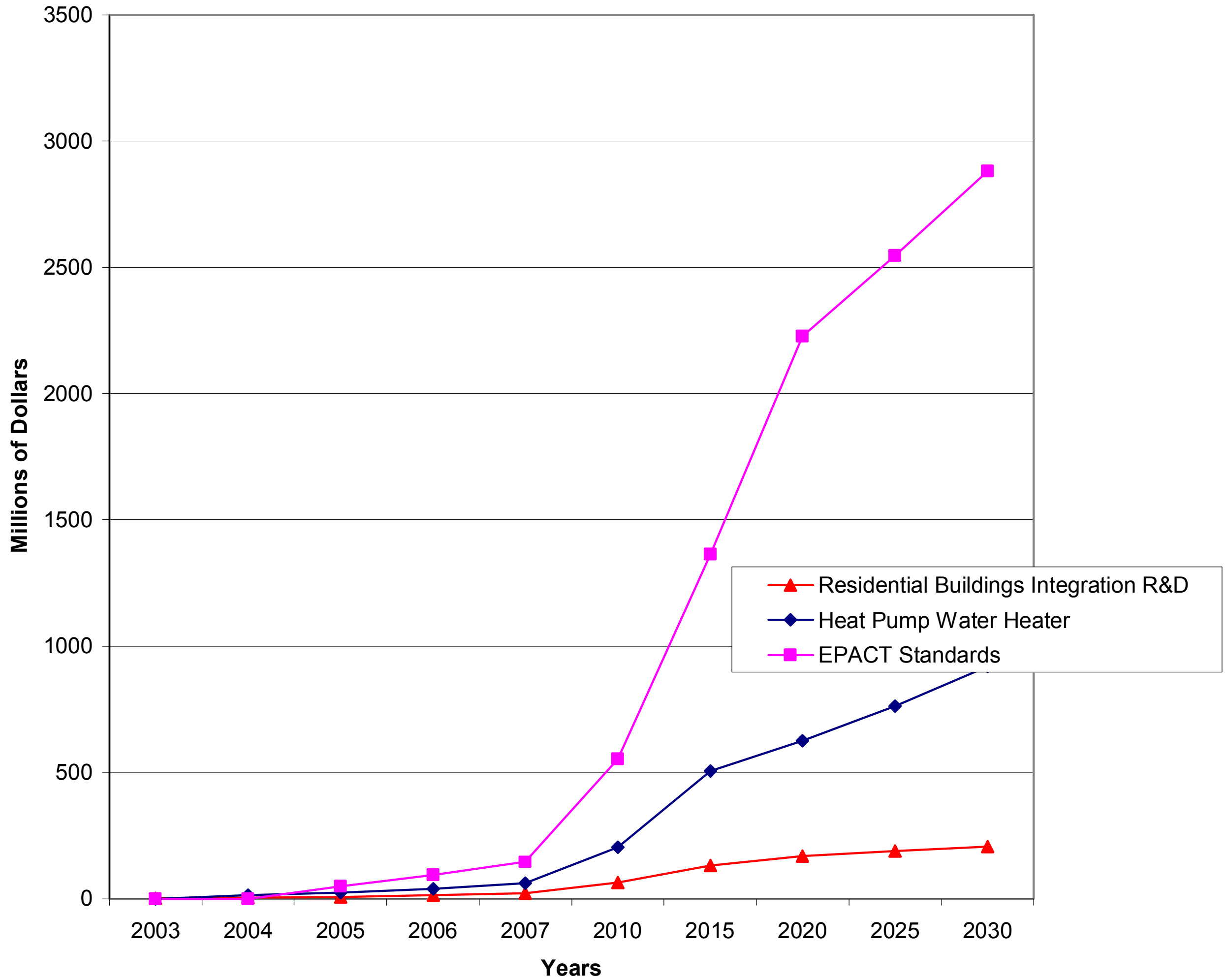

Figure 3.2. Value of Energy Savings by Year Relative to Baseline for GPRA Metrics Market Scenarios

3.2 Heat Pump Water Heater

Figure 3.3 shows the employment impacts associated with variations of the GPRA Metrics heat pump water heater scenario. An essential feature of this scenario is the accelerating investment in heat pump water heaters throughout the forecast period out to 2010, with a high level of new investment thereafter. This 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 surplus with the potential to create up to several thousand jobs.[a] The Base Case includes the negative net impact on jobs of the investment in water heaters (spending is

(a) 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).

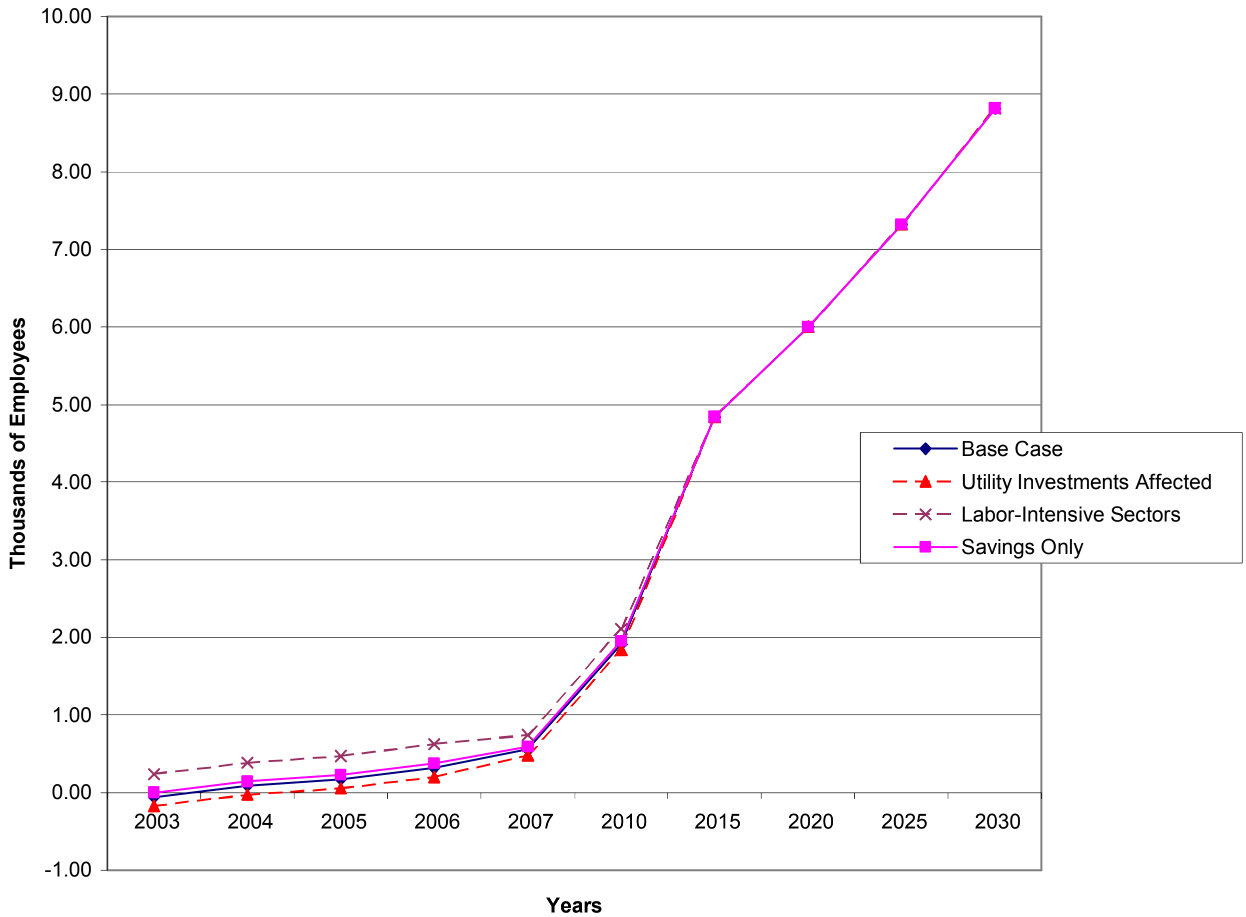

Figure 3.3. Employment Impacts of Investment in Heat Pump Water Heaters

transferred from labor-intensive to capital-intensive sectors). Thus, the Base Case lies slightly 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.[(a)] Reduced investment by utilities releases resources from the utility construction sector, which is relatively capital-intensive, to the economy as a whole, which is slightly less so. The net effect is small – an

(a) 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).

increase of just 1000 jobs (the net employment impact is about 9800 instead of 8800). Thus, saved utility investment, to the extent it occurs, has a slightly positive impact on employment.[a]

So far, this analysis has assumed that the cost premium for heat pump water heaters 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 higher, and the overall net effects could be above those of the energy savings alone.[b] 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 HPWH 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 in water heaters. Employment impacts are estimated for the Heat pump water heater 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 water heater investment are drawn proportionately from the all sectors of the economy.[c] 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 loanable 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.

(a) 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.

(b) The differential employment impact of the HPWH investment arises because the appliance manufacturing sector and its suppliers are slightly more capital-intensive as a group 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 HPWH 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.

(c) 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.

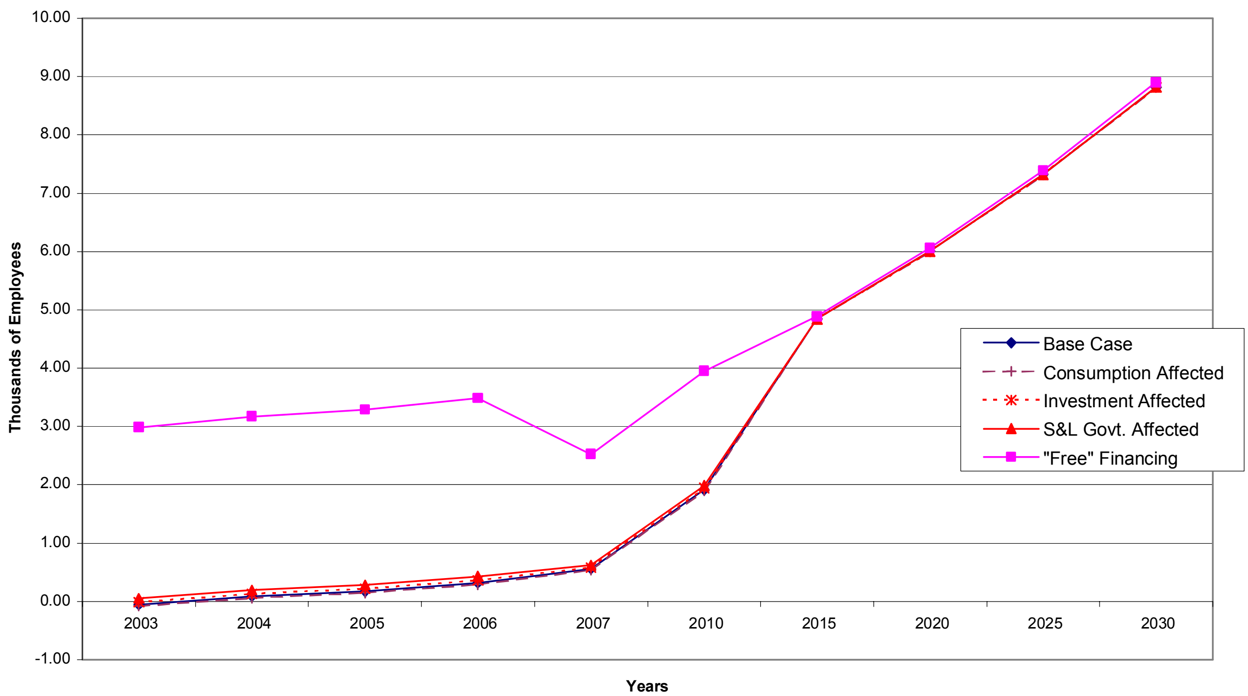

Figure 3.4. Effect of HPWH Financing on Employment

The other scenarios in Figure 3.4 demonstrate to slight-but-varying degrees that the employment impact would be temporary, if the new incremental investment in water heaters displaces enough other consumer spending or business investment.(a) However, because the effects of energy savings are relatively large, the net effect on employment is positive. A major reason for the slight negative investment impact is, although the HPWH technology is cost-effective, it is slightly less employment-intensive than the general economy.(b)

Because the amount of the funds needed for investment in heat pump water heaters 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, although government activity is particularly labor intensive, the differences in employment that would occur if domestic spending were reduced in different ways to make the HPWH investments are very small.

(a) 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 water heater investments. Business investments could be reduced instead because lenders provide loans to households to pay water heaters 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.

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

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 earnings as well as employment. Figure 3.5 illustrates the effects on national earned 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 water heater 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 domestic investments are foreclosed by water heater investments. The difference if government investment is crowded out is near zero in the short run.

Figure 3.6 is the wage income equivalent of Figure 3.3, but does not show the same results. Because the initial investment has a larger gross product multiplier than the economy as a whole and occurs in a high-wage, capital-intensive sector, activity created in water heater manufacturing and its supplying

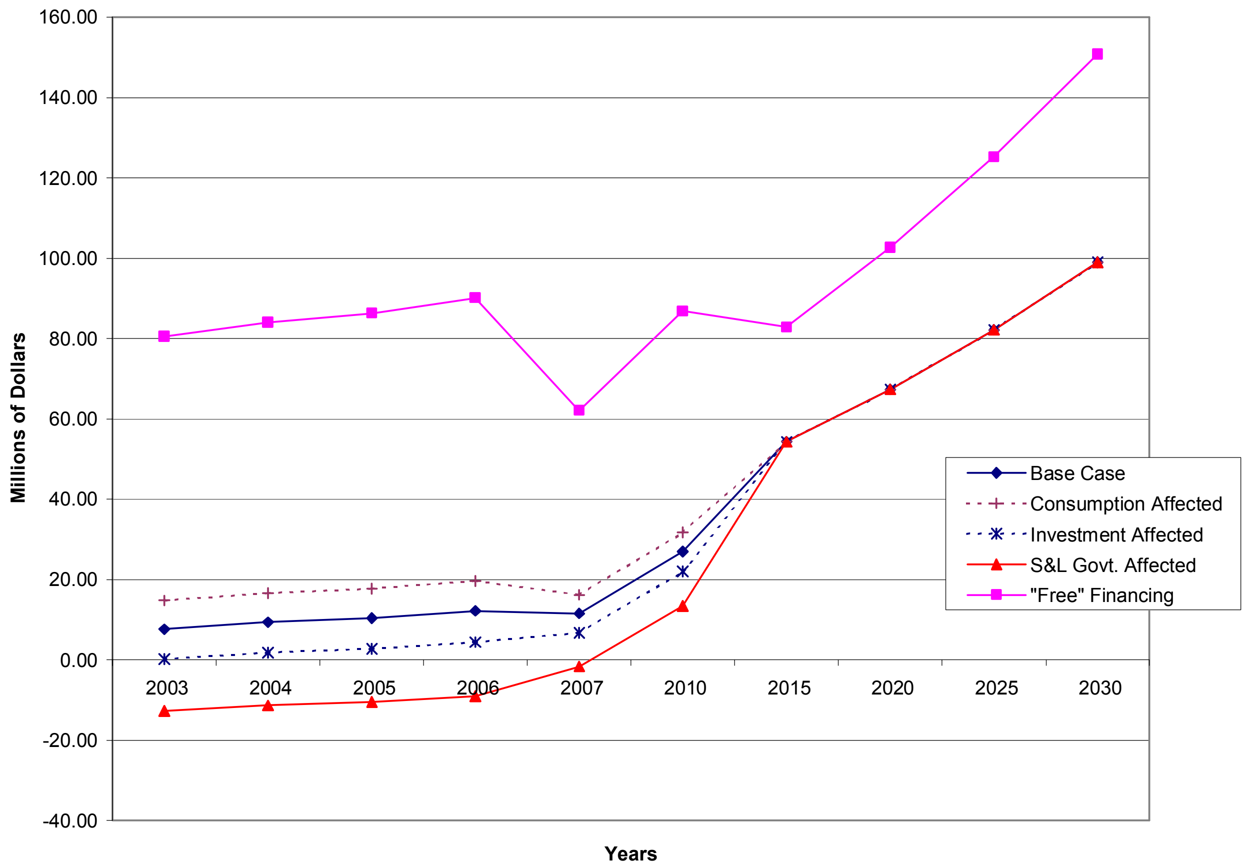

Figure 3.5. Impact of HPWH Investment on National Wage Income

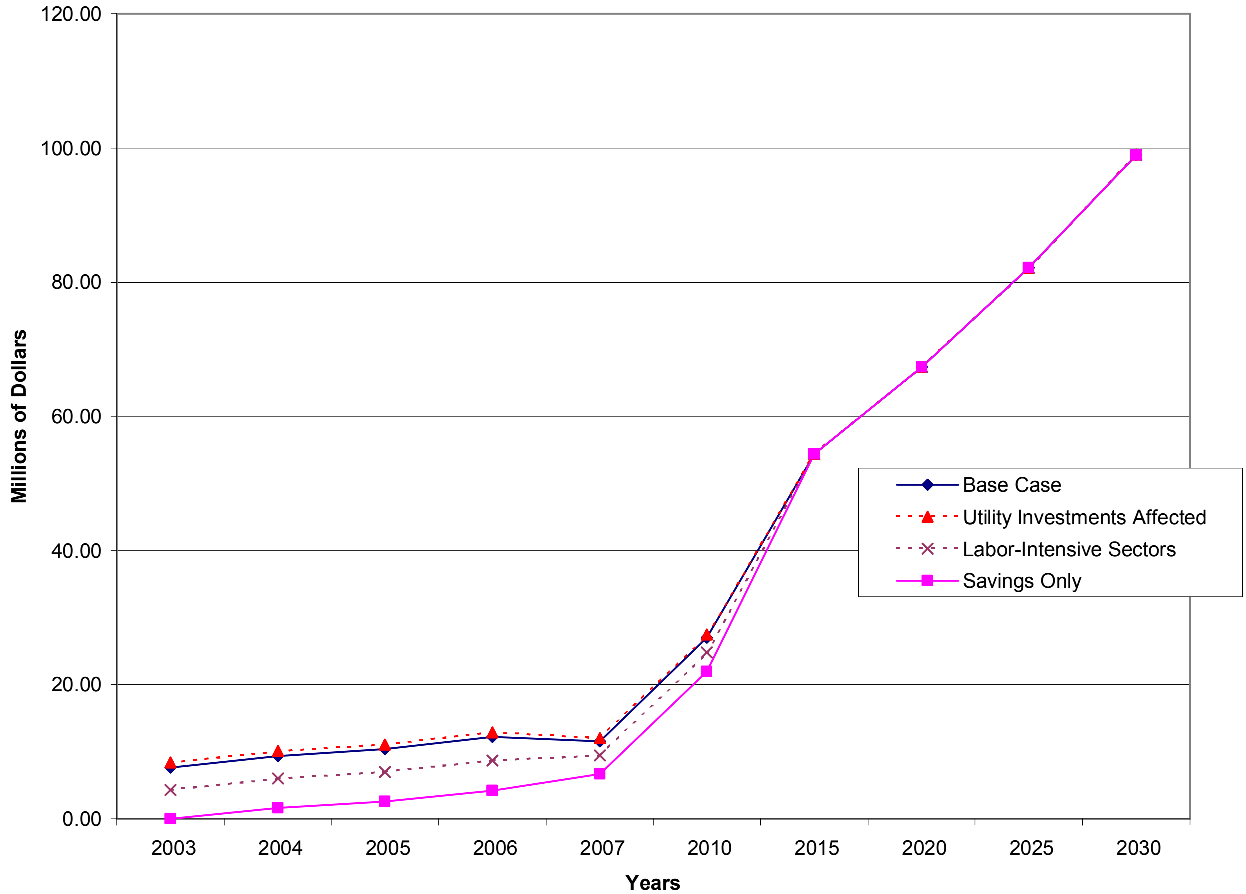

Figure 3.6. Sensitivity of Impacts on National Wage Income to HPWH Investments

industries employs fewer workers per dollar of activity than the national average but generates more-than-average income. 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.[a] Thus, the net impact on national wage income is very slight increase relative to the base case.

(a) In the case analyzed, this sign is the opposite of the comparable employment effect and is the combined result of inter-sector 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.

Finally, the figure shows that if the investment in water heaters were distributed across more labor-intensive industries rather than just appliance manufacturing, then there is a the net drag on national wage income, because the altered investment pattern would then represent a diversion of investment dollars into low-wage labor-intensive retail and wholesale distribution as well as high-wage construction and capital-intensive manufacturing.[a] As before, however, it is likely that most of the premium in cost would be the additional cost of manufacturing.

3.3 EPACT (Commercial Air Conditioning) Efficiency Standards

Unlike heat pump water heaters, high-efficiency air conditioners (HEACs) installed in commercial buildings are not expected to require an incremental investment. Current assumptions for the EPACT program are that no additional cost will be required for the advanced equipment. Thus, the national economy is not stimulated by additional final demand focused on the manufacturing sectors that make commercial air conditioning equipment. Also, the national macroeconomic impacts are not sensitive to the financing of the investment premium because no premium is assumed.

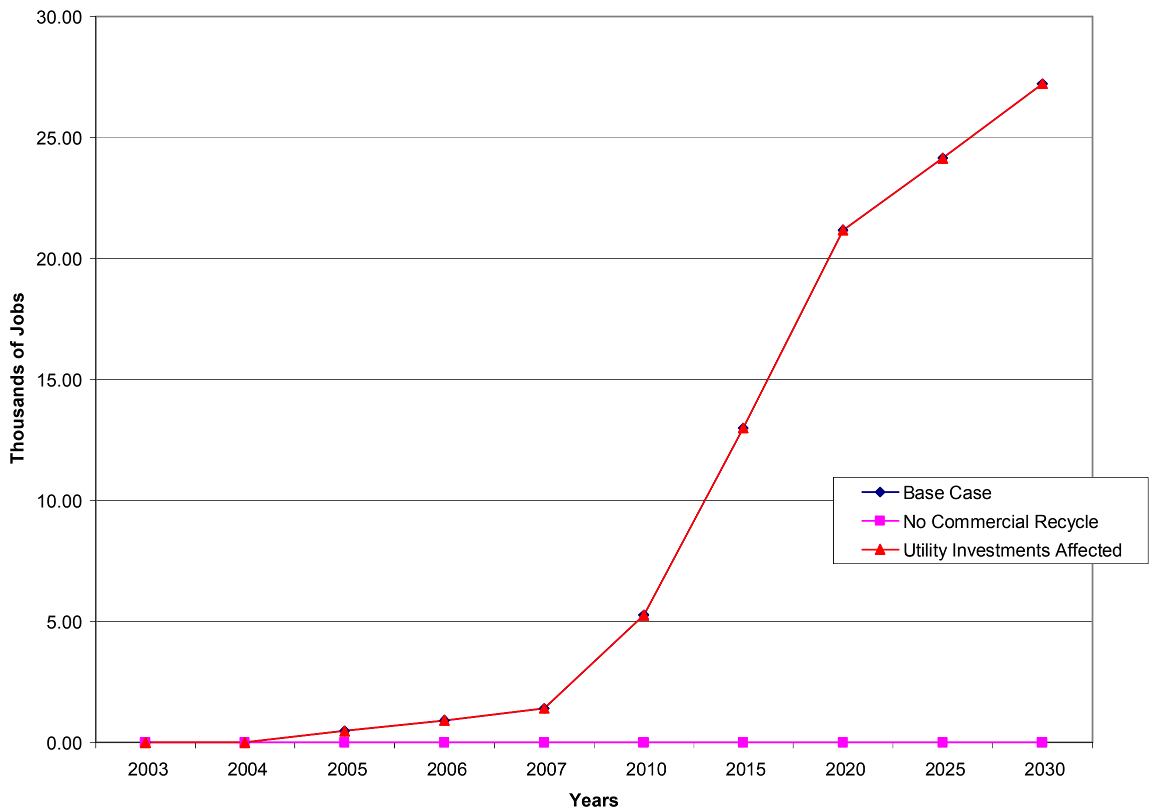

Figure note: Base Case and Utility Investment Cases are nearly identical

Figure 3.7. Impact on National Employment of EPACT Standards

(a) 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.

The HPWH and HEAC scenarios also differ because the target market for HEAC 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 HEAC; 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. If the cost savings were not re-spent inside the U.S. economy (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. This is illustrated as the No Commercial Recycle case in the figure. As before, if the energy savings allow for the deferral of electric and gas utility infrastructure investments, there is a (very slight) positive impact on overall employment.

Figure 3.8 shows the net impact of the HEAC investments on the wage economy is significant and also positive (due strictly to energy savings).

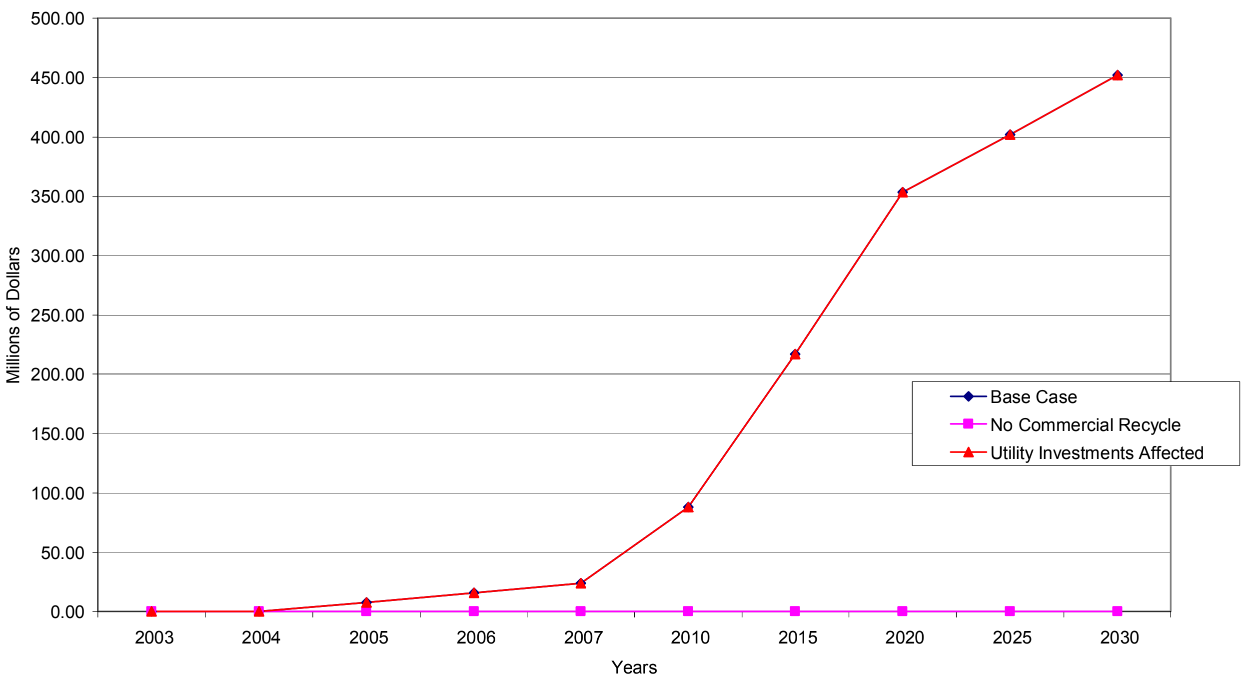

Figure 3.8. Impact of EPACT Standards Energy Savings on National Wage Income

3.4 Residential Building Integrated R&D

The final example program in this chapter is Residential Building Integrated R&D, 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 about 2% more than their conventional competitors. The national economy is stimulated by additional final demand focused on the manufacturing sectors that make new products and equipment, and on sectors that implement the new processes. On the other hand, this additional investment requires capital that the nation's households and businesses otherwise would have had available to spend for other general investment and consumption purposes. Figure 3.9 illustrates this. The impacts of savings alone are slightly greater than the impact of the base case (which is virtually identical to the utility savings case in the figure), because the Base Case includes the net negative employment impact of diverting investment into equipment manufacture. Figure 3.9 also illustrates that, had the investment been made in labor-intensive sectors, the impact of the investment on employment would have been still lower, mostly because the effects of concentrating investment in retail, wholesale , and construction produces relatively little GDP despite being labor intensive. As before, if utility capital investment can be saved because of reduced energy demand, the employment impacts are slightly larger.

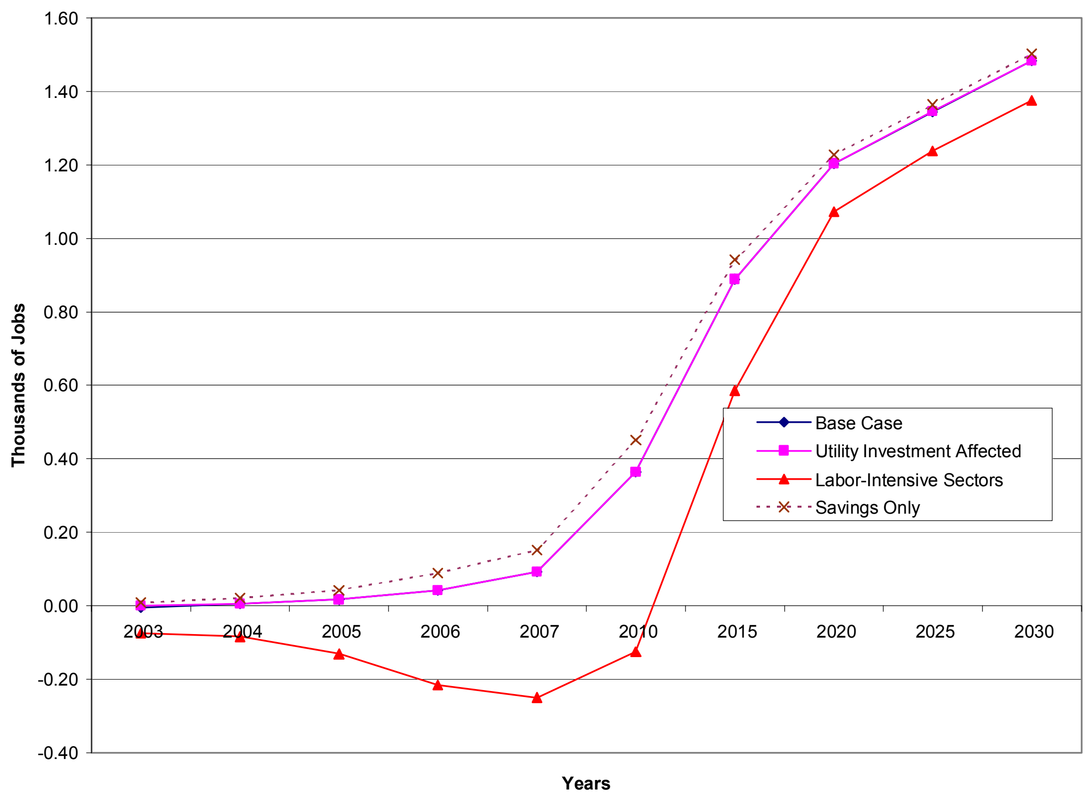

Figure note: Base Case and Utility Investment Cases are nearly identical

Figure 3.9. Impact of Building America Energy Savings on National Employment

The earned income consequences of Residential Building Integrated R&D arise from both the energy savings (which positively influence the economy as a whole) and the investment effects (which positively affect the high-wage manufacturing and construction sectors, but divert funds out of the relatively low-wage service sector). Thus, the Base Case lies above the Savings Only case. This impact is illustrated in Figure 3.10. The market penetration of energy-efficient homes creates additional jobs by moving activity out of the capital-intensive utility sector into manufacturing sectors that are generally more labor-intensive and high-wage. If the investment related to Integrated R&D is spread across labor-intensive, low-output, sectors the impact on overall income is negative. These other sectors generally pay lower average wages, acting as a net drag on incomes. If the reduced energy demand also reduces utility capital expenditures, the income consequences are slightly positive, for the same reasons as were found with the HPWH technology.

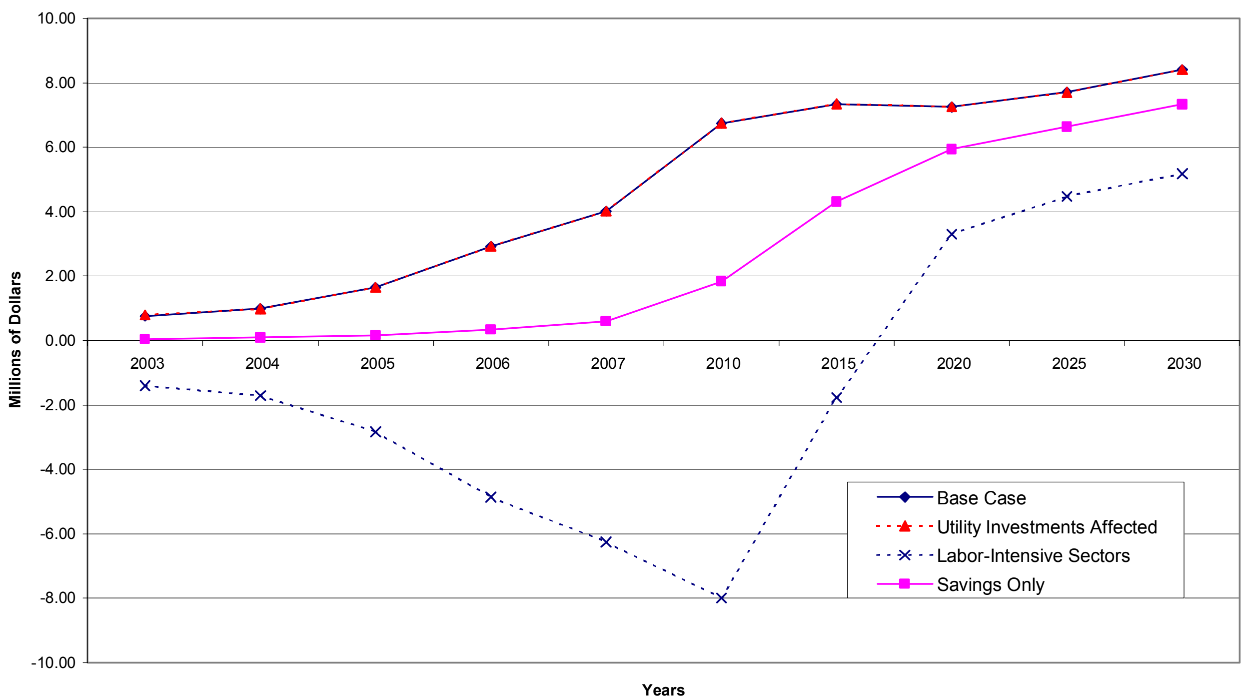

Figure note: Base Case and Utility Investment Cases are nearly identical

Figure 3.10. Impact of Building America Energy Savings 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 (Minnesota IMPLAN Group 1997) 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 II 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 II model.[a]

Because the ImBuild II model and ACEEE (Geller et al. 1992) analysis have some different sectors, some differences in impacts are present due to these differences.[b] 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.[c]

(a) 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.

(b) It should also be pointed out that the ACEEE model is based on the 1987 benchmark input-output matrix for the US, while IMBuild II is based on the 1992 benchmark matrix. These structural differences can be significant depending on specific detailed sectors of interest. Some portion of the difference of the ACEEE numbers is due to the structural change represented in the 1992 benchmark matrix.

(c) 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 Version of IMPLAN and ImBuild II Model

Industry	Output (Total $ Output per $ Final Demand)		Jobs (Total per Million $ Final Demand)	
	ACEEE	**ImBuild II**	**ACEEE**	**ImBuild II**
Agriculture	2.1198	2.2485	26.86	26.55
Other Mining	1.8170	Mining exc. Nonmetallic minerals =1.9149	13.51	Mining exc. Nonmetallic minerals =10.31
Coal Mining	1.8690	1.9149	12.88	10.31
Oil and Gas Extraction	1.3438	1.9149	7.02	10.31
Stone and Clay Mining	Use "Other Mining"	Nonmetallic Mineral Mining= 1.8029	Use "Other Mining"	Nonmetallic Mineral Mining=16.82
Construction	1.9228	Res. = 2.1370 Comm.= 2.0223 Other = 1.9880	20.97	Res. = 20.26 Comm.= 21.26 Other = 15.73
Wood Products	Use "Other Mfg."	Other wood Prod. = 2.3549 Millwork = 2.3753 Fabricated Bldgs = 2.4105 Furniture and Fixtures = 2.1412	Use "Other Mfg."	Other wood Prod. = 22.00 Millwork = 24.79 Fabricated Bldgs = 22.42 Furniture and Fixtures = 22.82
Paper	2.1011	Paper Prod. Exc. Containers = 2.2548 Containers and Boxes = 2.4290 Newspapers and Printing = 1.8713	14.29	Paper Prod. Exc. Containers = 15.61 Containers and Boxes = 18.10 Newspapers and Printing = 24.16
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"	Other Glass Prod. = 1.9202 Glass Containers = 1.9714	Use "Stone, Clay & Glass"	Other Glass Prod. = 17.39 Glass Containers = 15.74
Stone and Clay Products	Use "Stone, Clay & Glass"	Cement = 2.0988 Lime and Gypsum =2.3267 Mineral Wool = 1.9620 Other Nonmetallic Minerals = 2.0555	Use "Stone, Clay & Glass"	Cement = 13.64 Lime and Gypsum =33.32 Mineral Wool = 15.27 Other Nonmetallic Minerals = 17.58

Table 4.1. (contd)

Industry	Output (Total $ Output per $ Final Demand)		Jobs (Total per Million $ Final Demand)	
	ACEEE	ImBuild II	ACEEE	ImBuild II
Metal Durables	1.9390	Metal Containers =2.8851 Structural Metal =2.2236 Metal Doors, etc. = 2.2916 Sheet Metal Work =2.2086 Other Structural Metal Products =2.2401 Screw Machine Products = 2.1828 Other Fabricated Metal Products =2.1079	17.28	Metal Containers =17.21 Structural Metal =22.29 Metal Doors, etc. = 21.29 Sheet Metal Work = 18.47 Other Structural Metal Products =24.76 Screw Machine Products = 13.08 Other Fabricated Metal Products =19.86
Food	2.4489	Food and Tobacco = 2.4342	19.77	Food and Tobacco = 18.16
General Industrial Machines	Use "Other Mfg."	Engines and Turbines = 2.2750 Machinery and Equip. = 2.0332	Use "Other Mfg."	Engines and Turbines = 15.85 Machinery and Equip. = 16.37
Office & Computing Equip.	Use "Other Mfg."	Computer and Office Equip. = 2.2966	Use "Other Mfg."	18.40
Service Industry Machines	Use "Other Mfg."	Comm. Laundry Equip. = 2.1471 Comm. Refrig. and Heating Equip. = 2.2693 Other Service Equip. = 2.0799 Power Equip. = 2.1467	Use "Other Mfg."	Comm. Laundry Equip. = 17.04 Comm. Refrig. and Heating Equip. = 18.26 Other Service Equip. = 16.86 Power Equip. = 20.55
Electric Industrial Equip.	Use "Other Mfg."	Motors and Generators =2.1398 Relays and Industr. Controls = 1.9052 Other Electrical Equip. = 1.9870	Use "Other Mfg."	Motors and Generators = 18.37 Relays and Industr. Controls = 17.15 Other Electrical Equip. = 16.24
Household Appliances	Use "Other Mfg."	Heating Equip. = 2.0574 Household Cooking =2 .4073 HH Refrig. and Freezers = 2.3763 HH Laundry = 2.3336 Electric Houseware & Fans = 2.2172 HH Vacuum Cleaners = 2.1232 HH Appliances n.e.c. = 2.4111	Use "Other Mfg."	Heating Equip. = 17.75 Household Cooking = 18.87 HH Refrig. and Freezers = 18.49 HH Laundry = 17.55 Electric Houseware & Fans = 20.70 HH Vacuum Cleaners = 14.54 HH Appliances n.e.c. = 19.08
Electric Lighting & Wiring	Use "Other Mfg."	Lighting Bulbs, Tubing = 1.8387 Other Lighting and Wiring = 2.0891	Use "Other Mfg."	Lighting Bulbs, Tubing = 18.35 Other Lighting and Wiring = 18.59

Table 4.1. (contd)

Industry	Output (Total $ Output per $ Final Demand)		Jobs (Total per Million $ Final Demand)	
	ACEEE	ImBuild II	ACEEE	ImBuild II
Electronic Components & Access.	Use "Other Mfg."	Communications Equip = 2.0176 Electronic Components = 2.0177 Misc. Electr. Supplies = 2.1555 Measuring and Control Devices = 1.8691	Use "Other Mfg."	Communications Equip = 14.07 Electronic Components = 16.50 Misc. Electr. Supplies = 17.61 Measuring and Control Devices =18.49
Other Mfg.	2.0310	Fabrics and Yarn=2.4393 Other Textiles=2.4835 Apparel=2.4761 Fabricated Textile Products=2.3786 Rubber and Plastic Products =2.2040 Footware and Leather = 2.3734 Other Manufacturing = 1.8997	20.75	Fabrics and Yarn=29.98 Other Textiles=20.44 Apparel=29.20 Fabricated Textile Products=25.71 Rubber and Plastic Products =17.83 Footware and Leather =26.17 Other Manufacturing =16.43
Chemicals	2.1282	Indust. Chemicals = 2.3165 Agr. Chemicals = 2.2837 Plastics = 2.4810 Synthetic Materials = 2.3576 Drugs and Cleaning =1.9355 Paints and Allied = 2.2987	13.06	Indust. Chemicals = 13.31 Agr. Chemicals = 14.29 Plastics = 16.28 Synthetic Materials = 17.72 Drugs and Cleaning =12.42 Paints and Allied = 13.73
Refining	2.0209	Petroleum Ref. = 2.6651 Other Petrol. Products = 2.5353	7.14	Petroleum Ref. = 11.81 Other Petrol. Products = 13.00
Primary Metals	2.0150	Iron and Steel = 2.2818 Aluminum = 2.6040 Other Nonferrous = 2.6021	13.05	Iron and Steel = 16.35 Aluminum = 15.19 Other Nonferrous = 21.12
Motor Vehicles	2.1871	Motor Vehicles =2.4137 Bodies, Trailers, Parts =2.7307 Aircraft and Parts = 2.1566 Other Transport Equip. = 2.0916	13.70	Motor Vehicles =16.12 Bodies, Trailers, Parts =18.89 Aircraft and Parts = 17.69 Other Transport Equip. = 18.43
Transport./Communication	1.5777	Rail Trans. = 1.8008 Motor Freight = 1.9660 Water Trans. = 1.9620 Air Trans. = 1.9213 Pipelines = 1.8427 Communications = 1.7330	16.37	Rail Trans. = 20.02 Motor Freight = 19.36 Water Trans. = 15.12 Air Trans. = 18.03 Pipelines = 16.39 Communications = 13.48
Electric Utilities	1.7821	1.6978	9.54	9.15
Gas Utilities	1.9921	2.6293	7.41	14.74
Water/Sewer Utilities	1.5943	2.1390	14.00	25.93

Table 4.1. (contd0

Industry	Output (Total $ Output per $ Final Demand)		Jobs (Total per Million $ Final Demand)	
	ACEEE	**ImBuild II**	**ACEEE**	**ImBuild II**
Retail Trade	1.5984	Wholesale & Retail Trade = 1.5175	32.24	Wholesale & Retail Trade = 23.64
Finance/Insurance/ Real estate	1.4220	See Below	10.10	See Below
Finance and Insurance	Use FIRE	1.7593	Use FIRE	16.60
Real Estate	Use FIRE	Owner Occ. Dwells. = 1.2343 Real Est and Royalties = 1.4514	Use FIRE	Owner Occ. Dwells. = 4.70 Real Est and Royalties = 7.63
Hotels and Lodging Places	1.5815	1.7630	36.13	34.92
Business & Prof. Services	Use "Other Svc."	Bus, Legal, Arch, Engin., Prof. , "Other"= 1.5667	Use "Other Svc."	Bus, Legal, Arch, Engin., Prof., "Other' = 18.00
Other Services	1.3726	Personal and Repair Services = 1.7289	26.45	Personal and Repair Services = 26.48
Eating and Drinking Places	Use "Other Svc."	2.0549	Use "Other Svc."	33.85
Auto Repair & Service	Use "Other Svc."	1.9315	Use "Other Svc."	19.17
Amusements & Recreation Service	Use "Other Svc."	1.7788	Use "Other Svc."	23.45
Health Services	1.9766	1.6006	23.15	21.59
Education & Other Svcs.	Use "Other Svc."	1.7747	Use "Other Svc."	35.10
Federal Enterprises	Use "Other Svc."	1.3370	Use "Other Svc."	22.84
State & Local Govt. Enterprises	Use "Other Svc."	S& L Enterprises = 2.2502	Use "Other Svc."	41.48
Government Industry	Use "Other Svc."	1.0000	Use "Other Svc."	21.74
Miscellaneous Prod. & Svcs.	Use "Other Svc."	Non-Comparable Imports = 0.00 Miscellany = 1.6265	Use "Other Svc."	Non-Comparable Imports = 0.00 Miscellany = 10.70

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)	2.1398 (Motors and Generators)	+$203.10	+$213.98
Revenue Impact: -$100 required to finance the investment	2.1011 (treated like loss of current sales by pulp and paper)	2.0827 (reduced business investment)	-$210.11	-$208.27
Substitution impact: $50 of savings on utility bills	2.1011 (treated like increase in current sales by pulp and paper)	1.7361 (average impact of commercial energy savings on output)	+$105.06	+$86.81
Displacement impact: -$50 revenue loss by utility sector	1.7821	1.6978	-$89.11	-$84.89
Net impact			+$8.94[(a)]	+$7.62
"Out Year" net impact (ignore investment effects on lines 1 and 2)			+$15.95[(b)]	+$1.94

(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 *Motors and Generators* 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.[(a)] Also, our substitution impact (calculated in Table 4.2) assumes that 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

(a) 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.

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, although there apparently were differences between the methods described in the text and those actually used.[a] As our analysis 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.[b] However, our analysis of the heat pump water heaters 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. 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 II to re-analyze the residential and commercial building sectors in Geller et al. 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. is based. Because no data were available on how Geller et al. allocated incremental energy efficiency investments across sectors, we assumed the following distribution: residential and commercial construction 10% each; lighting tubes and bulbs and other lighting and wiring, 15% each; household cooking, refrigeration and laundry appliance manufacture, 5% each; commercial laundry, computer and office equipment, and motors and generators, 5% each; and household and commercial heating equipment manufacture, 10% each. 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 6% each for state and local government investment and operations. Energy efficiency in the residential and commercial sectors generated roughly 46% of the investment and 41% of the total national energy savings by value in all sectors in the Geller

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(a) 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. Subsequent personal contact with Skip Laitner, the economist for the ACEEE project, reveals several differences between the example given in the text and the actual production runs of IMPLAN: a) about 80 percent of all improvements were financed at 10% over 5 years, with the balance assumed to be funded either through savings or retained earnings; b) the large reductions in demand would put a downward pressure on energy prices; c) sector-specific labor productivity improvements such that one million dollars saved in ten years hence (measured, of course, in constant dollars), would have a reduced labor impact as a result of ongoing productivity gains); d) program costs of 15 percent of investment would be needed to drive the results of the scenario.

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

et al. (1992) analysis. Not too surprisingly, we show energy efficiency in residential and commercial buildings alone generates about 60% of the employment and 24% 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 higher than shown by about 16% and the income effects also about 16% higher.

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	Res. $28.8	Res. $42.5			
	Comm. $5.2	Comm. $15.4	Comm. $25.8			
Total	$20.6	$44.2	$68.3	$54.8	$109.9	$167.0
Net Impact on Employment (Thousand Jobs)	198	420	647	471	776	1087
Net Impact on Income (Billion 1990 $)	$2.5	$5.1	$6.9	$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.

4.2 Comparisons to Recent Studies

One recent study similar to Geller et al. (1992) is Laitner et al. (1998), in which a later version of the IMPLAN model and the National Energy Modeling System (NEMS) were used to estimate employment and other macroeconomic impacts of an "innovation-led" climate strategy for the United Sates. In this study, an energy-efficient, low-carbon future of the economy is developed through a series of sector-specific energy policies and programs, such renewable content standards, emissions performance allowances, an advanced vehicles initiative, investment tax credits, information programs, market transformation activities, and appliance and building standards. NEMS and auxiliary analyses estimated the incremental costs and savings to the U.S. economy, while IMPLAN was used to estimate the resulting effects on Gross Domestic Product, employment and wage income. Laitner et al. made several modifications made to the standard IMPLAN analysis: a) 10% of efficiency investments would be outside of the United States; b) forecasted annual increases in labor productivity were used to reduce the employment impacts associated with any given change in sector output; c) about 80% of the investment upgrades were assumed to be financed with bank loans; and d) government program and marketing expenditures were assumed to be necessary to achieve the efficiency investments recorded in the building and appliance sectors. These costs were projected at 15% of the efficiency investments.

Because Laitner et al. supplied their input data only in summary form, it was not possible to compare analyses directly by running ImBuild II using the same assumptions.

4.3 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 II model shows positive employment impacts from energy cost savings of about 10.5 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 II 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 5,100 jobs nationally. At 10 cents per kWh saved, the net job creation is about 10,300[a], roughly the same as the Council on Economic Priorities figures.

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 8,000 to 13,000 new jobs for the state, increasing wages and salaries by $300 million. When ImBuild II is run with a $1 billion per year investment (in 1992 dollars) for 5 years, the energy savings associated with the initial national impact create about 11,200 jobs and $162 million in wages (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 11,900 jobs net and $118 million in wages (in 1992 dollars) are created nationally by the energy savings associated with the investments.[b]

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

(a) We assumed $105 million in additional investment, adjusted to 1992 dollars from 1979 dollars, distributed as residential and commercial construction 10% each; lighting tubes and bulbs and other lighting and wiring, 15% each; household cooking, refrigeration, and laundry appliance manufacture, 5% each; commercial laundry, computer and office equipment, and motors and generators, 5% each; and household and commercial heating equipment manufacture, 10% each. Annual energy savings were based on an average load factor of 0.65.

(b) A total of 100 trillion Btu were assumed divided 25% each for residential and commercial natural gas and electricity. Investment was distributed residential and commercial construction 10% each; lighting tubes and bulbs and other lighting and wiring, 15% each; household cooking, refrigeration, and laundry appliance manufacture, 5% each; commercial laundry, computer and office equipment, and motors and generators, 5% each; and household and commercial heating equipment manufacture, 10% each. 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

To use IMBUILD a user would necessarily have had to install the software with the SETUP.EXE program provided. This will ensure that all components of the model are properly installed. Once installed on a desktop PC the user starts the program as per normal Windows program methods.

Once started the IMBUILD program will display an introductory splash screen, then present the user with an introductory instructions screen. The user should select Continue to advance to the main "Run specifications" screen. It is in this screen that the user will add records to represent specific program assumptions.

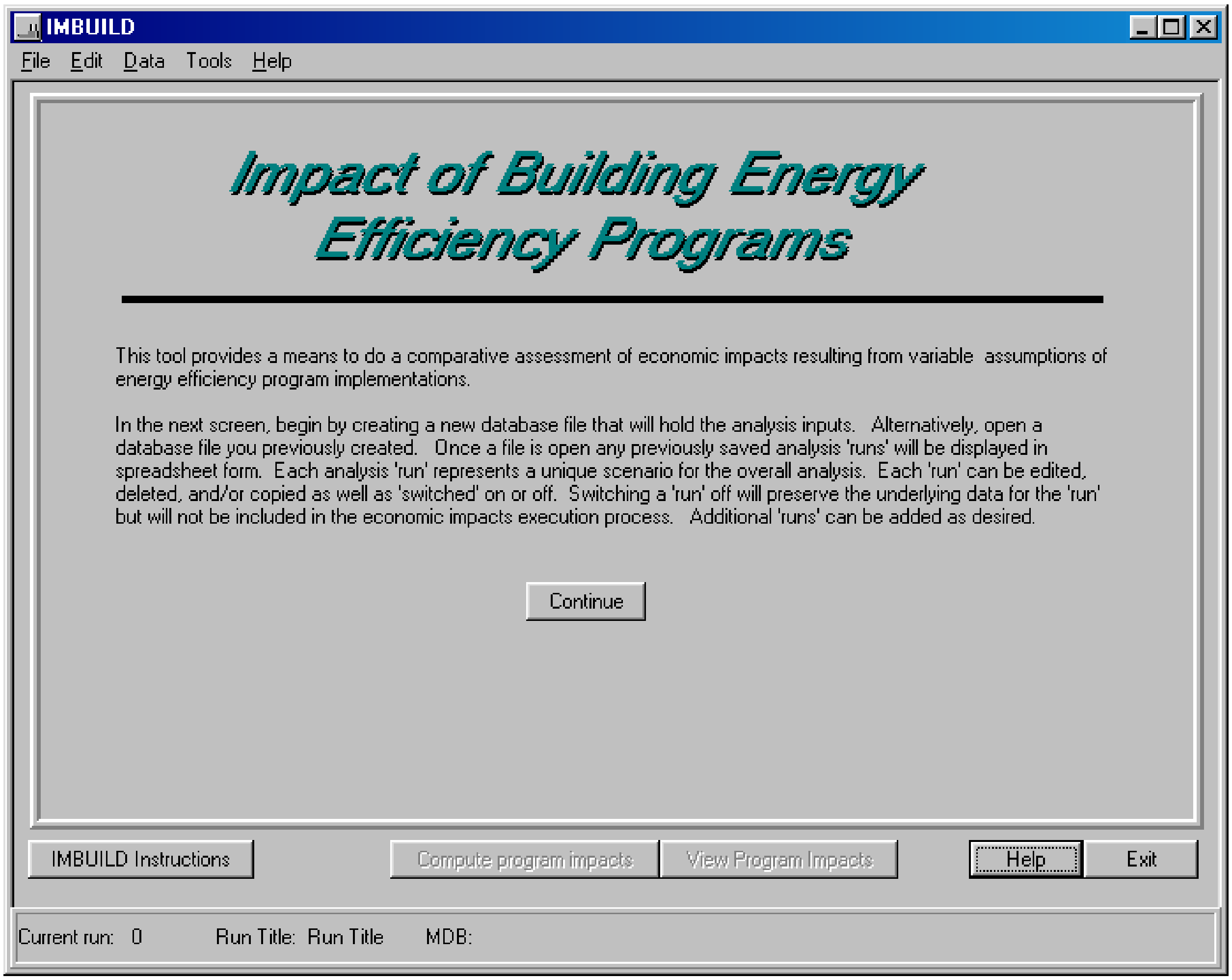


Figure 5.1. ImBuild Title Page

5.1 ImBuild Options

The "Run specification" screen is used to specify unique program scenarios. Add as many records as there are unique scenarios to be compared. Only the records that have "Execute run" checked will be run and displayed in the results screen. Before specifying "run specifications" the user must first create a new "run database" using the menu options under the "File" menu. The "run database" will hold all information and results specific to the scenarios established and specified. Thus, a user can make any number of "run databases" for specifying unique scenarios.

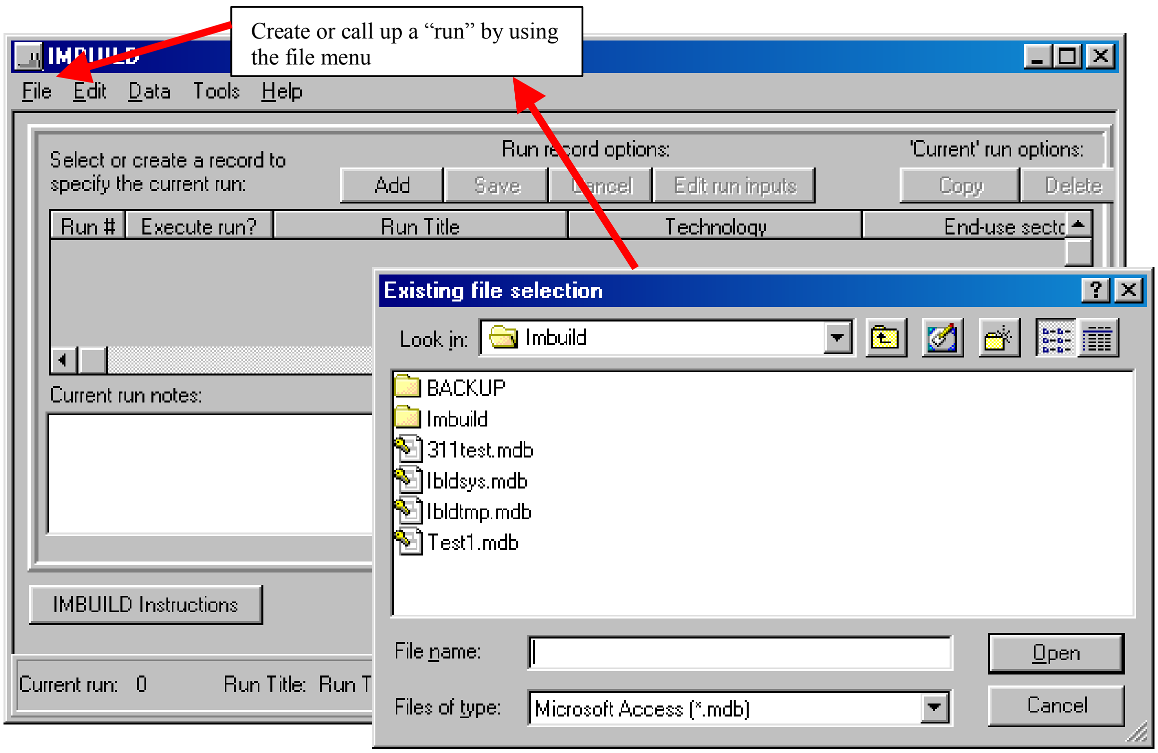


Figure 5.2. Run Specifications Screen

The "Run specification" screen is used to specify unique program scenarios. Add as many records as there are unique scenarios to be compared. Only the records that have "Execute run" checked will be run and displayed in the results screen.

Functionality of this screen is described below:
Add – Adds a "run" record to the spreadsheet.
Save – Saves the current "run specification" records to the currently opened database file.
Cancel – Cancels any changes to the "run specification" spreadsheet and refreshes the display.
Edit run inputs – Displays a screen of detailed "run inputs" that can be edited by the user.
Copy – Copies the currently selected "run record" (indicated by yellow marker in left most column and/or in status bar at the bottom of the screen.

Delete – Deletes the currently selected “run record” from the spreadsheet and the database. A “confirmation prompt” will be displayed to verify the request. The “confirmation prompt” can be “turned off” for future deletions by checking the appropriate check box in the “confirmation prompt” screen.
IMBUILD instructions – Simply introductory instructions will be displayed.
Compute program impacts – Computations of program/technology impacts will be run on all “run specifications” that have the “Execute run” column checked. After computations are done the results screen will be displayed.
View program impacts – Displays the results screen without running computations. Results will be displayed for the last computed impacts.
Help – Displays the help file.
Exit – Exits the IMBUILD program.

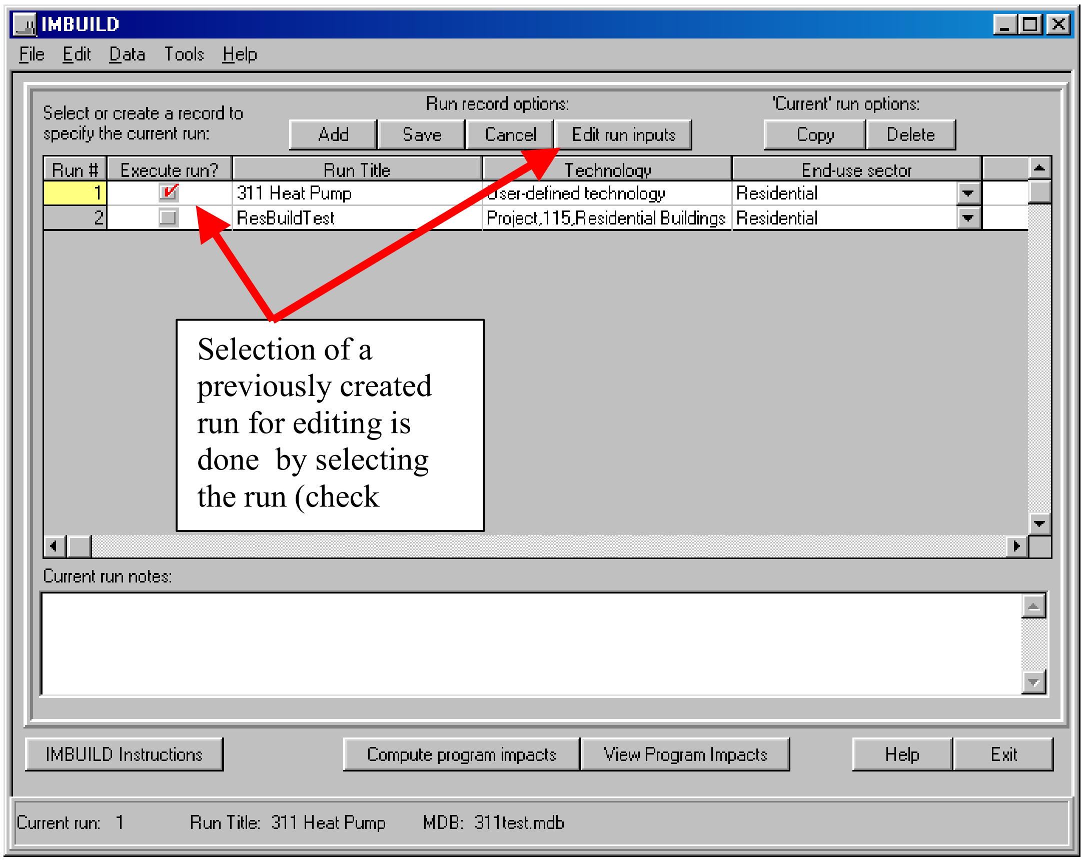


Figure 5.3. Run Specification Spreadsheet

“Run specification” spreadsheet columns –

Run # – A unique identifier for a “run specification” record. This is a non-editable column and is determined programmatically.
Run title – User provided description of the “run specification”.

Technology – The technology/program that is assigned to the "run specification". When a "run specification" record is added the technology list will be displayed as a drop-down list containing all default technologies/programs. Select the appropriate choice.
Note: you cannot change your technology choice after you have saved the "run specification" record. However, after saving the record, you can edit the technology description and edit its underlying data and/or copy the edited technology to another "run specification" record.
End-use sector – Identifies the appropriate end-use sector for the "run specification" record. The selection determines what set of economic sector distribution factors you will have access to in the "run inputs" screen.
User name – User provided name for reference purposes only.
Date – User provided date for reference purposes only.
Last run time – Indicates the time the record impacts were last evaluated.
Last run date – Indicates the date the record impacts were last evaluated.

If a new "run database" has been newly created it will appear without any "run specification" records. Click the "Add" button to add a new record then fill in the cells. All cells except user name and date must be specified. Select "Save" to save any new records or changes to existing "run specification" records. To access the underlying economic and technical data of the "run specification" record, select the "Edit run inputs" button and review/edit the data as needed.

When all data have been specified the user should select "Compute program impacts" to do the actual calculations and display the results. Note that only those "run specification" records that have "Execute run" checked will be included in the calculation process and displayed in the results screen. If there are no changes since the last calculations were run and the user simply wants to review the results then select the "View program impacts" button.

5.2 Technology Data

The technology data spreadsheet is used to specify the incremental programmatic impacts on capital cost, installation cost, energy or resource cost, O&M cost, and energy or resource savings. The appropriate units for each are displayed in the row headings. Note that all data are specific to the "run specification" described in the drop-down list at the top of the screen. Furthermore, the rows that are displayed in the spreadsheet are dependent on the "end-use sector" that is selected for the "run specification". To see other technology data select a different "run specification" record at the top of the screen.

Add technology to list of default technologies – Enables the user to add a technology to the "default " technology list. This feature allows the user to establish customized versions of a technology that can then be used repeatedly when adding new "run specification" records. More specifically, the user may have a particular set of technology data and years that are not currently represented in the "default" technology list. To create a new "default" technology simply select an existing "default" technology, modify its data accordingly, save any changes, then select the "Add technology to list of default technologies" pop-up choice. You would then see a new "Add technology" screen appear in which you

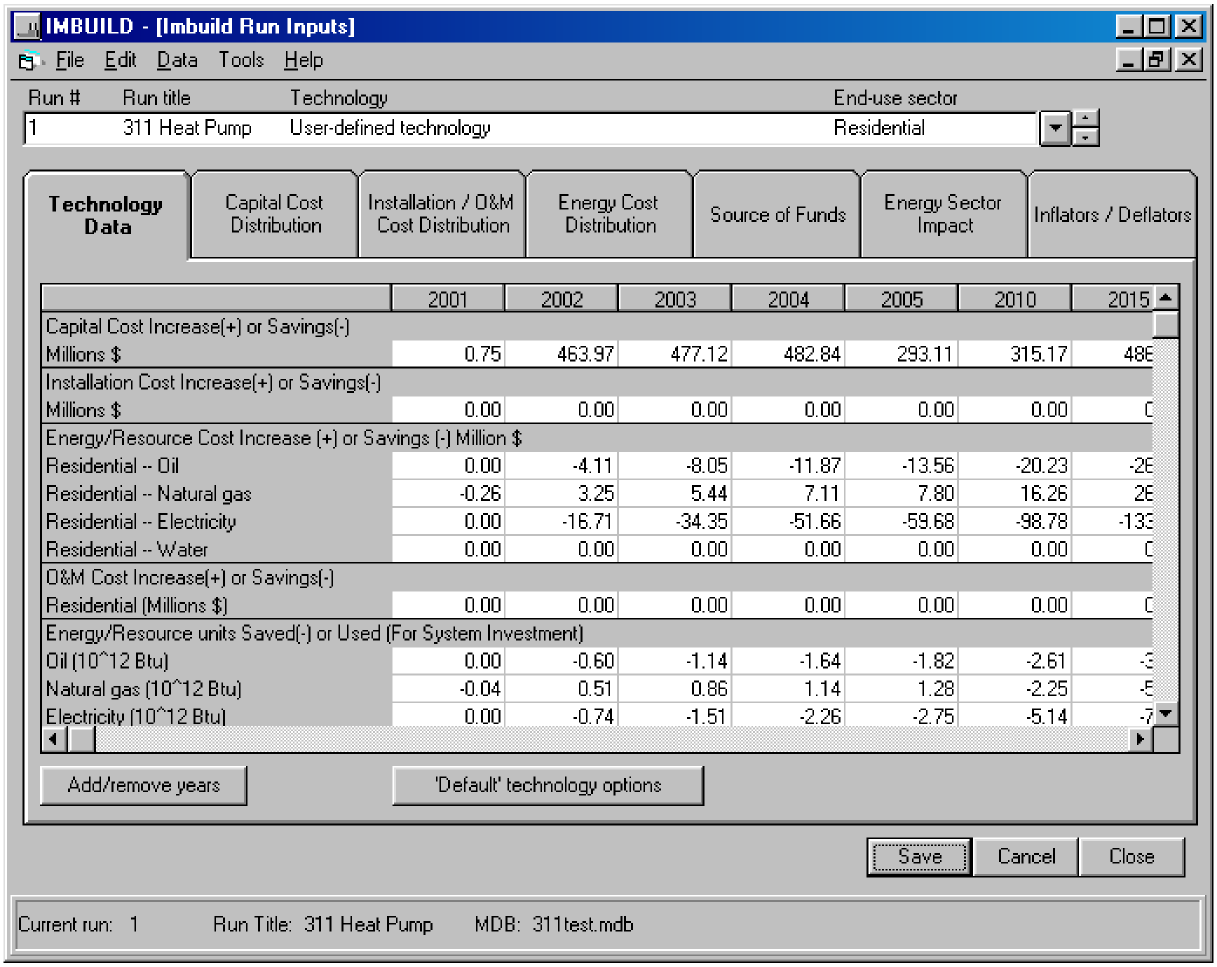


Figure 5.4. Technology Spreadsheet

enter a unique technology name where requested then select “Add” and “Close”. At this point you can return to the “run specification” screen and if you add new “run specification” records the newly created technology will appear in the drop-down list of “default” technologies.

5.2.1 Technology Data

The technology data spreadsheet is used to specify the incremental programmatic impacts on capital cost, installation cost, energy or resource cost, O&M cost, and energy or resource savings. The appropriate units for each are displayed in the row headings. Note that all data are specific to the “run specification” described in the drop-down list at the top of the screen. Furthermore, the rows that are displayed in the spreadsheet are dependent on the “end-use sector” that is selected for the “run specification.” To see other technology data select a different “run specification” record at the top of the screen.

The data on the technology data screen can be input or edited by hand. The years covered by the scenario also can be adjusted. Note that all costs or savings are considered to relate to *differences* from the conventional competing technology. For example, in example shown in Figure 5.4, the technology costs the economy an additional $463.67 million in investment during the year 2002. The annual level energy and water impact in the same year is $4.11 million saved in oil, an additional $3.25 million used in natural gas, $16.71 million saved in electricity, and no change to water use or non-energy operating costs. The energy, water, and operating cost savings are annual levels in the year shown that depend on cumulative investments. The capital costs are the cash investments in the year shown. This accounting is required by the input-output model's requirements for annual cash flow.

The following are some key functions:

"Advanced technology options" – Enables the user to add a technology to the "default" technology list and/or delete technologies from the "default" technology list. This feature allows the user to establish customized versions of a technology that can then be used repeatedly when adding new "run specification" records.

"Add/remove years" – Enables the user to add and/or remove years from the currently displayed "run specification".

Note: The choices only affect the currently displayed "run specification". Before "runs" can be processed all "run specifications" must have the same set of years.

Changing the default technology options

Add technology to list of default technologies – Enables the user to add a technology to the "default" technology list. This feature allows the user to establish customized versions of a technology that can then be used repeatedly when adding new "run specification" records. More specifically, the user may have a particular set of technology data and years that are not currently represented in the "default" technology list. To create a new "default" technology simply select an existing "default" technology, modify its data accordingly, save any changes, then select the "Add technology to list of default technologies" pop-up choice. The user would then see a new "Add technology" screen appear in which he enters a unique technology name where requested, then select s "Add" and "Close". At this point return to the "run specification" screen. If the user adds new "run specification" records, the newly created technology will appear in the drop-down list of "default" technologies.

Delete technology from list of default technologies – Enables the user to delete technologies from the "default" technology list. Note: the deletion of a technology only affects the "default" technology list and in no way deletes records from the user database file.

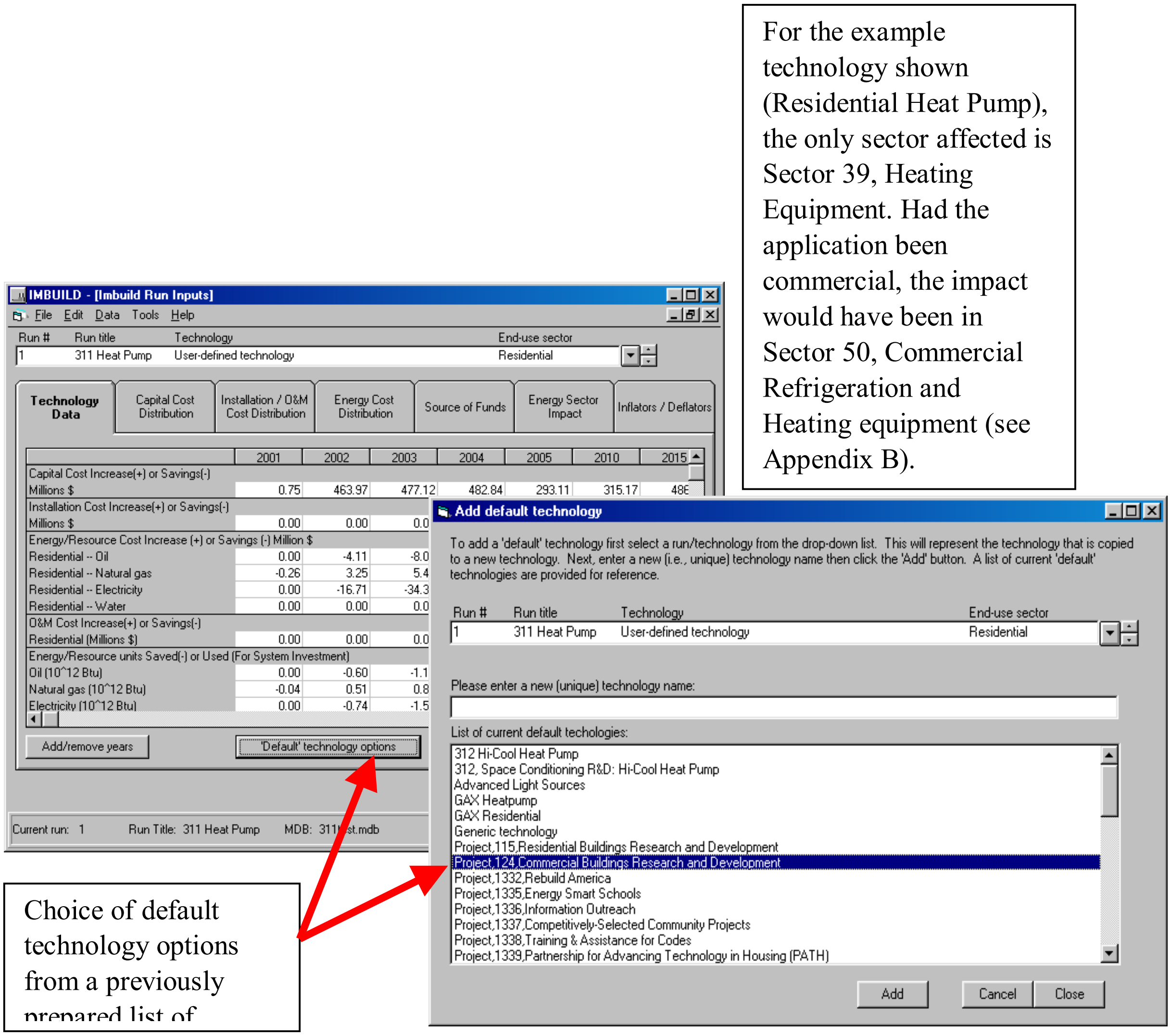


Figure 5.5. Adding to the Technology Options

5.2.2 Capital cost distribution

Enter the percentage values (enter 50% as 50) that represent the distribution of capital cost premiums for the applicable sectors. The total of all values must equal 100. In the example shown in Figure 5.6, 100% of the capital cost premium is spent on heating equipment (Sector 39).

5.2.3 Energy and Water Cost Savings Distribution

Enter the percentage values (enter 50% as 50) that represent the distribution of energy and water cost savings for the applicable sectors. The total of all values must equal 100. Note that the sectors shown will be dependent on the end-use sector targeted by the technology/program. For example, commercial end-use sectors will be the sectors numbered 82 through 95, industrial end-use sectors will be sectors 1 through 72, transportation will be sectors 73 through 77. Residential end-use technology/program cost savings will all impact final demand; thus, there will be no industry sectors to specify.

In the original version of ImBuild, energy savings in commercial buildings were allocated to sectors 82 through 95 in proportion to each sector's baseline purchase of each fuel; e.g., if Sector 82, Wholesale and Retail Trade, purchased 30.00 percent of electricity purchased in sectors 82 though 95, Sector 82 would have seen 30.00 percent of the savings as well. The user is now free to change these proportions. The new model also includes water cost savings. This is important for some water-using equipment such as laundry equipment.

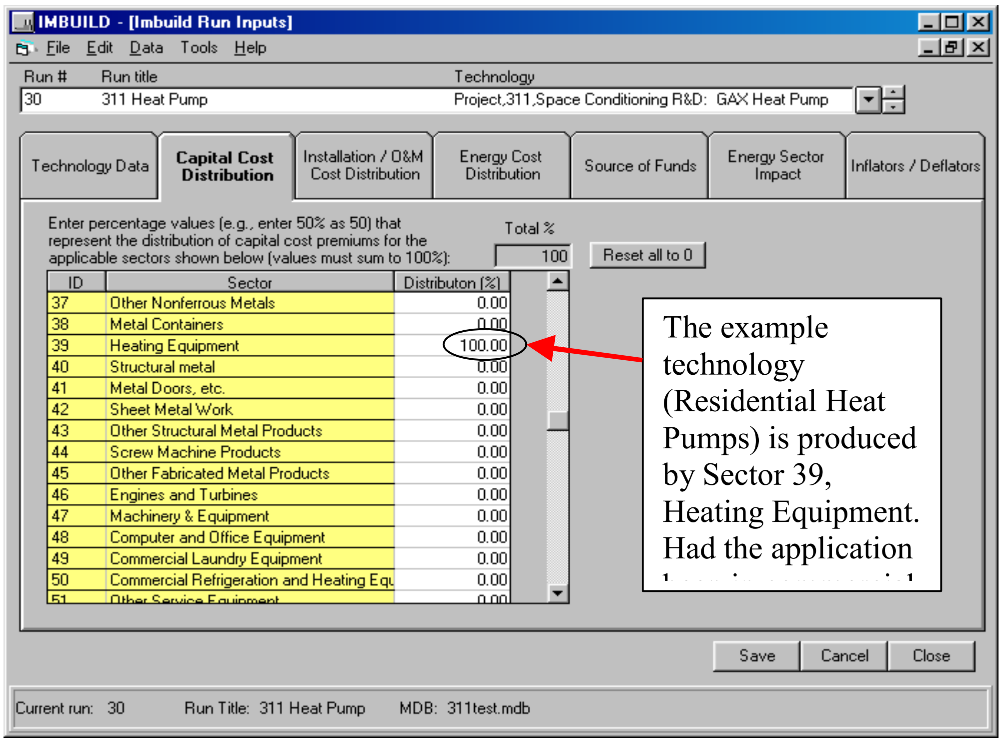
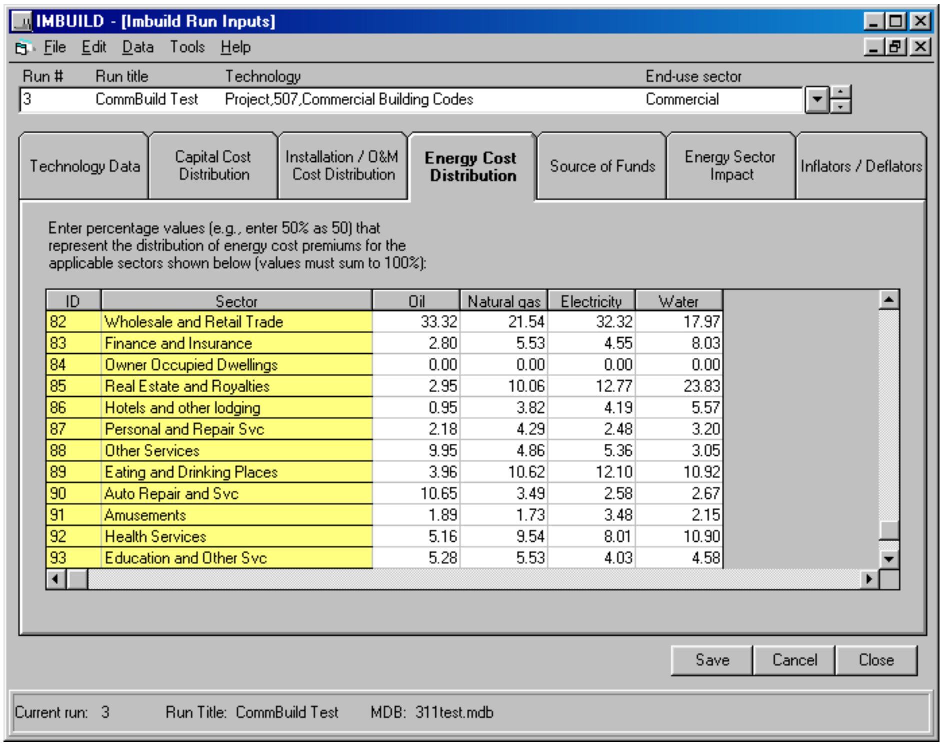


Figure 5.6. Allocation of Capital Cost



ID	Sector	Oil	Natural gas	Electricity	Water
82	Wholesale and Retail Trade	33.32	21.54	32.32	17.97
83	Finance and Insurance	2.80	5.53	4.55	8.03
84	Owner Occupied Dwellings	0.00	0.00	0.00	0.00
85	Real Estate and Royalties	2.95	10.06	12.77	23.83
86	Hotels and other lodging	0.95	3.82	4.19	5.57
87	Personal and Repair Svc	2.18	4.29	2.48	3.20
88	Other Services	9.95	4.86	5.36	3.05
89	Eating and Drinking Places	3.96	10.62	12.10	10.92
90	Auto Repair and Svc	10.65	3.49	2.58	2.67
91	Amusements	1.89	1.73	3.48	2.15
92	Health Services	5.16	9.54	8.01	10.90
93	Education and Other Svc	5.28	5.53	4.03	4.58

Figure 5.7. Energy Cost Savings Distribution Across Sectors

5.2.4 Source of Investment Funds

Investment funds spent on energy-efficient equipment have an opportunity cost; that is, they would have been spent somewhere else in the domestic economy or overseas if they were not spent on energy-efficient equipment. The source of funds sheet allows the user to specify the source of the funds used for investment. Enter the percentage values (e.g., enter 50% as 50) that represent the share of investment funding provided by each applicable. The sum of the sector allocations does not need to equal 100%, but if it does not, the model will allocate the remaining percentage to sum to 100% unless it is overridden, and will allocate spending reductions within the remainder using the average proportions in all final demand. However, even if all of the explicit shares are set to zero, each sector will have its spending reduced by the proportion it represents of all final demand *unless* the override box is checked. The override check box allows some or all of the opportunity cost of invested funds to not be counted against domestic final demand. There are occasions when the user may not want to consider the opportunity cost of the funds used for investment. If, for example, only the impacts on a local region were being considered and the funds came from the national financial markets, then the local area might see the positive impact of the investment as well as any energy savings, but would not experience the costs to the national economy. These costs would be "somewhere else." Another reason might be if the displaced spending were somewhere else in the world and only the domestic impact was important. If opportunity cost of the investment funds is irrelevant to the analysis or the source of funds is "magic," then all values can be set to 0. To do this, set all of the sectors to zero, check the check box, and then set the remainder box to zero as well.

The most common assumption is that investment funds will come proportionately from all domestic spending.

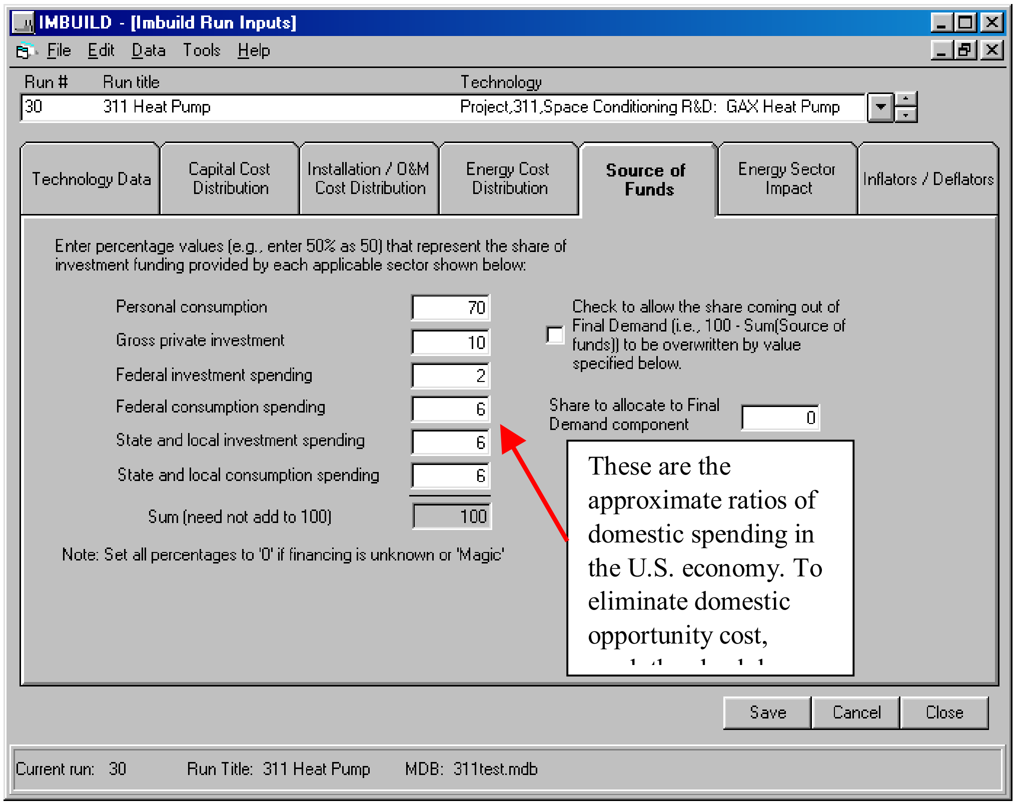


Figure 5.8. Opportunity Cost of Invested Funds

5.2.5 Energy Sector Impact

This screen allows the user to specify how the technology/program impacts will affect the investment in the energy sector, in particular the electricity and industries. Significant energy savings might allow electricity and natural gas production, transmission, and distribution companies to reduce the amount of investment that they undertake, which frees up investment capital for the general economy (this is the mirror image of the “source of funds” allocation). If reductions in investment occur due to the technology/program then enter “Yes” for the applicable question and enter any changes to load/capacity factors and costs as necessary. If either “Yes” is selected then enter where (percentage shares) investment dollars would be going to (what sectors would benefit) in the right hand box. In the example in Figure 5.9, the investment is proportionately distributed to the economy as a whole. Note that in this case the sum of those shares is handled the same way as the as the opportunity cost of invested funds. The “benefit” of investment savings need not remain in the region of interest.

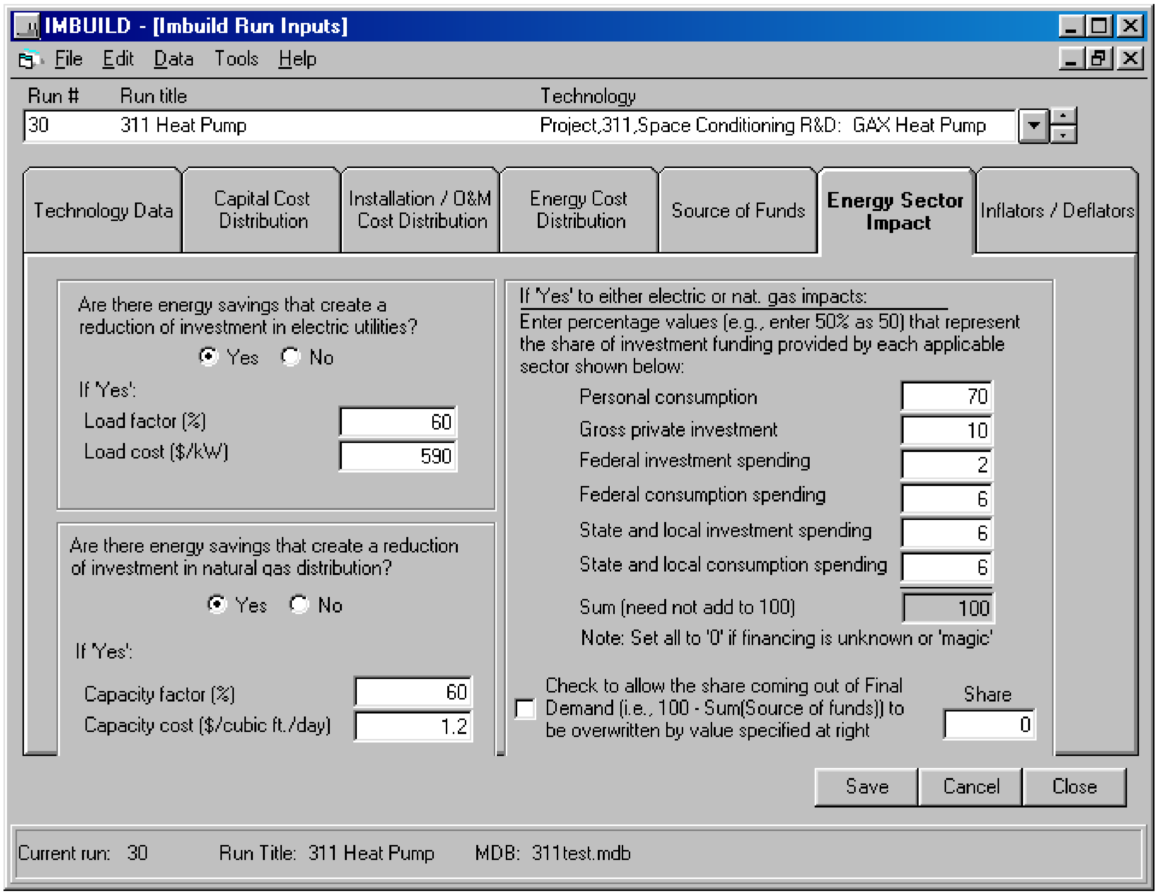


Figure 5.9. Impact of Energy Savings on Energy Sector Investments

5.2.6 Inflators/Deflators

The inflators/deflators page is designed to allow easy conversion of costs and savings to the appropriate year's dollars. The input-output table at the core of ImBuild is in 1992 dollars, so inputs to the model need to be converted to a 1992 basis. For example, in the first version of the ImBuild model, capital costs and savings were in 1995 dollars, which needed to be converted to 1992 dollars. This is the purpose of the deflators. On the other hand, for reporting purposes many users would like to see earnings numbers in some later year's constant dollars, not 1992. For example, in recent use of the model, results have been reported in constant 1999 dollars. This is the purpose of the inflators. Enter the appropriate inflators /deflators to use in the model. Note that capital cost deflators are used to adjust capital cost, installation costs, and utility impact costs to the base input-output year (1992). Operations cost deflators are used to adjust energy costs and O&M costs to the base input-output year and to adjust the base input-output results for 'output' dollars back to the year assumed by the technology data. Both of these are based on Gross Domestic Product deflators. The inflator input is based on the appropriate year's Consumer Price Index and is used to adjust base input-output results for earnings to the technology data base year, or to some other year for reporting purposes.

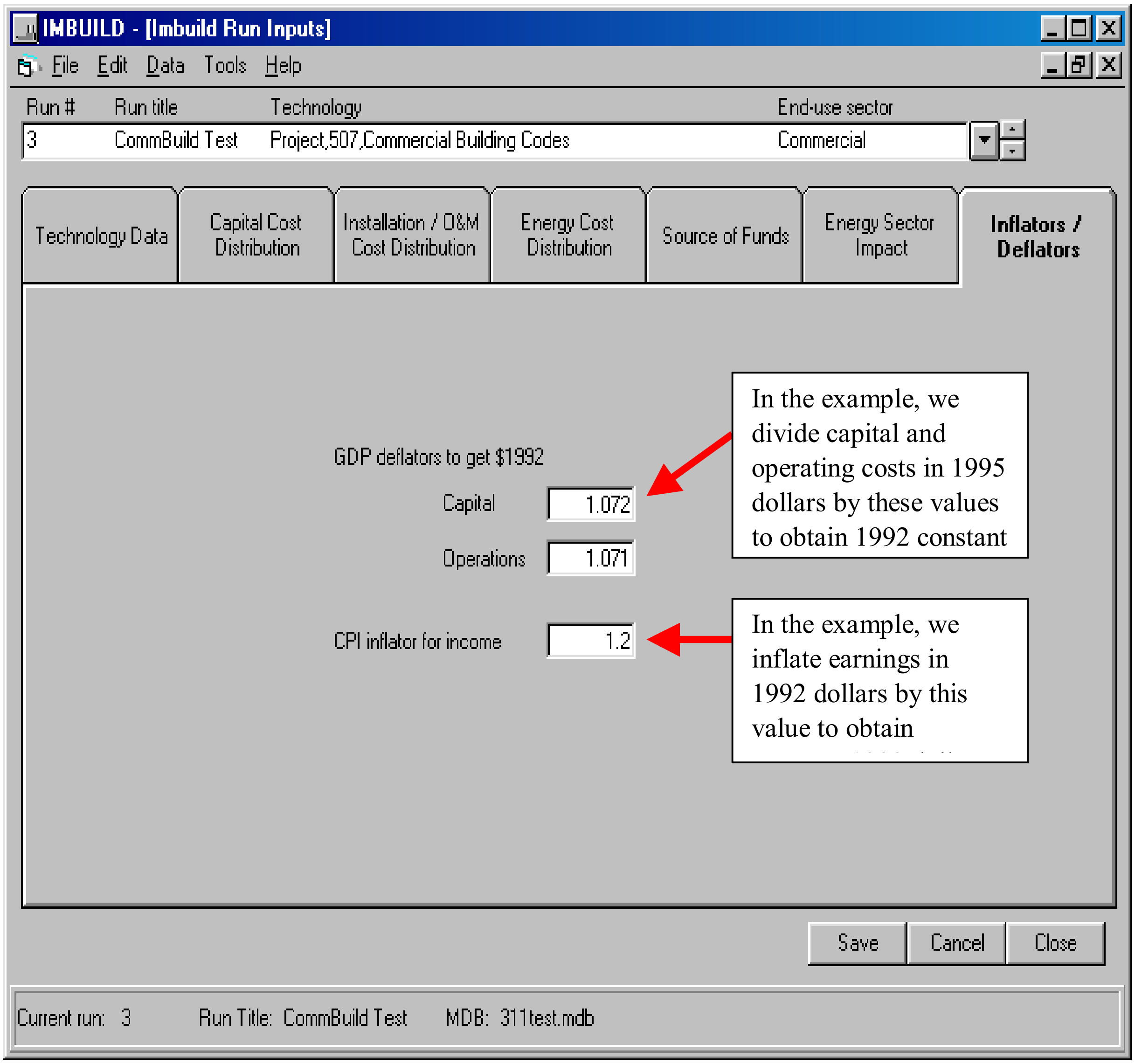


Figure 5.10. Assigning Inflators and Deflators

5.3 Computing Program Impacts

Selecting the "Compute program impacts" will run the computations for determining the impacts of the "run specifications". Only those records marked with "Execute run" will be processed. Before running computations the program checks for a common set of years between all technologies/programs. It will also test for conditions where there are no years represented.

With data integrity checks complete, the process loops through each "run scenario" and, in turn, creates an associated ASCII file of data that will be read by the ImBuild model. The processing code (QMIO.EXE) is then called and when finished, the process retrieves the ASCII output file created by the model and parses and stores the results to the user database file. With that process complete, the IMBUILD tool opens the results screen and presents the calculated impacts in spreadsheet and graphical form.

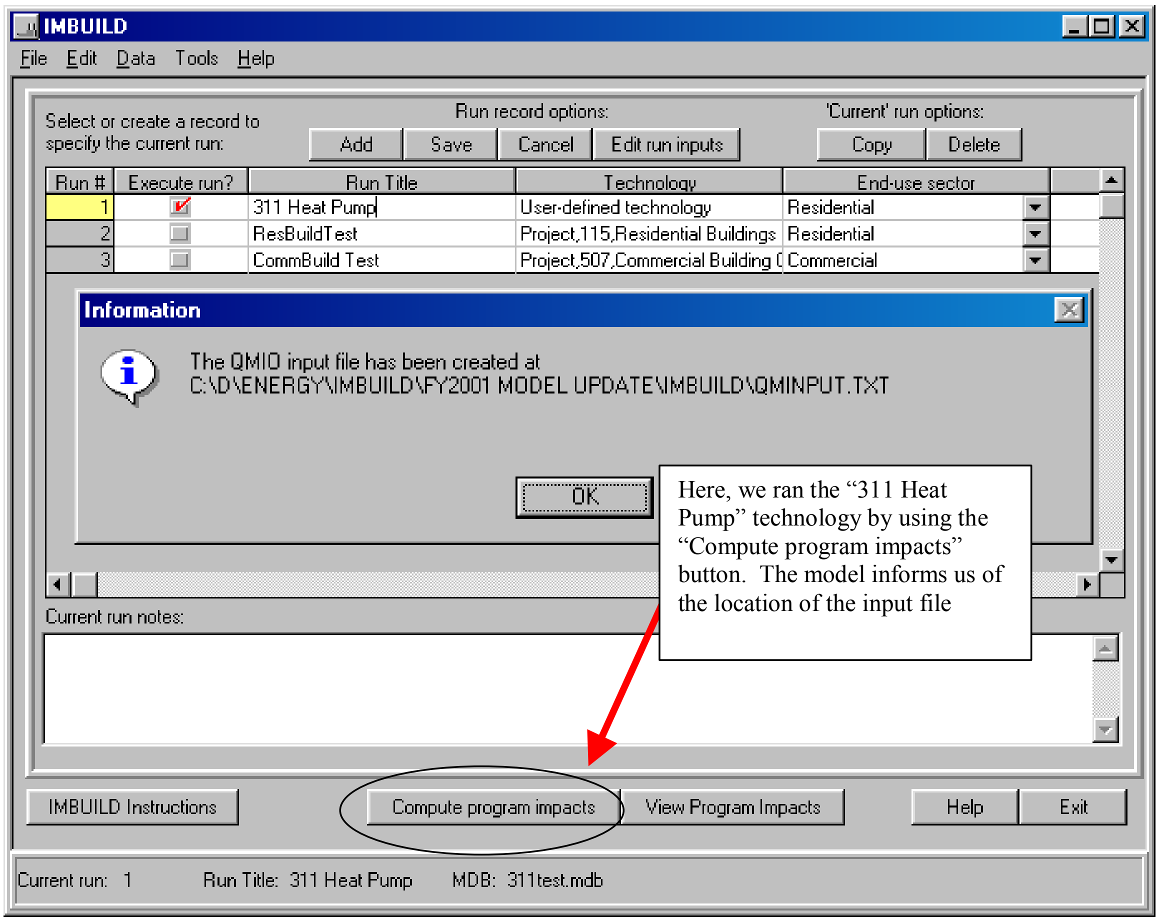


Figure 5.11. Running the ImBuild Model

5.4 Viewing Program Impacts

If the user wishes to view the last computed impacts without rerunning the calculations then he/she should select the "View program impacts" button. The results can be viewed in two display formats. The first will be in a spreadsheet form and second will be a graphical form. In either form the displayed data will be dependent on the "Impacts data type" choice that is available at the top of the screen. Additional options in this screen include printing the spreadsheet and all the data types and exporting all impact data types to an Excel spreadsheet file. The name assigned to the Excel file will be the same as the user database file. The graphical portion of the "Results" screen offers the user a rich set of options for changing the graph displayed. The user should feel free to "play" with the different option available including printing the graph to file or printer.

Results presentation

There are two styles of results presentation. The first style shows the results in tabular form and in graphical form presented in individual "tab" frames. Use the "Results type" drop-down list at the top of the screen to select the individual results data that are available. Select the "Print" button to print these as they appear on the screen. In this presentation style the user has liberty to access the graph properties pages to customize and print the graph in a customized fashion. The user also has the option of selecting which results to graph by selecting the appropriate button. The second results presentation is made available by clicking the "Reports manager" button in the "Results" screen. The "Report Manager" screen will present a spreadsheet contained all available reports. Each of these types of reports will display both a graph (Table 5.12) and cross-tabbed table (Table 5.13) of the selected results. This presentation of the results enables the user to export the results to a host of file formats.

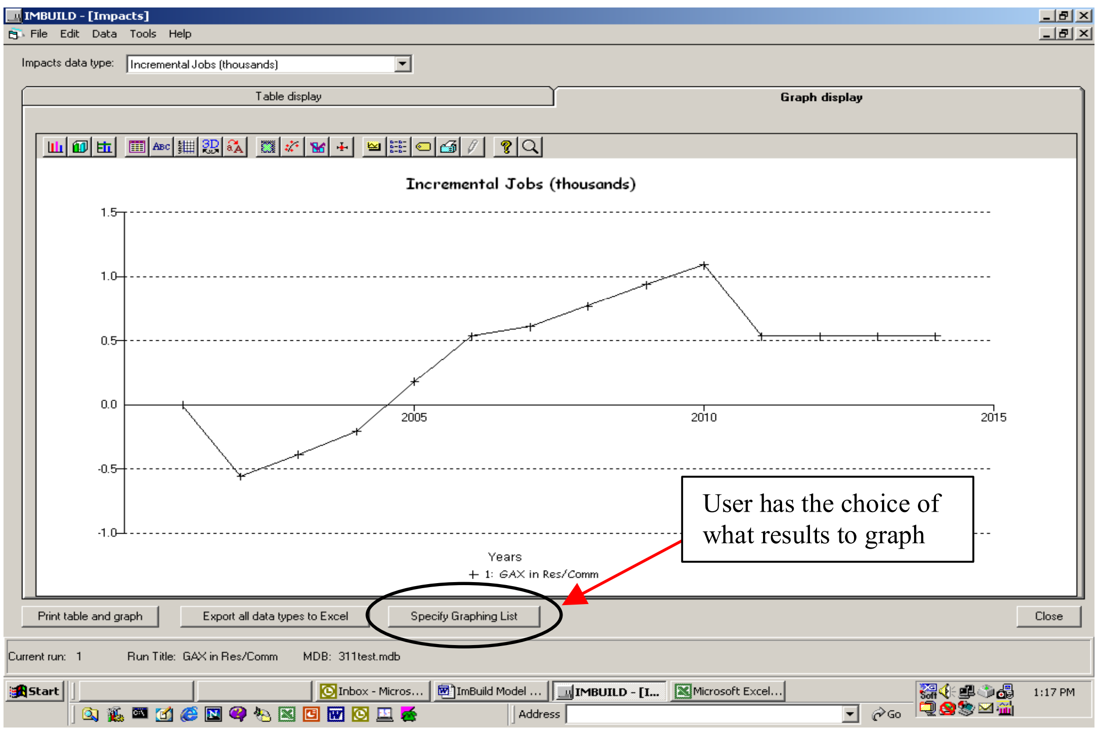


Figure 5.12. Report Manager Screens for Output (Graphical Display)

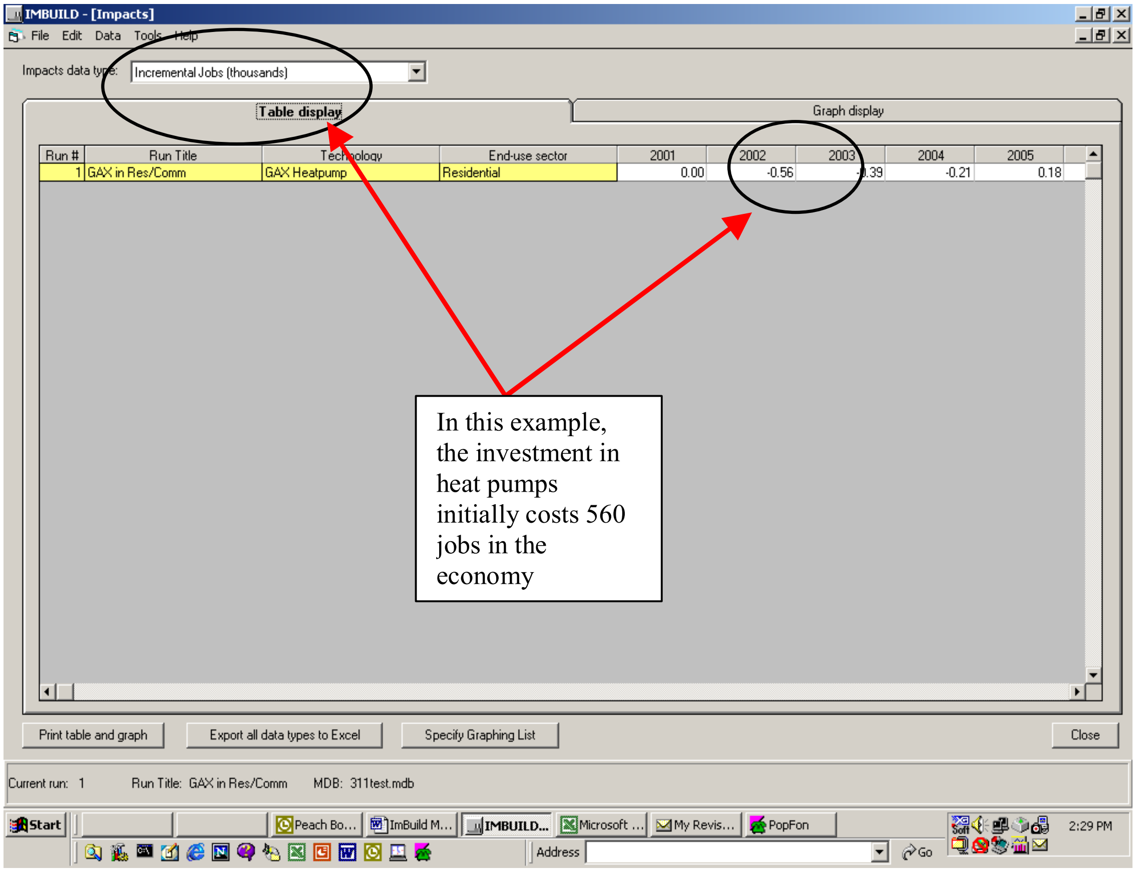


Figure 5.13. Report Manager Screens for Output (Table Display)

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Appendix A

Base Cases for Building Energy Efficiency Technologies

Table A.1. Heat Pump Water Heater Base Case

Base Case	Heat Pump Water Heater									
	2003	**2004**	**2005**	**2006**	**2007**	**2010**	**2015**	**2020**	**2025**	**2030**
Installation Cost Increase (+) or Savings(-) Million $										
	190.74	193.29	195.23	198.23	123.17	126.57	0	0	0	0
Installation Cost Increase (+) or Savings(-) Million $										
	0	0	0	0	0	0	0	0	0	0
Energy/Resource Cost Increase (+) or Savings (-) Million $										
Residential -- Oil	0	0	0	0	0	0	0	0	0	0
Residential -- Natural Gas	0	0	0	0	0	0	0	0	0	0
Residential -- Electricity	0	-14.96	-23.87	-39.28	-61.54	-203.48	-504.69	-625.64	-762.9	-919.02
Residential -- Water	0	0	0	0	0	0	0	0	0	0
Commercial -- Oil	0	0	0	0	0	0	0	0	0	0
Commercial -- Natural Gas	0	0	0	0	0	0	0	0	0	0
Commercial -- Electricity	0	0	0	0	0	0	0	0	0	0
Commercial -- Water	0	0	0	0	0	0	0	0	0	0
Industrial -- Oil	0	0	0	0	0	0	0	0	0	0
Industrial -- Natural gas	0	0	0	0	0	0	0	0	0	0
Industrial -- Electricity	0	0	0	0	0	0	0	0	0	0
Industrial -- Water	0	0	0	0	0	0	0	0	0	0
Transportation -- Oil	0	0	0	0	0	0	0	0	0	0
Transportation -- Natural Gas	0	0	0	0	0	0	0	0	0	0
Transportation -- Electricity	0	0	0	0	0	0	0	0	0	0
Transportation -- Water	0	0	0	0	0	0	0	0	0	0
O&M Cost Increase (+) or Savings (-) (Million $)										
Residential	0	0	0	0	0	0	0	0	0	0
Commercial	0	0	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0	0	0
Transportation	0	0	0	0	0	0	0	0	0	0
Energy/Resource Units Saved (-) or Used (For System Investment)										
Oil (10^{12} Btu)	0	0	0	0	0	0	0	0	0	0
Natural Gas (10^{12} Btu)	0	0	0	0	0	0	0	0	0	0
Electricity (10^{12} Btu)	0	-0.67	-1.09	-1.78	-2.81	-9.3	-22.93	-28.22	-34.18	-40.9
Water (10^{9} Gallons)	0	0	0	0	0	0	0	0	0	0

Table A.2. EPACT Standards Base Case

Base Case	EPACT Standards									
	2003	**2004**	**2005**	**2006**	**2007**	**2010**	**2015**	**2020**	**2025**	**2030**
Installation Cost Increase (+) or Savings (-) Million $										
	0	0	0	0	0	0	0	0	0	0
Installation Cost Increase (+) or Savings (-) Million $										
	0	0	0	0	0	0	0	0	0	0
Energy/Resource Cost Increase (+) or Savings (-) Million $										
Residential -- Oil	0	0	0	0	0	0	0	0	0	0
Residential -- Natural gas	0	0	0	0	0	0	0	0	0	0
Residential -- Electricity	0	0	0	0	0	0	0	0	0	0
Residential -- Water	0	0	0	0	0	0	0	0	0	0
Commercial -- Oil	0	0	0	0	0	0	0	0	0	0
Commercial -- Natural gas	0	0	0	0	0	-15.95	-43.45	-74.23	-100.51	-127.87
Commercial -- Electricity	0	0	-48.95	-95.35	-145.36	-535.95	-1321.91	-2152.66	-2447.39	-2752.04
Commercial -- Water	0	0	0	0	0	0	0	0	0	0
Industrial -- Oil	0	0	0	0	0	0	0	0	0	0
Industrial -- Natural gas	0	0	0	0	0	0	0	0	0	0
Industrial -- Electricity	0	0	0	0	0	0	0	0	0	0
Industrial -- Water	0	0	0	0	0	0	0	0	0	0
Transportation -- Oil	0	0	0	0	0	0	0	0	0	0

Table A.2. (contd)

Base Case	Heat Pump Water Heater									
	2003	**2004**	**2005**	**2006**	**2007**	**2010**	**2015**	**2020**	**2025**	**2030**
Transportation -- Natural gas	0	0	0	0	0	0	0	0	0	0
Transportation -- Electricity	0	0	0	0	0	0	0	0	0	0
Transportation -- Water	0	0	0	0	0	0	0	0	0	0
O&M Cost Increase (+) or Savings (-) (Million $)										
Residential	0	0	0	0	0	0	0	0	0	0
Commercial	0	0	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0	0	0
Transportation	0	0	0	0	0	0	0	0	0	0
Energy/Resource Units Saved (-) or Used (For System Investment)										
Oil (10^{12} Btu)	0	0	0	0	0	0	0	0	0	0
Natural gas (10^{12} Btu)	0	0	0	0	0	-2.9	-7.9	-13	-17.3	-21.6
Electricity (10^{12} Btu)	0	0	-2.5	-5	-7.9	-30.4	-74.6	-118.8	-133.3	-147.8
Water (10^{9} Gallons)	0	0	0	0	0	0	0	0	0	0

Table A.3. Residential Technology R&D Base Case

Base Case	Residential Technology Research and Development									
	2003	**2004**	**2005**	**2006**	**2007**	**2010**	**2015**	**2020**	**2025**	**2030**
Installation Cost Increase (+) or Savings(-) Million $										
	18.16	22.7	37.71	65.48	86.42	124.04	76.63	33.22	27.21	27.21
Installation Cost Increase (+) or Savings(-) Million $										
	0	0	0	0	0	0	0	0	0	0
Energy/Resource Cost Increase (+) or Savings (-) Million $										
Residential -- Oil	-0.04	-0.09	-0.2	-0.35	-0.6	-1.81	-3.78	-4.86	-5.54	-6.26
Residential -- Natural gas	-0.59	-1.45	-3.15	-6.29	-10.56	-30.71	-59.65	-74.59	-82.62	-90.57
Residential -- Electricity	-0.61	-1.5	-2.92	-6.06	-10.45	-31.35	-67.61	-89.58	-99.68	-109.78
Residential -- Water	0	0	0	0	0	0	0	0	0	0
Commercial -- Oil	0	0	0	0	0	0	0	0	0	0
Commercial -- Natural gas	0	0	0	0	0	0	0	0	0	0
Commercial -- Electricity	0	0	0	0	0	0	0	0	0	0
Commercial -- Water	0	0	0	0	0	0	0	0	0	0
Industrial -- Oil	0	0	0	0	0	0	0	0	0	0
Industrial -- Natural gas	0	0	0	0	0	0	0	0	0	0
Industrial -- Electricity	0	0	0	0	0	0	0	0	0	0
Industrial -- Water	0	0	0	0	0	0	0	0	0	0
Transportation -- Oil	0	0	0	0	0	0	0	0	0	0
Transportation -- Natural gas	0	0	0	0	0	0	0	0	0	0
Transportation -- Electricity	0	0	0	0	0	0	0	0	0	0
Transportation -- Water	0	0	0	0	0	0	0	0	0	0
O&M Cost Increase (+) or Savings(-) (Million $)										
Residential	0	0	0	0	0	0	0	0	0	0
Commercial	0	0	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0	0	0
Transportation	0	0	0	0	0	0	0	0	0	0
Energy/Resource units Saved (-) or Used (For System Investment)										
Oil (10^12 Btu)	0	-0.01	-0.03	-0.05	-0.08	-0.24	-0.48	-0.61	-0.67	-0.74
Natural gas (10^12 Btu)	-0.09	-0.22	-0.47	-0.95	-1.6	-4.7	-9.26	-11.39	-12.59	-13.79
Electricity (10^12 Btu)	-0.03	-0.07	-0.13	-0.27	-0.48	-1.43	-3.07	-4.04	-4.47	-4.89
Water (10^9 Gallons)	0	0	0	0	0	0	0	0	0	0

Appendix B

Sectoral Detail

Table B.1. Cross Reference Between ImBuild Sectors and 1992 U.S. Input-Output Table Sectors

Correspondence Between IMBUILD II Sectors and Benchmark 1992 Input-Output Table			
IMBUILD Sector #	**IMBUILD Title**	**I/O 2-Digit Category**	**I/O Industry Number**
1	Agriculture, Forestry and Fisheries	01 through 04	010100 – 040002
2	Mining except Nonmetallic minerals	05 through 08; part of 09 plus 10	050001 – 100000 X 090001 – 090003
3	Nonmetallic mineral mining	Part of 09	090001 – 090003
4	Residential Construction	Parts of 11 and 12	110101, 110102, 110105, 110108, 120101
5	Commercial Construction	Parts of 11 and 12	110800, 120300
6	Other Construction	Parts of 11 and 12	110400, 110501, 110601, 110602, 110603, 110900, 120214, 120215
7	Food and Tobacco Products	14 and 15	140101 – 150200
8	Fabrics and Yarn	16	160100 – 160400
9	Other Textiles	17	170100 – 171100
10	Apparel	18	180101 – 180400
11	Fabricated Textile Products	19	190100 – 190306
12	Other Wood Products	Part of 20, 21	200100 – 200400, 200502 – 200701, 200800 – 210000
13	Millwork	Part of 20	200501
14	Fabricated Buildings	Part of 20	200702, 200703
15	Furniture and Fixtures	22+23	220101 – 230700
16	Paper and Products except Containers	24	240100 – 240800
17	Containers and Boxes	25	250000
18	Newspapers and Other Printing	26A + 26B	260100 – 260806
19	Industrial Chemicals	27A	270100 – 270406
20	Agricultural Chemicals	27B	270201 – 270300
21	Plastics	Part of 28	280100
22	Synthetic Materials	Part of 28	280200 – 280400
23	Drugs and Cleaning	29A + 29B	290100 – 290300
24	Paints and Allied Products	30	300000
25	Petroleum Refining	Part of 31	310101
26	Other Petrol Products	Part of 31	310102 – 310300
27	Rubber and Plastic Products	32	320100 – 320600
28	Foot-ware and Leather	33 + 34	330001 – 340305

Table B.1. (contd)

Correspondence Between IMBUILD II Sectors and Benchmark 1992 Input-Output Table			
IMBUILD Sector #	**IMBUILD Title**	**I/O 2-Digit Category**	**I/O Industry Number**
29	Other Glass Products	Part of 35	350100
30	Glass Containers	Part of 35	350200
31	Cement	Part of 36	360100
32	Lime and Gypsum	Part of 36	361300 – 361400
33	Mineral Wool	Part of 36	362000
34	Other Nonmetallic Minerals	Part of 36	360200 – 361200, 361500 – 361900, 362100, 362200
35	Iron and Steel	37	370101 – 370402
36	Aluminum	Part of 38	380400, 380800, 381100
37	Other Nonferrous Metals	Part of 38	All of 380000 except above
38	Metal Containers	39	390100, 390200
39	Heating Equipment	Part of 40	400300
40	Structural metal	Part of 40	400400
41	Metal Doors, etc.	Part of 40	400500
42	Sheet Metal Work	Part of 40	400700
43	Other Structural Metal Products	Part of 40	400100 – 400200, 400800 – 40902
44	Screw Machine Products	41	410100 – 410203
45	Other Fabricated Metal Products	42	420100 – 421100
46	Engines and Turbines	43	430100 – 430200
47	Machinery & Equipment	44 – 50	440100 – 500400
48	Computer and Office Equipment	51	510102 – 510400
49	Commercial Laundry Equipment	Part of 52	5202000
50	Commercial Refrigeration and Heating Equipment	Part of 52	520300
51	Other Service Equipment	Part of 52	520100, 520400, 520500
52	Power Equipment	Part of 53	530200
53	Motors and Generators	Part of 53	530400
54	Relays and Industrial Controls	Part of 53	530500
55	Other Electrical Equipment	Part of 53	530300, 530700, 530800
56	Household Cooking	Part of 54	540100
57	HH Refrigeration and Freezers	Part of 54	540200
58	HH Laundry	Part of 54	540300
59	Electric House-wares and Fans	Part of 54	540400
60	HH Vacuum Cleaners	Part of 54	540500
61	HH Appliances, n.e.c.	Part of 54	540700
62	Lighting Bulbs and Tubes	Part of 55	550100

Table B.1. (contd)

Correspondence Between IMBUILD II Sectors and Benchmark 1992 Input-Output Table			
IMBUILD Sector #	**IMBUILD Title**	**I/O 2-Digit Category**	**I/O Industry Number**
63	Other Lighting and Wiring	Part of 55	550200, 550300
64	Communications Equip	56	560100 – 560500
65	Electronic Components	57	570100 – 570300
66	Misc. Electric Supplies	58	580100 – 580700
67	Motor Vehicles	59A	590301
68	Bodies, Trailers & Parts	59B	590100, 590200, 500302
69	Aircraft and Parts	60	600100 – 600400
70	Other Transport Equipment	61	610100 – 610700
71	Measuring and Control Devices	Part of 62	620200, 620300, 621100
72	Other Manufacturing	13, Part of 62, 63 64	130100 – 130700; All of 620000 except above; 630200 – 641200
73	Rail Transport	65A	650100, 650200
74	Motor Freight Transport	65B	650301, 650302
75	Water Transport	65C	650400
76	Air Transport	65D	650500
77	Pipelines	65E	650600 – 650702, 680201
78	Communications	66 + 67	660100 – 670000
79	Electric Utilities	68A	680100, 780200, 790200
80	Gas Utilities	68B	680202
81	Water Utilities	68C	680301, 680302
82	Wholesale and Retail Trade	69	690100, 690200
83	Finance and Insurance	70	700100 – 700500
84	Owner Occupied Dwellings	71A	710100
85	Real Estate and Royalties	71B	710201, 710202
86	Hotels and other lodging	72A	720101
87	Personal and Repair Svc	72B	720201 – 720300
88	Other Services	73	730101 – 730303
89	Eating and Drinking Places	74	740000
90	Auto Repair and Svc	75	750001 – 750003
91	Amusements	76	760101 – 760205
92	Health Services	77A	770100 – 770305
93	Education and Other Svc	77B	770401 – 770900
94	Federal Enterprises	Part of 78	780100, 780500
95	S&L Enterprises	Part of 79	790100, 790300
96	Non-comparable Imports	80	800000
97	Miscellany	81, 83,84, 85	810001, 810002, 830000, 840000, 850000
98	General Govt. Industry	82	820000

Table B.2. Detailed 1992 Input-Output Sectors

Sector Number	1992 Input-Output Sector Description
01 Livestock and livestock products	
010100	Dairy farm products
010200	Poultry and eggs
010301	Meat animals
010302	Miscellaneous livestock
02 Other agricultural products	
020100	Cotton
020201	Food grains
020202	Feed grains
020203	Grass seeds
020300	Tobacco
020401	Fruits
020402	Tree nuts
020501	Vegetables
020502	Sugar crops
020503	Miscellaneous crops
020600	Oil bearing crops
020701	Forest products
020702	Greenhouse and nursery products
03 Forestry and fishery products	
030001	Forestry products
030002	Commercial fishing
04 Agricultural, forestry, and fishery services	
040001	Agricultural, forestry, and fishery services
040002	Landscape and horticultural services
05+06 Metallic ores mining	
050001	Iron and ferroalloy ores, and miscellaneous metal ores, n.e.c.
060100	Copper ore
060200	Nonferrous metal ores, except copper
07 Coal mining	
070000	Coal
08 Crude petroleum and natural gas	
080001	Crude petroleum and natural gas

Table B.2. (contd)

Sector Number	1992 Input-Output Sector Description
09+10 Nonmetallic minerals mining	
090001	Dimension, crushed and broken stone
090002	Sand and gravel
090003	Clay, ceramic, and refractory minerals
090004	Nonmetallic mineral services and miscellaneous
100000	Chemical and fertilizer minerals
11 New construction	
110101	New residential 1 unit structures, nonfarm
110102	New residential 2-4 unit structures, nonfarm
110105	New residential additions and alterations, nonfarm
110108	New residential garden and high-rise apartments construction
110400	New highways, bridges, and other horizontal construction
110501	New farm residential construction
110601	Petroleum and natural gas well drilling
110602	Petroleum, natural gas, and solid mineral exploration
110603	Access structures for solid mineral development
110800	New office, industrial and commercial buildings construction
110900	Other new construction
12 Maintenance and repair construction	
120101	Maintenance and repair of farm and nonfarm residential structures
120214	Maintenance and repair of highways & streets
120215	Maintenance and repair of petroleum and natural gas wells
120300	Other repair and maintenance construction
13 Ordnance and accessories	
130100	Guided missiles and space vehicles
130200	Ammunition, except for small arms, n.e.c.
130300	Tanks and tank components
130500	Small arms
130600	Small arms ammunition
130700	Ordnance and accessories, n.e.c.

Table B.2. (contd)

Sector Number	1992 Input-Output Sector Description
14 Food and kindred products	
140101	Meat packing plants
140102	Sausages and other prepared meat products
140105	Poultry slaughtering and processing
140200	Creamery butter
140300	Natural, processed, and imitation cheese
140400	Dry, condensed, and evaporated dairy products
140500	Ice cream and frozen desserts
140600	Fluid milk
140700	Canned and cured fish and seafoods
140800	Canned specialties
140900	Canned fruits, vegetables, preserves, jams, and jellies
141000	Dehydrated fruits, vegetables, and soups
141100	Pickles, sauces, and salad dressings
141200	Prepared fresh or frozen fish and seafoods
141301	Frozen fruits, fruit juices, and vegetables
141302	Frozen specialties, n.e.c.
141401	Flour and other grain mill products
141402	Cereal breakfast foods
141403	Prepared flour mixes and doughs
141501	Dog and cat food
141502	Prepared feeds, n.e.c.
141600	Rice milling
141700	Wet corn milling
141801	Bread, cake, and related products
141802	Cookies and crackers
141803	Frozen bakery products, except bread
141900	Sugar
142002	Chocolate and cocoa products
142004	Salted and roasted nuts and seeds
142005	Candy and other confectionery products
142101	Malt beverages
142102	Malt
142103	Wines, brandy, and brandy spirits

Table B.2. (contd)

Sector Number	1992 Input-Output Sector Description
142104	Distilled and blended liquors
142200	Bottled and canned soft drinks
142300	Flavoring extracts and flavoring syrups, n.e.c.
142400	Cottonseed oil mills
142500	Soybean oil mills
142600	Vegetable oil mills, n.e.c.
142700	Animal and marine fats and oils
142800	Roasted coffee
142900	Edible fats and oils, n.e.c.
143000	Manufactured ice
143100	Macaroni, spaghetti, vermicelli, and noodles
143201	Potato chips and similar snacks
143202	Food preparations, n.e.c.
15 Tobacco products	
150101	Cigarettes
150102	Cigars
150103	Chewing and smoking tobacco and snuff
150200	Tobacco stemming and redrying
16 Broad and narrow fabrics, yarn and thread mills	
160100	Broadwoven fabric mills and fabric finishing plants
160200	Narrow fabric mills
160300	Yarn mills and finishing of textiles, n.e.c.
160400	Thread mills
17 Miscellaneous textile goods and floor coverings	
170100	Carpets and rugs
170600	Coated fabrics, not rubberized
170700	Tire cord and fabrics
170900	Cordage and twine
171001	Nonwoven fabrics
171100	Textile goods, n.e.c.

Table B.2. (contd)

Sector Number	1992 Input-Output Sector Description
18 Apparel	
180101	Women's hosiery, except socks
180102	Hosiery, n.e.c.
180201	Knit outerwear mills
180202	Knit underwear and nightwear mills
180203	Knitting mills, n.e.c.
180300	Knit fabric mills
180400	Apparel made from purchased materials
19 Miscellaneous fabricated textile products	
190100	Curtains and draperies
190200	Housefurnishings, n.e.c.
190301	Textile bags
190302	Canvas and related products
190303	Pleating and stitching
190304	Automotive and apparel trimmings
190305	Schiffli machine embroideries
190306	Fabricated textile products, n.e.c.
20+21 Lumber and wood products	
200100	Logging
200200	Sawmills and planing mills, general
200300	Hardwood dimension and flooring mills
200400	Special product sawmills, n.e.c.
200501	Millwork
200502	Wood kitchen cabinets
200600	Veneer and plywood
200701	Structural wood members, n.e.c.
200702	Prefabricated wood buildings and components
200703	Mobile homes
200800	Wood preserving
200901	Wood pallets and skids

Table B.2. (contd)

Sector Number	1992 Input-Output Sector Description
200903	Wood products, n.e.c.
200904	Reconstituted wood products
210000	Wood containers, n.e.c.
22+23 Furniture and fixtures	
220101	Wood household furniture, except upholstered
220102	Household furniture, n.e.c.
220103	Wood television and radio cabinets
220200	Upholstered household furniture
220300	Metal household furniture
220400	Mattresses and bedsprings
230100	Wood office furniture
230200	Office furniture, except wood
230300	Public building and related furniture
230400	Wood partitions and fixtures
230500	Partitions and fixtures, except wood
230600	Drapery hardware and window blinds and shades
230700	Furniture and fixtures, n.e.c.
24 Paper and allied products, except containers	
240100	Pulp mills
240400	Envelopes
240500	Sanitary paper products
240701	Paper coating and glazing
240702	Bags, except textile
240703	Die-cut paper and paperboard and cardboard
240705	Stationery, tablets, and related products
240706	Converted paper products, n.e.c.
240800	Paper and paperboard mills
25 Paperboard containers and boxes	
250000	Paperboard containers and boxes
26A Newspapers and periodicals	
260100	Newspapers
260200	Periodicals

Table B.2. (contd)

Sector Number	1992 Input-Output Sector Description
26B Other printing and publishing	
260301	Book publishing
260302	Book printing
260400	Miscellaneous publishing
260501	Commercial printing
260601	Manifold business forms
260602	Blankbooks, looseleaf binders and devices
260700	Greeting cards
260802	Bookbinding and related work
260803	Typesetting
260806	Platemaking and related services
27A Industrial and other chemicals	
270100	Industrial inorganic and organic chemicals
270401	Gum and wood chemicals
270402	Adhesives and sealants
270403	Explosives
270404	Printing ink
270405	Carbon black
270406	Chemicals and chemical preparations, n.e.c.
27B Agricultural fertilizers and chemicals	
270201	Nitrogenous and phosphatic fertilizers
270202	Fertilizers, mixing only
270300	Pesticides and agricultural chemicals, n.e.c.
28 Plastics and synthetic materials	
280100	Plastics materials and resins
280200	Synthetic rubber
280300	Cellulosic manmade fibers
280400	Manmade organic fibers, except cellulosic
29A Drugs	
290100	Drugs

Table B.2. (contd)

Sector Number	1992 Input-Output Sector Description
29B Cleaning and toilet preparations	
290201	Soap and other detergents
290202	Polishes and sanitation goods
290203	Surface active agents
290300	Toilet preparations
30 Paints and allied products	
300000	Paints and allied products
31 Petroleum refining and related products	
310101	Petroleum refining
310102	Lubricating oils and greases
310103	Products of petroleum and coal, n.e.c.
310200	Asphalt paving mixtures and blocks
310300	Asphalt felts and coatings
32 Rubber and miscellaneous plastics products	
320100	Tires and inner tubes
320200	Rubber and plastics footwear
320300	Fabricated rubber products, n.e.c.
320400	Miscellaneous plastics products, n.e.c.
320500	Rubber and plastics hose and belting
320600	Gaskets, packing, and sealing devices
33+34 Footwear, leather, and leather products	
330001	Leather tanning and finishing
340100	Boot and shoe cut stock and findings
340201	Shoes, except rubber
340202	House slippers
340301	Leather gloves and mittens
340302	Luggage
340303	Women's handbags and purses
340304	Personal leather goods, n.e.c.
340305	Leather goods, n.e.c.
35 Glass and glass products	
350100	Glass and glass products, except containers
350200	Glass containers

Table B.2. (contd)

Sector Number	1992 Input-Output Sector Description
36 Stone and clay products	
360100	Cement, hydraulic
360200	Brick and structural clay tile
360300	Ceramic wall and floor tile
360400	Clay refractories
360500	Structural clay products, n.e.c.
360600	Vitreous china plumbing fixtures
360701	Vitreous china table and kitchenware
360702	Fine earthenware table and kitchenware
360800	Porcelain electrical supplies
360900	Pottery products, n.e.c.
361000	Concrete block and brick
361100	Concrete products, except block and brick
361200	Ready-mixed concrete
361300	Lime
361400	Gypsum products
361500	Cut stone and stone products
361600	Abrasive products
361700	Asbestos products
361900	Minerals, ground or treated
362000	Mineral wool
362100	Nonclay refractories
362200	Nonmetallic mineral products, n.e.c.
37 Primary iron and steel manufacturing	
370101	Blast furnaces and steel mills
370102	Electrometallurgical products, except steel
370103	Steel wiredrawing and steel nails and spikes
370104	Cold-rolled steel sheet, strip, and bars
370105	Steel pipe and tubes
370200	Iron and steel foundries
370300	Iron and steel forgings
370401	Metal heat treating
370402	Primary metal products, n.e.c.

Table B.2. (contd)

Sector Number	1992 Input-Output Sector Description
38 Primary nonferrous metals manufacturing	
380100	Primary smelting and refining of copper
380400	Primary aluminum
380501	Primary nonferrous metals, n.e.c.
380600	Secondary nonferrous metals
380700	Rolling, drawing, and extruding of copper
380800	Aluminum rolling and drawing
380900	Nonferrous rolling and drawing, n.e.c.
381000	Nonferrous wiredrawing and insulating
381100	Aluminum castings
381200	Copper foundries
381300	Nonferrous castings, n.e.c.
381400	Nonferrous forgings
39 Metal containers	
390100	Metal cans
390200	Metal shipping barrels, drums, kegs, and pails
40 Heating, plumbing, and fabricated structural metal products	
400100	Enameled iron and metal sanitary ware
400200	Plumbing fixture fittings and trim
400300	Heating equipment, except electric and warm air furnaces
400400	Fabricated structural metal
400500	Metal doors, sash, frames, molding, and trim
400600	Fabricated plate work (boiler shops)
400700	Sheet metal work
400800	Architectural and ornamental metal work
400901	Prefabricated metal buildings and components
400902	Miscellaneous structural metal work
41 Screw machine products and stampings	
410100	Screw machine products, bolts, etc.
410201	Automotive stampings
410202	Crowns and closures
410203	Metal stampings, n.e.c.

Table B.2. (contd)

Sector Number	1992 Input-Output Sector Description
42 Other fabricated metal products	
420100	Cutlery
420201	Hand and edge tools, except machine tools and handsaws
420202	Saw blades and handsaws
420300	Hardware, n.e.c.
420401	Plating and polishing
420402	Coating, engraving, and allied services, n.e.c.
420500	Miscellaneous fabricated wire products
420700	Steel springs, except wire
420800	Pipe, valves, and pipe fittings
421000	Metal foil and leaf
421100	Fabricated metal products, n.e.c.
43 Engines and turbines	
430100	Turbines and turbine generator sets
430200	Internal combustion engines, n.e.c.
44+45 Farm, construction, and mining machinery	
440001	Farm machinery and equipment
440002	Lawn and garden equipment
450100	Construction machinery and equipment
450200	Mining machinery, except oil field
450300	Oil and gas field machinery and equipment
46 Materials handling machinery and equipment	
460100	Elevators and moving stairways
460200	Conveyors and conveying equipment
460300	Hoists, cranes, and monorails
460400	Industrial trucks and tractors
47 Metalworking machinery and equipment	
470100	Machine tools, metal cutting types
470200	Machine tools, metal forming types
470300	Special dies and tools and machine tool accessories
470401	Power-driven handtools
470402	Rolling mill machinery and equipment

Table B.2. (contd)

Sector Number	1992 Input-Output Sector Description
470404	Electric and gas welding and soldering equipment
470405	Industrial patterns
470500	Metalworking machinery, n.e.c.
48 Special industry machinery and equipment	
480100	Food products machinery
480200	Textile machinery
480300	Woodworking machinery
480400	Paper industries machinery
480500	Printing trades machinery and equipment
480600	Special industry machinery, n.e.c.
49 General industrial machinery and equipment	
490100	Pumps and compressors
490200	Ball and roller bearings
490300	Blowers and fans
490500	Mechanical power transmission equipment
490600	Industrial process furnaces and ovens
490700	General industrial machinery and equipment, n.e.c.
490800	Packaging machinery
50 Miscellaneous machinery, except electrical	
500100	Carburetors, pistons, rings, and valves
500200	Fluid power equipment
500300	Scales and balances, except laboratory
500400	Industrial and commercial machinery and equipment, n.e.c.
51 Computer and office equipment	
510102	Calculating and accounting machines
510103	Electronic computers
510104	Computer peripheral equipment
510400	Office machines, n.e.c.
52 Service industry machinery	
520100	Automatic vending machines
520200	Commercial laundry equipment
520300	Refrigeration and heating equipment
520400	Measuring and dispensing pumps
520500	Service industry machinery, n.e.c.

Table B.2. (contd)

Sector Number	1992 Input-Output Sector Description
53 Electrical industrial equipment and apparatus	
530200	Power, distribution, and specialty transformers
530300	Switchgear and switchboard apparatus
530400	Motors and generators
530500	Relays and industrial controls
530700	Carbon and graphite products
530800	Electrical industrial apparatus, n.e.c.
54 Household appliances	
540100	Household cooking equipment
540200	Household refrigerators and freezers
540300	Household laundry equipment
540400	Electric housewares and fans
540500	Household vacuum cleaners
540700	Household appliances, n.e.c.
55 Electric lighting and wiring equipment	
550100	Electric lamp bulbs and tubes
550200	Lighting fixtures and equipment
550300	Wiring devices
56 Audio, video, and communication equipment	
560100	Household audio and video equipment
560200	Prerecorded records and tapes
560300	Telephone and telegraph apparatus
560500	Communication equipment
57 Electronic components and accessories	
570100	Electron tubes
570200	Semiconductors and related devices
570300	Other electronic components
58 Miscellaneous electrical machinery and supplies	
580100	Storage batteries
580200	Primary batteries, dry and wet
580400	Electrical equipment for internal combustion engines
580600	Magnetic and optical recording media
580700	Electrical machinery, equipment, and supplies, n.e.c.

Table B.2. (contd)

Sector Number	1992 Input-Output Sector Description
59A Motor vehicles (passenger cars and trucks)	
590301	Motor vehicles and passenger car bodies
59B Truck and bus bodies, trailers, and motor vehicles parts	
590100	Truck and bus bodies
590200	Truck trailers
590302	Motor vehicle parts and accessories
60 Aircraft and parts	
600100	Aircraft
600200	Aircraft and missile engines and engine parts
600400	Aircraft and missile equipment, n.e.c.
61 Other transportation equipment	
610100	Ship building and repairing
610200	Boat building and repairing
610300	Railroad equipment
610500	Motorcycles, bicycles, and parts
610601	Travel trailers and campers
610603	Motor homes
610700	Transportation equipment, n.e.c.
62 Scientific and controlling instruments	
620101	Search and navigation equipment
620102	Laboratory apparatus and furniture
620200	Mechanical measuring devices
620300	Environmental controls
620400	Surgical and medical instruments and apparatus
620500	Surgical appliances and supplies
620600	Dental equipment and supplies
620700	Watches, clocks, watchcases, and parts
620800	X-ray apparatus and tubes
620900	Electromedical and electrotherapeutic apparatus
621000	Laboratory and optical instruments
621100	Instruments to measure electricity
63 Ophthalmic and photographic equipment	
630200	Ophthalmic goods
630300	Photographic equipment and supplies

Table B.2. (contd)

Sector Number	1992 Input-Output Sector Description
64 Miscellaneous manufacturing	
640101	Jewelry, precious metal
640102	Jewelers' materials and lapidary work
640104	Silverware and plated ware
640105	Costume jewelry
640200	Musical instruments
640301	Games, toys, and children's vehicles
640302	Dolls and stuffed toys
640400	Sporting and athletic goods, n.e.c.
640501	Pens, mechanical pencils, and parts
640502	Lead pencils and art goods
640503	Marking devices
640504	Carbon paper and inked ribbons
640700	Fasteners, buttons, needles, and pins
640800	Brooms and brushes
640900	Hard surface floor coverings, n.e.c.
641000	Burial caskets
641100	Signs and advertising specialties
641200	Manufacturing industries, n.e.c.
65A Railroads and related services; passenger ground transport	
650100	Railroads and related services
650200	Local and suburban transit and interurban highway passenger transportation
65B Motor freight transportation and warehousing	
650301	Trucking and courier services, except air
650302	Warehousing and storage
65C Water transportation	
650400	Water transportation
65D Air transportation	
650500	Air transportation
65E Pipelines, freight forwarders, and related services	
650600	Pipelines, except natural gas
650701	Freight forwarders and other transportation services
650702	Arrangement of passenger transportation

Table B.2. (contd)

Sector Number	1992 Input-Output Sector Description
66 Communications, except radio and TV	
660100	Telephone, telegraph communications, and communications services, n.e.c
660200	Cable and other pay television services.
67 Radio and TV broadcasting	
670000	Radio and TV broadcasting
68A Electric services (utilities)	
680100	Electric services (utilities)
68B Gas production and distribution (utilities)	
680201	Natural gas transportation
680202	Natural gas distribution
68C Water and sanitary services	
680301	Water supply and sewerage systems
680302	Sanitary services, steam supply, and irrigation systems
69A Wholesale trade	
690100	Wholesale trade
69B Retail trade	
690200	Retail trade, except eating and drinking
70A Finance	
700100	Banking
700200	Credit agencies other than banks
700300	Security and commodity brokers
70B Insurance	
700400	Insurance carriers
700500	Insurance agents, brokers, and services
71A Owner-occupied dwellings	
710100	Owner-occupied dwellings
71B Real estate and royalties	
710201	Real estate agents, managers, operators, and lessors
710202	Royalties
72A Hotels and lodging places	
720101	Hotels
720102	Other lodging places

Table B.2. (contd)

Sector Number	1992 Input-Output Sector Description
72B Personal and repair services (except auto)	
720201	Laundry, cleaning, garment services, and shoe repair
720202	Funeral service and crematories
720203	Portrait photographic studios, and other miscellaneous personal services
720204	Electrical repair shops
720205	Watch, clock, jewelry, and furniture repair
720300	Beauty and barber shops
73A Computer and data processing services	
730104	Computer and data processing services
73B Legal, engineering, accounting, and related services	
730301	Legal services
730302	Engineering, architectural, and surveying services
730303	Accounting, auditing and bookkeeping, and miscellaneous services, n.e.c.
73C Other business and professional services, except medical	
730101	Miscellaneous repair shops
730102	Services to dwellings and other buildings
730103	Personnel supply services
730106	Detective and protective services
730107	Miscellaneous equipment rental and leasing
730108	Photofinishing labs and commercial photography
730109	Other business services
730111	Management and public relations services
730112	Research, development, and testing services, except noncommercial
73D Advertising	
730200	Advertising
74 Eating and drinking places	
740000	Eating and drinking places
75 Automotive repair and services	
750001	Automotive rental and leasing, without drivers
750002	Automotive repair shops and services
750003	Automobile parking and car washes

Table B.2. (contd)

Sector Number	1992 Input-Output Sector Description
76 Amusements	
760101	Motion picture services and theaters
760102	Video tape rental
760201	Theatrical producers (except motion picture), bands, orchestras and entertainers
760202	Bowling centers
760203	Professional sports clubs and promoters
760204	Racing, including track operation
760205	Physical fitness facilities and membership sports and recreation clubs
760206	Other amusement and recreation services
77A Health services	
770100	Doctors and dentists
770200	Hospitals
770301	Nursing and personal care facilities
770303	Other medical and health services
770304	Veterinary services
770305	Other medical and health services
77B Educational and social svc, and membership organizations	
770401	Elementary and secondary schools
770402	Colleges, universities, and professional schools
770403	Private libraries, vocational schools, and educational services, n.e.c.
770501	Business associations and professional membership organizations
770502	Labor organizations, civic, social, and fraternal associations
770503	Religious organizations
770504	Other membership organizations
770600	Job training and related services
770700	Child day care services
770800	Residential care
770900	Social services, n.e.c.
78 Federal Government enterprises	
780100	U.S. Postal Service
780200	Federal electric utilities
780500	Other Federal Government enterprises

Table B.2. (contd)

Sector Number	1992 Input-Output Sector Description
79 State and local government enterprises	
790100	State and local government passenger transit
790200	State and local government electric utilities
790300	Other State and local government enterprises
80 Noncomparable imports	
800000	Noncomparable imports
81 Scrap, used and secondhand goods	
810001	Scrap
810002	Used and secondhand goods
82 General government industry	
820000	General government industry
83 Rest of the world adjustment to final uses	
830001	Rest of the world adjustment to final uses
84 Household industry	
840000	Household industry
85 Inventory valuation adjustment	
850000	Inventory valuation adjustment
88 Compensation of employees	
880000	Compensation of employees
89 Indirect business tax and nontax liability	
890000	Indirect business tax and nontax liability
90 Other value added	
900000	Other value added
91 Personal consumption expenditures	
910000	Personal consumption expenditures
92 Gross private fixed investment	
920000	Gross private fixed investment
93 Change in business inventories	
930000	Change in business inventories
94 Exports of goods and services	
940000	Exports of goods and services
95 Imports of goods and services	
950000	Imports of goods and services investment

Table B.2. (contd)

96C Federal Government consumption expend: National defense	
9600C0	Federal Government consumption expenditures, national defense,
96I Federal Government gross investment: National defense	
9600I0	Federal Government gross investment, national defense, gross
97C Federal Government consumption expenditures: Nondefense	
9700C0	Federal Government consumption expenditures, nondefense, consumption
97I Federal Government gross investment: Nondefense	
9700I0	Federal Government gross investment, nondefense expenditures
98C State and local government consumption expend: Education	
9800C1	State and local government consumption expenditures, elementary and secondary public school systems, consumption expenditures
9800C2	State and local government consumption expenditures, public educational facilities beyond high school, consumption expenditures
9800C3	State and local government consumption expenditures, other education and libraries, consumption expenditures
98I State and local government gross investment: Education	
9800I1	State and local government gross investment, elementary and secondary public school systems, gross investment
9800I2	State and local government gross investment, public educational facilities beyond high school, gross investment
9800I3	State and local government gross investment, other education and libraries, gross investment
99C State and local government consumption expenditures: Other	
9910C1	State and local government consumption expenditures, hospitals and categorical health programs, consumption expenditures
9910C2	State and local government consumption expenditures, public welfare institutions and activities, consumption expenditures
9910C4	State and local government consumption expenditures, sanitation, consumption expenditures
9920I3	State and local government gross investment, correctional institutions, gross investment
9920C1	State and local government consumption expenditures, police, consumption expenditures
9920C2	State and local government consumption expenditures, fire fighting organizations and auxiliary services, consumption expenditures
9920C3	State and local government consumption expenditures, correctional institutions, consumption expenditures

Table B.2. (contd)

Sector Number	1992 Input-Output Sector Description
9930C1	State and local government consumption expenditures, public highways (non-capital expenditures of toll roads), consumption expenditures
9930C8	State and local government consumption expenditures, natural and agricultural resources and recreation facilities, consumption expenditures
9930C9	State and local government consumption expenditures, other general government activities, n.e.c, consumption expenditures
99I State and local government gross investment: Other	
9910I1	State and local government gross investment, hospitals and categorical health programs, gross investment
9910I2	State and local government institutions and activities, gross investment, public welfare investment
9910I3	State and local government gross investment, public sewerage systems, gross investment
9910I4	State and local government gross investment, sanitation, gross investment
9920I1	State and local government gross investment, police, gross investment
9920I2	State and local government gross investment, fire fighting organizations and auxiliary services, gross investment
9930I1	State and local government gross investment, public highways, gross investment
9930I2	State and local government gross investment, water sports and airports, gross investment
9930I3	State and local government gross investment, government-operated transit systems, gross investment
9930I4	State and local government gross investment, other commerce activities n.e.c., gross investment
9930I5	State and local government gross investment, gas and electric utilities, gross investment
9930I6	State and local government gross investment, government-operated water supply facilities, gross investment
9930I7	State and local government gross investment, redevelopment projects, gross investment
9930I8	State and local government gross investment, natural and agricultural resources and recreation facilities, gross investment
9930I9	State and local government gross investment, other general government activities, n.e.c, gross investment

Appendix C

FORTRAN Calculator

This appendix describes the input file generated by the Visual Basic program IBLD20, three FORTRAN routines used to do the calculations, and the output file that returns the calculations to IBLD20.

C.1 The Input File

The FORTRAN calculator is designed to process a data stream generated by the program ImBuild 2.0. Such a file, labeled “qminput.txt,” is shown below in the box.

```
QMIO INPUT FILE.  Data provided by IMBUILD 2.0
Run number:  1
Run title: Test3
Technology: GAX Residential
End-use sector: Residential
User name: jmr
70,10,2,6,6,6,0
70,10,2,6,6,6,0
10,4
1,2,3,4,5,10,15,20,25,30
79,99,0,0,0,0,0,0,0,0,0,0
80,99,0,0,0,0,0,0,0,0,0,0
39,99,0.7,43.8,44.07,45.41,27.4,29.0,45.7,52.287,612.938,716.091
25,99,0,-3.83,-7.5,-11.03,-12.61,-18.89,-24.46,-30.99,-38.08,-
45.05
80,99,-0.24,3.03,5.08,6.64,7.28,15.18,24.4,40.57,55.817,70.803
79,99,0,-15.6,-32.1,-48.2,-55.7,-92.23,-125.06,-154.86,-186.92,-
220.1
```

The file contains six lines of text ending with the user name. The text is followed by two sets of seven weights (the two lines beginning with 70, 10, etc.), a line that tells the calculator how many years of data are included (10) and the number of changes to read (4), and the year numbers (1, 2, etc.). These year numbers are added to 2000 so the results are reported as 2001, 2002, etc. Following the year numbers, there are two lines that report the capacity adjustments as a result of energy savings, one for electricity (79) and one for gas utilities (80). In this case, there are no changes to capacity, so all ten of the numbers are zero. Following these capacity changes are four sets of changes to the data, one for each of the sectors 39, 25, 80, and 79. Cross referencing these sectors (see Appendix A) reveals that the changes are for heating equipment (39), petroleum products, gas, and electricity sectors. For a gas heat pump, the equipment purchases and incremental gas use are positive, while this equipment saves on electricity and heating oil.

The second index number, 99, indicates that these changes are to be made to the final demand vector. If commercial equipment was considered rather than residential equipment, there would be changes to other industry sectors which would be represented by the second index number and would be one of the 98 industries identified in Appendix B.

C.2 The FORTRAN Programs

There is a FORTRAN main program, IBLDCALC, which calls two FORTRAN subroutines, QM3 and DEMAND. The main program reads in the data file described above and transfers the data to the calculating subroutine QM3, which returns the results to the main program and writes the data file that is then read by the VB program. The subroutine QM3 first reads the core data from a binary file that holds the 1992 Benchmark I-O data, then calculates the base period employment, earnings, and output. It then loops through each of the years to be processed, changing the Use matrix data or the final demand data, then recalculating the employment, earnings and output. When all years are processed, the routine transfers the results back to the main program. In the course of this processing, QM3 calls the DEMAND subroutine to make adjustments to final demands and assure that the final demand vector is appropriately rescaled. In addition, there are five other routines that multiply, add, and invert matrices, which are briefly described but not shown here.

C.2.1 The Main Program, IBLDCALC

The main program, IBLDCALC, is shown in the text boxes on the next two pages. While comments in the code explain most of the operations, this explanation will be cued to the input file, shown above. After a number of parameter and variable definitions, the program opens two files, the input file above, and the file to which the results will be printed, QM-CHG.DAT. The program then skips over the six lines of text that are not used by the calculator. The next read statements put the first set of seven weights into the variable iwgt, and the second set of weights into the variable jwgt. Since these are read in as integer percentages, they are converted to floating point decimal numbers in the loop that begins, DO 14. The next two read statements assign the number of years processed to JYR and the number of changes to be made to N.

The continuation text box begins with reading the capacity changes into the variable y and all the I-O changes into X. Two other variables, inx and indx, hold the set of industry or final demand indexes.

At this point the program has input the data stream and turns over processing to QM3. When the results are returned from QM3, they are contained in six variables: SUMJ, SUMH, and SUMQ contain the base period jobs, earnings and total output. The vectors SJ, SH, and SQ contain the calculated model results, one for each year, of which there are JYR (=10) years. The program next prints the base period values to the output file, then calculates and prints out the difference between subsequent year calculated values and the base period values to this same file.

The program is then completed, so control is transferred back to the VB program.

C.2.2. The Calculator – QM32

The lengthy text box on pages C.6 through C.8 is a listing of the calculation routine, QM3. The first set of comments explains how the naming convention changes from the main program within this routine. Parameters and variables are than defined and the binary file that contains the 1992 Benchmark I-O data is opened. The variables read from this file are D, the market share matrix (derived from the make matrix), U, the use matrix, Q, the vector of industry outputs, DF, the final demand matrix, and EI, the matrix of employment and earnings intensity by industry. The dimensionality of each of these variables can be determined from the variable definitions at the beginning of the program.

Once the I-O data is returned, the data are used to construct the base period employment, earnings and output. Base period results are constructed by multiplying industry output, the first column of Q, by two sets of industry intensities. These intensities are found in the variable EI, with the first column job intensities and the second earnings intensities. Multiplying each industry's output by these intensities yields jobs and earning, which are cumulated over all industries. Total output is also cumulated and returned in the scalar variables SUJ, SUE, and SUQ, as indicated in the comments on page C.6 in the comments after statement numbered 63. The last set of statements on this page first zero out the set of variables used to differentiate between changes to capital purchases, changes to fuel use and changes in water use. Then, beginning on page C.7, vectors are defined that allow the program to identify which changes fall into each of these categories. These are the vectors, FL, KL, and WL, consisting of zeros and ones, where the units identify the change as falling into the specific categories, with F, K, and W referencing fuel, capital and water respectively.

After these assignments, QM3 begins processing each year's data. The processing of each year begins by rewinding and re-reading the binary file that contains the I-O data, to assure that any changes will be made to the original data, since the changes to this data will be different for each year. Then after zeroing out two variables to hold the sum of final demand and the sum of changes to value added, identified by fuel type, the total to capacity adjustment is calculated for this year. That is stored in the variable ADJK. Then the changes to final demand and the use matrix are made, identifying the capital, fuel, and water final demand changes separately. The value-added changes to the use matrix are made to each of the appropriate columns, then cumulated by fuel. While specific industries have their use of the fuels adjusted within the use matrix, the impact on the fuel supplying industry is applied to the final demand vector.

Once these changes are made and results for this year have been zeroed out, I-O data are processed to create a total requirements matrix. This is done by creating a matrix, B, which is derived from the use matrix by dividing each element in the columns by that industry's output. This loop is also used to create the identity matrix ai. Then B is premultiplied by D, the market share matrix – this is derived from the make matrix. This matrix multiplication relies on a call to a matrix multiply subroutine, MMULT, which multiplies a (k x n) matrix by a second (n x m) matrix and returns a (k x m) matrix. A similar routine, MMULT1, multiplies a (k x n) matrix by an (n x 1) vector to create a (k x 1) vector. This B*D matrix (called "a" in the program) is then subtracted from the identity matrix, ai, using the subroutine MADD (which adds or subtracts, depending on the value of j, -1 in this case for subtraction). The result, which replaces the Use matrix, is then inverted using two subroutine from *Numerical Recipes*[a]. The resulting inverse (replacing ai) then is premultiplied by the market share matrix to yield the total requirements matrix, labeled t. At this point, we are ready to create the final demand vector, so a call is made to the subroutine DEMAND. This returns the final demand vector x, which is then premultiplied by the total requirements matrix, t, to yield the output vector, y. Output then is multiplied by each column of the intensity matrix to yield this year's jobs, and earnings. This period's output is then just the sum of all of the industry outputs. When each of the JYRs of data have been processed, the big loop is complete and the results are returned to the main program.

(a) Press, William H., et al. 1986. *Numerical Recipes: The Art of Scientific Computing*. New York: Cambridge University Press. For matrix inversion, see p. 38.

```
PROGRAM IBLDCALC
C
C     This program will read in data, make a few calculations, then
C   transfer operation to QM3, which does the work:  Changes the
C   Use matrix, then calculate output then multiply the outputs by
C     the employment intensities, after adjusting final demands by iwgt.
C     JYR is the number of years.  JWGT is used for capital distribution.
C   The years for analysis are then read in as 1, 2, etc., then
C   these are added to 2000 to construct the vector of years reported.
C   There are eight categories of final demand: C, I, X, M, FI, FC, SLI
C   and SLC, but just six are read in -- no X or M.  The seventh column
C   is total final demand.  If iwgt(7)=100 changes are just made to the
C   total vector.
C   This version allows up to 350 changes and 50 years of data.
C
      INTEGER MP,iyr(50)
      PARAMETER(MP=350)
      INTEGER i,j,m,indx(MP,2),l1,l2,n,iwgt(9),jwgt(9),JYR,inx(2,2)
   REAL*8 X(MP,50),SUMH,SUMJ,SUMQ,SH(50),SJ(50),SQ(50),wgt(9)
   REAL*8 wgt2(9),Y(2,50)
   CHARACTER*1 A(1)
C   WRITE(*,*) ' BEGIN EXECUTION'
      OPEN(10,FILE='QM-CHG.DAT')
   OPEN(11,FILE='QMINPUT.TXT')
      i=0
C
C     This section reads in the input file, for one technology
C     First skip the first 6 lines, then read in two sets of 7 weights
C   one for final demand (wgt), one for capacity savings (wgt2)
C     These integer values are divided by 100 to change to floating point
C
   READ(11,*) A
   READ(11,*) A
   READ(11,*) A
   READ(11,*) A
   READ(11,*) A
   READ(11,*) A
      READ(11,*) (iwgt(I),I=1,7)
   READ(11,*) (JWGT(I), I=1,7)
C       WRITE(*,*) iwgt
      DO 14, j=1,7
   k=j
   If(j.gt.2) k=j+2
   wgt(k)=iwgt(j)
   wgt2(k)=jwgt(j)
   wgt2(k)=wgt2(k)/100
14    wgt(k)=wgt(k)/100
C
C   Now read the # of years and number of changes to read in
C
   READ(11,*) JYR, N
C
C   Now read in the vector of years, to which we add 2000
C
   READ(11,*) (IYR(J),J=1,JYR)
   DO 12, J=1,JYR
12  IYR(J)=IYR(J)+2000
C
```

```
PROGRAM IBLDCALC (Continued)

C   Now read in the dollar values of the capacity savings to be
C   adjusted using wgt2
C
    Read(11,*) inx(1,1),inx(1,2),(y(1,j),j=1,JYR)
    Read(11,*) inx(2,1),inx(2,2),(y(2,j),j=1,JYR)
C
C      Now read in all changes to the Use matrix or Final Demand vector
C   If the column ID is 99, the change effects final demands.
C
10     CONTINUE
    DO 11 I=1,N
       READ(11,*,END=11) indx(i,1),indx(i,2),(X(i,m),m=1,JYR)
11     CONTINUE
C
C      N is the number of changes read in total
C      indx points to the row and column of either the USE matrix
C   or the final demand column (= 99) to change
C      and X are the change values for the JYR years
C
C      Now do the calculations
C   This version of the calculator handles capacity savings
C
       CALL QM3(X,n,indx,inx,SUMJ,SUMH,SUMQ,SJ,SH,SQ,wgt,JYR,Y,wgt2)
C
C      Now write results
C
       WRITE(10,102) SUMJ,SUMH,SUMQ
       DO 26 j=1,JYR
       DJ=SJ(j)-SUMJ
       DH=SH(j)-SUMH
    DQ=SQ(j)-SUMQ
       WRITE(10,103) iyr(j),DJ,DH,DQ
26     CONTINUE
C
C      That's a wrap
C
101    FORMAT(2I3,2I5,6F10.2)
102    FORMAT(/'     Results for Experimental Data Set '/,
      1'     Base Year Jobs (in Thousands) =',F12.1,/,
      1'  Base Year Earnings (in Millions) =', F12.1,/,
      2'    Base Year Output (in Millions) =',F12.1,//,
      3'  Year   New-Base Jobs   New-Base Earnings  New-Base Output',/)
103    FORMAT(' ',I5,F13.3,2F16.3)
C
C   WRITE (*,*) 'FINISHED'
       STOP
   END
```

C.2.3 Changing Final Demands -- DEMAND

The call to this transfers the changes to final demand read in by the main program, contained in the vectors CV, CF, CK, and CW, and the array of final demands, DF, read in from the binary file. In addition, the weights to distribute the financing charges and the weights to allocate the capacity changes are transferred in the wgt and WGT2, along with the value of the capacity changes, contained in ADJK. Finally, all the value-added variables, a total and a variable for each of the fuel changes, are transferred. The first set of statements below the initial comments zero out cumulators, aggregate the finance and capacity weights, and sum each of the components of final demand. The ninth column in this array is the total final demand vector, with the other columns corresponding to consumption, investment, exports, imports, Federal government investment and consumption and state and local investment and consumption. The next block of calculations zero out the vector of final demands to be returned and cumulates the changes to final demand partitioning these changes into capital purchases, which affect investment, and fuel and water purchases, which affect consumption.

The next block of code treats the case where final demand is treated as an aggregate rather than being concerned about the financing being distributed across components of final demand. This case first checks to see if the final weight associated with financing is one. If not, the routine branches to statement 15 near the end of the page and continues on the next page. Otherwise, the changes to final demand are combined with the total final demand vector. Recall that in the case of investment purchases, these will be positive, while energy savings will be negative. All final demand savings to consumption are re-normalized back to the original consumption total while the investments are financed according to the total finance weight, sw. Then if there are capacity adjustments to be made, these are subtracted from the "Other Investment" activity that is in row six of the final demand vector. The two scalars created to make these adjustments are used to expand (or contract) the vector of final demand so it is scaled appropriately.

```
SUBROUTINE QM3(X1,j1,l1,INX,SuJ,SuH,SuQ,SJ,SH,SQ,wgt,JYR,Y1,wgt2)
C
C   In this subroutine, j1=n, l1=INDX, and X1 is X in Imblcalc.for
C      This program will change the Use matrix, then calculate output
C      then multiply the outputs by the employment intensities
C      X1 contains j1 rows and up to 50 columns of changes to the
C   Final Demand vectors and/or the Use Matrix.
C      l1 is j1x2: first element is the row ID, second is the column ID
C
       INTEGER MP,NP,NZ
       PARAMETER(MP=98,NP=98,NZ=350)
       INTEGER j,j1,k,l,m,indx(NP),l1(NZ,2),INX(2,2)
       REAL*8 FL(NZ),KL(NZ),WL(NZ),CF(98),CW(98),CK(98)
       REAL*8 a(NP,NP),b(NP,MP),ai(NP,NP),x(NP),y(NP),sva,wgt(9)
    REAL*8 CV(NP),TFD,wgt2(9),Y1(2,50),X1(NZ,50),ADJK
       REAL*8 t(MP,MP),SuJ,SuH,SuQ,SJ(50),SH(50),SQ(50),z
       REAL*8 U(98,98),Q(98,2),D(98,98),DF(98,9),EI(98,2)
       OPEN(11,FILE='IO-92',FORM='BINARY')
C
C   Read binary file containing 1992 I-O files and EI=employment &
C   earnings intensitites
C
       READ(11) D,U,Q,DF,EI
C
C      Zero out results to be returned
C
       SUJ=0.0
       SUH=0.0
    SUQ=0.0
C
C      Now calculate employment and hours with output, Q
C
       DO 63 l=1,MP
         SUJ=SUJ+Q(l,1)*EI(l,1)
         SUH=SUH+Q(l,1)*EI(l,2)
       SUQ=SUQ+Q(l,1)
63     CONTINUE
C
C   SU"J,H.Q" are all base case numbers (jobs, earning, and output)
C   Identify Fuel, Capital, and Water changes so each can be treated
C
    WRITE(*,*) ' BEGIN BIG LOOP'
C
C      Now process changes
C      BIG LOOP:  EACH YEAR FROM 2001 TO whenever
C
       DO 40 m=1,JYR
       REWIND(11)
       READ(11) D,U,Q,DF,EI
C
C   Zero out vectors -- Final Demand changes from x1
C   TFD is the sum of all of final demand
C   sva is the sum of the value added changes
C
```

```
SUBROUTINE QM3, Continued
C
   DO 14 I=1,98
   CV(I)=0.0
   CW(I)=0.0
   CK(I)=0.0
14 CF(I)=0.0
   TFD=0.0
     sva=0.0
C
C  Clear out then identify fuel, capital and water changes
C
   DO 30 I=1,j1
   K=L1(I,1)
   FL(I)=0.0
   KL(I)=0.0
   WL(I)=0.0
   IF(K.EQ.79.OR.K.EQ.80.OR.K.EQ.25) FL(I)=1.
   IF(K.NE.79.AND.K.NE.80.AND.K.NE.81.AND.K.NE.25) KL(I)=1.
   IF(K.EQ.81) WL(I)=1.
30 CONTINUE
C
C  First construct ADJK, capacity adjustments for this period
C  Capacity savings are negative, so change sign
C
   ADJK=-1.0*(Y1(1,M)+Y1(2,M))
C
C     Make the changes to the use matrix first, J1=N.
C  Aggregate all final demand changes into CV
C  Partition CV into Fuel, Capital and Water Changes (for future use)
C  Value added is also identified as total, and by fuels
C
     DO 12 l=1,j1
     i=l1(l,1)
     j=l1(l,2)
   IF(J.EQ.99) CV(I)=X1(L,M)
     IF(J.EQ.99) CF(I)=(X1(L,M)*FL(L))
     IF(J.EQ.99) CK(I)=(X1(L,M)*KL(L))
     IF(J.EQ.99) CW(I)=(X1(L,M)*WL(L))
   IF(J.NE.99) U(i,j)=U(i,j)+X1(l,m)
     IF(J.NE.99) sva=sva-X1(l,m)
12   CONTINUE
C
C
C     Zero out results to be returned
C
     SJ(m)=0.0
     SH(m)=0.0
   SQ(m)=0.0
C
C     Construct the B, based on modified Use matrix,
C  a vector with all ones, and the identity matrix, ai
C
    DO 13 l=1,MP
        DO 11 k=1,MP
          ai(l,k)=0.0
```

```
SUBROUTINE QM3, Continued
C
          IF (Q(l,1).EQ.0.0) b(k,l)=0.0
          IF (Q(l,1).NE.0.0) b(k,l)=U(k,l)/Q(l,1)
11      CONTINUE
          ai(l,l)=1.0
          x(l)=1.0
13    CONTINUE
C
C     create a=B*D and subtract from ai
C
      CALL MMULT(b,MP,MP,D,NP,a)
      j=-1
      CALL MADD(ai,MP,MP,a,u,j)
C
C     Now invert I-BD; perform decomposition and invert by columns
C
      CALL ludcmp(u,MP,MP,indx,z)
C
      DO 17 k=1,MP
        CALL LUBKSB(u,MP,MP,indx,ai(1,k))
17    CONTINUE
C
      CALL MMULT(D,MP,MP,ai,MP,t)
C
C   Now construct final demand vector x(l)
C
   CALL DEMAND(x,CV,CF,CK,CW,DF,wgt,WGT2,ADJK,sva)
C
C   Now construct output, y
C
      CALL MMUL1(t,MP,MP,x,y)
C
C     Now construct employment, earnings and output for this year
C
      DO 23 l=1,MP
        SJ(m)=SJ(m)+y(l)*EI(l,1)
        SH(m)=SH(m)+y(l)*EI(l,2)
     SQ(m)=SQ(m)+y(l)
23    CONTINUE
C
C     Complete BIG loop and close binary file
C
40    CONTINUE
C   WRITE(*,*) ' END BIG LOOP'
      CLOSE(11)
C
C   That's a wrap
C
      RETURN
      END
```

These capacity adjustments might not be fully added back in, depending on sum of the capacity weights. This scalar adjusts the vector of final demand that will be returned and the program branches to the concluding section that makes adjustments to this vector of final demand to correct for value added changes. These changes will be considered after we handle the case where final demand is not handled as a single vector, which begins on page C.10.

In the event that weights are specified, financing of capital expenditures (i.e., the source of these funds) is to be extracted from other final demand sectors according to those weights. Similarly, if weights are defined for capacity savings, these must be redistributed (i.e., returned) to the categories of final demand specified by the weights. Either of these reallocations will alter the distributions of the separate categories of final demand which will, in turn, affect the aggregated final demand vector slightly differently than if the total vector was adjusted. Recall that all fuel savings to consumption are redistributed back to consumptions. These adjustments begin with the creation of a new variable, Y, which is structured like the eight columns of final demand.

The first step is to "add" (usually subtract, since these costs are saved) the fuel and water expenditure changes to consumption expenditures and the capital expenditures to the investment column. Then these expenditures are added to each of the columns of final demand. First we adjust consumption to reflect that savings are reallocated. Then a vector of adjustment scalars is constructed that allocates the cost of the equipment among the components of final demand, according to the weights. Then each component of final demand is scaled to adjust for the changes made to investment and new totals (sy1) are calculated.

The next step adjusts for capacity changes. Capacity savings reduce "other" (heavy industrial) construction, which is row six of the investment vector. The sum of this vector is also adjusted and these savings are reallocated to other sectors according to the vector wgt2. This reallocation requires the calculation of another set of adjustment multipliers, which are used to scale each of the final demand vectors again. After these two adjustments have been made, the eight columns of final demand are added to construct the total final demand vector, x, and cumulate the sum in the scalar SCV. The remaining task is the adjustment for changes in value-added if changes were made to the use matrix. (The continuation statement 45 shows the entry point from the section where final demand is treated as a single vector; recall that the same variable, SCV, was used to sum total final demand.) A scaling multiplier, z1, is constructed by adding the sum of value added, SVA, to SCV, then dividing by SCV. Z1 is then used to multiply each element of the final demand vector x, which is then returned to QM3.

```
SUBROUNTINE DEMAND(x,CV,CF,CK,CW,DF,wgt,WGT2,ADJK,sva,svp,sve,svg)
C
      INTEGER MP
      PARAMETER(MP=98)
      INTEGER m,I,J,K,L
   REAL*8 CF(MP),CK(MP),CW(MP),sw,sw1,scf,s2w,s2w1,scf,sck,SVA
      REAL*8 x(MP),ADJK,WGT2(9),CV(MP),wgt(9),DF(MP,9),Z1,ztot
   REAL*8 SDF(9),SCV,Y(MP,9),x1(MP),z(9),sy(9),sy1(9),T,T1
C
C  This routine calculates changes to final demands and adjusts
C  these to scale depending on the wgt vectors.  This routine
C  returns a vector x, used to calculate output and employment.
C  CV contains all the changes to the use matrix and final demand;
C  DF is the original set of final demands; ADJK is the change to
C  capacity, and sva is the sum of changes to value added (in the
C  use matrix).  sw is the sum of weights for capital financing.
C
C  Zero out all required variables
C
   sw=0.0
   sw1=0.0
   s2w=0.0
   s2w1=0.0
```

```
SUBROUTINE DEMAND (Continued)

SCF=0.0
SCK=0.0
SCV=0.0
Ztot=0.0
DO 10 J=1,9
SW=SW+WGT(J)
IF(J.LT.9) sw1=sw1+wgt(j)
IF(J.LT.9) s2w1=s2w1+wgt2(j)
S2W=S2W+WGT2(J)
sy(J)=0.0
sy1(j)=0.0
z(J)=0.0
SDF(J)=0.0
DO 10 I=1,MP
Y(I,J)=0.0
10  SDF(J)=SDF(J)+DF(I,J)
C
C   Zero out final demand vector
C
DO 11,I=1,MP
x1(I)=0.0
x(I)=0.0
SCK=SCK+CK(I)
SCF=SCF+CF(I)+CW(I)
11  SCV=SCV+CV(I)
C
C   The case where final demand is treated as a single vector.
C
IF (sw1.NE.0.0) GO TO 15
DO 12 I=1,MP
12  X(I)=DF(I,9)+CV(I)
X(6)=X(6)-ADJK
Z1=(SDF(9)-(SCK*sw)+ADJK*S2W)/SDF(9)
Z(1)=(SDF(9)-SCF)/SDF(9)
C
C   Reallocate consumption savings and capital expenses
C
SCV=0.0
DO 13 I=1,MP
X(I)=X(I)*Z(9)
13  SCV=SCV+X(I)
C
C   X is the modified final demand vector
C   SCV is now the sum of the new (or old) FD vector
C   Branch to the value added correction
C
GO TO 45
15  CONTINUE
C
C   Create Y, which contains the changes to final demand, then
C   subtract financing for capital purchases
DO 20 I=1,MP
Y(I,1)=Y(I,1)+CF(I)+CW(I)
Y(I,2)=Y(I,2)+CK(I)
DO 20 J=1,8
Y(I,J)=Y(I,J)+DF(I,J)|
```

```
SUBROUTINE DEMAND (Continued)
C
20  SY(J)=SY(J)+Y(I,J)
C
    Z(1)=(SY(1)-SCF)/SY(1)
    sy1(1)=0.0
    DO 25 J=2,8
    sy1(J)=0.0
25  Z(J)=(SY(J)-wgt(J)*SCK)/SY(J)
C
C   Now adjust each FD vector by z and get new totals
    DO 22 I=1,MP
    Y(I,1)=Y(I,1)*Z(1)
22  SY(1)=SY(1)+Y(I,1)
C
C   Consumption adjustment complete; adjust for investment
C
    DO 25 J=1,9
    Z(J)=(SY(J)-wgt(J)*SCK)/SY(J)
25  SY(J)=0.0
C
C   Now adjust each FD vector by z and get new totals --
C   recall that the 9th column is the difference between SFD and
C   the weighted sum of the first eight columns.
C
    DO 30 I=1,MP
    DO 30 J=1,8
    Y(I,J)=Y(I,J)*Z(J)
30  sy1(j)=sy1(j)+Y(I,J)
C
C   Now adjust for capacity changes, if needed
C
    IF(ADJK.EQ.0.) GO TO 50
    Y(6,2)=Y(6,2)-ADJK
    sy1(2)=sy1(2)-ADJK
    DO 35 J=1,8
    Z(J)=(sy1(J)+(WGT2(J)*ADJK))/sy1(J)
    DO 35 I=1,MP
35  Y(I,J)=Y(I,J)*Z(J)
C
C   Now aggregate final demand and adjust for value added
C
    SCV=0.0
    DO 40 I=1,MP
    DO 41 J=1,8
    SCV=SCV+Y(I,J)
41  X(I)=X(I)+Y(I,J)
40  CONTINUE
C
45  CONTINUE
    Z1=(SCV+SVA)/SCV
    DO 42 I=1,MP
42  X(I)=X(I)*Z1
C
C   That's a wrap
C
    RETURN
    END
```