

# ASSESSING THE JOB CREATION POTENTIAL OF ENERGY CONSERVATION INVESTMENTS

Charles J. Kibert<sup>1</sup>, Ph.D., P.E., LEED-AP, Richard Fobair<sup>2</sup>, MSBC, LEED-AP, and James Sullivan<sup>3</sup>, Ph.D., LEED-AP

## ABSTRACT

*This paper presents a model for assessing the job creation potential of energy conservation investments resulting from construction related installation activities. It also addresses indirect job creation in manufacturing resulting from the purchase of energy conservation related equipment and materials. The model is based on construction estimating techniques and is designed to be flexible for the purpose of addressing job creation due to a wide variety of energy conservation investments. It uses a reverse estimating technique that begins with the scale of the energy conservation investment and then backs out the contractor's profit and overhead and then the cost of equipment/materials. Next, the model allocates the labor portion of the investment based on loaded labor rates and typical crew make-up. The input variables, including worker skill level, allocation of worker time per skill level, regional effects on job creation, rate of pay, and worker benefits, can be modified for the purpose of fine-tuning the model for geographic region and specific energy conservation programs. Outputs from the model include construction job creation and manufacturing job creation.*

## KEY WORDS

job creation, energy conservation, building retrofit, weatherization, construction, manufacturing

## INTRODUCTION

Job creation is an important issue among environmental advocates. Numerous studies have been conducted to determine the employment impacts generated by renewable energy, green building, building reuse, and 'sustainable economy' investments. Some company case studies focused on direct job creation, while others attempted to quantify the indirect impacts of jobs created by linking energy conservation investments to job creation in the community and in manufacturing.

A review of previous studies linking energy conservation investments to job creation was performed to determine their applicability to this research. Several papers and studies cited numbers of jobs created that could be attributed to energy conservation investments; however,

<sup>1</sup>Professor, M.E. Rinker, Sr. School of Building Construction, College of Design Construction & Planning, University of Florida, ckibert@ufl.edu, P.O. Box 115703, Gainesville, FL, 32611-5703

<sup>2</sup>Graduate Research Assistant, Ph.D. Student, M.E. Rinker, Sr. School of Building Construction, College of Design Construction & Planning, University of Florida, rfobair@ufl.edu, P.O. Box 115703, Gainesville, FL, 32611-5703.

<sup>3</sup>Charles R. Perry Assistant Professor, M.E. Rinker, Sr. School of Building Construction, College of Design Construction & Planning, University of Florida, sullj@ufl.edu, P.O. Box 115703, Gainesville, FL, 32611-5703.

none of these studies described explicitly how they defined a job nor how job creation was calculated. The lack of these important details can hinder policy-making and indicate a need for a more systematic analysis that clearly develops the cost-benefit relationship between energy conservation investments and job creation.

This research defined a 'job' and developed a model that can be used to predict the number of direct and indirect jobs created by an investment in energy conservation. Direct jobs are construction and installation activities. Indirect jobs are manufacturing activities. A range of variables thought to be important in direct job creation are considered in the model: type of energy conservation activity; construction trades employed for each activity; overhead, profit, callback and warranty assumptions for the various subcontractors engaged in energy conservation activities; general crew make-up of construction trades; labor burden for each type of subcontractor; split of investment between labor and equipment/materials; type of building being upgraded (residential/commercial/institutional); value of a trade's work in relation to total building cost; percent of a trade's value by building type retrofitted; and, region of the country. Analysis of the equipment/materials portion of the investment was performed to determine the level of job creation in manufacturing. It does not include job creation due to materials extraction and processing nor due to the effects of more income in the community.

Three methods were developed to determine the number of jobs created for the installation phase of energy conservation investments. Method 1 assumes the entire energy investment is for one type of energy conservation activity, for example installing additional insulation, and that only one trade subcontractor is involved. Method 2 assumes the entire energy investment is for one building type, and each energy conservation activity is weighted to distribute the energy investment over CSI MasterFormat (1995 edition) divisions. This approach utilizes a default 50%–50% split for labor and equipment/materials. Method 3 is similar to Method 2. It assumes the entire energy conservation investment is for one building type and weights each trade to distribute the energy conservation investment over CSI divisions; however, Method 3 emphasizes the division between labor and materials in the installation phase by providing a split based on experience of the investigators for each CSI division as they directly or incidentally relate to the energy efficiency retrofit. Although the model can be used for specific regions of the U.S., in this paper the results are for national average job creation.

## BACKGROUND

This research was based on the assumption that energy conservation activities are very similar to construction activities because the worker skills are identical. Indeed for the most part, construction industry subcontractors also engage in remodeling and retrofitting activities using the same workers. For instance, the *National Weatherization Training & Technical Assistance Plan* (U.S. Department of Energy, Office of Weatherization & Intergovernmental Program for the Weatherization Assistance Program 2009) indicates weatherization 'installers' may be contractors. In addition, *Core Competencies for the Weatherization Assistance Program* (The Weatherization Trainers Consortium 2009) describes the work of an 'installer' and 'crew chief.' An installer is equivalent to a semi-skilled construction worker who possesses some knowledge of several trades. The description of 'crew chief' is similar to 'installer' but with management duties. The 'crew chief' is equivalent to a 'working foreman' in construction.

The model in this research, based on construction estimation techniques, calculates the number of full-time equivalent (FTE) jobs created based on dollars of energy conservation

investments. FTE jobs are based on an 8-hour workday and assumed to be located within the United States. The benefits of using FTE jobs are two-fold: 1) the procedure is consistent with the Office of Management and Budget (Johnson 2010), and 2) it provides an aggregate measure that encompasses less than full-time employment.

Some attempts at calculating the job creation potential of investments in energy conservation determine the 'economic multiplier', that is, how different combinations of purchases and investments generate more economic activity than the initial investment itself. The economic multiplier effect occurs because dollars invested cascade through the local economy. Additionally, money not spent on energy purchased from outside the community remains in the community and results in more money available to local residents, increasing job creation by indirect effects. The economic multiplier was not considered in this research; instead, the focus was to create a fully developed model that conservatively estimates job creation based on industry norms. Finally, the loss of jobs due to lower energy consumption was not considered in this research. The number of jobs in other market sectors attributable to fewer power plant jobs was generally considered to be negligible.

## RELATED STUDIES

Although there is a significant body of literature on the economics of job creation, there is not a great deal of literature specifically about the impacts of energy conservation investments on job creation. Other studies indicate that energy conservation investments produce jobs, either directly or indirectly; however, many of the studies did not define 'jobs' or the metric used by other studies was something besides dollars. In fact the inconsistency of the definition of 'jobs' and the undeveloped relationship between non-dollar based metrics and jobs created can be confusing. The following are summaries of some of the major studies on the subject of job creation as they related to energy conservation investments.

### *Energy Dollars*

A U.S. Department of Energy study (Laitner 1996) discussed *energy dollars*, which are the funds a community spends on energy each year. The hypothesis was that reducing energy consumption resulted in savings. This assumed that energy was generated outside the community, which resulted in the savings remaining in the community for other types of consumption. This additional consumption created indirect jobs. In general, each \$1.00 used to purchase local consumer goods produced \$1.90 of economic activity in the local economy because the store paid its employees who in turn purchased more goods using the same \$1.00. The economic activity of \$1.00 invested in petroleum products was about \$1.51; for utility services \$1.66; and, for energy efficiency \$2.23.

### *Non-Energy Benefits*

Schweitzer and Tonn (2002) suggested there were substantial energy and non-energy benefits from weatherization. For every dollar of federal funding invested in weatherization, the study predicted \$1.83 worth of energy benefits and \$1.88 worth of non-energy benefits. Non-energy benefits were divided into three major categories: ratepayer benefits, household benefits, and societal benefits. Societal benefits can be classified in part as economic, which includes job creation. The researchers identified that weatherization expenditures can directly result in new jobs, but the number and type of jobs is not quantified.

### ***Non-Monetary Benefits***

Tonn and Peretz (2007) discussed the benefits, implementation difficulties, cost-effectiveness, and model programs of state-level energy efficiency programs. They identified numerous non-monetary benefits, including the creation of jobs and avoidance of job destruction. The results indicated energy efficiency initiatives create jobs. In fact, job creation numbers of several state programs were provided; however, insufficient explanation was given about how the numbers were calculated and what the numbers represent. Sometimes the numbers were discussed in terms of revenue and other times in terms of costs. A clear distinction was not made between the construction industry and manufacturing industries that support construction and all other industries falling under the umbrella of the energy efficiency sector. Furthermore, the job creation results provided by the state programs did not indicate if the jobs were full-time or less than full-time. Consequently, the number of jobs created per level of investment could not be determined.

### ***Job Creation—Iowa Study***

Berry (1997) summarized an Iowa Study (The Statewide Low-Income Collaborative Evaluation (SLICE) of Iowa 1994) that used input-output analysis to measure economic activity and job creation benefits. The SLICE investigators concluded \$240,000 worth of additional economic activity was produced for each million dollars of program spending and determined 5.6 additional jobs were supported from the additional economic activity. This translates to about 23 jobs per \$1 million invested. Specific dollar values were not assigned to the non-energy benefits; therefore, it was not possible to determine if the additional economic activity supporting the additional jobs was fully or only partially funding the jobs.

### ***Job Creation—Louisiana Energy Fund***

Kaiser et al. (2004) reviewed, among other things, the employment that could be created by The Louisiana Energy Fund, a public-private endeavor designed to provide publicly funded institutions with low cost, tax exempt financing to implement energy and water conservation projects in Louisiana. The report stated that for a total investment of \$13.7 million by the Fund in projects across seven parishes, the associated employment increase was 297 jobs, or about 22 jobs per \$1 million invested. They also predicted the creation of 16.2 jobs for ongoing maintenance of the systems, costing approximately \$490,000 annually, which approximates to 33 jobs per million dollars. The report does not describe the methodology employed in this research and does not describe the types of energy conservation activities, types of jobs, nor how the job creation numbers were determined.

### ***Job Creation—Energy Saving Trust***

Wiltshire et al. (1998) reported on the *Standards of Performance* program run by the United Kingdom Energy Saving Trust (EST). It was designed to stimulate the provision of cost-effective energy saving measures throughout all sectors of the electricity franchise market. The scheme was funded via a customer levy of up to £1 per year for each customer, amounting to a total of £25 million over a four year period (1994-1998). The Public Electricity Suppliers (PESs) were required to give priority to schemes likely to exert general downward pressure on the charge per kWh to consumers in order to encourage demand side management measures. The report calculated that the program had generated 394 full time jobs per year over the four

years, of which approximately half were in installation and half are in project management and administration. This corresponds to approximately 10 direct jobs per \$1 million invested. The report also calculated that a total 67 indirect jobs have been generated.

### ***Development and Construction Contributions to the US Economy***

Fuller (2007) examined the ripple effect of construction spending across the life cycle of development, from the initial idea creation of a development project, through construction, and forward during ongoing maintenance and operations. He concluded that \$1 million in new construction spending supported 28.5 annual full-time jobs. He further states the multiplier effect of a dollar invested in construction is 3.42.

### ***Job Creation—National Association of Home Builders (NAHB)***

Fei Liu and Emrath (2008) report that the NAHB estimated 1.11 (FTE) jobs were created per \$100,000 spent on residential remodeling. This corresponds to 11.1 jobs per \$1 million. Of the 11.1 jobs created per \$1 million, construction jobs equal 5.4, manufacturing jobs equal 1.8, and other jobs equal 3.9. This estimate is based on national averages of home values.

## **METHODOLOGY**

The approach taken to determine the number of jobs created by energy conservation investments uses “Jobs Created per \$1 Million Investment” as the basis for the analysis. Any other level of investment can be easily translated into the number of jobs it would create. The basic process of reverse estimating an energy conservation investment takes into account actual industry norms for allocating project costs into labor and materials and continuing this process at the various stages in the supply chain. For the purposes of this study two stages in the supply chain, the installation phase and the manufacturing phase, are taken into account. Typical energy conservation activities are assessed for their job creation effects. These include insulation, weatherization, and the retrofit of heating, cooling, and lighting systems. Commercial, institutional, and residential energy conservation activities are addressed.

### ***Energy Conservation Investment Deconstruction Process***

The flow chart in Figure 1 shows the process for reverse estimating energy conservation investments into jobs. The emphasis of the trade approach is on the subcontractor.

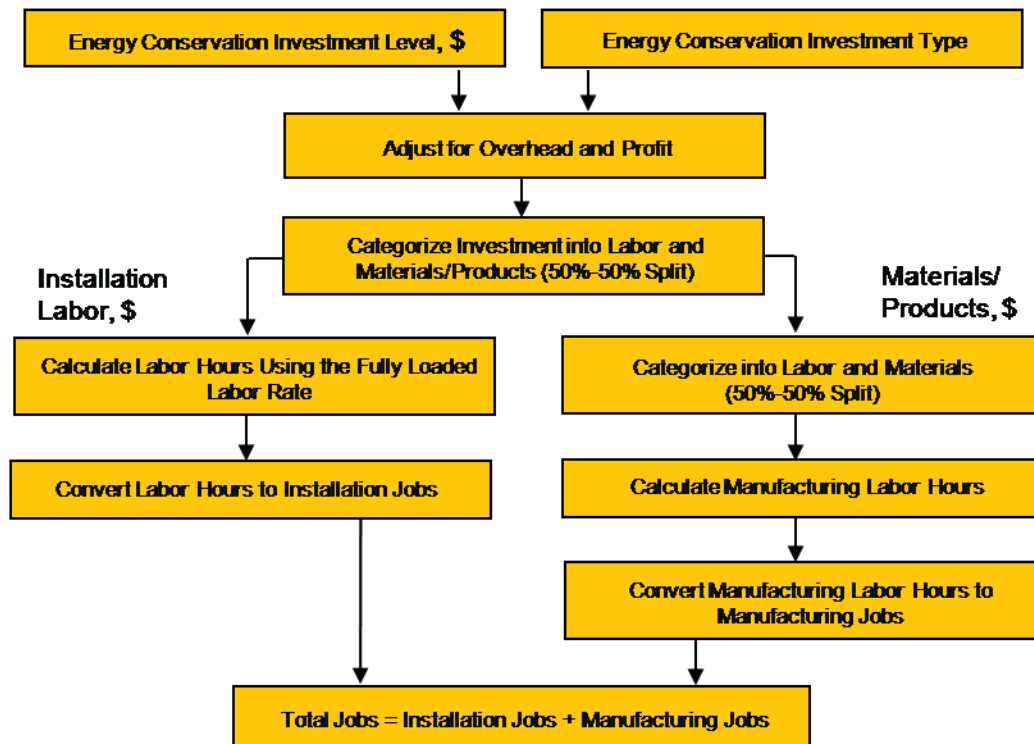
The analysis starts with determining the level of investment and the type of investment. The type of energy conservation investment is needed to establish the types of workers required for the particular project. Generally, workers engaged in projects requiring higher skill levels and education are paid more than workers in industries requiring less sophisticated skills. Workers retrofitting heating, air-conditioning, and electrical systems will be compensated at higher rates than those engaged in insulation, weatherization, and retrofit of windows/doors.

### ***Determining the Base Energy Conservation Investment***

When the level and type of energy conservation investment has been established, the base energy conservation investment must be determined by deducting the overhead and profit utilized by the industry. For example, starting with an investment of \$1 million, and assuming 10% profit and 10% overhead, the remaining investment is about \$0.8 million. Overhead and profit calculations are based on estimation techniques typically used by General Contractors; that is, costs are subtotaled and overhead and profit is applied to that amount. Subcontractors



**FIGURE 1.** Schematic of Method 1—Per Trade.



use various methods to determine overhead and profit, but the standard for backing out the quantity of money available directly for the energy conservation project is the same. For example, a subcontractor may quote an “all inclusive” rate per hour or per unit of work, but these rates can be reconfigured to labor and materials plus overhead and profit.

### ***Estimating Assumptions: Demolition and Incidental Work***

Retrofitting an existing building will require demolition, such as removing ceiling tiles to access HVAC ductwork or removing old ductwork to replace with new ductwork. The cost for demolition is included in each estimate by adding a square foot cost as a demolition line item. Demolition does not imply all old systems being retrofitted have to be removed. On the contrary, parts of some systems may be left in place, such as ductwork or light fixtures. New ductwork may be routed around old ductwork, and new light fixtures may be installed below old fixtures if ceiling height allows it. Demolition costs are held to a minimum and only necessary demolition work is performed. Demolition not specifically performed by a trade is performed by the general contractor. Incidental work is work performed as needed to finish a building after the retrofit is complete. Examples of incidental work to be performed would be drywall patching, wood trim repair, and painting.

### ***Breakdown of Energy Conservation Investment into Labor and Equipment/Material Allocations***

The energy conservation investment must be broken down into labor and equipment/material allocations. In general the allocation between installation labor and equipment/materials varies depending on the scope of work for each type of subcontractor. Subcontractors that install

more technically sophisticated products, such as high SEER air-conditioning units, may have a bias toward material/product costs while those with unsophisticated products, such as cellulose insulation, could have a bias toward labor. For simplicity, Method 1 assumed a 50%-50% split between labor and materials.

### ***Conversion of Labor Allocation into Jobs***

For the purposes of this research, a job is defined as one full year of employment. A full year of work would be 2,080 hours assuming 40 hours per week for 52 weeks. With 2 weeks paid vacation and 10 paid holidays, the actual working year is 1,920 hours. The actual working year (1,920 hours) is used as the starting point to calculate FTE annual jobs.

The base wage rate is then added to health, vacation, holiday, and pension benefits plus overhead on labor to determine the fully loaded labor rate. Fully loaded means the base labor rate has been adjusted to include benefits for the worker plus any overhead on labor such as health and/or worker's compensation insurance. Worker benefits may vary across regions of the country, but the model developed in this research can be adjusted to account for differing practices.

The labor portion of the investment is divided by the fully loaded labor rate to determine the number of hours of labor generated per year. For the base case, dividing the number of labor hours by 1,920 is the number of annual jobs created. As an additional refinement, the crew size for a typical energy conservation effort is determined to allocate wages across four levels of craftspeople: supervision, skilled, semi-skilled, and unskilled. This reflects the standard approach used by construction industry subcontractors in organizing crews to perform typical energy conservation tasks.

### ***Conversion of Equipment/Materials Allocation into Manufacturing Labor***

The equipment/materials allocation has a number of jobs that can be associated with it. Similar to the installation phase where a subcontractor must determine the base energy conservation investment by estimating labor hours and equipment/materials, the manufacturer must also determine the split between labor and equipment/materials cost. The labor and equipment/materials split may vary greatly depending on the type of equipment and materials being manufactured. For example, a relatively simple product like cellulose insulation made from recycled content will have a very different ratio than a technologically sophisticated product such as a heat pump. In the same pattern as the installation phase, the overhead and profit for manufacturing must be first determined, and then the manufacturer's labor and material split can be applied to the factory work. As an initial estimate, this research assumes a 50%–50% split as the starting point in the model.

### ***Effects of Building Type on the Model***

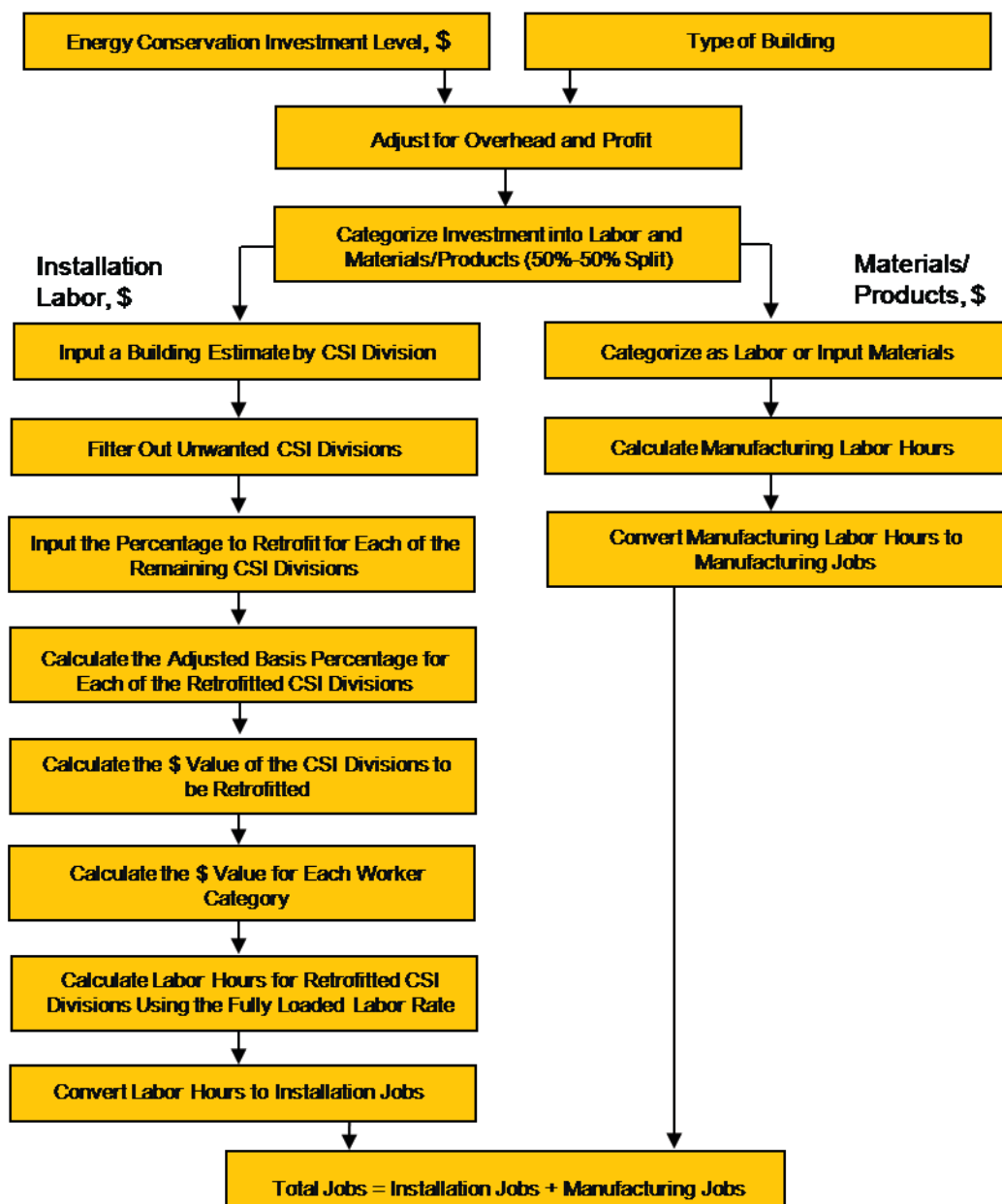
One of the potential variables for the model developed in this research is the effect of building type on the number of jobs created for a level of investment in energy conservation. For a given level of investment, some typical questions might be: Is there a difference in the number of jobs created insulating a home versus a commercial building? Is there a difference in jobs created in retrofitting a home's air-conditioning system with a high SEER system versus retrofitting a commercial building HVAC system with a high Coefficient of Performance (COP) system? Are there differences in jobs created by retrofitting home windows with high performance glazing versus those of a commercial building? The research in this study addressed this issue for commercial, institutional, multi-family residential and single-family residential.

As may be expected, some commercial/institutional building retrofits require additional skills not needed in single-family residential or other buildings using residential scale systems. Additionally, there are issues to be addressed with larger buildings such as increased heights and different types of windows, doors, and roofing systems. In order to account for these differences, job creation by type of building was considered in this research.

### ***Additional Approaches Based on Building Type***

The model incorporated type of building by utilizing a square foot cost estimate by CSI division of the building type to be retrofitted. Nine categories of buildings were considered. Costs for the buildings were based on estimates from ENR Square Foot Costbook, 2007 Edition

**FIGURE 2.** Schematic of Method 2—Per Building Type.



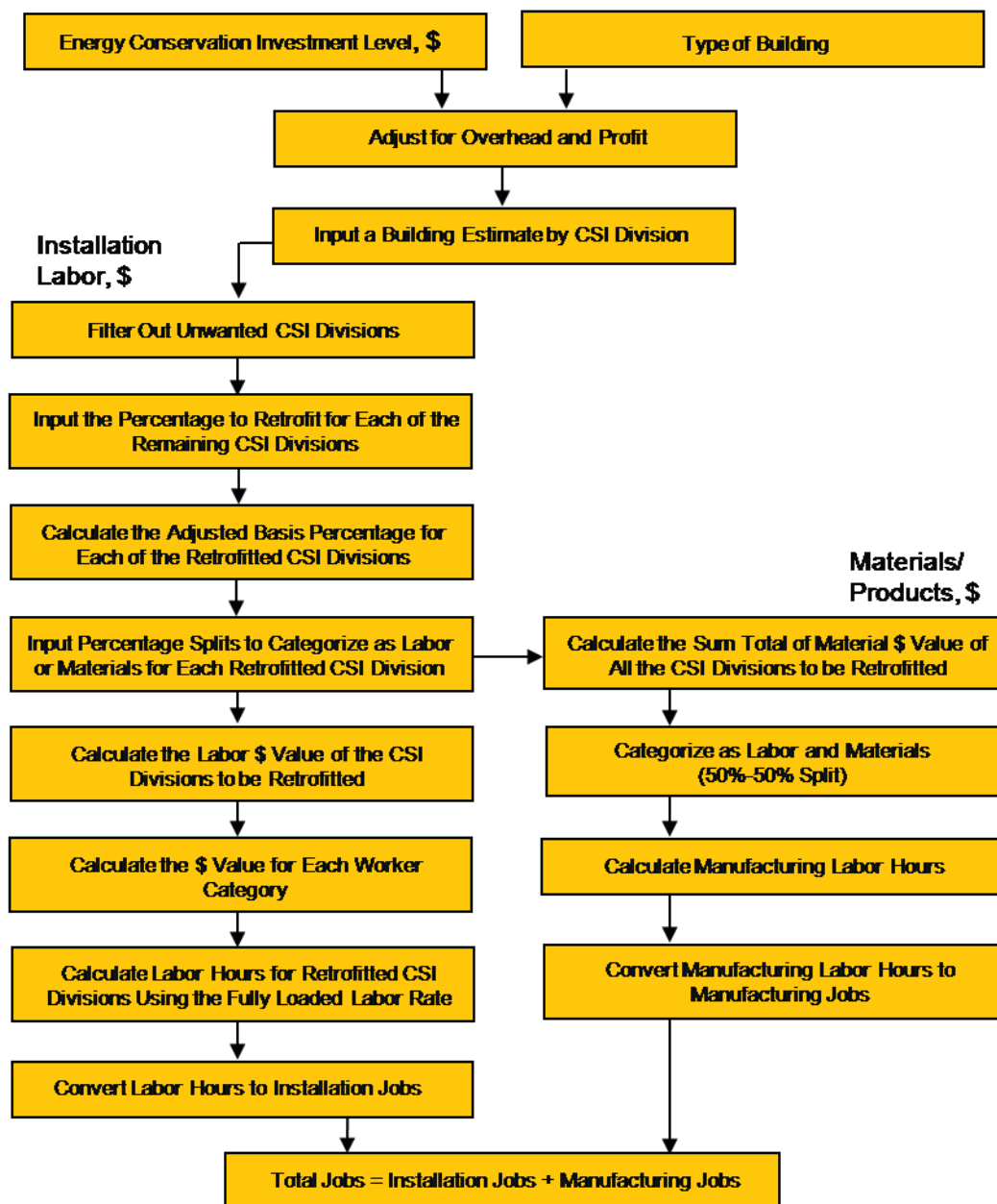


(Design and Construction Resources 2006), and adjusted based on the experience of the investigators from direct involvement on health care, school, institutional, retail and single family residential projects. The flow charts in Figure 2 and Figure 3 show the processes for deconstructing energy conservation investments into jobs.

Allocation between labor and equipment/materials also varies depending on type of building and its characteristics. Residential single family will differ in labor and equipment/materials from residential institutional. Likewise, low-rise offices will vary in labor and equipment/materials from health care.

Allocation of labor and equipment/materials using a general 50%–50% split was based on published sources and investigators' experience. RS Means Estimating provides a residential

**FIGURE 3.** Schematic of Method 3—Percentage Split by CSI per Building Type.



single family estimate that is approximately a 50%–50% split between labor and materials. For commercial buildings, the U.S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design—New Construction 2.2 (LEED-NC 2.2) guidelines for material credits allow a material default of 45% of construction cost (for divisions 2–10), excluding division 11 (equipment/appliances), division 12 (furnishings), division 14 (conveying systems), division 15 (mechanical) and division 16 (electrical) which are equipment/material heavy (USGBC 2006). If LEED guidelines included divisions 11–16 in its materials calculation, the material cost would be greater than 45%. Thus, based on the investigators' experience a general 50%–50% split was chosen as the starting point; however, project specific factors may require adjusting the split  $\pm$  5%. The base model uses this 50%–50% split as a starting point for commercial and residential construction.

Method 2 also utilizes the general 50%–50% split; however, Method 3 allows the user to choose the input labor and equipment/material splits for each individual CSI division based on the user's experience. All CSI divisions are adjustable, regardless if the division is directly or incidentally related to the energy efficiency retrofit. The labor/material splits by CSI division used in the model for the initial results are based on industry experience of the investigators.

## RESULTS AND ANALYSIS

The model developed in this research was used to produce results for three separate methods to calculating jobs. Table 1 summarizes the results based on National averages. The knowledge of the construction industry required to use the methods contained in the model progressively increases. Method 1 requires the least construction knowledge and Method 3 requires the most construction knowledge. Methods 1 and 2 are best suited for broad-based policymaking. Method 3 is recommended for evaluating specific projects seeking public funding in conjunction with an economic development program. PayScale (2007) and U.S. Bureau of Labor Statistics (2006) were used as sources for manufacturing wage rates. The ranges provided encompass both sources; however, the PayScale data is more specifically related to equipment/materials for construction purposes and the U.S. Bureau of Labor Statistics data is more general for all types of manufacturing.

**TABLE 1.** Jobs Created per \$1 Million Investment.

Jobs Created per \$1 Million Investment								
		Required	Installation	Installation	Manufacturing		Total	
		Construction	Jobs	Jobs	DOL	PayScale	DOL	PayScale
		Knowledge	Range	Average	Average		Average	
Method#1	Per Trade	Least	8-11	9.54	3.14	5.51	12.68	15.05
Method#2	Per Type of Building	More	9-11	9.59	3.14	5.51	12.73	15.1
Method#3	Percentage Split by CSI per Building Type	Most	12-14	12.93	2.55	4.38	15.48	17.31

The results of Method 1 indicate a range of 8 to 11 installation jobs and 3 to 6 manufacturing jobs per \$1 million investment in energy conservation. Consequently, the total job creation, based on National averages, ranges from 11 to 17 jobs. When examining results based on region and type of subcontractor, the range of jobs varied from 11 to 18. The difference in ranges between the National average versus region and type of subcontractor is due to variances in wage rates given that Method 1 emphasizes the trade performing the work.

The results of Method 2 indicate a range of 9 to 11 installation jobs and 3 to 6 manufacturing jobs per \$1 million investment in energy conservation. Consequently, the total job creation, based on National averages, ranges from 12 to 17 jobs. When examining results based on region and type of building, the range of jobs varied from 12 to 17, which matches the National average results.

The results of Method 3 indicate a range of 12 to 14 installation jobs per \$1 million investment in energy conservation. Manufacturing jobs per \$1 million investment in energy conservation range from 2 to 5. Consequently, the total job creation, based on National averages, ranges from 14 to 19 jobs depending on manufacturing wage rates. When examining results based on region and type of building, the range of jobs varied from 14 to 20. The differences in ranges between the National average versus region and type of building is due to variances in wage rates, a function of the split between labor and materials, and the magnitude of work per CSI division dependent upon the type of building.

The results vary little between Method 1 and Method 2. Although the model changes from attributing the entire investment to one trade to dividing the investment pro rata based on ENR cost data (Design and Construction Resources 2006) over multiple trades per type of building, Methods 1 and 2 each utilized a 50%–50% labor and material split. Method 3 results are noticeably different from Method 1 and Method 2, but this is to be expected given that the user has a greater level of control over the percentage split between labor and materials. With the ability to customize labor and material splits instead of defaulting to a 50%–50% split, more accurate job numbers can be forecast; however, greater working knowledge of construction costs is necessary.

Analyzing the job creation numbers of other studies is problematic. At times, the word choice describing job creation can be ambiguous. For example, jobs are presented as ‘supported by’ or ‘resulted from’ a program; however, one does not know if the jobs were directly or indirectly created. Other inconsistencies existed in the metrics used to present the results. Across studies, the dollar amount indicated is not always the same measure of accounting; the measure changed between revenues and costs. Furthermore, complications of common denominator arise when the cost of an investment does not clearly explain if the investment is the total business cost or only some fraction. Some studies presented only the job creation results of a program without discussing the monetary implications. Faced with insufficient information, a rate illustrating jobs created per level of investment dollar could not be determined. Clearly, spending money on energy conservation measures has its benefit, which includes job creation; however, it is also important to know the cost of creating these jobs.

Due to the problems previously noted, the results of other studies and research cannot readily be compared to the results of this research. For example, Kaiser et al. (2004) predicted 22 jobs per \$1 million invested in energy conservation projects while the Iowa Study (The Statewide Low-Income Collaborative Evaluation (SLICE) of Iowa 1994) translates to 23 jobs. It is unclear from the information in these studies which of these jobs are direct jobs, which

are due to manufacturing, and which may be due to the effect of shifting energy dollars to the community. The Wiltshire et al. (1998) report provides results that appear to be based on the type of approach in this research, the result being that for a £25 million investment (\$39.5 million at the exchange rate of 1.58 dollars per pound sterling at that time), 10 direct jobs were produced per \$1 million invested. This is exactly the same level of employment predicted by the model developed for this analysis. This seems to be a reasonable number based on industry standard practices. If a very large national investment in energy conservation were made which required that a substantial portion of the investment were to be devoted to job training, wages would be generally lower, at least temporarily, and the number of jobs would be correspondingly higher for this time frame. For the general conditions today, the number of jobs indicated as being produced in this research is thought to be both conservative and reasonable.

## CONCLUSIONS AND RECOMMENDATIONS

This research produced a model for estimating job creation due to energy conservation investments. It considers direct job creation due to installation activities and indirect job creation in manufacturing the materials and products used by installation subcontractors in the final stage of the supply chain. It does not consider job creation beyond the final stage in the supply chain nor does it consider the economic impacts of keeping money in the community with the possibility of creating even more jobs. It is designed to conservatively estimate the number of jobs created based on reasonable assumptions, using actual data from contractors engaged in energy conservation projects. The model employs construction industry norms for wages, benefits, overhead, profit, callbacks, and warranty work and backs out the number of jobs created as a consequence of investing in energy conservation projects. Results for national average conditions have been produced and summarized.

This model provides a conservative estimate of jobs created for various levels of energy conservation investments and uses construction industry standards for wages, benefits, profit, overhead, callbacks, and warranty work for the installation phase of the energy conservation work. In addition, using the best available information on manufacturing industry job production, the number of jobs created in the last level of the supply chain prior to the installation phase is estimated. The mean number of jobs created in installation is about 10 jobs per \$1 million investment and in the manufacturing stage directly supplying the installation companies about 4 jobs per \$1 million investment.

The model developed for this research is based primarily on the installation phase of energy conservation projects and the level of detail is quite high, taking into account details of worker compensation and benefits as well as industry standards for overhead and profit. It also includes consideration of other costs that are normally considered by industry in its accounting and costing, namely callback and warranty costs. The modeling of manufacturing jobs is very simple by comparison and generally assumes that overhead and profit is about the same as construction industry and that the split between materials and labor is about equal. More detailed modeling of the actual practices of manufacturing industry would produce a more refined model and more insight into the number of jobs produced. Additionally, modeling of jobs in the other stages of the supply chain such as resource extraction and primary materials production could be included. In general it is probable that the number of jobs in

each succeeding state of production is about 40% of the prior stage. For example, 10 installation jobs produces 4 manufacturing jobs and probably 1 to 2 jobs in primary materials manufacturing and materials extraction. The effects of primary materials manufacturing and the effects of resource extraction were not included in this model. Additionally the economic effects of transferring energy dollars from purchased energy outside the community to energy conservation jobs within the community were not included. These effects could be modeled to produce a more detailed picture of the total impact of energy conservation investments in a community.

This research resulted in the development of a model that can be used to predict the number of jobs created by an investment in energy conservation. It uses an investment of \$1 million as the base model and deconstructs this investment into the number of jobs likely to be created in the installation phase and the manufacturing phase. The model is based on commonly accepted methods for computing overhead and profit by subcontractors engaged in energy conservation retrofits, on industry standard wage rates, on industry standard crew sizes, and on standard practice for determining the wage rates of various worker types and skill levels. The model also estimates the number of jobs created in manufacturing the equipment/materials used in the installation phase based on commonly accepted allocations of labor and materials in these industries. The model can be varied to change all basic inputs and assumptions to assess a wide variety of scenarios.

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