ESTIMATING JOBS FROM BUILDING ENERGY EFFICIENCY

ERIC SUNDQUIST

COWS

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What numbers and kinds of jobs result from investment in building energy efficiency (EE)? This report, based on joint work by COWS (University of Wisconsin-Madison) and the Powell Center for Construction and Environment (University of Florida), suggests a way to get at least policy-level answers to this question for state and local programs. Program designers, armed with better knowledge of the building stock, energy costs, specific EE measures likely to be supported, and other local data, will be able to provide much more robust estimates as they move toward program implementation. The hope here is simply to get them started.

To define our scope at the outset, we treat the question above deliberately narrowly — limiting ourselves to jobs in direct installation of EE measures. This excludes indirect "upstream" jobs in the production and sale of the many parts, equipment, and materials used in those measures (hereinafter, "materials"); "downstream" jobs in the disposal or recycling of replaced materials; jobs induced by demand from new income; and any jobs resulting from EE's increase of property value and building occupant health and productivity. We define job numbers for installers not by actual positions, many of which are part-time, but "job-years" (2080 hours) of work. We distinguish job "kind" only by broad skill levels in the work involved (not getting without getting into the maze of vocational training that more advanced ones require), which we assume to be constant across all EE measure categories, and those categories themselves. So, for example, we say how many people in HVAC will be needed, but not how many steamfitters vs. sheetmetal workers. Finally, we report only EE measures that achieve simple cost-effectiveness (benefits greater than cost) in ≤ 10 years.

Within this scope and set of conventions, this report identifies the sorts of EE measures applicable to different building types and the sorts (and cost) of labor needed to apply those measures. It then puts these two together to estimate answers to the question asked above, on different assumptions of project focus and labor cost. Given wide variation in the EE universe across and within building types, and variation in labor cost across and within regions, the exercise has more than the usual limits of reporting means and modes. But it does identify the sorts of questions that should be asked here (which buildings, what measures, what skills requirements and associated labor costs) and some ballpark answers, providing at least a starting point for more detailed local investigations.

What sorts of EE measures?

We start with the work itself, the EE measures applied to buildings. These determine project cost, capital intensity, and the amount and skill of labor required. Appropriate EE measures will vary by building type; what is needed in an owner-occupied home, for example, is typically different from what is needed in an apartment complex, office building, or school. What exactly are these measures, how widely applicable are they, and what do they cost?

In the residential space, the best data we know comes from a local source, the Energy Center of Wisconsin (ECW)'s extensive surveys of opportunities for cost-effective EE measures in owner-occupied and rental housing (Pigg & Nevius, 2000; Pigg & Price, 2005). Table 1 shows the results for owner-occupied housing. It lists typical measures, the percentage of owner-occupied buildings with opportunities for these measures, and those measures' average cost, circa 2000. Table 2 does the same for multi-family rental housing, of 5-19 units and 20+ units per building, circa 2005.

Table 1: Pigg & Nevius, 2000
EE opportunities in WI owner-occupied homes

Measure	% of homes with opportunity	Average cost per home
Wall insulation	14	$1,097
Ceiling insulation	21	$403
Floor insulation	3	$446
Rimjoist insulation	21	$68
Air leak sealing	19	$278
Furnace replacement	9	$500
Electric water heater switch to natural gas	4	$600
Water heater temperature reduction	23	$0
Water heater wrap	21	$20
Low-flow showerhead	2	$6
Refrigerator replacement	10	$541
Compact fluorescent lighting	76	$58

Table 2: Pigg & Price, 2005
EE opportunities in WI rental housing

Measure	% of dwelling units with opportunity (5-19 unit buildings)	% of dwelling units with opportunity (20+ unit buildings)	Average cost per dwelling unit
Wall insulation	7	0	$957
Ceiling insulation	6	0	$474
Rimjoist insulation	10	5	$34
Furnace upgrade on failure	4	0	$485
Heating fuel switch from electric	20	16	$4,000
Boiler replacement	4	9	$513
Boiler upgrade on failure	6	10	$375
Boiler controls	27	8	$ 73
Boiler pipe insulation	13	13	$6
Water heater switch from electric	1	12	$569
Water heater temperature reduction	60	38	$0
Water heater replacement (small)	1	0	$150
Water heater replacement (large)	1	23	$125
Water heater wrap	82	93	$18
Low-flow showerhead	70	93	$10
Pipe insulation	41	27	$6
Refrigerator replacement	51	53	$455
Washer replacement (in-unit)	6	5	$313
Washer replacement (common)	52	81	$53
LED exit lighting	20	56	$16
Common-area lighting replacement	87	69	$83
In-unit lighting replacement	100	100	$62
Outdoor/entry lighting controls	30	18	$48

These WI data have obvious limits. Differences in climate, age of building stock, and energy prices, for example, make their precise numbers of little use in the Southwest. Even in the cold and old upper Midwest, they are already dated by increases in energy prices, decreases in the cost of commodity efficiency measures (e.g., CFL lighting), advances in technology, and the gradual evolution of markets for efficiency. All these widen the reported sphere of cost-effective EE opportunity. Nationally, at the same time, the composition of the building stock has changed. There are millions more square feet of building space; newer and generally more energy-efficient buildings have replaced older ones; more property owners have increased the efficiency of the older stock. We are confident the net of this is positive on opportunity, i.e., that it is still expanding, but don't pursue that question here. Whether greater or less than when ECW looked, there is a huge amount of cost-effective work undone. And if it's done, it will be in these broad areas. So we find the ECW numbers useful as starting framers for discussion.

Turning then to commercial office buildings and non-profit institutional buildings — the "MUSH" category of **m**unicipal (and state) government buildings, **u**niversities and **s**chools, and **h**ospitals — things get more complicated. Variations in use, type, mechanical systems, and other factors make generalization more difficult. One can piece together a picture of EE measures in these different categories, however, by looking at the activity of the ESCOs (energy service companies) that their owners engage for that. The Lawrence Berkeley National Laboratory, where Charles Goldman maintains a large database on ESCO activities, is probably the best source of data, relied on here (Hopper, et al., 2005; Osborn, et al., 2002; Goldman, 2007). Table 3 summarizes the results of a multi-step effort (details of which we spare the reader here), working back and forth between records of EE measures applied in different building types separate records of the cost of different measures. The result is an estimate of the share of project costs, for different categories of measures, for different non-residential buildings.

Table 3: COWS from Hopper, et al., 2005
Percent of project cost for different EE measure, by building type

	K-12	University	Hospital	Office
Lighting	42%	32%	17%	28%
Major HVAC	19%	25%	28%	23%
HVAC controls	9%	15%	21%	19%
Miscellaneous	9%	15%	21%	19%
Building envelope	21%	12%	13%	11%

What kinds of jobs?

Once we know what sorts of measures we're talking about, we can consider the labor needed to install them. We assume a crew composition, by hours, of 7 percent supervisory, 27 percent skilled, 36 percent semi-skilled and 29 percent entry-level.

There is then the question of labor compensation. This varies enormously in construction, which is a particularly highly segmented market, with relatively low costs of entry, and low levels of unionization. Much work in residential and small commercial EE business is notoriously low paid. The better paying jobs tend to be in larger commercial and MUSH work, where unions have more presence and average skill levels are higher. But even here there is enormous variation, even on the public projects requiring that "prevailing (typically union) wages" be paid. This has recently been highlighted in the ARRA (American Recovery and Reinvestment Act) requirement that prevailing wages be paid for federally assisted programs in residential construction. The extremely low and uneven level of unionization in that sector leads to wide wage disparities. According to the U.S. Department of Labor, current prevailing hourly wage plus fringe benefits for a residential insulator, for example, is $9.21 in Fairfax County, Va.; $49.83 in Milwaukee; and $73.83 in Manhattan (Berger, 2009).

Tables 4 and 5 show some examples of variation in local labor costs in one city: Chicago. Table 4 reports labor compensation for different EE measures for a unionized contractor working primarily in commercial buildings and MUSH. Table 5 reports labor compensation for a residential weatherization program, run by the non-profit Delta Institute in Chicago. At 2,080 hours per year, the annual “loaded” (i.e., including wages, benefits, and insurance) labor costs in these examples runs from $37,440 for an entry-level laborer in the weatherization program to $191,516 for an electrician supervisor in a union shop.

Table 4: Lowden, 2008
Hourly loaded labor costs, Leopardo Construction (union scale)

Trade	Supervisor	Skilled	Semi-skilled	Entry level
Insulation, air sealing	$83.66	$83.66	$49.30	$39.44
Electrical	$93.88	$93.88	$51.10	$40.88
Plumbing	$92.41	$92.41	$56.55	$45.24
HVAC	$88.57	$88.57	$53.65	$42.92
General labor	$77.38	$77.38	$46.40	$37.12

Table 5: Dick, 2008
Hourly loaded labor costs, Delta Institute residential weatherization

Trade	Supervisor	Skilled	Semi-skilled	Entry level
Insulation	$42.00	$40.00	$25.00	$19.00
Air sealing	$37.00	$35.00	$30.00	$18.88
Electrical	$42.00	$38.00	$25.00	$20.00
General labor	$37.00	$35.00	$28.00	$18.00

Along with knowing the cost of different sorts of labor, we want to know how much labor of any kind is needed for different measures. The Powell Center estimated materials and labor splits, as shown in examples in Table 6 and Table 7.

Table 6: Kibert, 2007
Labor vs. materials cost for measures in non-residential buildings

Measure type	Labor	Materials
Lighting	65%	35%
HVAC	65%	35%
Building Envelope	80%	25%

Table 7: Kibert, 2007
Labor vs. materials cost for measures in single-family homes

Measure type	Labor	Materials
Insulation	**75%**	**25%**
Air sealing	75%	25%
Mechanicals	50%	50%
Appliances	25%	75%

How many jobs of different kinds?

Using these assumptions we can generate policy-level estimates of the jobs created per dollar invested in an EE program. For convenience, we'll report these in millions of dollars. Again using the industry conventions reported by the Powell Center, we assume contractors will take 10 percent of the total invested for overhead, and 10 percent for profit (Kilbert & Fobair, 2007). So, to take our first $1M, we would assume that it was immediately reduced by 200K. That leaves $800K. The number of jobs generated by this is then a function of the labor vs. materials split on cost, and the amount of compensation per worker. In the estimates that follow — simply for convenience, but not too far from averages across different measures — we assume that labor and materials costs are equal. Of the $400K remaining for labor, then, the number of jobs is that divided through by compensation per worker. If that compensation is $40K — which is about the national median, 10 jobs would be generated for every million spent. If that is $60K, then 7.5 jobs would be created. And so on.

Tables 8-10 show estimates for job-years per $1 million invested in commercial, multifamily residential, and single-family residential EE work done, respectively by a large union contractor, a non-profit weatherization program, and smaller commercial contractors. The sources on the first two (large commercial and multi-family), are from the same sources used above for Chicago. The source on the third is a survey done by the Powell Center (Kibert & Fobair, 2007) of contractors working in that area, with these results adjusted to Midwest labor costs using a standard industry reference, from Engineering News-Record (2007).

Table 8
Job-years per $1 million invested in large commercial EE

Measure	Supervisor	Skilled	Semi-skilled	Entry level	Total
Lighting	0.1	0.4	0.5	0.4	**1.4**
HVAC	0.2	0.6	0.8	0.6	**2.2**
Building envelope	0.1	0.2	0.3	0.2	**0.7**
Total	**0.3**	**1.2**	**1.6**	**1.3**	**4.3**

Table 9
Job-years per $1 million invested in multifamily EE

Measure	Supervisor	Skilled	Semi-skilled	Entry level	Total
Insulation & infiltration	0.1	0.5	0.6	0.5	**1.7**
HVAC	0.2	0.8	1.1	0.9	**3.1**
Boilers	0.0	0.1	0.2	0.1	**0.5**
Plumbing	0.0	0.1	0.2	0.1	**0.5**
Lighting	0.1	0.2	0.3	0.3	**0.9**
Appliances	0.1	0.2	0.3	0.2	**0.8**
Total	**0.5**	**2.0**	**2.7**	**2.2**	**7.4**

Table 10
Job-years per $1 million invested in single family residential

Measure	Supervisor	Skilled	Semi-skilled	Entry level	Total
Insulation & infiltration	0.5	1.9	2.5	2.0	**6.8**
HVAC	0.1	0.2	0.3	0.2	**0.8**
Plumbing	0.0	0.1	0.2	0.1	**0.5**
Appliances	0.1	0.3	0.4	0.3	**1.0**
Total	**0.6**	**2.5**	**3.3**	**2.7**	**9.1**

Use and limits of the exercise

The estimates here give a general idea of the type and number of jobs that might be created in EE installation programs. For example, using Table 8 above, if policymakers in Chicago were considering a $500 million program for multifamily housing retrofits at this pay scale, and they had no specific EE measures in mind, they could predict that the program would provide 3,700 job-years, with about half of those jobs in HVAC. This would give them enough to begin a conversation with area contractors or unions to see if 3,700 job-years could be absorbed by the relevant labor force, or whether training and recruitment might be required.

Since these estimates are based on averages across many buildings, they have no relevance to EE work on an individual building, but only to large programs that do work on many structures. In addition, measure categories such as “HVAC” involve many specific measure types, including furnaces, blowers, and thermostats. Without knowing the fine details of an EE program, it is difficult to predict which of these measures will be employed. Nor does the model adjust labor-cost ratios for differences in labor costs. To restate what we said at the outset, what it does do is provide policy-level estimates, based on conventional construction cost estimation techniques, to give a first look at the number and type of jobs that would likely be created by a proposed EE program. It gets the conversation started.

Sources

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