The Most Volatile Non-Energy Benefits (NEBs): New Research Results "Homing In" on Environmental And Economic Impacts

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ABSTRACT

Research indicates that non-energy benefits (NEBs) are large, and can outweigh the bill or energy savings from programs. However, a large proportion of the benefits hinge on two key "societal" benefits: the environmental or green-house gas (GHG) benefits, and the economic or job-creation benefits of the programs. The valuations assigned to these categories can be large, but are very sensitive to underlying assumptions – and NEB totals can vary more than 200% based on alternative values from these categories. We conducted extensive research to develop more reliable and defensible estimates of these benefits categories.

- Economic and Job Creation Benefits: We corrected a major flaw from much of the existing literature on direct and indirect economic multipliers and job-creation benefits of DSM programs. Several key studies in the existing literature err in estimating only the "gross" impacts of expenditures on programs; they do not recognize that the expenditures replace expenditures that would have occurred in different sectors of the economy. Using an input-output model, we correct this problem and develop more realistic values and ranges for the economic impacts of key categories of DSM programs.
- Environmental Benefits: Using data from scores of sources, we assembled data on the emissions by fuel and generation type, and gathered dollar valuation information that were computed based on health effects, technology retrofits, "regulatory" numbers, tracking prices, and other derivations. Using these data, we estimated environmental / emissions NEBs. We estimated valuation results for these emissions that were more reliable and "citable", but also more easily "tailored" to local conditions and priorities. The results illustrate how values change in relation to key assumptions, and provide results based on well-documented sources of data.

The revised figures have been used to compute more reliable estimates of non-energy benefits, and we present improved numbers that can be used in regulatory tests and other applications.

Introduction and Background

Benefits from Demand Side Management (DSM) program efforts accrue not only to the utility or to participants, but also provide "public" or societal benefits. These benefits include direct and indirect economic benefits, reductions in emissions and other environmental effects, as

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well as an array of benefits related to reductions in stress on water sources and infrastructure (if water measures are included), and other benefits.

As part of work for several clients over the last several years, we were interested in continually refining the methods by which important NEBs are calculated. To facilitate computation, we developed a comprehensive non-energy benefits (NEBs) estimation model (called "NEB-It")[2]. We tested the NEB computations that result from modifying the underlying assumptions used as inputs to calculations, and conducted extensive scenario analysis related to NEB values for a wide range of NEB categories. This research identified two NEB categories that, under certain assumptions, could have very high values associated. Our work with scenario analysis found that these sectors were also extremely volatile in value, depending on these assumptions (Skumatz 1998). The volatile sectors were economic impacts and environmental / emission impacts.[3]

Depending on the assumptions made on the incremental impacts or multipliers for these sectors, the range for their share of total estimated NEBs for a typical low income weatherization program we have evaluated may range as follows:

- Economic impacts from a program could range from 20% to 70% of total NEBs, depending on assumptions made, and this represents dramatic swings in the dollar value of total NEBs.
- Environmental / emission effects could range from 3% to more than 80%, depending on assumptions, and the resulting dollar value of total NEBs varies dramatically.

Therefore, this paper focused on improving the non-energy benefits estimates for two important, and as we found in previous research, volatile sectors.

Background on Economic Non-Energy Benefits (NEBs)

Important secondary economic benefits are derived from DSM program efforts. Net economic activity spurred by DSM programs can increase employment, earnings, and tax revenues, increase economic output, and decrease unemployment payments. Investment in programs can have net economic and job creation benefits, with ripple effects in taxes, transfer payments, and other economic output.

Several agencies have attempted to develop estimates of these types of benefits. Pigg and Dalhoff (1994) provide estimates for economic impacts to the State of Iowa based on different aspects of program design. They noted that the net economic impact of Iowa's low-income weatherization expenditures of $11.1 million was $14.1 million in industry output, $7.1 million in personal income, $7.6 million in value added, and the creation of 381 jobs. Dalhoff (1996) notes that 64 cents of every dollar spent on the program remained in Iowa as income). Multipliers and work has also been conducted in Minnesota, New York, Austin, and other locations. Some of these studies have attempted to separate benefits to the local economy from broader economic impacts.

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[2] The model estimates more than 60 NEB categories including net (positive and negative) benefits accruing to utilities, society, and participants – both commercial / industrial and residential.

[3] We are currently working to upgrade the estimates of health effects from program efforts.

Brown et.al. (1993) also calculated these types of economic benefits. The Brown estimates (in net present value terms) include: $55 in taxes from direct employment; $506 in income from indirect employment, and $82 in reduced unemployment benefits.

Multipliers for both direct and indirect economic and employment benefits have been estimated by numerous studies, and the estimates vary widely (and are listed below). They range from 24% to 380% of investment, and some of the figures are represented in terms of program expenditures, and other economic multiplier estimates are based on impacts per one million dollars in energy savings associated with the program. Most are based on results from input-output models. However, one key difference between estimates is in the assumptions they make about whether the program expenditures represent new funds or whether they displace other applications to which the money might have been put. The latter is the only appropriate assumption, and differences in estimates can be generated based on what types of industries or activities are assumed to be displaces – and whether or not they are labor-intensive activities. In fact, it could be argued that some program designs would lead to negative net economic benefits. Ignoring the fact that these benefits must be "net" leads to very serious overestimates of the impacts from programs. The ranges are provided below.

We reviewed and categorized the literature on economic benefits and found the following:

- There are four studies that estimate direct output multipliers. These studies show estimated impacts of 43% to 91% multipliers for direct output effects as multiples of program expenditures (with a computed average of 63%).
- Six studies estimating total output multipliers derived multipliers ranging from 74% to 320%, with a mean of 197%. Four studies examine total output derived as a multiple of program savings developed estimates ranging from 37% to 120%, for a mean of 73%.
- Job creation multipliers were estimated in nine studies. These studies estimated between 5.6 and 71 jobs were created per one million dollars in program expenditures, with an average of 33 jobs per million dollars in expenditures.

In a more simplistic vein, several years ago, the Northwest Power Planning Council (NWPPC) established a policy related to the calculation of benefits from demand-side management (DSM) efforts in relation to power from new supply. NWPPC policy attributes a 10 percent "adder" as an estimate for secondary economic benefits for conservation-based efforts. The NWPPC assumed that a conservation program leads to expenditures within the local area that have greater local impacts than if new power is purchased (generally from outside the area). This factor is ordinarily assigned to the avoided costs for the program. Discussions with NWPPC staff (Harris (1996)) indicate that this economic benefits factor may understate benefits from certain types of programs, and in particular, for low-income weatherization programs. The 10 percent factor was developed for "average" DSM programs; however, weatherization programs tend to use more local supplies and are more labor intensive, indicating the factor for these types of programs in general might appropriately be higher.

Transfer Payments Avoided

Additional societal benefits can be estimated from information on job creation. These benefits are realized from lower unemployment benefits because of the job creation impacts of weatherization and other programs. As mentioned above, job multiplier figures based on these factors range as high as 71 per one million dollars in energy savings.

A quantitative estimate of these benefits is included in Brown, 1993. The net present value is estimated as $1 (using Brown's assumptions of 20 year stream, discounted at 4.7 percent, 1989 dollars), or avoided costs of unemployment benefits of $82 net present value.

Another method of calculating these benefits is to work with the estimates of number of jobs created from the program, and compute the transfer payments avoided. Full employment situations complicate calculations; however, we assume that the jobs created will shift some employees "up" in jobs and free up lower jobs for currently unemployed workers. Work for Iowa, Minnesota, and others provide estimates of the number of jobs created for every million dollars spent on the program. Although one of these studies makes an error in assuming that the money is "new" money and not displaced from elsewhere, others provide more rigorous results. Most of these studies are somewhat dated, but because they are in terms of jobs they can be updated to current salary levels, etc. The other information needed is data on the level of benefits provided and the terms for unemployment benefits.

Updating Estimates of Economic Impacts and NEBs

We reviewed studies from a number of states, including Iowa (Pigg, 1994, Dalhoff, 1996), Nationwide (Brown, 1994), Wisconsin (Hagler 1993), New York (Eisl, cited in Pye, 1996), and others. Several of these studies examined the impacts of the conservation investments in a gross sense – looking at all jobs created by the expenditures – and did not compute the "net" impact of the output and jobs that would be created in the sectors of the economy from which the money is being diverted.

We used an input-output model (Implan™) with the intent to clearly model the economic multiplier and jobs impacts realized from a transfer of expenditures from generation TO conservation programs – specifically, we used the business sector / industry classifications most related to the efforts and measures most appropriate to a low income weatherization program. Thus, the sectors we modeled were an increase in funds in sectors related to maintenance and repair, and a decrease in the generation portion of the electricity sector.

The following are the multipliers for the two sectors that are affected by the transfer of funds between the relevant sectors, and the multipliers are illustrated in Tables 1-3.

- The direct multiplier is the direct change in output, employee compensation (in millions of dollars) or employment (number of jobs) per million dollar change in final demand in that industry.
- The indirect multiplier is the change in output, labor income, or jobs per million dollar change in final demand resulting from interaction of local industries.
- The induced multiplier is the induced change in output, labor income, and jobs resulting from an increase of 1 million dollars in final demand resulting from interaction of institutions – usually increased spending on the part of households.
- Type I multiplier is defined as (direct + indirect)/direct
- Type II or SAM multiplier is defined as (direct+indirect+induced)/direct

Table 1. Output Multipliers for Estimating Net Impacts of $1 million Investment from DSM Programs

Industry	Direct	Indirect	Induced	Type I	Type II
Maintenance &Repair – Residential	1.000	0.388	0.411	1.388	1.799
Electric Utilities	1.000	0.133	0.174	1.133	1.307

Table 2. Employment Multipliers for Estimating Net Impacts of $1 million Investment from DSM Programs

Industry	Direct	Indirect	Induced	Type I	Type II
Maintenance & Repair	11.866	4.125	4.915	1.348	1.762
Electric Utilities	1.689	1.267	2.077	1.751	2.980

Table 3. Labor Income Multipliers for Estimating Net Impacts of $1 million Investment from DSM Programs

Industry	Direct	Indirect	Induced	Total
Maintenance & Repair	0.444	0.152	0.159	0.755
Electric Utilities	0.191	0.061	0.067	0.319

Economics Results in Multiplier Terms

Using the appropriate multipliers from the input/output modeling work, our results find that for an increase of $1 million dollar in the repair & maintenance sector the following impact occurs (the figures are illustrated in Table 4):

- Total Output (all sectors):
  - Direct economic impacts in terms of expenditures created from the DSM program work= $1,000,000
  - Indirect economic impacts=1,000,000*0.388 = $388K.
  - Induced = $411K
  - Total Effect (including induced) = $1M * Type II multiplier = $1,799K increase in total output
- Employment:
  - Direct = 11.9 jobs,
  - Indirect = 4.1 jobs,
  - Induced = 4.9 jobs
  - Total = 20.9.
- Labor Income:
  - Direct = $1,000,000*0.444=$444K increase in labor income.
  - Indirect=$1,000,000*0.152=$152K increase in labor income.
  - Induced = $159K.
  - Total = $755K increase in labor income for all sectors

Table 4. Impact from Adding Gross $1 million investment to Repair & Maintenance

	Direct	Indirect	Induced	Total
Output	$1,000,000	$388K	$411K	$1,799K
Employment	11.9	4.1	4.9	20.9
Labor Income	$444K	$152K	$159K	$755K

The same analysis is applied to the electric utilities sector using a $1 million dollar subtraction from the sector. The gross impacts are listed in Table 5 below. The figures were computed in the same way as the $1 million dollar increase to the maintenance & repair sector, using the electric utility multipliers.

- Total Output (all sectors): Direct = $1,000,000 Indirect=-1,000,000*0.133 = -$133K Induced = -174K. Total Effect (including induced) = -$1,307K (decrease) in total output
- Employment: Direct = -1.7 jobs, Indirect = -1.3 jobs, Induced = -2.1 jobs Total = -5.0
- Labor Income: Direct = $1,000,000*0.444203=$444,203 increase in labor income. Indirect=-$1,000,000*0.191=-$191K decrease in labor income. Induced = -$61K. Total = --$319K decrease in labor income for all sectors

Table 5. Impact from Removing Gross $1 million from Electric Utilities Sector

	Direct	Indirect	Induced	Total
Output	-$1,000,000	-$133K	-$174K	-$1,307K
Employment	-1.7	-1.3	-2.1	-5.0
Labor Income	-$191K	-$61K	-$67K	-$319K

The net results are just the difference of the two impacts, and is shown in Table 6. [4] Thus, for $1 million in transfer of expenditures from generation to the weatherization-type DSM program, we see the following net impacts.

- Total Output (all sectors): Direct = $1,000,000 Indirect=1,000,000*0.256 = $256K Induced = $237K. Total Effect (including induced) = $1M * Type II multiplier = $492K increase in total output
- Employment: Direct = 10.2 jobs, Indirect = 2.9 jobs, Induced = 2.8 jobs Total = 15.9.
- Labor Income: Direct = $1,000,000*0.253=$253K increase in labor income. Indirect=$1,000,000*0.091=$91K increase in labor income. Induced = $92K. Total = $435K increase in labor income for all sectors

Table 6. Net Impact – Estimated Net Economic Impacts from $1 million Investment in DSM Programs

	Direct	Indirect	Induced	Total
Output	$0	$256K	$237K	$492K
Employment	10.2	2.9	2.8	15.9
Labor Income	$253K	$91K	$92K	$436K

The net is an increase in output and labor income, and a net increase in jobs – the multipliers indicate that the repair and maintenance sector is clearly more labor-intensive than the electricity generation sector.

[4] The input/output model reported both Type I and Type II multipliers for both employment and labor income. They do not however use them when reporting their impact analysis. Since the denominator is not 1, the multiplication of $1million * type I or II multiplier does not equal the total increase in jobs or labor income.

Comparison of Results and Use of the Economic NEB Multipliers

These net multipliers are considerably smaller than the figures shown in the literature, because they represent net, not gross, output, income, and employment multipliers. Based on the sectors we used to compute these multipliers, they apply best to retrofit programs like low income weatherization programs, audit and retrofit programs, remodeling programs, and others of this nature. The multipliers may not be as well suited to new construction programs (residential or commercial), and this will be the focus of future research.

Note that these multipliers are based on nationwide information, and thus, assume that all the generation impacts are relevant to the net modeling. However, the values for these multipliers would vary on a state-by-state basis depending on the share of electricity production that is indigenous to the state, and other factors.[5] If the figures were applied to a state in which no generation occurred, then most of the negative impacts noted in Table 5 would not be relevant, and the appropriate multipliers would be much higher, and would be close to those presented in Table 4.

Table 7 provides a summary of the results from earlier studies, and the modifications implied by the results presented here.

Table 7. Comparison of Economic NEB Results as Share of Total NEBs for Sample Program

	Range from literature	Average from literature	Estimates from this research
Resulting estimate of Economic NEB as share of all NEB for low income program	20%-70%	50%	25%

The multipliers from the literature ranged from 24% to 360% (average was 136%). This variation in inputs led to a range for economic NEBs from 21% to 71% of the total value of NEBs from the program. However, even with these lower assumptions, the NEBs from the economic impacts still represent about 25% of the total NEBs from a low income weatherization program, for instance.

Environmental Benefits

DSM programs can provide environmental benefits to the region and to society, particularly due to their role as a pollution abatement strategy. Reductions in energy use lead to decreases in harmful emissions, which have economic value especially as communities struggle to meet air quality attainment goals. These include assisting in meeting Clean Air Act goals, reduction in acid rain, and a variety of other environmental benefits.

Brown, et.al. (1993) develops quantitative estimates of these benefits relative to the low-income weatherization assistance program. Brown attributes a net present value of $172 (1989 dollars, discounted at 4.7 percent over 20 years). The Northwest Power Planning Council (NWPPC, Harris, 1996) provides policy guidance to utilities in the area regarding valuing the benefits from conservation relative to new power. The NWPPC assigns a 15 percent "adder" for

[5] For instance, energy intensity, etc. Thanks to an anonymous reviewer for pointing out the issues associated with using figures at the state level.

environmental benefits associated with conservation programs. This factor is applied to the avoided costs of the program.

Negotiated numbers estimates of environmental non-energy benefits for State programs exist in some cases for California, and these "adders" are submitted with the program year filings. At one point, these values increase from $0.062 per kilowatt-hour in 2000 to $0.105 per kilowatt-hour by 2018. The values increase from $0.055 per therm in 2000 to $0.093 per therm in 2018. These figures were applied to some work we performed in California. For another project, we used adders of $0.0072 per kWh and $0.0635/therm levelized costs to represent these value.

Revised Methods for Computing Environmental / Emissions NEBs

Early computations for NEBs used multiplier-type estimates from sources in New England, the Northwest, or based on established or mandated per kilowatt hour savings resulted in dramatic swings in the estimates of environmental benefits. These impacts ranged from a low of about 15% of all NEBs to a high of more than resulted in estimates of the share of total NEBs represented by the environmental / emissions factor as about 16% of the total NEBs from the program (using very conservative assumptions) to values greater than 80% of savings (based on much more aggressive and "green" assumptions about emissions and values).[6]

However, in work for states and utilities, SERA has developed an emissions-based computational technique that tailors the results based on fuel mix, emissions, and valuations. An extensive array of literature and regulatory sources were reviewed to develop a fairly comprehensive list of values for two key inputs:[7]

- The emissions, by product, from various types of generation plants, by fuel, technology, and vintage, and
- Dollar values to assign to the emission tonnages by product.

As mentioned, information is certainly available on the several critical components that can be used to derive estimates fairly directly. A number of reports include information on emissions based on generation fuel, including Ottinger et.al. (1990), and Consumer Energy Council of America Research Foundation (1993), Tellus (1993), Galvin (1999), Woolf (1999), and many others. Important assumptions include the air emissions from each kWh of electricity from a variety of fuel sources, and dollar values for important pollutants and greenhouse gas (GHG) constituents -- either based on calculated risk, or "cap and trade" values for some limited materials. However, the valuation of environmental benefits is complicated.. The value of an environmental benefit varies dramatically depending on the air shed zone, time of day, number of persons in and near the air shed, quality of air, and numerous other factors. The tons of emissions for each greenhouse gas (GHG) constituent vary based on the generation fuel type. Deriving estimates using these generation inputs requires several simplifying assumptions: 1) even though the power may not be generated within the utility territory, the benefits still accrue

[6] Dollar values from these multiplier-based emissions NEBs ranged from under $15 per household per year to over $1,000.

[7] We located and input several dozen sources on emissions from plants, and more than 50 sets of valuations for emissions by source.

to society, and 2) even though power sources are currently varying dramatically, we use data provided by the literature or utility sources on “average” power generation fuel mix..[8]

To generate the estimate of the NEB for environmental emissions, we specify the fuel mix by percent (e.g. 20% hydro, 32% coal, etc.), the type and age of plants, and then select the most appropriate valuations based on the client’s situation. We can select specific values, averages across multiple sources, conservative or more aggressive assumptions and values, etc. The fuel mix can be specified from natural gas combustion, coal, nuclear, oil, hydro, biofuels, and several other categories). This approach provides a clear link between the assumptions (and the cited sources for those values) and the estimated emissions value estimates.

Using this approach, the computed results for emissions NEBs have come become less volatile, and can be adjusted much more easily to suit individual utility or state situations. Moving from multiplier-based situations to improved emissions estimates, we have found that the emissions values for a fairly representative low income weatherization changed from estimates ranging from $26 to more than $1,000 (using a very aggressive / optimistic multiplier from one source).

Table 8 summarizes the share of total NEB values that were estimated to be attributable to the environmental benefits of the programs, and compares the results with the updated estimates derived based on the research described in this paper.

Table 8. Comparison of Environmental/Emissions NEBs as Share of Total NEBs for Sample Program

	Range from multiplier-based literature	Average from multiplier-based literature	Estimates from this research
Resulting estimate of Environmental emissions NEB as share of all NEB for typical low income program	3% - 80%	50%	15%-30% of total NEBs for range of assumptions[9]

Summary and Conclusions

Based on past research into non-energy benefits (NEBs), we found that the estimates for two key NEB categories had been problematic: economic and environmental multipliers. Economic and environmental impacts are important to the overall NEB computations – they are among the largest of the “societal” benefits and largest of all NEBs, but the underlying studies raised concerns. Based on past studies (Skumatz 2001, Skumatz and Dickerson 1998 and others), these two NEB categories together have represented more than 35% of the total NEB value estimated for some programs. This paper summarizes work in two key areas.

- Economic NEBs: New research on the economic multipliers implies that the multipliers used in the past were considerably overestimating the impacts, based on the example computation of economic multipliers for a low income weatherization program. Previous

[8] Note that some emissions may not have values if they are non-criteria materials. Also note that, at this point, we are omitting any environmental effects from natural gas measures.

[9] Range depends on generation source, emissions included, and valuations selected, but range computed using fairly realistic ranges for key factors. Results can be higher or lower depending assumptions made. These estimates were made assuming a generation mix of 10% natural gas combustion, 25% coal, 20% nuclear, 15% oil, and 30% hydro. Dollar value estimates of NEBs were at the higher end when assumptions of 50% coal and 50% natural gas were made. Other assumptions affect results in expected ways.

research tended to estimate gross, not net impacts, and as a result, multiplier estimates from the literature ranged from 24% to more than 300%. Our research, using an input-output model, found that *net* multipliers in the range of 0.5 could be easily justified, and higher multipliers might be possible adding in secondary impacts and job creation. These values result in economic NEBs that represent about 25% of the total NEBs for a sample low income weatherization program, and a multiple of perhaps 15-40% of energy bill savings for that program.[10]

- Environmental NEBs: The environmental results vary dramatically based on the constituents that are included in the computation of emissions reductions, and whether trading, regulatory, or other metrics are used for valuing the benefits categories. Because these uses and assumptions will also vary between clients, we have developed a model to incorporate these different uses and values, and presented a fairly reasonable range of values that arise from these different assumptions for a template program. These estimates provide an indication of ranges of values for those concerned about the NEB values for emissions. The results estimated in this way can be computed based on clear and citable assumptions, adding confidence to the results. While multipliers in the literature ranged from 15% to more than 300%, revised (and somewhat conservative) computations based on generation mix, emissions, and "average" dollar values, led to environmental NEB estimates that represented about 15-30% of the total of NEBs for the program. The results also indicate that environmental NEBs in the range of 20-50% of energy bill savings may be reasonable (and somewhat conservative) for a typical low income weatherization program.

This research shows that societal NEBs are an important part of the benefits that accrue from DSM activities, and improved estimates can help move these benefits computations to better acceptance in the literature, and in benefit-cost computations.

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[10] Of course, estimates for both economic and environmental NEBs will vary for other programs based on measures, utility, generation mix, etc., but these figures provide useful benchmarks (as NEBs for low income weatherization programs have been much studied in the literature).

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