SKUMATZ ECONOMIC RESEARCH ASSOCIATES, INC.

■ Consulting to Government & Utilities

Boulder Office: 762 Eldorado Drive, Superior, CO 80027
Voice: 303/494-1178 FAX: 303/494-1177
email: skumatz @ serainc.com
Website: www. serainc.com; payt.org

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Considering the Inclusion of NEBs in IL TRM for Single and Multi-family Whole Building Retrofit Programs: The Issue of Measure-Based NEBs

Work Paper

Prepared by
Lisa A. Skumatz, Ph.D.
Skumatz Economic Research Associates, Inc. (SERA)
762 Eldorado Drive, Superior, CO 80027

Prepared for Chris Neme, Energy Futures Group
For NRDC

July 31, 2015

Organization of the Document

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Acknowledgements: The Author wishes to thank Dana D'Souza and Dawn BeMent from Skumatz Economic Research Associates for their valuable assistance in completing this work paper.

Executive Summary

Non-energy benefits (NEBs)[1] are the wide variety of positive and negative effects beyond energy savings that are delivered to utilities, participants, and society as a consequence of delivering energy efficiency programs and measures. The historical approach to program, measure, and portfolio benefit-cost screening omitted these effects because they were harder to measure than energy savings – and they were not generally the primary program goal. However, omitting impacts (positive or negative) biases decision-making, and runs the risk of misallocating public funds. Given that there is now 20-plus years of literature estimating NEBs, more than a dozen states around North America incorporate some subsets of NEBs as adders, direct estimates, or hybridized approaches in their screening processes.

This quick-turnaround study was conducted to identify whether recommendations can be made for non-energy benefit (NEB) values that can be used in Illinois for:[2]

- Single family (SF) retrofit programs, for important classes of measures, and
- Multifamily (MF) retrofit programs, for important classes of measures.

What this Study Does:

The study reviewed the existing literature on NEBs for residential retrofit measures – both single family and multi-family – and studies that addressed the question of measure-specific NEB values.

- We identified the values from studies, and looked for patterns and consistencies in the NEB values to help confirm the suitability of their application to the question of how values vary in single vs. multifamily situations for these types of programs. We found significant NEBs in the utility, societal, and participant categories, which means that historic computations are excluding potentially large effects. However, we also generally focused our discussion on the participant NEBs because:
    - They were the largest set of NEBs;
    - The utility NEBs were small excluding the non-low-income elements (which had been the most-frequently measured);
    - The societal NEBs hinged on carbon effects (which are already measured elsewhere in Illinois) or on economic multipliers (which vary with the local / state job mix and we did not identify studies for Illinois weatherization programs).

- We examined whether NEBs needed to be measure specific; if not, perhaps an overall adder for NEBs would suffice (and be much simpler). However we note that only a few NEBS categories are generally independent of the measures included or the target population. A more complex inclusion methodology is needed / justified (since NEBs are not a trivial value).
- We examined the studies for single and multifamily programs, and for landlord / occupant perspectives within the multifamily group. We also reviewed the available literature on gas vs. electric programs. A review of the available literature showed that:

[1] *Also called non-energy impacts, co-benefits, multiple benefits and other terms.*
[2] *Specifically excluding the categories of emissions, and water bill savings, which are accounted for elsewhere in the TRM.*

- There is less literature available for multi-family than single-family, and a fair share of the literature focuses on low income programs. Fewer studies examine NEBs from the landlord perspective than the occupant perspective, and there are fewer studies of gas vs. electric programs than for the programs combined.
- Our review of values indicates, however, that there is quite a bit of agreement in values, and that we see the opportunity for avoiding over-complicating the question of which NEB values to assign. The single and multifamily, and the gas and electric values for these types of programs were all of similar magnitudes. The landlord NEB values were a little lower than occupant values. Overall, we saw total participant NEB values in the range of about 100% to 115% (of customer energy bill savings) for these retrofit programs, with values of closer to 70% for landlords.

- The literature does not include measure-specific NEBs for these "whole building-type" programs. We note four options available for computing these measure specific NEBs – regression, savings-based, estimate based on stratified samples / surveys, and applying the average value (these are described in the document). We find / illustrate examples of two of the approaches, and we based our recommendations on one of these approaches – attribution based on savings. We believe that for the near-term this provides the most practical approach for providing measure-based NEBs that can be included in the Illinois TRM / process.

- We then adapt these values from the literature to the Illinois case – excluding the NEBs associated with water, emissions, and for lighting, omitting maintenance / lifetime effects – because those are already incorporated into other steps in the Illinois TRM screening process. The resulting recommendations are provided in Figures 1 and 2.

Of course, given that this is a quick-turnaround, low budget study that necessarily has some limitations, we also provide recommendations for next steps.

What this Study Found / Recommends:

The study examined literature from across the nation, and finds:

- Consistency in some NEB categories, sufficient to indicate strong NEB values;
- Attribution to some measures;

The need for studies to conduct additional work to disaggregate program NEBs to individual measures, to enhance the literature. Our analysis finds that the literature currently supports simplification of estimates – allowing use of similar values for single and multifamily programs for both gas and electric programs. The differences for these subgroups are relatively small and the calculation complexity may not warrant further refinements beyond this level at this time. We exclude the utility and societal values for Illinois at this time because of the separate treatment of emissions (and water savings) elsewhere in the process, and because of the lack of local economic impact estimates for the program.

The paper recommends consideration of the use of the following values for NEBs to be added to the savings calculations from the Illinois TRM. Note that NEBs in these cases are multipliers applied to the value of customer bill savings, since we are only dealing with participant impacts (the rationale for this is discussed below). Our recommended NEB values are provided in Figures 1 and 2.

Figure 1: Recommended NEB Values as Multipliers on Bill Savings
(Derived from Figure 11 below; adapted from NMR Massachusetts Cross-cutting Study[3].)

Measure	NEI Multiplier on Energy Savings	Measure	NEI Multiplier on bill savings
Air Sealing	47%	Insulation	116%
Appliance (refrigerators and freezers)[4]	See Figure 2	Lighting[5]	70% (See Figure 2 and footnote)
Cooling systems	27%	Service to heating or cooling system	4%
Duct Sealing	4%	Low Flow Showerhead	1%
Heating & Cooling system	24%	AC system sizing	4%
Heating & Hot water system	7%	Programmable Thermostats	12%
Heating system	231%	Window	6%
Hot Water System	8%	Weatherization	114%

Figure 2: Estimates of Appliance NEBs as a Percent of Measure Savings – Bill Savings Multipliers
(derived from Skumatz, 2006)[6]

Household appliances	Refrig-erators	Dish-washers	Clothes Washer	Room Air Condit-ioner	CFL Bulbs[7]	Lighting Fixture[8]
NEB Multiplier as a percent of the measure's energy savings	29%	65%	54%	71%	70%	30%

Note that these multipliers are based on participant perspective NEBs and are multipliers applied to bill savings associated with the energy saved – the value of the retail bill savings. They apply to both gas and electric programs, and single-and multi-family programs. The multipliers should apply as long as the savings from the measures last (measure lifetimes or EULs); they are annual savings multipliers. Finally, note that refinements of these values can be conducted at modest cost by integrating some NEBs into evaluation surveys – process or impact.[9]

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[3] *NMR Group, 2011, "Massachusetts Special and Cross-Sector Studies Area, Residential, and Low Income Non-Energy Impacts (NEI) Evaluation*

[4] *The value in the original table of this citation was 1%. Our preference is to replace this with NEB multipliers from specific studies of lighting. See next table.*

[5] *The value in the original table of this citation was 105%. Our preference is to replace this with NEB multipliers from specific studies of lighting. See next table.*

[6] *Skumatz, Lisa A., 2004, Non-Energy Benefits from ENERGY STAR®: Comprehensive Analysis of Appliance, Outreach, and Homes Programs, Proceedings of the 2004 ACEEE Summer Study, Asilomar, CA, August.*

[7] *The value in the original table for this factor is 90% for CFL. Note this is a similar order of magnitude as presented in the original data in Table 1, which was 105%. However, for Illinois, we are discounting this factor to exclude the "lifetime" benefits of CFLs and efficient lighting. The specific study (Skumatz 2004) estimates that the share of the lighting CFL that is due to the extended lifetime is 13% and O&M is 8% (it is 9% and 6% for the fixture NEB). For this reason, we substitute in a value that is (13+9) or 22% lower than the 90% estimated value for NEBs for CFLs as the recommendation for Illinois only (70%). If we were to apply similar logic to fixtures (if warranted) the new value would be 26%.*

[8] *See previous footnote.*

[9] *The author has long recommended this enhancement to traditional process evaluation surveys (in publications from 1995 on), and includes NEBs in most process evaluations SERA conducts. However, achieving measure-level estimates would require modifications to current stratification practices for most process evaluations.*

Background and Context

States across the nation are reconsidering the definition and design of cost-effectiveness test procedures used in the energy efficiency regulatory arena, including the State of Illinois. Twenty years of research and measurement of traditionally-omitted program impacts, or non-energy benefits (NEBs), have provided increasingly robust and consistent results. The regulatory tests are designed to assess costs and benefits, but protocols omitted some benefits, presumably because reliable values were not available. This leads to computational bias in benefit-cost ratios (from the omission of net benefit categories, but not omission of costs), and as a result, bias in decision-making using these ratios. Zero is the wrong proxy value; research has proceeded, and the results for a number of subcategories of NEBs can be properly reintroduced into these regulatory tests. Revising the tests (TRC, Societal Tests, or whichever others best reflect the state's energy goals) and incorporating subsets of NEBs reduce sources of bias in program and portfolio decision-making, and more appropriately directs the investment of millions of public or shareholder dollars.

The literature on NEBs has evolved through several levels of maturation,[10] and now consists of more than 300 studies of various types including results from programs around the country. Modeling methods[11] and consistency of values for many utility-, societal-, and participant-perspective NEBs has improved, and NEBs have become more familiar, through their use in marketing and other applications across North America. As a consequence, about a dozen states have already come to include some NEBs-related treatment in their regulatory benefit-cost testing procedures. Iowa, Colorado, Oregon, Washington, Vermont, New York, DC, and others include at least simple adders (between 7.5% and 25%) reflecting subsets of NEB contributions. Massachusetts, Vermont, Colorado, New Hampshire, BCHydro, Oregon, Connecticut, Rhode Island, Maine, DC, and others allow inclusion of subsets of "readily measured" or specific NEBs in benefit-cost tests, and the list is growing. The states have taken one of three approaches:[12]

- incorporating an "adder" (dollar or multiplicative form assigned to savings) that serves as a proxy for a subset of NEBs categories;

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[10] The evolution included four stages. Stage 1 (1994-1998) involved background organizing NEBs into perspectives, identify measurement principles for "net" NEBs, and preliminary estimations of two dozen categories. Stage 2 (1998-2001) included early rounds of documented derivations / estimates of NEBs, suggested incorporation into B/C tests, refinement of three main NEB estimation methods (models, incidence times valuation, and survey-derived estimates), and work on academic basis for survey approaches. Stage 3 (2001-present) included continuing expansion of estimates to more types of programs, enhancements of best practices, increasing familiarity of NEBs among stakeholders, application to marketing, and peer reviewed publications of results. Stage 4 (2008 to present) includes a period of refocus on the role of NEBs in regulatory and benefit-cost test applications.

[11] Estimation methods representing state of the art fall into three main approaches. Modeling approaches like third-party input-output models are used to estimate net economic multipliers from transferring dollars from generation to industries affected by energy efficiency programs, and models are also used for emissions impacts, and potentially reliability, etc. 'Incidence times value' approaches use primary and secondary data to estimate the value of program-related changes, for example arrearage studies, value of fewer bill-related calls or fewer emergency incidents, etc. Finally, very specialized survey-related approaches (with basis in academic literature) are used to determine values of several important participant-side NEBs, including comfort, value of reliability, etc.

[12] Skumatz, Lisa A., Ph.D., "Non-Energy Benefits / Non-Energy Impacts (NEBs/NEIs) and their Role & Values in Cost-Effectiveness Tests: State of Maryland", March 2014.

- incorporating direct estimates of a variety of NEB categories, usually subsets[13] that are well demonstrated, or easily measured and with economic value; or
- using a hybrid approach, with an adder representing some NEBs augmented by direct estimation of other NEB categories.

Estimating program-specific NEBs values is not necessarily expensive; however, there is certainly merit to streamlining the process – where it makes sense -- to save time and money and reduce risk to those whose compensation or decision-making may hinge on the results of the analyses.

Therefore, we classify NEBs into those that vary with program and measures and location, vs. those that do not (generally). We suggest that an "adder" approach is well-suited to those NEB categories that are measure-invariant (and drive almost exclusively off the energy savings, and can therefore be calculated as a multiple of the energy savings), vs. those that depend on the specific measures included in the program. The far right column of Figure 4 provides indications of these classifications, but they are also briefly listed below – focusing on residential programs only for this paper. The NEB category plus the associated beneficiary "perspective" (utility, societal, or participant) are listed in Figure 3. These factors are taken into account in the remainder of the paper. Note that the major program-invariant factor – emissions – are addressed elsewhere in the TRM in Illinois, and will not be the focus of additional discussion in this work paper. Water will also not be a factor in Illinois, as it is treated separately, but matters (and is not small) in other states / contexts.

Figure 3: Residential NEBs and their Relative Variation with Program Measures and Targets

Program / measure invariant (suitable for "adder")	Program / measure dependent (not as suitable for "adder")	Residential Target dependent
• Environmental / emissions	• Economic - societal • Health and safety, health care, illnesses – societal and participant • Water / wastewater infrastructure and water bill savings – societal and participant • Participant benefits including: equipment operations, lifetime, O&M, comfort, noise, control / education, home-improvements.	• Payment related – utility (arrearages, etc. stronger for low income targets) • Health and safety, health care, illnesses – societal and participant (higher with chronically ill, vulnerable populations) • Participant benefits related to hardship and payments

[13] *The broadest list is in Massachusetts. See Malmgren, Ingrid, and Lisa A. Skumatz, Ph.D., 2014, "Lessons from the Field: Practical Applications for Incorporating Non-Energy Benefits into Cost-Effectiveness Screening", ACEEE 2014.*

Brief Review of the Literature

A targeted literature review was conducted to identify the state of the art on specific topics relevant to this working paper. The findings on each major topic area follow.

Single- and multi-family NEBs Quantification: The literature on NEBs for single family (low income and standard) is fairly robust and has been recently summarized[14]; information on the multifamily sector is scarcer. We identified fewer than half a dozen studies, and few had hard estimates of NEBs overall or by category. We focus on three studies[15] (Skumatz 2010 for Xcel Energy; NMR 2011 for Massachusetts, and Cluett and Amann for ACEEE, 2015) and work to draw inferences to the sector using comparison. Note that the multifamily programs that have been analyzed are mostly low income programs; however, we have calculated ratios or deleted benefit categories specifically associated with low income in this working paper.

MultiFamily owners / managers vs. occupants: The NMR study (2011) reported no NEB analyses related to participating owners. The ACEEE study, which includes a case study from Illinois, provides indications of one-off quantification of a few benefit categories from other literature, but relatively little consistent quantification within the study. We were able to readily identify and analyze one other study that included benefits to multifamily owners (Skumatz 2010, again, low income). We used this work to compare renter, owner, and single family results for similar programs to determine the extent to which results were similar and potentially transferable.

Gas vs. Electric NEBs: In our very quick review, we found only a few studies that explicitly identified the NEBs for gas vs. electric participants[16]. Most studies seem to study program-wide savings, perhaps because NEB studies are combined with broader process evaluations that sample for other goals. We provide information from this study to demonstrate apparent (preliminary) patterns between gas and electric NEBs.

NEBs for Individual Measures: There is minimal information on NEBs for individual measures in the residential sector, because most programs "bundle" measures within programs. The exception is the occasional air conditioning program, programs measuring NEBs for EnergyStar™ appliances (but appliances are not the primary focus of this working paper), or sometimes lighting (well-studied in commercial, but less so in the residential sector). We identified two types of studies that looked at NEBs for individual measures within a whole home retrofit program. One is represented by work by Skumatz Economic Research Associates, using regression methods to assign the participant NEB values to specific

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[14] *Skumatz, Lisa A., Ph.D., "Non-Energy Benefits / Non-Energy Impacts (NEBs/NEIs) and their Role & Values in Cost-Effectiveness Tests: State of Maryland", March 2014.*

[15] *Skumatz, Lisa A., Ph.D., 2010, "Non-Energy Benefits Analysis for Xcel Energy's Low Income Energy Efficiency Programs", May; NMR Group, 2011, "Massachusetts Special and Cross-Sector Studies Area, Residential, and Low Income Non-Energy Impacts (NEI) Evaluation (http://www.rieermc.ri.gov/documents/evaluationstudies/2011/Tetra_Tech_and_NMR_2011_MA_Res_and_LI_NEI_Evaluation%2876%29.pdf) and Cluett, Rachel, and Jennifer Amann, 2015, "Multiple Benefits of Multifamily Energy Efficiency for Cost-Effectiveness Screening, ACEEE Report A1502.*

[16] *Skumatz, Lisa A., Ph.D., 2010, "Non-Energy Benefits Analysis for Xcel Energy's Low Income Energy Efficiency Programs", May. Early work for the California utilities separately sampled for SoCalGas customers as well. Additional studies could not be reviewed thoroughly to identify variations for gas vs. electric.*

measures included. The other type, represented by the NMR Massachusetts work (NMR 2011), assigns percentages of NEBs to measures based on the energy savings.

The main conclusion of this work is that there is relatively little work on multifamily buildings – either from the resident perspective or the owner / manager perspective – and much of what exists focuses on the low income sector. In addition, the work on gas measures or gas programs is relatively limited. Most importantly, the work assigning NEBs to individual measures should be studied more.

Because this is a very short-time-frame, low budget analysis, we leverage off previous work, specifically single-family NEB review work SERA conducted for NRDC for Maryland (Skumatz 2014[17]).

[17] *Skumatz, Lisa A., Ph.D., "Non-Energy Benefits / Non-Energy Impacts (NEBs/NEIs) and their Role & Values in Cost-Effectiveness Tests: State of Maryland", March 2014.*

NEBs for SF Retrofit Programs

In previous work (Skumatz 2014), we identified the ranges for NEBs for single family weatherization programs. These analyses are summarized in Figure 4.

The review of the various categories of NEBs indicates:

- **Utility NEBs** are a minority of the estimated NEBs values (perhaps 3-4% of total NEB values estimated). Although very important, not all categories have been estimated (there is only limited work on power quality / reliability / security, etc.) we will not spend a great deal of time on these NEBs.
- **Societal perspective NEBs**: These NEBs are dominated (in estimates to date) by economic and emissions impacts. Emissions impacts are addressed elsewhere in Illinois' TRM.[18] Water savings are addressed elsewhere. Economic impacts are the major category remaining, and the estimates are highly dependent on the measures included in the program, and the industries located within the utility's territory – they are location and program measure dependent. This limits: 1) transferability from other studies conducted in other communities, and 2) limits transferability between programs, because measures drive the savings.[19]
- **Participant NEBs**: Participant NEBs are substantial (multiples of the bill savings, leading to a potentially significant change in the B/C ratio when included). However, the size of the NEBs associated with particular measures of interest have yet to be investigated; these are program-wide NEBs, and this is addressed in a later section.

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[18] Note that Illinois' TRM actually addresses the carbon impacts. There are other emission impacts, and these presumably also have value, but few of the published studies (including the authors') have been able to identify strong market values to use for some of the additional emissions. Therefore, for this quick study, we omit further consideration of these impacts. For further discussion of the state of the literature on this issues, see Skumatz 2014 (Skumatz, Lisa A., Ph.D., "Non-Energy Benefits / Non-Energy Impacts (NEBs/NEIs) and their Role & Values in Cost-Effectiveness Tests: State of Maryland", Skumatz Economic Research Associates, prepared for NRDC, March 2014). and Skumatz et. al. 2009, "Lessons Learned and Next Steps in Energy Efficiency Measurement and Attribution: Energy Savings, Net to Gross, Non-Energy Benefits, and Persistence of Energy Efficiency Behavior", Skumatz Economic Research Associates, Prepared for CIEE, November.

[19] Skumatz, Lisa A., Ph.D., 2006. "Net NEB Multipliers for NEB Impacts – Do Multipliers Vary Significantly by State and Program Type?", Proceedings of the ACEEE Summer Study on Buildings, Asilomar, CA, August. And Imbierowicz, Karen, and Lisa A. Skumatz, Ph.D., "The Most Volatile Benefits (NEBs) – New Research 'Homing in; on Values for Environmental and Economic Impacts", Proceedings of the 2004 ACEEE Summer Study on Buildings, Asilomar, CA, August. In the later study, we used input/output models to estimate the economic impacts of two type of energy efficiency programs (appliance replacement and weatherization/ retrofit in each of three different geographic territories (California, Wisconsin, and nationa) and compare the economic multiplier results. We found that, for a similar amount of money spent, the effects are substantially higher for weatherization/retrofit programs than appliance replacement, for all geographic areas, and for this program, the effects differed between the states, and were much larger when you considered the territory as the nation. The interpretation is that local industry matters in the results, but that, in simplistic terms, the programs are labor intensive, which leads to higher impacts, and the inputs used (insulation, etc.) are at least made somewhere in the US. The results for the appliance retrofit program told a different story. The high level message was that the impacts were quite low per dollar spent, and there wasn't a "spike" for the national results; appliances are generally not made in the US anymore. In relative terms, if the impact multiplier for appliance retrofit at the national level was the lowest value (and is scaled to 1.0), the factors for appliances for California, Wisconsin, and National, respectively, were 1.2, 1.0, 1.0; and for weatherization the three geographic areas were 2.1, 2.0, and 5.0, respectively. The local economic / job mix matters. Both studies were internally funded by SERA.

A review of Figure 4 shows that the "typical value" column for percentages (fifth column heading) shows the following approximate multipliers:

- Utility NEBs: About 24%, but excluding low income factors, the remainder is about 8%
- Societal NEBs: about 55%, with the largest share economics (31%) and emissions about 7% (treated elsewhere for Illinois).
- Participant NEBs: About 144% of the value of household bill savings. For Illinois, if the water element is subtracted (20%) an overall multiplier would be about 124%.

For Illinois, generally, if we applied these "typical" values, the total NEBs would be about 163% (8%+31%+124%), excluding factors related to water and emissions. About 76% of the multiplier comes from participant NEB, and as mentioned above, these are the NEBs of focus for the rest of the work paper.

Figure 4: Summary of Ranges and "Typical" Values for NEBs for Weatherization / Retrofit Programs [20]

Note: Relative consistency indicator: ** low variation / relative consistency across programs; * low variation / relative consistency within program types; ~somewhat consistent; Variations by program, target audience, or limited variation by program are noted in the last column.

Subtotals by major categories Weatherization Programs	Dollar NEB Values Range Low-High	Typical Value	Percentage NEB Values Range Low-High	Typical Value	Consis- tency	Varies with Pgm Target Audience, et
UTILITY PERSPECTIVE						
Payment-related	$2.55 - $14.50	$6.40	1% - 14.5%	4.7%	*	Pgm
Added if Low Income subsidies avoided	$3.00 - $25.00	$13.00	4% - 29.0%	16.4%	*	Pgm & target
Service Related	$0.10 - $8.50	$3.25	0.1% - 2.7%	0.8%	*	Pgm
Other Primary Utility	$0.13 - $2.60	$1.40	2.1% - 3.3%	2.4%		
TOTAL UTILITY NEBs	$5.78 - $50.60	$24.05	7.4% - 49.5%	24.4%		
UTILITY NEBs MULTIPLIER	3% - 25%	12%				
SOCIETAL PERSPECTIVE						
Economic	$8.00 - $340.00	$115.00	3.0% - 237.6%	31.1%	*	Pgm
Environmental / Emissions	$3.00 - $180.00	$60.00	0.7% - 57.9%	7.1%	**	Ltd variation
H&S equipment / fires	$0.00 - $0.30	$0.00	0.3% - 0.3%	0.0%		Pgm
Health Care	$0.00 - $0.00	$0.00	0.0% - 0.0%	0.0%		Pgm
Water / Wastewater infrastructure	$1.00 - $28.00	$15.00	0.9% - 33.1%	17.0%		Pgm
TOTAL SOCIETAL NEBs	$12.00 - $548.30	$190.00	5.0% - 329.0%	55.3%		
SOCIETAL NEBs MULTIPLIER	6% - 274%	95%				
PARTICIPANT PERSPECTIVE						
Water and Other bills	$2.85 - $54.00	$15.00	4.5% - 63.4%	20.0%	*	Pgm
Financial / customer service	$0.27 - $36.70	$3.60	8.7% - 16.4%	3.4%	*	Pgm & target
Economic Dev'p / Hardship	$0.00 - $115.00	$75.00	26.3% - 55.3%	8.0%		Pgm & target
Equipment Operations	$26.00 - $127.00	$82.00	17.1% - 42.7%	28.4%		Pgm
Comfort, Noise, Related	$26.00 - $105.00	$69.00	12.2% - 51.3%	26.6%	*	Pgm
Health / Safety	$3.02 - $100.50	$16.50	1.5% - 59.5%	12.8%	*	Pgm
Control / Education and Contributions	$26.25 - $177.00	$89.75	19.8% - 72.0%	26.2%	*	Pgm
Home Improvements	$10.50 - $77.00	$36.00	8.3% - 38.4%	18.8%	~	Pgm
Special / reliability / other	$0.00 - $4.05	$0.00	0.0% - 4.8%	0.0%		Ltd, target
TOTAL PARTICIPANT NEBs	$94.89 - $796.25	$386.85	98.5% - 403.8%	144.1%		
PARTICIPANT NEBs MULTIPLIER	47% - 398%	193%				
All NEBs Multipliers: **Relative to Bill Savings**						
Utillity	3% - 25%	12%	7% - 49%	24%		
Societal	6% - 274%	95%	5% - 329%	55%		
Participant	47% - 398%	193%	99% - 404%	144%		
ALL Multiplers - relative to bill savings	56% - 698%	300%	111% - 782%	224%		
NOTE: Ltd variation for emissions are for peak / off-peak focused programs.						

Source: Skumatz, 2014.

[20] *From Skumatz, Lisa A., Ph.D., "Non-Energy Benefits / Non-Energy Impacts (NEBs/NEIs) and their Role & Values in Cost-Effectiveness Tests: State of Maryland", March 2014. Minor edits included here.*

NEBs for MF Retrofit Programs

NEBs results for several multifamily programs for Xcel Energy (Skumatz 2010)[21] are presented in Figure 5. The three programs are all low-income. They are, in turn, a multifamily retrofit program, a landlord-based program for non-profits serving low income (landlord perspective), and a single family low income retrofit program (presented because we use it for comparison purposes).

Figure 5: NEB Estimates for Three MultiFamily Programs in Colorado
(Reproduced from Skumatz 2010)

	LI - MultiFam Weath	LI-Multifam Weath Electric	LI Multifam Weath - Gas	LI NonProfit Weath	LI Non-Profit Weath Electric	LI Non-Profit Weath - Gas	LI Single Fam Weath	LI Single Fam Weath-Electric	LI Single Fam Weath-Gas
Water/sewer bill (savings)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Shutoffs	$6.49	$3.84	$6.99	$4.85	$3.70	$4.81	$3.05	$2.85	$3.39
Calls to the utility	$0.06	$0.06	$0.09	$0.09	$0.07	$0.09	$0.06	$0.06	$0.06
Reconnects	$0.54	$0.83	$1.59	$2.13	$1.55	$1.11	$1.57	$0.86	$0.00
Property value effects	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Fires-related safety changes	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Indoor Air quality (CO-related)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Moving costs / mobility	$1.40	$1.40	$1.40	$1.40	$1.40	$1.40	$1.40	$1.40	$1.40
Illnesses and lost days from work/school	$4.08	$4.08	$4.08	$4.08	$4.08	$4.08	$4.08	$4.08	$4.08
Transactions costs (limited measures)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Health & Safety	$42.11	$12.65	$27.98	$500.45	$298.42	$202.04	$44.02	$12.58	$31.66
Comfort	$20.77	$6.54	$13.82	$233.43	$139.19	$94.24	$20.66	$5.96	$14.51
Appliance function	$63.48	$18.99	$42.95	$576.62	$343.83	$232.78	$62.14	$17.85	$44.23
Hardship (not incl. elsewhere)	$66.87	$20.39	$46.49	$1,669.95	$995.78	$674.17	$61.76	$17.51	$44.25
Neighborhood Value	$24.25	$7.37	$15.54	$173.91	$103.70	$70.21	$21.43	$6.08	$15.40
Water Bills	$22.41	$6.99	$14.70	$166.82	$99.47	$67.35	$20.30	$5.95	$14.39
Knowledge and Control	$51.48	$15.59	$33.37	$428.34	$255.42	$172.93	$43.06	$12.38	$30.83
Doing "good" for environment	$22.13	$6.67	$13.96	$237.48	$141.61	$95.87	$21.67	$6.23	$15.27
Productivity	$0.00	$0.00	$0.00	$171.54	$102.29	$69.25	$0.00	$0.00	$0.00
Coll'n	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$19.76	$5.71	$13.50
Other	$23.51	$7.11	$15.98	$166.82	$99.47	$67.35	$22.52	$6.39	$16.18
TOTAL Participant NEBs	$349.56	$112.51	$238.92	$4,337.90	$2,589.98	$1,757.66	$347.46	$105.88	$249.15
Participant NEBs EXCL Low income Specific & Water	$253.20	$80.40	$169.07	$2,494.06	$1,489.40	$1,010.13	$260.72	$78.65	$187.05
Non-Low Inc Participant NEBs as Ratio to Bill savings		101%	93%		94%	94%		116%	110%

Whether landlord perspective or household perspective, the ratio of participant NEBs to bill savings are between about 93% and 116%. This is true across single and multifamily programs, for gas and electric program participants. If we were to include benefits expected to be higher for low income customers – or exclusive to low income customers – these ratios would be higher. The estimates subtract water, hardship, and payment-related NEBs in developing the ratios for this working paper.

[21] *Skumatz, Lisa A., Ph.D., "Non-Energy Benefits Analysis for Xcel Energy's Low Income Energy Efficiency Programs", for Xcel Energy, Denver CO, May 2010. We found additional studies that examined multifamily new construction programs, etc. but they are not included.*

Three programs are also addressed in a study by Myers and Skumatz (ACEEE 2006)[22]

Figure 6: Participant NEBs from Multifamily Programs
(Reproduced from Myers and Skumatz 2006)

Category (percent of total Participant NEBs)	Energy Star MF	MF Metering Program	Low Income MF Retrofit
Operating cost (excl. energy)	14%	6%	0%
Equip maintenance	10%	8%	-13%
Equip Performance	9%	4%	14%
Equip Lifetime	10%	2%	3%
Occupant satisfaction	9%	11%	1%
Occupant Comfort	8%	4%	3%
Aesthetics / Appearance	5%	19%	17%
Lighting / Quality of Light	5%	2%	13%
Noise	6%	0%	8%
Building Safety	2%	3%	5%
Ease of leasing/selling	6%	10%	17%
Doing good for environment	12%	16%	27%
Power quality / reliability	4%	10%	
Labor requirements		11%	
Ability to Stay in Units/avoid moving due to bill consistency			5%
NEBs as Multiple of energy savings	67%	44-110%	108%

Each program shows NEB estimates in the range of about 70-100% of the value of bill savings, with lower values for the EnergyStar program (which is not a retrofit program).

We provide the following table from the NMR study, addressing participant NEBs.

Figure 7: Mean NEI Values from MF Occupants – Non-Low Income Population
(Interpreted from Table 9-5 in report)

NEI category	Dollar Value per year	Pct of Bill Savings
Thermal Comfort	$272	37%
Noise reduction	$31	11%
Health Benefits	$4	3%
Property Value	$1998	
Equipment Performance	$124	36%
Lighting life / quality	$49	7%
Durability of Home	$49	12%
Sum of NEIs (excl property value)	$382	112%

[22] *Myers, Jody, and Lisa A. Skumatz, Ph.D., 2006. "Evaluating Attribution, Causality, NEBs, and Cost-Effectiveness in Multifamily Programs: Enhanced Techniques", Proceedings from the ACEEE Study on Buildings, Asilomar, CA, August.*

The NEB value total is a little more than the value of the energy bill savings – 112%.

Figure 6 in the ACEEE 2015[23] study notes the following impacts from the owner and manager perspective, pulled from the NMR study.

Figure 8: Valuation of Impacts from building Owner and Manager Perspective (from NMR 2011)

Impact	Value per building	Percent of Bill savings
Marketability of Rental Units	$113	8%
Equipment Maintenance	$500	3%
Lighting Maintenance	$2,927	28%
Durability	$1,065	10%
Tenant Satisfaction (pos & neg)	$221	4%
Other (pos & neg)	$3,439	18%
Total		71%

Table note from original authors (edited): Values adjusted for overlap. Other includes the bottom line due to lower energy bills, increasing tenant awareness of energy efficiency, increased safety, respect from the community, and bulbs not lasting as long as they were supposed to.

The building owner realizes a value of about 71% of energy bill savings from the participant perspective NEBs.

Examining the results from this section, we find that participant-perspective NEB results are fairly similar in order of magnitude terms, for gas and electric programs, and for single family and multi-family occupants. They are a little lower for owners / managers of the buildings (as might be expected).

[23] *Cluett, Rachel and Jennifer Amann, "Multiple Benefits of Multifamily Energy Efficiency for Cost-Effectiveness Screening", ACEEE, Washington DC, June 2015 Report A1502*

Disaggregation / Attribution from Programs to Measures

There are four ways to estimate measure-specific NEBs commonly delivered through whole building retrofit programs:

1. Regression: Use regression analysis to tease apart measure-specific values;
2. Savings share: Allocate program level NEBs to measures in proportion to the savings individual measures produce;
3. Stratified Estimates: Conduct NEB studies that sample participants using stratified techniques that allow sufficient respondents to estimate NEBs separately by measure[24];
4. Across the Board: Assign all program measures the same program-level NEBs multiplier (Percent of retail energy costs saved).

Each has pros and cons, a few of which are listed below:

- Pros: Options 1, 2, and 4 can be conducted "after the fact"; 2 and 3 can identify impacts of demographics and other influencing factors; 2 and 4 are easy.
- Cons: The cons are the "inverse" of the pros, and examples include: Option 4 would apply NEBs for some categories that may not apply (comfort to water heaters, etc.) but would be right on average; 1 and 3 are more complicated; 2 and 4 do not identify influencing factors.

We have found examples of the use of two of these approaches to disaggregate program-level savings to measures in the literature.[25]

- Regression methods estimating the share of NEBs due to specific installed measures, and
- Assignment of NEB values to measures based on savings.

Examples of these results are shown in Figures 9-11.

The results of estimates using regression to identify the sources of NEB values found the following. [26]

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[24] Where those measures are installed outside a "bundle". This statistical "identification" problem arises in both 1 and 3. When some measures are installed together, or when all households get some measures, separate NEBs would not be available for each measure, but could be estimated for the "bundle".

[25] We understand a version of Option 3 may be completed this year.

[26] Smith-McClain, Lisa, Lisa A. Skumatz, Ph.D., and John Gardner, 2006, "Attributing NEB Values to Specific Measures: Decomposition Results from Programs with Multiple Measures", Proceedings of the ACEEE Summer Study on Buildings, Asilomar, CA, August.

Figure 9: Results from Models to Distribute Non-Energy Benefits across Measures (bold indicates 85% significance or better; reproduced from Smith-McClain, Skumatz, and Gardner, ACEEE) [27]

	Model 1: Linear Model		
Parameter	**Coef.**	**t[9]**	**P>|t|**
Furnace repair	**207.3**	**1.98**	**0.05**
Furnace replacement	98.1	0.87	0.39
Hot water heater repair	132.1	0.64	0.52
Hot water heater replacement	-40.1	-0.34	0.73
Insulation	**288.4**	**2.88**	**0.01**
New CFL light bulbs	-129.0	-1.28	0.20
New appliances	111.2	1.08	0.28
Testing for drafts	63.2	0.42	0.68
Caulk on windows	109.0	0.84	0.40
New Thermostat	-178.7	-1.39	0.17
CO2 and/or smoke detector	7.3	0.06	0.95
Fix/replace doors	0.5	0.00	1.00
Fix/replace windows	71.6	0.79	0.43
Fan installation	-105.0	-0.60	0.55
Fix/install A/C	-285.7	-1.32	0.19
Fix/replace vents	-152.7	-1.12	0.27
Seal crawlspace	11.4	0.05	0.96
Household income	**0.01**	**1.62**	**0.11**
Number of residents	-19.9	-0.46	0.65
Number of children	**144.5**	**1.52**	**0.13**
Number of elderly residents	**-129.5**	**-1.91**	**0.06**
Number of disabled residents	67.7	0.83	0.41
Constant	186.6	1.14	0.26
Intercept 2	n/a	n/a	n/a
Model "Fit" Statistics	F=2.18, Prob>F=0.0049		

The study worked to disaggregate NEBs from a statewide single family weatherization / retrofit program. The results from Model 1 indicate that, in the sample, households that received insulation valued the NEBs they received an average of $288 greater than those that did not. Other measures with stronger NEBs are furnace repair, and indications are good for caulking, furnace replacement, new appliances, and others. Some, probably because they are in packages in a way, were not positive (including CFLs, new thermostats, fans, and air conditioners). This does not mean the NEBs were negative; rather, the NEBs were lower than the constant term, and the net (plus the factors from the demographics) are used to compute the NEBs for any one measure in this approach. We also find that NEB perceptions vary based on the demographics of the residents – with stronger NEBs for households with children.

Figure 10 provides an example of Option 2, allocating NEBs based on the share of program savings delivered by the measure. This study is from Massachusetts. The study identified a combined participant NEB value for the weatherization program of 114%, which is very in line with the other studies noted in this working paper. The allocations between measures are shown in Figure 10, and summarized / summed for convenience in Figure 11.

[27] *Smith-McClain, Lisa, Lisa A. Skumatz, Ph.D., and John Gardner, 2006, "Attributing NEB Values to Specific Measures: Decomposition Results from Programs with Multiple Measures", Proceedings of the ACEEE Summer Study on Buildings, Asilomar, CA, August.*

Figure 10: Assigning NEB Values to Measure Savings, Apportioning on Energy Savings for Measures (non-low income MultiFamiily), (Reproducing Table 9-10 from NMR Cross-cutting study)[28]

	Thermal Comfort		Noise Reduction		Health Impacts		Property Value		Equipment Maintenance		Lighting Quality		Durability of Home	
	% bill savings	$[157]	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$	% bill savings	$
Sample size, by NEI[158]	*209*	*180*	*147*	*187*	*209*	*190*	*209*	*171*	*139*	*125*	*47*	*41*	*209*	*188*
Air sealing	8%	$10.13	16%	$4.88	8%	$0.32	7%	$135.83	-	-	-	-	8%	$3.95
Appliance (refrigerators and freezers)	-	-	-	-	-	-	<1%	$1.44	-	-	-	-	-	-
Cooling systems	3%	$3.92	9%	$2.83	3%	$0.13	3%	$62.65	6%	$7.54	-	-	3%	$1.54
Duct sealing	<1%	$0.16	-	-	<1%	$0.01	<1%	$2.51	-	-	-	-	<1%	$0.06
Heating & cooling syst.	4%	$5.05	-	-	4%	$0.16	4%	$80.69	8%	$9.42	-	-	4%	$1.98
Heating & hot water sys.	1%	$1.83	-	-	1%	$0.06	1%	$29.17	3%	$3.41	-	-	1%	$0.72
Heating system	39%	$48.63	-	-	39%	$1.56	34%	$678.52	83%	$102.40	-	-	36%	$17.42
Hot water system	-	-	-	-	-	-	4%	$82.56	-	-	-	-	4%	$2.13
Insulation	20%	$25.15	37%	$11.54	20%	$0.80	19%	$378.05	-	-	-	-	20%	$9.82
Lighting	-	-	-	-	-	-	5%	$96.61	-	-	100%	$49.00	-	-
Service to heating or cooling system	<1%	$0.47	-	-	<1%	$0.01	<1%	$7.44	1%	$0.87	-	-	<1%	$0.18
Low flow showerhead	-	-	-	-	-	-	<1%	$0.03	-	-	-	-	-	-
AC system sizing	<1%	$0.19	-	-	<1%	$0.01	<1%	$3.01	<1%	$0.37	-	-	<1%	$0.07
Programmable thermo.	3%	$3.99	-	-	3%	$0.13	3%	$51.49	-	-	-	-	3%	$1.33
Window	1%	$0.68	2%	$0.54	1%	$0.02	<1%	$6.72	-	-	-	-	<1%	$0.21
Weatherization[159]	20%	$25.00	36%	$11.22	20%	$0.79	19%	$381.28	-	-	-	-	19%	$9.57
Total Value	100%	$125	100%	$31	100%	$4	100%	$1,998	100%	$124	100%	$49	100%	$49

Figure 11: Total of NEB value by Measures as a Percent of Bill Savings
(Calculated from Table 8)

Measure	Sum of NEIs -Multiple of associated bill savings
Air Sealing	47%
Appliance (refrigerators and freezers)	1%
Cooling systems	27%
Duct Sealing	4%
Heating & Cooling system	24%
Heating & Hot water system	7%
Heating system	231%
Hot Water System	8%
Insulation	116%
Lighting	105%
Service to heating or cooling system	4%
Low Flow Showerhead	1%
AC system sizing	4%
Programmable Thermostat	12%
Window	6%
Weatherization	114%

Finally, one study that analyzed NEBs for residential appliances was found quickly. The study was conducted in New York, and examined NEBs for the ENERGY STAR® products program. Its results are provided in Table 12 below.

[28] *NMR Group, 2011, "Massachusetts Special and Cross-Sector Studies Area, Residential, and Low Income Non-Energy Impacts (NEI) Evaluation (http://www.rieermc.ri.gov/documents/evaluationstudies/2011/Tetra_Tech_and_NMR_2011_MA_Res_and_LI_NEI_Evaluation%2876%29.pdf)*

Figure 12: Estimates of Appliance NEBs as a Percent of Measure Savings
(derived from Skumatz, 2006)[29]

Household appliances	Refrig-erators	Dish-washers	Clothes Washer	Room Air Conditioner	CFL Bulbs	Lighting Fixture
NEB Multiplier as a percent of the measure's energy savings	29%	65%	54%	71%	90%	30%

These last two tables provide a very attractive set of numbers that can suit the immediate needs of the Illinois process. The values are disaggregated according to savings, and the "big picture" numbers are consistent with the literature reviewed above. The value of 114% for a weatherization / retrofit program is consistent, and the values for lighting are similar orders of magnitude between the studies in New York and Massachusetts. We adapt these figures in two ways for consideration for the process in Illinois:

- We delete values associated with appliances and lighting in Figure 11, preferring the measure-specific values in Figure 12; and
- We delete that share of the lighting values in Figure 12 that are associated with measure lifetimes and maintenance savings.

The figures with these refinements are presented in Figures 1 and 2 in the Executive Summary (Recommendations) at the beginning of this document.

[29] *Skumatz, Lisa A., 2004, Non-Energy Benefits from ENERGY STAR®: Comprehensive Analysis of Appliance, Outreach, and Homes Programs, Proceedings of the 2004 ACEEE Summer Study, Asilomar, CA, August.*

Findings

Relative to the values of most interest to Illinois, Figure 11 shows NEB values for key measures of interest:

- Shell – including sealing, insulation, duct insulation, and sealing
- Domestic hot water measures
- Lighting
- And some furnace-related measures.
- We do not see values for boiler reset controls.
- Appliance figures are provided in Figure 12.

We do not use / recommend these values from the original sources directly; we recommend some modifications to the values, particularly for lighting. Illinois already addresses maintenance-related benefits for lighting, and an adjustment to the figures from the original report is incorporated into the recommendations in Figures 1 and 2 in this work paper.

Of course, this is a first work paper on this topic, and we provide estimates based a limited analysis and number of studies. However, the results appear consistent, and a little additional work, easily conducted, would lend additional reliability to the work.

The disaggregation using regression results probably provides the most reliability and accounts for differences in populations. However, the attribution by savings, as in Figure 10 and Figure 11 – and refined for recommendations in Figures 1 and 2 – probably represents the simplest and most practical approach for the near term. The savings values as calculated for Massachusetts could be used (as in the Figure) or they could be refined for Illinois to be consistent with the TRM (which could be accomplished with some additional work).

Implications and Next Steps

The results show:

- The NEBs for utility benefits are relatively small, but should be studied and included in the future.
- The societal NEBs are important and valuable. The multipliers for different studies show substantial job creation and economic output, but also indicate the multipliers vary based on program and regional economics. Studies from other states are not likely to be suitable for Illinois. We strongly recommend this be addressed in the near future. We do not address the also-substantial emissions benefits because they are addressed by other means in Illinois.
- The participant NEBs are valuable – whether they are valued from the perspective of the households that are participants, or the landlords / managers. In each case, we find the NEBs multipliers for these benefits – excluding water savings – range from about 70% to more than 100% of the bill savings.
    - Participant NEB Values for landlords similar to households: between about 70% and 100+%
    - Participant NEB Values for gas about the same as electric: The figures varied little between the two sets of participants
    - Disaggregating to Measures: There are two main methods that have been used to disaggregate NEBs to measures: regression techniques and assignment by energy savings.

Our recommendations follow:

- We recommend using the values in Figure 1 and Figure 2 as NEB values in the Illinois process, particularly for shell, heating, and water heating measures, and appliances. The multiples would be tied to the customer energy bill savings in the existing tables, or could be adapted to be consistent with the Illinois TRM values. The NEB value multipliers are straightforward calculations and could be readily added to the Illinois TRM-based benefit-cost process.
- We recommend adding economic benefit NEBs as state-level figures become available. If nearer-term figures are desired, we can work to adapt values from other “similar” states.
- We also recommend continuing work in this area.