Evidence for Multiple Benefits or NEBs: Review on Progress and Gaps from the IEA Data and Measurement Subcommittee

Theresa Weinsziehr, Leipzig University, Germany
Lisa A. Skumatz, Ph.D., Skumatz Economic Research Associates, Inc., Superior Colorado, USA

ABSTRACT

The International Energy Agency (IEA) has established a working group, and associated subcommittees, focused on Multiple Benefits (MB) (or Non-energy benefits NEBs) and their role in energy efficiency (EE). The working group includes members from around the world, and the "Evidence" committee has been examining evidence on MB values and their transferability, measurement methods and best practices, and important research gaps. The "Evidence" subcommittee is considering the measurement of all MBs, not just those of current interest, to support continued progress in measurement and the broader application of MBs to cost-effectiveness work, as well as political and policy development. This paper presents a summary of the review of key evidence findings to date are presented in this paper.

Introduction

The IEA's attention on Multiple Benefits (MB) or Non-Energy Benefits (NEBs) includes wide-ranging research and policy work on MBs to support its members improve their policy and program development in energy efficiency (EE) and more broadly. The subcommittee on "Evidence" is focusing on issues related to methods, values, best practices, application, and gaps – with an eye toward advancing research to a situation in which MBs are well- and consistently-measured, values and the concept are widely accepted and well-known, and MBs are integrated into program and policy applications on a routine basis. The committee's active membership includes representatives from academics, industry, consulting, and government from Germany, US, UK, Sweden, Australia, France, Netherlands, and elsewhere, all of whom contributed to this paper. [1]

It is important to consider measurement all Non Energy Benefits (NEBs) or Multiple Benefits (MB) categories, not just those of current interest, so measurement progress may continue. In the near term, priority categories will expect to garner most attention, including NEBs for cost-effectiveness work, those with political or program attention (health), and others. However, the Evidence committee is interested in continuing work on multiple and improved measurement methods, and in identifying best measurement practices for the variety of types of NEBs – whether based on primary data, models, secondary data, or survey-based. There has been significant progress best practices over the last 20 years, and some are relatively-well-

[1] Summaries or inputs to this literature review were conducted by: Theresa Weinsziehr of Liepzig University, Germany; Lisa A. Skumatz, Ph.D., Dana D'Souza, and Michael Santulli of Skumatz Economic Research Associates USA; Luc van Summeren and Ruth Mourik of Duenworks, Netherlands; Johannes Thema of Wuppertal Institute, Germany; Bruce Tonn of Three3 Inc. USA; Niall Kerr of Leeds University UK; Josefine Rasmussen of Linoping University, Sweden; Alison Smith of Environemtnal Change Institute, Oxford University UK; Hilary Thomson of University of Glasgow, UK; Stanislas Nosperger, EDF R&D, France; Ian Hamilton of UCL Energy Institute, UK; Denise Mulholland of EPA, US; and Stephen Berry of the University of South Australia, Australia.

known (model-based economic and emission estimates, arrearage studies, survey-based participant-benefit approaches), and others are in flux or being further explored. Organizing existing work will improve the understanding of NEBs, encourage their use, and illuminate priority gaps for next research. The goal is defensible, well-estimated NEB values. The committee believes it is important to continue to improve methods and innovate to uncover more accurate, efficient, and encompassing NEB estimation approaches.

The Committee's goal is to review the existing literature to create a matrix of NEB values, and for each sector (residential, commercial, R&D, etc.) devise a map of estimated values for each NEB benefit category against specific measures installed and "whole building" or "design" categories. Further, the Committee is interested in identifying where normalized NEBs (e.g. jobs per kW installed, etc.) may be reliably transferred to programs and regions beyond where the estimates were developed. In addition, new estimation methods are critical to continued progress. Evidence on the opportunities to apply NEBs research to program and policy development are of interest, so the strategies and research results may be leveraged by policymakers internationally. Finally, identifying and filling gaps in research is a priority.

To reflect these goals, this paper is organized into six main sections to examine status quo and progress in NEB Values, Methods, Application Best Practices, Transferability, Research Gaps and Next Committee Steps. We summarize results identified from review of an initial round of literature research. At least 50 additional studies have been identified that will be a next focus of the committee.

Evidence on Values

Literally hundreds of studies and papers in the US and internationally have presented evidence on individual NEB values from individual programs and measures. In addition, a number of papers have reviewed and accumulated values found on lists of utility, societal /environmental, and participant values (Skumatz 2009, Urge-Vorsatz et al 2009, OECD/IEA 2014, and others). Skumatz addresses methods, value ranges for more than 30 NEB categories, and research gaps in US research (updated in Skumatz 2014). Urge-Vorsatz is a very detailed literature review of existing worldwide papers that quantify "co-benefits" and ancillary benefits in health, ecology, economic, service provision and social/political categories, assembled from around the world. The OECD/IEA paper conducts a literature analysis of benefit categories including macroeconomic development, public budgets, health, productivity and other topics. These studies identified gaps and areas of research interest, and the Committee has been assembling and reviewing studies on a number of these topics.

Beyond these and other general studies and reviews on values, interesting research producing values has been conducted in a number of specific topic areas. The COMBI project (COMBI 2015) includes literature reviews on values related to air pollution, health impacts, social welfare / comfort / productivity, macro-economic impacts (GDP, employment, public budget), energy system and energy security impacts, and other topics.

Health: Health benefits have been a noticeable gap in US NEBs research. Work has been conducted by Thompson and Thomas (2015), in Scotland, which conducted a literature review of 39 qualitative and quantitative studies to develop a logic model and examine evidence for the impacts of housing improvement on health. They conclude the best evidence indicates improved housing (size, warmth) improves social situations and reduces absences from school and work.

Rose et. al. (2015) found that the Weatherization and Healthy Homes Initiative (Washington State US) examined pre- and post- intervention data and found both weatherization and healthy homes elements of the initiative led to a significant dollar decrease in Medicaid-related costs for asthma and reduction of insurance claims. In a UK study, Milner et. al. (2014) modeled current and future distributions of indoor radon levels to examine lung cancer mortality, and examined the impact of potential energy efficiency / building remediation work on health. Increased air tightness increased radon concentrations (by 57%) led to 4,700 life years lost per year, and at peak, 278 deaths. Other models were also investigated. Jensen et al (2013) examined and quantified the health co-benefits from household energy programs, including impacts on years of life, disabilities, labor supply, and healthcare costs. Barnard et. al. (2011) conducted work estimating the impact of New Zealand's "Warm Up" home retrofit program (including insulation, heating, and other measures) on hospitalizations, pharmaceutical costs, and mortality. The study found insulation was responsible for the lion's share of the health impacts (100 times the impact from heating), annual, on-going benefits of about $560 for retrofitted insulation. Benefits were about 3.5 times higher than others for some subgroups in the study. Values for furnaces / heaters were insignificant for hospitalizations, and about $5 annually for the total of other health effects. In a study from England, Hamilton, et. al. (2015) developed a cost benefit analysis of fuel payment and energy efficiency retrofits interventions among select sub-populations. In a study of the US Weatherization Assistance Program (WAP), Tonn et. al (2014) monetized numerous health and household related benefits attributable to the weatherization of low income homes. The study assessed benefits to thermal stress, asthma, food assistance, missed days from work, CO poisoning, home fires, low birth weight babies, and other sources. The accumulated impacts were estimated to be $14,148 per household unit retrofitted. Reflecting work by an intergovernmental panel on climate change, Lucon et. al. (2013) conducted a literature review and found health benefits of $0.49 for every $1 invested in warming homes (UK), or health benefits per ton of CO2 not emitted from power plants of $2 (EU) to $7 (China) or $46 (India).

Emissions: A USEPA study (USEPA 2011) reviewed literature on the quantitative impacts of energy efficiency on pollution, health impacts, economic development, and system security. Laitner and McDonnell (2014) finds a 20 percent reduction in electricity savings by 2030 can reduce carbon pollution by 971 million metric tons, and sulfur dioxide and nitrogen oxides by 700,000 and 800,000 tons, respectively. Lucon et. al. (2013) identified studies that fid substantial benefits from reduced emissions, but that other types of monetized benefits are as large or larger than pollution impacts (including poverty-related effects).

Jobs and Macro-Economic Development: The USEPA (2011) study also found studies estimating the economic impact of one million dollars of investment in EE ranges from 1.62.8 jobs, vs. 5.7 jobs in wind or PV, and 3.9 jobs for coal power (results from studies cited in the paper). Gardner et. al. (2007) finds that net job impacts from weatherization programs are substantially higher than for appliance replacement-type programs, and that impacts for individual states are very dependent on local industry. Results were presented for two states and nationwide programs. Laitner and McDonnell (2014) conducted a literature review and found that 20 percent electricity savings by the year 2030 can catalyze a net consumer savings that supports a gain of 800,000 jobs for the American economy, wage increases of $45 billion, and

GDP increases of $26 billion. Lucon et. al. (2013) found that EE in buildings generates 13 job-years per million US dollars spent (2010 dollars).

Productivity from EE and Indoor Air Quality: The Lucon, et.al. (2013) literature review also noted that increasing the energy efficiency of buildings can increase productivity by 1-9% or higher, depending on the specific activities or case studies. Loftness et. al. (2003) note that improving IAQ does not have to cost more, and that the ability of owners to control temperature locally at the office increases productivity by 3.5-36.6%. Gains from improved ventilation and "task air" led to 0.48-11% productivity gains, improvements from outside air resulted in 0.62-7.37% productivity gains, and reduction of primary pollutant increased performance by 3-13.2%. Lighting improvements increased productivity by 3-13.2% and daylight simulating fixtures improved productivity by 0.7-2%.

Property Values: In a UK paper, Chegut, Eicholtz, et. al, (2010) conducted a review of the international green building literature and found that green buildings lease for 21% more and transit for 26% more money per net square meter than non-green buildings. The premium decreases as the neighborhood saturation of green buildings increases. In a US study, Pivo and Fisher (2009) looked at benefits to homes and businesses and found that energy Star properties had 5.9% higher net incomes per square foot, dues to 9.8% due to lower utility bills, 4.8% higher rents, and 0.9% higher occupancy rates. These buildings also had 13.5% higher market value per square foot, 0.5% lower cap rates.

Evidence on Applied Measurement Methods

An assessment of the quality and reliability and costs of the methods used to estimate NEB values – and development of improved methods – is of key interest.

ECD/IEA (2014) challenges the assumption that the broader benefits of energy efficiency cannot be quantified, providing practical examples of how existing methodological tools can be applied to measure and even monetise the value of energy efficiency to the economy and society. The COMBI papers (2015) review NEB quantification challenges. Skumatz et. al. (2009) reviewed the status quo and recent developments on methods to estimate utility, societal, and participation NEBs, including primary research, induced impacts / secondary approaches, third-party models, and survey-based monetization, and discusses pros, cons, and performance associated with the methods. It also laid out criteria for best measurement practices. US EPA (2011) reviews multiple benefits for policy-makers and analysts and methods for calculating them. The benefits guide provides an overview of a range of basic to sophisticated approaches to quantifying the energy, electricity system, air, health, and/or economic impacts (particularly benefits) of energy efficiency and renewable energy policies and program and includes numerous examples and caveats for consideration.

A modeling approach for health effects is provided in Hamilton et. al. (2015), and Milner et. al. (2014) models home energy efficiency and radon related risks of lung cancer. Jensen, et. al. (2013) demonstrates the importance of health co-benefits in macroeconomic assessments of UK Greenhouse Gas emission reduction strategies. Laitner and McDonnell (2014) use the DEEPER model to develop estimates of the relationships between energy efficiency, electricity savings, pollution, jobs, and economic effects. In a Swedish study, Nehler and Rasmussen (2015) used questionnaires and interviews with a small number of industrial firms to explore

benefits and motivations behind EE investments, including work environments, health, safety, maintenance, and other effects. They found their interviewees had difficulty in linking observed changes with monetary values.

US EPA has at least two tools for measuring the health benefits associated with a reduction in criteria air pollutants from power plants[2] (as opposed to effects from IAQ), which are available to help analysts project the economic value of these impacts.

Evidence on Applications, Uses, and Users

Another key topic is to identify the range of applications to which NEBs have been applied – including benefit-cost, program planning, marketing, etc. Assembling case studies – and assessing the quality and costs -- can illustrate the relative advantages of using NEBs, or subsets of NEBs, in different applications.

Studies have targeted their findings to a variety of audiences. Milner and Hamilton (2014) addressed national healthcare in their review and economic analysis of excess winter deaths and illnesses. Nehler and Rasmusssen (2016) focus on effects for firms and their decision-making. Skumatz (2014) focuses on cost-effectiveness applications for states and regulatory agencies. Skumatz et. al. (2009) provided information on the role of NEBs in program marketing. Gardner, et. al. (2007) provides information to program planners on the differences in program designs on job impacts.

In work that is underway, a German study, Weinsziehr (2016) focuses on providing information on the MBs of building refurbishment for municipal decision makers in middle sizes cities in Germany.

Policy applications are the focus of multiple studies. Rider, et. al. (2015) used a combination of research and professional judgment, along with stakeholder comments to develop reasonable assessments of the economic impacts of energy-related policies on businesses. OECD/IEA (2014) showed that as much of two-thirds of energy efficiency potential will remain untapped unless policies change, and benefits are better valued. They estimate that the GDP impacts from large-scale EE policies should spur economic growth of 0.25 – 1.1% per year, job creation of 8-27 jobs per one million euro investments in EE, productivity benefits of 2.5 times the value of energy savings, would reduce unemployment expenditures, and lead to other benefits. They also estimate that the benefits-cost ratio of EE investment is four-to-one when well-being and health benefits are included. The Pivo and Fisher (2009) study's estimation of residential and commercial building value improvements provided advice useful to both developers and to policymakers. Lucon et. al. (2013) addressed policymakers and governmental officials in results that estimate the productivity, emissions, and health benefits from investment in energy efficiency. USEPA (2011) describes multiple benefits for policy makers and analysts and methods for calculating them, addressing benefits to electrical system, air, health, and economics, from energy efficiency and renewables strategies.

In on-going research, Kerr is reviewing the use of NEBs and normal energy benefits (EB) in energy efficiency policy impact assessments, identifying evidence of the degree to which NEBs are currently valued in EE policy in the UK and three other countries.

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[2] BenMAP (https://www.epa.gov/benmap) and COBRA (https://www.epa.gov/statelocalclimate/co-benefits-risk-assessment-cobra-screening-model. COBRA is a US-specific model, targeted at state governments and others who want to assess the health (and related economic) benefits associated with energy efficiency and renewable energy. BenMAP is used internationally.

Evidence on Transferability

To the degree well-researched NEB values (and methods) can be applied from one location or program to another areas, results can be leveraged, money can be saved, and greater confidence is realized in NEB results. In addition, transferability of results means estimates or ranges for program NEBs are better known prior to implementation of a program. The risk associated with ex post NEB values has been a significant barrier to US utilities and program implementers considering NEBs in program benefit cost equations because of their financial reimbursement for programs would incorporate a "risky" factor -- NEBs. They prefer greater certainty prior to investment in programs, and transferable, "deemed" values – or progress in that direction – would further increase acceptability and adoption in the US.

The Committee is reviewing the existing work for patterns and places where existing existing values seem may be easily adaptable to other programs and locations. This may include values that are consistent or are weather insensitive, or values whose variations can be easily modeled in a predictive calculation for use in other programs.

Skumatz (2016) has conducted work to classify specific NEB categories into: program independent vs. those that are likely to always require local research to identify values, vs. those that can be transferred or adapted to other locations or programs. The paper notes the implications these results have for the use of "adders" vs. tailored estimation work vs. "hybrid" approaches in the best ways for NEBs to be integrated into cost-effectiveness tests at the State and Utility level. Kerr is currently working on identifying the different approaches in different national contexts in terms of the transferability of approaches between countries.

Evidence and Assessment of Research Gaps

The review of these studies identifies research gaps in each topic area.[3]

Values: There is better evidence on some MB categories than others (e.g. maintenance has more evidence than productivity). Carbon benefits are fairly well understood, and thus, may not be a research priority. There are a few strong health studies, but transferability is inconclusive. Macroeconomic benefits have the potential to be very large and influential in decision-making; strong work on this topic yields benefits. The degree to which difficult-to-quantify benefits will be able to be incorporated into decision-making is currently unclear. Although some work has been conducted on methods to disaggregate program-level NEBs to individual measures (McClain, et. al. 2006), fairly substantial gaps remain in estimates of NEB values for specific measures. These values would be helpful in transferability to other programs with specific measures, and in designing programs with maximum NEBs. In addition, there are relatively fewer NEB studies with values for the multifamily sector.

Measurement Methods: A review of the reliability of the estimation methods in current use would be valuable; however, expansions and creativity in new methods continues in a range of NEB topics – including maintenance and financial effects. Methods based on models – like economics and emissions – have the benefits of multiple models and may not be priorities.

[3] These gaps were identified by committee discussion and contributions, discussions at ECEEE informal sessions 2015, and review of the literature.

Applications / Uses: The actors and beneficiaries can be far apart – utilities for energy efficiency investments, but households, health systems, and governments for health benefits, for example. The governance, and the cost and benefit relationships, are complicated and difficult to resolve. How can far-flung benefits from EE investment encourage the behavior; can health policies pay for insulation in homes? How can these links be mapped and realized / operationalized? How the financial value from NEBs can be incorporated into real monetized value from those making investments (especially the private sector) is a difficult task, and may need policy consideration.

Transferability: Even in areas where the scientific researcher economic evaluation of a particular benefits / impact may be settled, the issues of transferring results from one country or context to another is not sufficiently well understood. More evidence is needed on the factors that support transferability, and the level of value-evidence that will be needed to support transferability. Some NEBs are by nature local; there will be limited transferability of the economic and job-creation benefits from EE because it depends on the job mix of the local / regional economy.

Underpinnings: Mourik et. al. (2015) examine the underpinnings or drivers for NEBs in a behavior and systematic construct. This kind of work examining drivers is relatively uncommon.[4] Skumatz et. al. (2009) draws the relationships of NEBs to economic theory of the utility curve, and the including on uptake of behaviors, programs, and measures. The IEA's DSM program, Task 24, is working on research about monitoring and evaluating behaviour change, and the role of Multiple Benefits in realizing behaviour change since for example residents may be more interested in benefits such as health than EE. The work is geared toward creating an understanding of how stakeholder perceptions of successful outcomes and the intervention meeting their needs, can be used to help design better interventions (mandates, drivers, needs and perceptions) from the outset.

Next Steps

The committee will also monitor on-going national and international research including IEA, EPA, and other work. Another example is work by IN-BEE that is examining the impact of NEBs on both consumers (residential and companies) and policy makers. This work is: developing metrics for measuring direct and intangible benefits of energy efficiency; studying relevant case studies and identifying best practices; and involving stakeholders and bridging policy makers and researchers on these topics. Steps the committee and its members are examining in the near term include:

- **Values**: The committee's research is designed to identify NEB categories with only limited research, or measures that have not been well-studied as particular candidates for preliminary research to "bound" the values. If the range for the basic research shows the NEB may be important, further research should be prioritized. Identify NEB categories that are high priority for additional research because they: Have political traction but

[4] The topic was addressed in a number of older papers by Lutzenheiser, Skumatz, and others presented at ACEEE in the early 2000s.

insufficient research to nail down a value; Have a (potentially) high value but high variation; or have unknown value. Current work is underway on reliable methods to disaggregate program-level NEBs to attributable measures, as well as work on multifamily NEB values. Additional exploration of NEB values in health effects is of interest by several members. The committee is working to develop a table of values for reference.

- **Measurement Methods**: Committee members are monitoring "next generation" estimation methods that are being explored in studies and research papers, and revisiting estimation methods that were proposed early on, but for which the literature was not sufficiently advance to pursue.

- **Applications / Uses**: Extensive research by committee members is underway on this topic, inventorying utilities that have used NEBs in planning and outreach uses, and developing the information that will make more US utilities and regulators comfortable considering NEBs formally in benefit cost and program planning / approval steps. Work on the MBs of building refurbishment and the best ways to appeal to municipal decision makers was previously mentioned. Primary research by committee members is also underway, including a project interviewing homeowners to understand which NEBs and other factors are motivators in EE participation. Modeling of business motivators are also being examined, as well as work on the value of brownfields development to residents and the building sector. Work on government motivations for investment and policy-making, as it applies to NEBs, is also underway, particularly examining why different countries choose to include some NEBs in their policy Impact Assessments and why others do not.

- **Transferability:** Tables examining the similarity of values for weatherization and low income programs have been developed; similar work is being undertaken for multifamily and commercial NEBs to help identify those NEBs that have consistent values across programs, measures, or climates zones, which are stronger candidates for transferability between utilities, programs and potentially nations. Research is underway to examine the different NEB (policy) approaches used in different nations, and the transferability of approaches between countries.

Conclusion

This paper summarized the first round of literature review undertaken by the committee, and addressed evidence on NEB values, measurement methods, applications / uses, transferability, and research gaps. The committee continues to acquire, review, and assess literature from around the world on Multiple Benefits. The Committee will continue to work to develop of useful tools and results, develop recommendations on reliable estimation methods, and provide information for outreach on the broader applicability of NEBs. These goals will continue to remain a focus of the Committee and the IEA initiative.

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