Accounting for Health Benefits

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Abstract

Energy efficiency (EE) and Weatherization (Wx)[1] significantly reduce health costs for low-income participants as well as for society. There is, however, rarely a full accounting of these health benefits. Not only is an important value of EE and Wx investment thus not adequately acknowledged,[2] but also possible sources of EE funding are overlooked. Among the reasons that health benefits are not fully accounted for are:

- The relationship between EE, Wx, and health is complicated and not entirely understood.
- Data are challenging to obtain.
- Separate populations need to be tracked.
- Regulators are not always interested in societal benefits or expensive studies.
- Large values for the benefit of reduced mortality can be difficult to accept.

These obstacles raise methodological issues for those conducting and overseeing evaluations of the health benefits of EE and Wx. Among the possible methods to measure health benefits are costly longitudinal assessments and less precise modeling based on clinical research. There are also questions about the role of survey research.

Research might estimate increased lifetime earnings due to reduced lost work and productivity, as well as from improved education opportunity, and provide options for valuing reduced mortality. There is debate in some quarters about whether counting health benefits due to bill reductions is double-counting if bill reductions finance food that improves health. In balancing the foregoing obstacles and objections, we conclude that developing a reasonable value for health benefits now is more important than taking the longer time required to reach a more precise, larger value; thus establishing that there is monetary value to the health benefits of EE and Wx. There should also be separate analyses of vulnerable populations, participant benefits, and societal benefits. Health benefit valuation can make an immediate and significant contribution without reaching a benefit:cost ratio of 1.0 for health benefits alone.[3]

This paper reviews the literature establishing the link between implementation of energy efficiency and weatherization measures and both health benefits and reduced health costs, It then reviews the obstacles encountered in accounting for these benefits and savings. Finally, the paper reviews methodological options for overcoming these obstacles. The paper concludes that analysis should initially be focussed on modelling monetization of health benefits of EE and Wx, with emphasis

[1] Weatherization is protecting buildings from the elements and is primarily achieved by attic, wall, basement, ceiling, and pipe insulation, as well as air sealing.

[2] The value of such non-energy benefits is typically agreed upon as part of the decision-making among competing EE and Wx measures and programs.

[3] At a benefit:cost ratio (BCR) of 1.0, benefits of a measure or program are sufficient to exactly justify the costs. Benefits that can add up to achieve a BCR of 1.0 include avoided energy, capacity, transmission, environmental compliance and other utility costs; saved water and increased health, comfort, property value, productivity, and other non-energy benefits. In some jurisdictions, societal benefits such as environmental and economic development are also included.

on low-income and other vulnerable populations and currently understood factors. Further research should be conducted on such questions as monetization of increased income and reduced mortality,

A. EE and Wx Significantly Reduce Participant and Societal Health Costs, but are Rarely Fully Accounted For

1. EE and Wx reduce health costs

Considerable research shows health benefits result from adequate home energy, including health outcomes (*e.g.*, EE and Wx),[4] especially for vulnerable populations.[5] For example, areas with high income inequality and low average income had excess mortality of 139.8 deaths per 100,000 compared with areas of low inequality and high income (Lynch et al. 1998, 1079).

While the Low Income Wx program in the US helps elderly householders reduce energy consumption, it also helps maintain home temperatures that are optimal for good health, especially during extreme weather conditions. Similarly, air sealing and related measures (ventilation, appliance venting, air filtering, carbon monoxide (CO) detectors, and lead-safe practices) control such pollutants as CO, particulates, DDT and other pesticides and herbicides, heavy metals and other spilled toxic wastes, NOx, lead, moisture, and dust -- thus removing contributors and triggers for asthma and other respiratory diseases, poisoning, cancer, cardiovascular diseases, birth defects and low birth weight. The US program is found to reduce drafts in 53% of treated homes, dust in 43%, with the incidence of reported drafts falling from 29% to 9%. Hospitalizations for asthma, hypo- and hyperthermia were also reduced (Tonn & Rose 2014, 36, 38, 40).

These measures, as well as the decrease in stress as a result of lower energy bills, also contribute to improved mental health, which in turn represents a reduced risk factor for physical diseases (Tonn & Rose 2014; Liddell, Morris & Page 2011). Households finding it very difficult to pay their utility bills dropped from 31% before Wx to 19% after; service disconnections were also reduced (Tonn & Rose 2014, 38).

One would expect the reduction of energy bills to improve health by releasing funds for such health-sustaining fundamentals as food. Research bears this out. Households foregoing food to pay for energy decreased from 33% to 23% (Tonn & Rose 2014, 38, T.1; *see* Liddell, Morris & Page 2011). Poor households reduce their caloric intake when energy bills rise due to weather extremes, to the detriment of their health (Bhattacharya et al.2002; Brown et al. 2007; Cullen, Friedberg & Wolfram 2005; Frank et al. 2006; Nord & Kantor 2006). Thus medical researchers have found that reductions in food expenditures in order to pay for cold weather energy bills led to a high incidence of pediatric emergency cases with age-weighted scales of weights below the fifth percentile in the period following

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[4] Cook et al. 2008; Daniels, Kennedy & Kawachi 2000; Enterprise Community Partners 2010; Fiscella & Franks 1997; Kaplan et al. 1996; Kennedy, Kawachi & Prothrow-Stith 1996 ; Levy, Nishioka & Spengler 2003; Lynch et al. 1998; Marmot 2004; Moore 2007; NMR Group 2011, 5-30 et seq., 6-3 et seq.; Shprentz 1996; Smith 2007; Wilkinson 1996, 2001, 2006; Wolfson et al. 2005. Note that quantitative estimates often include the effects of air pollution and are therefore specific to their time since, in general, electricity production has become cleaner over time.

5 Many indirect benefits from reducing poverty and inequality are also documented, including increased education, earnings and tax receipts, and reduced crime. These may also be ascribed to the poverty-reducing impact of EE and Wx and have been summarized at Oppenheim & MacGregor 2002a, 2002b, 2006.

the coldest month (Frank et al. 1996).

The connection between energy bills and health costs is made by research results showing that a 2% annual energy price impact over 15 years increases medical costs by $70B (NPV) (authors' projections for US based on Cook & Weiss 2013, 3-4). "The biggest 'take home' from this study is that energy prices, especially increasing energy prices, have significant non-energy impacts on health, health care utilization, and health care costs" (*id*. 5). A longitudinal study of US low-income Wx program participants found reductions in the incidence of heat- or cold-related medical attention of 1.1 and 2.1 percentage points (Tonn & Rose 2014, 37-38).

2. Despite the evidence linking reduced energy costs, including as a result of EE and Wx, to good health, full accounting of the value of this connection is rare

In the energy regulatory and evaluation worlds, the *lingua franca* of cost-effectiveness is money, so health outcomes need to be translated into currency. Then the monetized health benefits need to be compared with the EE and Wx costs to obtain them -- a benefit-to-cost ratio greater than one (BCR > 1.0) would suggest that health benefits alone justify the expense of weatherizing the homes of low-income families, whether from energy[6] or health funding or a combination. A BCR above 1.0 based on any combination of benefits justifies the overall regulated EE and Wx investment.

Cost-effectiveness analysis incorporating monetized health benefits has been criticized, in part because of the impossibility of measuring the value of health and loss of life (Ackerman & Heinzerling 2004). However, this type of analysis is widely used and has value in demonstrating, however imprecisely, the relative value of various programmatic responses to social problems. In particular, cost-effectiveness analysis is the standard method of assessing energy efficiency activities and determining which are worthy of public funding in the United States (Massachusetts Department of Public Utilities 2009; Migden 2014; Woolf et al. 2012).

The point of BCR analysis in the context of energy efficiency is certainly not to definitively determine the value of human life. The purpose is not even to decide whether to invest in energy efficiency or how much to invest. Those decisions are properly made in a political process, where non-quantitative values are weighed. BCR analysis is a useful tool, however, once energy efficiency program budgets are set, for deciding among alternative efficiency investments. This is how BCR analysis is used in the utility regulatory process.[7] We submit that it could also provide a valuable input into deciding amongst public health expenditures, although we acknowledge the moral (and consequently political) difficulties of putting monetary values on human health and life in making these decisions (*see* Ackerman & Heinzerling 2004, 232-234).

Monetization of health benefits may also help attract additional funding for EE and Wx. Monetization may speak particularly cogently to those directing health and social welfare budget expenditures, especially where investment in energy efficiency may produce greater public health benefits than alternative investments now made with public health funds. As described above and will be further seen, the idea of energy efficiency as medicine has a solid factual basis.

6 However, energy regulators generally demand a significant energy-saving component of benefits.

7 We state results across studies in BCR terms because BCR analysis is widely used by utility regulators in the US. Regulated investments are usually funded by ratepayers (via utilities) or taxpayers. Relatively inexpensive, high energy-saving measures, such as lighting, refrigerators, and weatherization, are typically cost-effective without accounting for health benefits, but relatively expensive, high energy-saving measures (*e.g.*, heating systems) may not be.

However, material on the analysis of cost-effectiveness with respect to monetized health benefits of EE and Wx is scant. A Massachusetts literature search found only four evaluations of health benefits of EE and Wx, resulting in a value for health benefits ranging from US$1 to US$330 per participant per year (NMR Group 2011, 2-10, 5-34 *et seq.*, *see* 6-5 re safety) – a $330 benefit from a $3000 project represents a BCR of 0.1.

A New Zealand study of the cost-effectiveness of a Wx program shows a BCR of 7.5 from health benefits alone (Barnard et al. 2011, Tables 21, 22; Grimes et al. 2012, iii, 1, 11, 23-25, Tables ES-3, ES-4, 2, 6, 7, 21, 24, 30). The results remain impressive even after making adjustments to more conservatively align the study with evaluation conventions in the US. Adjusting project costs to add back in the "producer surplus"[8] and free riders, counting only direct CSC[9] cardholder (low and moderate income) reduced mortality and health benefits (*i.e.*, not counting as benefits avoided lost school and work days or caregiver costs) and their proportionate share of costs, reduces the health BCR to a still very substantial 3.4, although limiting the analysis to direct health benefits (reduced hospital and pharmaceuticals costs, increased medical visits, but not counting reduced mortality) yields a still respectable BCR of 0.4 (authors' calculations).

While these are plausible results, it should be recognized that (a) the total health BCR is sensitive to the value assigned to human life, and (b) in any case, large values can be difficult for some regulators and policymakers to accept, especially since the total health value (including reduced mortality) dwarfs other non-energy benefits (and even energy benefits).

A UK study found a National Health Service (NHS) benefit from physical health improvements that compute to a BCR of 0.5 at a 3% discount rate over 20 years, replacing heating systems and roof insulation in all homes with a below average energy efficiency rating to achieve an average rating (authors' calculation from Nicol et al. 2010*)*. The study apparently considered diseases associated with excess cold (cardiovascular and respiratory conditions, rheumatoid arthritis, and hypothermia), with a focus on those 65 and older (Roys et al. 2010*)*. In any case, the study focused only on NHS costs and thus placed a very low value on reduced mortality (Roys et al. 2010).

Another UK study shows a mental health benefits BCR of 0.2 (Liddell, Morris & Page 2011, 22, 23, 27-28, 31, 32). Other UK studies show BCRs of 0.9 for participant Quality Adjusted Life Years (QALYs), especially including mental health benefits, and 0.2 for reduced NHS costs, based on before-and-after surveys (authors' calculation from Gilbertson & Green 2013, 11, 17) and show QALY benefits of 1.9 for wall insulation, 3.0 for loft insulation, and 0.1 for boiler replacement, apparently for a program focussed on fuel poor elderly, infants and disabled, based on modelling increased risk (authors' calculations from Ewins 2013, 3, 5-7).

An Oak Ridge National Laboratory evaluation of the US low-income Weatherization Program that may add to our understanding of health impacts on the population served is, hopefully, forthcoming (Tonn & Rose 2014). The International Energy Agency is scheduled to publish a study shortly that will include a survey of health benefits research, including many of the papers referenced here (Campbell forthcoming).[10]

As noted, UK studies use an analytical device called QALY to value morbidity and mortality – possibly a useful alternative to willingness-to-pay (WTP) research but not always accepted outside the

[8] Defined as "The difference between the price and the costs of supply" (Grimes et al. 2012, 5), thus an element of measure cost.

[9] Community Service Card.

[10] The study of benefits of energy efficiency is expected to include a chapter on the health and well-being impacts of energy efficiency, to which the authors contributed.

UK, as this description demonstrates:

> A quality-adjusted life year (hereafter a QALY) is a measure of the performance of medical treatments and interventions that captures in a single metric two important dimensions of medical outcomes: the degree of improvement in health, and the time interval over which the improvement occurs, including any increase in the duration of life itself.
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> [Health improvement is based on survey question responses that] start with a description of a health state including symptoms, degree or level of pain, degree of impairment of activity or function, and so forth.
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> * * *
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> Where WTP estimates of health values are available, they are likely to be superior reflections of individuals' preferences. (Freeman n.d., footnotes omitted).

For this and other reasons, health cost studies do not cross borders easily. There are also significant differences in energy costs, generation fuel mix, climate, building practices, social and health systems and costs, diet, living conditions, and even cultures, which even vary significantly over such things as adequate building temperature. For example, buildings in Finland are well designed for heating but poorly for cooling while buildings in Athens are well designed for cooling and poorly for heating. Among people aged 65-74, there is no mortality response to cold in Finland, but there is danger above 20°C; in Athens, danger from heat starts at 30°C (Jantunan 2013, 13). There is much learning possible across borders, but differences are sufficient that the final studies probably need to be country-, or at least region-, specific.

B. Reasons That Health Benefits Are Not Fully Accounted For

1. The relationship between EE/Wx and health is complicated and not entirely understood

The health effects of temperature and environmental quality are relatively easy to track, as are respiratory issues. Extended exposure to cold can increase susceptibility to influenza, respiratory diseases, ear infections, and hypothermia (*e.g.*, CDC 2012). But other relationships and medical issues are more complex. Not all hospital admissions, for example, for hypothermia, heat stroke, heat exhaustion, or asthma can be attributed to a lack of weatherization. On the other hand, smoke inhalation, asthma, carbon monoxide poisoning, and other respiratory conditions can be brought on by efforts to heat space with unsafe cook stoves or unvented heaters (Fire Administration 2011). Associating particular health expenses with particular housing conditions is difficult.

2. Obtaining health data can be a substantial challenge

Medical costs can include hospitalization, emergency room visits, doctor and other clinical visits, medications (including over-the-counter), nursing home care, home health care, equipment, and other goods and services. While hospitalization, medical visit, and doctor-prescribed medication are relatively easy to track on an individual basis, other costs are less readily so. Similarly, physical facts may be unknown, *e.g.*, indoor air quality before and after

Wx (Tonn & Rose 2014). Of course, whatever data are collected must be rigorously protected.

3. Populations differ

Low-income baseline heating efficiency is likely to be lower than non-low-income, so heating efficiency upgrades would likely have greater average impacts on lower income households than on others. More vulnerable populations, including low-income, elderly, infants, and disabled, may reap greater health benefits because their baseline health level is lower. A comparison of the UK studies above – one apparently focused on fuel poor elderly, infants and disabled (Ewins 2013) – illustrates the point. The New Zealand study (Barnard et al. 2011; Grimes et al. 2012) showed similar differences in results from lower income and other populations, demonstrating the importance of separately tracking these populations.

4. Regulator and policymaker perspectives differ

The New Zealand experience shows that reduced mortality is the major source of health benefits. "The benefits from reduced mortality are the most significant health benefits, comprising approximately 74% of the total health benefits" (Grimes, et al. 2012, 26).[11] In many utility jurisdictions, participant benefits are counted in an energy efficiency cost-effectiveness analysis, but those accruing to society at large are not. (A Health Ministry or medical funding point of view might be the opposite.) It would be difficult to argue that reduced mortality is not a participant benefit. Whether analyzed through WTP or QALY studies, reduced mortality values are based on measures of value to participants. The New Zealand work is based on a life value, derived from WTP studies, of US$2.9M, or $130,000 per year of reduced mortality. (This value falls in the middle of other regulatory statistical life values. US agencies value life at $1.5M-$5.8M (Ackerman and Heinzerling 2004, 83; *see* Freeman 2003, 317 *et seq.*)).

However, as noted, the computed reduced mortality values are substantial. The value of life is, of course, ultimately immeasurable (Ackerman & Heinzerling 2004, 67) and applying benefit-cost analysis can lead in perverse directions (Ackerman & Heinzerling 2004, 87-89 cite the case of Ford Motor's infamous exploding Pinto gas tanks, which benefit-cost analysis justified <u>not</u> recalling to alleviate their danger.) Yet it is undeniable that people and policymakers make life-and-death decisions daily regarding, for example, smoke detectors, seat belts, and automobiles (Freeman 2003, 318: preferences have been calculated as valuing life at between $1.4 and $21.1M per life). The wide range of values that have been calculated does not make the analysis any easier.

A former well-respected colleague at the Massachusetts Attorney General's office lived by what he called the "Too Big Rule" governing the plausibility of utility rate adjustments. Even though a large BCR for reduced mortality benefit, well in excess of avoided energy benefits, may be about right analytically, its size may strain the credulity of many policymakers.

[11] "However, the programme would still have positive net benefits even in the absence of mortality benefits" (Grimes et al. 2012, 26). With an overall health BCR of 7.5, mortality benefits by themselves thus represent a BCR of more than 5.5 (74%); 2.5 after the authors' adjustments (see sec. A.2., above).

C. Methodological Options for Valuing the Health Benefits of EE and Wx.

1. Longitudinal studies

Before-and-after Wx assessments of households over time are time-consuming and costly. Time and cost depend on what clinical data already exist, but in any case, several years and hundreds of thousands of dollars are likely required to obtain credible, statistically meaningful results. Ideally the analysis would include matched samples pre- and post-Wx for as long a period as practical. The EE-Wx program should be reasonably consistent across time.

The New Zealand study compared treated houses with an untreated control group, matched for location (Census area unit, similar to a suburb), dwelling and house type, number of levels, age (decade of build), floor area and number of bedrooms, whether there is a garage under the main roof and its size (number of vehicles), house construction material (walls and roof), whether or not the house was modernized, and quality (building and roof condition) of the dwelling (Grimes et al. 2012, ii, n. 7, 21; Barnard et al. 2011, 7, 13-23).

Note that the longitudinal method described here focuses on costs such as hospitalization, medical visits, and pharmaceuticals and need not necessarily focus on specific illnesses, although such a study could be limited to costs related to specific illnesses known to be affected by lack of Wx, such as respiratory and circulatory diseases, including asthma, and mental health impacts. For example, a study of the health status of families before and after installation of weatherization measures might comprehensively measure and monetize hospitalizations, clinical visits, and other medical costs (even indirect items such as lost work days) without the need to fully understand the links to specific diseases such as asthma or causes such as poor nutrition.

The US study follows a cohort before and after Wx, with adjustment for external factors such as weather (Tonn & Rose 2014).

2. **Modelling based on clinical research**

Based on published studies, models can be constructed to compare the odds of studied outcomes (poor health) in non-treated homes (or homes generally) with those in treated homes (Liddell, Morris & Page 2011; Cook et al. 2008). Current and projected health costs are published and can be stated in net present value terms, using projections of population and energy costs from published government sources, and consumption savings from EE/Wx program evaluations. It is thus possible, using regression analysis, to estimate adverse health outcomes as a function of energy efficiency costs, all else equal. Sensitivity analysis can test the resulting estimates.

The U.K. Building Research Establishment (BRE) study uses a similar strategy, modeling the relative likelihood of harm for houses of the particular age and type targeted in the study, which were houses in below average condition (*i.e.*, below average energy efficiency) (Nicol, et al. 2010; Roys, et al. 2010).

While modelling will not yield estimates as precise as longitudinal studies, in our experience they are about an order of magnitude cheaper. If the choice is between conducting no study – thus possibly assuming few or no health impacts of energy efficiency – and a modelling study, the latter is the superior option.

3. Survey research

Survey research has been conducted of participant perceptions before and after EE and Wx, asking participants to value benefits in terms, for example, of a percentage of their bill savings (NMR Group 2011, 9-1 *et seq.*). Survey research is a perfectly appropriate way to quantify subjective benefits such as increased comfort or decreased noise, since these are benefits which are by their nature subjective. However, survey research seems particularly inapt for relatively objective benefits such as reduced medical costs. Indeed, medical costs such as those for hospital stays and doctor visits are not likely to be tracked or even well known to most participants, particularly if they are insured, let alone the degree to which these costs were incurred before or after weatherization. Nor do most participants have the medical or building knowledge to connect particular medical conditions with particular housing EE and Wx measures.

On the other hand, survey research has been used in a structured protocol to, for example, track perceptions of specific health conditions on a before-and-after basis (e.g., Tonn & Rose 2014), which can yield useful results.

4. Other health-related non-energy benefits

There are other participant and societal benefits that result from improved health. These include increased lifetime earnings due to reduced lost work and productivity, as well as from improved educational opportunity due to reduced lost school days (Jyoti, Frongillo & Jones 2005; Alaimo, Olson & Frongillo 2001). The New Zealand study shows, for example, that among the principal health-related benefits are the indirect benefits of reduced lost school and work days and the reduced cost of childcare. Similarly, the EE and Wx work performed has a significant economic development impact – jobs, the economic value of which ripples through the economy. In the New Zealand study, this benefit is 45% of the EE-Wx cost (authors' calculation). In most jurisdictions that distinguish participant from societal benefit, economic development would be a societal benefit except to the extent it could be tracked to program participants.

The health benefit of improved nutrition has also been shown to relate to school performance and thus to both individual lifetime earnings and societal costs of remedial education (Fulton 2010).

These effects may not affect healthcare budgets, but they are benefits relevant to EE and Wx and may bring savings to social welfare systems.

5. Track populations separately

As noted, separate estimates are advisable for different populations, especially low-income and other vulnerable populations where the benefits are much higher than they are for the general population.

6. The double-count debate

There is debate among some evaluators about possible double-counting: if bill reductions finance food that improves health, the theory goes, perhaps it is double-counting to account for the health benefit since the bill savings that finance them are already accounted for (*e.g.*, NMR Group 2011, 1-5, 5-1, 5-20, *C-5 et seq.*). (This may not apply to reduced mortality, which is primarily a function of respiratory and circulatory conditions directly improved by EE and Wx.) Some of the same evaluators appropriately promote the accounting for economic development benefits, which are generally based on complex models of indirect benefits called multiplier effects (Petraglia, et al. 2010); it is difficult to understand a principled distinction between indirect health benefits and indirect employment benefits. There is an established causal chain from EE and Wx to bill reductions to improved nutrition to improved health. As noted above, low-income households make tradeoffs by postponing or foregoing expenditures on food, medical care, and prescription drugs to keep the heat on. The resulting stress can be damaging to adults' and children's health. Even a threatened utility shutoff for nonpayment can initiate a cascade of stresses that lead to health care costs that dwarf the value of the utility bill,

Indeed, evaluators without question routinely count utility benefits explicitly based on bill savings (arrearage reductions, bad debt write-off reductions, termination and disconnection reductions, avoided discount credits) (NMR Group 2011, 1-3). It is thus difficult to understand a reduction in the value of health benefits other than perhaps deducting bill savings if they have in fact already been counted.

In any case, this question relates more to energy regulators' assessment of cost-effectiveness than it does to healthcare budgeting.

7. Reduced mortality

The value of reduced mortality benefits is large – as noted, at least 74% of the New Zealand health benefit[12] – so they will require particular care and conservatism in computing and great skill in persuasively communicating. However, the value is certainly not zero, so applying a large uncertainty factor would still yield a more accurate estimate than the zero now assumed in most BCR calculations. For example, instead of valuing a life at US$3M, as in the New Zealand study, a life could be valued at $1.5 M or $6.0M (Ackerman & Heinzerling 2004, 81-83). The UN's Intergovernmental Panel on Climate Change (IPCC) has used a worldwide value of $1M (Ackerman & Heinzerling 2004, 74).

D. Conclusions

12 A National Academy of Science study found reduced mortality to be 94% of the health benefit (Cohon 2009, 3-9, 48-52, 62-66, 72, 86-87, 109-110, 168-170, 178, 243-244, 258; Cropper 2010, slides 5-6, 8). This was a study of the air pollution effects on health from electricity generation, valuing life at $6M. It found impacts of 3.2 cents/kWh from coal-fired generation – 1.2 cents if a life is valued at $2M – 0.16 cents/kWh from gas-fired generation, and 11 cents/MCF from gas heating. The electricity findings are plant-specific; so, for example, the coal results are 43% less if the dirtiest 10% of plants are retired, which by now may nearly be the case.

Based on the foregoing, we conclude that it is possible and important to monetize the health benefits of EE and Wx, particularly for low-income and other vulnerable populations, with sensitivity to constraints imposed by the audience for the analysis, be it utility regulators or healthcare funders.

1. Most cost-effectiveness studies of EE and Wx assume the value of health benefits is zero, which is surely incorrect

Our review of proprietary research proposals demonstrates that, while the longitudinal approach to estimating health benefits may be preferable, it is very expensive. Regulators and policymakers seeking to value the health benefits of EE and Wx need not allow this ideal to be the enemy of the good. It is not unusual for important questions that are too costly to answer with precision to not be answered at all even though the correct answer is certainly not zero. On the other hand, regulators and policymakers often accept second-best approximations rather than paralysis waiting for the perfect statistical analysis. Examples in the EE and Wx world are the frequent use of literature and data from other jurisdictions to estimate benefits to utilities from reduced arrears, reduced bad debt, reduced terminations and reconnections, reduced customer calls including emergency safety calls, reduced collection notices, and savings in insurance costs. In the utility world, load and avoided cost forecasting are imprecise arts at best. In this case, conservative modelling is a cost-effective way to obtain a good approximation of the true value.

Thus it may be that once a health cost study is performed using generally accepted research methods, its conclusion will gain wide acceptance. In the US, the forthcoming study of the federal low-income Wx program (Tonn & Rose 2014) may provide an example of this practice. As noted above, literature is already available from the UK and New Zealand that suggests a value for health benefits in the BCR range of 0.4-0.5 and reduced mortality BCRs well above 1.0. Even a modest placeholder value, pending study, would be more appropriate than the zero, or close to zero, now often assumed.

2. Analyze vulnerable populations separately

Low-income health benefits are likely to be significantly larger than non-low-income health benefits. “Recipients on low incomes saw greater improvements in health [than others] following energy efficiency interventions” (Maidment et al. 2013, 10). One may project that the same holds true for other vulnerable populations, such as the elderly, infants and the disabled. Benefits for non-vulnerable populations in good health may be too small to be worth measuring, although a meta-analysis found that “on average, interventions had a small, but significant, positive impact on [all] residents' health” (*id.* 4).

Most EE programs already identify low-income and/or fuel poor households. However, some identify inefficient homes, either on ideological/policy grounds (no utility regulatory distinctions should be made by income, as in Arkansas) or practical ones (it is much easier to identify inefficient buildings than to develop and apply criteria to households (*e.g.*, Boardman 2013; Howden-Chapman 2013). There is, of course, considerable overlap between low-income and energy inefficient housing.

On the other hand, there is a strong social and economic argument that the cost of identifying households in need is worthwhile (*see*, *e.g.*, Oppenheim & MacGregor 2006 (total benefit:cost ratio of low-income energy efficiency to society is 7:1); 2008 (benefit:cost ratio 34:1 including economic development and jobs).

3. Acknowledge regulatory concerns

Regulatory concerns often include distinguishing between participant and societal benefits and avoiding controversy.

Many utility regulators see their job as protecting ratepayers, including program participants, but not as making broad societal decisions. Thus they consider the benefits of EE and Wx programs to utilities (thus to ratepayers) and to program participants, but often not to society at large. By this reasoning, regulators might be willing to assess the participant health benefit of lost work days or expenditures for medicines, but unwilling to take account of the benefit of reduced costs to a public health program such as Medicaid in the US.

It is not necessary for health benefits all by themselves to justify the cost of the investment, at least from an energy point of view. A health ministry might look at this differently, of course, though it could also see the opportunity to leverage energy funds for public health purposes. That is, a health-only BCR of 0.5, for example, means that a health program could fund up to half an energy efficiency program's requirements and still reduce its own funding requirements. At the same time, the energy efficiency program would pass the typical Total Resource Cost Test of cost-effectiveness adding together energy savings, health, and other non-energy benefits:

> "The Department will rely on the Total Resource Cost Test to determine cost-effectiveness. The Total Resource Cost Test includes all benefits and costs associated with the energy system, as well as all benefits and costs associated with Program Participants. … An Energy Efficiency Program shall be deemed cost-effective if the cumulative present value of its benefits… are equal to or greater than the cumulative present value of its costs, … benefits that are specific to Program Participants [shall include] …
> Non-resource benefits, which include, but are not limited to: (A) reduced costs for operation and maintenance associated with efficient equipment or practices; (B) the value of longer equipment replacement cycles and/or productivity improvements associated with efficient equipment; (C) reduced environmental and safety costs, such as those for changes in a waste stream or disposal of lamp ballasts or ozone-depleting chemicals; and (D) all benefits associated with providing energy efficiency services to Low-Income Customers."
> (Massachusetts DPU 2009, 48, 40-51, secs. 3.4.3, 3.4.3.1, 3.4.4.1(b).)

Over the years, this definition has been interpreted to include benefits such as lighting quality, comfort, quiet, property value, safety, and health (Massachusetts Energy Efficiency Program Administrators 2012).

4. Judgments must be made and defended

Among the judgments that must be made and defended are:

- Computation of participant and/or societal benefits.
- Disaggregation of population, *e.g.*, low-income, frail elderly, others.
- Analysis, if any, of indirect benefits related to health, such as lost school and work days, cost of childcare, lifetime income impacts.
- Assessment methods.
- Method (if any) for quantification of reduced mortality, including value of statistical life.
- Discount rate.
- EE/Wx measure lives.
- Selection of data sources.

5. The rationale, tools and data are at hand

Geographic-specific research will provide additional comfort to regulators and policymakers. But enough is known now to at least develop and adopt substantial placeholders while conducting further research. Analysis should initially be focussed on modelling monetization of health benefits of EE and Wx, with emphasis on low-income and other vulnerable populations and currently understood factors. Further research should be conducted on such questions as monetization of increased income and reduced mortality.

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