Assessing Low-income Health Impacts of Energy Efficiency Supports Expansion of Energy Efficiency

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ABSTRACT

This paper describes how evaluation increased monetized health benefits of low-income weatherization and heating systems by factors of 50 and 8.0, respectively, significantly increasing cost-effectiveness. In 2014, it was possible to say only that "There is substantial evidence that energy efficiency (EE) significantly reduces participant health costs … But rarely is there a full accounting of the health benefits" (Oppenheim & MacGregor 2014); about twenty years of academic research had clearly established the health benefits of energy efficiency for low-income families. Now, in what is believed to be the first time in the US, Massachusetts utilities accept a 2016 systematic study monetizing low-income health-related non-energy impacts. The study was built upon groundbreaking methodology developed for the national evaluation of the Department of Energy's (DOE) Weatherization Assistance Program in 2015. The dollar impacts are sometimes greater than energy cost savings. This paper describes the technical work, its decade-long history, prior efforts, political obstacles, and findings; and focuses on the complex policy and regulatory issues in applying the results. For example, large increases in non-energy benefits allow more expensive measures to be cost-effective, thus increasing the cost of acquiring energy savings. Further, some cost-effective measures save total energy but increase electricity use. The study also opens opportunities for co-funding of energy efficiency programs by healthcare institutions that share in EE program benefits. Finally, potential integration of evaluated health and energy benefits raises concerns across the hitherto very separate energy and health operational silos about program measures, delivery, governance, and regulation.

Introduction

Energy efficiency evaluation, including choice of evaluation topics and communication of results, can have a critical role in the development of energy efficiency policy. Evaluated non-energy impacts (NEIs) are important to the political foundation of energy efficiency programs because they can quantify the benefits[1] customers receive other than energy savings. By quantifying non-energy benefits (NEBs), they can also expand the menu of energy efficiency measures that are cost-effective at a given measure cost[2] and support program marketing (Chan et al. 2017 at 13). While budget and rate impact constraints dictate the level of energy efficiency activity, so can the availability of

[1] Non-energy impacts (NEIs) can include positive impacts (benefits) and/or negative impacts. The point of this paper is to assess the programmatic impact of certain benefits. Benefits can also be used as a sales tool in the promotion of energy efficiency. NMR Group, Inc. and DNV-GL, 2018 at 1-3, 4-22, 5-47 to 48, 5-49.

[2] Cost-effectiveness is the ratio of benefits to costs, where benefits include energy savings (including with respect to capacity, transmission, distribution and environmental compliance) and costs include measure costs (at least to the program administrator and, depending on the cost-effectiveness policy of the regulator, also to participants) (Massachusetts Department of Public Utilities 2009; R. Hornby et al. 2013). Where regulatory policies provide for it, benefits also include utility benefits (such as reduced arrearages), participant benefits (such as increased comfort and property value, as well as operation and maintenance savings), and often also societal benefits (such as economic development and greenhouse gas reduction). Thus, where a measure cost is constant, an increase in the value of a measure's non-energy benefit increases the value of the ratio of benefits to cost and thus increases the cost-effectiveness of the measure.

cost-effective energy efficiency measures. The approaching lighting standard deadline[3] illustrates the latter point: lighting measures, which constitute a large fraction of energy savings in most energy efficiency programs[4] are expected to become largely cost-ineffective in the US by the early 2020s, when today's efficient lighting (LEDs) will become the standard available replacement in most situations.[5] Without cost-effective alternative measures, energy efficiency programs may necessarily shrink. Finally, in some cases evaluation can help shine a light on possible co-funding sources for energy efficiency.

This paper demonstrates the potential for the quantification of one such non-energy benefit -- enhancement of low-income health and safety -- to increase program cost-effectiveness and thus sustain a low-income energy efficiency program in the absence of a measure previously heavily relied upon. Increased cost-effectiveness is initially achieved by increasing quantified benefits, but potentially also, from the energy efficiency program point of view, by increasing outside funding from health sector institutions that benefit from the quantified health benefits. Also described are non-trivial non-technical obstacles to communication and use of the quantification.

In 2014, it was possible to say only that "There is substantial evidence that energy efficiency (EE) significantly reduces participant health costs as well as, with respect to low-income participants, societal health costs. But rarely is there a full accounting of the health benefits of EE." (Oppenheim & MacGregor 2014) About twenty years of academic and medical research had clearly established the health benefits of energy efficiency for low-income families. And such non-energy benefits have long been recognized in principle by Massachusetts and other energy efficiency regulators as part of benefit:cost analysis, albeit with very low values.[6] Now it can be reported that, in what is believed to be the first time in the US, Massachusetts utilities and their evaluators have accepted a 2016 systematic study assessing and monetizing health- and safety-related non-energy impacts experienced by low-income single-family energy efficiency participants; the study was built upon groundbreaking methodology developed during the national evaluation of the Department of Energy's (DOE) Weatherization (Wx) Assistance Program (WAP) published in 2015. The dollar impacts are substantial -- nearly as much as energy cost savings.

This paper provides an overview of the technical work involved, including its decade-long history, prior efforts, political obstacles, and findings; and focuses on the policy impact of the findings and the complex policy and regulatory issues involved in applying the results to energy efficiency programs, in particular to low-income weatherization and heating systems.

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[3] The US federal Energy Independence and Security Act of 2007 (EISA) requires that from 2020 most lights be 60%-70% more efficient than standard incandescent lightbulbs (US Environmental Protection Agency 2011).

[4] E.g., 82% of Massachusetts lifetime residential program savings in 2016, 72% of annual savings. (Massachusetts Energy Efficiency Advisory Council Consultant Team 2017b, at 2).

[5] There is some debate about exactly when this will become true, but not if. (E.g., Massachusetts Energy Efficiency Advisory Council Consultant Team 2017a, at 22, 27 (predicts lighting program end by 2020 or 2021); NMR Group, Inc. 2017a, at 4-5) (cites Northeast Energy Efficiency Partnership forecast of 98% residential saturation if program continues through 2022, but a DOE forecast of 79% LED and CFL saturation in 2020, 90% in 2025). "While there is still some life left in residential lighting programs, most of these programs will end in a few years." (Amann 2018.)

[6] For example, a literature search commissioned by the Massachusetts Program Administrators found only four evaluations of health benefits of energy efficiency and weatherization, resulting in a value for health benefits ranging from US$1 to US$330 per participant per year (NMR Group 2011, at 2-10, 5-34 et seq., see 6-5 re safety) – a $330 benefit from a $5000 project represents a Benefit:Cost Ratio (BCR) of 0.07. (See also International Energy Agency 2015; US Environment Protection Agency 2009.)

As background to this achievement, the next sections provide an overview of the technical work involved, including its decade-long history, prior efforts, and obstacles

History[7]

•1975 -- Congress enacts Federal Weatherization Assistance Program (WAP), which requires that installed measure cost be less than or equal to energy bill savings. US Code.

•1980s -- Utilities begin programs that piggyback on WAP.

•1988 -- Massachusetts Department of Public Utilities (DPU) includes conservation as a pre-approved resource in Integrated Resource Management if net comparative benefits to ratepayers (Massachusetts Department of Public Utilities 1988).

•1998 -- Massachusetts General Court (legislature) restructured electric industry, required expanded energy efficiency programs for gas and electricity, including a dedicated financial share for low-income programs. Massachusetts General Court 1997.

•2000 -- DPU adopts Guidelines for evaluating EE cost-effectiveness, specifically including low-income participant benefits, including safety (updated by Massachusetts Department of Public Utilities 2009).

•2000 (approx.) -- Utilities adopt low-income non-energy benefits, including negotiated $150 per year as health non-energy benefit. (Personal communications.)

•2008 -- General Court enacts Green Communities Act, further expanding energy efficiency. (Massachusetts General Court 2008.)

Meanwhile ...

•At least from 1995 -- US and worldwide academic research establishes health benefit of energy efficiency, but without quantifying monetary value of the benefit.

•At least from 1997 -- Evaluation studies estimate monetary value of health benefit of energy efficiency, at low levels (see NMR Group Inc. 2011).

In sum:

•42 years of cost-effective energy efficiency.

•At least 22 years of academic and EE evaluation research.

•Development of monetized non-energy benefits.

•But health benefits not seriously monetized, until ...

•2008, 2010 -- WAP program evaluations by Oak Ridge National Laboratory begun by Bruce Tonn and others at Oak Ridge National Laboratory. Completed by 2014, but non-technical debate slows release.

•2009 -- DPU adopts revised Guidelines, adding “all benefits associated with providing energy efficiency services to Low-Income Customers” (Massachusetts Department of Public Utilities 2009.)

•2010/2011 -- UK study finds health benefit:cost ratio (BCR) of 0.5 without including reduced mortality; New Zealand study finds BCR of 3.4 (see Oppenheim & MacGregor 2014).

•2013 -- Boston Medical Centre study quantifies health benefit from lower energy bills (see Oppenheim & MacGregor 2014).

•2010 -- Setback: National campaign begins to displace Total Resource Cost (TRC) economic test for energy efficiency, which calls for quantification of non-energy benefits; loss of TRC would threaten NEBs.

•2012 -- Another setback: Massachusetts utilities adopt reduced $19 year low-income health NEB (apportioned among all relevant measures), based on participant survey (see Chan et al. 2017, at 11, 13; see NMR Group Inc. 2011).

•2014 -- Oak Ridge National Laboratory (ORNL) study of WAP program completed (Tonn, B.,et al. 2014).

•2015/2016 -- Forward progress resumes: Oak Ridge National Laboratory study of WAP program published after internal review and non-technical debate. Public national release at meetings of National Association of Regulatory Utility Commissioners (NARUC) and National Energy

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[7] Summarized from Oppenheim & MacGregor 2014 and Oppenheim 2016.

& Utility Affordability Coalition (NEUAC) of ORNL WAP evaluations, including health NEBs. Massachusetts leverages ORNL investment by commissioning much less costly study applying local cost data to ORNL survey (Hawkins 2016).

•2017 -- Massachusetts utilities adopt significantly increased values for health and safety benefits for low-income single family participants, based on comprehensive study by Three^3 (e.g., NMR Group Inc. 2017b).

Methodology

Among other benefits, the Massachusetts study, conducted by Three^3 (pronounced "three cubed"), examined these health- and safety-related non-energy benefits produced by weatherization and heating system replacement in low-income homes: reduced asthma triggers and thermal stress (heat- and cold-related) experienced by occupants; reduced home-fire-related injuries, deaths, and property damage; and reduced injuries and death from monitoring for carbon monoxide (CO) and smoke.[8]

Among the particularly important preceding studies were two. In 2011, the NMR Group had conducted a broad evaluation study of non-energy impacts (NEIs) attributable to the Massachusetts Program Administrators' (PAs')[9] residential and low-income (LI) energy efficiency programs, including health- and safety-related benefits to LI residents (NMR Group Inc. 2011). In the meantime, the Oak Ridge National Laboratory was conducting a national evaluation, published in 2015, of the U.S. Department of Energy's (DOE) Weatherization Assistance Program (WAP), including the assessment and monetization of twelve health- and household-related impacts attributable to the weatherization of low-income single-family (SF) homes (Tonn et al. 2014; summarized in Chan et al. 2017). Research staff now at Three^3 conducted this DOE-funded evaluation.

With this history in view, the Massachusetts PAs contracted with Three^3 to complement NMR's findings by assessing and monetizing the aforementioned NEIs, selected by the PAs based on their estimates of likely direct household impact.[10] (This paper is limited to the health and safety NEIs.[11]) Thus the national WAP NEI evaluation research became the foundation for the state-specific study,

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[8] Also studied but not discussed in this paper were these benefits due to health and energy cost savings: increased income as a result of fewer lost days of work; lower interest and fee payments due to reduced use of short-term, high interest loans; and increased home productivity due to improvements in sleep.

[9] The investor-owned gas and electric utilities (IOUs) in Massachusetts and the Cape Light Compact, a compact of towns served by IOUs on Cape Cod and Martha's Vineyard. The Massachusetts PAs operate ratepayer-funded energy efficiency programs pursuant to statute, under supervision of the Department of Public Utilities. Massachusetts General Court 2008.

[10] Societal impacts studied nationally were not studied in Massachusetts for legal reasons (see Massachusetts Supreme Judicial Court 1994, which is interpreted to require benefits to pertain directly to ratepayers; this is not the place to parse the fine points of this decision as it relates to subsequent events). The NEIs thus omitted in Massachusetts were reduced need for food assistance, improvement in prescription adherence, increased productivity at work due to improved sleep, and reduction in low-birth weight babies from the "heat or eat" dilemma.

[11] NEIs studied in Massachusetts but not discussed here are lost days of work, improved productivity at home, and reduced use of short-term high-interest loans. Other NEIs potentially related to health and safety may also be worthy of subsequent study, including avoided lost days at school, increased productivity at school, increased productivity at work, avoided lost lifetime earnings, avoided increased childcare costs, increased social resilience (e.g., avoided violence), and other health benefits (including avoided trips and falls, avoided scalding hot water, avoided food poisoning from malfunctioning refrigeration, avoided heart disease, avoided cancer, and improved mental health).

with obvious economies since its survey research did not have to be repeated, although appropriate adjustments to inputs were necessary. The experience recounted below suggests this may be a successful model for other states to adopt.

The national WAP evaluation employed a national Occupant Survey of a random and representative sample of weatherized single-family[12] homes pre- and post-weatherization -- just prior to the energy audits completed in the treatment group households, and approximately 18 months post-weatherization -- along with a post-weatherization comparison group of homes, weatherized one year before the treatment group received weatherization services. (For detailed information on the national Occupant Survey, see Carroll et al. 2014).

NEIs were grouped into tiers. Asthma and thermal stress health impacts were assigned to Tier 1, where estimates were based on observed monetizable outcomes attributable to weatherization and highly reliable data. CO poisoning and home fires were assigned to Tiers 2 and 3, respectively, where estimates were established to have underlying sound methodologies but may have lacked direct observations of improved health or well-being and/or required relatively more assumptions.
Massachusetts-specific modifications included:

- Program-wide impacts (i.e., not household-specific) were removed,
- Discount rate was raised to that in use in Massachusetts, 0.44%,[13]
- The Value of Statistical Life (VSL)[14] was updated for inflation and accounted for as a household benefit (excepting firefighters), rather than societal,
- Because they were judged to be more statistically robust, with a much higher sample size, local weatherization agency data were used for the number of CO monitors installed that could reduce the probability of CO poisoning, and the number of smoke detectors and other weatherization measures installed that could reduce the probability of home fires,[15]
- National average medical costs (note that only out-of-pocket and uninsured costs were accounted for as participant costs, as opposed to societal) were adjusted to reflect Massachusetts costs and price-inflated, and
- Findings from the Occupant Survey specific to respondents residing only in the cold climate zone of the U.S. were used (excepting with respect to asthma incidence, the incidence of which does not significantly vary by climate region).

Results

It should be noted that Three[3] sets out the following limitations and sources of uncertainty, some of which may have conservatively resulted in underestimating the benefits:

[12] In DOE parlance, single-family homes include mobile homes and two-to-four unit multifamily buildings.

[13] Measure Life was assumed as 20 years, except five years for CO monitors.

[14] A measure of the value of human life used to compare regulatory costs to benefits. At the time of the WAP evaluations, U.S. government agencies used values that ranged from $5-9 million.To be conservative, the WAP National Evaluation adopted a value of $6 million in 2000 dollars, inflated to $7.5 million in 2008 dollars. For the Massachusetts study, this was updated to a 2016 value of $9.6M recommended by the U.S. Department of Transportation (DOT) (US Department of Transportation 2016; see Chan et al. 2017 at 7).

[15] Expert research panels approved including triangulation (relying on multiple sources) in design, such as supplementing findings with anecdotal evidence.

• Results are limited to low-income single-family homes (as defined) and perhaps some "larger multifamily complexes consisting of 'single-family like' units."[16]
• There is considerable uncertainty in the VSL.[17]
• Except for asthma and reduced CO poisoning, only one (1) occupant per household is assumed to be affected for each NEI.
• The prevalence of asthma in MA could be higher (e.g., larger percentage of communities of color), and asthma analysis does not account for multiple re-admittances.
• For thermal stress, extreme winter and summer weather events that could occur in any given year are unaccounted for. In addition, national (not MA) incidence rates for treatment type and death from thermal stress are applied.

The PAs hired NMR to review the methodology utilized for the national WAP evaluation, as well as the findings from the Massachusetts LI SF NEI study presented in this report. The purpose of this task was to determine the extent to which the NEIs quantified in this WAP-based evaluation overlap with, augment, or supersede the health- and safety-related NEIs previously examined and/or currently claimed by the PAs, and to develop recommendations for integrating the results.
As shown below, the differences between the 2011 NMR and 2016 Three[3] results are substantial. The reasons for these substantial differences are:

• The substantial increase in the health-related NEIs are largely attributable to the thermal stress NEIs, the increase in which is due principally to avoided deaths.[18] The risks of heat and cold-related mortality due to thermal stress are demonstrated by a National Health Statistics Report estimate of 2,000 weather related deaths per year in the US from 2006 to 2010 (during the WAP study period) (Berko et al. 2014; see Chan et al. 2017, at 12), about 31% from heat and 63% from cold. Analysis of the report's estimates by region, assuming deaths proportional to state population, yields 36 deaths per year in Massachusetts, 29 from cold, eight from heat.
• Although there are relatively few avoided deaths due to thermal stress, CO poisoning, and fire In the Three[3] analysis, they were monetized assuming a VSL of $9.6 million, which substantially increased NEI values.
• NMR post-weatherization (only) survey respondents were asked to report health effects monetized by their willingness to pay for improved health *relative to their energy bill savings*, whereas the Three[3] estimates are (a) based on respondents' changes in health and household status from pre- to post-weatherization, with a comparison group, and (b) monetized using a robust set of medical incidence and cost data.
• Three[3] could detect rare events such as the need for urgent care and potential number of deaths due to thermal stress that could be avoided from weatherization because its sample size was substantially larger.
• NMR's survey questions referenced multiple health benefits collectively, whereas the Three[3] surveyed each health benefit separately (asthma and thermal stress).

[16] The same analysts are currently studying health and safety benefits from energy efficiency in low-income multi-family homes in Massachusetts and elsewhere. The Massachusetts Program Administrators have identified moderate-income homes for possible similar analysis (NMR Group, Inc. and DNV-GL. 2018).
[17] On the other hand, surely the appropriate value is a large number that is not zero.
[18] As noted above, the VSL used was large ($9.6M), uncertain, and accounted for as a participant benefit. Objections are sometimes made on moral grounds to attempts to value human life (e.g., Ackerman and Heinzerling 2004) but surely it is no more moral to ignore the fact of a life-saving measure.

• NMR estimated the benefit of improved safety from reduced CO poisoning and fires due only to a single measure (heating system retrofit/replacement), whereas Three[3] estimated this benefit from a wider range of measures and using a more robust set of secondary national and state CO and fire incidence data.

Small non-energy benefits have long been recognized by Massachusetts and other energy efficiency regulators as part of benefit:cost analysis (NMR Group Inc. 2011). In Massachusetts, however, this work increases the monetized health and safety benefits of, for example, heating systems by a factor of 8, a significant impact on benefit:cost analysis.[19] This is shown in Table 1.[20]

Table 1. Massachusetts air source heat pump (ASHP) health and safety cost-effectiveness

Massachusetts ASHP health & safety benefits	2011 (1)	2016 (2)
Annual benefit	$50.32	$401.94
Life of measure - years (3)	18	18
Discount rate (4)	0.44%	0.44%
NPV (5)	$868.98	$6,941.17
Cost of measure - low (6)	$9,300	$9,300
Cost of measure - high (6)	$17,500	$17,500
BCR range ex energy (7)	0.05-0.09	0.40-0.75

(1) *Source:* Massachusetts Program Administrators 2015, at 413.
(2) *Source:* NMR Group Inc. 2017b, at 2, Table 2; personal communication, Oct. 31, 2017.
(3) *Source:* Massachusetts Program Administrators 2015, at 73.
(4) *Source:* Hawkins 2016, at xviii, Table E.5, based on method established in Hornby 2013, Appendix E.
(5) *Source:* Author's calculation from annual benefit, measure life discount rate; Excel formula.
(6) *Source:* Action for Boston Community Development (ABCD) experience, varies by house size (Personal communication, Jan. 12, 2018).
(7) *Source:* Author's calculation: NPV/cost; health and safety only, so excludes energy.

Health and safety NEIs thus transform Air Source Heat Pumps from cost-effective under limited circumstances, where only energy savings are considered, to robustly cost-effective when health and energy savings are included. Weatherization is already robustly cost-effective, but with health and safety NEIs it makes an even more substantial contribution to program and portfolio cost-effectiveness by increasing health and safety NEIs 50 times, to a typical health-and-safety-only benefit:cost ratio of 2.0.[21] The weatherization energy efficiency measure is thus justified by health and safety benefits alone, as shown in Table 2.

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[19] Note that this calculation uses the PA-approved 18-year life for air source heat pumps, rather than 20 years.

[20] The table reflects NMR's apportionment of total health-related NEIs among measures by assigning a portion of each NEI value proportionately to average energy bill savings. Thus values are distributed to weatherization (air sealing, 29.9%; duct sealing, 0.7%; and insulation, 25.1%) and heating systems (27.7%). Heating System Retrofit/Replacement includes Health, Thermal Comfort, and Safety NEIs apportioned for heating system, smoke detectors, and CO detectors. The NEI for CO is based on CO monitor installation and therefore the entire value is applied to projects that include CO monitors.

[21] A typical low-income whole house weatherization project cost is $5000.

Table 2. Comparison of 2016 Three[3] and 2011 NMR estimates of weatherization cost-effectiveness, on annual and 20-year bases

	Annual		NPV (20 years at 0.44%)	
	NMR 2011	Three3 2016 (1)	NMR 2011	Three3 2016 (1)
By NEI category				
Health benefits	$19.00	$768.58	$363.00	$14,683.78
Thermal comfort	$101.00	$119.88	$1,929.61	$2,290.22
Improved safety	$45.05	$94.46	$860.68	$1,281.40
By key measure				
Weatherization, electric or gas (3)	$10.46	$553.37	$199.84	$10,010.70

(1) Three[3] 2016 annual NEI estimate for Improved Safety, Weatherization, and Heating System Retrofit includes annual estimate for CO monitors of $38.67 (5-year life).
(2) Three[3] 2016 NPV NEI estimate for Improved Safety, Weatherization, and Heating System Retrofit includes 5-yr (not 20-yr) NPV estimate for CO monitors of $183.30.
(3) Weatherization includes Health, Thermal Comfort, and Safety NEIs apportioned for air sealing, insulation, smoke detectors, and CO detectors.

Conclusions

This case study demonstrates the role of evaluation in developing energy efficiency policy as well as the value in support of energy efficiency of collaboration among evaluation scientists, non-academic practitioners, and academic researchers. About 20 years of academic and medical research clearly established the health benefits of energy efficiency to low-income families. For example, research shows there are reduced emergency room visits for asthma due to reductions in dust and vermin as a result of air sealing. However, the monetary value thereof was not (in the US and rarely elsewhere) rigorously addressed so the information could not be used by energy efficiency program administrators or utility regulators. Massachusetts Program Administrators, their evaluation professionals and contractors, as well as stakeholders and Energy Efficiency Advisory Council[22] evaluators, understood this gap and the opportunity to fill it presented by the national DOE study.[23]

> "The results of this study substantially bolster the benefits of the LI single-family weatherization program in MA and potentially allow the PAs to expand its program offerings. In addition, the NEB values estimated in this study represent a better account of the 'real' benefits to LI occupants beyond just the energy savings and could potentially be used to help promote program participation." (Chan et al. 2017 at 13)

Many utility regulators credit energy efficiency programs for proven benefits other than reduced energy use, such as increased comfort and increased property values, counting the benefits in determining cost-effectiveness and utility incentives based on net benefits. But to do so in a

[22] The advisory council to the Department of Public Utilities, chaired by the Department of Energy Resources, established by statute. Massachusetts General Court (codified).
[23] Of course, they also possessed the technical operational knowledge necessary to enable the study to be designed and implemented. This author, on behalf of a stakeholder, played a role in assuring that the practical programmatic implications of the study would be clearly considered and set out.

regulatory setting, the benefits must be quantified, or at least carefully estimated,[24] in terms that can be reduced to monetary ones. It is believed that this case represents the first time that academic research into health and safety benefits of energy efficiency was used by evaluators with the advice of practitioners to provide usable data in a US regulatory setting. The result is recognition of a very substantial health benefit of energy efficiency, in some cases greater than energy savings itself (thus by itself justifying investments in energy efficiency). This result would not have occurred without academic research followed by an understanding of the needs of the regulatory environment. This included the recognition that evaluators and regulators need to understand monetary impacts of energy efficiency physical improvements. From utilities' point of view, regulatory acceptance is essential, of course. The value to utilities lies further in their provision of recognized customer benefit, regulatory and political goodwill therefrom -- not to mention the potential for increased benefit-based incentives, the possibility of additional efficiency measures, and, in the longer term, possible contributions to efficiency programs from the healthcare sector.

At the same time, there are broader and complex policy and regulatory issues involved in applying the results to energy efficiency programs. Among the regulatory shoals to be navigated, for example, are these.

"Too big" rule. The regulatory process is inherently cautious and incremental, rarely taking big steps. All else equal, for example, a series of small price increases is preferred to one large one. Thus there is a natural caution about large increases in non-energy benefits. One reason is that they allow more expensive measures to be cost-effective, thus increasing the cost of acquiring energy savings. While in the current context this may be useful to cost-effectively replace lost lighting savings to some extent, it will not be without a noticeable increase in the cost per unit of saved energy.

Further, some of the more expensive measures save increased amounts of energy in total but increase the use of electricity, albeit cost-effectively, an issue in itself and also raising energy regulatory concerns about supporting the switching from unregulated competitive fuels (in regions where there is substantial use of such unregulated carbon-rich fuels as oil, wood, and coal, or costly propane) to regulated electricity.

Unanticipated consequences. Large new NEIs invite close examination and may be found to partially overlap with those already accounted for. As an example, property value benefits may be seen, in part, as based on the health and safety benefits of energy efficiency. Bill savings are often viewed similarly.

Additionally, customers -- particularly large customers paying large surcharges for energy efficiency -- may object to paying for benefits that exceed the cost of a measure, seeing the amount above the cost of a measure as paying for individual customer comfort or health rather than system energy savings from which all customers benefit. This is most likely to come up in the context of low-income programs because (1) the programs already generally pay the full cost of measures, and (2) benefits such as health benefits are particularly large because baselines (i.e., for example, underlying health conditions) are particularly low so the non-energy benefit of energy efficiency is particularly high. Thus the cost-effective cost of a measure may exceed the narrowly defined economic value (avoided cost) to the utility system. Economics has no black-and-white answer to the resulting dilemma of who should pay the difference, viewing it as an equity issue to be determined by policymakers. Generally, participant co-payments obviate the issue but, in the case of low-income customers (who, by definition, cannot afford co-payments) it is this author's view that distributional

[24] Percentages of quantified energy benefits are used in some jurisdictions for at least some non-energy benefits.

equity demands that the cost be spread across all other customers (Accord, T. Eckman, retired Director of the Power Division, The Northwest Power and Conservation Council, and co-author, (The) National Efficiency Screening Project 2017, pers. comm. , Sept. 27, 2017).[25]

An evolving social role of utilities and a possible future integration of health and energy. It has been a long time since utilities were expected to do little more than efficiently deliver power and natural gas.[26] While it varies across jurisdictions, today's utilities often assume responsibilities for many social policies -- closing the income gap (with rate discounts, payment plans, restrictions on service terminations, and other programs), protecting the elderly and the very young, environmental stewardship (energy efficiency, purchase and/or development of renewables, research and development of battery storage), socializing objectives (average pricing across rural and densely populated areas, universal service pricing), economic development and innovation (special rates for industry, promotion of new technologies such as nuclear power), and charitable support of community institutions (Oppenheim 2016, at 9 and notes 32-41).

In the longer term, since the results described here show that monetized health benefits of energy efficiency can be more valuable than energy benefits, there are significant implications for both health and energy policy. For example, questions arise about the proper source of funding for low-income energy efficiency programs. If a primary benefit of energy efficiency is reduction in healthcare costs, how should measures, costs and benefits be allocated between the energy sector (utility ratepayers) and the health sector (healthcare funders such as insurance companies, governments, hospitals, and patients), and how and by whom should the programs be delivered, governed, and regulated? How should an existing successful low-income energy efficiency program be integrated? These questions also illustrate a potential program opportunity, combining energy and health objectives, that would have been impossible without the work described here.

The study thus opens conversations about potential opportunities for appropriate cost-sharing between energy efficiency and healthcare funders that share in energy efficiency program benefits. Thus, based in part of the study described in this paper, the Massachusetts Energy Efficiency Council Consultant Team proposes consideration of a co-funding strategy with the healthcare sector (Massachusetts Energy Efficiency Advisory Council Consultant Team 2017c, at 8). As the study shows, low-income home weatherization reduces the incidence of asthma hospitalizations, which the healthcare sector has a strong economic interest in reducing. Potentially, other energy efficiency and non-energy measures (e.g., safety grab bars in showers) could also be installed at the same time as weatherization, resulting in benefits to both the electric system (energy savings) and the healthcare system (hospital utilization savings). Perhaps energy efficiency Program Administrators and healthcare providers could work together for mutual benefit. From the energy efficiency standpoint, the opportunity is for shared funding of such program costs as audits, measures, and overhead, resulting in improved Benefit:Cost Ratios as the same savings are achieved at reduced (i.e., shared) cost.

A similar logic may work for the healthcare sector, achieving improved health in asthma patients by employing measures such as weatherization that are less costly than chronic hospital use.

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[25] Even proponent of deregulation Alfred Kahn conceded, in his classic work, that "The economist can not say it (subsidization desired by society) is wrong. He can only point out that this is … inefficient … Such ideas as fairness, equality of opportunity, or national security are obviously potentially far more important than economic efficiency." Fairness, as he points out earlier in the work rests on non-economic "political" determinations and "cannot be ignored." (Kahn 1970-1971, at I-91, II-241, and I- 31 and n.26.)

[26] *Ibid*. Ten years earlier, the classic text of the time expressed considerably more discomfort with departures from "economic" cost-based rules (Bonbright 1961).

This will require an analysis of the relevant healthcare economics that makes sense to healthcare providers. For example, healthcare institutions tend to need to see cash benefits from reduction in "super-users," a somewhat different economic focus from the utility world's more generalized interest in usage reduction.

Such integration of evaluated health and energy efficiency benefits will raise concerns across the hitherto very separate energy and health operational silos about program measures, delivery, and governance, not to mention the very different forms and objectives of their regulation. There are also likely to be operational differences in approach, e.g., choice and delivery of measures serving both energy and health needs, choice of participants and assessing needs of specific households, evaluation of results and measurement of performance.

Some very preliminary work has begun. Berkshire Health Systems has joined with its local utility and community groups to deliver energy efficiency, including enhanced weatherization with heat or energy recovery ventilation, to selected patients in Adams, Massachusetts and nearby, with severe asthma or other respiratory illness. Project results will be measured by changes in energy use, indoor air quality, and hospital and emergency room use (Center for EcoTechnology 2017). Boston Medical Center is investing in community development corporations and others to build or rehabilitate housing for its homeless patients. Dignity Health in San Francisco and Nationwide Children's Hospital in Columbus, Ohio, are making similar investments (McCluskey 2017). Tennessee Valley Authority has hired Three[3] to explore the health impacts of Knoxville's Extreme Energy Makeover energy efficiency program, including weatherization and heating system replacement, to guide development of low-income energy efficiency and healthy housing programs. Preliminary results show, for example, that days of poor health in the previous month fell 44% and that incidence of severe headaches dropped 50% (ThreeCubed web site; Tonn et al. 2017).

Evaluation will help determine the success of these initiatives.

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