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Evaluating direct energy savings and market transformation effects: A decade of technical design assistance in the northwestern USA

Kevin Van Den Wymelenberg [a,*], G.Z. Brown [b], Heather Burpee [c], Ery Djunaedy [a], Gunnar Gladics [a], Jeff Kline [b], Joel Loveland [c], Christopher Meek [c], Harshana Thimmanna [a]

[a] University of Idaho, Integrated Design Lab, 306 S. 6th Street, Boise, ID 83702, United States
[b] University of Oregon, Energy Studies in Buildings Laboratory, OR, United States
[c] University of Washington, Integrated Design Lab, WA, United States

HIGHLIGHTS

- ▸ Estimated direct energy savings of a market transformation program are presented.
- ▸ A methodology to evaluate energy savings from multiple baselines is documented.
- ▸ Level of integrated design can be used to estimate energy savings in new buildings.
- ▸ Quantitative evaluation indicators of efficiency market transformation are provided.
- ▸ Electric energy saved from design assistance costs between \$0.0016 and \$0.0092/kWh.

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ABSTRACT

This paper documents the direct energy savings and energy efficiency market transformation impacts of a multi-state design assistance program in the northwestern US. The paper addresses four specific aims. (1) It provides a conservative and justified estimate of the direct energy savings associated with design assistance activities of a market transformation program from 2001 to 2010. (2) It provides a rigorous methodology to evaluate direct energy savings associated with design assistance market transformation programs. (3) It provides a low-cost replicable method to predict energy savings in new buildings by evaluating the integrated design process. (4) It provides quantitative indicators useful for estimating indirect energy savings from market transformation. Applying the recommended analysis method and assuming a 12-year measure life, the direct energy savings of the population (626 buildings; 51,262,000 ft^2) is estimated as 45.3 aMW (average megawatts) (electric), and 265,738.089 therms (non-electric). If the entire program budget were divided into the electric savings only, the Lab Network cost per kWh saved ranged from \$0.0016 to \$0.003 using the recommended method and \$0.0092/kWh using the most conservative method. These figures do not isolate contextual influences or represent total resource cost. Statistically significant correlations ($r^2 = 0.1 - 0.3$) between integrated design scores and energy savings are reported.

1. Introduction

1.1. Background

The Northwest Energy Efficiency Alliance (NEEA) is an energy efficiency market transformation (MT) organization funded by electric utilities in the Pacific Northwest (PNW). NEEA aims to "…catalyze changes in the marketplace that accelerate the acceptance of energy-saving products and services. This is often called market transformation (Eckman et al., 1992). The total resource cost (TRC) is expected to be between \$0.01 and \$0.035/kWh saved by program activities (Northwest Energy Efficiency Alliance, 2006, 2010). In 2000, NEEA began funding regional university-based laboratories (Lab Network), in conjunction with other NEEA implementation contractors, to provide technical design assistance and project-based education (Hellmund et al., 2008; Jennings et al., 2010; Van Den Wymelenberg et al., 2009) for the promotion of energy efficiency in commercial buildings as part of their BetterBricks (NEEA-BB) program. In 2006, NEEA-BB

* Corresponding Author. Tel.: +1 208 401 0641, +1 208 429 0220x641; fax: +1 208 343 0001.
E-mail address: kevinv@uidaho.edu (K. Van Den Wymelenberg).

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introduced its vision of the *integrated design*[1] (Brown and Cole, 2006) process developed by the Lab Network in order to focus its efforts to transform the "energy-related business practices in Northwest buildings" (About Us—Betterbricks, n.d.).

MT involves diffusing knowledge to and changing the values and behaviors of many individuals and organizations in the region. Evaluating MT is complex, especially when compared to traditional utility demand-side management (DSM) programs, and requires regular monitoring of behaviors, attitudes, process development, technology development, and market development (Neij, 2001). See Blumstein et al. (2000); Neij (2001); Vine et al. (2006) for more about MT evaluation theory and practice[2] . Because NEEA's funding comes primarily from electric utilities, which are responsible to public regulating agencies and influenced by investment principles, cost-effectiveness and expenditure prudency must be maintained. Direct energy savings from program activities is thus one important measure of success; however, the primary measure of MT success is arguably the business practice change and reduction of market barriers that ultimately generate far greater energy savings than direct program activities. However, evaluation of energy savings from MT programs in commercial buildings is complex and expensive. Neij (2001) suggests that 5–10% of the cost of MT programs must be dedicated to evaluation. The identification of an appropriate baseline and the interpretation of the collected modeled or utility energy consumption data are controversial. Evaluating long-term multi-state design assistance must also accommodate jurisdictions adopting energy codes asynchronously, and multiple evolving utility incentive programs. While ISO 50001 (ISO—International Organization for Standardization, 2011) may provide useful consistency and standardization to this process, it will primarily affect existing buildings. There is also evidence of new practices by which utilities recover the cost of efficiency (Idaho Power Company, 2011) and increased regulations to achieve all cost-effective efficiency (State of Washington Department of Commerce, 2006), thus continuing to increase the scrutiny of MT evaluation methods. The Northwest Power and Conservation Council's Regional Technical Forum (RTF) plays a critical role in validating energy savings from technologies and practices in the PNW. The RTF is an advisory committee established in 1999 "…to develop standards to verify and evaluate conservation savings" (Regional Technical Forum, n.d.). However, the RTF's mechanisms are primarily applied to equipment driven measures (e.g., retrofitting light fixtures) rather than business practices and design process approaches (e.g., the integrated design process) or passive architectural design strategies (e.g., nighttime ventilation of mass).

Early NEEA-BB evaluations established a useful evaluation framework and documented energy savings in categories defined within that framework (Heschong Mahone Group (HMG), 2007, 2008). Heschong Mahone Group (HMG) (2007) described the challenge of evaluating a design assistance program aimed at business practice change because "there are no prescriptive lists of energy efficiency measures from which savings will be derived." HMG proposed a three-part evaluation framework: (1) *direct involvement,* (2) *direct influence* and (3) *indirect influence*. Direct and indirect influences capture the MT effects of the program while direct involvement captures the energy savings directly involved with the program. Due in part to limited evaluation funding, subsequent NEEA-BB evaluations have not adequately measured direct energy savings or indirect energy savings using MT indicators. Based upon cumulative evaluations from 2006 to 2010, the *direct involvement* energy savings from the design assistance program were reported as 1.65 aMW and 565,255 therms of natural gas (Research Into Action & ECONorthwest and Mike, 2010; The Cadmus Group, 2009). These savings represent only 39 *direct involvement* buildings (3,893,767 SF) of the 481 *direct involvement* buildings in NEEA's database for the same period. Reported modeled savings (26 of 39 buildings) were reduced by a *savings realization ratio* (SRR) of 0.63 (based upon just four buildings with both actual and simulated data). The determination of the SRR did not account for differences in weather, patterns of occupancy, or as-built system definitions between the consumption data and the modeled code baseline as is recommended by the International Performance Measurement and Verification Protocol (IPMVP) (DOE EERE IPMVP Committee, 2002).

One report stated: "We suspect that [program] impacts to date far exceed the savings the impact evaluators have found…Based on these research activities conducted over several years, it is the opinion of this team that [the program] has the potential to deliver significant measurable savings" (Research Into Action & ECONorthwest and Mike, 2010). Market Progress Evaluation Reports (MPER)[3] have tracked indicators of program progress and the most recent report (McRae et al., 2010) suggests that firms engaged provided the types of services promoted by the program (e.g., energy benchmarking, energy modeling) at a higher rate and had a higher level of awareness of program related methods (e.g., the integrated design process) than firms that did not participate in the program. The report also stated: "…there was still very little data to tie these changes to energy savings….", and while the authors "…believe that there are energy savings which resulted from this change, the data do not exist to validate this." A more comprehensive and cost-effective methodology has not yet been established to measure energy savings from MT effects of NEEA's design assistance program (Research Into Action & ECONorthwest and Mike, 2010).

The objectives of this paper are as follows. (1) To provide a conservative and justified estimate of the direct energy savings associated with design assistance activities of a market transformation program from 2001 to 2010. (2) To provide a rigorous methodology to evaluate direct energy savings associated with design assistance market transformation programs while building upon previous program evaluations (Heschong Mahone Group (HMG), 2007, 2008; Research Into Action & ECONorthwest and Mike, 2010; The Cadmus Group, 2009). (3) To examine the merits of a low-cost replicable method to predict energy savings in new buildings by evaluating the *integrated design process*. (4) To provide quantitative indicators and data useful for estimating indirect energy savings from energy efficiency MT effects beyond direct energy savings.

2. Methodology

2.1. Population and sample definitions

A list of 722 buildings in which the Lab Network had *direct involvement* were compiled from NEEA's database.[4] Accurate

[1] Integrated design synthesizes climate, use, loads and systems resulting in a more comfortable and productive environment, and a building that is more energy-efficient than current best practices.

[2] Vine et al. (2006) noted that market transformation type activities, namely educational information programs were not included in utility cost effectiveness tests due to their complexity; "Beginning in 1995, energy efficiency programs eligible for utility incentives (shareholder earnings) had to be cost-effective on a forecast basis. Each shared-savings program had to pass both the TRC [total resource cost] and UC [utility cost] tests of cost-effectiveness as a condition for funding. General information programs were excluded from these tests because of the extreme difficulty in establishing meaningful estimates of their load impacts."

[3] Reports available at: http://neea.org/research/evaluationreports.aspx (BetterBricks tab).

[4] Due to changes in NEEA's database in 2005–2006, data from many of the projects entered previously were lost; thus, the actual number of project consultations is greater than reported.