Learning from the Past and Predicting the Future: Linking Program Evaluations to Energy Efficiency Planning Studies

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Issue Statement

- Energy efficiency (EE) potential studies are experiencing a new wave of attention in the US and around the world
- Potential studies now taking center stage in policy and resource planning activities that go well beyond the scope and objectives of the first wave of utility-sponsored planning studies conducted in the 1990s
- It is thus critical to assess the quality of the tools and key data used in potential studies, identify key uncertainties, and implement strategies to reduce these uncertainties on an ongoing basis going forward

Issue Statement (2)

- In many ways, program evaluations are mirror images of potential studies
- Potential studies face the challenge of accurately characterizing measure-level technology and participation data across the entire spectrum of EE technologies and programs and face a host of uncertainties that are very dynamic in nature
- Program evaluations hold the promise of being an important vehicle to reduce key uncertainties in potential studies on a continual and ongoing basis, ***if explicitly designed to do so***

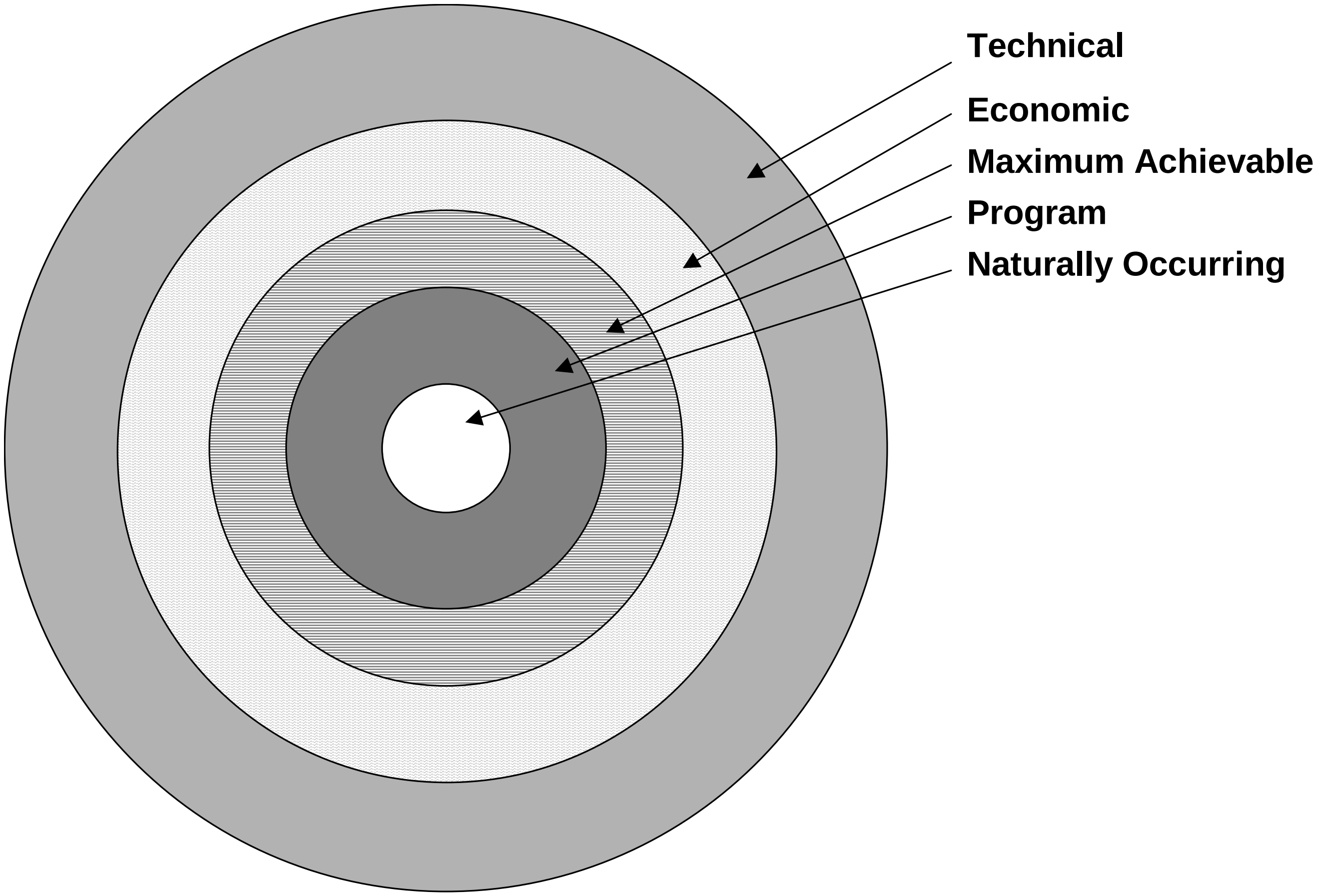
Presentation Overview

- Basics of EE potential studies
- Sources of uncertainty in EE forecasting
- The role of evaluation-based data in EE forecasting
- Roadmap for going forward

Basics of EE Potential Studies

- Definitions of EE potential are similar to definitions of potential developed for finite fossil fuel resources like coal, oil, and natural gas
  - > resources are typically characterized along two primary dimensions: 1) the degree of geologic certainty with which resources may be found and 2) the likelihood that extraction of the resource will be economic
- Somewhat analogously, EE planning studies have defined several different types of energy efficiency potential
  - > most common types of potential defined are *technical, economic, achievable, program, and naturally-occurring* potential

Basics of EE Potential Studies



Main Input Data and Analytic Elements

- Most studies start with assembling “baseline data” that provide a bottom-up characterization of energy use at the end-use and technology level in the particular market segments of interest
- These baseline data are then interacted with “measure data” to produce estimates of technical potential

$$\text{Technical Potential (GWh)} = \overbrace{\left(\begin{matrix}\text{Units of}\\ \text{Consumption}\\ (10e6\ ft^2)\end{matrix}\right)\left(\begin{matrix}\text{End-use Tech}\\ \text{Saturation}\\ (\%)\end{matrix}\right)\left(\begin{matrix}\text{Base Tech}\\ \text{EUI}\\ (kWh/ft^2)\end{matrix}\right)}^{\textit{Baseline Data}}\overbrace{\left(1 - \begin{matrix}\text{Measure}\\ \text{Saturation}\\ (\%)\end{matrix}\right)\left(\begin{matrix}\text{Measure}\\ \text{Feasibility}\\ (\%)\end{matrix}\right)\left(\begin{matrix}\text{Measure}\\ \text{Savings}\\ (\%)\end{matrix}\right)}^{\textit{Measure Data}}$$

Baseline End Use Data

Data Type	Units	Common Sources
Units of consumption	• Number of households or kWh sale (residential) • Square feet of floor space or kWh sales (commercial) • kWh sales (industrial)	• Utility billing data • CIS data • Regulatory commissions
End-use technology saturation	• Share of households with technology installed (residential) • Share of floor space with technology installed (commercial) • Share of load with technology installed (industrial)	• Self-report surveys • On-site surveys • Market tracking studies
End-use technology density	• Cost units per consumption unit (e.g., lamps/home, tons cooling/square foot, motor horsepower/kWh)	• Self-report surveys • On-site surveys
End-use energy intensity	• Annual kWh/household (residential) • Annual kWh/square foot (commercial) • None or kWh/unit of production or kWh/value of shipments (industrial)	• Building simulations • Engineering estimates • End-use metering studies • Utility load research • Econometric studies (e.g. conditional demand analysis)
End-use load shapes	• Distribution of end-use energy consumption across times of the day, days of the week, and season	• Building simulations • End-use metering studies • Utility load research

Measure Data

Data Type	Units	Common Sources
Measure costs	• $/cost unit (e.g. per lamp, per ton of cooling capacity, per square foot of insulation)	• Measure cost studies • Market tracking studies
Measure savings	• Savings relative to base case technology at equivalent level of service	• Measure impact evaluations (e.g. billing analysis, M&V) • Engineering analysis
Measure saturation	• % of households with measure installed (residential) • % of floor space with measure installed (commercial) • % of load with measure installed (industrial)	• Self-report surveys • On-site surveys • Market tracking studies (including supply-side analyses)
Measure feasibility	• % of eligible households where measure is technically and practically feasible (residential) • % of eligible floor space where measure is technically and practically feasible (commercial) • % of eligible load where measure is technically and practically feasible (industrial)	• Engineering judgment

Main Input Data and Analytic Elements (2)

- Cost-effectiveness calculations
  - > Common cost-effectiveness metrics include Total Resource Cost Test (TRC), Utility Cost Test (UCT), Rate Impact Measure Test (RIM), and Participant Test (PT)
  - > Calculations use baseline and measure data combined with information on electric/gas retail rates, avoided costs, and discount rates
- Adoption modeling
  - > How much of the cost-effective efficiency resource is likely to be captured through programs
  - > Customer adoption usually modeled as a function of stock turnover, customer awareness, cost-effectiveness to customer, and market barriers

Sources of Uncertainty

- Two principal classes of uncertainty in EE potential studies
  - > "Current market" uncertainty
    - Associated with estimates of the current characteristics of end-use electricity consumption and energy efficiency measure data
  - > "Forecast" uncertainty
    - Associated with future energy prices and electric load forecasts, changes in market and energy efficiency measure characteristics over time, and forecasts of customer adoption of measures
- Considerable overlap in the underlying data associated with both types of uncertainty
  - > E.g. current market uncertainty directly affects forecast uncertainty
  - > However, the types of research necessary to reduce these two types of uncertainties are sometimes significantly different

Current Market Uncertainty

- Baseline data
  - > In best case, baseline data developed from up-to-date and statistically accurate studies (e.g. large-sample on-site surveys)
  - > When baseline data are absent, outdated, or inaccurate, the uncertainty in baseline estimates directly impacts the accuracy of EE potential estimates
- Measure cost and savings data
  - > In general, new measures have somewhat greater uncertainty in costs and savings than measures that have been on the market for longer periods (e.g. 3 years or more)
  - > Dynamic markets for existing EE measures can also lead to substantial declines in incremental measure costs over time, making it difficult to maintain up-to-date information (e.g. high efficiency lighting)

Current Market Uncertainty (2)

- Measure feasibilities
  - > Generally derived from engineering judgment and experience
  - > Highest for evaporative coolers, whole-house fans, tankless water heaters, perimeter dimming, variable frequency drive controls, energy management systems, and commercial cool roofs
- Measure saturations
  - > Self-report surveys can produce fairly accurate saturation estimates for certain types of measures (e.g. CFLs, ENERGY STAR appliances) but suffer from self-report bias and high levels of misreporting for other measures (e.g. residential floor and wall insulation)
- Measure useful lives
  - > Over- or underestimating useful lives will concomitantly over- or underestimate the measure's benefit-cost ratio

Forecast Uncertainty

- Even with perfect data on current market conditions, forecasts are subject to their own uncertainties by nature
- Key areas of forecast uncertainty include:
  - uncertainty in future levels of end-use energy service demand
  - uncertainty in future cost-effectiveness of measures
  - uncertainty in future customer adoption preferences and behavior
  - uncertainty in interactions between current measure portfolios with new measures, future codes and standards, and other future demand-side management (DSM) programs and initiatives

Role of Evaluation-Based Data

- Measure saturation estimates
  - On-site verification of self-report surveys
  - Leveraging energy audit programs as sources for observation-based data
    - Evaluations of audit programs often focus on determining the energy savings impacts of those programs, rather than constructing a systematic, detailed characterization of the customer base
    - Standardized, central databases of audit information could yield a wealth of on-going, observation-based measure saturation estimates
    - Estimates derived from entirely from audit data are subject to self-selection bias and would likely need to be validated by periodic survey studies

Role of Evaluation-Based Data (2)

- Measure cost and savings estimates
  - Program application data
    - Customers and/or installers are often required to submit unit price information for eligible measures as part of rebate application process
    - Such applications are a natural, low cost, and on-going source of up-to-date measure cost data
    - Could serve as an important source of measure cost data for commercial lighting and HVAC measures that are generally procured for customers by contractors
  - Integrated measure evaluations
    - Integrated measures often suffer from aggregation bias in measure cost data and significant uncertainty in measure savings data due to a severe lack of real-world, evaluation-based impact estimates
    - Need for evaluations designed to explicitly assess costs and savings of such integrated measures implemented through custom retrofit programs or new construction programs

Role of Evaluation-Based Data (3)

- Customer adoption behavior data
  - > Conjoint and double-bounded choice studies have been the traditional means to quantify customer adoption preferences
  - > One alternative approach is to leverage the diversity of current programs being offered across different service territories and regions as large scale “natural experiments”, the results of which could feed into revealed preference analyses
    - Advantage is potential scope of data collected
    - Disadvantage is increased possibility of spurious correlation from a lack of strict study controls
  - > Another alternative approach is to integrate follow-up procedures for all customers that have participated in an energy audit
    - Likely subject self-selection bias and would likely need to be periodically validated by more controlled discrete choice studies

Challenges with Integrating Evaluation and Planning

- Timeliness in a dynamic world
  - > Program evaluations are typically time-intensive processes
  - > Final evaluation results often reflect the market conditions from 3-4 years previous
  - > Key challenges is ensuring timely availability of evaluation results for use in planning studies
- Whole-market vs. utility program perspectives
  - > Evaluations traditionally focus on assessing impacts from measures supported directly through utility programs whereas EE potential studies attempt to characterize the entire suite of measures commercially available
  - > Key challenge is strategically re-defining program implementation and evaluation activities beyond only measures directly supported by utility programs in a manner that does not hinder the effectiveness of program delivery or introduce significant additional costs
- Balancing evaluation priorities with planning study needs

Roadmap for Going Forward

- These types of integrations are really longer term goals
- Nonetheless, a host of initiatives can be pursued in the near-term:
  - > Coordinated phasing of program evaluations and planning studies
    - Avoid "lost opportunities" by sequencing evaluations to feed planning studies in a organized and timely manner
  - > Testing experimental evaluation approaches
  - > Evaluating compliance with building codes and appliance standards
    - Represents a separate activity from utility program evaluation that need not cannibalize scarce utility program evaluation resources
  - > Increasing the use of scenario analysis
    - Critical to bound forecasts of EE potential under a wider variety of possible futures, rather than focusing solely on outcomes related to increasing incentives (e.g. retail energy rates, avoided costs, technology learning, or changes in end-use energy service demand)