Energy Technologies Area Lawrence Berkeley National Laboratory

Setting Baselines for Planning and Evaluation of Efficiency Programs

August 2, 2016

EM&V Webinars Facilitated By:
Lawrence Berkeley National Laboratory
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In Collaboration With:
U.S. Environmental Protection Agency

National Association of Regulatory Utility Commissioners
National Association of State Energy Officials

Introduction

- LBNL is supported by the U.S. Department of Energy to conduct non-classified research, operated by the University of California

- Provides technical assistance to states—primarily state energy offices and utility regulatory commissions

The presentation was funded by the U.S. Department of Energy's Office of Electricity Delivery and Energy Reliability-Electricity Policy Technical Assistance Program under Lawrence Berkeley National Laboratory Contract No. DE-AC02-05CH11231.

Technical Assistance

- LBNL's provides technical assistance to state utility regulatory commissions, state energy offices, tribes and regional entities in these areas:
  - Energy efficiency (e.g., EM&V, utility programs, behavior-based approaches, cost-effectiveness, program rules, planning, cost recovery, financing)
  - Renewable energy resources
  - Smart grid and grid modernization
  - Utility regulation and business models (e.g., financial impacts)
  - Transmission and reliability
  - Resource planning
  - Fossil fuel generation
- Assistance is independent and unbiased
- LBNL Tech Assistance website: https://emp.lbl.gov/projects/technical-assistance-states
- US DOE Tech Assistance gateway: http://energy.gov/ta/state-local-and-tribal-technical-assistance-gateway

Webinar Series

- Webinars designed to support EM&V activities for documenting energy savings and other impacts of energy efficiency programs
- Funded by U.S. DOE in coordination with EPA, NARUC and NASEO
- Audience:
  - Utility commissions, state energy offices, state environment departments, and non-profits involved in operating EE portfolios
  - Particular value for state officials starting or expanding their EM&V
  - Evaluation consultants, utilities, consumer organizations and other stakeholders also are welcome to participate
- For more information (upcoming and recorded webinars, EM&V resources) see:
  - https://emp.lbl.gov/emv-webinar-series
  - General Contact: EMVwebinars@lbl.gov

Series Contact:
Steve Schiller
Senior Advisor, LBNL
SRSchiller@lbl.gov

Next Webinars

- Evaluation of Behavior Based Programs - scheduled for mid-September
- Transmission and distribution (T&D) efficiency programs and their EM&V – Scheduled for mid-October

Today's Webinar

Introduce considerations and common practices for defining baselines and provide examples of how different jurisdictions are addressing market baseline studies, setting baselines for retrofit measures, and market transformation program baselines.

- Introduction and the basics of energy efficiency baselines – Steven Schiller, Senior Advisor, Berkeley Lab
- The Michigan Experience and Approach to Market Baseline Studies for Program Planning – Robert G. Ozar P.E., Assistant Director, Electric Reliability Division, Michigan Public Service Commission
- The California Experience and Approaches to Setting Baselines for Program Evaluation – Carmen Best, Energy Efficiency Commercial Programs & Evaluation - Supervisor at California Public Utilities Commission
- Market Transformation Baselines – Jeff Harris, Chief Transformation Officer, Northwest Energy Efficiency Alliance
- Q&A with panelists

Introduction and Basics of Energy Efficiency Baselines

Steven Schiller, Senior Advisor, LBNL

What is a Baseline

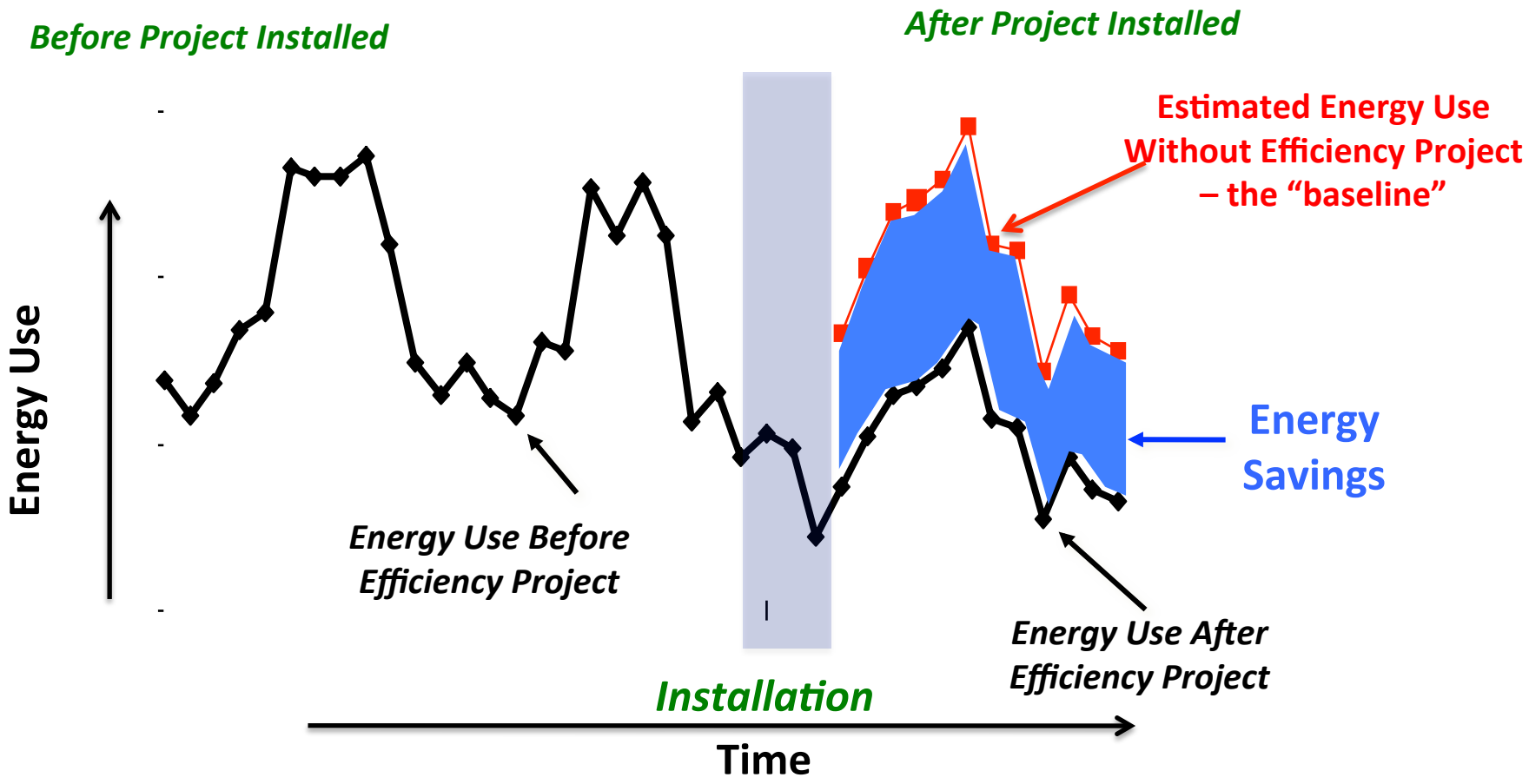
- Basic equation for calculating impacts of efficiency actions (programs, projects, measures) is (for example, for energy savings):
  - Energy Savings = (energy use without efficiency) – (energy use with efficiency)

  Or

  - Energy Savings = (baseline energy use) – (observed energy use)
- Baseline:
  - Conditions, including energy consumption and demand, which would normally (typically, commonly) occur
  - Baseline conditions are the counterfactual, sometimes referred to as "business-as-usual" conditions
  - Baselines can also include definition of non-energy metrics that are being evaluated, such as air emissions and jobs

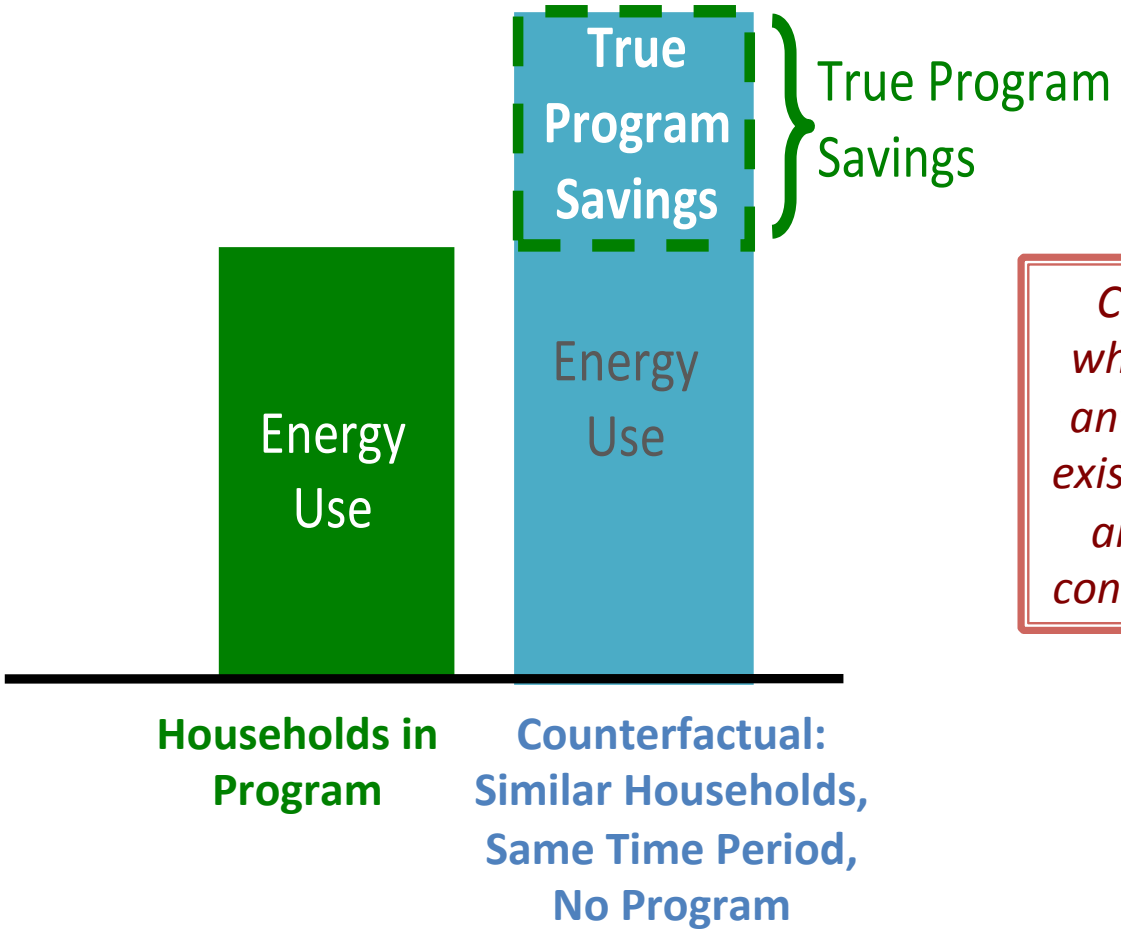
Why have to determine baselines? Because savings cannot be measured!

They Are Estimated



Energy Consumption Before, During And After an Efficiency Project Is Installed

Savings are determined with a counterfactual



Counterfactual analysis occurs when a person modifies a factual antecedent (a thing or event that existed before or logically precedes another) and then assesses the consequences of that modification.

Sorting out baselines is one of two big issues of EM&V

How good is good enough?

- Fundamental issue of EM&V
- How certain does one have to be of savings estimates and is that certainty balanced against the amount of effort utilized to obtain that level of certainty?

As compared to what?

- First – Defining a baseline against which efficiency actions are compared for determining energy savings and whether attribution should be considered—the counterfactual
- Second – Assessing efficiency relative to other energy resource options for meeting energy requirements and cost, reliability, etc. goals

Net Saving and Baselines

- Savings from utility customer funded programs are typically calculated as one or both of the following metrics:
  - **Gross savings:** Changes in energy consumption that result directly from program-related actions taken by participants of an EE program, regardless of why they participated.
  - **Net savings:** Changes in energy use that are attributable to a particular EE program. These changes may implicitly or explicitly include the effects of free ridership, spillover, and induced market effects.
- Each of these metrics has to be defined in the context of a baseline and these metrics can overlap depending on how the baseline is defined
  - This is particularly true with net savings values overlapping with gross savings values if the baseline is defined as common practice, what would have occurred in the absence of the efficiency program
  - This is called an adjusted gross savings in some jurisdictions

Options for defining baselines, page 1 of 2

- ***Existing Conditions Baselines*** are what in place (e.g., equipment, controls, procedures) at the project site before the energy efficiency measures are implemented. This is the perspective that consumers often have.

- ***Common Practice Baselines*** are estimates of what a typical consumer would have done at the time of the project implementation. Essentially, what is "commonly done" becomes the basis for baseline energy consumption. For example, if the program involves incenting consumers to buy high-efficiency refrigerators that use 20% less energy than the minimum requirements for ENERGY STAR® refrigerators, the common practice baseline would be refrigerators that consumers typically buy, on average.

Options for defining baselines, page 2 of 2

- ***Codes and Standards (C&S) Baselines*** are the energy consumption associated with buildings or specific pieces of equipment that meet the legal requirements in place, in the location where a project is implemented. For example, for a motor replacement program, the C&S baseline standard might consist of a motor that meets the minimum requirements of the federal Energy Independence and Security Act of 2007 (EISA) for new motors.

- ***Minimum Efficiency Baselines (MEB):*** The required (i.e., by codes or standards) or minimum efficiency on the market for new equipment or new construction. This definition is often applied for equipment that is being replaced at the end of its useful life (e.g., replace-on-burnout).

Which Baseline – Depends on what type of program and basis for efficiency action

Program Category for Purposes of Baseline Determination	Existing Conditions Baseline	Codes and Standards Baseline	Common Practice Baseline Or Minimum Efficiency Baseline
Early replacement or retrofit of functional equipment still within its current useful life; Process improvements	X - Existing conditions baseline for the remaining life of what is replaced	X - C&S baseline for the time period after the remaining life of the replaced equipment	X - Common practice baseline for the time period after the remaining life of the equipment
Replacement of functional equipment beyond useful life		X	X
Unplanned replacement for (of) failed equipment		X	X
New construction		X	X
Non-equipment based programs (e.g., behavior-based and training programs)			X – What control group would be doing in the absence of the program

Help with defining baselines - EM&V Resources

- DOE/EPA SEE Action EM&V Resources website: http://www4.eere.energy.gov/seeaction/topic-category/evaluation-measurement-and-verification

- U.S. DOE Uniform Methods Project website: http://energy.gov/eere/about-us/ump-home

Now - Our Other Speakers

- The Michigan Experience and Approach to Market Baseline Studies for Program Planning – Robert G. Ozar P.E., Assistant Director, Electric Reliability Division, Michigan Public Service Commission

- The California Experience and Approaches to Setting Baselines for Program Evaluation – Carmen Best, Energy Efficiency Commercial Programs & Evaluation - Supervisor at California Public Utilities Commission

- Market Transformation Baselines – Jeff Harris, Chief Transformation Officer, Northwest Energy Efficiency Alliance

The Michigan Experience and Approach to Market Baseline Studies for Program Planning

Lawrence Berkeley National Lab - Webinar Series

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Robert G. Ozar P.E.
Assistant Director, Electric Reliability Division
Michigan Public Service Commission
ozarr@michigan.gov
https://www.linkedin.com/in/robert-ozar-46224a78

Multi-year Process

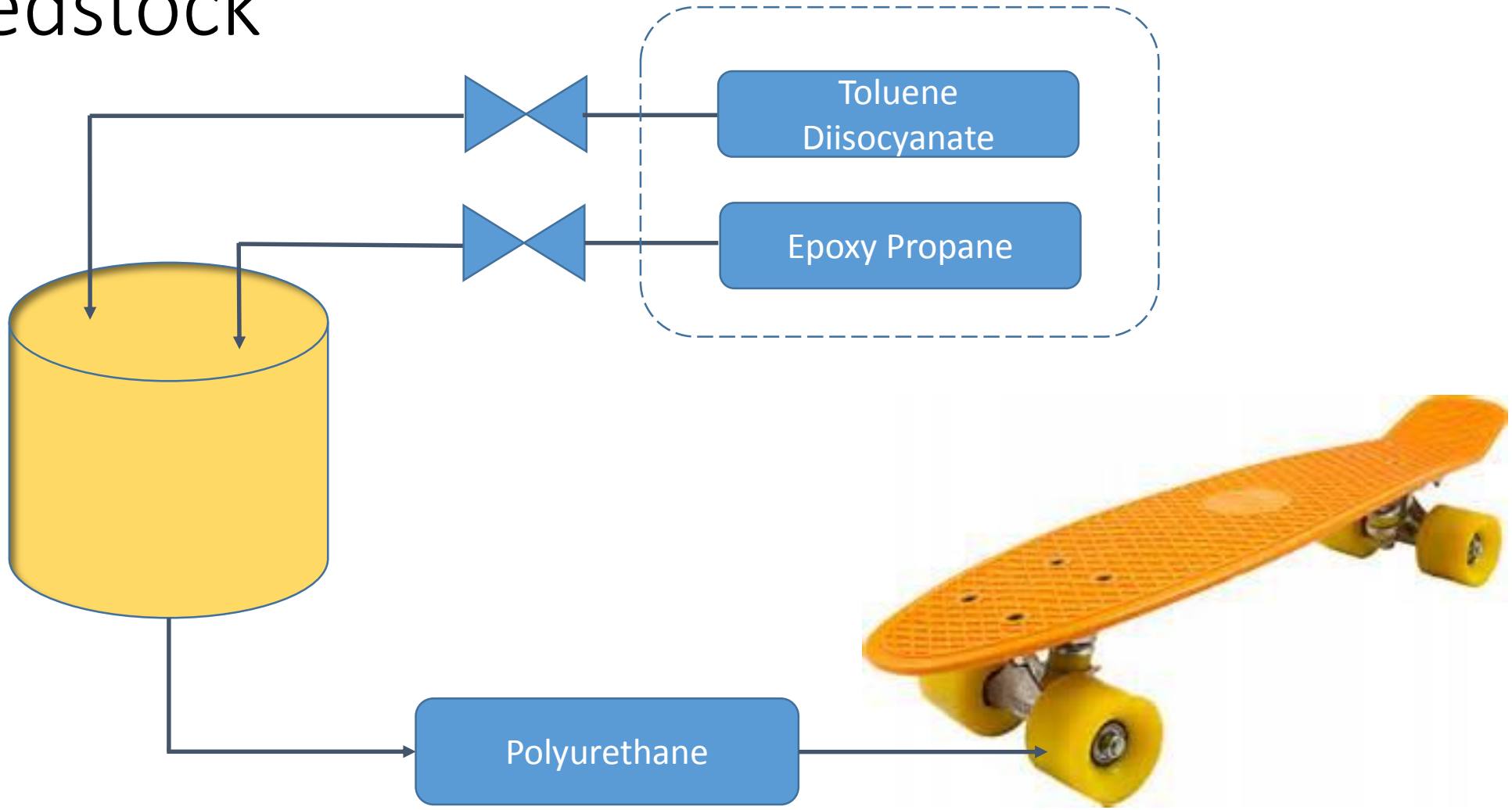
- 2009 - 2011 **Michigan Market Baseline Study**
  - [Residential and Commercial]
  - Prepared by *The Cadmus Group Inc., Opinion Dynamics Corp., Consumer Insights, Mad Dash*
- 2011, 2013 **Michigan Electric and Natural Gas EE Potential Study**
  - Prepared by *GDS Associates*, Inc.
- 2013 **Options For Establishing Energy Efficiency Targets in Michigan 2016 – 2020**
  - Prepared by *Optimal Energy*
- *2013* **Readying Michigan to Make Good Energy Decisions**
  - Prepared by the *Michigan Public Service Commission, Michigan Energy Office*
- 2014 -2016 Legislative discussions at the Michigan Legislature

Baseline Study + Other Research to Understand How Energy is Used in Michigan and What Savings Opportunities Exist

Context of Market Baseline Study

- **End-goal to Re-establish Michigan Utility EE Resource Targets**
  - Previously set in 2008 legislation [2008 PA 295]
  - 1% of retail electric sales; 0.75% natural gas sales
- Market Baseline
  - Foundation of multi-step process
  - Provides the underlying data needed to assess of the amount of electric and gas savings still available

Market Baseline Analogy – Like a Chemical Feedstock



Market Baseline is a EE Potential Study Input

Market Baseline Data
Utility Retail Sales Forecast
Avoided-cost projection
Technical Resource Manual (TRM) [measure savings]
EIA Residential Energy Consumption Survey (RECS)
EIA Commercial Building Energy Consumption Survey (CBECS)
Incremental-Measure Cost-Projections
Market Adoption Curves

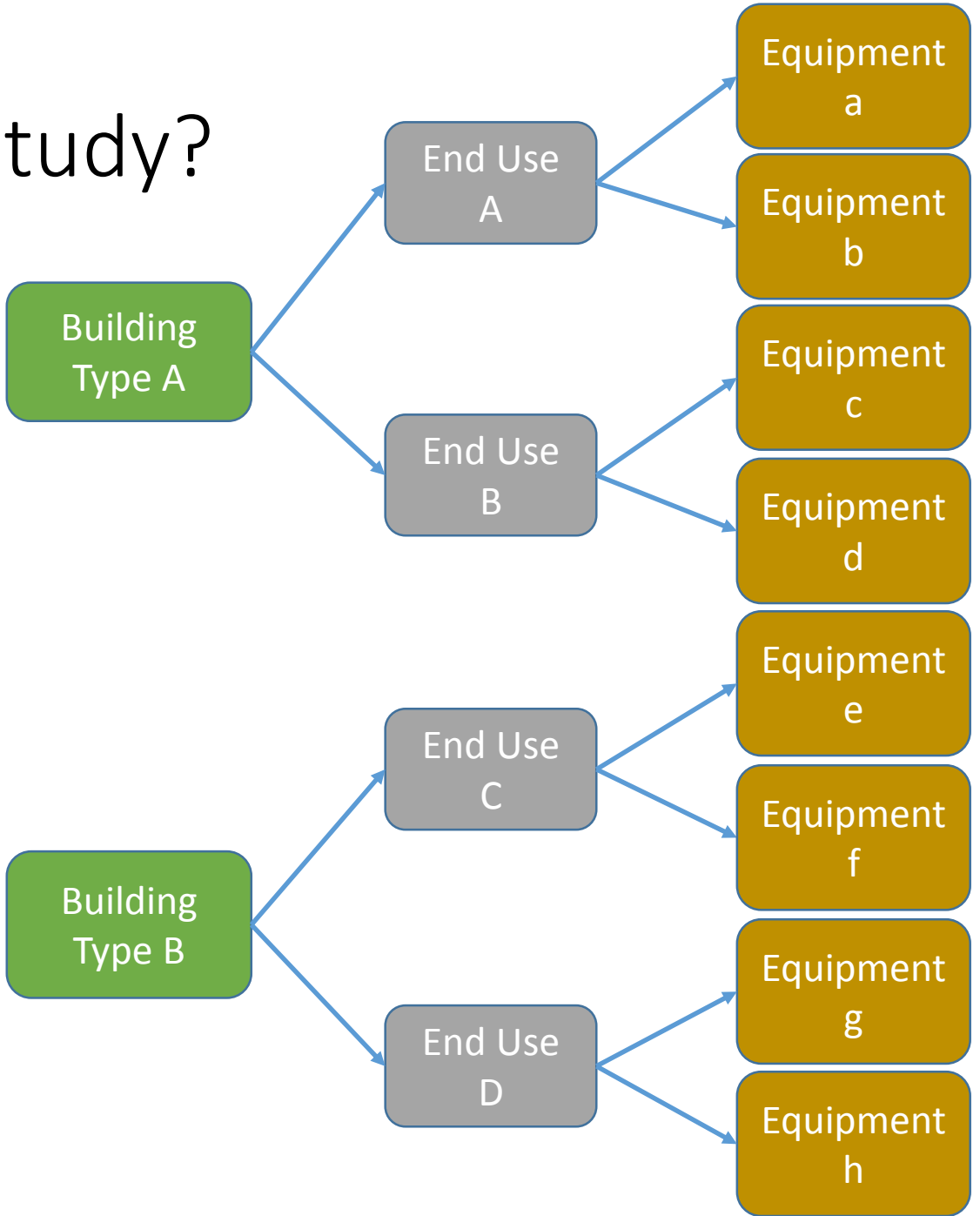
EE Potential Study

Utility EE Program Targets

What is a Market Baseline Study?

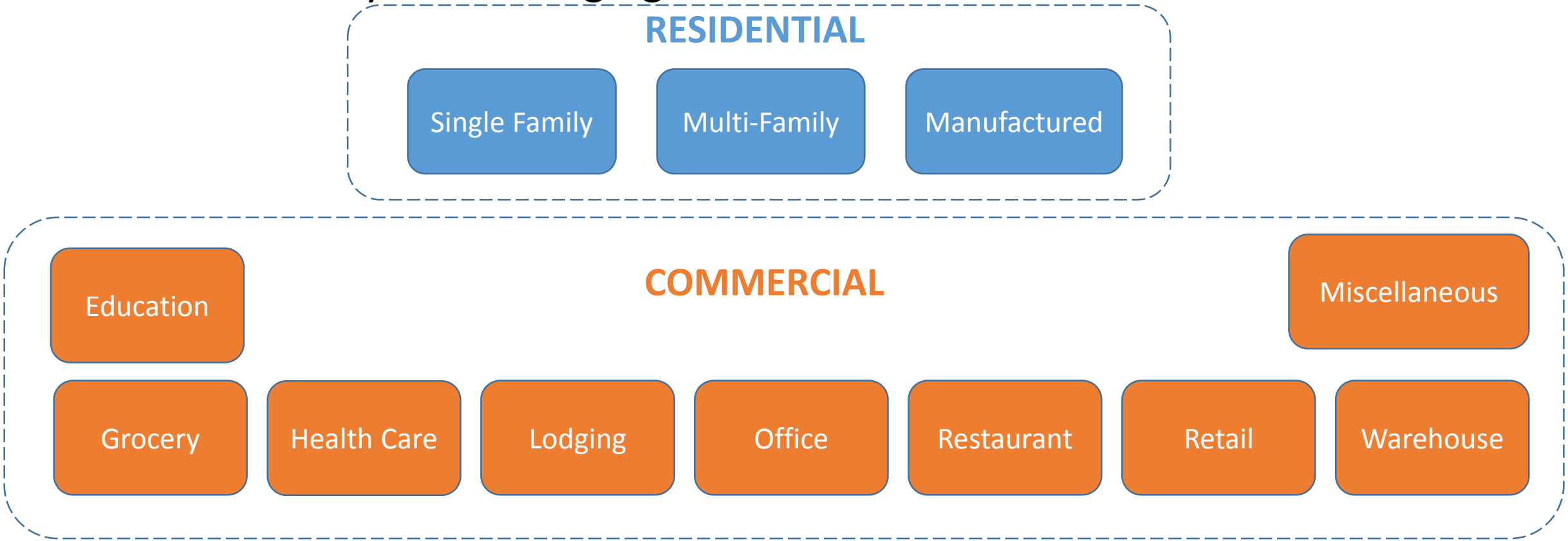
Market Baselines allow the assessment [for various building types] of energy consumption associated with particular end-uses and with particular end-use equipment

- Onsite audit (quantitative)
  - Building envelope
  - Electric equipment and plug-load
- Telephone survey (qualitative)
  - Decision Making
  - Knowledge
  - Attitudes
  - Behaviors
  - Perceptions



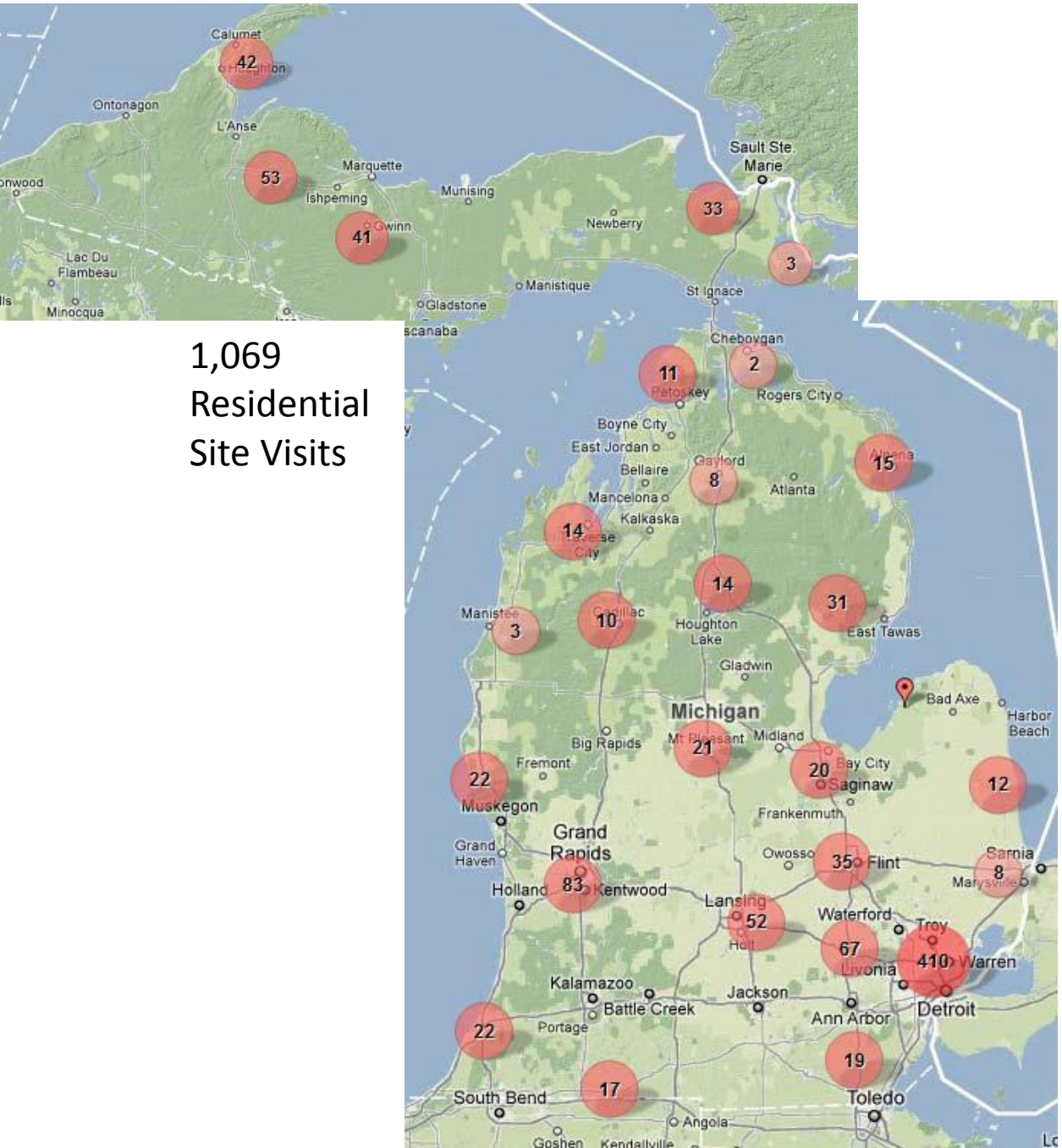
Individual Market Baseline for the Residential and Commercial Customer Classes

- Separate studies for the Residential and Commercial sectors
- Industrial sector diversity (especially in Michigan) makes standard baseline analysis challenging

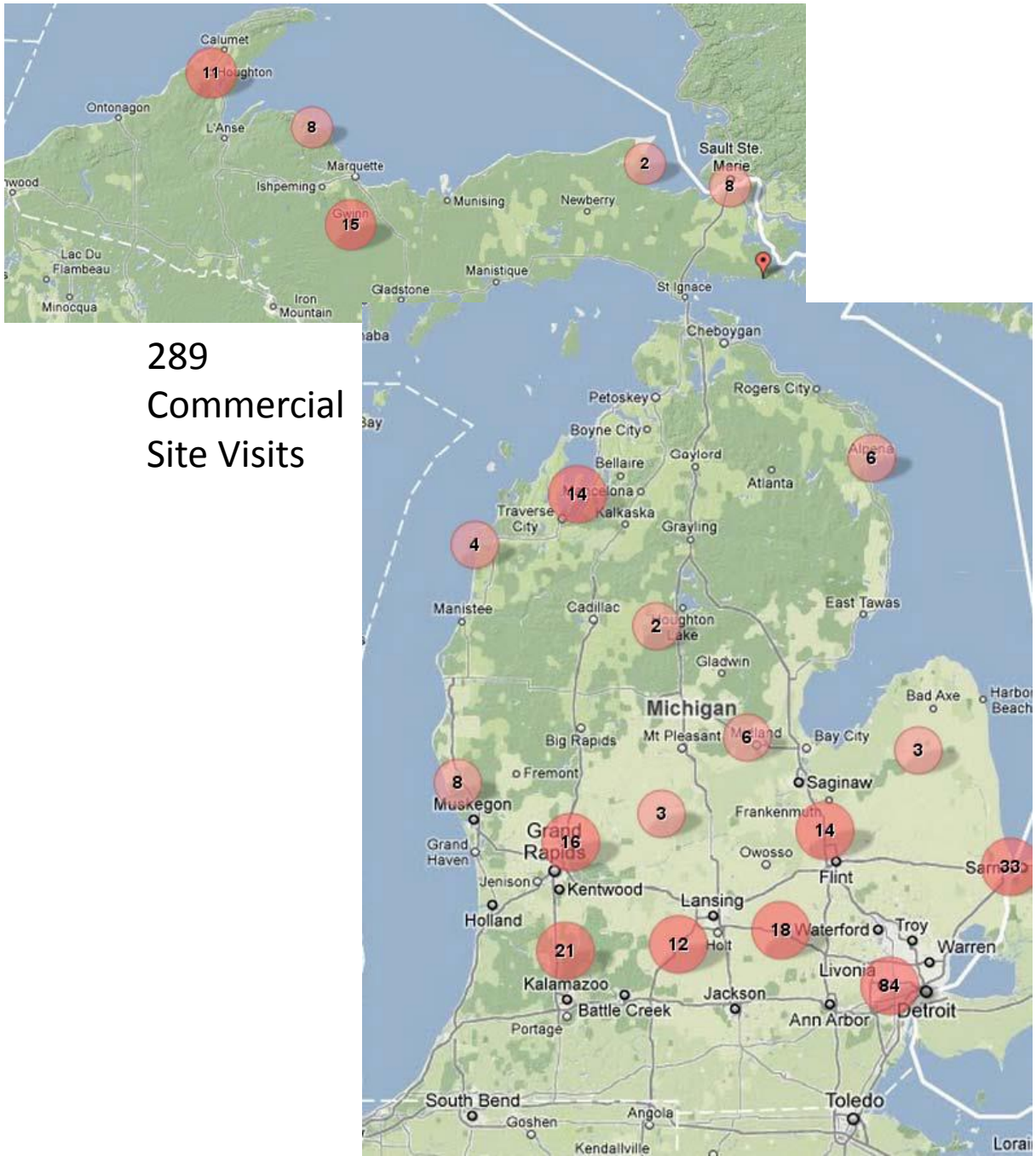


Michigan Baseline Studies: Geographic Distribution of Site Visits

1,069 Residential Site Visits



289 Commercial Site Visits



Baseline Characteristics

Residential Onsite Audit

- Building envelope
  - Windows
  - Basement dehumidification
- Heating & cooling
- Water Heating
  - Water efficiency measures
- Laundry
  - Clothes washers
  - Clothes dryers
- Kitchen Appliances
  - Cooking appliances
  - Dishwashers
  - Refrigerators & freezers
- Swimming Pools
- Consumer Electronics
  - Televisions
  - Home audio & TV accessories
  - Computers
  - Home office equipment
- Lighting

Commercial Onsite Audit

- Building envelope
  - Wall framing & insulation
- Foundation & roofing
  - windows
- Lighting
  - Interior
  - exterior
- HVAC
  - Unitary HVAC
  - Air handlers
  - Boilers
  - chillers
- Water Heating
- Appliances
- Office Equipment
  - Computers
  - Printers, scanners, & fax machines
- Laundry
- Cooking equipment
- Compressed air systems

Key Market Baseline Terms

Definitions

- **Market Penetration** – proportion of buildings with at least one unit of a given equipment type or characteristic; represents the level of market adoption
- **Market Saturation** – average number of units across all buildings
- **Mean Units** – average number of units for buildings with at least one unit

Equations

- $$Penetration = \frac{Number\ of\ buildings\ with\ at\ least\ one\ unit}{Total\ number\ of\ Buildings}$$
- $$Saturation = \frac{Total\ number\ of\ units}{Total\ number\ of\ Buildings}$$
- $$Mean\ Units = \left[\frac{Saturation}{Penetration}\right]$$
- $$Mean\ Units = \frac{Total\ number\ of\ units}{Number\ of\ Building\ with\ at\ least\ one\ unit}$$

Example of Penetration Data

Table 15. Interior Lighting Control Penetrations

Business Type	Dimmer Switch	EMS*	Manual Circuit	Manual Dual Switch	Manual Switch	Occupancy Sensor	Timer
Education (n=16)	6%	0%	13%	6%	94%	13%	13%
Grocery (n=14)	0%	0%	36%	0%	86%	7%	7%
Health (n=18)	0%	6%	0%	0%	94%	6%	0%
Lodging (n=32)	0%	0%	3%	3%	100%	3%	0%
Office (n=76)	1%	0%	30%	1%	96%	5%	0%
Restaurant (n=37)	5%	0%	11%	0%	95%	8%	3%
Retail (n=73)	0%	0%	3%	0%	96%	4%	1%
Warehouse (n=22)	0%	0%	23%	0%	95%	5%	0%
Overall (n=288)	**1%**	**0%**	**15%**	**1%**	**98%**	**6%**	**2%**

* Energy Management System (EMS)

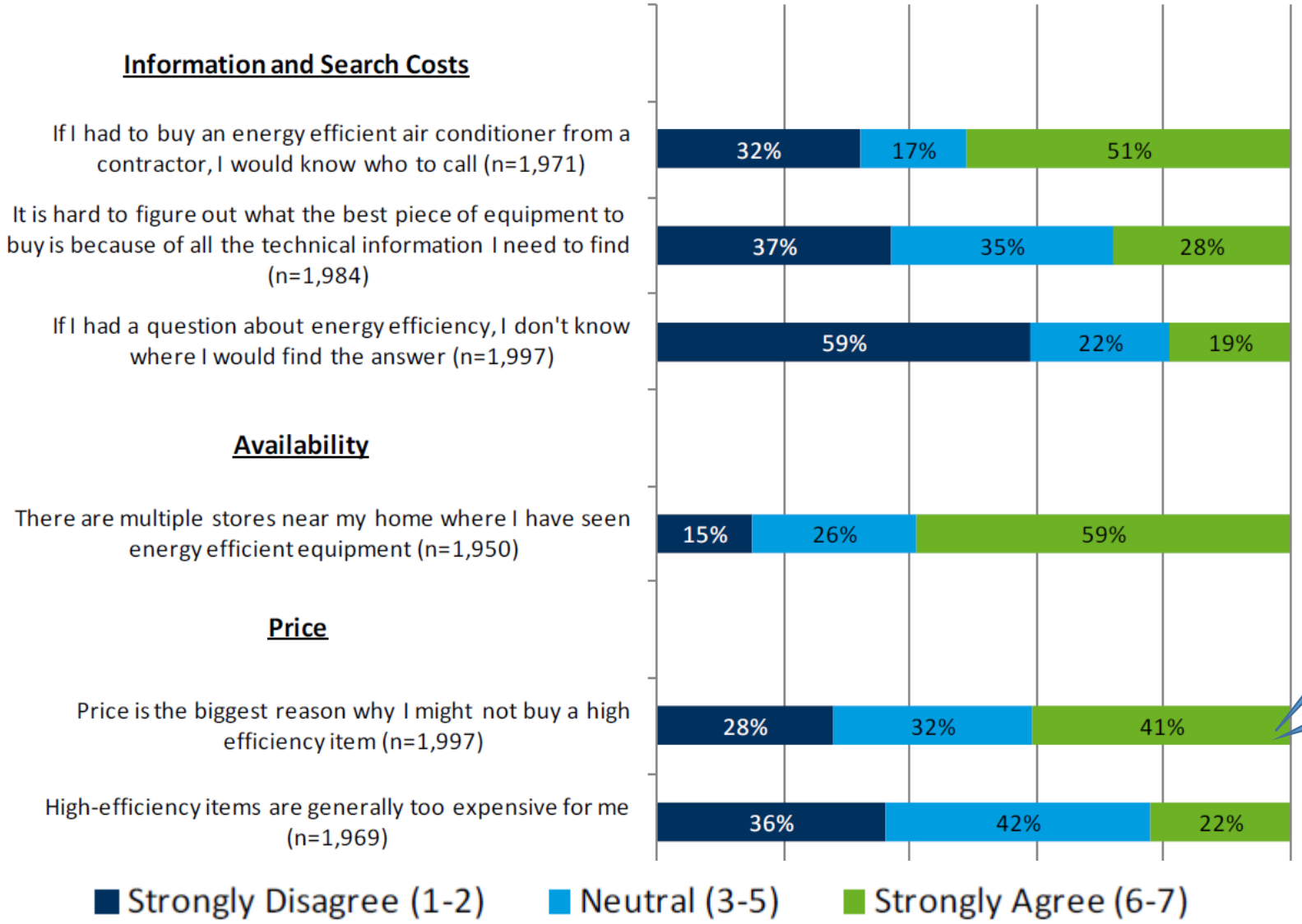
Source: Michigan Baseline Study
2011 Commercial Baseline Report

Telephone Survey Questions

- Interest and importance of energy efficiency
- Drivers for energy efficiency interest (e.g., reduce cost, reduce environmental impact, preserve resources, etc.)
- Awareness of energy efficient technologies
- Barriers to taking energy efficiency actions
- Likelihood to adopt energy efficient technologies or take energy efficient actions

Residential Telephone Survey Findings

Figure 75. Barriers to Energy Efficiency



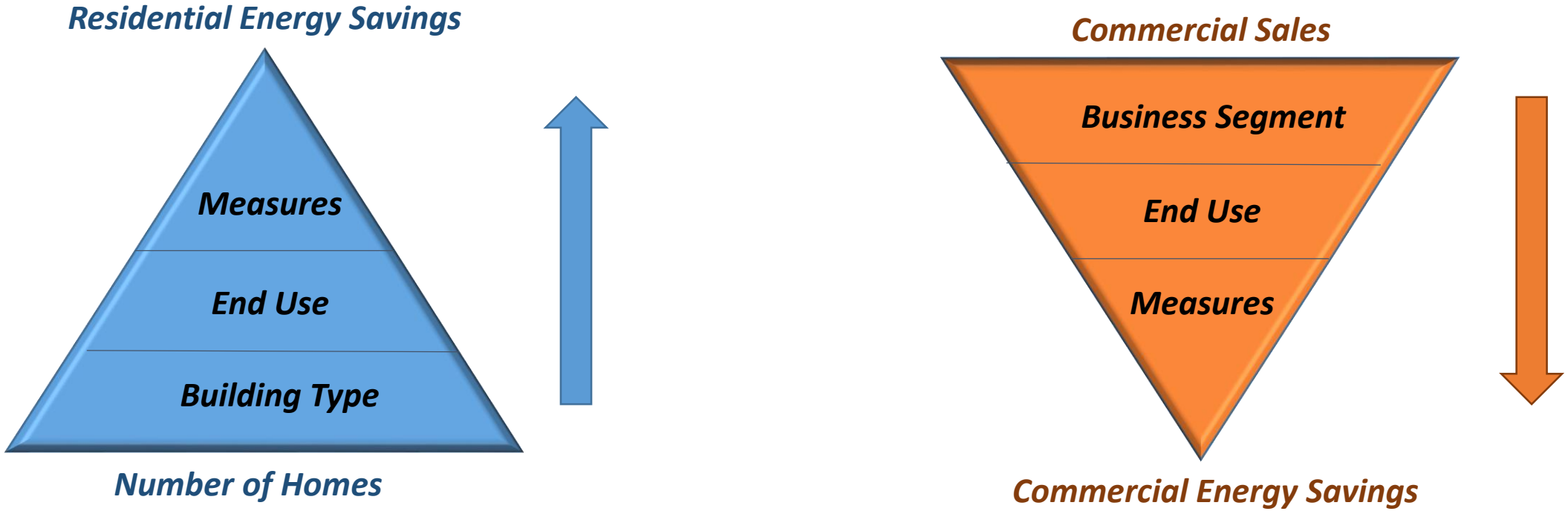
Rebates and Rebate levels important factor

Financing Options are key

Source: Michigan Baseline Study
2011 Residential Baseline Report

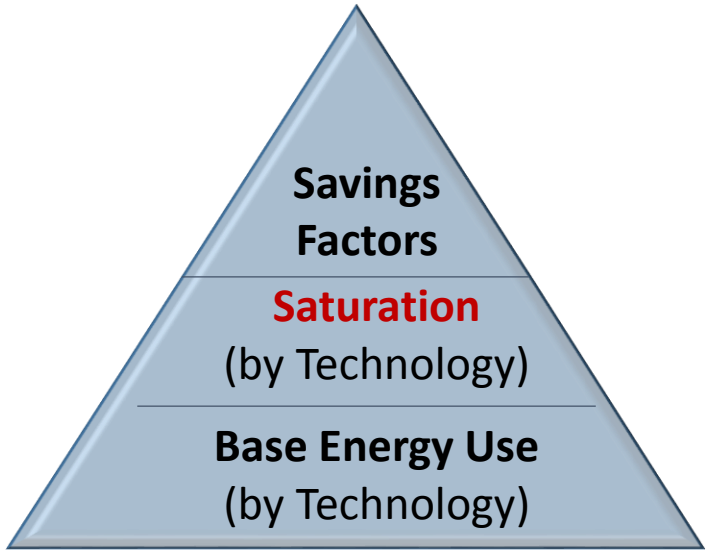
How is the Michigan Baseline Study Used in the Michigan EE Potential Study

- Residential sector
  - Provided input to bottom-up approach to estimate EE potential
- Commercial sector
  - Commercial EE potential estimated by means of a top-down approach



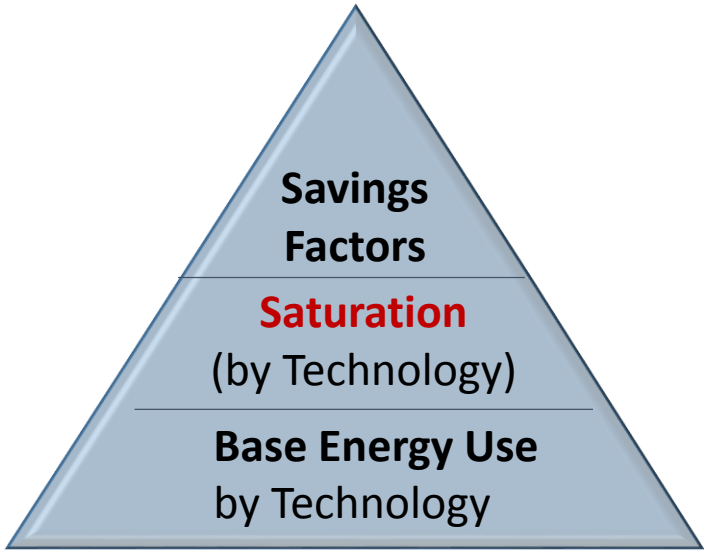
Residential EE Potential Savings

Single Family Energy Savings



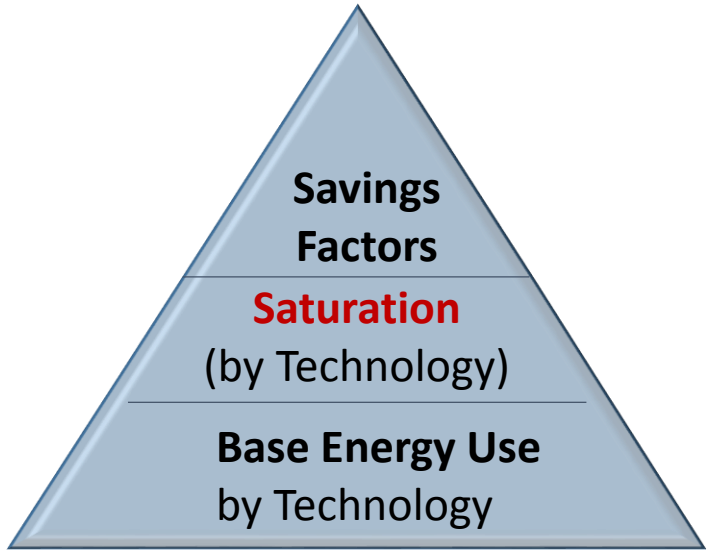
# of Single Family Homes

Multi-Family Energy Savings



# of Multi-family Units

Manufactured Home Energy Savings

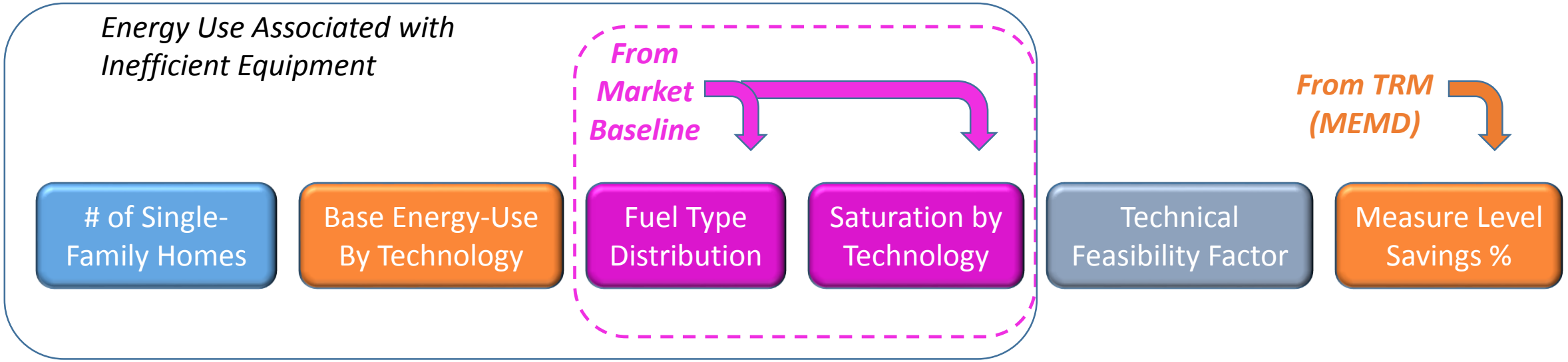


# of Manufactured Housing (Mobile Homes)

MARKET SEGMENTS

Energy Savings Equation [Building Blocks]

Technical Potential



Economic Potential

The portion of the technical potential for which the cost is less than that of the alterative resource (i.e., supply side option)

Energy Savings Equation [Building Blocks]

Achievable Potential

Energy Use Associated with Inefficient Equipment

# of Single-Family Homes

Base Energy-Use By Technology

From Market Baseline

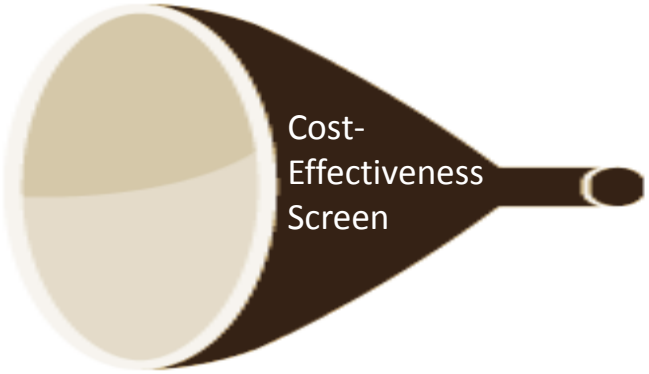
Fuel Type Distribution

Saturation by Technology

From TRM (MEMD)

Technical Feasibility Factor

Measure Level Savings %



Economic Potential

X

Informed by Market Baseline

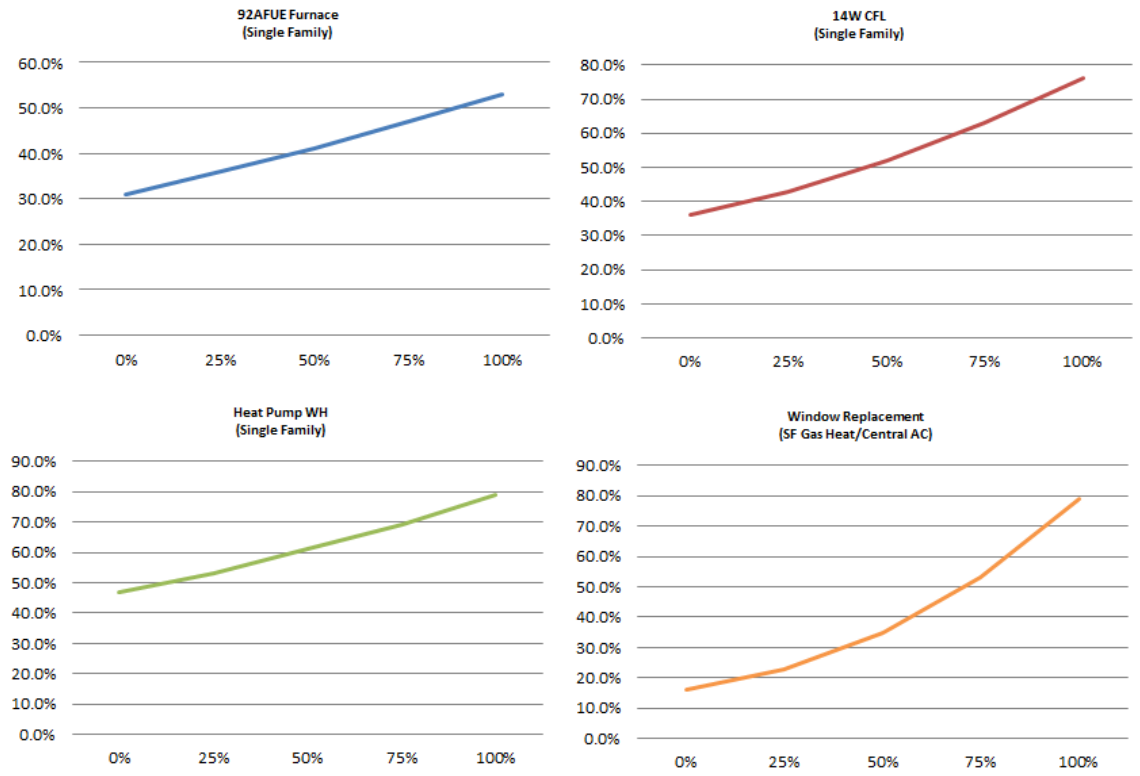
Long-Term Market Penetration (Based on Incentive Level)

Year-by-Year Market Adoption Curve Factor

Quantification of Market Barriers Can be Informed by Qualitative Baseline Data

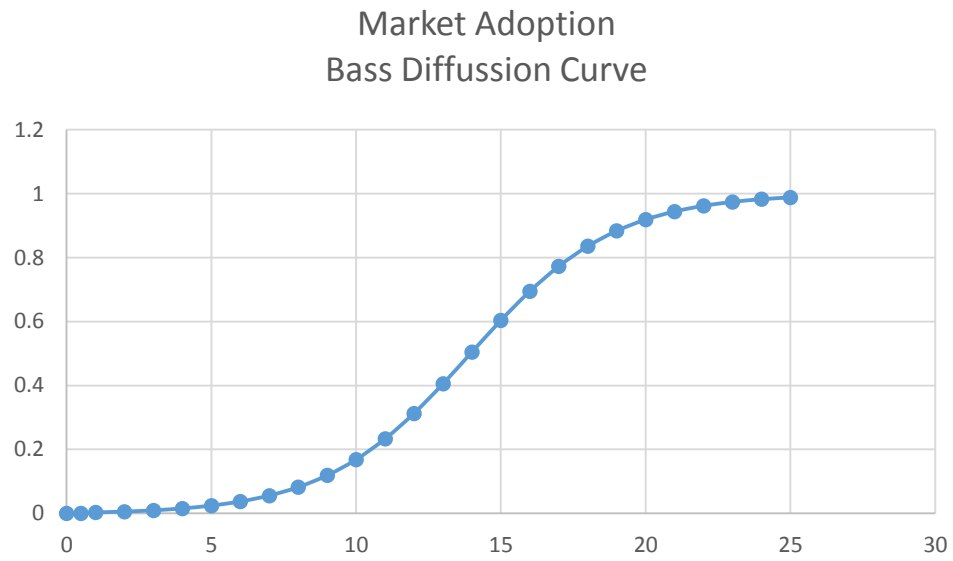
Maximum Adoption Rates

(As a function of Incentive Level)



Source: Michigan EE Potential Study, GDS Associates Inc.

Market Adoption Curve



Market Baseline Observations

- Adoption of new technologies can be lightning fast – rendering market baselines quickly out-of-date; e.g. LED lighting
- Commercial building stock in Michigan has a highly inefficient building envelope ~ little to no insulation in many buildings
- Ground-sourced heat pumps are a promising technology that has little penetration in Michigan
- Stakeholder inclusion in study process is critical to acceptance of authoritative source of data for regulatory & legislative process
- While program tracking can inform changes from baseline since the last study, market effects need to be accounted for – updated baseline analysis can help identify the market effects resulting from the energy efficiency policies and programs

Documents

- Michigan Residential Market Baseline

  http://www.michigan.gov/documents/mpsc/Michigan_Residential_Baseline_Study_367668_7.pdf

- Michigan Commercial Market Baseline

  http://www.michigan.gov/documents/mpsc/Michigan_Commercial_Baseline_Study_367665_7.pdf

Baselines and Evaluation Measurement & Verification

Lawrence Berkeley National Laboratory

Webinar Series on Evaluation, Measurement and Verification (EM&V) for Energy Efficiency

August 2, 2016

Prepared by Carmen Best

Overview

- Review of CPUC – Specific Working Definitions
  - EM&V Framework
  - Policy Manual
- Sources of Information and Data via EM&V
  - Pre-defined savings estimates (deemed)
  - Calculated savings estimates (custom)
- Ongoing Discussions and Opportunities
- Baselines of the Future

Link to Useful Reference Documents on EM&V/Baselines at the CPUC:

http://www.cpuc.ca.gov/General.aspx?id=5399

The California Evaluation Framework

167 matches on "baseline" in the 487 page document

Glossary includes 4 key definitions:

- ***BASELINE DATA*** *- The measurements and facts describing facility operations and design during the baseline period. This will include energy use or demand and parameters of facility operation that govern energy use or demand.*
- ***BASELINE FORECAST*** *- A prediction of future energy needs which does not take into account the likely effects of new conservation programs that have not yet been started.*
- ***BASELINE MODEL*** *- The set of arithmetic factors, equations, or data used to describe the relationship between energy use or demand and other baseline data. A model may also be a simulation process involving a specified simulation engine and set of input data.*
- ***BASELINE PERIOD*** *- The period of time selected as representative of facility operations before retrofit.*

http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy/Energy_Programs/Demand_Side_Management/EE_and_Energy_Savings_Assist/CAEvaluationFramework.pdf

CPUC Policy Manual Provides Guidelines

65 matches on "baseline" in the 99 page document

For Example:

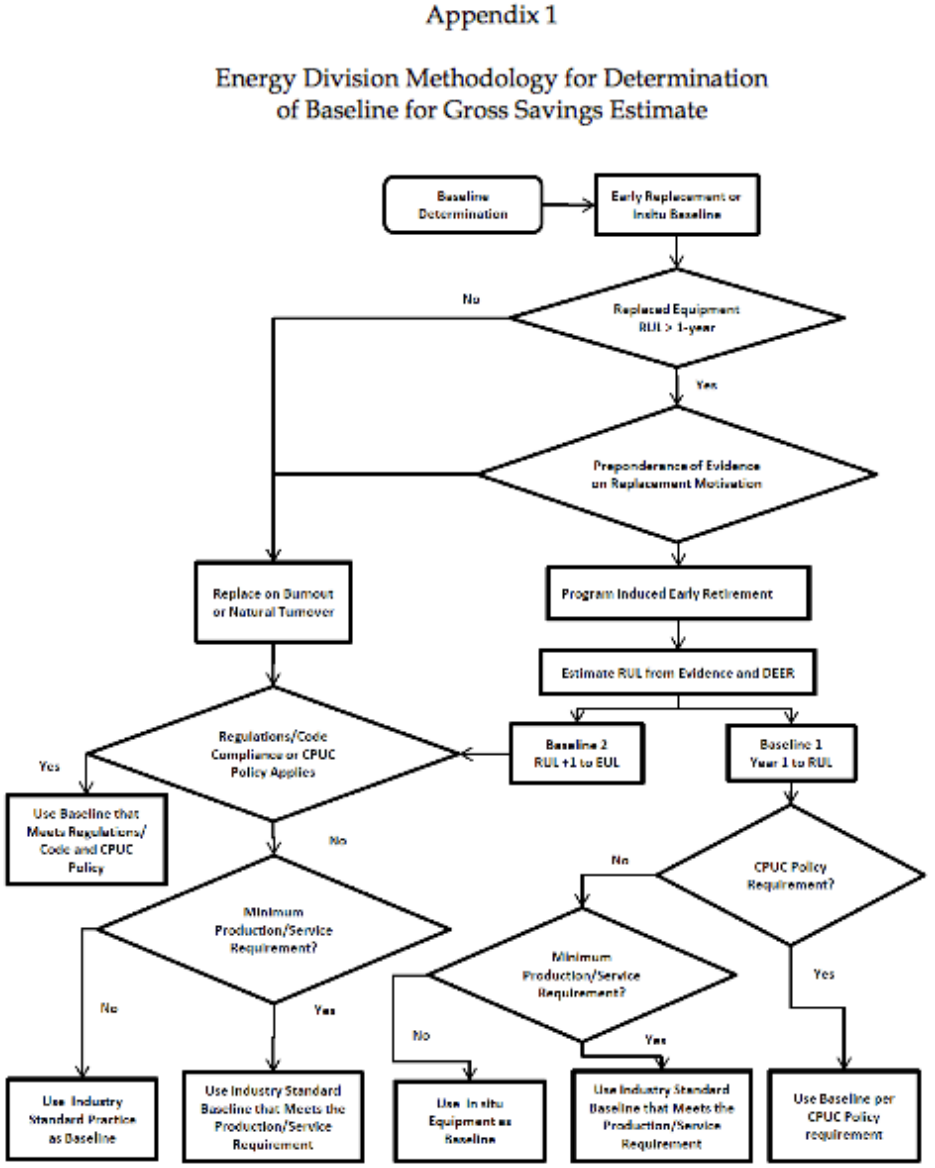
- "…requires the review of the evidence related to one of the three baseline choices:
  - (1) new equipment that is replaced on burnout (ROB),
  - turnover or replacement due to normal retrofit and remodeling activities (NR), and new construction (NC); or
  - (2) the pre-existing equipment used in the program induced early retirement (ER) case."
- "A "dual baseline" must be utilized for program-induced early retirement measures.
  - the difference between the savings that should be credited for the initial years of installation based upon the pre- existing or replaced equipment versus the savings credit in later years that should be based upon an eventual pre-existing equipment replacement assumed to occur if the measure had not been installed as part of the program.

http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy/Energy_Programs/Demand_Side_Management/EE_and_Energy_Savings_Assist/CPUCEnergyEfficiencyPolicyManualv5.pdf

CPUC Policy Manual Provides Guidelines

Appendix 1 Provides a Decision Tree to help identify appropriate baseline:

- Data needs and requirements for each path
- When one would need to provide a preponderance of evidence
- Consideration of regulations, code in the determination of the baseline
- When and where industry standard practice may be the most appropriate baseline



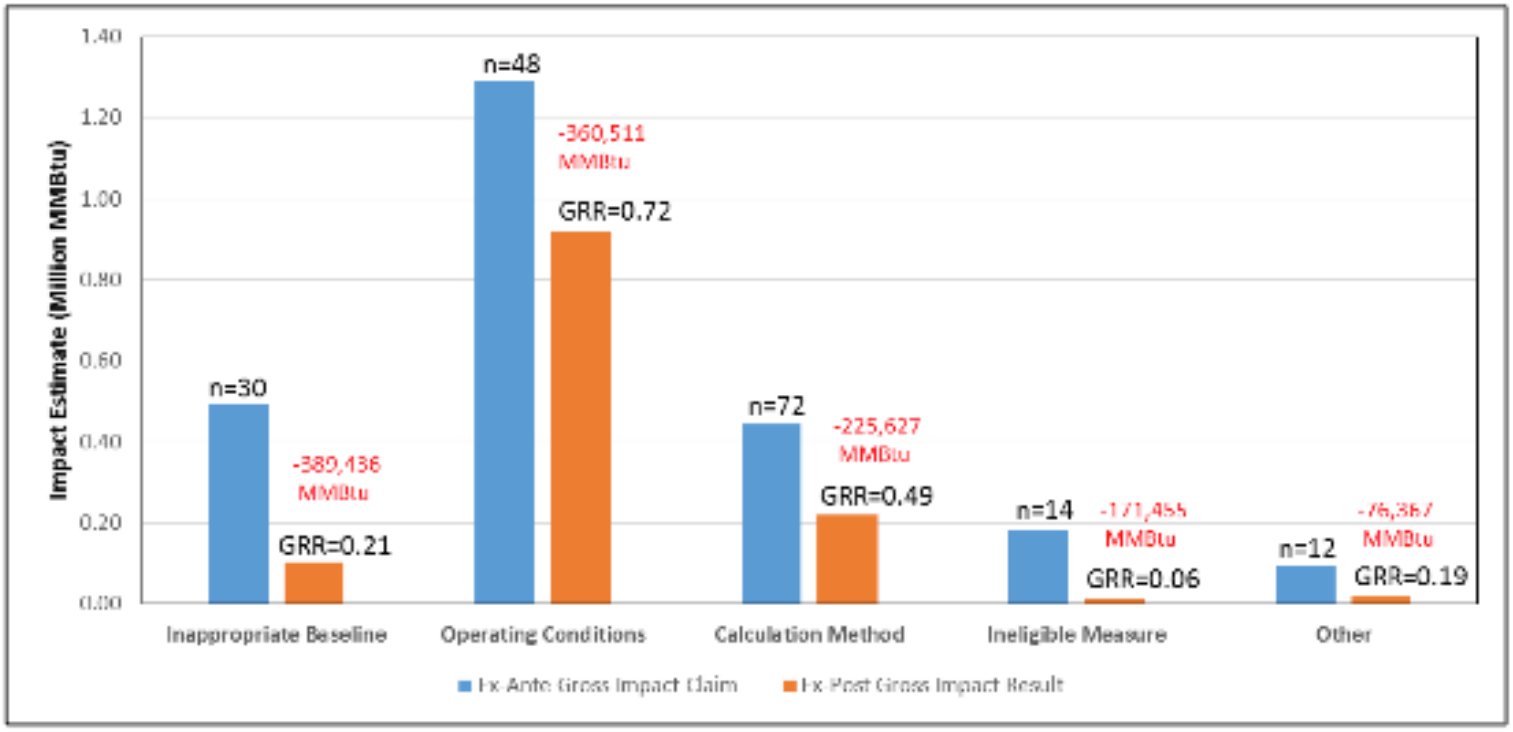
Sources of Information and Data via EM&V

- Field data collected through EM&V activities is used to verify the appropriate baselines were used.
- It can also inform what was actually installed, or other aspects of the "existing condition" assumptions including:
  - Wattage change out on a light bulb (or even bulb type)
  - Operating conditions (like hours of use)
  - If it was early retirement or not (dual baselines)
- Results of the EM&V field data or corrections on baselines would be revealed in updates to the:
  - Unit Energy Savings for a specific measure
  - Gross realized savings for custom projects

Sources of Information and Data via EM&V

- Inappropriate baselines can have a significant effect on a final evaluation result

Figure 1-3: Summary of Discrepancy Factors Resulting in Downward Adjustments to Ex-Ante MMBtu Impacts - All PAs



2013 Custom Impact Evaluation Report:
http://calmac.org/publications/IALC%5F2013%5FReport%5FFinal%5F071715ES%2Epdf

Ongoing Discussions and Opportunities

- Reviews of baseline rules started in 2014 and workshops were held in early 2015

  http://www.cpuc.ca.gov/general.aspx?id=4130

- Legislation (AB802) adopted at the end of 2015:
  - Allowed for incentives for existing buildings to bring them into conformity with, or exceed code; and adjust goals
  - Overall reduction in **Normalized Metered Energy Consumption** shall be considered as a measure of savings

  https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160AB802

- Energy Division staff revisited baseline policies to ensure consistency with procurement and statewide forecasting as a result of the legislation

  http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M161/K471/161471852.PDF

Baselines of the Future

- Need to continue to be grounded in the principles of incremental effects of an intervention
- Should reflect the intent of the policies or actions funding the interventions
- More granular data and more data overall, does not erase baseline uncertainties, but
  - It may provide more opportunities to track absolute changes in consumption
  - May allow for dynamic baseline modeling for on going improvements and
- Baselines should continue to be informed by information gathered from the field

Establishing Baselines in Market Transformation Programs

Presentation to US DOE EM&V Webinar Series

August 2, 2016

Jeff Harris, Chief Transformation Officer - NEEA

Today's Talk:

Market Transformation Baselines:

- Why do we need a baselines?
- Fundamentals of Market Transformation Programs
- Establishing and measuring baselines for MT programs
- Example 1: High-efficiency TVs
- Example 2: Heat pump water heaters.

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What is Market Transformation?

*The **strategic process** of **intervening in a market** to create **lasting change** in **market behavior** by **removing identified barriers** and/or **exploiting opportunities** to **accelerate the adoption** of **all** cost-effective energy efficiency as a matter of **standard practice**.*

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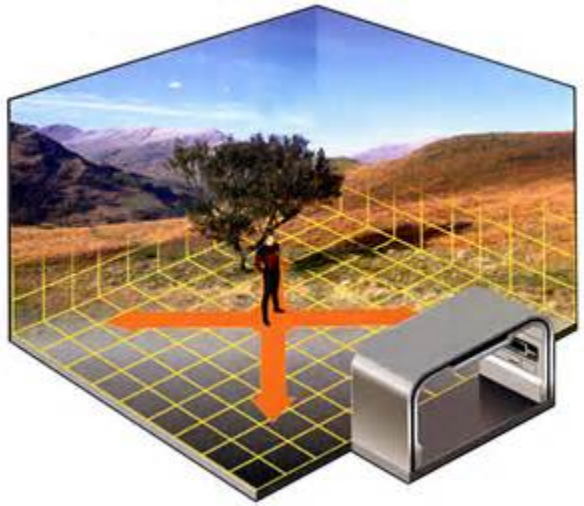
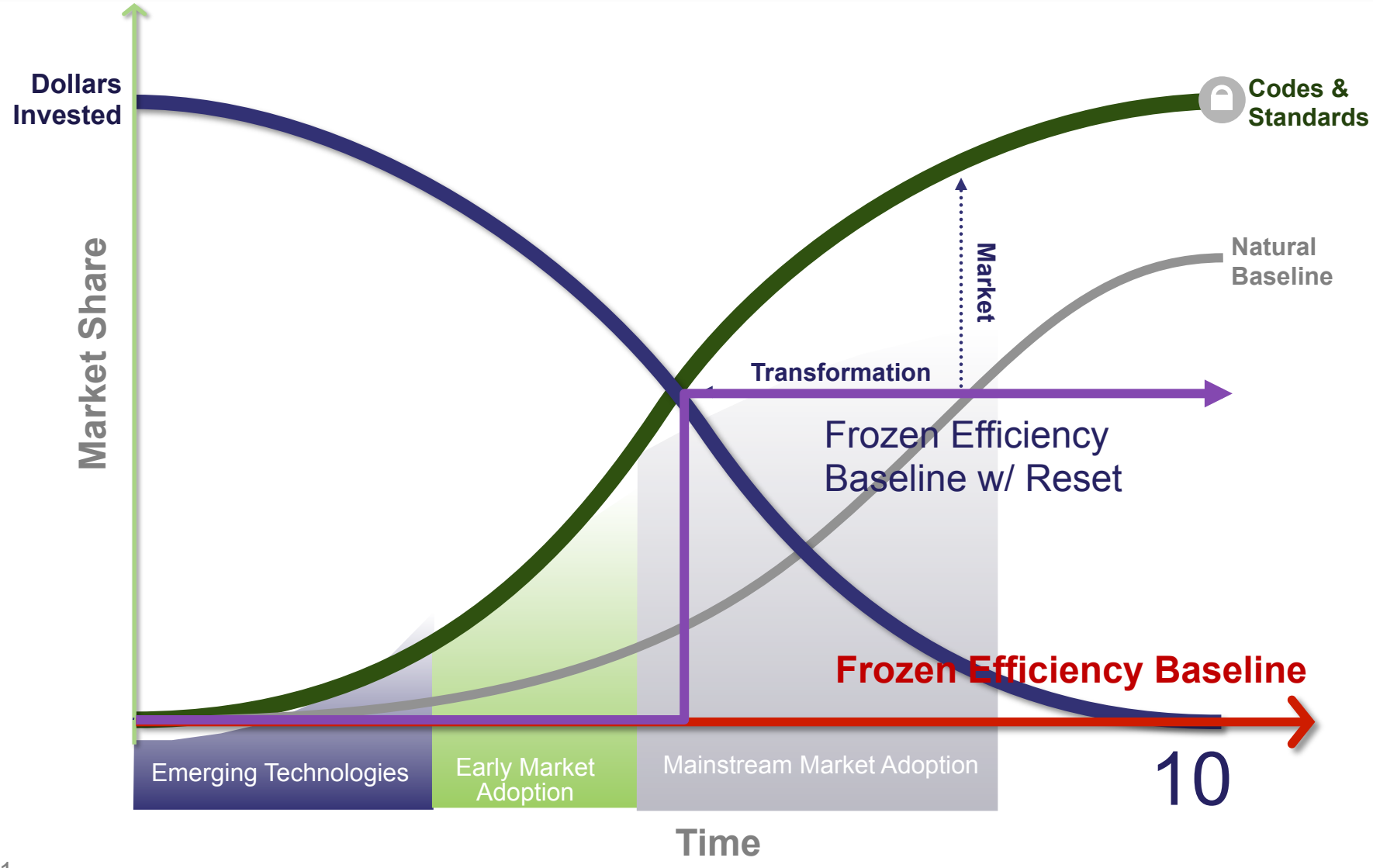
Why do we need a baseline?

Context is Crucial:

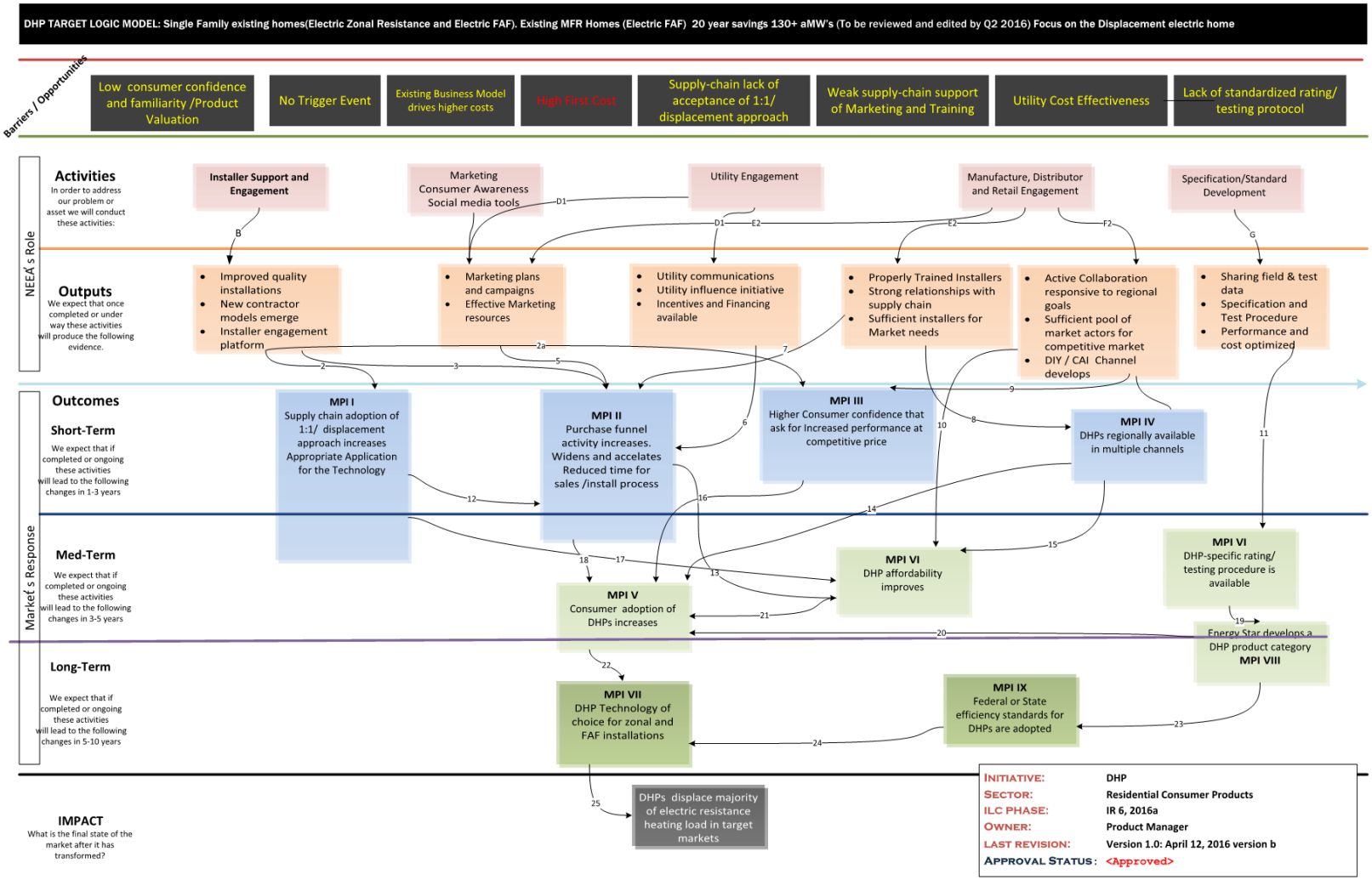
- MT programs are different than traditional resource acquisition programs
- Two primary purposes for baselines:
  - Estimate impacts on total power system loads
  - Facilitate prudency determination of program design and logic
- It's not about *attribution*…..
- It's *"counter-factual"*



Market Transformation is a long-term process that accelerates market adoption of EE innovations



Documenting intent: Logic Models and Measurement



Key considerations for MT Baselines:

1. Metrics:

- Normalized, total market unit energy consumption.

2. Data requirements:

- Full category sales data for consumer products
- Statistical data on building stock or component changes over time
- Frequency in market measurement is crucial. Quarterly to monthly
- Pre-intervention period of 12 months minimum to establish trends
- Alternately, find independent market trend forecasts

3. Sequence and priority:

- First get total market change off fixed baseline right;
- Then worry about “alternate universe” of “naturally occurring baseline”

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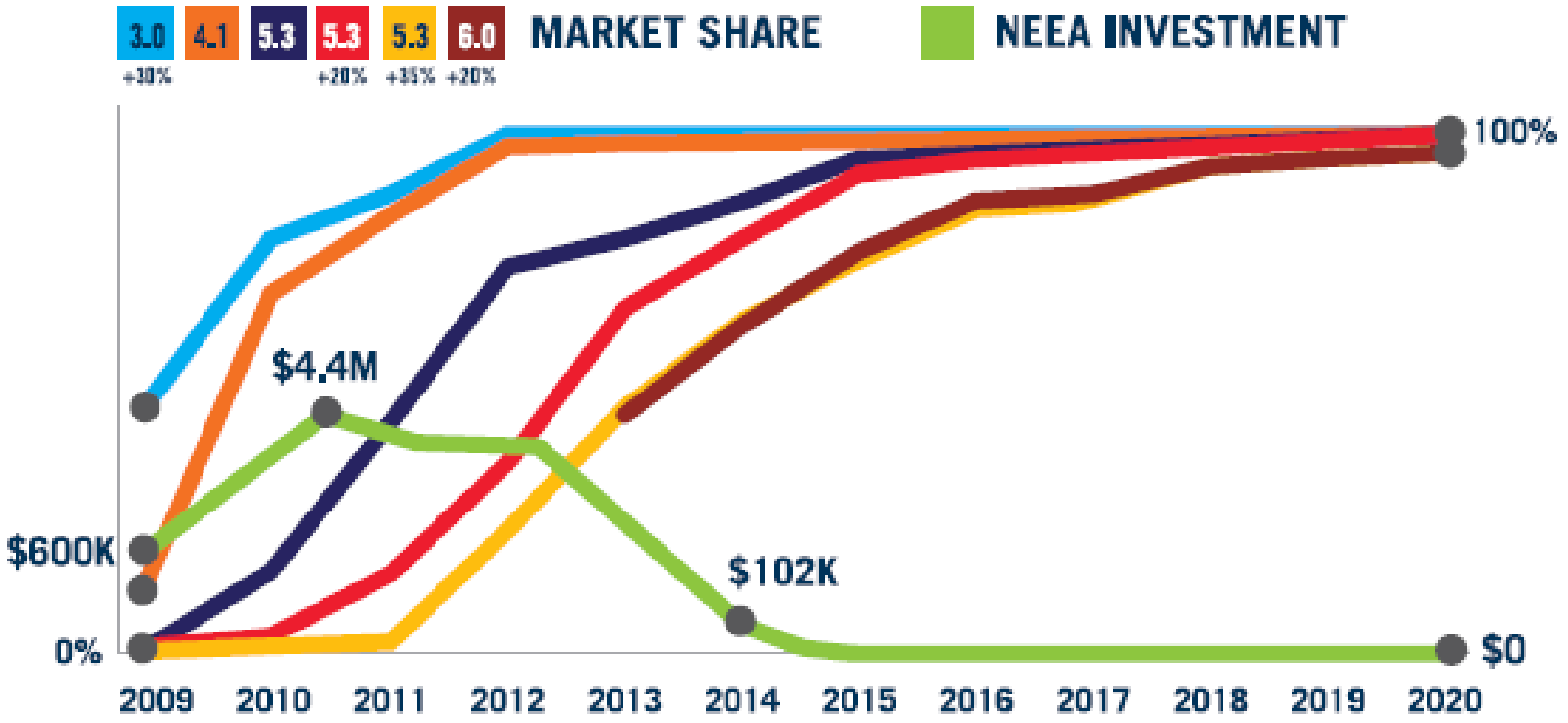
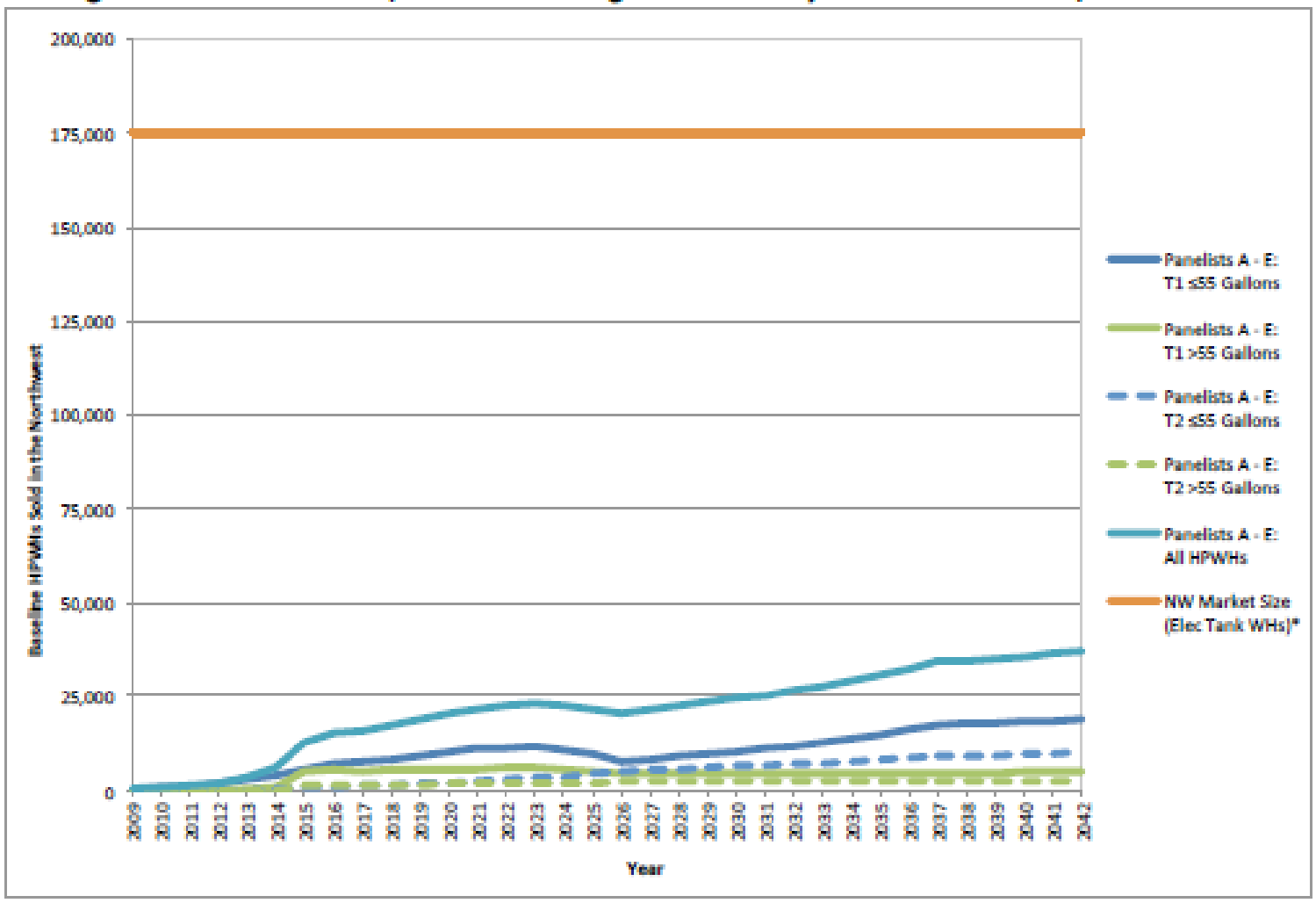
Example 1. High efficiency TVs

Market: Flat-panel TVs



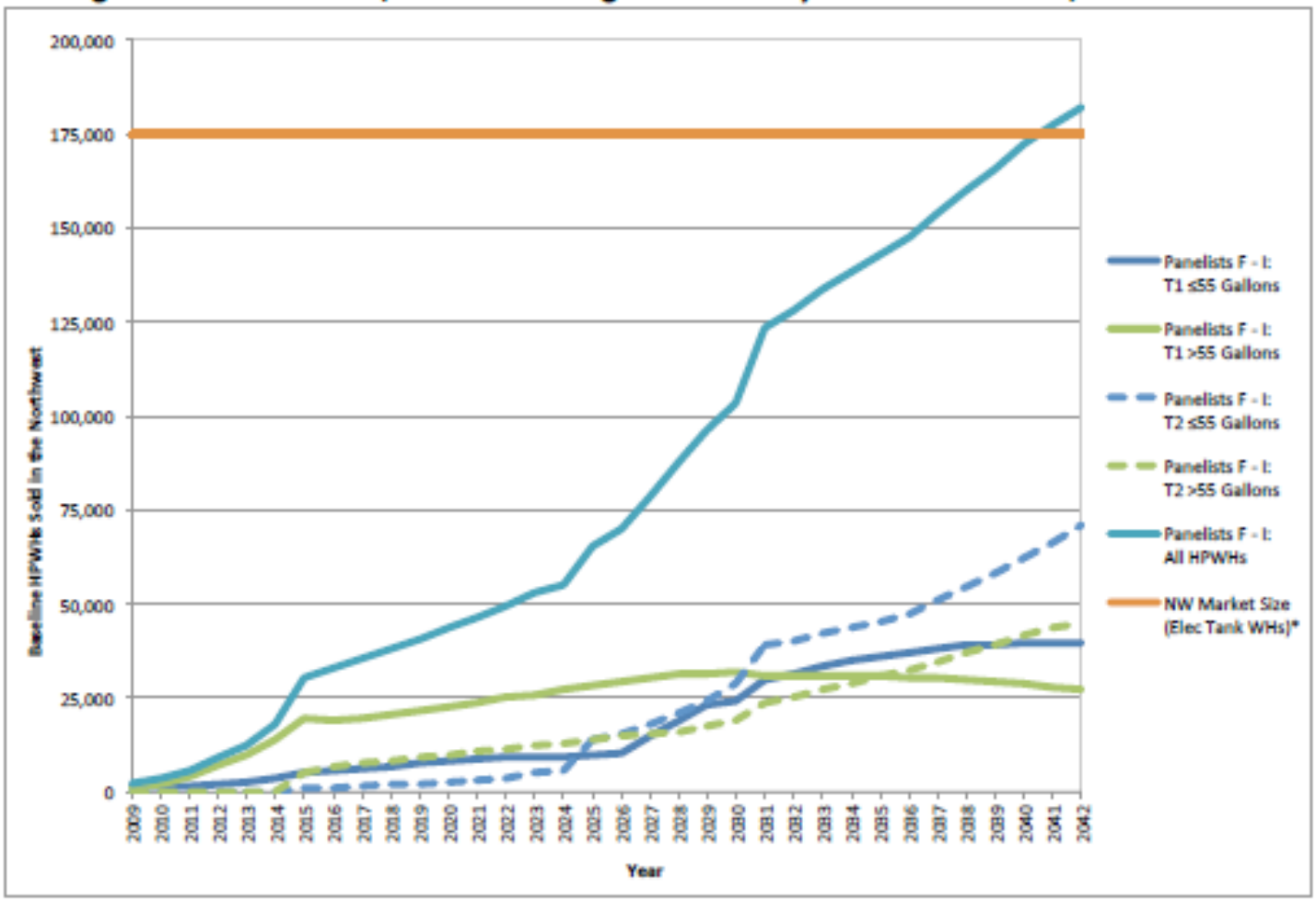
Example 2: Heat Pump Water Heaters (1)

Figure 1: Panelists A – E, Blended Average Forecasts by Tank Size and Tier, and Overall



Example 2: Heat Pump Water Heaters (2)

Figure 2: Panelists F – I, Blended Average Forecasts by Tank Size and Tier, and Overall



Conclusions

- Market Transformation Programs are different; require unique approaches
- Important to understand key objectives: Load impacts or prudency? Or both?
- Data requirements are challenging; market data is expensive; Delphi panels are not always reliable
- Other than frozen efficiency, estimates of market baselines are inherently uncertain and are best used to inform program design and logic.

Thank You!

Accelerating Market Adoption

Filling the Energy Efficiency Pipeline

Delivering Regional Advantage

Jeff Harris
Chief Transformation Officer, NEEA

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Discussion/Questions

For more EM&V information see:

- Webinars: https://emp.lbl.gov/emv-webinar-series
- For technical assistance to state regulatory commissions, state energy offices, tribes and regional entities, and other public entities see: https://emp.lbl.gov/projects/technical-assistance-states
- Energy efficiency publications and presentations – financing, performance contracting, documenting performance, etc. see: https://emp.lbl.gov/research-areas/energy-efficiency
- New Technical Brief - *Coordinating Demand-Side Efficiency Evaluation, Measurement and Verification Among Western States: Options for Documenting Energy and Non- Energy Impacts for the Power Sector* https://emp.lbl.gov/publications/coordinating-demand-side-efficiency

From Albert Einstein:

"Everything should be as simple as it is, but not simpler"

"Everything that can be counted does not necessarily count; everything that counts cannot necessarily be counted"