Energy Efficiency Measure Cost Studies

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SEE Action Webinar – EM&V Working Group

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PRESENTATION OVERVIEW

- Program and regulatory context: why is this topic important?
- How are measure costs used in regulatory and program planning activities?
- Key analytic and data collection challenges in estimating measure costs
- Overview of the 2014 CPUC Measure Cost Study
- Recommendations for the road forward

SOME DEFINITIONS

Costs vs. prices, measures vs. technologies, measure costs vs. incremental measure costs

- We commonly use the term “costs” but we’re really talking about prices paid by final consumers
  - In the economics and business literature, “costs” usually refers to production costs or opportunity costs
- Similarly, we commonly use the term “measure”
  - In practice, measures often involve replacing one technology with another
  - Measure cost studies require estimating prices and cost streams for both high-efficiency technologies and their in-situ or standard-efficiency counterparts
- We often refer to “measure costs” but what’s applied in cost-effectiveness analysis is “incremental measure costs”, strictly due to energy efficiency improvements

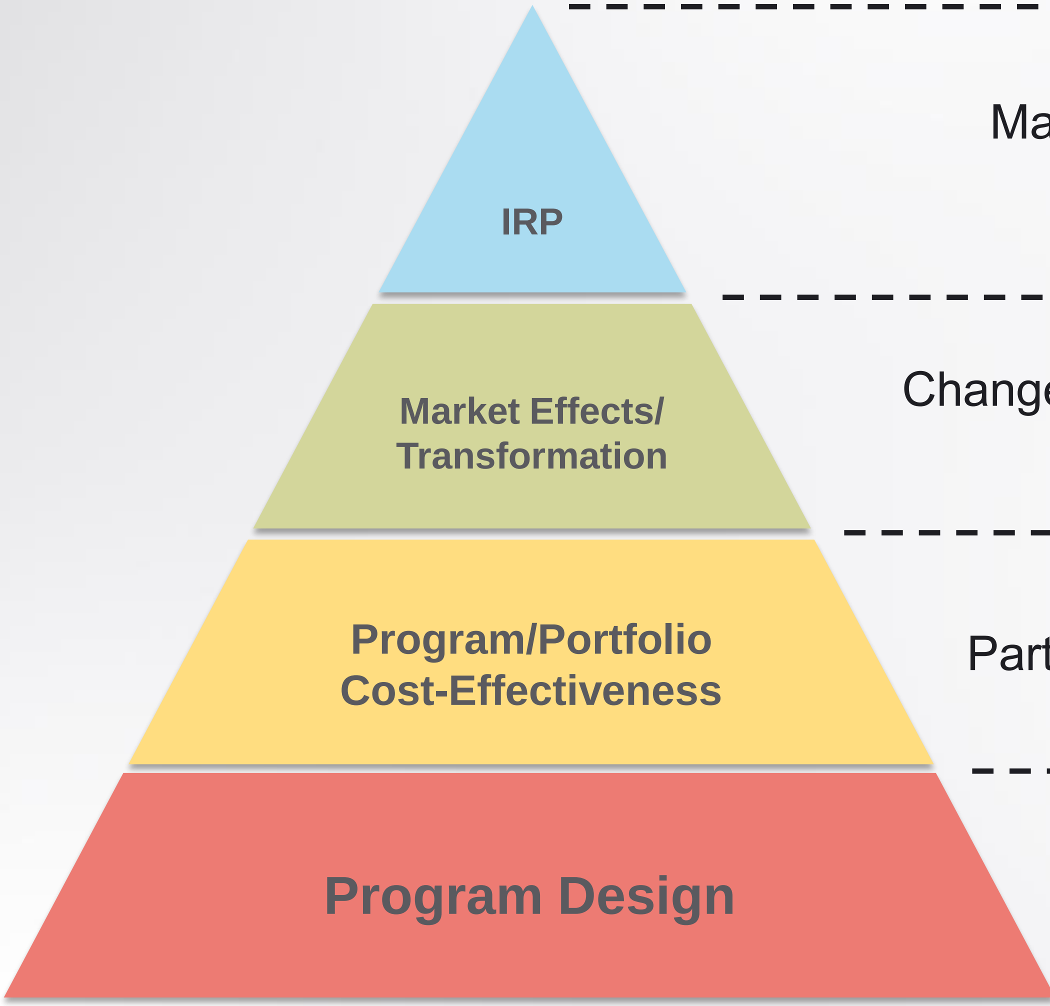
PROGRAM AND REGULATORY CONTEXT

Why is this topic important?

- Significant movement in the U.S. towards regulatory frameworks that rely heavily on *ex ante* measure costs and savings values
  - To date, 36 states in the U.S. use some type of “deemed” or ex ante measure costs and savings values in regulatory processes
- Parallel growth in resources used to develop those values
  - In U.S., 15 states have developed Technical Resource Manuals (TRMs)
- However, most research has focused on ex ante *savings* estimation, with comparatively very little dedicated to measure costs
  - Only 3 of the 15 state TRMs contain ex ante measure cost estimates
- Even in CA (5 measure cost studies since ‘96), investment in impacts-related research roughly 100x more than cost research
- <u>Current body of knowledge is small and innovations have lagged</u>

REGULATORY & PROGRAM APPLICATIONS

Measure costs play a central role nearly every level of the larger EE endeavor



Marginal cost of EE compared to supply side resources

Changes in prices, incremental costs and market shares over time

TRC (incremental costs)
Participant Test (participant costs)
RIM, PAC (incentive costs)

Incentive levels (deemed)
Incentive caps (custom)

KEY DATA COLLECTION CHALLENGES

» **Fundamental challenge #1**: lack of comprehensive, reliable measure cost data in the public domain
  - True "population" of actual prices paid for a given product in a given jurisdiction is unknowable
  - Market actors, supply chains, delivery channels vary across "universe" of EE technologies and products

» **Fundamental challenge #2**: cost studies must bridge gap between generalized "measures" and actual products
  - For energy analysis, technologies can be grouped together according to energy performance criteria (SEER, AFUE, R-value)
  - Cost studies must account for diversity of products (and prices) within generalized measure definitions
    - Required sample sizes in the 100s or 1000s

KEY DATA COLLECTION CHALLENGES

» **<u>Fundamental challenge #3</u>**: today's measures vs. tomorrow's measures vs. someone else's measures

- In past, typical approach has been to collect data for measures defined in current portfolios
  - Limited shelf life due to changes in measure definitions/specs
  - Limit transferability to other jurisdictions
- In today's program & regulatory environment, high degrees of flexibility and granularity should be preferred
  - <u>Flexibility</u> - ability to produce defensible cost estimates for a variety of different measure specifications without the need for additional, measure-specific data collection
  - <u>Granularity</u> - ability to produce cost estimates for a wide variety of very specific measures and more aggregate, prototypical measures using the same basic analytic framework and data sources

KEY DATA COLLECTION CHALLENGES

Common data sources are all imperfect

Data Source	Pros	Cons
Program invoice data	• actual prices paid for in-program products • often contain make/model number • estimates of sales volumes	• in-program products only (not whole market) • no installation costs • no baseline information
DI and 3P price lists	• often includes separate installation costs	• small sample sizes • narrow measure coverage • no sales volumes
Retail shelf surveys	• rich data on product prices and features	• no sales volumes • time-consuming and expensive
Web-crawlers/lookups	• rich data on product prices and features	• no sales volumes • no installation costs
Manufacturer catalogues	• rich data on product features	• no sales volumes • no installation costs • MSRP are not actual prices
Market actor interviews	• separate estimates of installation costs • can be tied to specific or prototypical system configurations and site conditions	• small samples sizes • self-reported estimates, not observed data
Construction pricing books	• widely used by contractors • separate estimates of installation costs	• equipment specs often lack energy performance • limited application to incremental cost analysis
Point-of-sales (POS) data	• very large samples of actual prices paid • rich data on product features • includes sales volumes	• limited to mass market measures • model number masking for low-volume products • moderately expensive for certain products

KEY DATA ANALYSIS CHALLENGES

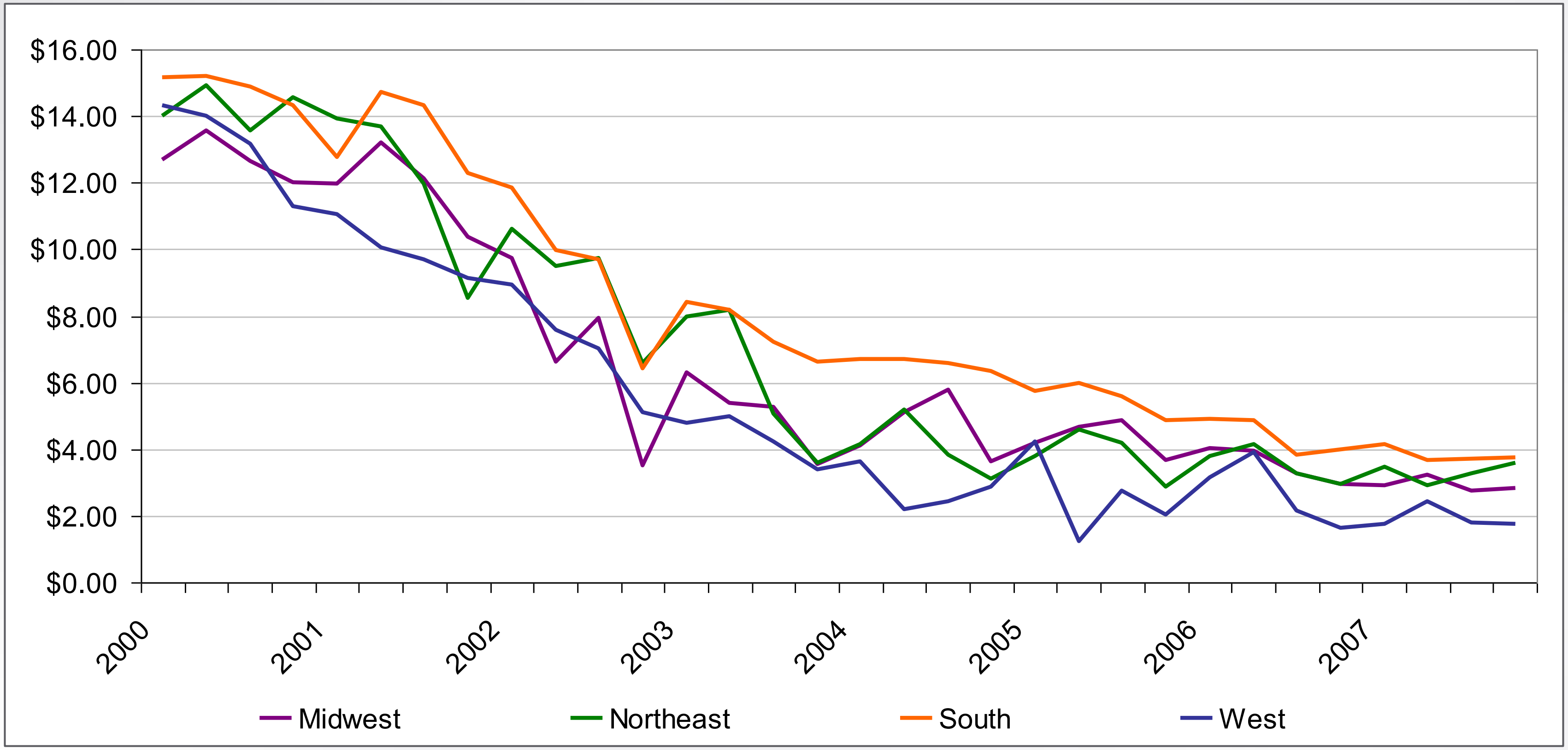
The fun is only beginning

- "Matched pair" analysis and baseline determination
  - Early replacement and replace-on-burnout measures
  - Straightforward for some (CAC, WH), not so for others (TVs)
- Isolating price difference strictly due to efficiency
  - Exterior finish, through-the-door water/ice influence price of refrigerators more than EE performance
- Dual baselines and lifecycle costs
  - TRC and most investment decision-making models (e.g. IRR) use lifecycle costs, not first costs
  - Requires host of other (largely under-studied) cost parameters: remaining useful life of in-situ equipment, O&M costs, salvage values, disposal costs
- Custom and new construction projects
  - Significant interactions between building design choices and equipment selection and sizing (and therefore cost), particularly for HVAC
  - Standard practice baselines for industrial process equipment

KEY DATA ANALYSIS CHALLENGES

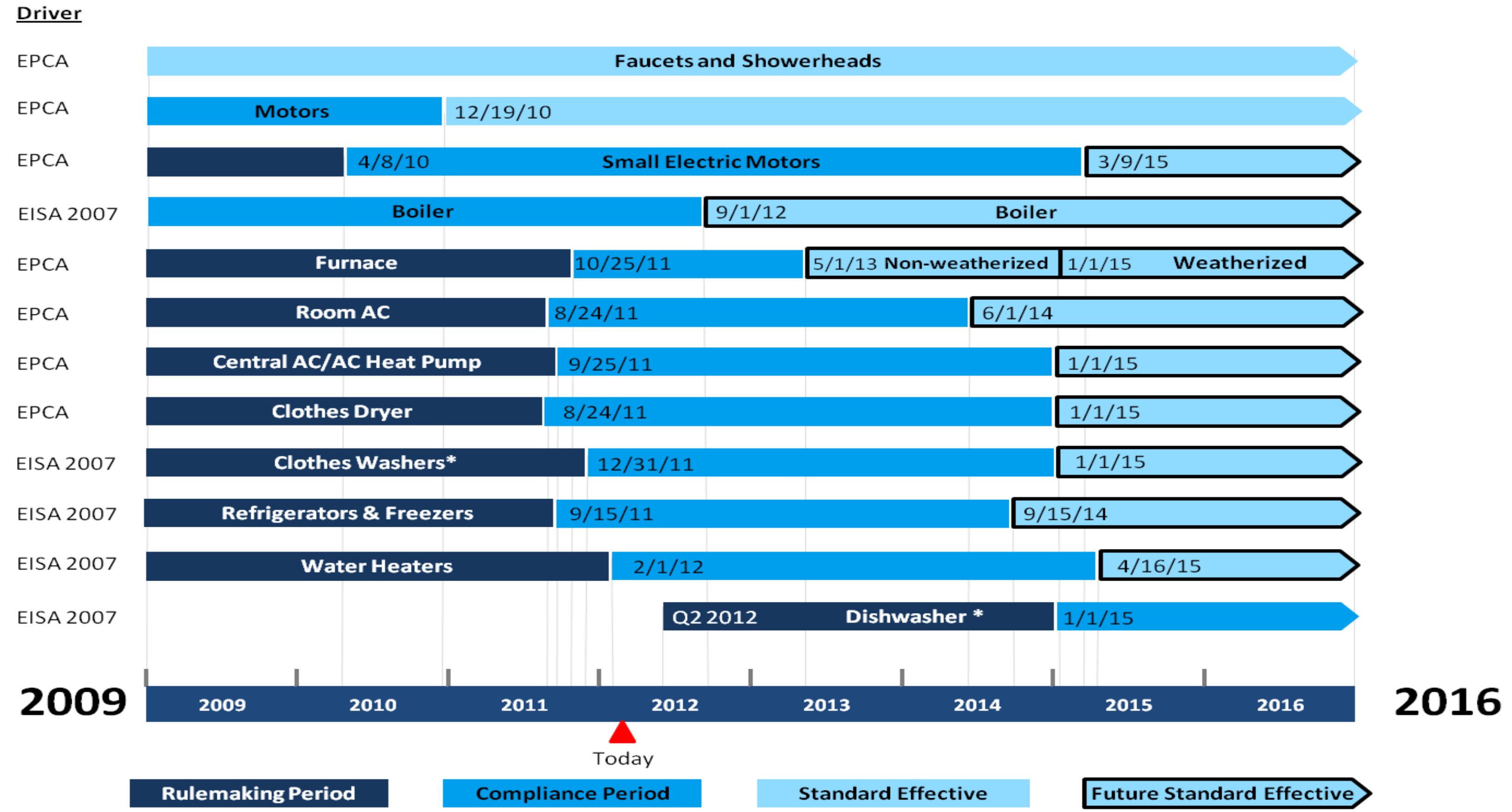
Price forecasting

» Measure cost estimates used for portfolio planning and goal-setting should, in principle, be forecasted forward (CFL example below)



KEY DATA ANALYSIS CHALLENGES

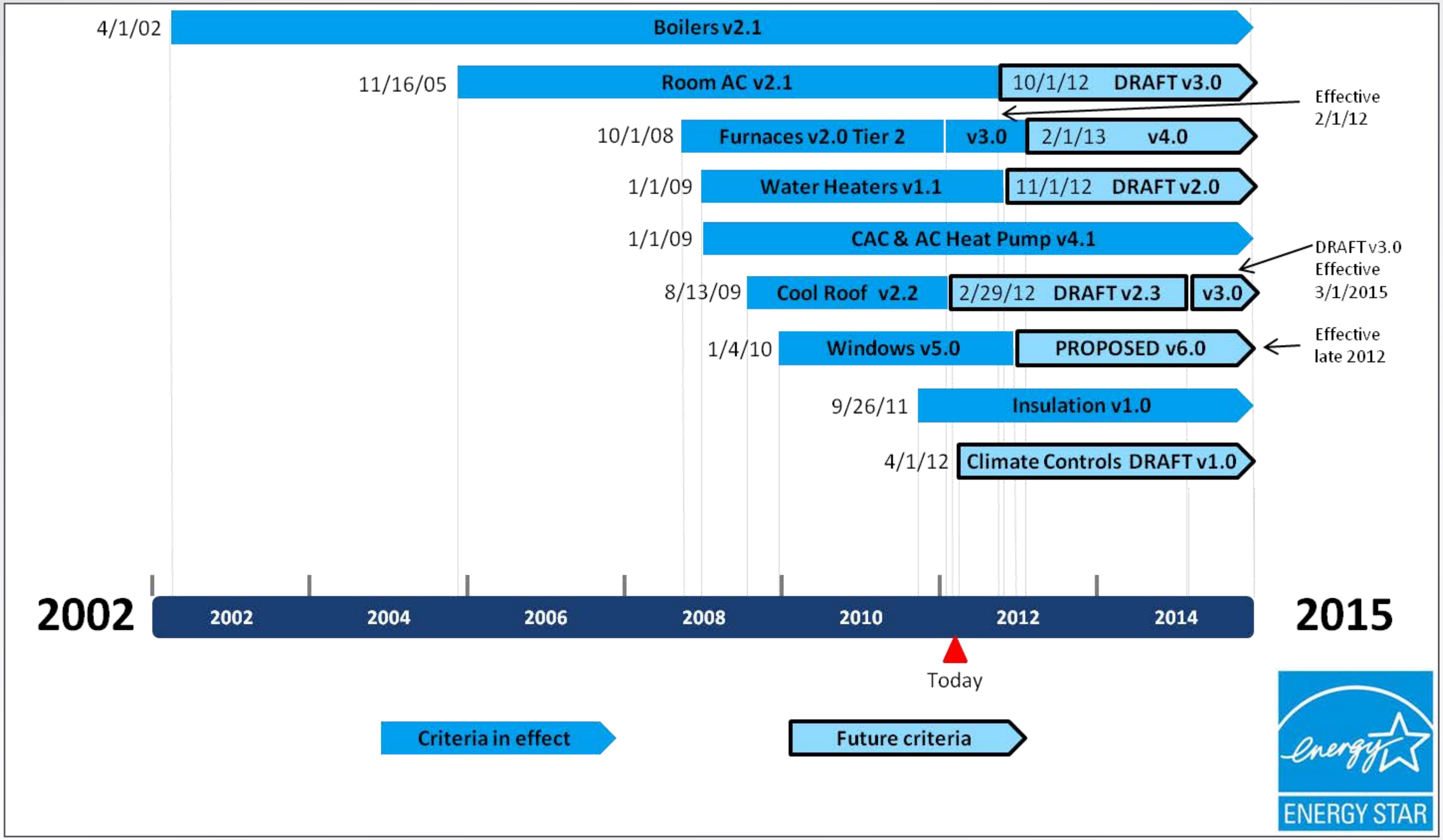
Interactions with future codes and standards



* The DOE was to conclude clothes washer rulemaking proceedings as of December 31, 2011 to determine if updated standards are warranted. The final rule is currently unavailable, but if new standards are deemed appropriate, the effective date is January 1, 2015 in accordance with EISA. New federal dishwasher standards took effect in early 2010. The dishwasher rulemaking from Q2 2012 to 1/1/2015 will determine if updated dishwasher standards are warranted.

KEY DATA ANALYSIS CHALLENGES

Interactions with future label specifications



DEMYSTIFYING THE BEAST

How can these challenges be overcome?

» **Three big questions emerge:**

1) Are there ways to acquire better-quality data sets than those used in the past?

2) Are there ways to increase the flexibility of measure cost estimates and otherwise increase their shelf-life/transferability/overall value?

3) Can all this be done more frequently and at lower cost?

2014 CPUC MEASURE COST STUDY

Project overview

Sponsor, Budget, and Timeline:

- Sponsor: California PUC (Energy Division)
  - Project manager – Katie Wu
  - EM&V portfolio oversight – Jaclyn Marks, Carmen Best
- Authorized budget = $2 million
- Timeline: March 2011 (project initiation) to May 2014 (final report)

Scope:

- Develop robust ex ante incremental measure costs for deemed measures likely to be included in next-cycle (i.e., 2015-2017) IOU program portfolios in California
  - Distinctly larger scope than any other measure cost study previously conducted in CA (DEER + non-DEER deemed)

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Data collection approaches for unit equipment prices

- **Mass market measures** – large samples of actual retail price observations
  - POS data (NPD, ACNeilsen) – appliances, electronics, res lighting
  - Retail shelf surveys – incandescents, CFLs, LEDs
- **Measures procured by third parties** – "retail price build-up" approach
  - Unit price data collected at the distributor level
  - Supplemented by explicit estimation of bulk purchase discounts, contractor mark-ups, warranties, etc.
  - Closely mirrors equipment and project pricing practices used by contractors, ESCOs, and implementers
  - *Team partnered with subcontractors in the supply chain to leverage their existing relationships with distributors to acquire large samples of distributor prices*

2014 CPUC MEASURE COST STUDY

Data analysis approaches for unit equipment prices

» Hedonic price modeling

- Statistical approach to estimating relative influence of individual features on final, observed product price:

$$Price = \alpha_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_4 X_4 + \beta_n X_n + \varepsilon$$

- where X_1, X_2, X_3, ...X_n are individual product features such as capacity, energy performance, color, brand, etc.

» Key advantages:

- Estimates explicitly controlled for cost-influencing factors that are not related to efficiency performance
- Allows incremental costs to be estimated across a continuum of technology specifications (high degree of flexibility and granularity)
- Explicit quantification of uncertainty (standard errors)

2014 CPUC MEASURE COST STUDY

Example of hedonic price model for refrigerators

Technology	Model Variables			Model Results					Model Stats
	Name	Type	Values	Coefficient	t-stat	Standard Error	Roll-up Wts	Wtd Coefficient	
Refrigerators (full size residential)	ENERGY STAR	Binary	Yes	-11.64	-1.03	11.340	N/A	-11.64	N observations
			No	0.00	--	--	N/A	0.00	7,372
	Capacity (ft3)	Continuous	7.8 - 31	23.79	17.60	1.350	N/A	23.79	N unit sales
	Type	Categorical	Freezer on Bottom	0.00	--	--	N/A	0.00	470,719
			Freezer on Top	-391.09	-24.90	15.740	N/A	-391.09	R2
			French Doors	308.33	18.40	16.780	N/A	308.33	0.860
			Side-by-Side	-548.29	-29.20	18.750	N/A	-548.29	Intercept
	Quarter	Categorical	1	0.00	--	--	0.129	-43.58	726.700
			2	-34.90	-3.90	8.860	0.271		MAE
			3	-42.00	-4.90	8.530	0.361		383.459
			4	-79.30	-8.70	9.080	0.239		Contr. Markup
	Color	Categorical	White	0.00	--	--	0.395	86.62	N/A
			Bisque	71.51	2.51	28.510	0.009		
			Black	14.77	1.92	7.710	0.185		
			Other	169.17	6.17	27.420	0.010		
			Stainless	250.38	32.31	7.750	0.312		
			Stainless Look	40.00	3.96	10.100	0.090		
	Dispenser	Binary	Yes	521.50	42.90	12.150	N/A	521.50	
			No	0.00			N/A	0.00	
	kWh/yr	Continuous	253 - 728	-0.47	-5.20	0.090	N/A	-0.47	

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Using hedonic model results to estimate measure costs

» **Refrigerator example:** Energy Star, side-mount freezer, TTD ice, large (27 ft3 TV), 620 kWh/yr

$$P_i = \alpha + \beta_1 ES_i + \beta_2 Capacity_i + \beta_3 Type_i +$$

$$\overline{Quarter}_i + \overline{Color}_i + \beta_6 Dispenser_i + \beta_7 kWh_i$$

$$P_{modeled} = 726.7 + (-11.64)(1) + (23.79)(27.0) + (-548.29)(1) +$$

$$(-43.58) + (86.62) + (521.5)(1) + (-0.471)(620) = \$1{,}082$$

Estimated Coefficients **Parameter Inputs**

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Other data analysis approaches for unit equipment prices

- For some measures, it proved difficult, inappropriate, or unnecessary to estimate incremental cost using hedonic modeling
  - Commercial refrigeration measures: more akin to "projects"
  - HVAC maintenance measures: include wide variety of interventions
  - Food service equipment: small markets with a limited number of products but wide variation in distributor pricing
  - Network power management software: final pricing typically negotiated with individual customers

- For these measures, team used built-up estimates developed by specialized subcontractors or simple averages (on a matched pair or whole-sample basis)

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Non-equipment installation costs

- Data collection approaches for **non-equipment installation labor hours and other non-equipment installation costs**:
  - CATI survey of HVAC and lighting contractors in CA
    - N = 123 (HVAC), 95 (Lighting)
  - Artificial project bids
    - 41 total, multiple installation scenarios for several technologies
  - DI prices (from ‘10-‘12 and ‘13-‘14 program cycles)
  - RSMeans, USDOE TSD, other secondary sources
- RS Means used as primary source for average **installation labor rates** ($/hr):
  - Internally consistent and easily customizable to specific locations (city cost indices)
  - Consistent with the labor cost estimation procedures used by many contractors and implementers

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Final scope of deemed measure results

- 75 hedonic price models (38 measure groups)
- 24 built-up equipment price estimates (8 measure groups)
- 17 simple average price estimates (14 measure groups)
- 92 non-equipment installation cost estimates (49 measure groups)
  - All add-on measures
  - All early replacement measures
  - All ROB measures w/cross-technology baselines
  - Some ROB measures claimed as early replacement in custom programs

- Final report: http://www.calmac.org/publications/2010-2012_WO017_Ex_Ante_Measure_Cost_Study_-_Final_Report.pdf

THE ROAD FORWARD

Recommendations for conducting better, cheaper, more frequent cost studies

1) Integrate make/model and installation cost data into program tracking databases
   - Make/model typically required on downstream rebate forms (to verify claims), but often not integrated into program tracking
     - Doing so would allow equipment size, efficiency, and other feature information to be easily appended each record
   - Installation costs hardly ever required on rebate forms
     - Feasible to require installation costs on rebate forms as information-only (not tied to incentives)
   - Integrating these data into program tracking would create a comprehensive, low-cost, and on-going source for:
     - Unit price data for in-program products
     - Market shares (by brand, feature type, efficiency level, etc.)
     - Installation costs for measures requiring third-party installation

THE ROAD FORWARD

Recommendations for conducting better, cheaper, more frequent cost studies

2) Standardize data development and analysis procedures for measure cost estimation
   i. Expanded and regular use of POS data (mass market)
      - Targeted updates possible as often as every quarter
   ii. Partner with supply chain actors for data collection (non-mass market)
      - Removes primary data-access barriers
   iii. Systematic use of product compliance databases
      - Publically available, regularly updated
      - Capacity and energy performance ratings based on common testing
   iv. Establish hedonic price modeling as primary analytic framework
      - Inherently flexible, provides empirical estimates of uncertainty
      - Transparent and reproducible results – comparability across studies/time!
   v. Expanded and consistent use of artificial project bids
      - Effective method to estimate installation costs for large capital equipment
      - Standardization would enable meaningful longitudinal analysis

THE ROAD FORWARD

Recommendations for conducting better, cheaper, more frequent cost studies

3) <u>Perform regular, targeted market assessments to inform frequency and depth of future cost data collection</u>

- Consistent recommendation in studies has been to conduct measure cost research more often, in more targeted way
  - Little evidence that this has actually resulted in less “lumpy” studies
- Conducting regular, targeted market assessments would serve to:
  - Identify which existing estimates are still valid
  - Identify changes in standard practices that impact incremental costs
  - Identify interactions with non-energy codes that influence baselines and product availability
  - Identify and strategically target specific market actors for data collection
  - Identify key performance metrics (particularly emerging ones) that should be included in hedonic models and measure definitions
- Directly enables the scope, budgets, and research activities of future measure cost studies to be more explicitly targeted and optimized than what was possible in previous studies

THANK YOU

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2014 CPUC MEASURE COST STUDY

Interpreting hedonic price model results

» **Binary** and **categorical** variables:

- Coefficient = average price difference due to presence of feature X relative to the reference case
  - Reference case identified as variable with coefficient value of zero
- *Refrigerator example:*
  - *average price premium for TTD dispenser is $521 (all else equal)*

» **Continuous** variables:

- Coefficient = average price difference per unit change in the continuous variable
- *Refrigerator example:*
  - *average price increases $0.47 for each decrease in rated annual electricity consumption of 1 kWh (all else equal)*

2014 CPUC MEASURE COST STUDY

Mapping hedonic model specifications to DEER measure definitions

MCS Model	
ENERGY STAR	Binary
Capacity	Continuous
Type	Categorical
Quarter	**Dummy**
Color	**Categorical**
Dispenser	Binary
kWh/yr	Continuous

DEER Measure	
ENERGY STAR	Binary
Capacity	Discrete
Type	Categorical
Dispenser	Binary
kWh/yr	Discrete

» $P_i = \alpha + \beta_1 ES_i + \beta_2 Capacity_i + \beta_3 Type_i + \beta_4 Quarter_i + \beta_5 Color_i + \beta_6 Dispenser_i + \beta_7 kWh_i + \varepsilon_i$

» $P_i = \alpha + \beta_1 ES_i + \beta_2 Capacity_i + \beta_3 Type_i + \overline{Quarter_i} + \overline{Color_i} + \beta_6 Dispenser_i + \beta_7 kWh_i + \varepsilon_i$

2014 CPUC MEASURE COST STUDY

Roll-up weights

- Necessary to develop "roll-up" weights (i.e. market shares) for any model variables not included in the DEER/IOU workpaper measure definitions to develop weighted average prices
- Team had direct access to most recent and comprehensive market share data available in California:
  - NPD POS data acquired for appliances and TVs
  - 2013 RMST – POS data
  - 2013 CLASS – on-site survey data
  - 2010-2012 Downstream Lighting Impact Evaluation (WO29) – on-site survey data
  - 2013 CSS/CMST– on-site survey data
  - 2006 California CEUS – on-site survey data