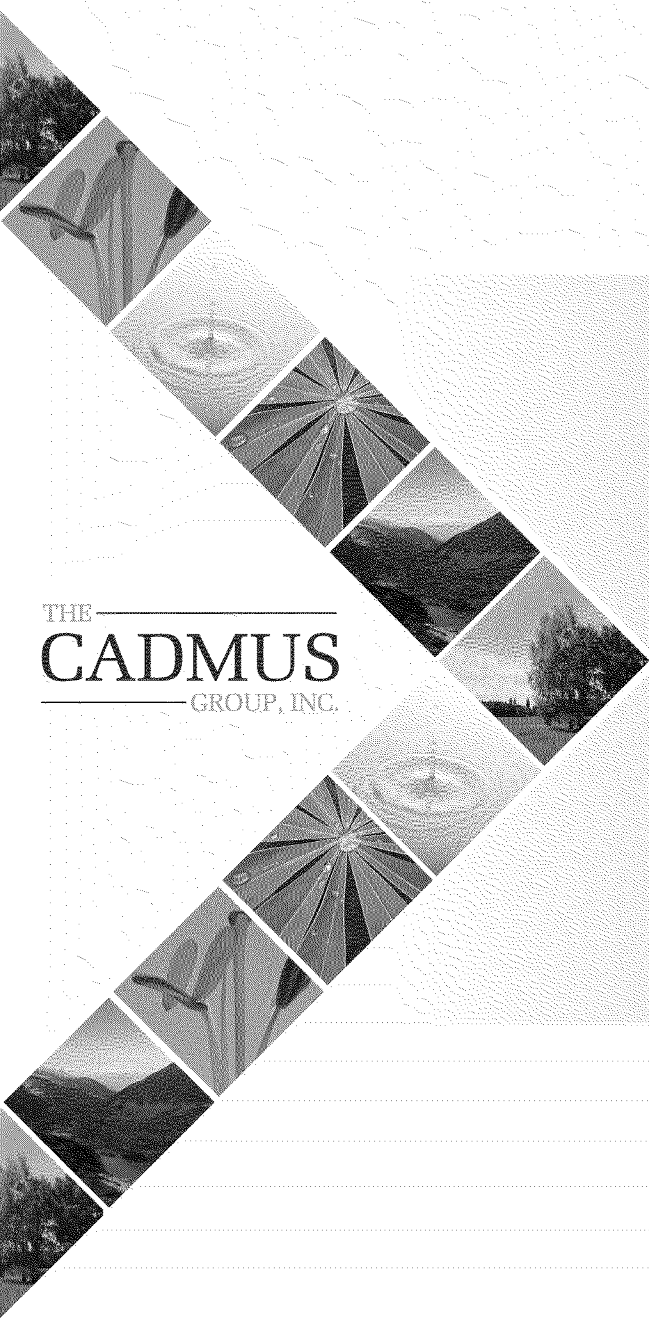

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White Paper: Assessment and Recommendations on Top-Down Evaluation Approaches

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Outline

- Summary
- Historical setting
- Study objectives
- Literature review
- California policy applications and recommendations
- Cadmus proposal
- Conclusions

Summary

- T-D approaches, based on macro-consumption (sales), have potential
- Address – in varying degrees - CPUC's policy objectives:
  - Attribution of savings
  - Market gross savings and progress towards GHG reduction goals
  - Long term forecast of energy savings
- Data requirements are modest and data are, for the most part, readily available
- Certain modeling issues exist, which must be addressed effectively
- Self-selection and accounting for non-programmatic savings present challenges – but can be overcome
- Estimate model using dynamic demand model by sector and utility
- Determine market gross savings, naturally occurring adoption, codes and standards, utility programs
  for each year between 2006-2010 and by utility and sector

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Historical Context

- Utility-sponsored programs have largely relied on B-U approaches to determine savings
  - Technical measure interactions
  - Double-counting savings
  - Rebound effect
  - Self-selection and free-ridership
- Discrete choice studies (Hartman, 1988; Train, 1988; Waldman and Ozog, 1996) showed utility programs save less than indicated by evaluation results
- B-U approaches are expensive to implement

Study Objectives

- Literature review: relevant theory, analytic methods, and results from T-D evaluation studies
- Assessment of applicability of T-D evaluation to California EE policy objectives
  - Attribution of savings
  - Market gross savings and progress towards GHG reduction goals
  - Long term forecast of energy savings
- Development of proposal for implementing T-D approach in California

REVIEW OF LITERATURE

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Literature Review

- Cadmus identified nine T-D savings evaluations (1996-2011), including one analysis by CEC
- Estimated savings attributable to utility programs or building codes in the United States, Canada, or California
- Similar research designs and data
  - Collected panel data on annual consumption and utility DSM expenditures for states or service territories from EIA
  - Applied panel regression methods to estimate savings

Basic Approach

- Use macro-level, panel data (sector or geographic area) on energy-use indicators
  - Energy use indicators measuring energy intensity (e.g., energy use per capita or dollar value added)
- Energy savings estimated in a double- or semi-log dynamic demand regression framework:

  $e_{it} = f(e_{it-1}, \text{weather}_{it}, \text{energy prices}_{it}, \text{income}_{it}, \text{EE expenditures}_{it}, \text{fixed effect}_{i}, \text{building codes}_{it})$

  - e_{it-1} captures fixed investments and partial adjustment of demand to energy price changes

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Findings about Utility Program Savings

- Despite similar research designs and data sources, estimates of utility program savings and cost effectiveness vary widely
  - Commercial sector: Parfomak and Lave 1996 (100% realization rate) and Horowitz 2004 (54%)
  - All retail sectors (Loughran and Kulick, 2004 (20-25%); Aufhammer, Blumstein, and Fowlie, 2008 (100%); Rivers and Jaccard, 2011 (0%)
- Estimates of savings tend to be imprecise
- Questions about reliability of EIA sales and EE expenditure data

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Necessary Assumptions for Identifying Utility Program Savings

- Energy-efficiency expenditures must be exogenous to consumption
  - Potential sources of endogeneity: correlation between utility programs and expected savings, attitudes toward energy efficiency
- No omitted variables correlated with energy-efficiency expenditures and consumption
  - Fixed effects control unobserved, time-invariant characteristics
  - State building codes and appliance standards, federal appliance standards, EE expenditures by state or quasi-governmental organizations
- Assumptions are strong and difficult to verify

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CALIFORNIA POLICY APPLICATIONS

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Potential California Policy Applications

- Attribution of utility program savings
- Market gross savings and progress towards GHG reduction goals
  - Market gross savings comprise savings from utility programs, codes and standards, naturally occurring adoption
- Development of long term forecasts of energy savings

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Data Collection and Preparation

- T-D evaluation of energy savings in California would be inexpensive, especially compared to estimating savings from the B-U
- Most required data are readily available
- Level of effort required to prepare data for analysis could be non-trivial
  - Use CEC/utility data on consumption and EE
  - Requires innovative approach to developing a reliable indicator of codes and standards savings

Issues of Bias and Precision in T-D Savings Estimation

- Endogenous EE expenditures and consumption not a significant concern
  - EE investments in CA driven by national and state energy supply crises
- Reliable indicators for C & S impacts
- T-D savings estimates tend to be imprecise
  - Uncertainty in impacts can be measured
  - Substantial uncertainty may limit policy applications

Assessment of Policy Applications

- Attribution of utility program savings
  - Utility savings estimates are imprecise
  - Savings realization rate/cost effectiveness may not applicable to latest evaluation cycle
- Market gross savings
  - Estimating naturally occurring and codes and standards savings is difficult
- Long term forecasts of electricity demand
  - Ability to quantify uncertainty about utility program savings and incorporate into forecast
  - Cost effective means of estimating savings than existing methods

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Recommendations

- There is the opportunity in California to:
  - apply T-D evaluation methods in estimating historical energy savings for developing forecasts of long-term demand
  - apply T-D evaluation in attribution of energy savings to utility programs but should not be only approach
    - T-D methods could be used to validate B-U savings estimates at the portfolio level
  - continue to explore the application of T-D methods to estimation of market gross savings

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PROPOSAL

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Proposal - Overview

- Estimate market gross savings from utility programs, codes and standards, and naturally occurring measures in CA retail energy sectors
  - Appropriate application of T-D models
  - Greatest value added
- Estimate market gross savings between 2006 and 2010 for each retail sector

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Potential Contributions

Issue	Solution
EIA data quality	Use CEC/utility consumption data to construct consumption and EE expenditures series
Partial/short run adjustment of demand to changes in prices and other factors	Develop dynamic demand model to estimate long-run market gross savings from utility programs, codes and standards, and naturally occurring savings
Omitted variable bias from codes and standards	Develop a reliable indicator of codes and standards impacts
Precision of savings estimates	Use CEC/utility consumption data to construct consumption and EE expenditures series, expand number of utilities

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Design of Proposed California T-D Savings Evaluation

- Estimate models for residential, commercial, industrial, and agricultural sectors
- Unit of analysis would be utility service territory
  - 75 EDCs in CA in 2009, but 5 utilities (PG&E, SCE, LADWP, SDG&E, and SMUD) accounted for 82 percent of retail sales
  - Sample could be enlarged to include other large municipal utilities (Santa Clara, Anaheim, Riverside)
- Model estimated with annual data between 1989 and 2009

Data Collection

- Collect data from CEC, U.S. Census Bureau, U.S. BEA, and NOAA
- Rely on CEC or utility data to estimate annual sector consumption and EE expenditures
- Map data reported at other geographic levels to utility service territory
- Adjust nominal economic series for changes in price level

Development of Codes and Standards Savings Indicators

- Indicators must account for
  - changes in building activity, code stringency, compliance and enforcement
  - geographic variations and temporal changes in appliance saturations
- Develop an indicator of savings from codes and standards for inclusion in model as an explanatory variable
- Build on Cadmus' experience in evaluating savings from California codes and standards

Analytic Framework

- Step 1: Estimate dynamic demand model of energy use (Houthakker, 1974; Rivers and Jaccard, 2011)
  - Energy use a function of lagged energy use, energy prices, time trend, codes and standards, energy-efficiency expenditures, and other observable variables affecting demand
  - Model partial adjustment of demand to energy price changes
  - Obtain short- and long-run elasticity values for independent variables

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Example Model Specifications

Variable	Residential	Commercial	Industrial	Agricultural
Dependent variable (energy-use indicator)	Energy sales in residential sector	Energy sales in commercial sector	Energy sales in industrial sector	Energy sales in agricultural sector
Energy-efficiency indicator	Energy-efficiency expenditures in residential sector	Energy-efficiency expenditures in commercial sector	Energy-efficiency in industrial sector	Energy-efficiency expenditures in the agricultural sector
Other Controls	Population, personal income, electricity price, gas price, weather, codes and standards	Value added in commercial sector, personal income, floor space, electricity price, gas price, weather, codes and standards	Value added in industrial sector, national GDP, manufacturing employment, electricity prices, natural gas prices, weather	Agricultural income, national GDP, electricity prices, gas prices, weather

Notes: All models would include utility fixed effects, a time trend, and lagged values of the dependent variable.

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Analytic Framework (cont.)

- Step 2: Estimate counterfactual consumption in absence of naturally occurring efficiency, codes and standards, and utility programs for each utility service territory in the state
  - Necessary to establish reference values or baselines
  - Derive expression for each component's contribution to savings as a function of long-run consumption

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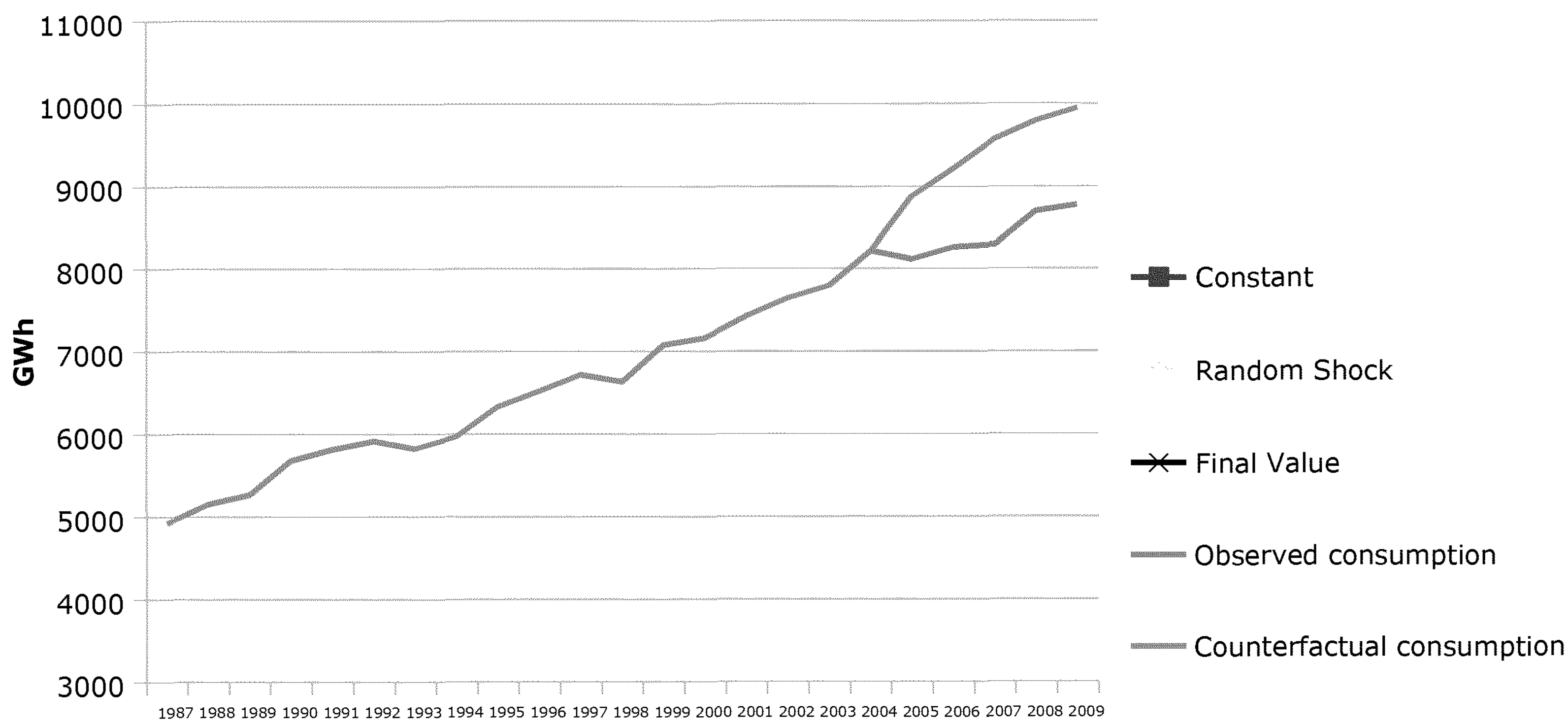
Illustration – Estimation Methodology



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Analytic Framework (cont.)

- Step 3: Estimate total market gross savings as the difference between counterfactual and observed consumption
- Step 4: Estimate state market gross savings by adding up market gross savings over the utility service territories

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Reporting

- Estimates of market gross savings from
  - naturally occurring adoption
  - codes and standards
  - utility programs

  for each year between 2006-2010 and by utility and sector
- Precision of savings estimates
- Comparisons to B-U savings estimates

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Project Timeline

Task	Sep-11					Oct-11				Nov-11				Dec-11					Jan-12				Feb-12			
Task 1: Project Initiation Meeting																										
1. Meeting between Cadmus and CPUC team																										
2. Development of revised workplan																										
Deliverable: Revised workplan based on kickoff meeting		*X*																								
Task 2: Data Collection and Preparation																										
1. Collect data																										
2. Prepare data for analysis																										
3. Develop indicator for codes and standards impacts																										
Task 3: Model Development																										
1. Develop model specifications																										
Task 4: Model Estimation and Savings Analysis																										
1. Model estimation																										
2. Estimation of market gross savings and uncertainty																										
3. Comparisons to other studies and robustness checks																										
Task 5: Draft and Final Reports																										
1. Write draft report																										
3. Revise final report																										
Deliverable: Draft final report																				*X*						
Deliverable: Final report																									*X*	
Task 6: Workshop Presentation																										
1. Present findings to CPUC and stakeholders																										

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Questions/Comments?

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