MEMD Measure Update: Appliance Recycling

The Cadmus Group, Inc.
Opinion Dynamics Corporation
July 2012

EO Collaborative – Joint Workgroup Meeting
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Overview

- Background
- Methodology
  - Metering Protocol
  - Sampling
  - Analysis
- Findings
- Application

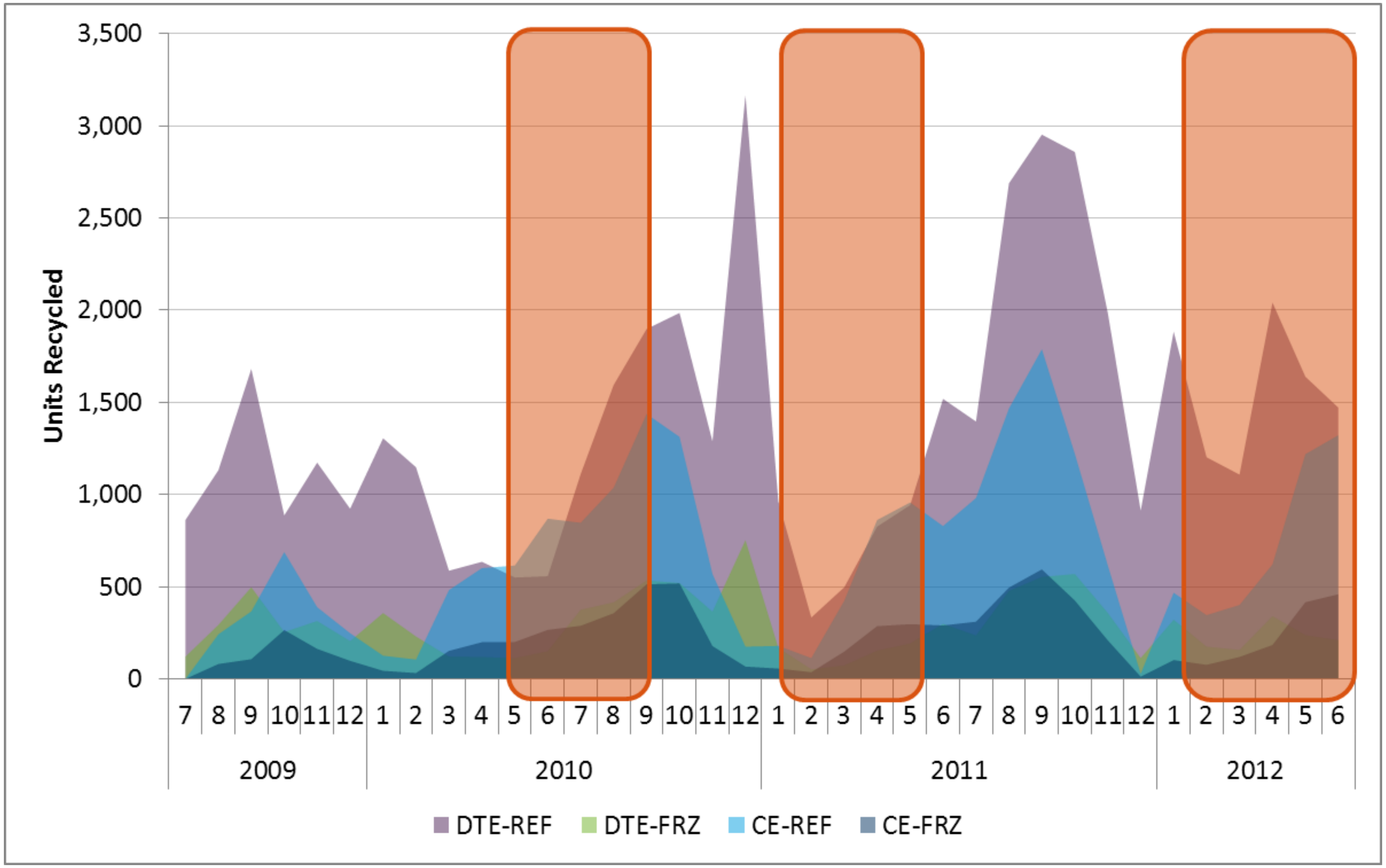
Background

- Consumers Energy and DTE Energy partnered on joint metering effort of recycled appliances
- Over 200 refrigerators and freezers metered throughout the state
- Preliminary results were presented to EWG last year

Background

- Metering was conducted in Consumers and DTE’s territory
  - Final values based on characteristics unique to each utility
- Wave 1: Summer 2010 (Consumers and DTE)
- Wave 2: Winter 2011 (DTE only)
- Wave 3: Winter 2012 (Consumers only)

Metering Timeline vs. Participation



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Metering Protocol

- *In situ* metering collects data on appliances operating in "real-world" context
  - Captures environmental factors, usage patterns, contents, etc.
- Each appliance was metered for 10 to 14 days in the participant's home.
- Five meters installed:

Metering Equipment	Data
HOBO UA-002 Temperature Gauge	Internal Temperature
HOBO U9-002 Light Sensor	Frequency/Duration Door Openings
HOBO U12-012 External Data Logger	Ambient Temperature/Humidity
HOBO CTV-A	Current
Watts up? Pro ES Power Meter	Energy Consumption

In Situ Metering

- Traditionally, program savings were estimated using DOE lab testing

- More recently, there has been a move toward *in-situ* metering
  - 2006-08 CPUC Residential Evaluation first to use solely *in-situ* values

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Comparison to Other Methods

- DOE-Protocol Testing:
  - Metering of appliances under controlled environment (constant temperature, empty cabinet, no door openings).
  - Good for relative efficiency, but tends to overestimate nominal energy consumption.
- Billing Analysis:
  - Quasi-experimental design using billing data from experimental and control group.
  - Problems with replacement units.

Sampling

- Sampling was done by configuration and use

Appliance Type	Characteristic		Proportion of Appliance Type	
			Overall Participant Population	Metering Sample
Freezer	Configuration	Upright	66%	60%
		Chest	34%	40%
Refrigerator		Top Freezer	67%	70%
		Side-by-Side	23%	21%
		Single Door	7%	8%
		Bottom Freezer	4%	3%
	Use	Primary	55%	23%
		Secondary	45%	77%

- 237 units used in final analysis
- Primary units were under-sampled due to changes in units being picked up by program
  - Variables controlled for in model as well

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Analysis: Unit Energy Savings

- Regression models used to estimate daily consumption as a function of:
  - Age/vintage
  - Size
  - Configuration
  - Usage type
  - Location

- Modeling effort sought to balance simplicity and explanatory power

Analysis: Unit Energy Savings

- Opted for a single equation model
  - Accounts for weather using average values
  - Allows for easily interpretable results
  - Can be used as a single algorithm

- Almost all variables already tracked by program implementer

Analysis: Demand Savings

- Average Demand:

$$Average\ kW = \frac{Average\ kWh/day}{24\ hrs./day}$$

- Summer Demand:

$$Summer\ kW = Average\ kW * CF$$

$$CF = \frac{Summer\ kWh/day}{Average\ kWh/day}$$

Findings: Refrigerator Regression

- n: 183
- R^2: 0.40
- Adj. R^2: 0.37

Independent Variables	Coefficient	p-Value*	VIF
Intercept	-1.608	0.21	0.0
Age (years)	0.045	0.10	1.3
Dummy: Manufactured Pre-1993	1.399	0.02	1.4
Size (ft.^{3})	0.115	0.12	1.9
Dummy: Single Door	-1.803	0.01	1.5
Dummy: Side-by-Side	1.571	0.02	1.4
Dummy: Primary	0.830	0.25	1.2
CDDs	0.007	0.84	1.2

*All p-values calculated using White's standard errors

Findings: Freezer Regression

- n: 54
- R^2: 0.78
- Adj. R^2: 0.76

Independent Variables	Coefficient	p-Value*	VIF
Intercept	-2.297	0.00	0.0
Age (years)	0.067	<.0001	1.1
Dummy: Manufactured Pre-1993	0.401	0.21	1.1
Size ($ft.^3$)	0.150	<.0001	1.3
Dummy: Chest	0.854	0.00	1.2
CDDs	0.046	0.07	1.4

*All p-values calculated using White's standard errors

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Findings: Extrapolation

- Using cumulative participation values:

Appliance Type	Average Annual Consumption (kWh/year)	Relative Precision at 90% Confidence
Refrigerators	1,264	±9%
Freezers	1,107	±6%

Appliance Type	Average Demand (kW)	Average Summer Demand (kW)
Refrigerators	0.144	0.145
Freezers	0.126	0.133

Comparison to MEMD Values

- MEMD values are the mean of five evaluations from 1996 to 2006

Evaluation	Refrigerator	Freezer
SCE 1996	2,148	2,058
California 2002	1,946	1,662
California 2004/5	1,732	1,263
Conn. 2004	1,383	1,181
Pac. Corp 2005/6	1,149	1,590
Average kWh	1,672	1,551
Average kW	0.191	0.177

Comparison to Current Values

- Differences from MEMD consumption and demand estimates can be explained by two major factors:
  - Many of these evaluations are older, and thus more units were manufactured prior to NAECA standard
  - All of these evaluations relied on DOE testing protocols

Savings Type	MEMD	Meter Results	Difference
Refrigerator - Energy	1,672	1,264	24%
Refrigerator - Demand	0.191	0.145	24%
Freezer - Energy	1,551	1,107	29%
Freezer - Demand	0.177	0.133	25%

Application

- In cases where evaluations are not being done, deemed values could be used
  - Based on a large sample of program participants

- Future evaluations can use algorithms to update savings values
  - Data tracked in detail by program implementers

Deemed Values

- Advantages:
  - Simplicity
  - Little risk of errors for program tracking
  - Most general/widely applicable

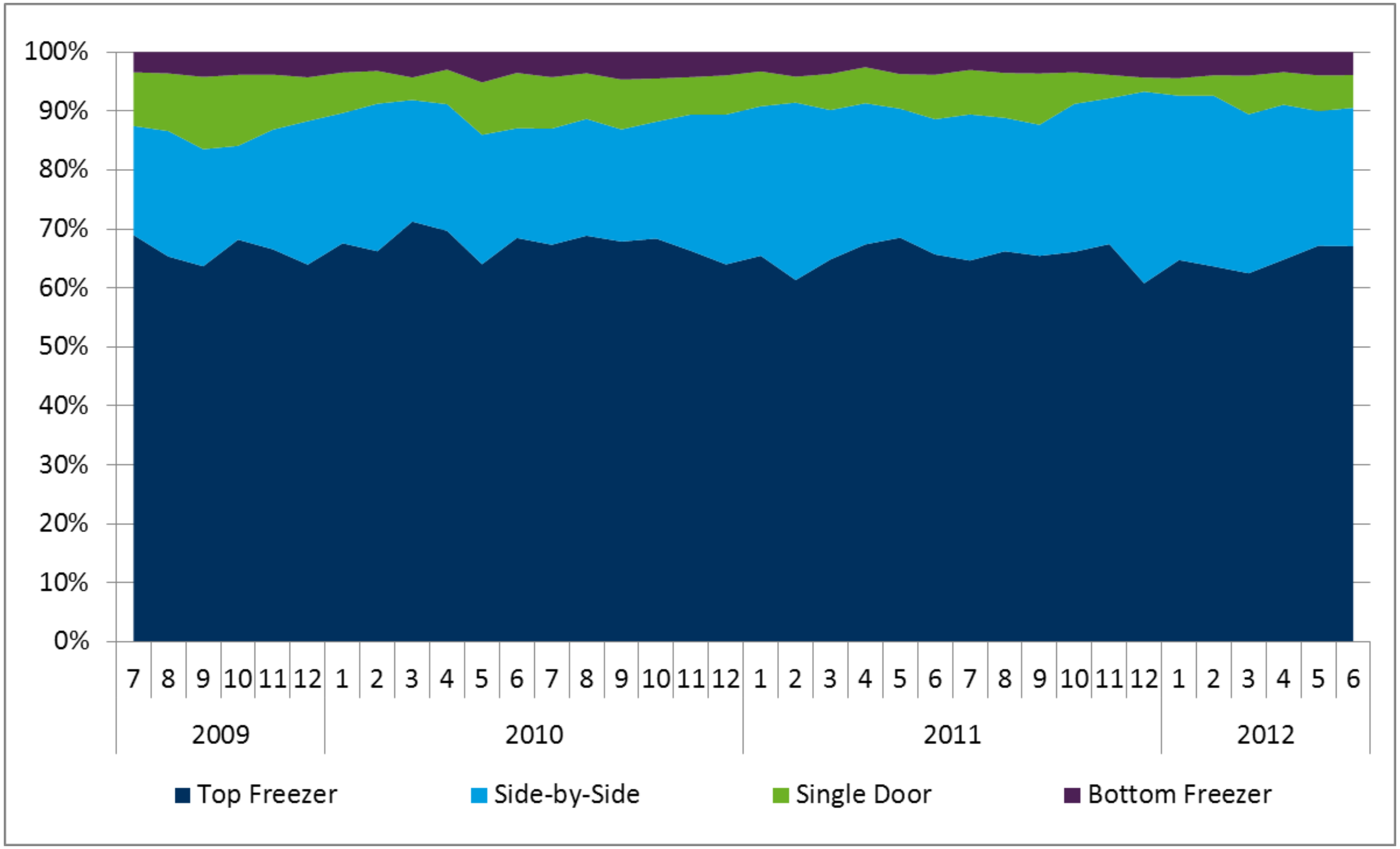
- Disadvantages:
  - Doesn’t track changes in program population
  - Doesn’t capture variation between programs

Algorithm Approach

- Advantages:
  - Represents program-specific savings
  - “Real-time” feedback for program design

- Disadvantages
  - Opportunity for error
  - Data tracking issues: may complicate the certification process or data leading up to it
  - Coordination with implementation contractor

Drivers of Consumption Over Time



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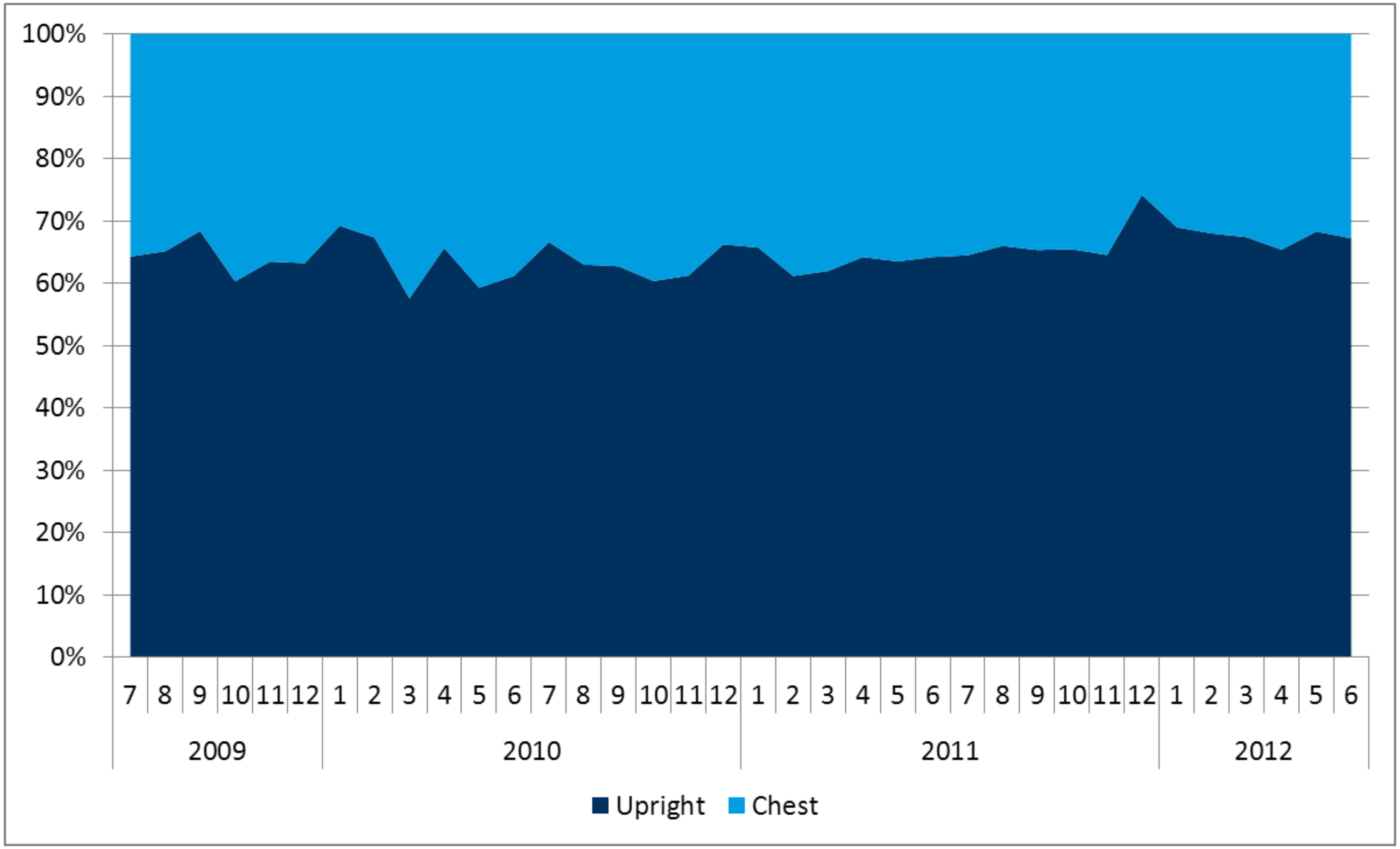
Drivers of Consumption Over Time



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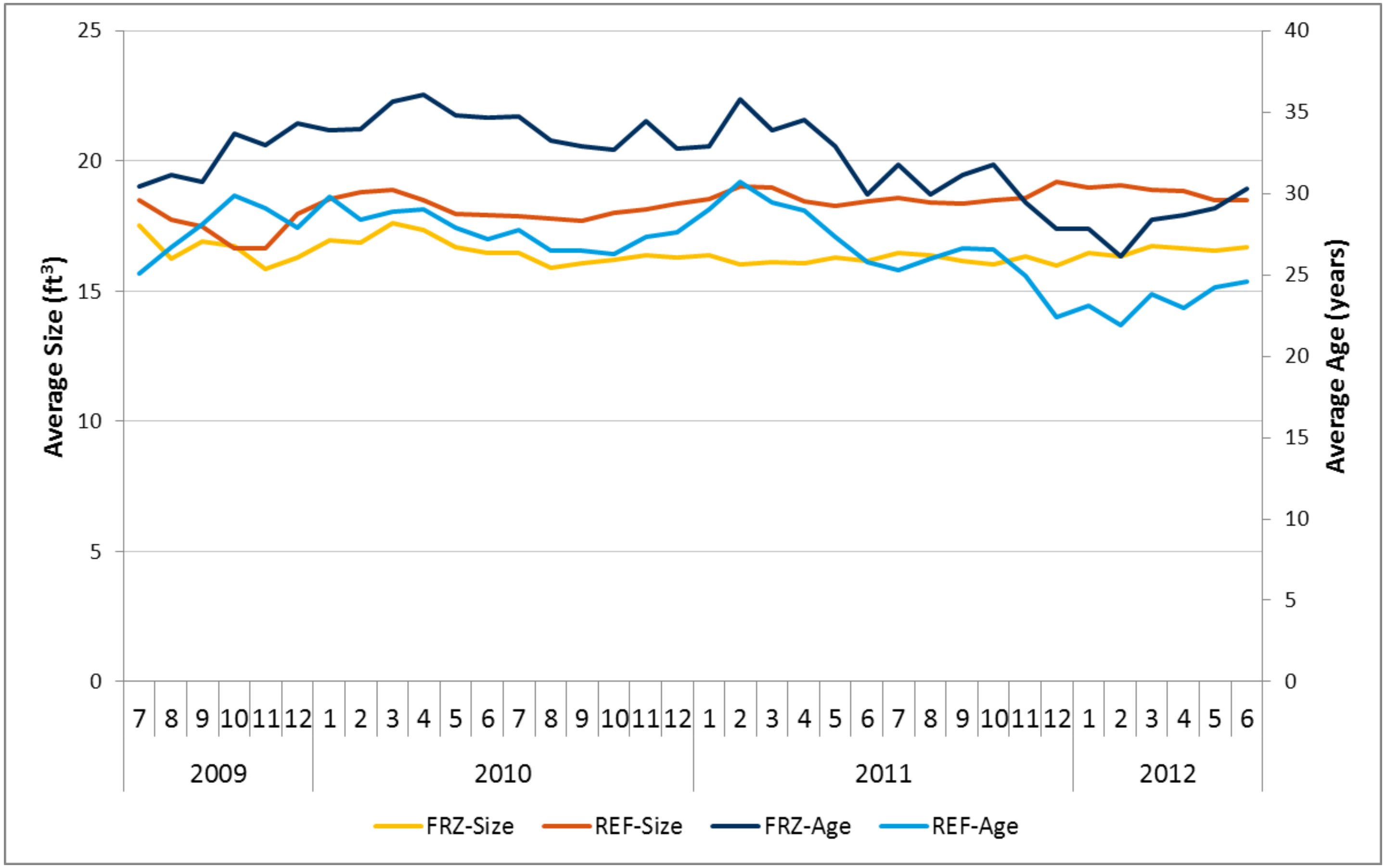
Drivers of Consumption Over Time



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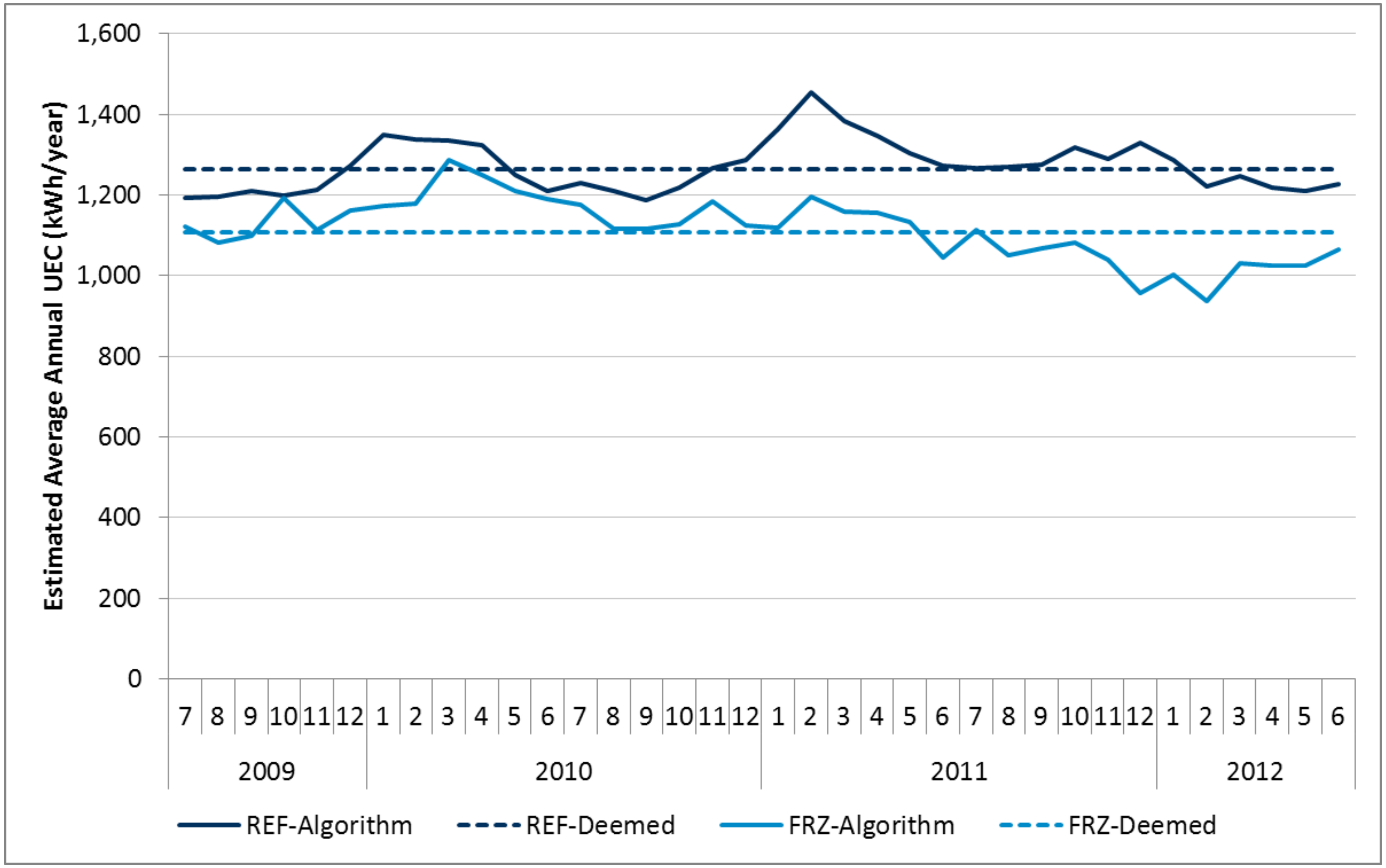
Unit Savings: Deemed vs. Algorithm



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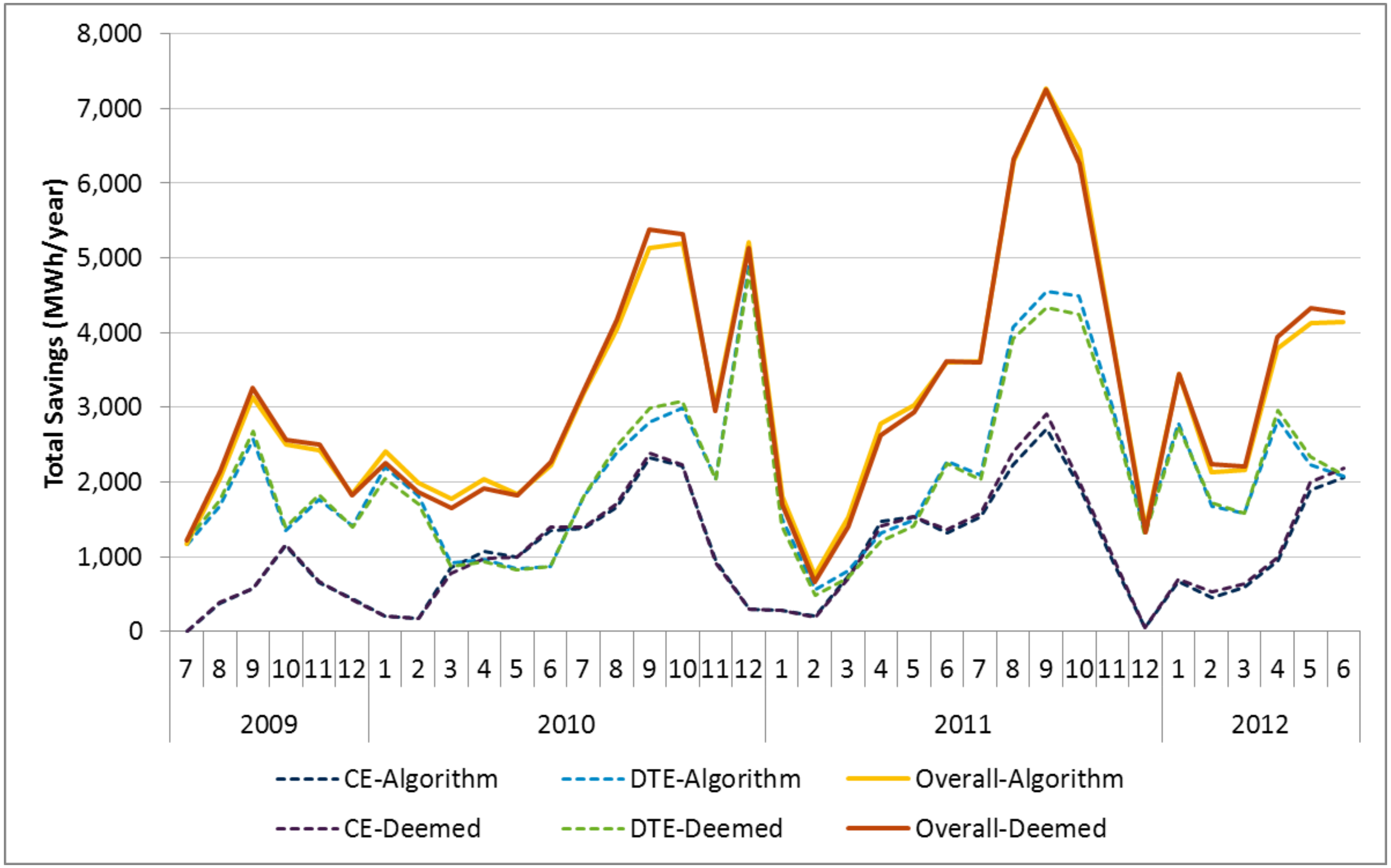
Total Savings: Deemed vs. Algorithm



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Recommendation

- Use deemed values as default
- Review inputs on a bi-annual basis
  - If significant differences, update values
- If particularly large changes, further metering may be warranted