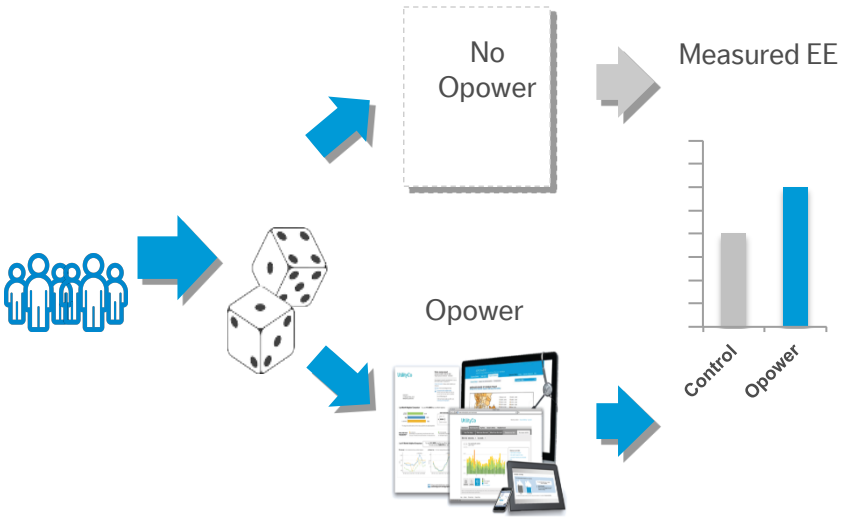
OPOWER

Updating M&V of Home Energy Report Programs

Updating M&V: Introduction

Opower Programs use Randomized Controlled Trials…..

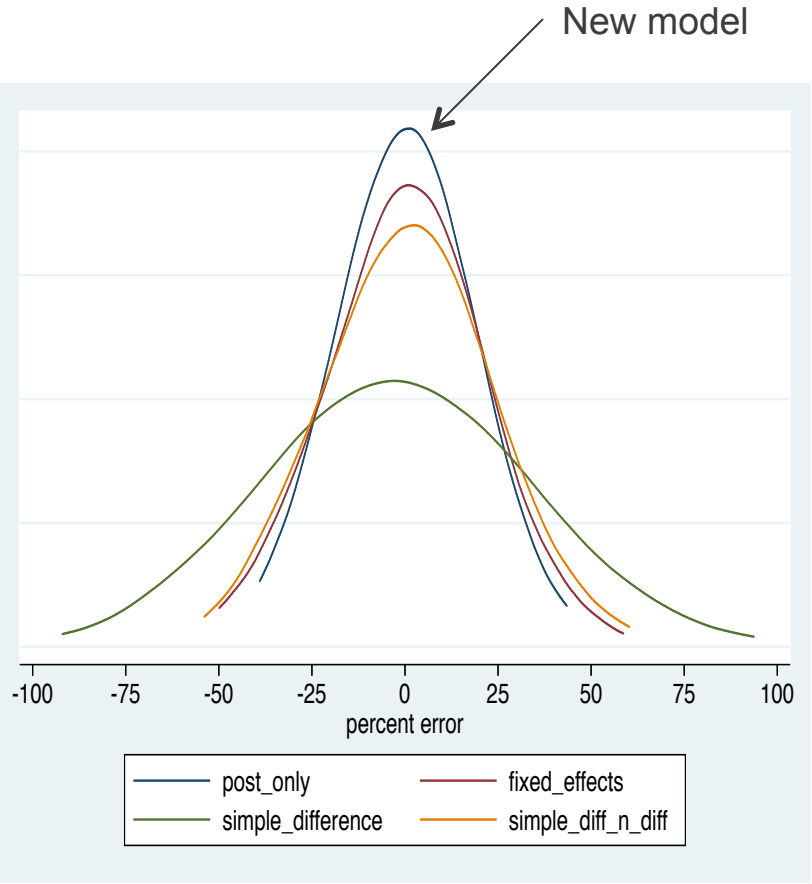


….which are measured using econometric models

- EE savings are measured via an **econometric model** which compares treatment & control populations
- Best practice employs panel data **regression** method to estimate the post-treatment difference in usage between treatment & control
- Opower is updating the **specification** of the regression model and some **data preparation** steps

Why are we updating the model?

- The post-period regression model with pre-usage controls more effectively handles naturally-occurring imbalances between treatment and control in the pre-treatment period
- This model used in academic publications and in independent evaluations
- Our own simulations confirm the new model has lower error (MSE) and analytic standard errors are generally smaller



What is changing?

Opower has a new energy savings model specification

Specifics: the regression specification is changing from a fixed effects model to a post period model with pre-usage controls

Opower has modified data treatment and cleansing steps

- *Estimated read true-up*
- *Program start-date standardization*
- *Customer active period definition*

Data

Estimated read true-up

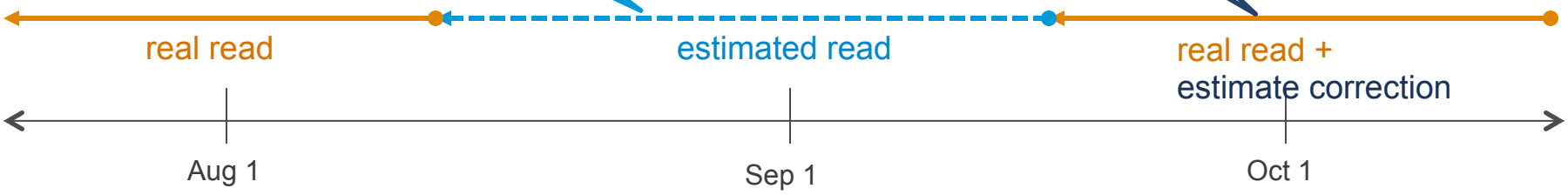
What are estimated reads?

- Some utilities estimate usage to save on operational costs
- Estimates will ultimately be trued-up by a subsequent read, which includes an actual usage reading plus the difference between the original estimate and the actual.
- The true-up takes the extra step of truing-up all estimates with their subsequent real reads

Electricity bill for the period Aug 15 – Sep 15 is based on estimated usage.

Correction received in October to account for difference between estimated and actual usage from Aug 15 – Sep 15

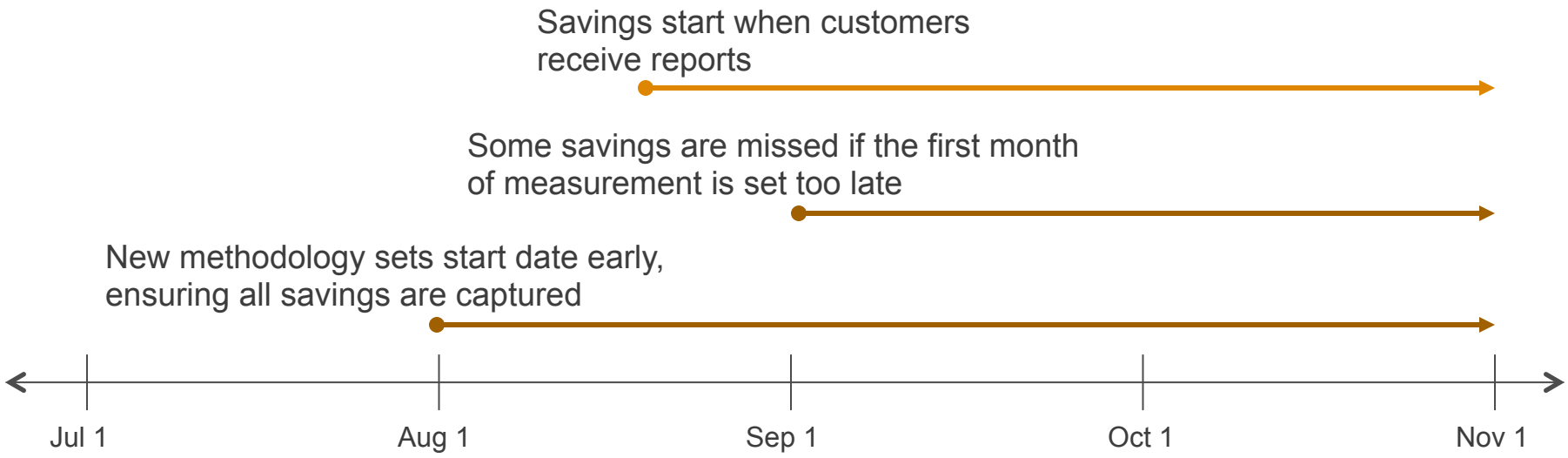
Truing up is the function of adding the correction to the estimate to get actual usage Aug 15 – Oct 15



Data

Program start date

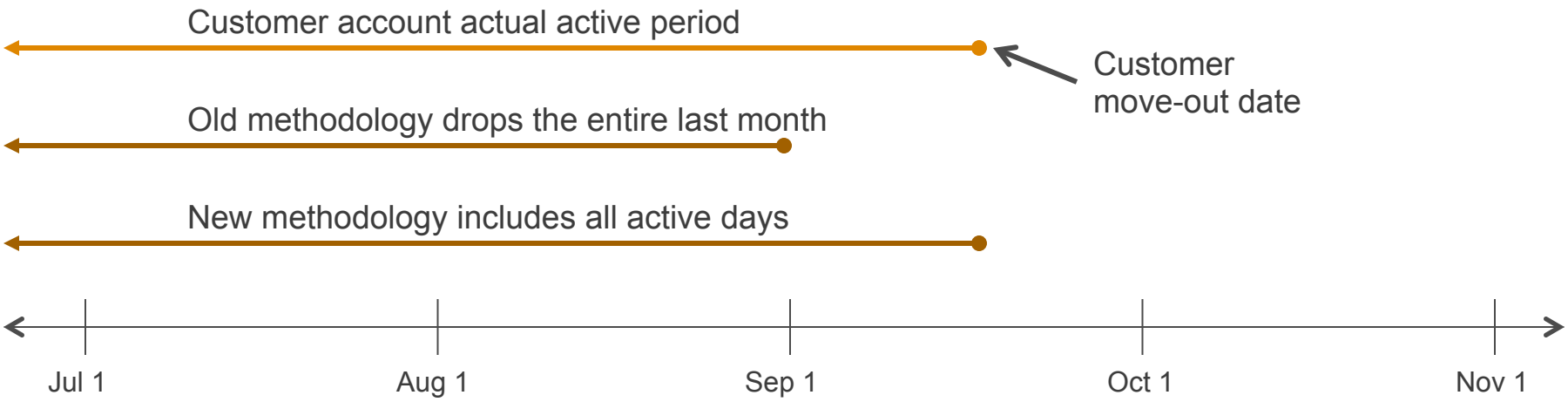
Program start date now defined in most consistent possible way.
Program start date is set to the first of the month prior to the first report generation date. This ensures that all savings are captured in the measurement



Data

Customer Inactive Date

Customers contribute to savings for their entire active period
The old methodology counted savings only for months in which customers were active for the entire month. Customers who moved-out of their homes in a given month were dropped for the entire month, even if they moved-out on the last day of the month. The new methodology counts savings for all active days.



Appendix

M&V models

Household Fixed Effects model (Traditional)

```
areg usage_per_day c.treatment##c.post i.mm,  ///
                   absorb(id) vce(cluster id)
```

Post-Period Regression with Pre-Usage Controls (New)

```
reg usage_per_day treatment ///
                  i.mm##c.pre_usage ///
                  i.mm##c.pre_winter ///
                  i.mm##c.pre_summer ///
                  if post == 1, vce(cluster id)
```

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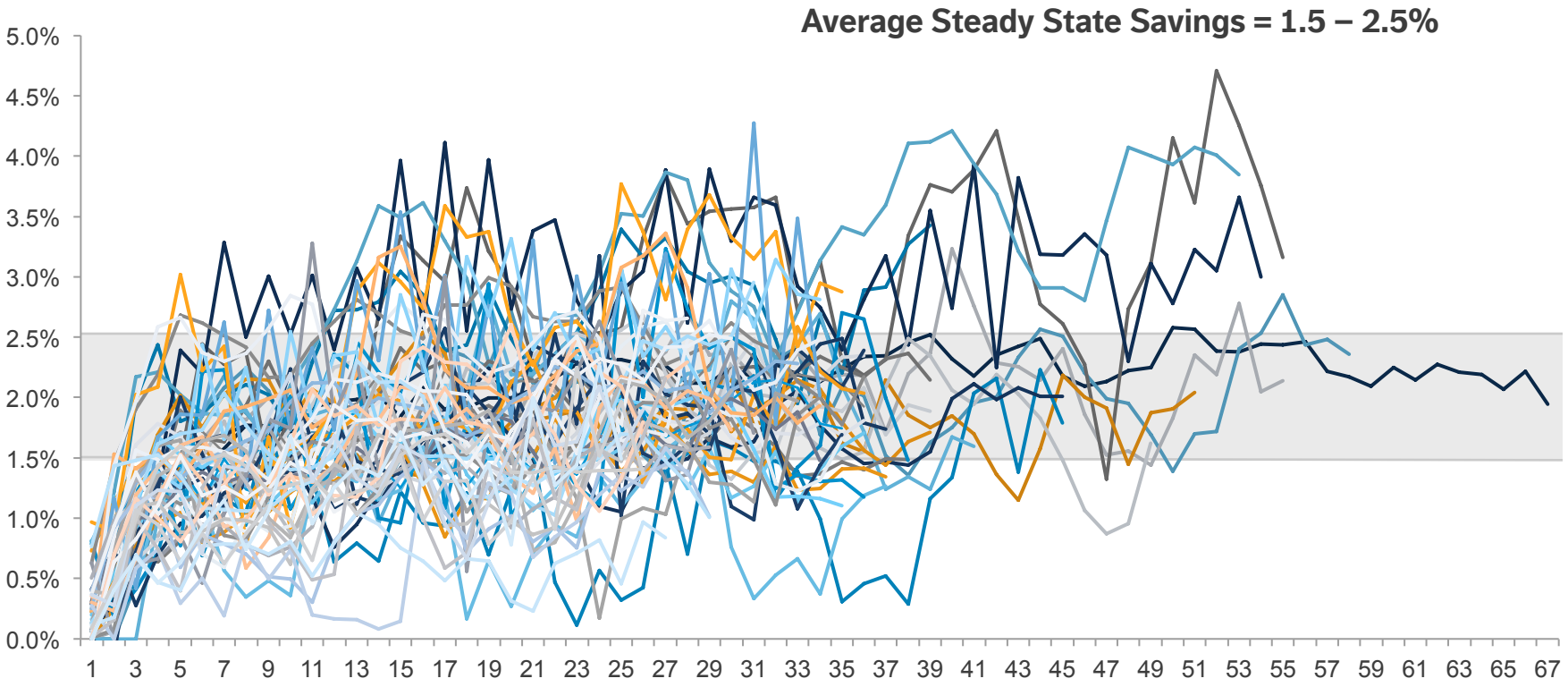
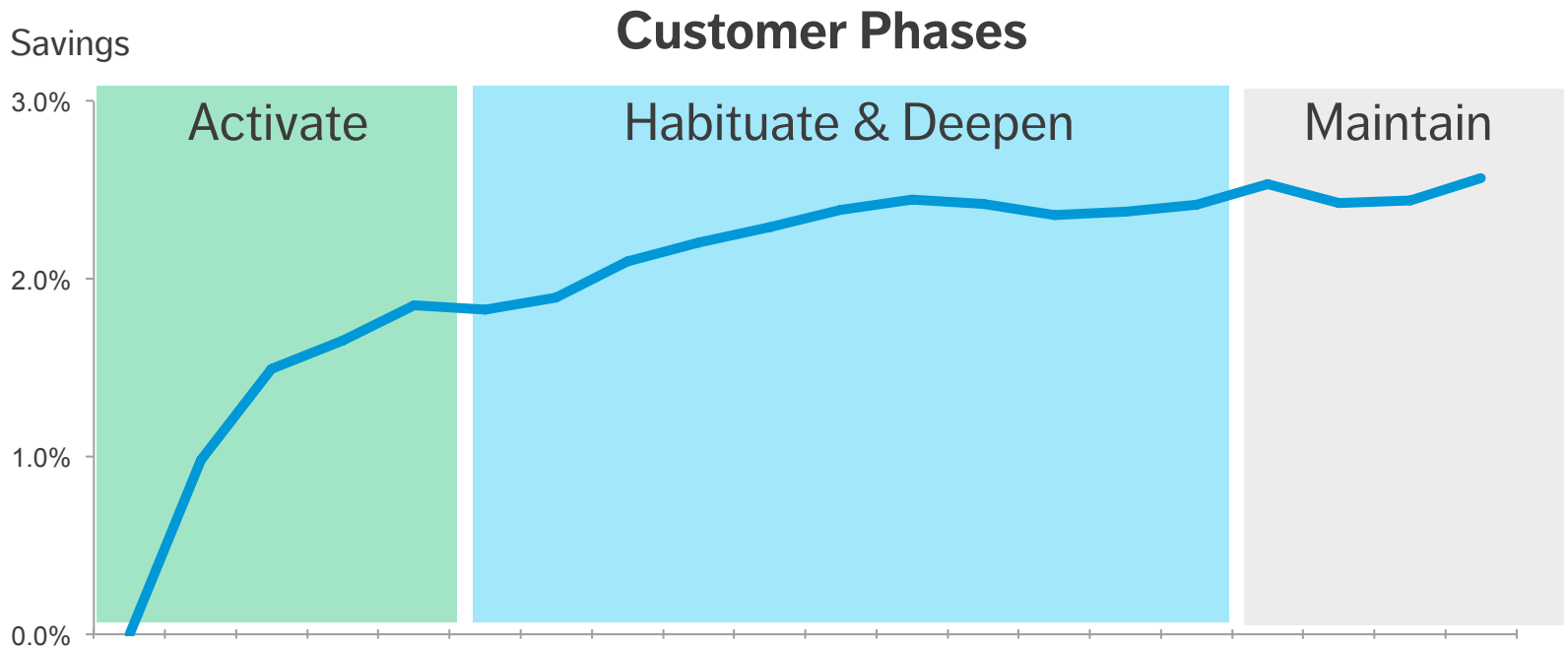
Durability of Energy Savings Beyond Year 3

In-treatment: More than 300 program years of savings



In-treatment: Opower savings curve over time



- Savings rapidly increase
- Reports are novel; customer have high recall and sharing rates

- Savings continue to grow gradually
- Savings are smooth between reports; customers have developed daily efficiency habits
- Customers exhibit “tracking” behavior with reports

- Savings grow at reduced rate
- Customers continue to exhibit tracking behavior

In-treatment: Durability of savings confirmed

Independent evaluations of multi-year Opower electric deployments

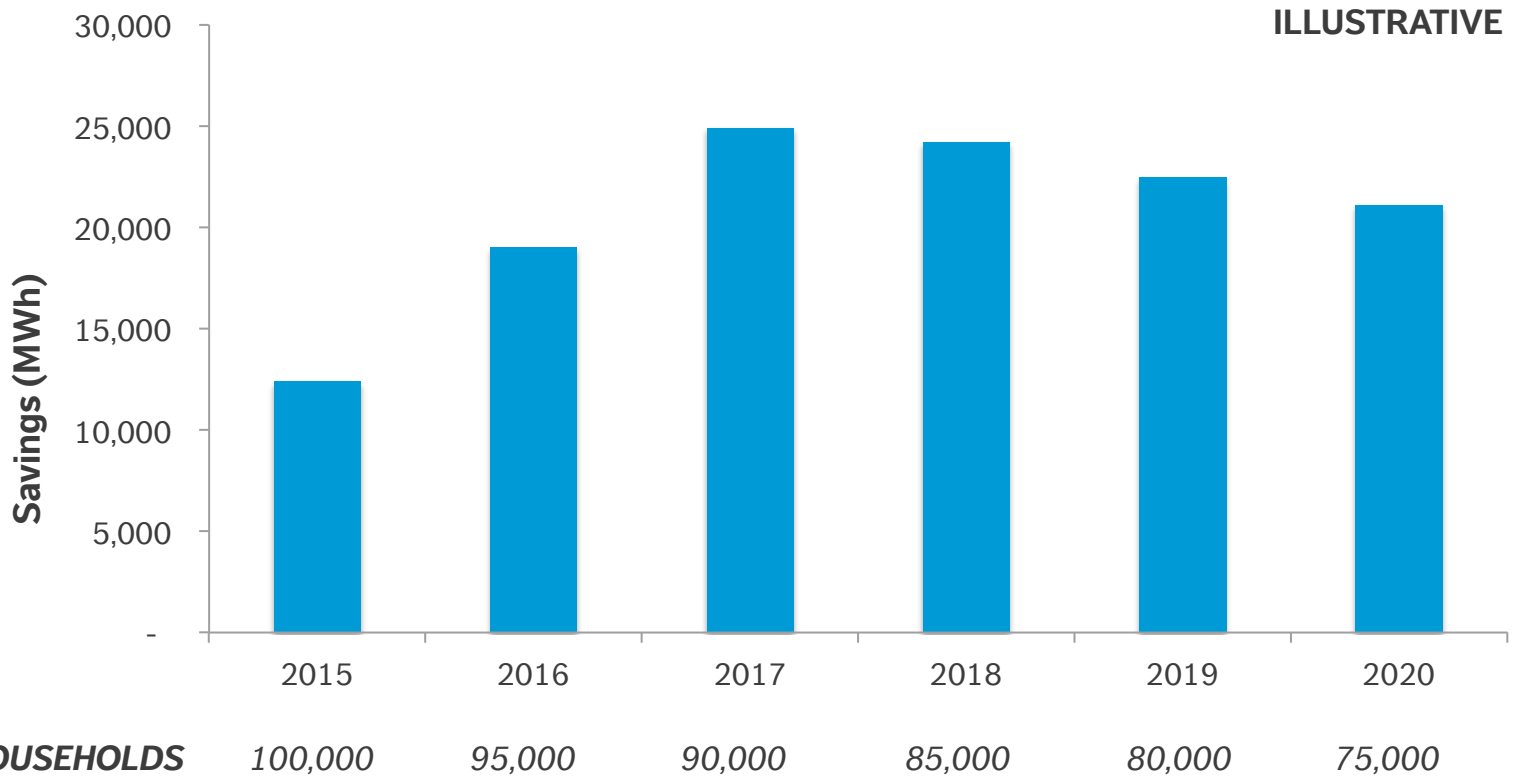
Utility / Evaluator	Y1		Y2		Y3		Y4		Y5	
	%	kWh	%	kWh	%	kWh	%	kWh	%	kWh
SMUD (High Usage)/ Navigant	2.4	317	2.9	381						
SMUD (Low Usage)/ Navigant	1.3	76	1.7	104						
Puget Sound Energy/ KEMA	-	170	-	235	-	274	-	306	-	334
National Grid (MA) Wave 1/ODC	1.6	184	2.1	223	2.4	263				
National Grid (MA) Wave 2/ODC	1.3	152	1.7	196	2.1	260				
Ameren Illinois Company/ODC	1.2	-	1.5	-						
ComEd (IL) Wave 1 / Navigant	1.4	-	1.8	-	2.2	-	2.2	-		

Independent evaluations of multi-year Opower gas deployments

Utility / Evaluator	Y1		Y2		Y3		Y4		Y5	
	%	Ths	%	Ths	%	Ths	%	Ths	%	Ths
Puget Sound Energy/ KEMA	-	11	-	14	-	12	-	13	-	15
National Grid (MA)/ ODC	0.8	10	1.3	17	1.6	19				
Ameren Illinois Company/ODC	0.7	-	1.1	-						

Impact of Attrition on Total Annual Savings

Savings may continue to increase on a percentage and per household basis, due to household attrition, it is possible that total annual savings will decrease in outer years



Savings have been verified by over 50 independent evaluations and counting

Evaluator	Utility	Results
Opinion Dynamics & Navigant	NSTAR & National Grid (MA)	1.25 – 2.06%
Navigant Consulting	ComEd (IL)	1.55 – 2.02%
KEMA	Puget Sound Energy (WA)	1.3% & 2.6%
Hunt Allcott, MIT	17 deployments	1.4 – 3.3%
Opinion Dynamics & Navigant	National Grid (MA)	1.61%
EDF	11 deployments	0.9 – 2.9%
Navigant Consulting	SMUD (CA)	1.3 – 2.9%
KEMA	Puget Sound Energy (WA)	1.26 & 1.84%
LBNL (meta-analysis)	Puget Sound Energy (WA)	1.26 & 1.84%
Power System Engineering	Connexus (MN)	2.05 – 2.10%
Power System Engineering	Lake Country Power (MN)	2.73 – 2.81%
Hunt Allcott, MIT	N/A	2.70%
Hunt Allcott, MIT	Connexus (MN)	2.3 – 2.4%
Ian Ayres, Yale	SMUD (CA) & Puget Sound Energy (WA)	2.1% & 1.2%
Summit Blue (d/b/a Navigant)	SMUD (CA)	2.13 – 2.24%

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Evaluator	Utility	Results
Opinion Dynamics & Cadmus Group	Ameren (IL)	1.14% & 0.70%
Integral Analytics, Inc.	SMUD (CA)	2.2%
Navigant	ComEd (IL)	2.20%
Navigant	Progress Energy Carolinas (NC)	1.23%
KEMA	Puget Sound Energy (WA)	2.8% and 1.3%
NMR	Connecticut Light & Power (CT)	2.2% (monthly); 1.2% (quarterly)
Freeman, Sullivan & Company	Pacific Gas & Electric (CA)	0.9% - 1.5% and 0.4% - 0.9%
Navigant	AEP Ohio (OH)	2.00%
Opinion Dynamics	NSTAR, National Grid (MA)	0.89 - 2.47% and 0.50 - 1.80%
ADM Associates	Indiana Michigan Power (IN)	1.70%
TecMarket Works	Indianapolis Power & Light (IN)	1.00%
Navigant	ComEd (IL)	1.16 – 2.2%
Evergreen Economics	Hawaii Energy (HI)	1.73%
Navigant	AEP Ohio (OH)	1.99%

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Evaluator	Utility	Results
KEMA	Pacific Gas & Electric (CA)	3.2 – 25.3 kWh/HH
KEMA	San Diego Gas & Electric (CA)	2.2%
James Stewart and Pete Cleff	PPL Electric (PA)	1.7 – 2.2%
Opinion Dynamics, Navigant	Ameren Illinois (IL)	0.92 – 1.65%
KEMA	National Grid (NY)	2.30%
Cadmus	PPL Electric (PA)	2.00%
Navigant	Duke Energy Progress (NC)	1.63%
ADM Associates, Inc	Center Point (AR)	1.00 – 1.96 %
ADM Associates, Inc	SourceGas (AR)	17.54 Therms/HH
DNV GL	Puget Sound Energy (WA)	3.00%
ADM Associates, Inc	First Energy Ohio (OH)	175.24 kWh/HH