Dynamic pricing works in a hot and humid climate

Evidence from Florida

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THE **Brattle** GROUP

There is some debate about the efficacy of dynamic pricing in hot and humid climates

Peak load is higher due to air conditioner use

- More opportunity to reduce load

But how much of this is discretionary?

- Comfort and health

Can customers reduce load without materially reducing comfort?

- Pre-cooling?
- Temperature off-set?
- Get out the house?
- Shift loads to later?
- Shift or reduce heat emitting loads?

We examine the impacts of dynamic pricing on conservation and load shifting in Florida

We evaluate the Energy Smart Florida (ESF) pilot study conducted by Florida Power and Light (FPL)

Pilot was both technological and behavioral

- In Home Displays (IHDs)
  - Better feedback over energy usage in near-real time
- Home Energy Controllers (HECs)
  - Same display as IHD
  - Control over thermostat, hot water heater and pool pump
- Critical Peak Price (CPP)
  - Behavioral and automated reactions to higher prices

The HEC connected with the smart meter and controlled devices using a one way HAN radio

- Technology was cutting edge in 2011
  - Replaced by internet of Things (IOT)

Customers were randomly offered one of three treatment groups

Treatment 1 (T1) - IHD

- Direct feedback over energy use

Treatment 2 (T2) - HEC

- Direct feedback over energy use
- Enhanced control

Treatment 3 – HEC and CPP

- Direct feedback over energy use
- Enhanced control
- CPP tariff
  - 12 peak events with peak price ~3 times higher than off-peak
  - ~ 10% discount in all other hours

Group	Sample Size
Control	378
T1	218
T2	107
T3	114

The three treatments yield several testable hypotheses

Conservation

- Better feedback over energy usage will induce conservation (T1, T2, T3 < C)
- Customers with increased control will conserve more (T2, T3 > T1)
- The critical peak price will increase the saliency of energy usage (T3 > T2)

Load shifting

- Customers will reduce load in the peak period (T3)
- Customers will shift load from the peak period to the periods preceding or following (T3)

The evaluation was conducted "double blind"

FPL did not share their knowledge of customer acceptance or technological issues

- Conducted 5 rounds of customer feedback during and after pilot
- Monitoring of technology
- Interactions with customers through complaints and truck rolls

Brattle did not inform FPL of the evaluation until it was complete

**The double blind approach helped remove "confirmation bias"**

Customer self-selection into treatments may induce a bias towards conservation if unaccounted for

Customers who opt-in to treatment may be different

- E.g. more conservation minded
- Analysis of load data shows similar usage patterns between treatment and control groups
- Account for this using customer lifestyle effects – fixed over time

Customers may opt-in to treatment given a change in lifestyle

- Unlikely given the narrow enrollment window
- Difficult to account for
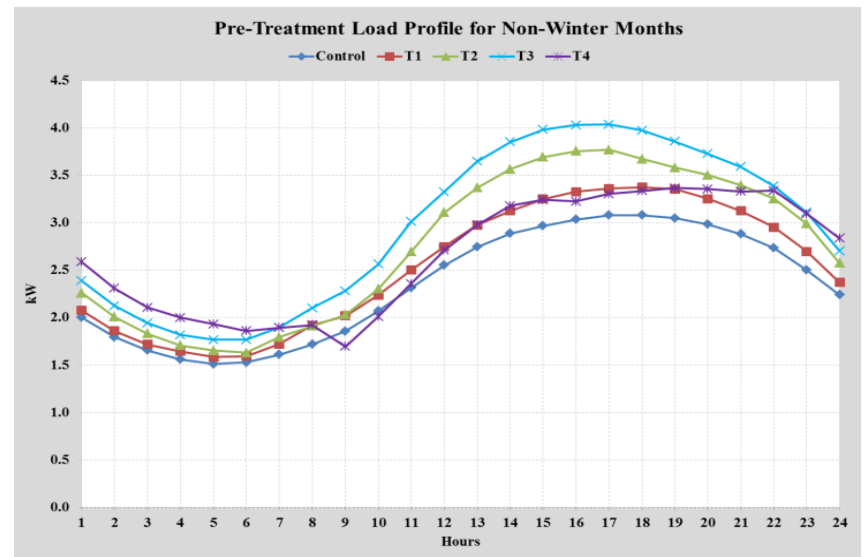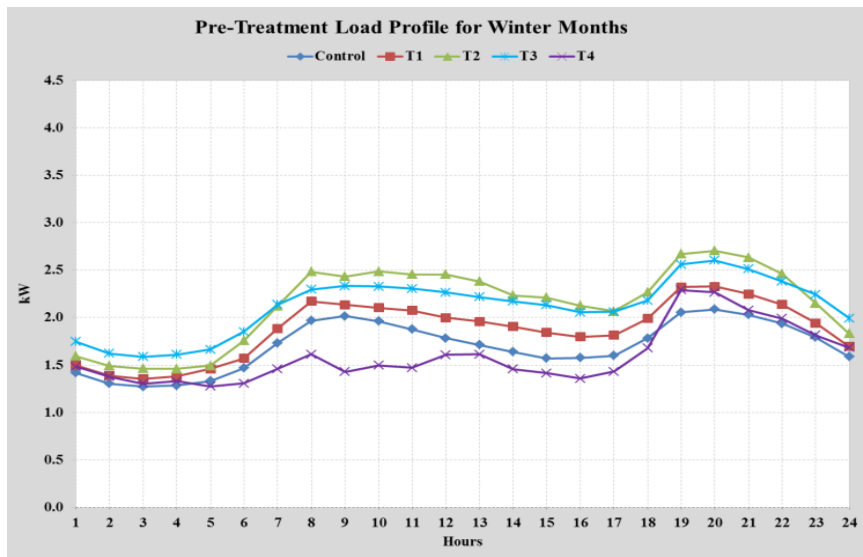
All estimation is conducted using a difference-in-difference methodology

The impact measure estimates:

- the difference between the treatment and control group in the treatment period
- net of any pre-existing differences

	Control Group	Treatment Group
Before Treatment	Cpre	Tpre
After Treatment	Cpost	Tpost

True Impact Measure = (Tpost-Cpost)-(Tpre-Cpre)

We included controls for fixed individual lifestyle effects, weather and calendar effects to increase precision

Conservation impacts were estimated at the daily level

Load shifting impacts were estimated for each hour in each event day using hourly level data

There are no statistically significant conservation impacts apart from treatment 3 in the winter months
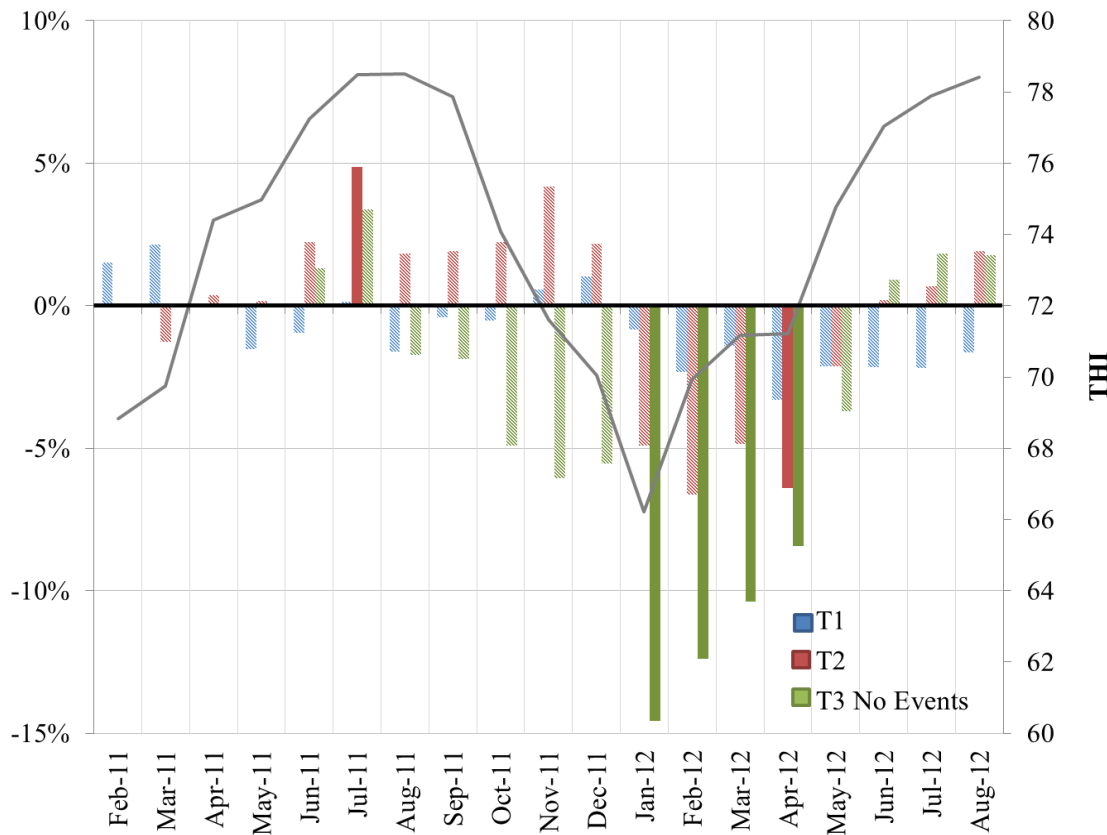

There is no statistically significant average conservation impact

- Test individually, all combined and HEC combined
- Minimal detectable impact for combined treatment is ~2%

We find that conservation has a statistically significant negative correlation with THI (the 'discomfort' index)

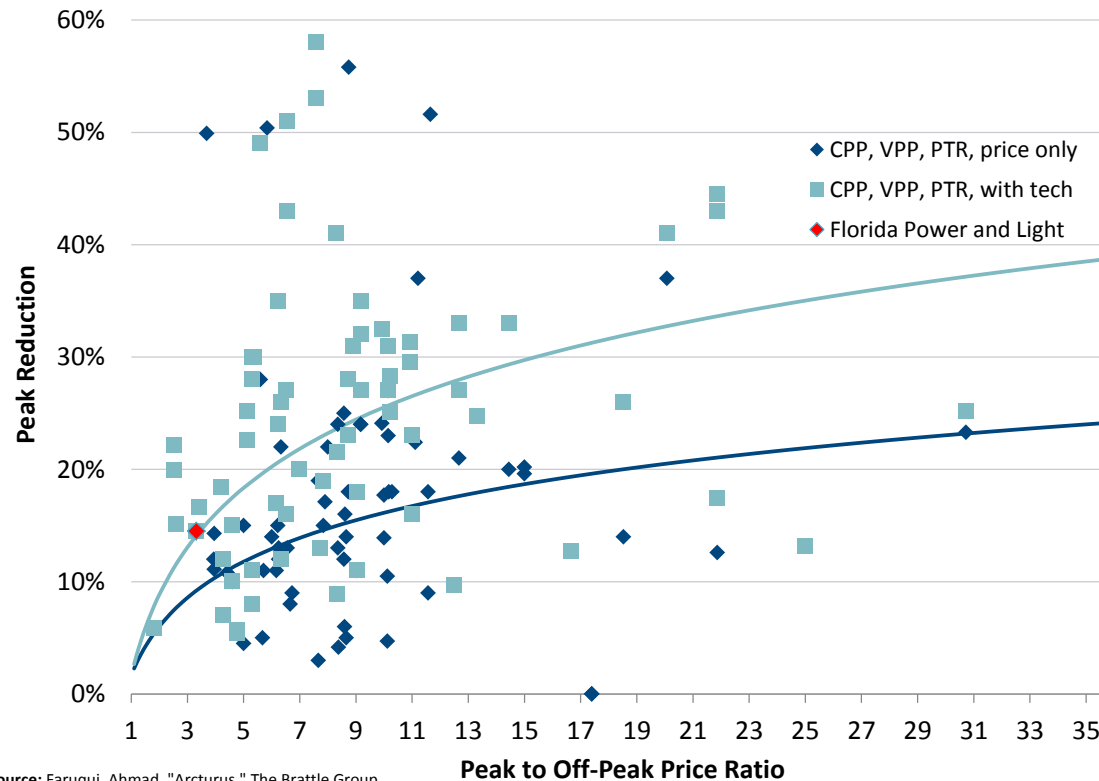# We found statistically significant evidence of load shifting for each event
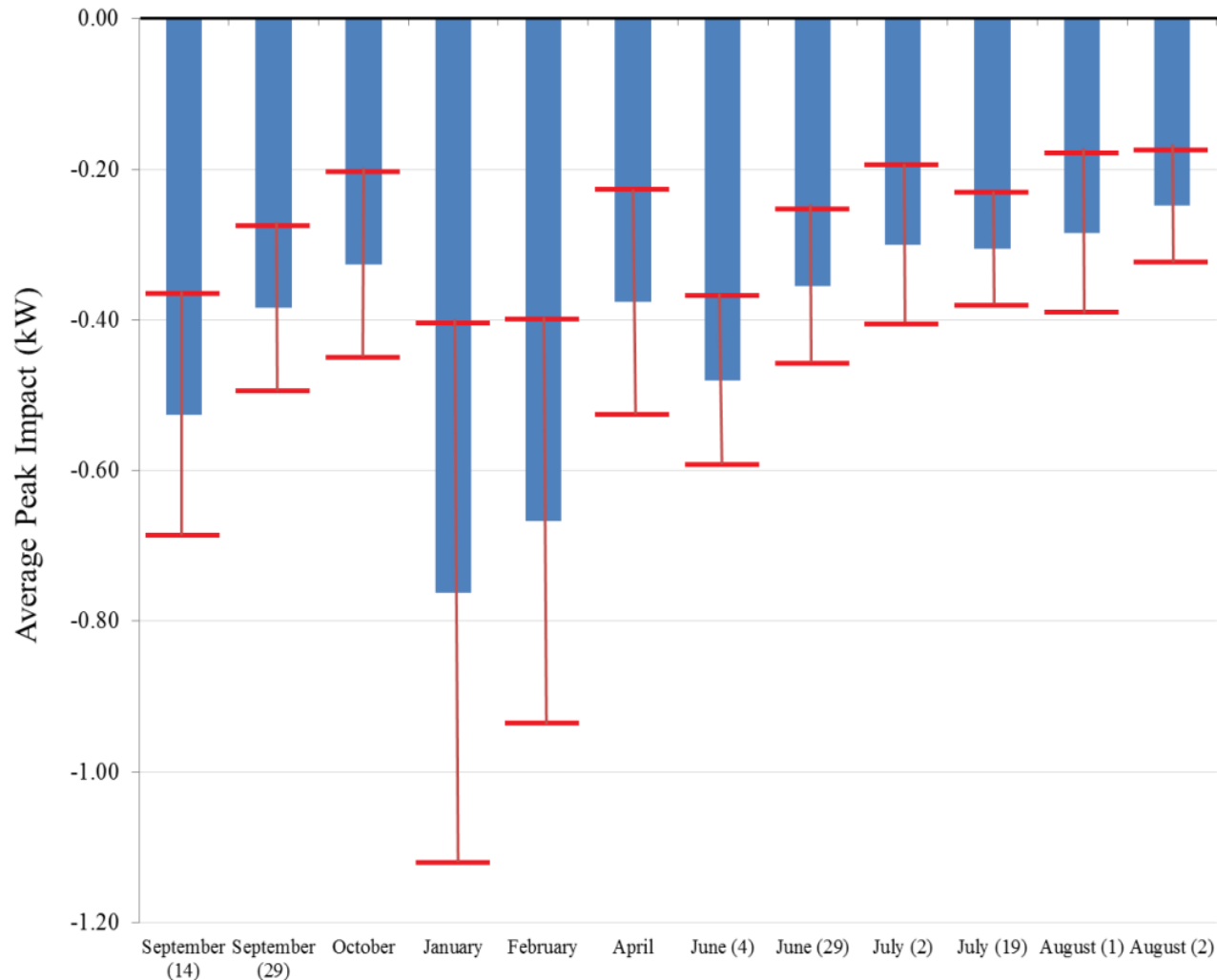
Note: Red bars indicate the 95 % confidence interval

Winter impacts were very large in percentage terms due to lower average load
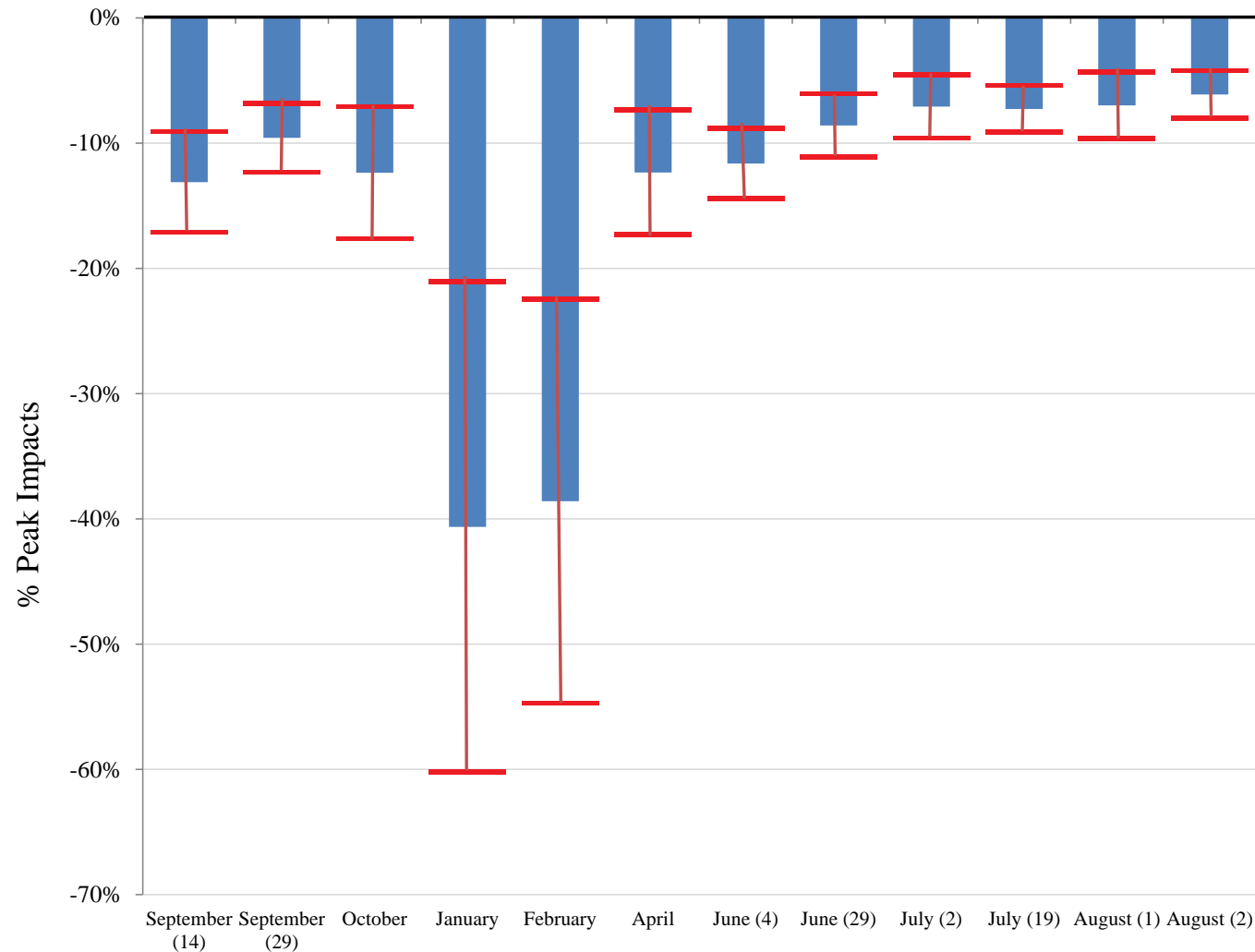
Note: Red bars indicate the 95 % confidence interval

Overall impacts are inline with what we have observed in 144 other dynamic pricing pilots around the world

Source: Faruqui, Ahmad. "Arcturus." The Brattle Group.
Notes: Chart includes 68 data points from dynamic pricing treatments without enabling technology and 70 data points with enabling technology.

Result is to some extent driven by large winter impacts

Summer load shifting impacts decreased over time

Initial hypotheses:

- Weather impacts – the second summer in the treatment period was hotter than the first
  - Results not statistically significant
- Treatment fatigue
  - Not testable with current data

New hypotheses after "double blind" removed

- Equipment failure increased over time
  - One way communicating radios made it difficult to know if equipment was communicating
  - Data indicates "join rate" fell over time
- Customer learning (increased equipment over-rides)
  - Evidence from surveys shows that override behavior increased

We found that customers in a hot and humid climate can and do respond to dynamic pricing.

On critical peak event days customers reduced their peak period usage by 14.5% compared to what they would have used otherwise.

- Reductions during winter event days were twice as large as those on non-winter event days

There was limited evidence of conservation

- Only during winter for the treatment group with HECs and CPP

Evidence is suggestive that while total summer load is higher, discretionary load is lower

Appendix

Table 1 – Standard Price versus Smart Price

FPL standard price (RS-1) Customer charge: $5.90 per month	FPL Smart Price (RSDPR-1) Customer charge: $4.75 per month	
Cost per kilowatt-hour (kwh):	at least 99% of the time	during Conservation Price Hours (up to 1% of the time)
up to 1,000 kwh 8.714¢	8.823¢	30.845¢
over 1,000 kwh 10.714¢	9.823¢	31.845¢

Prices reflect fuel and non-fuel charges effective June 1, 2011. Taxes and the standard storm charge are not included.

About Table 1: FPL's "customer charge" is the fixed monthly fee for electric service. You also pay for the electricity you consume per kilowatt-hour (kwh). The price per kwh varies, depending on how much energy you use (more or less than 1,000 kwh) during each billing period. FPL Smart Price participants will pay an overall discounted price for electricity 99 percent of the time, including the customer charge plus the cost of electricity per kwh. You will pay a much higher price up to 1percent of the time during CPHs.

Table 2 – Smart Price Discount

Average monthly energy use (kwh)	Annual discount with no Conservation Price Hours
1,000	$0.72
1,500	$54.12
2,000	$107.64
2,500	$161.04

About Table 2: Table 2 shows the annual discount you could realize from FPL Smart Price based on your average monthly energy usage. We'll designate occasional CPHs when energy conservation is needed, and your savings over the year-long pilot will be affected by how you respond during these periods. If you reduce your energy use during CPHs, you will save. If you ignore the CPHs, expect to offset your discount and pay about the same as you do today. If your energy use increases during CPHs, you could pay more. Actual savings will vary, depending on how much energy you use during CPHs.

Conservation impacts were estimated using daily level data

$$kWh_{it} =$$
$$\beta_o +$$
$$\sum_{G=1}^{3}(\beta_{1G} * TreatCust_{G_i} + \beta_{2G} * TreatPeriod_{G_t} + \beta_{3G} * TreatCust_{G_i} * TreatPeriod_{G_t}) +$$
$$\beta_4 * CPPDay_t + \beta_5 * CPPDay_t * TreatCust_{3_i} + \beta_6 Month_t + \beta_7 * THI_t + \beta_8 * Month_t * THI_t +$$
$$\beta_9 * DayOfWeek_t +$$
$$\beta_{10} * FE_i + \varepsilon_{it}$$

Where:

|	
$TreatCust_{G_i}$	: Dummy variable indicating that customer *i* is in treatment group *G*
$TreatPeriod_{G_t}$	: Dummy indicating the treatment period for treatment group *G*.
$TreatCust_{G_i} * TreatPeriod_{G_t}$	: Dummy indicating that customer *i* is in treatment group *G* and is receiving treatment
$CPPDay_t$	: Dummy indicating that a CPP event occurred on that day
$CPPDay_t * TreatCust_{3_i}$	: Dummy indicating that a CPP event occurred and customer *i* was in treatment group 3.
$Month_t$	: Month of the year specific effects
THI_t	: Average daily Temperature Humidity Index
$Month_t * THI_t$	: Month of the year specific THI effects
$DayOfWeek_t$	: Day of the week specific effects
FE_i	: Customer specific effect
ε_{it}	: Error term, assumed to be clustered at the individual level

Load shifting impacts were estimated for each hour in each event day using hourly level data

$$kW_{it} = \beta_o + \beta_1 * TreatCust_{3_i} + \beta_2 * TreatPeriod_{3_t} + \beta_3 * TreatCust_{3_i} * TreatPeriod_{3_t} + \beta_4 * CPPDay_t + \beta_5 * CPPDay_t * TreatCust_{3_i} + \beta_6 Month_t + \beta_7 * THI_t + \beta_8 * Month_t * THI_t + \beta_9 * DayOfWeek_t + \beta_{10} * FE_i + \varepsilon_{it}$$

Where:

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$TreatCust_{3_i}$	: Dummy variable indicating that customer *i* is in treatment group *3*
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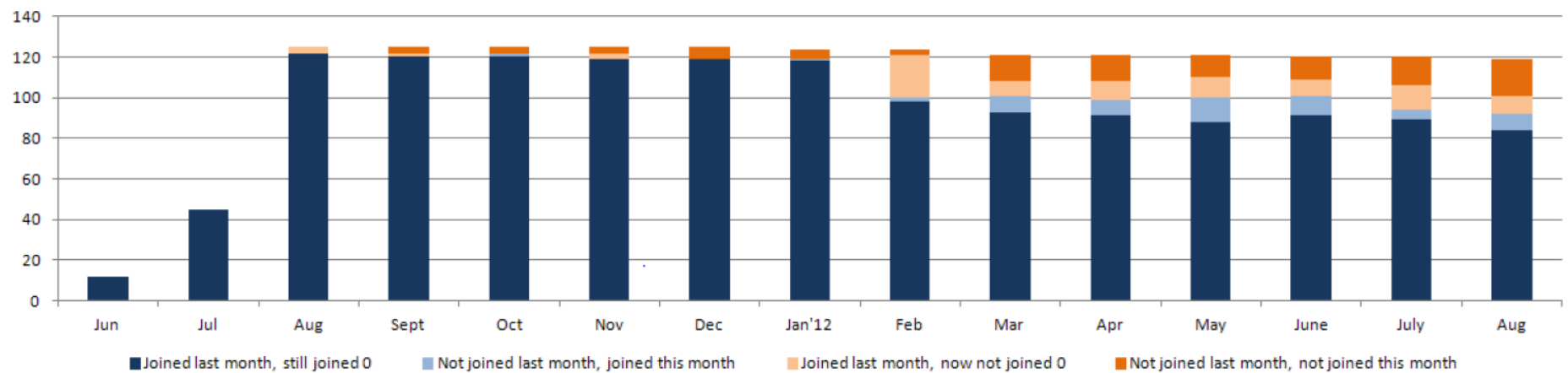# Example of estimation for September events by hour
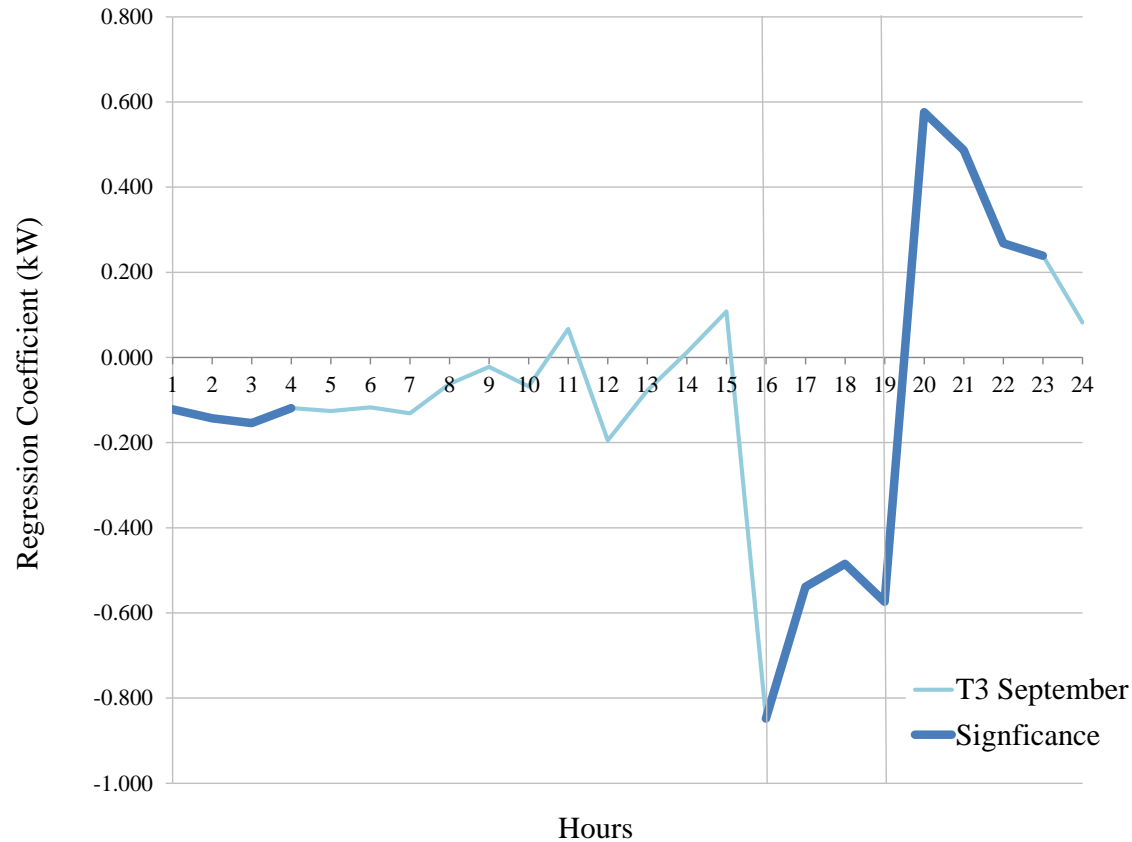
Note: The dark shaded line indicates statistical significance

Indications of Learning Over Time

Notice CPP events, Override thermostat response
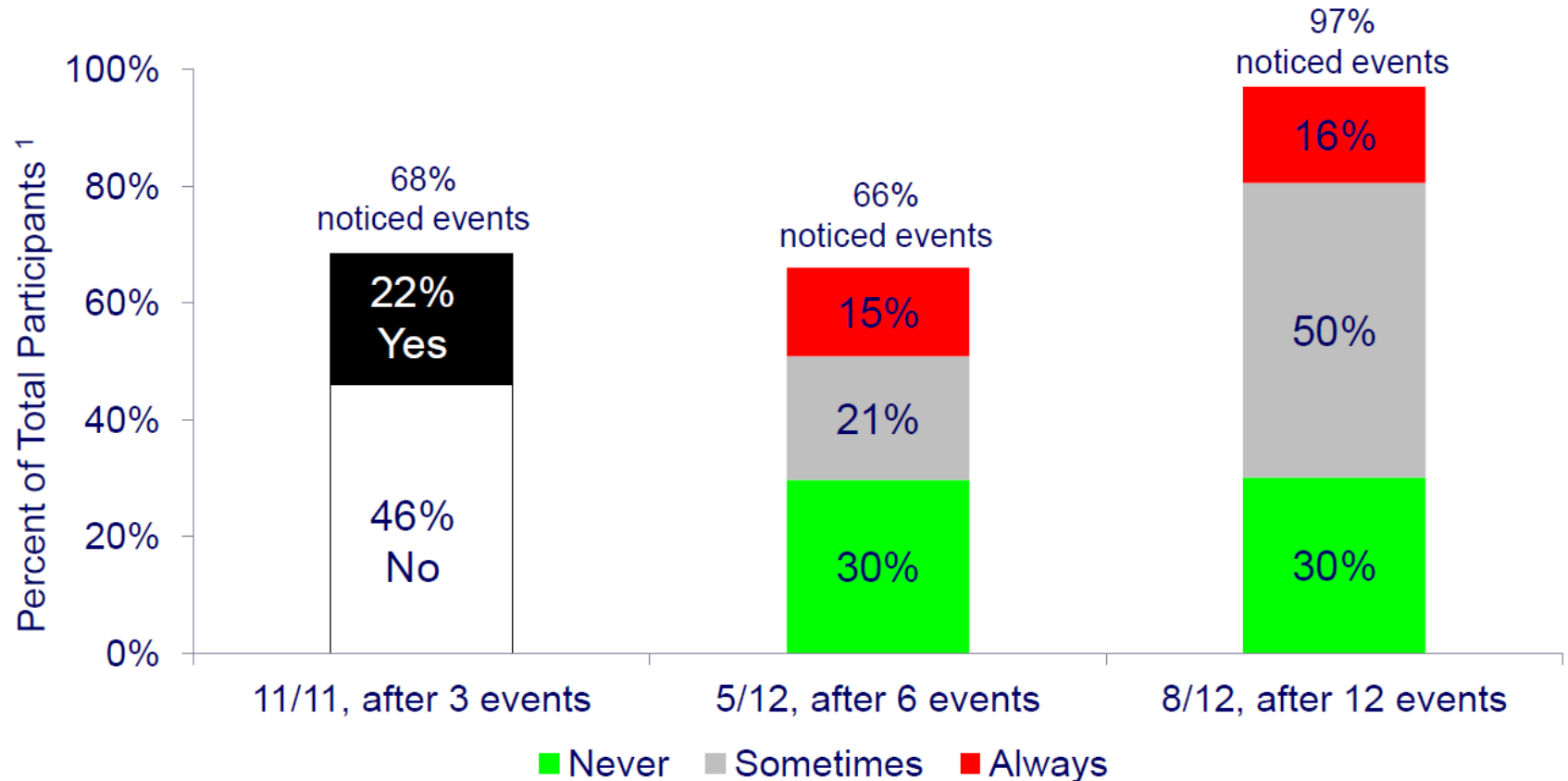
Join between Smart Meter and HEC Over Time

Presenter Information

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Neil Lessem is an expert on consumer behavior and energy markets. He has assisted clients around the world on issues such as wholesale market design, regulated tariffs and cost allocation, innovative customer and pricing programs, and policy impact measurement.

He has worked with more than 50 clients across North America, Asia-Pacific and the Middle-East. His clients include regulators, policy makers, utilities, system operators, consumer representatives, tech startups and infrastructure owners. He has published in peer-reviewed journals such as the Journal of Economics and Environmental Management and Business and Society; and trade journals such as The Electricity Journal and the Public Utilities Fortnightly. He has presented on pressing energy topics to audiences in Brazil, Hong Kong, the United States, Canada, Malaysia and Hong Kong. In his graduate studies, Neil Lessem conducted extensive research examining consumer adoption of environmentally-friendly products and conservation behaviors, utilizing both field experiments and utility data.

He holds a Ph.D. and M.A. in Economics from the University of California, Los Angeles and an honours degree in Business, Economics and History from the University of Cape Town.

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Ahmad Faruqui's consulting practice is focused on the efficient use of energy. His areas of expertise include rate design, demand response, energy efficiency, distributed energy resources, advanced metering infrastructure, plug-in electric vehicles, energy storage, inter-fuel substitution, combined heat and power, microgrids, and demand forecasting. He has worked for nearly 150 clients on 5 continents. These include electric and gas utilities, state and federal commissions, independent system operators, government agencies, trade associations, research institutes, and manufacturing companies. Ahmad has testified or appeared before commissions in Alberta (Canada), Arizona, Arkansas, California, Colorado, Connecticut, Delaware, the District of Columbia, FERC, Illinois, Indiana, Kansas, Maryland, Minnesota, Nevada, Ohio, Oklahoma, Ontario (Canada), Pennsylvania, ECRA (Saudi Arabia), and Texas. He has presented to governments in Australia, Egypt, Ireland, the Philippines, Thailand and the United Kingdom and given seminars on all 6 continents. His research been cited in Business Week, The Economist, Forbes, National Geographic, The New York Times, San Francisco Chronicle, San Jose Mercury News, Wall Street Journal and USA Today. He has appeared on Fox Business News, National Public Radio and Voice of America. He is the author, co-author or editor of 4 books and more than 150 articles, papers and reports on energy matters. He has published in peer-reviewed journals such as Energy Economics, Energy Journal, Energy Efficiency, Energy Policy, Journal of Regulatory Economics and Utilities Policy and trade journals such as The Electricity Journal and the Public Utilities Fortnightly. He holds BA and MA degrees from the University of Karachi, an MA in agricultural economics and Ph. D. in economics from The University of California at Davis.

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