ORACLE

Sundown Showdown

Behavioral Efficiency and Demand Response in Arizona

RUSSELL M. MEYER

—

Oracle | Opower

Behavior, Energy & Climate Change Conference

November 13, 2023 — Sacramento, CA

This Summer was *HOT*

Phoenix just endured the hottest month for any US city as historic heat streak comes to an end

By Jennifer Gray, CNN Meteorologist

3 minute read · Updated 2:26 PM EDT, Tue August 1, 2023

Phoenix's Month in Hell: A 31-Day Streak of Record Heat Ends

A continuous stretch of days reaching or exceeding 110 degrees has filled emergency rooms. On Monday, the city hit 108 degrees, breaking the run, but setting a new, brutal record.

Phoenix also sweated through a record 16 consecutive days when overnight lows didn't dip below 90 degrees (32.2 degrees Celsius), making it hard for people to cool off after the sun went down.

PBS NEWS HOUR

≡ Menu

By –
Associated Press

Leave your feedback

Phoenix hit 110 degrees on 54 days in 2023, setting another heat record

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f ♥

Nation   Sep 10, 2023 10:57 AM EDT

Russell M. Meyer. Oracle | Opower. Behavior, Energy & Climate Change Conference. November 13, 2023. Sacramento CA.

Keeping the grid up is a public health necessity!

Arizona power demand breaks records during heatwave

Reuters

July 18, 2023 9:54 AM EDT · Updated 3 months ago

APS touts infrastructure after Arizona's record-breaking summer heat wave

A Phoenix power outage amid a heat wave could possibly kill thousands, study says

If the city were to lose power for air conditioning, roughly half the city could end up in the emergency room

By Kate Selig

July 13, 2023 at 8:00 a.m. EDT

The Grid of the Future Involves End-Users

- We are asking a lot of the grid
  - Electrification can help decarbonize our energy use. We need to think carefully about how that is going to work.
- Decarbonizing the grid means more renewables.
  - Matching demand with supply makes can make that process easier.
  - There isn't a single solution that solves this.
- In extreme weather conditions, grid health is public health.
  - Heat waves (and other extreme weather events) are not going away.

- Customers have a role to play

Education + **Motivation** = **Action**

APS' Behavioral Programs
Translating Ability to Action

—

Program Types

- **Home Energy Report**
  - Ongoing energy efficiency communications
  - Multiple versions depending on rate code status
- **Plan Coach**
  - Ongoing peak-load reduction communications
  - Comes in two flavors depending on customer rate structure:
    - Time-of-Use rate Plan Coach
    - Demand rate Plan Coach
- **Energy Saving Days**
  - Event-based communication for particular days and hours
- **High Usage Alerts**
  - Lets customers know if they are on pace for a higher than normal electricity bill.

Education + Motivation = Action

Sample Communications
Education and Motivation!
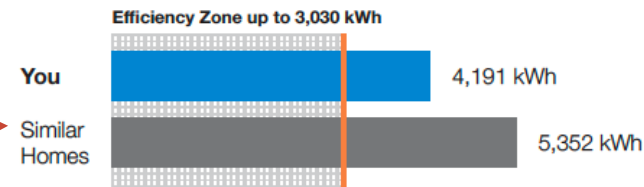
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Section of a **Home Energy Report**

Motivation

\+

Education

Your energy use at a glance

Fair | Good | Great

A closer look at your energy use
Jun 20, 2013 - Jul 21, 2013

Efficiency Zone up to 3,030 kWh

You — 4,191 kWh

Similar Homes — 5,352 kWh

Who are you being compared to?
Similar Homes includes homes in your area that have a similar square footage and heating/cooling type. The Efficiency Zone represents the similar homes that used the least energy this billing period.

❌ Your electricity use was not in the Efficiency Zone.

✅ You used 22% less electricity than similar homes.

Resolve to save
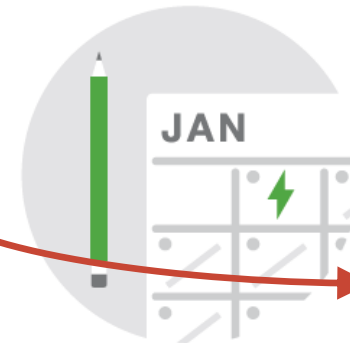
New year, new energy savings

You don't have to make major lifestyle changes to save energy—even small adjustments can have a big impact.

Turning off lights and power strips when you leave a room can help you save more energy each month. 2023 has just begun, and there's no better time to start saving.

→ Explore new ways to save at **aps.com/save**.

Tips to help you manage your usage

Use a smart thermostat to program your savings all day long

Avoid washing dishes during event hours

Sample Communications
Education and Motivation!

Section of a Plan Coach Report

Motivation

+

Education

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Sample Communications

Education and Motivation!

Section of a Energy Saving Day Alert
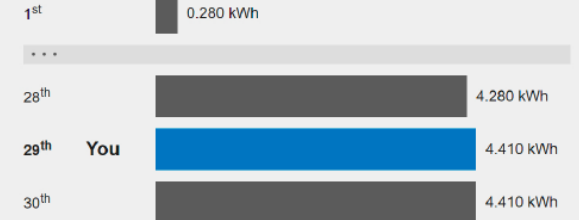
Motivation

+

Education

Please join your community in reducing energy use tomorrow:

January 13
11am – 5pm

You're currently the 29th most efficient among similar homes.

1st		0.280 kWh
. . .		
28th		4.280 kWh
29th	You	4.410 kWh
30th		4.410 kWh

Last Energy Saving Day: Monday, January 2, 11am – 5pm
Your rank is based on 100 similar homes in your area.

ℹ **What are Energy Saving Days?**

Energy Saving Days are an opportunity for you to take small actions to save energy when it's most needed. Together, we can more reliably meet energy needs throughout the region and help keep energy costs affordable for our community.

If you're on a time-of-use plan, the Energy Saving Day hours may not coincide with on-peak and off-peak hours. Continue to shift energy use to lower-cost off-peak hours before and after posted Energy Saving Day hours.

See more ways to save

Turn off lights when they're not in use during event hours
Turn off or reduce lighting in areas that aren't occupied. In areas that are occupied, take advantage of natural sunlight or spot lighting especially during Energy Saving Day hours.

Try to avoid using your oven during event hours
Plan ahead and use your oven outside of Energy Saving Day hours. If you need to heat your food, use the microwave or toaster oven instead of your larger oven.

Install a smart thermostat
If you install a smart thermostat, you can schedule it so your heating or cooling system runs less during Energy Saving Days

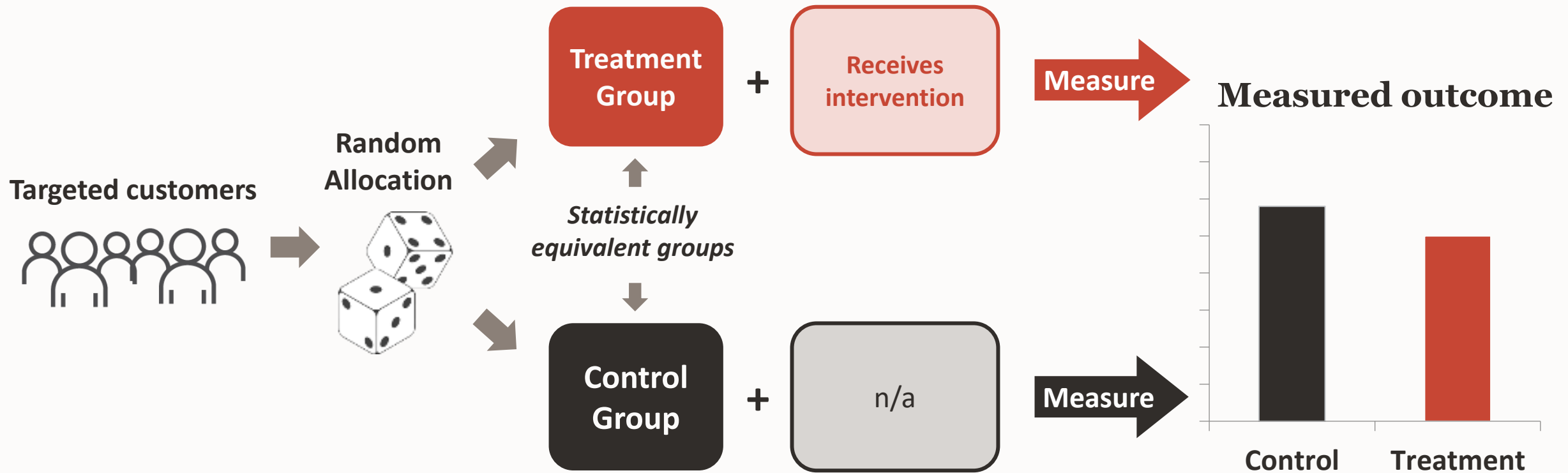# How do we know behavioral interventions actually make a difference?

Randomized Control Trials (RCTs) are the gold standard for impact measurement

RCT methodology endorsed by:

U.S. DEPARTMENT OF **ENERGY**

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Randomized Control Trials → Causal Inference

Targeted customers

Random Allocation

Treatment Group + **Receives intervention** → **Measure**

Statistically equivalent groups

Control Group + n/a → **Measure**

Measured outcome

Control   Treatment

Measurement Approaches

—

1. Simple Difference
   - Compare the means: treatment vs control
   - Readily understandable by the broadest audience.
   - Does not require pre-treatment data.

2. Fixed-Effects Regression
   - Increase effect precision by controlling for household-level pre-treatment idiosyncrasy
   - Narrower confidence intervals, more likely to find "statistically significant" effects

3. Lagged-Dependent Variable Regression
   - Improve the precision of the FE regression by consuming fewer degrees of freedom
   - Best estimation method for accuracy (required) and precision (maximized)

Measurement Methods Aside — FE & LDV

- General form of a fixed-effects regression:

$$y_{i,t} = \alpha_i + \beta x_{i,t} + \varepsilon_{i,t}$$

  - Absorbs time-invariant household variation in y_i via the inclusion of *i* α terms (consumes *i* degrees of freedom in doing so)

- Form of a lagged-dependent variable regression:

$$y_{i,t>0} = \alpha + \beta x_i + \delta \bar{y}_{t<0,i} + \varepsilon_{i,t}$$

  - Controls for pre-treatment household variation in y_i with a single continuous variable $\bar{y}_{t<0,i}$
  - Can include multiple forms of $\bar{y}_{t<0,i}$ to capture seasonality effects more robustly.
  - Can include time-fixed effects (same as FE model)

Measurement — LDV family of models

- Home Energy Reports
  - Measurement objective: cumulative kWh by month
  $$daily.usage_{i,t} = \alpha + \beta treatment_i + \gamma_t \mathbf{Y}_{o,i} + mm_t + \varepsilon_{i,t}$$
  - β is an estimate of daily treatment household kWh change

- Rate Coach
  - Measurement objective: monthly average kW by hour of day
  $$hourly.usage_{i,t} = \alpha + \beta_t treatment_i + \gamma_t \mathbf{Z}_{o,i} + \varepsilon_{i,t}$$
  - β_t is an estimate of treatment household average monthly kW change in hour of day t
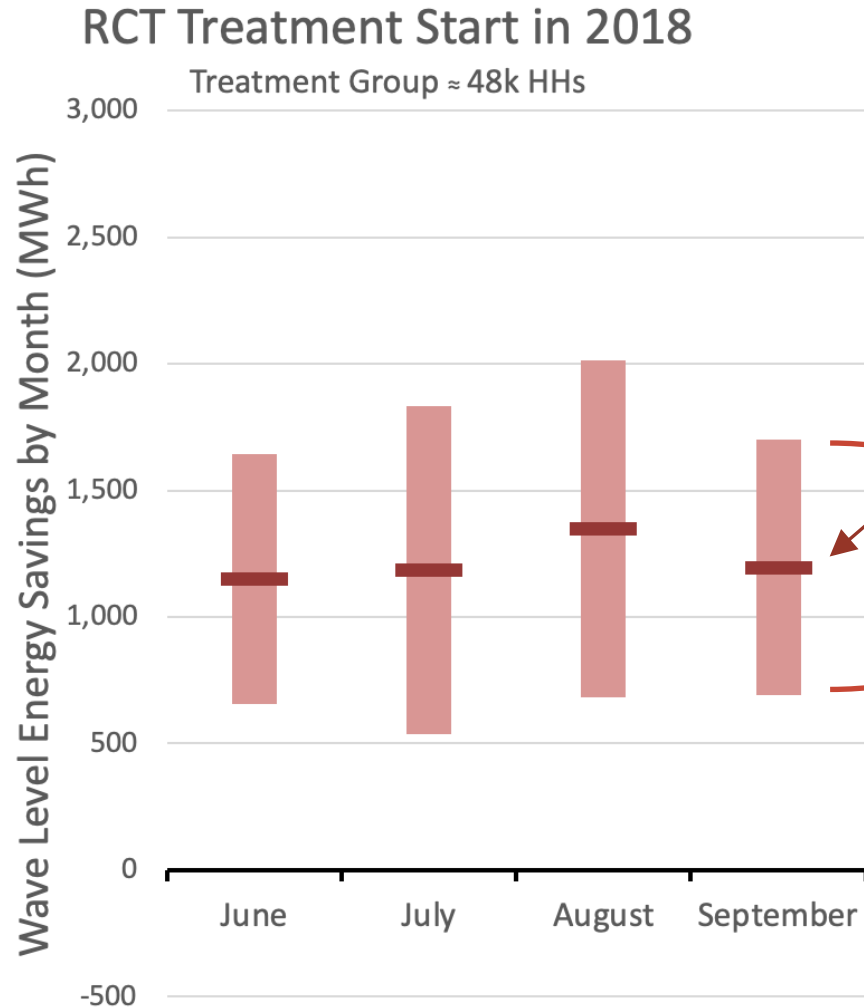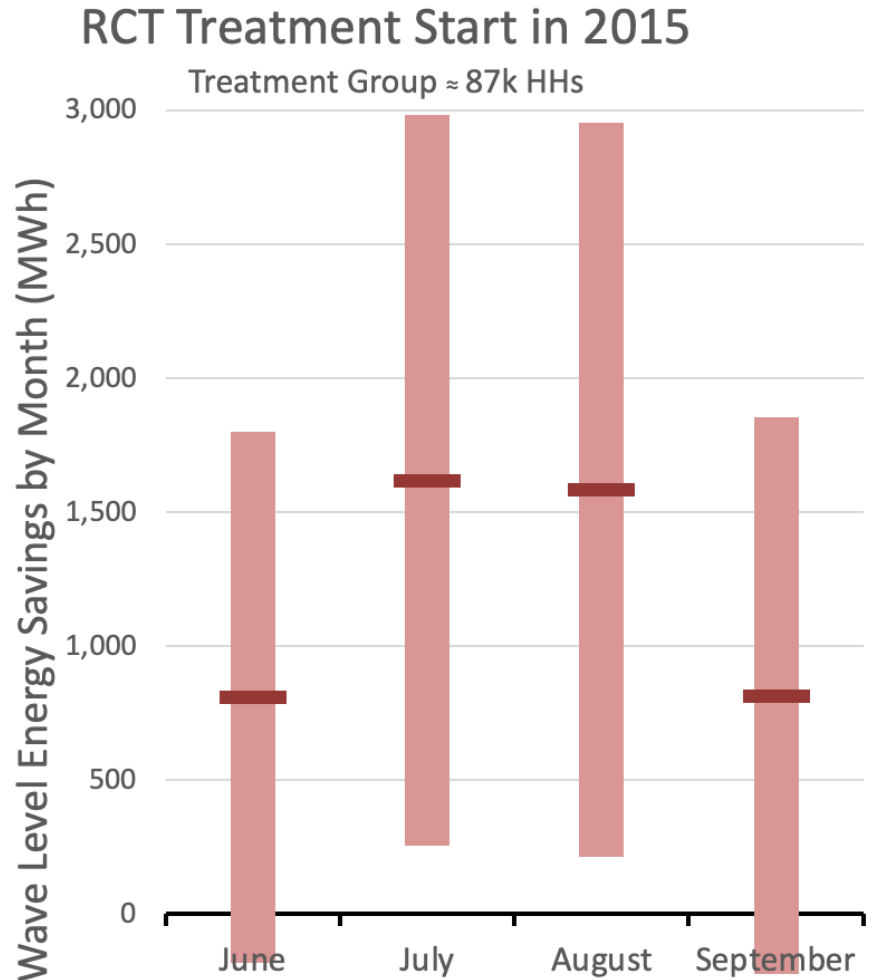
- Behavioral Demand Response Event
  - Measurement objective: kW for specific single hour
  $$hour.usage_i = \alpha + \beta treatment_i + \gamma X_i + \varepsilon_{i,t}$$
  - β is an estimate of treatment household kW change for a single given hour

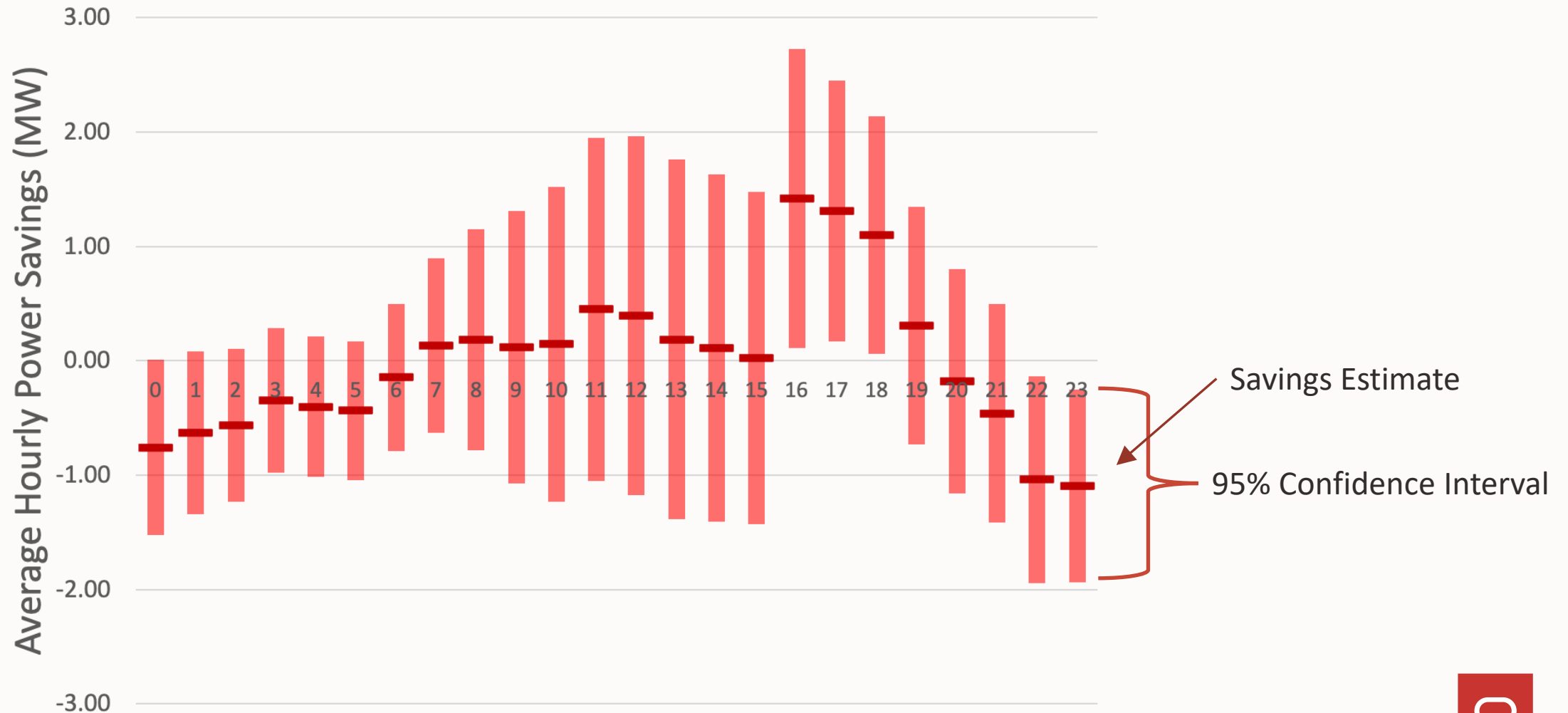# Example Results – Home Energy Report Energy Savings for 2 Waves

Example Results – Plan Coach Hourly Average Savings, July

RCT Treatment Start in 2021

Treatment Group ≈ 37k HHs

Savings Estimate

95% Confidence Interval

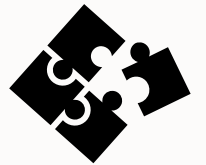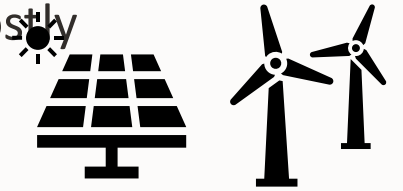# Does Behavioral Work When It's **HOT**?

- ≈500,000 Households received behavioral communications this past summer
  - Most households are enrolled in multiple streams of communications
- Home Energy Reports saved >21 GWh of energy between June and September.
  - Nearly 6.5 GWh in July alone!
- Average demand savings topped 20MW for the 4pm hour in both July and August across all RCTs!

August Average Hourly Behavioral Savings (MW)
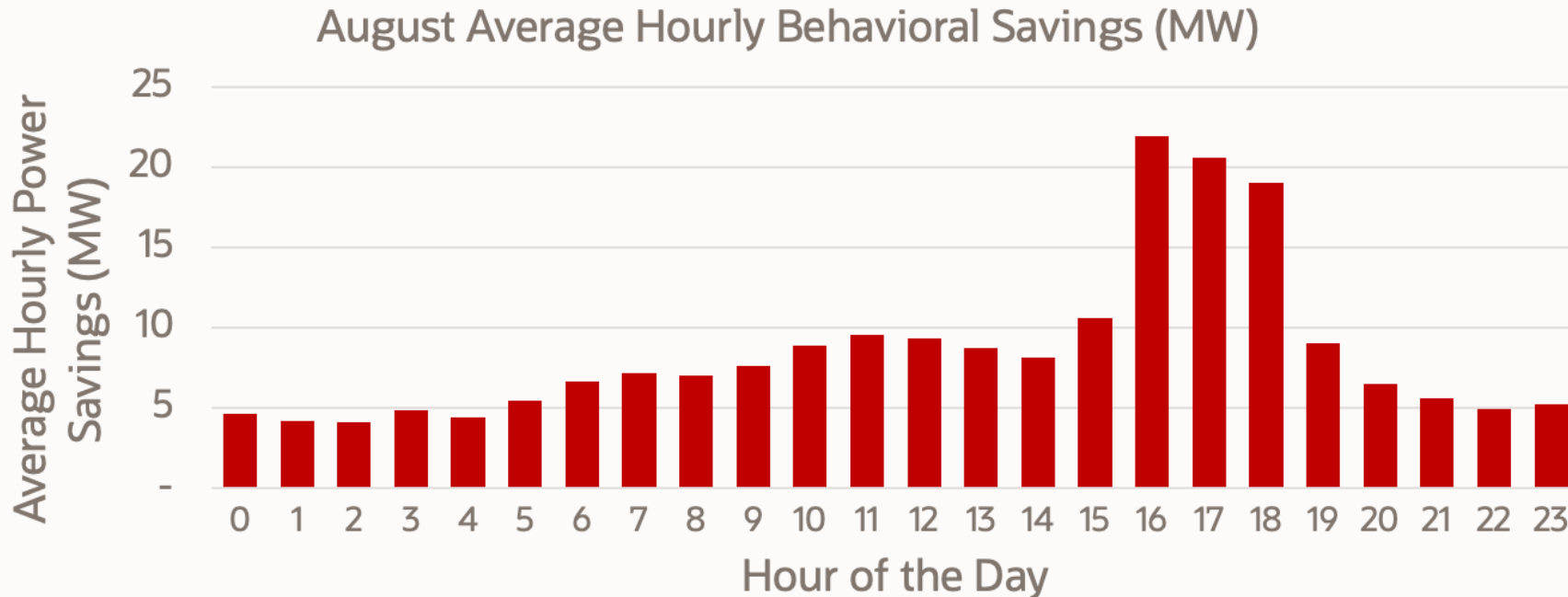
Key Takeaways

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- We are increasing our reliance on the electricity grid for a broader variety of energy needs.

- Renewables are coming online at a faster and faster rate, but are intermittent without costly energy storage.

- Energy (and climate) challenges rarely (ever?) have a single silver bullet solution. A variety of pieces are needed to solve the puzzle.

- End-use customers can be enlisted to align demand with supply (and distribution capacity) as a part of the solution to building out a modern energy delivery system!

Thank You!

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