

The logo for CADMUS, featuring the word "CADMUS" in white, uppercase letters on a blue rectangular background. Below this, a yellow horizontal bar with a white arrow pointing to the right is partially visible.

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# Peak-Coincident Demand Savings from Residential Behavior-Based Programs

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# Research

- Issue
  - Electricity savings of PPL Electric behavior-based (BB) program during system peak hours
- Approach
  - Hourly energy-use data → Estimation of BB-program savings during specific times
  - Regression analysis of hourly energy-use data
    - 20,000 PPL Electric customers and 44 million records
- Main findings
  - BB program saved about 2% of peak energy use
  - Some savings were from air-conditioning measures
  - Cost per kW of savings close to average cost for utility residential LM programs

# Potential Role of BB Programs in Peak Load Management

- High marginal costs of supply during system peak hours
- U.S. utilities spent \$1.3 billion on load management (LM) programs (EIA, 2012)
  - Reduced peak energy use by 13.2 GW → ≈\$96/kW
- Residential BB programs may be able to help :
  - can target end-uses that contribute to system peaks
  - are scalable
  - reach customers not interested in participating in conventional LM programs

# PPL Electric's Behavior and Education Program

- Implemented by Opower
- Primary objective was energy savings but demand savings count
- Delivered 6 energy reports annually to about 100,000 residential customers
  - Legacy Group: received first reports in 2010
  - Expansion Group: received first reports in 2011; includes past EE program participants
- Reports included personal energy-use analysis, peer comparison, and energy savings tips
  - Savings tips targeted some end uses that contributed to system peaks
- Implemented as a large field experiment
- In 2012-2013, saved 36,470 MWh or 2% and was cost-effective

# Data

- Randomly sampled treatment and control group homes

Analysis sample

Program population	Treatment Group (N)	Control Group (N)
Legacy	5,000	5,000
Expansion	5,000	5,000

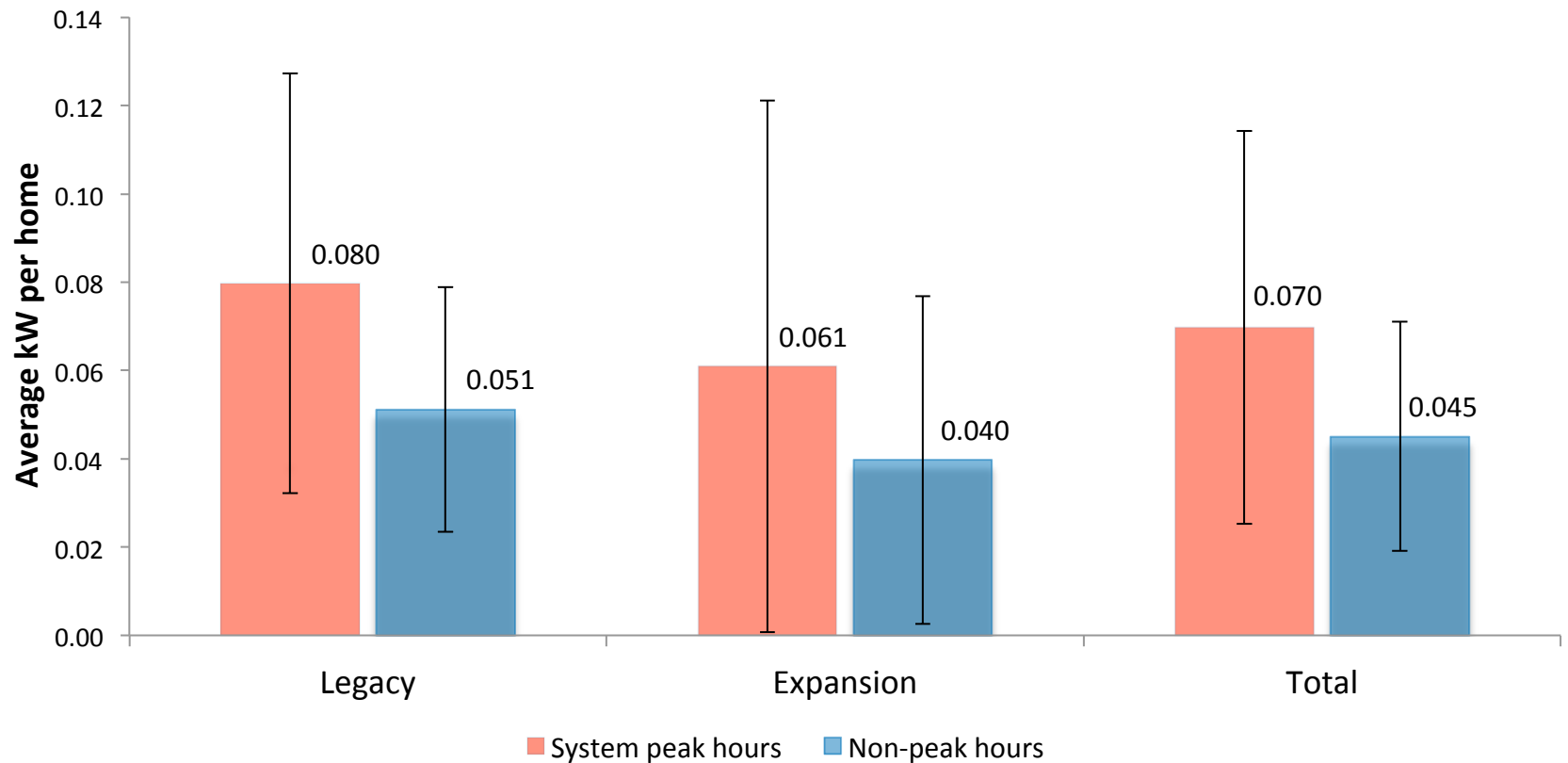
- Collected data on hourly energy-use during summer 2012
- Verified there was balance in pre-program energy use between...
  - sampled treatment group and control group homes
  - sampled and non-sampled treatment (control) group homes

# Peak Savings Estimation

- Panel regression of hourly kWh
  - Separate models for legacy and expansion groups
- Estimated savings during PPL Electric system peak hours
  - Defined as top 100 hours of utility system demand
  - Occurred during warm weekday afternoons or evenings
  - Air-conditioning loads main driver of system peaks
- Savings estimates are unbiased and robust because of program's experimental design
  - Hour fixed effects control for correlation between residential energy use and system peak hours

# PEAK DEMAND SAVINGS ESTIMATES

# System Peak Demand Savings Estimates



Note: Error bands show 90% confidence intervals. Standard errors are clustered on homes.



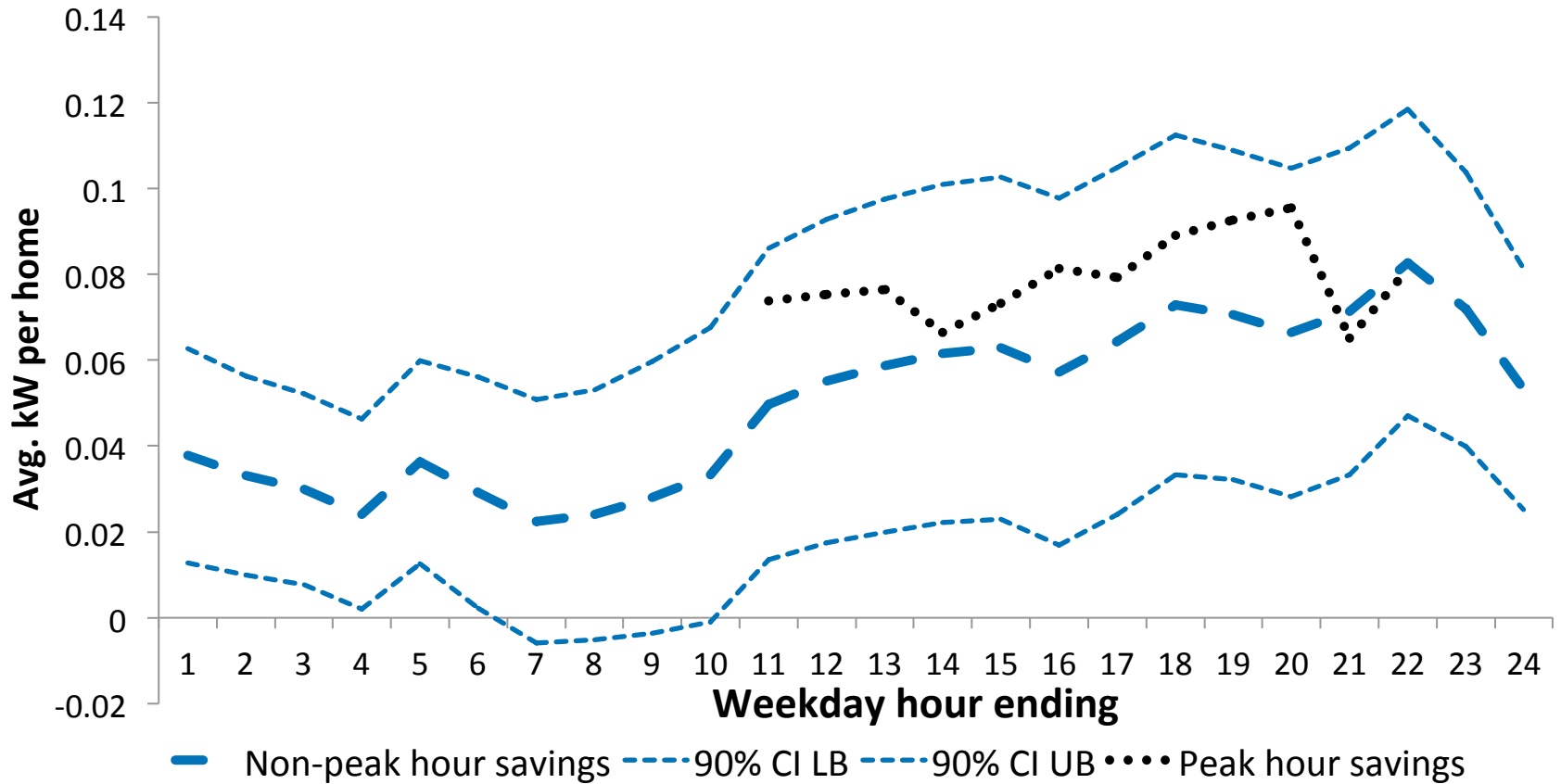
# Other Findings

- System peak savings were about 2% of energy use
- Peak savings could have been achieved by:
  - Turning off one 60 or 80 watt light bulb; or
  - Reducing runtime of air conditioner by about 5 minutes per hour
- Sending energy reports to 9 homes (0.63 kW) yields same peak energy savings as cycling AC in one PPL Electric Peak Saver home
- PPL Electric saved 6.5 MW from BB program

# SOURCES OF BEHAVIOR SAVINGS

## SOME SUGGESTIVE EVIDENCE

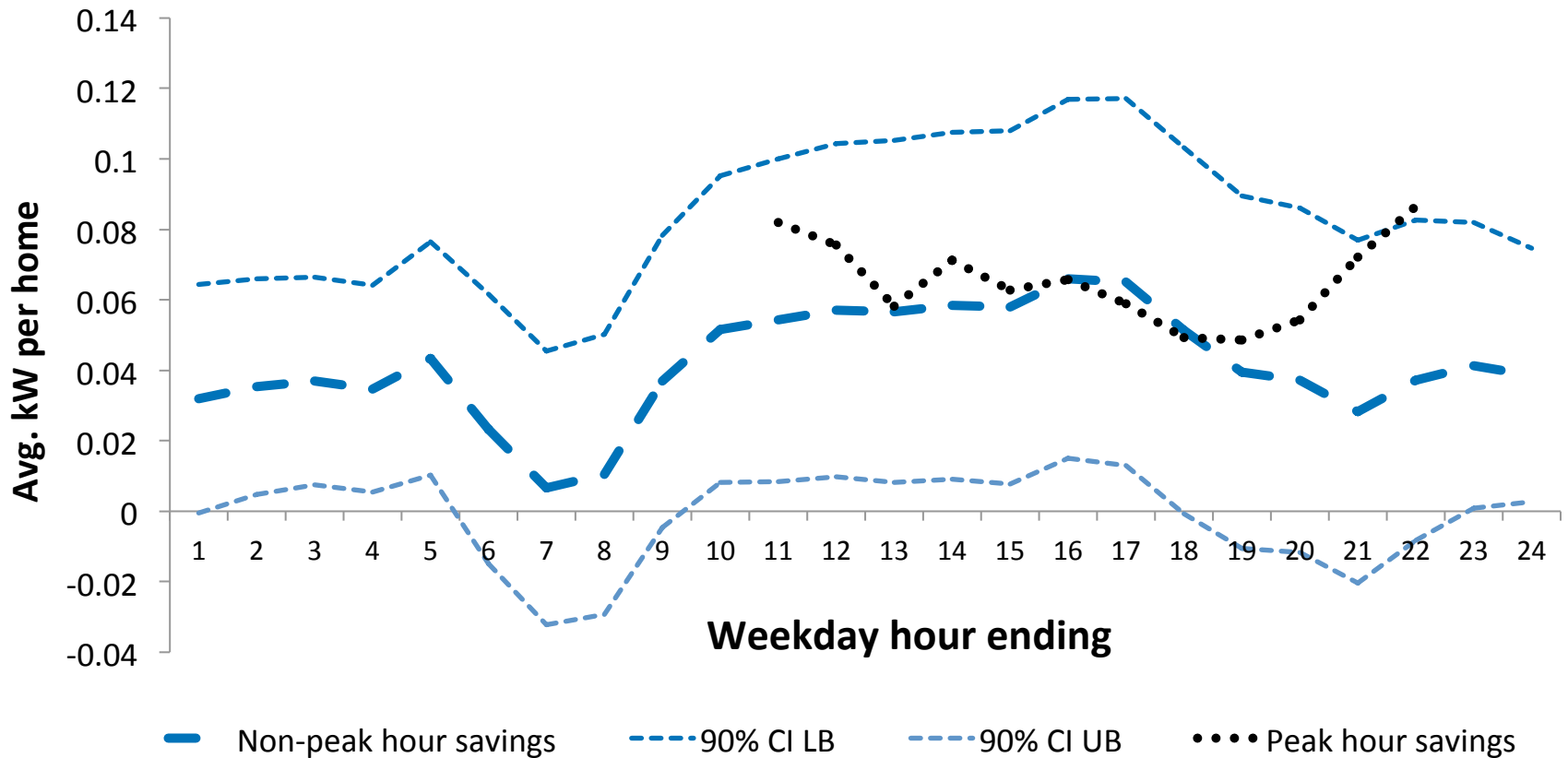
# Legacy Group Peak and Non-peak Savings



Note: Confidence interval estimated using standard errors clustered on homes.

# Expansion Group

## Peak and Non-peak Hour Savings



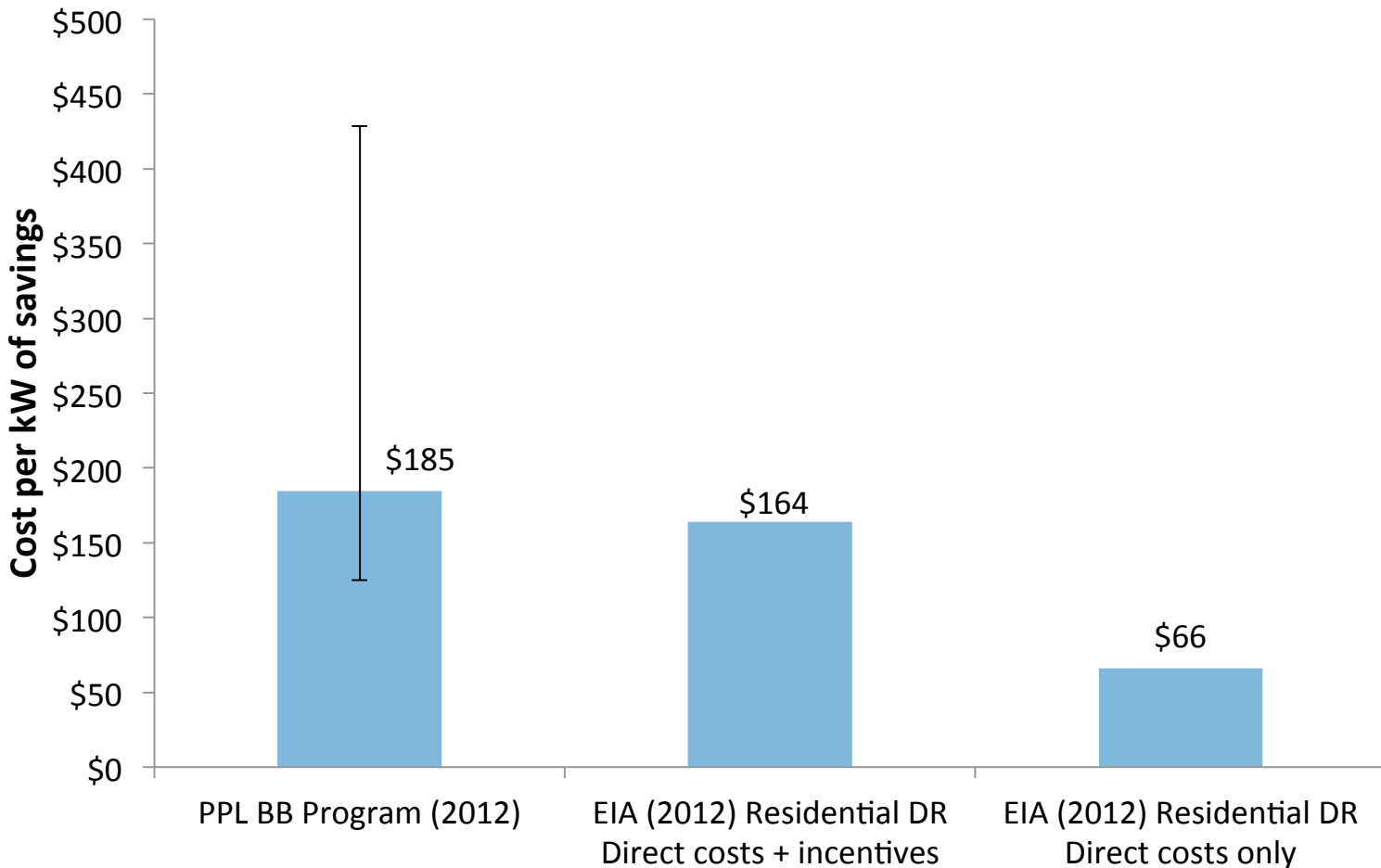
Note: Confidence interval estimated using standard errors clustered on homes.

# BB PROGRAM COST OF SAVINGS

# Behavior and Education Program Demand Savings Costs

- Collected data on
  - PPL Electric Behavior and Education Program costs from Act 129 filings
  - U.S. utility DR program costs and peak load reductions in 2012 from EIA-861
    - Residential LM direct costs
    - Residential LM incentives
    - Residential LM actual peak reductions
- Compared BB-program and residential DR-program average cost of peak savings
- Note: Comparison ignores BB-program energy savings

# Cost of Peak Demand Savings



Note: Error band shows 90% confidence interval.

# Conclusions

- Hourly energy-use data enabled estimation of BB-program savings during specific times
- BB program resulted in significant peak savings
- More research is needed, but some savings derived from air-conditioning measures
- PPL Electric BB program's average cost of kW savings close to average cost for utility LM programs
- May be possible to increase BB peak savings
  - Focus messaging and education more on peak energy use
  - Pair behavioral interventions with enabling technologies