Effect of Enhanced Smart Outlet Control on Energy Efficiency in Low-Income Households

The Atlanta Ghouls

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Mission

Decrease energy consumption from phantom loads
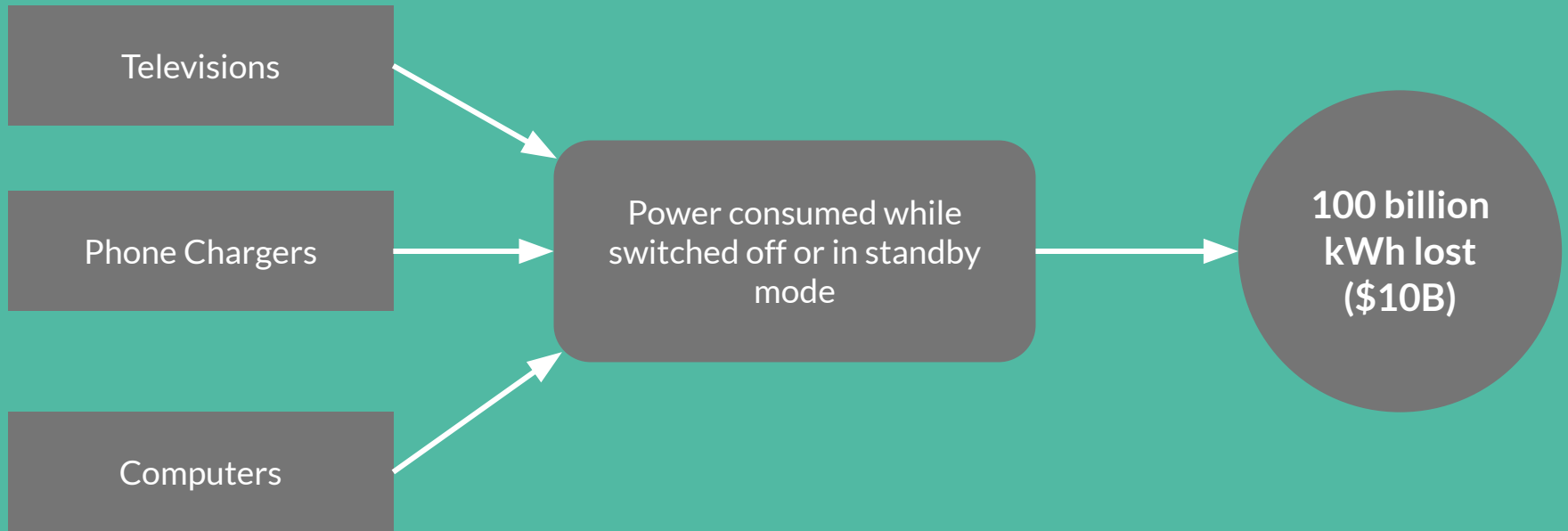
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in low-Income households

↓

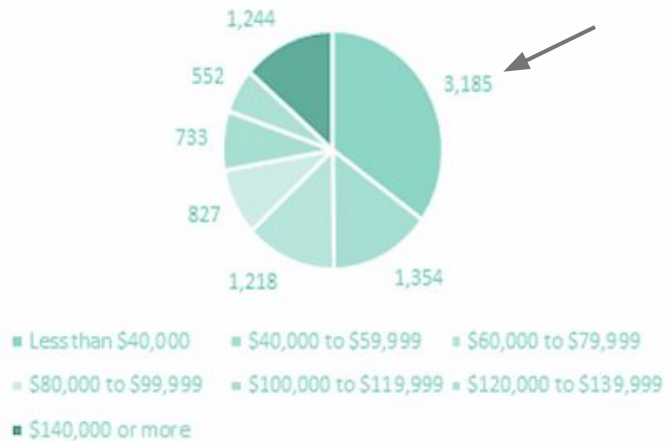through smart outlet application improvement

↓

with increased cost-savings visibility

Phantom Loads

Televisions

Phone Chargers

Computers

Power consumed while switched off or in standby mode

100 billion kWh lost ($10B)

Total Energy Consumption (Trillion Btu) Division by Income-level Household Units

1,244
552
733
827
1,218
1,354
3,185

- Less than $40,000
- $40,000 to $59,999
- $60,000 to $79,999
- $80,000 to $99,999
- $100,000 to $119,999
- $120,000 to $139,999
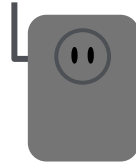- $140,000 or more

Households with income less than $40,000:

- Account for about 35% of the total energy consumption in the U.S.
- Had over $76 billion in energy expenditures
- Spend 50% more of their annual income on energy than other income brackets

Smart Outlets - Today

$8-$10

Scheduling & Remote Access

Energy Usage Metrics
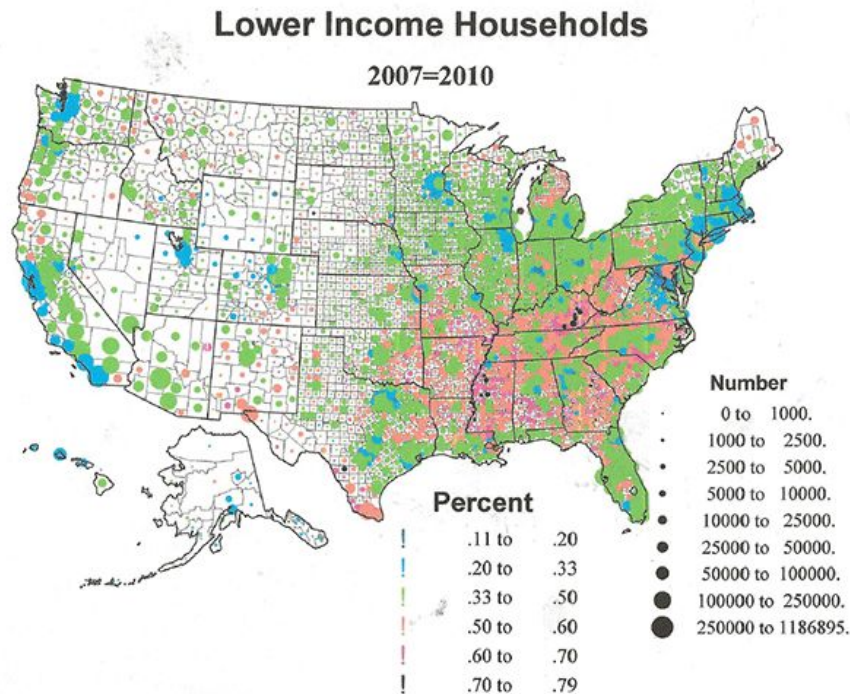
Experiment Design

Research Question: What are the effects of smart outlets on reducing residential energy consumption in low-income households in the U.S?

Hypothesis: We hypothesize that energy consumption **will decrease** if smart outlets and a **corresponding mobile application** are deployed in low-income households to control plug load devices and track energy expenditures.

Methodology: *Randomized Experiment*
- **300 low-income households in Georgia**
  - Low Income Home Energy Assistance Program (LIHEAP)
  - Georgia Power
  - United Way
  - Community Action Agencies
- **210 testing households with the access of Smart Plugs and Mobile Apps**
- **90 control households**

Why Georgia?

Lower Income Households

2007=2010

Percent

!	.11 to	.20
!	.20 to	.33
!	.33 to	.50
!	.50 to	.60
!	.60 to	.70
!	.70 to	.79

Number

0 to 1000.
1000 to 2500.
2500 to 5000.
5000 to 10000.
10000 to 25000.
25000 to 50000.
50000 to 100000.
100000 to 250000.
250000 to 1186895.

- Low-Income Households are mostly located in Southeast United States

- The research team is located in the State of Georgia

Smart Plugs

Price

Kasa Smart
($14.49/2-pack)

Meross ($19.99/3-pack)

Tp-Link ($17.99/2-pack)

Energy Savings

Decrease phantom load

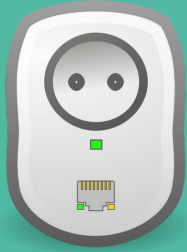Automatically "unplug" devices

Remote Control

User-friendly applications

Smart home connectivity

Timing ability
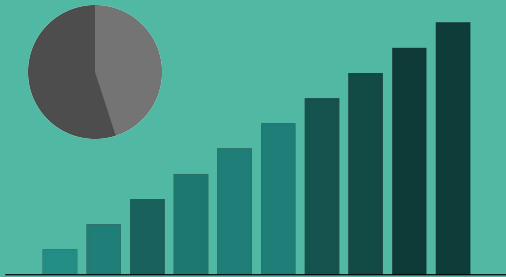
Cost Estimation
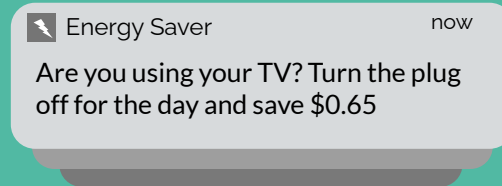
Smart Plugs

Mobile Application

Cost Visualization
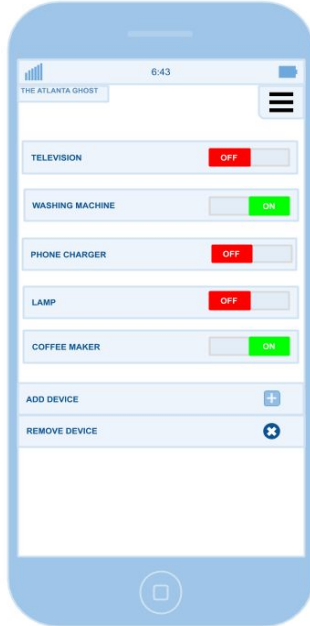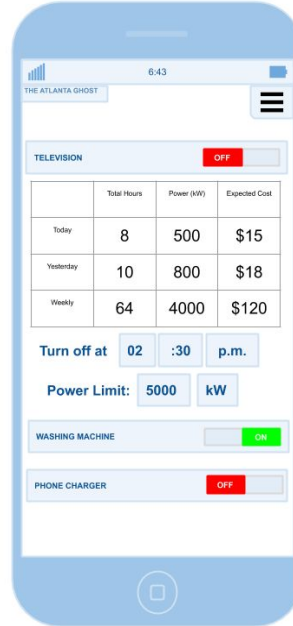
Reminder Notifications

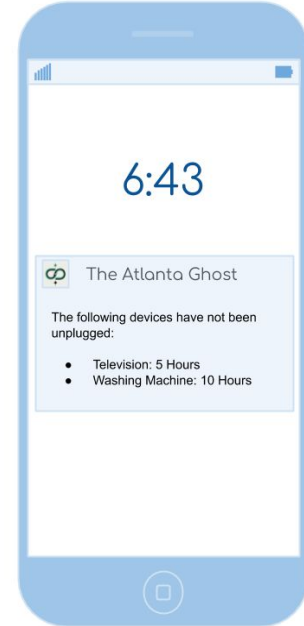1

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3

4

Energy Saver   now

Are you using your TV? Turn the plug off for the day and save $0.65

Mobile Application

APP INTERFACE

ANALYTICS AND SETTINGS

NOTIFICATION

Tech-to-Market

- Deploy smart plugs in neighborhoods around Atlanta

    - Information pamphlets
        - Waste and savings statistics
    - App Development
        - API access from smart plug developers
    - Post-Experiment Trial Period
        - Households keep smart plugs after participating in the study
        - Discounted price for participants
    - Future Data Usage
        - Develop outlets that determine optimal scheduling using machine learning

Privacy Protections

- Allow for request and deletion of data
- De-identify usage data
- Choose common appliances to collect data from

Expected Usage and Benefits

- Households should have multiple devices connected to the app to maximize effectiveness
  - Near accurate estimations of energy consumption and costs
  - Helpful reminders on which devices to deactivate
  - Reduces energy costs overall
- Potential Benefits for stakeholders:
  - Companies developing smart plugs
  - Energy Providers
  - Governments
- Reduce CO2 transmissions (further vision)

Metrics Table

	Total Hours	Power (kWh)	Estimated Costs
Today	8	0.5625	$0.03
Yesterday	24	1.6875	$0.095
Weekly	64	4.5	$0.255

How can we calculate the estimated cost?

$$Estimated\ Costs\ for\ Daily/Weekly = Power\ (kWh) * \$0.056582$$

$$Estimated\ Costs\ for\ Monthly = \$10\ (base) + Total\ Power\ (kWh) * \$0.056582\ + 7\%\ (sale\ tax)$$

$$I.e: Estimated\ Costs = \$10 + 18 * \$0.056582 + 7\% * (\$18 +* \$0.056582) \approx \$12/device$$

Well, it looks not much, doesn't it?

However, what if...

$Estimated\ Costs\ for\ 10\ devices = \$120/households$

$Estimated\ Costs\ for\ 300\ low-income\ households\ in\ Georgia = \$36000/month$

$Estimated\ Costs\ for\ 300\ low-income\ households\ in\ Georgia = \$432000/year$

… this is just a small population => How much for the all households across the U.S?

❖ This is equivalent to **498 metric tons CO2** released in the environment (United States Environmental Protection Agency)

    ❖ 1,236,881 Miles driven by an average passenger vehicle

    ❖ 63,570,120 number of smartphones charged

    ❖ 651 acres of U.S forests in one year