Behind the Meter

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Some Background on Energy Efficiency
Consumption Trends Changed In All Sectors of the US Economy After the 1973 Oil Embargo

After the 1973 Oil Embargo, energy consumption trends changed dramatically in all sectors of the US economy.
Energy Efficiency, Domestic Supply, Imports

Data Source: EIA, Monthly Energy Review
Factors Reducing US Carbon Dioxide Intensity

Pre 1973 Energy Intensity Trend
Enhanced Energy Efficiency
Carbon Intensity of the Economy
Decarbonization of Energy Consumption

Index of Carbon Dioxide Per Dollar of Real GDP (1973=1)
Instruments: For More Efficient Buildings
Nudges/Disclosure

- Energy Star or LEED rating -- buildings.
Information

• Performance rating and rating disclosure -- Commercial building

  – Provides incentives for building owners to invest in energy efficiency. Provides incentives for potential tenant to demand performance improvement.
Instruments: More Efficient Appliances and Equipment
Nudges

- Energy Star Appliance Labels -- appliances, refrigeration, equipment, pool pumps …
Information: Energy Labeling

Energy Guide

XX Corporation
Model ABC-L
Capacity: 23 Cubic Feet

Estimated Yearly Operating Cost

$67

Cost Range of Similar Models

$57 - $74

630 kWh

Estimated Yearly Electricity Use

Your cost will depend on your utility rates and use.

Energy Star

For more information, visit www.ftc.gov/appliances.
Information: Calculators

The Appliance Calculator helps you:
- Find out how much your current refrigerator is costing in electricity use.
- Determine when it makes sense to upgrade.
- Shop for a new refrigerator based on electricity consumption and other features.

Follow the instructions below—note that your Results will get updated anytime you change a dropdown selection.

### Electricity Saving Refrigerator Calculator

#### Step 1: Describe Your Current Refrigerator
- **State:** [Select]
- **Refrigerator Type:** [Select]
- **Approx Model Year:** [Select]
- **Size:** [Select]
- **Icemaker:** [Select]
- **Energy Star:** [Select]

#### Step 2: Describe Your Desired New Refrigerator
- **Price Range:** [Any]
- **Brand:** [Any]
- **Refrigerator Type:** [Any]
- **Color:** [Any]
- **Size:** [Any]
- **Icemaker:** [Any]
- **Energy Star:** [Any]

**Electricity Consumption (Select Min & Max kWh/year):** 0 - 1500

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### Your New Refrigerator Search Results

<table>
<thead>
<tr>
<th>New Refrigerators</th>
<th>Price</th>
<th>Annual Electricity Use</th>
<th>Lifetime Electricity Cost</th>
<th>Annual Cost Savings for New Vs Old</th>
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<tr>
<td>LG 22.4 cu. ft. Bottom Freezer LDC22720S</td>
<td>$1,100</td>
<td>465 kWh</td>
<td>$633</td>
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<td>See at Sears</td>
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# Federal Equipment Efficiency Standards: Residential

www.appliance-standards.org/

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<th>First Year</th>
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</table>
Instruments: Operations
Information

- Building Information Management systems
  - Allow managers of commercial building to understand and control their energy use
Big Data for Energy Efficient Management

Courtesy of Microsoft
Nudges

- Electricity Use Comparison with Other Homes; approval or disapproval symbols (e.g. smiles, frowns), motivate people to use less electricity (e.g. Opower or Tendril)
Home Energy Reports and Dashboards (Tendril)
Smart Meters
(Not just to not hire meter readers)

- Energy use disaggregation
- Segmentation of customers for Demand Side Management (DSM)
- Linked to games
- Feedback potential
Disaggregation allows us to take a whole building (aggregate) energy signal, and separate it into appliance specific data (i.e., plug or end use data). A set of statistical approaches are applied to accomplish this.
Smart Meters and Analytics to Guide Program Targeting

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DATA:
- Smart meter
- Weather
- Subsample survey

Sense

Learn
- Feature extraction
- Segmentation
- Profiling

Match
- Targeting
- Program matching
- M & V

Predict
- Response modelling

Feedback to customers

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Work by Ram Rajagopal and team
Feedback: Controlled Experiment with Google Powermeter

![Daily Energy Use, kWh (smoothed)](image)

- Only treatment group has access to the feedback technology
- Both groups have access to the feedback technology

**Graph Details:**
- Y-axis: Daily kWh (15 to 30)
- X-axis: Date (2010) from Mar 1 to Nov 1
- Two lines: Treatment Group (solid) and Control Group (dashed)
Learning Thermostats: Nest
Pricing Strategies

• Tiered Pricing
  – Theory: consumers respond to the marginal price
  – Empirical evidence: consumers respond to the size of their bill, but not to the marginal price (Ito)

• Time varying pricing
  – Time of use: consumers can adjust their habitual activities to adjust to different pricing. Example – charging of electric vehicles
  – Critical peak pricing: Alerts to consumers so they can adjust next day’s activities
  – Real time pricing: Too data intense for non-automated responses. But with information, automatic control, possibly can create responses.
In this election season, you may enjoy:
“The Great Energy Debate”

UTube Video: at http://peec.stanford.edu