A New Approach for Residential Real-Time Feedback using a Low-Cost Non-Intrusive Load Monitoring Framework

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Tests of giving users feedback on energy use show savings mostly good, although results vary. Not clearly improving over time.

(Delmas, Fischlein, and Asensio 2013)
Various ways of *providing* information

<table>
<thead>
<tr>
<th></th>
<th>Standard Billing (for example, monthly, bi-monthly)</th>
<th>Enhanced Billing (for example, info and advice, household specific or otherwise)</th>
<th>Estimated Feedback (for example, web-based energy audits + billing analysis, est. appliance disaggregation)</th>
<th>Daily/Weekly Feedback (for example, based on consumption measurements, by mail, email, self-meter reading, etc.)</th>
<th>Real-time Feedback (for example, in-home displays, pricing signal capability)</th>
<th>Real-time Plus (for example, HANs, appliance disaggregation and/or control)</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

“Indirect” Feedback (provided after consumption occurs) vs “Direct” Feedback (provided real-time)

Information availability Cost to implement

Low High

Figure ES-1
Feedback delivery mechanism spectrum

(EPRI 2009)
Energy Channel - Motivation

- Various ways of displaying information

By Cotopaxi Energy - Large display layout
Energy Channel - Goals

- Best results for energy savings:
  - informs and empowers
  - engages
  - encourages and motivates

- The main goal of the Energy Channel project is to develop a proof-of-concept energy display that is also:
  - low-cost
  - plug-and-play
  - easy to use
Research indicates that feedback should:

1. allow easy access to the information
2. be provided real time or as soon after consumption as possible
3. be presented simply in meaningful and motivating terms
4. provide comparisons with other references
Energy Channel - Framework

Requirements: Easy access
Energy Channel - Framework

Requirements: Easy access

Devices in use - (left) Intel stick with windows 10 and (right) MK809 stick with Android 5.1.
Energy Channel - Framework

Requirements: Easy access

Devices in use - (left) Intel stick with Windows 10 and (right) MK809 stick with Android 5.1.
Energy Channel - Requirements

2. Provided real time or as soon after consumption as possible
   - View the amount and cost of energy per hour as they use it
   - Connect energy peaks to users’ actions or habits
     - Identify savings opportunities
     - Identify optimal scheduling strategies
Energy Channel - Framework

Requirements: Easy access

Devices in use - (left) Intel stick with windows 10 and (right) MK809 stick with Android 5.1.
Energy Channel - Framework

Requirements: Easy access + real-time data

Devices in use - (left) Intel stick with windows 10 and (right) MK809 stick with Android 5.1.
3. Presented in meaningful and motivating terms

- Consumption breakdown
- Challenges with disaggregation
- Supplement smart meter data with other sources
3. Presented in meaningful and motivating terms
3. Presented in meaningful and motivating terms

![Graph showing energy usage levels](image)
Energy Channel - Requirements

3. Presented in meaningful and motivating terms
3. Presented in meaningful and motivating terms

Warm weekend coming up; please keep windows open and fans on to save on air conditioning!
4. Provide comparisons with other references such as:

- Previous periods
4. Provide comparisons with other references such as:

- Previous periods
- Neighborhood average
Energy Channel - Framework

Requirements: Easy access + real-time data

Devices in use - (left) Intel stick with windows 10 and (right) MK809 stick with Android 5.1.
Energy Channel - Framework

Requirements: Easy access + real-time data + comparison

Devices in use - (left) Intel stick with Windows 10 and (right) MK809 stick with Android 5.1.
Research indicates that feedback should:

- allow easy access to the information
- be provided real time or as soon after consumption as possible
- simply presented in meaningful and motivating terms
- provide comparisons with other references

Great, but what does it look like?
Energy Channel – Front End

Your Monthly Energy Usage

- 350 kWh
- 280 kWh
- 210 kWh
- 140 kWh
- 70 kWh
- 0 kWh


Current Power Demand

- NOW 2,045 w
- DAILY PROJECTED 1,097 w
- SO FAR TODAY 55 kWh
- DAILY AVG. 125 kWh

- Air Conditioning
- Electrical Vehicle
- Home Appliances
- Miscellaneous Energy Use

Planned Outage in your area 11/10 2 - 5 am. Reason: Equipment upgrade

Warm weekend coming up; please keep windows open and fans on to save on Air Conditioning.

Serv. Account: 2-932-1007-64
SMITH, JOHN

Energy Channel – Front End

Last Week Energy Usage

- Air Conditioning: 237.6 kWh
- Electrical Vehicle: 514.8 kWh
- Home Appliances: 369.6 kWh
- Misc. Energy Use: 198 kWh

Avg. Similar Home in Irvine, CA

- Air Conditioning: 199.2 kWh
- Electrical Vehicle: 415 kWh
- Home Appliances: 581 kWh
- Misc. Energy Use: 464.8 kWh

Current Power Demand

- NOW: 2,045 W
- SO FAR TODAY: 55 kWh
- DAILY AVG.: 125 kWh

Great job saving energy in home appliances. Try to schedule your laundry after 7 pm this Sunday.

Lower your bill: Enroll in a SCE DR program at https://www.sce.com/drp
Energy Channel – Front End

Daily Savings 11/08/16 - 11/09/16

Potential Savings

Congratulations on saving energy! You saved 60 kWh today compared to yesterday’s 55 kWh.

Current Power Demand

NOW
2,045 w

SO FAR TODAY
55 kWh
DAILY AVG.
125 kWh

Potential Savings

Last Week

This Week

Target Energy Usage
Previous Avg. Usage

TOTAL ENERGY

Air Conditioning  Electrical Vehicle  Home Appliances  Miscellaneous Energy Use

Lower your bill: Enroll in a SCE DR program at https://www.sce.com/drp
Energy Channel – Mobile App

**Potential Savings by Category**

<table>
<thead>
<tr>
<th>Energy Usage from 01/01/17 - 01/07/17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Conditioner</td>
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<tr>
<td>Last Week</td>
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<tr>
<td>Last Week</td>
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<tr>
<td>Last Week</td>
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<tr>
<td>Total Energy</td>
</tr>
</tbody>
</table>

**Daily Savings**

01/04/17 to 01/05/17

- Last Week
- This Week
- Potential Savings
- Target Energy Usage
- Previous Avg. Usage

**Potential Savings**

- 40 kWh
- 30 kWh
- 20 kWh
- 10 kWh

Congratulations on saving energy! You saved 30 kWh today compared to yesterday's 20 kWh.

**Calendar Savings**

December 2016

- Sun
- Mon
- Tue
- Wed
- Thu
- Fri
- Sat

- 1
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- 8
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- 30
- 31
Energy Channel – Next Steps

- Refining the disaggregation algorithms
- Field testing user response
Thank you!

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