

OPOWER

Energy efficiency through behavioral science and technology.

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A recent nationwide poll found 87% of households want to save more energy at home [1]. Interest in efficiency is driven by varied concerns—the environment; reliance on foreign energy; or simply wanting lower energy bills—but the overall breadth of interest is clear. Despite near universal interest, however, most people don't have the information or motivation they need to act efficiently. Utility efficiency programs typically have less than 1% participation. The problem is that while interest is very broad, it is also very thin. Energy efficiency isn't as interesting as Facebook, movies, or so many other options, nor is it financially compelling for most people.

This disconnection between intention and action is a huge lost opportunity for reducing carbon emissions and energy bills. McKinsey's 2009 efficiency report highlighted the potential for reducing projected 2020 U.S. energy consumption by 23%, eliminating 1.1 gigatons of greenhouse gases [3], through more efficient measures and actions. Unlike costly, capital-intensive renewable projects, efficiency is cost effective today. The initiatives identified by McKinsey would save \$700 billion, even taking into account upfront investment. While solar and wind power are an important part of an overall national energy portfolio, they cannot match the economics of energy efficiency. The cheapest, cleanest form of energy is the energy we never use.

A growing variety of companies are making great efforts to facilitate energy efficiency, and in particular there has been a lot of attention on the opportunity to provide consumers with better information to manage their home energy use. Hardware companies such as Honeywell and Cisco are producing in-home devices to monitor and control

energy usage, and software companies including Google and Microsoft are providing online tools to examine energy usage.

These high-tech solutions are facing a similar challenge—very few customers are intrigued enough by energy data to spend up to \$200 on an in-home monitoring device, or even to take the time to seek out this information online. Preliminary accounts show that the percent of customers who log on to explore their energy usage data online

is well below 5%.

At OPOWER, we're taking a unique approach to engaging customers. By proactively "pushing" targeted information to households through existing communications channels including the web, email and mail, OPOWER is managing to grab the attention of nearly three million U.S. households, resulting in 2% to 4% aggregate energy savings. At first glance, this may not seem like much, but when applied at broad-scale, the aggregate savings are substantial (See **Figure 1**). This year, the CO₂ reduction will be equivalent to 24 million gallons of gasoline.

In this article, we're going to talk about three critical components to successful, broad-scale customer engagement on the subject of energy use:

- *Behavioral science*: Applying proven techniques to motivate action;
- *Analytics*: Extracting actionable insights from energy usage, demographic, housing and other data; and,
- *Technology*: Enabling delivery of 100% customized content to each

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Figure 1. Energy savings after pushing targeted information to households. Note each line in the graph shows rate of energy saving at a particular utility.

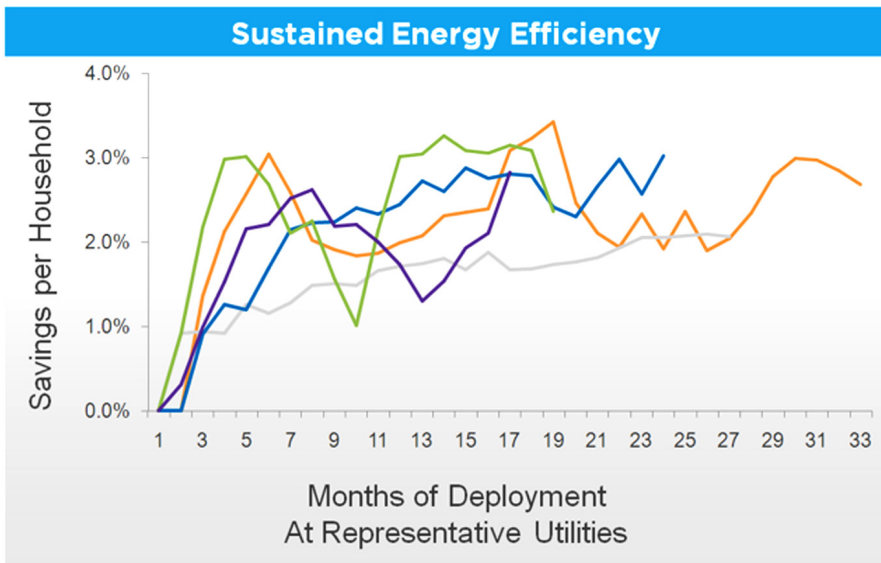
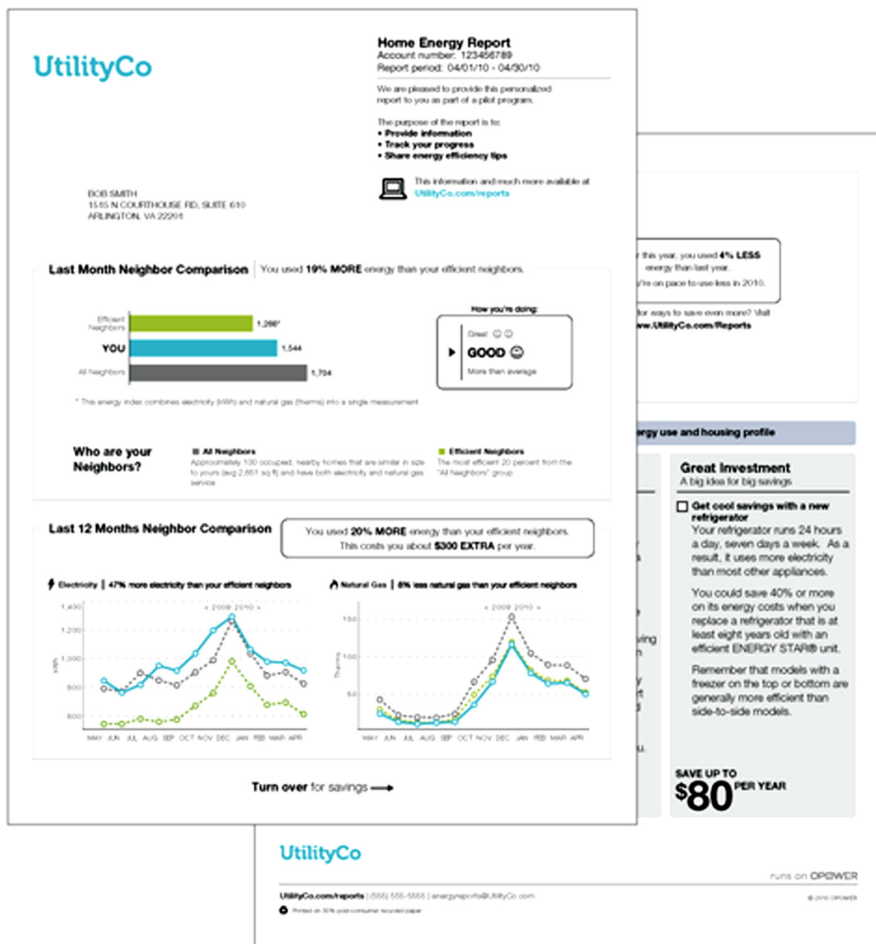


Figure 2. Effective information compares users to peers.



customer at a very large scale.

BEHAVIORAL SCIENCE

It's not easy to get people to change their energy usage on an ongoing basis, which explains the importance that behavioral science plays in having a significant long-term impact. Since OPOWER's founding, we have worked closely with Dr. Robert Cialdini, an expert in the field of influence and persuasion, to develop the right ways to present the right information for maximum impact.

Cialdini has spent much of the last decade studying conservation and efficiency, looking for the best ways to influence behavior. His findings were consistent across numerous experiments with varied conservation objectives, including hotel towel reuse, national park preservation, and electricity usage. In each case, people were most likely to conserve when presented with information about their peers exhibiting the desired behavior (see Figure 2). Cialdini proved that descriptive social normative messages consistently beat messages focused on environmental, societal, or financial benefits. For example, in a hotel towel reuse study, guests who were asked to help save the environment by reusing their towels were significantly less likely to comply than those who were told that they should join the 75% of fellow guests who are reusing their towels.

Perhaps most interesting is the fact that the measured impact of messaging based on social norms was far greater than messages that put greater weight on environmental, societal, or financial benefits (see Figure 3). Most people understated the influence other people's behaviors have on their own actions. Field testing data clearly showed, however, that most people were strongly compelled to "keep up with the Joneses," even if they don't realize or acknowledge it.

This powerful finding became a cornerstone of OPOWER's approach to engagement. More broadly, we continue to work with Cialdini and other behavioral scientists to increase the impact we have on home energy use. OPOWER optimizes and expands its product features through a combina-

Figure 3. Behavior science explores what motivates users to conserve energy.

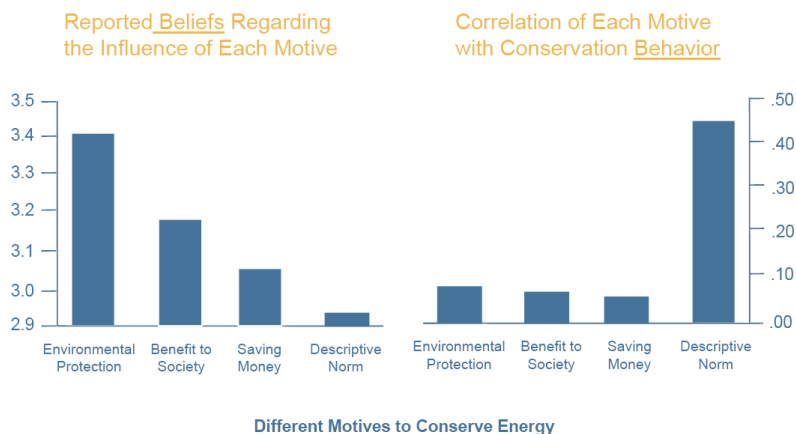
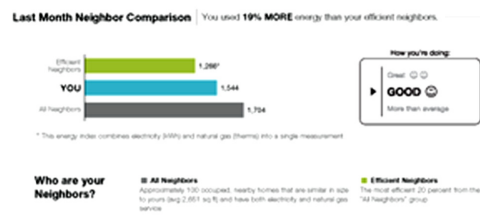


Figure 4. Visual comparisons impact user behavior.



tion of expert input, robust user experience design and testing, and large-scale measurable experiments. Here are some key examples of applied behavioral science.

Descriptive social norm. Descriptive social-normative messages provide the centerpiece of OPOWER’s Home Energy Reports. Each household receives a personalized analysis showing how their recent energy use compares to that of average neighbors, as well as to their most efficient neighbors (The neighbors used for the comparison are a unique set of similar homes chosen by an algorithm described later). This data is presented simply and clearly, so report recipients can readily understand not only what’s typical among neighbors residing in similar homes, but what is possible in more efficient homes.

The very simple graph depicted in **Figure 4** often elicits an emotional response from recipients who see how their energy usage compares to that of others for the first time. Even those who are not motivated by money or the environment can be motivated by competition. People who already use less than average are often motivated to do even better if they see that they are below the efficient energy level.

Injunctive message. The Neighbor Comparison module incorporates another proven behavioral science tactic—an injunctive message to indicate social approval for good behavior. It turns out that everyone still appreciates a “pat on the back.” Research by Cialdini showed a risk of providing people solely with the descriptive

norm: people who used less energy than average could view the data as a sign they can, or even should, use more; and their energy usage would actually increase. The addition of the injunctive message (in this case, a smiley face) to call out good behavior eliminated this usage increase.

Loss language. Another best practice incorporated from behavioral science is the use of loss language. Research has shown that more people are motivated by fear of loss than hope of gain. In **Figure 5**, the customer is told that his higher energy use costs \$275 per year. Cialdini and colleagues have found that a sense of loss is substantially more motivating than the opportunity to “gain \$275.” Proof that even small changes in phrasing can have a substantial impact on consumer behavior.

Behavioral science sits at the core of all OPOWER’s product design decisions—whether they relate to new product features to build, the critically important user experience, or optimized language and imagery to drive the most favorable response from customers. We believe this seemingly unlikely marriage of behavioral science, software, engineering, and UX design has been instrumental to the success of our products.

ANALYTICS

With the rollout of Advanced Metering Infrastructure (AMI) across the nation and abroad, usage data will increasingly become available at a daily or even hourly level. In addition, demographic, housing, and weather data can be integrated to construct even

more complete energy usage profiles.

A great opportunity and challenge is to extract useful information from these otherwise overwhelming reams of mundane data. OPOWER can deliver specific, personalized insights and content to each customers, converting otherwise inscrutable data into actionable insights.

Some examples of how analytics are used to derive personalized insights and messaging includes:

Neighbor comparison. Every customer is provided with an energy usage comparison to a set of nearby similarly sized homes (“neighbors”) chosen uniquely for that customer. Types of homes are selected based on key home characteristics such as square footage, heating or cooling system, and location. The algorithm for neighbor identification looks for nearly identical homes in the immediate vicinity; if it cannot find enough qualifying neighbors, the constraints are relaxed in sequential iterations until enough are identified.

Heating and cooling disaggregation. With hourly usage data, our analytics engine can estimate the amount of energy used for heating and cooling by a given household without any specialized hardware inside the home. We have developed statistical algorithms to automate complex multi-variable regression analysis that combines energy usage, housing, and weather data to estimate the amount of heating and cooling energy used by each household. This ‘disaggregation’ breaks down overall usage into useful buckets, so customers can receive

more specific insights and recommendations about where to focus their attention, making it easier for them to identify and eliminate wasted usage.

For example, instead of learning that she used 10% more energy overall than her neighbors, a customer can discover she specifically used 30% more energy on heating, and therefore may discover that her furnace needs maintenance, her home needs new insulation, and/or her thermostat may be set at too high a temperature. Such personalized insights are giant leaps ahead of what can be garnered from today's utility bills.

Targeted advice. Another key analytical component of the OPOWER platform is the tip targeting engine, which ensures that each customer receives the most impactful energy efficiency advice (the relevance and potential impact of these tips, which vary from utility to utility, rely on a number of customer profile attributes, including household demographics, housing characteristics, and energy usage patterns). For example, the advice given to a single woman who rents an apartment and rarely uses her heat will be quite different from the advice given to a family in a large suburban home with heavy, consistent heat usage. The analytical engine's ability to engage in "a million simultaneous but different" conversations with energy users is key to achieving sustained engagement and a high level of customer response.

Finally, no matter how complex the underlying data and algorithms become, the output generated is always presented to customers in the form of insights and recommendations that are easy to use and understand (see **Figure 6**).

TECHNOLOGY

Although fueled by behavioral science and proprietary analytics, the heart of OPOWER is a highly scalable software platform. Many of the biggest challenges we faced were related to the technical ability to simultaneously deliver personalized energy reports and interactive experiences to millions of households. The solution consists of a series of technical decisions ensuring that every aspect of the platform, down to the seemingly inconsequential features, are designed with scalability and extensibility in mind. In

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our experience, spending up to 30% of every development iteration discussing the optimal design of each feature is time well spent to ensure that our SaaS platform remains scalable, reliable and highly configurable.

The following are a few examples:

Scaling neighbor selection. Devising an algorithm that searches for the fairest possible set of neighbors for the neighbor-comparison feature is a process that typically requires process-

ing thousands of calculations for every home receiving a report. This is doable for a few hundred homes, but the technical complexity grows exponentially for systems that need to simultaneously generate reports for millions. This complexity can become prohibitively time-consuming if the algorithm is not optimized. The key to success was a clever subroutine that intelligently varies the extent of constraint relaxation in each neighbor's search iteration, reducing the total number of iterations by 60%, allowing the system to scale.

Delivering a personalized web page in the mail. One of the major challenges in launching the first Home Energy Report program was figuring out how to print and deliver reports (that are essentially HTML-based web pages stored as PDFs). While many companies send tremendous volumes of personalized mail (such as credit card or utility bills), most existing technologies print only black text (such as name, address, or transactions) into designated fields on preprinted forms.

Figure 5. Loss language of a wasted \$275 motivates customers to take action.

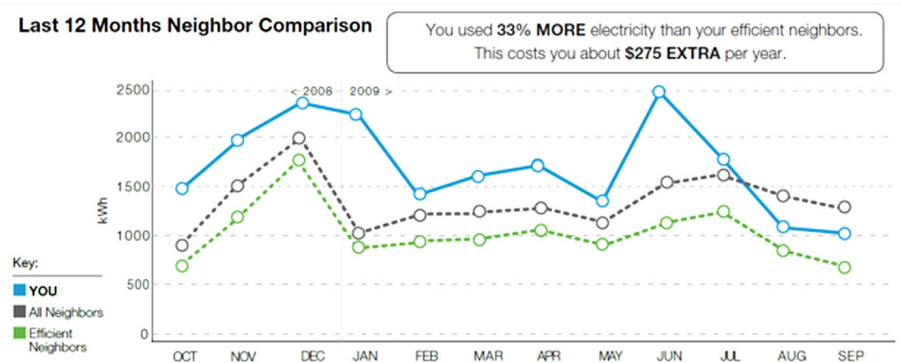
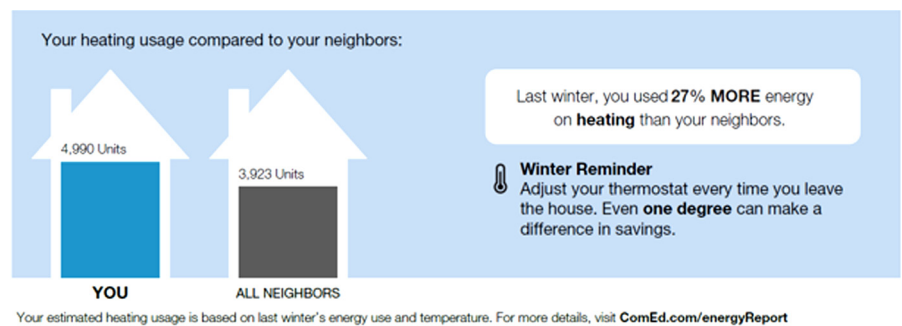


Figure 6. Heating disaggregation modules give households insight into their heating use.



The challenge for OPOWER was to produce mailings that included full-color graphics with personalized charts, commentary, and advice: no two reports are quite the same. Our development team has created proprietary PDF scripting engine, allowing for every full-colored report to be rendered in under 0.6 seconds, the rate necessary to keep high-powered printers working at its optimal cost-effectiveness. The time we took to extend the off-the-shelf PDF development kit was once again critical to success.

We work with one of the largest and most technically advanced printing companies in the world, and its CTO commented that, “OPOWER has turned paper reports into a dynamic product, customized for each household—these reports are the most sophisticated project we’re working on today.”

Integration with external services. One of the general challenges for a software-as-a-service company is striking the balance between the need for a standardized product and the pressure to address the specific requests from individual customers. More flexibility in how the OPOWER web portal is integrated with existing utility websites and in-home devices is an interest to a growing number of OPOWER clients. While it’s a good sign that utilities want to integrate OPOWER with their existing customer channels, the technical challenge integrating in a way that preserves the customer experience and minimizes customization costs for each client is formidable. To address this, the OPOWER software team has re-architected the system into a highly modular design, and is developing a suite of APIs to expose the various modules and provide enough flexibility for utilities and third parties to easily extend or customize our platform without the need for additional development time to be spent by our engineers.

THE RESULTS AND A LOOK AHEAD

OPOWER is on track to deliver 400GWh of energy saved in 2011; comparable to roughly one-third of the entire solar capacity of the U.S. The fact that this can be achieved by a single, young company is a testament to the combined power of behavioral sci-

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ence, analytics, and technology.

Although OPOWER’s approach is unique, other Smart Grid companies are incorporating elements of customer engagement into their products. There are also efforts to apply the same underlying principles in other arenas—for example, Paul Ferraro and Michael Price ran an experiment to reduce water consumption through norm-based messaging, and saw impressive results in reducing peak summer water consumption [2].

Looking forward, we are eager to help consumers understand and truly benefit from the next wave of smart energy technologies. Electric vehicles, smart appliances, and distributed generation, such as solar panels and fuel cells, are examples of new technologies that will transform the way consumers use energy. Time-of-use differentiated rates will also become more common and will create incentives to change usage patterns. Utilities recognize the important and difficult role they must play in guiding their customers through this increasingly complex energy ecosystem.

We see a great opportunity for us to help utilities provide their customers with the right personalized insights to make the most of these smart energy products and services.

We are doubling the size of our R&D team this year, because the opportunities are large and complex—we know we’ll encounter big new technical challenges along the way. This big push is exciting for us, especially because these new technologies expand the scope and scale of energy savings that we are driving.

Biographies

Alex Laskey is OPOWER’s President and Founder, and works to promote the potential of behavior-based energy efficiency worldwide. Laskey has shared OPOWER’s efficiency vision everywhere from Davos World Economic Forum to the White House, where he served as a cleantech business advisor to President Obama. He holds a BA in history of science from Harvard University.

Ogi Kavazovic is OPOWER’s Vice President of Strategy and Marketing, working to help the company shape the emerging Smart Grid space toward an efficient-consumer focus. A former management consultant in Katzenbach Partner’s energy practice, Kavazovic holds BA and MS degrees in computer science from Harvard University.

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