CALIFORNIA ENERGY COMMISSION

Energy Research and Development Division

**FINAL PROJECT REPORT**

# Reduce Your Plug Loads

Scalable Energy Efficiency Platform

**Gavin Newsom, Governor**

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# PREFACE

The California Energy Commission's Energy Research and Development Division supports energy research and development programs to spur innovation in energy efficiency, renewable energy and advanced clean generation, energy-related environmental protection, energy transmission and distribution and transportation.

In 2012, the Electric Program Investment Charge (EPIC) was established by the California Public Utilities Commission to fund public investments in research to create and advance new energy solutions, foster regional innovation and bring ideas from the lab to the marketplace. The California Energy Commission and the state's three largest investor-owned utilities—Pacific Gas and Electric Company, San Diego Gas & Electric Company and Southern California Edison Company—were selected to administer the EPIC funds and advance novel technologies, tools, and strategies that provide benefits to their electric ratepayers.

The Energy Commission is committed to ensuring public participation in its research and development programs that promote greater reliability, lower costs, and increase safety for the California electric ratepayer and include:

- Providing societal benefits.
- Reducing greenhouse gas emission in the electricity sector at the lowest possible cost.
- Supporting California's loading order to meet energy needs first with energy efficiency and demand response, next with renewable energy (distributed generation and utility scale), and finally with clean, conventional electricity supply.
- Supporting low-emission vehicles and transportation.
- Providing economic development.
- Using ratepayer funds efficiently.

*Reduce Your Plug Loads* is the final report for the Reduce Your Plug Load project, Contract Number EPC-15-025, conducted by Home Energy Analytics. The information from this project contributes to Energy Research and Development Division's EPIC Program.

For more information about the Energy Research and Development Division, please visit the Energy Commission's website at www.energy.ca.gov/research/ or contact the Energy Commission at 916-327-1551.

# ABSTRACT

California faces two major obstacles on the road to achieving the aggressive residential energy reduction goals set forth in Senate Bill 350: low participation in existing energy efficiency programs and increasing energy consumption due to plug loads. California has successfully set appliance and building efficiency standards that have achieved one of the lowest per capita energy use scores in the nation. However, the proliferation of plugged-in devices, in type and quantity, requires new approaches to energy reduction. Homes increasingly contain more devices that remain plugged in and draw power while in a standby mode. Progress has been made in setting standards for the more common appliances, such as set-top boxes and game stations, but new types of devices are expanding faster than can be regulated. The premise behind this research is that education and accurate, specific recommendations can help residents reduce energy waste in their homes due to the idle load of devices plugged in but not in use. The research resulted in the Reduce Your Plug Load platform consisting of: the Dr. Power app, the informational web portal, AskDrPower.com; and the Idle Load Database, an open-source database containing information and standby power for 169,440 unique devices, a public interface, and the necessary protocols so it can be used and expanded by any organization. The platform shows promise in engaging residents and encouraging them to take steps to reduce their idle load. However, the team encountered two significant barriers to greater use and acceptance: the ability to reach a large number of residents and encourage them to try Dr. Power, and access to electric smart meter data from two of the three California investor-owned utilities.

**Keywords:** Idle load, plug loads, residential energy efficiency, MELs, smart meters, data analytics

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# TABLE OF CONTENTS

Page

# LIST OF FIGURES

Page

# LIST OF TABLES

## EXECUTIVE SUMMARY

# Introduction

Plug loads make up nearly 60 percent of residential energy use and are forecast to grow faster than other energy-use categories. The project team developed the Reduce Your Plug Load (RYPL) platform to address residential idle loads—the power consumed in a home when all devices are turned off, yet all are plugged in to an outlet. Most devices continue to draw power even when they are turned off, wasting energy. Residential idle loads account for nearly $19 billion worth of electricity used across America per year. Most residents are not aware of the idle load of their home and are surprised at the waste it represents. Once they learn of the potential for low-cost energy savings associated with these idle loads, they frequently are willing to take simple steps to reduce it.

# Background

The RYPL platform helps residents measure and reduce the idle load of their home, the energy measured by the home smart meter during periods when all appliances are not in use or are turned off. Many people do not realize that even in the "off" setting, appliances are consuming power, and when all the idle loads from the various appliances are combined, the continuous energy consumption can be high. The study "Home Idle Load: Devices Wasting Huge Amount of Electricity When Not in Active Use" estimates that the idle load represents one-third of the yearly electric use in the average home. The potential for statewide savings is high with widespread participation, even from modest idle-load reductions. The premise of this research is that residents can reduce their idle load easily, with little investment in time or money when given access to accurate information and a customized list of actions.

The biggest challenge is that residential plug loads encompass a diverse set of energy-consuming devices. Starting in 1977, California set its first efficiency standards for refrigerators. The different types of appliances falling under efficiency standards have continued to grow; however, the variety of plug-load devices is expanding faster than standards can be set. New categories of appliances that do not have efficiency standards are proliferating pet water fountains, heated baby wipe dispensers, Wi-Fi-enabled BBQs, heated towel racks, and many others.

It is not possible to rely on device standards alone to reduce idle loads. Unregulated devices often have high standby loads, and in some cases—such as most heated towel racks—do not even have an "off" switch. Appliance standards are a cornerstone in the effort to reduce per-capita energy consumption but are not capable of expanding fast enough to keep up with new devices as they come onto the market. Instead, residents need a simple way to learn about devices with high idle loads so they can take action.

# Project Purpose

The goal was to determine if it is possible to develop a low-cost, scalable, accurate, and easy-to-use app for encouraging residents to reduce the idle load of their home. The result is the RYPL platform, consisting of (1) the Dr. Power app, (2) the informational Web portal at AskDrPower.com, and (3) the Idle Load Database (ILDB), formerly referred to as Plug Load Database (PLDB), an open source database containing information on standby power for (as of August 2019) 169,440 devices, together with the necessary protocols so it can be used and expanded by any organization. Users will interact mostly with the Dr. Power app. AskDrPower.com was developed to provide expert content and aid in recruiting new users. The Idle Load Database is the repository for appliance information used by Dr. Power.

# Project Approach

Dr. Power was designed and built to reduce residential idle load through user education and low-cost interventions customized to each home. The website is based on behavioral science techniques, such as "nudge theory" (which uses positive reinforcement and indirect suggestions), that have proven successful in other applications.

While many energy reduction apps exist, Dr. Power was designed to incorporate smart-meter data and measure standby power for specific devices to test the theory that users will save more energy when the information presented to them is accurate and not an estimate. Users can link Dr. Power to their utility accounts to measure the actual idle loads of their houses. After measuring the idle load and presenting this metric to the user in easy-to-understand terms, such as "It's like leaving a blender on nonstop in your home," Dr. Power creates a list of actions to reduce the idle loads of appliances the user indicated are in the home. The ILDB is an open source, expandable database of documented standby power for appliances organized by manufacturer, model, and device category. When a user indicates an appliance is in the home, Dr. Power accesses the information from the ILDB, if available, to show the role of that device in the overall idle load. Users can then make accurate choices on prioritizing which devices can be unplugged, put on timers, or plugged into smart power strips to reduce idle loads. Once users indicate their choices, Dr. Power predicts the power reduction. Ideally, Dr. Power is linked to their utility accounts, so their energy information is downloaded after 30 days, and they receive positive reinforcement for their actions through reduced idle loads, as verified by actual energy data.

User participation has been an important component for this project, and AskDrPower.com was developed in an attempt to increase participation when other methods for recruiting users were falling short. AskDrPower.com is an informational website that focuses on residential energy, particularly on reducing energy consumption. It includes a forum, articles, and interviews. Details about AskDrPower.com are presented in Chapter 4.

# Project Results

The project achieved several major goals:

- Dr. Power is an engaging app that has been highly rated by users:
  - Users rated their experiences 3.5 out of 5 within the Dr. Power app.
  - At the iTunes store, the app has 5 out of 5 stars.
  - At the Google Play Store, the app has 4.8 out of 5 stars.
- 1,742 Californians learned about home idle loads during the project, and 1,286 of them (74 percent) analyzed the idle loads of their homes using smart-meter data:
  - 727 Pacific Gas and Electric (PG&E) customers created Dr. Power accounts.
  - 90 Southern California Edison (SCE) customers created Dr. Power accounts.
  - 843 San Diego Gas & Electric (SDG&E) customers used a predecessor tool (UnplugStuff) to analyze their idle loads during the same period. (SDG&E did not allow the study to replace UnplugStuff with Dr. Power.)
  - 82 additional Californians analyzed their homes' idle load using a Green Button "Download My Data" service.
- Customers realized 5.8 kW of demand reduction and 15.2 MWh of measured electric savings. A subset of users provided access to sufficient smart-meter data so researchers could analyze their idle load changes from the 30 days before they uses the tool compared to the most recent 30 days of data collected. Detailed results from that subset include the following:
  - Across 341 PG&E Dr. Power users, on average their idle load was reduced by 5.4 watts (from 209 watts down to 204 watts). The average duration in the program for these users was 296 days.
    - Within these 341 users, the 190 "most engaged" with the Dr. Power app (those who inventoried more than 10 devices), reduced their individual idle loads by 16.8 watts.
  - Across 142 SDG&E UnplugStuff users, on average their idle load was reduced by 27.0 watts (from 248 watts down to 221 watts). The average duration in the program for these users was 181 days.
- Creation of the Idle Load Database, an open source database of energy consumption information used by Dr. Power:
  - The database contains data on nearly 170,000 appliances.

    - The public application programming interface (API) has been used by three applications: the Dr. Power app, Keewi's Smart Plug dashboard, and AskDrPower.com.
- Creation of AskDrPower.com, a unique and comprehensive on-line resource for exploring residential energy use. It is still quite new, but the number of organic visitors (those who use a search engine like Google or Bing) whose internet search led them to the site has increased more than 120 percent over the past six months, with a continued month-over-month growth rate of 14 percent. This equates to a 500 percent annual growth rate from initial content development alone, using no additional resources to execute other effective search-engine optimization traffic growth tactics, such as backlinks.
- Finally, the project provided much needed bridge funding for Home Energy Analytics to continue advanced research into smart meter analytics and behavioral energy efficiency methods as the study awaited implementation by the California Public Utility Commission (CPUC) and investor-owned utilities (IOUs) of newly passed legislation (Senate Bill 350 [De León, Chapter 547 Statutes of 2015], Assembly Bill 802 [Williams, Chapter 590, Statutes of 2015], and Assembly Bill 793 [Quirk, Chapter 589, Statutes of 2015). This new legislation has now resulted in several residential pay-for-performance programs in which Home Energy Analytics is playing a key role as contractor to PG&E, SCE, and SoCalGas, and leveraging results from this project. To date, this new program has delivered more than 10,000 million British thermal units (MMBtu) of measured cost-effective savings. This grant funding was critical to sustaining the study operations during the waiting period.

The project was not successful in some important respects:

- The study had challenges in engaging users affordably, and did not reach the goal of 20,000 users.
- The team was unable to integrate with SCE and SDG&E to access customer advanced metering infrastructure data. Despite claims that both utilities supported Green Button Connect, their customers could not initiate data access from Dr. Power. This greatly limited California IOU ratepayer participation.

# Technological Advancements

The project created and applied an expert system, a form of artificial intelligence (AI), to provide an intelligent guide for identifying and estimating idle loads within a home using only advanced metering infrastructure data and answers to simple questions. This classification system allowed Dr. Power users to easily identify devices in their home contributing to their idle load through a convenient method of "swiping" categories of devices, and then further refining the associated effect by answering simple questions about the devices. The questions were developed for each category to characterize accurately the standby loads of specific devices within the category. This is the first application of expert system technology to address the problem of residential plug loads.

# Assessments and Recommendations

The Reduce Your Plug Load platform, particularly Dr. Power, supports two important goals set forth by the Energy Commission:

- Increasing energy savings through behavioral changes, particularly in regard to plug loads
- Using energy data to promote ongoing energy savings

While the Reduce Your Plug Load platform addresses these goals, the supporting infrastructure does not yet exist, enabling Dr. Power to become a resource available to all California residents. Ratepayers will not benefit from this project unless the following issues can be resolved:

- During this project, only PG&E customers had a simple path to see the actual idle loads of their homes. Other California investor-owned electric utilities did not provide an easy-to-use method for granting access to user energy data.
- Dr. Power is not tied to the statewide energy education program, Energy Upgrade California®, which is heavily funded and the natural channel for promotion.
- Dr. Power, AskDrPower.com, and the Idle Load Database require modest on-going support so existing and new users can benefit.

As noted, SCE and SDG&E have not provided customers with an easy-to-use method to grant access to their energy data. The process of granting access for both utilities is so difficult that Dr. Power is effectively not supported for either one. Without analyzing the actual energy used by the resident, Dr. Power can make only generic recommendations and cannot track changes in energy use, one of the most important goals of the app. Neither IOU is living up to the goal highlighted in the California Existing Buildings Energy Efficiency Action Plan, DRAFT March 2015. As stated by Commissioner J. Andrew McAllister in the introduction:

> "Every consumer of energy deserves straightforward access to relevant information. …A quickly growing array of third-party analytical tools, including many that leverage smart meter functionality, can produce highquality, customer-specific intelligence at relatively low cost. Pervasive application of data analytics and other common-sense information tools, provided either through utilities or direct-to-consumer, will allow the energy efficiency marketplace to ideate and grow, over time encouraging a shift toward informed behavior and well-targeted investment."

The Reduce Your Plug Load platform clearly furthers this goal but SCE and SDG&E have not enabled the services envisioned above.

Again, from the 2015 plan under Goal 4, Section 4.2:

> Educate, motivate, and activate consumers to take action on energy efficiency with a comprehensive suite of target marketing, education, and outreach materials…. Leverage Energy Upgrade California.

Both Dr. Power and AskDrPower.com could contribute significantly to this goal; a mechanism for promoting them to California residents already exists at EnergyUpgradeCA.org.

Dr. Power has reached a level of maturity making it capable of engaging and supporting a large number of users. It encourages behavioral change based on the user's actual energy data. The biggest outstanding engineering issues are linking to SCE and SDG&E so ratepayers in those jurisdictions can analyze their energy use. There may be minor, on-going engineering support to implement enhancements and fix bugs as they arise, but the great majority of engineering development is completed, and Dr. Power is now a commercial-quality app. However, without a plan to promote Dr. Power and simplify data access with SCE and SDG&E, ratepayers will not benefit from this project.

Researchers recommend the following steps:

1. Mandate that SCE and SDG&E follow through on their commitments to support a customer-friendly mechanism for granting access to energy data. The CPUC is pursuing this mandate through proceedings A.18-11-016 and A.18-11-017. Home Energy Analytics has filed a protest to A.18-11-017, where SDG&E requests not to provide click-through data access, and is participating as a member of Mission: data in the protest of A.18-11-016, where SCE argues that there is no need to streamline data access. The value of the Reduce Your Plug Load platform to ratepayers would be greatly increased with easy data access for customers of these two large utilities.
2. Include Dr. Power as part of the EnergyUpgradeCA.org website. Dr. Power fits the goals for EnergyUpgradeCA.org as stated in the proposed decision by the CPUC on August 12, 2016 in proceeding A.12-01-007, page 9 "Statewide marketing, education and outreach will lead consumers to products, services and rate that empower all Californians to take actions that will lead to lower bills, higher energy efficiency…" Dr. Power is an excellent fit for this website, but requests to be included were not successful. Home Energy Analytics needs guidance on how to approach the CPUC to achieve this.
3. Provide modest funding to provide ongoing engineering, customer support, and integration work for SCE and SDG&E when both utilities support customer-friendly data access.

# Conclusion

Most of the work has been completed to design and build a professional app with the accompanying database and informational website to encourage user participation. However, few Californians have taken advantage of Dr. Power. To have a meaningful effect, more residents need to know about Dr. Power. California already has a statewide outreach program dedicated to energy knowledge; including Dr. Power as part of the program seems that logical next step to increase the benefit of this project to rate payers. However, prior to statewide promotion, SCE and SDG&E must provide easy data access for their customers. Until then, most California residents will not be able benefit from this project.

# CHAPTER 1: Introduction

Home idle load is generally defined as continuous electric energy consumption inside a residence. It is usually measured with hourly smart meter data, so "continuous" here means, "occurring in every hour of the day." In addition to standby power, idle loads include devices that may cycle on and off continuously and automatically to keep things running, such as a refrigerator or freezer. Standby power is the electricity a device draws even when it is switched "off" or is in standby mode. Idle load is a form of residential energy waste that operates in the background with no resident action, drawing electricity continuously, unnoticed when drawing hundreds or even thousands of watts.

Because idle loads often provide very little to zero utility to a resident, it is deemed a true waste and unnecessary addition to a resident's monthly electricity bill. Once properly identified, fixes to reduce idle loads for a majority of situations require very little effort or cost. Reducing idle load can be one of the easiest ways to make the home more affordable, while making it more energy efficient without altering the comforts of the home. To address this growing problem, the State of California needs to design and build a public resource deployable to millions of households throughout California.

## Background

Idle load is an unnoticed and unnecessary burden to people's monthly bills, the state's electric grid, and the atmosphere's carbon pollution. Its cost to individuals and to society is substantial; however, residential idle loads have been largely immune to statewide efficiency efforts. Because of the long-tail statistical distribution of residential idle load sources for any given home, idle load identification and mitigation has traditionally required expensive expertise or tedious monitoring. The designs and experimentations show that a trusted public resource providing immersive education can reduce idle loads for millions of Californian households.

### National Resources Defense Council Report

According to a report published by the National Resources Defense Council (NRDC), idle load accounts for $19 billion worth of electricity used across America per year (Delforge, Schmidt, & Schmidt, 2015). This amount of energy is equivalent to 50 large (500-megawatt) power plants' worth of electricity. To generate this electricity with fossil fuel would mean an extra 1-billion tons of greenhouse gas emissions a year.

In Northern California, the always-on portion of idle load (standby loads) accounted for 23 percent of household electricity consumption, costing each Californian resident between $210 and $440 per year on average[1]. More than 51 percent of that load came from consumer electronics, including televisions, computers, printers, game consoles, and the like. One of the biggest problems is the proliferation of digital devices that draw electricity even when on standby mode. Only 15 percent came from other forms of always-on usage such as heating, cooling, lighting and continuous refrigeration loads. The rest came from other miscellaneous electrical loads, such as recirculation pumps, fishponds, or GFCI outlets. Because of the ubiquity of electronic devices and household features across the state, these percentages and figures are a good approximation for a big part of California's residential building stock.

The other key finding from the NRDC report was that the source and makeup of idle load across audited homes varied greatly. Over the past half century, American homes have ended up with a variety of devices built into them, while American households have acquired a variety of devices. This heterogeneity makes it impossible to target awareness around only a select group of devices. Reducing an individual home's idle load first requires identifying the most offensive devices—the "long tail" devices within that particular residence. This detective work would be a difficult and tedious undertaking even for motivated residents with the proper knowledge and tools.

The NRDC report suggests an effective methodology in reducing idle load, which is simple and cost-effective for the resident. The methodology can be summarized in three steps.

1. Identify devices contributing to a home's idle load.
2. Make simple modifications.
    a. Unplug device.
    b. Install smart power switches.
    c. Adjust device settings (if available).
3. If economically feasible, replace devices with ENERGY STAR® alternatives.

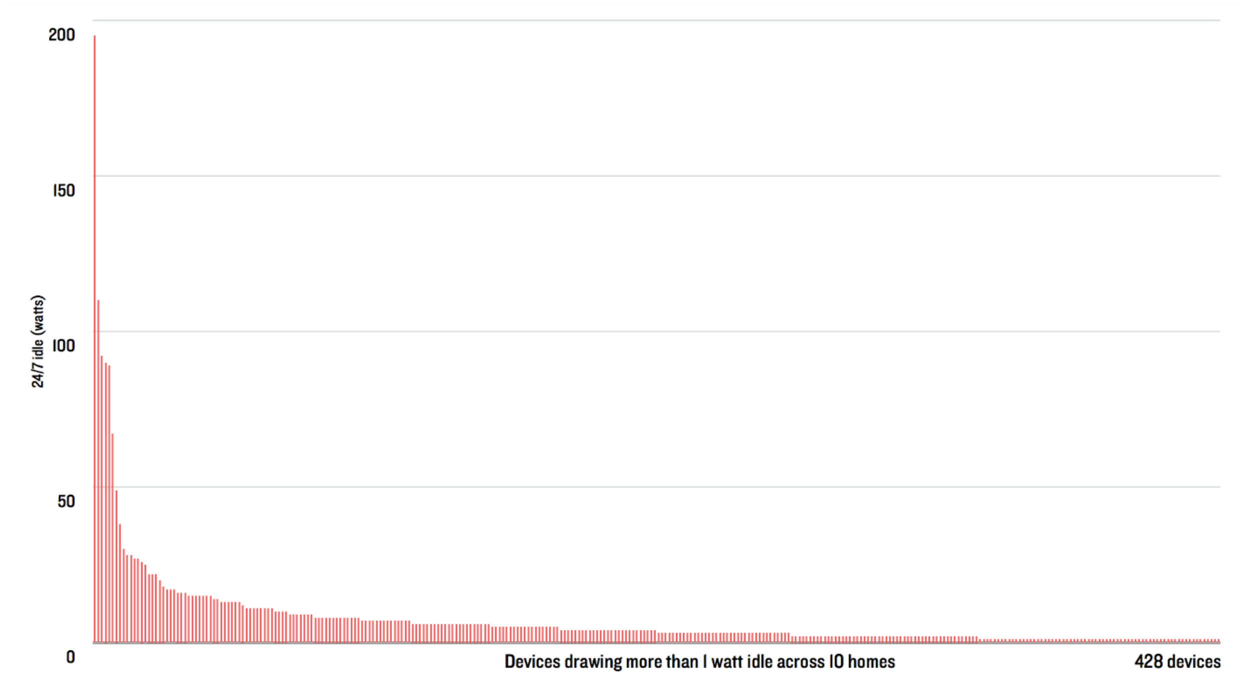
Smart power switches outlined in the report include smart power strips and timers. Most residents are already familiar with these devices that can be easily purchased and safely installed without expert knowledge. The report estimates that this methodology could save Americans about $8 billion per year in electricity bills and prevent about 44-million metric tons of carbon dioxide from electricity generation.

[1] Combined with intermittent idle loads like refrigerator compressors, this percentage grows. From page 11 of the report: "…average idle load (including both always-on and intermittent) varying from 203 watts and 35.6 percent of total electricity use in the Bay Area to 233 watts and 31.0 percent of total electricity use in the Central Valley."

## Idle Load Long-Tail Problem

The most difficult problem in reducing a home's idle load is identifying the devices that contribute to it. Figure 1 shows the idle load of 428 devices in ten homes in Northern California (Delforge, Schmidt, & Schmidt, 2015).

**Figure 1: Long Tail of Idle Load across 10 Homes**




Source: Home Energy Analytics

The long-tail distribution stems from two factors:

1. Idle loads can vary dramatically within the same device category.
2. Household ownership among a vast selection of devices is unpredictable.

The range of idle loads for any device type can be very large, depending on various characteristics of the device. First, the manufactured date of a device can dramatically affect its energy efficiency, so knowing only the brand and type of device is insufficient to gauge idle load. For example, the standby power of televisions can range from 0.5 watts to 30 watts, depending on its screen size, technology, and when it was made. The manufactured date is especially important if it is before or after any legislation around energy efficiency, such as ENERGY STAR compliance (Bertoldi, 2002). Second, the features of the device can significantly affect its idle load. Third, the design of the device across manufacturers can alter how much electricity a device consumes when on standby. Table 1 shows the estimated idle load ranges of several common household devices from the team's data aggregation, including direct measurements and downloads from such websites as HomeEnergy.org.

**Table 1: Low and High Idle Loads for Selected Household Device Types**

| Household Device Type | Low (watts) | High (watts) |
|---|---|---|
| Refrigerator or Freezer | 7 | 780 |
| Stereo | 0 | 150 |
| Continuous Hot Water Recirc. Pump | 20 | 110 |
| Continuous Fans | 2 | 100 |
| Inkjet Printer | 1 | 25 |

Source: Home Energy Analytics

Recognizing the existence of a device in a home is the first step. To accurately assess each device's idle load requires either direct measurement or trusted product information at the make and model level. Given a device type, estimating its idle load requires details about a device's brand, features, settings, and manufacturing date.

The second factor behind the long-tail distribution stems from the heterogeneity of device ownership across American households. The variety of devices found in American homes has proliferated to about 100-million different products (Scrapehero.com, 2018). A report published by an organization that monitors Amazon.com's product catalog provides some estimates shown in Table 2.

**Table 2: Number of Products for Sale on Amazon.com**

| Product Category | Number Available for Sale |
|---|---|
| Home and Kitchen | 86.09 million |
| Electronics | 37.78 million |
| Cell Phones & Accessories | 23.03 million |
| Tools & Home Improvement | 16.15 million |

Source: Home Energy Analytics

Furthermore, each audited home looked different from the next in the data that produced the long-tail distribution shown in Figure 1. More than half of the devices (with one watt idle load or more) were found in only one of the 10 homes, and 87 percent were found in less than half of the homes.

## Existing Solutions

Identifying each individual home's sources of idle load has been the biggest obstacle in scaling widespread adoption of simple measures to reduce it. Existing solutions to the identification problem listed below either have proven technically infeasible or rely on processes that cannot be scaled affordably to millions of residents.

### In-Person Home Audit

The most reliable method is to have an expert go through an individual home residence for several hours investigating and verifying its sources of idle load. This solution not only requires a trained work force, it can also be inconvenient and expensive for the vast majority of residents. Home audits work, but they are neither scalable nor affordable.

### Machine Learning

Another popular approach has been the use of machine learning and statistical methods to fully automate the identification of household devices from high-resolution electric use data. Tech giants Microsoft and Google, and a variety of well-funded startups, such as Sense Home Energy Monitor, have attempted this full automation for more than a decade. Despite concerted attempts by data scientists, no technical solution has come close to identifying what devices are inside a home, much less sources of its continuous base or idle loads. The other problem is that even if such a computational method is found, it will rely on resolution of data beyond the smart meter, requiring homes to install additional hardware. So far and in the near future, machine learning is neither scalable nor feasible.

### Awareness Campaigns

Perhaps the most attempted method in reducing idle load has been awareness campaigns launched by nonprofit organizations or commercial enterprises. Despite their best intentions, the vast majority of these campaigns resulted in disappointment and very little reduction in idle load. Awareness campaigns alone can run into the danger of losing public trust, because there are too many false positives: idle load sources follow a long-tail distribution, so campaigning around a few devices will not apply to the vast majority of residences. Further, commercial enterprises have sometimes eroded their reputations by focusing on expensive replacements or installation of yet more devices. Awareness campaigns alone do not work because idle load for an individual residence must be handled case by case.

## Need for Public Resource

Idle load reduction needs a public resource freely available to residents without the need to sell hardware or services to fund itself. The most scalable and feasible solution to the idle load identification problem is to have a trusted resource that facilitates guided self-service. The Reduce Your Plug Load (RYPL) platform covered in the next chapter is designed and built to be this public resource.

## Trust is Tantamount

The study's results and findings show that trust is tantamount to successful deployment. It can be built in two ways. One, the tools and information provided to the resident must be personally relevant and actionable; otherwise, the RYPL platform runs the risk of trust erosion from too many false positives; this is true in general, but especially pertinent to idle load reduction because of the long-tail distribution of its sources. Two, the RYPL platform needs to come from an entity with strong reputation for public good: the general populace has grown dismissive of advertisers making claims that are too good to be true. Precisely because idle load reduction is affordable and easy, persuading residents that it is effective requires a strong reputation of public goodwill; otherwise, the introduction runs the risk of being ignored at the outset.

# Keys to Nudging

Creating a public resource for idle load reduction faces similar challenges as those found in the fields of public health or behavioral economics. The experimental findings and user feedback show that what works in choice architecture and nudge theory also works for a self-service platform guiding users through idle load reduction. Nudge theory centers around "positive reinforcement and indirect suggestions as ways to influence the behavior and decision making of groups or individuals" (Thaler & Sunstein, 2009). The design and deployment of the publicly available RYPL platform use this key principle in nudging residents.

Similar to dieting or smoking cessation in public health, energy efficiency has developed several bad associations in the minds of the public:

- Painful sacrifices
- Expensive services
- Too hard to tackle

To overcome these objections, the most important aspect of applying new technology becomes its ability to help engage and nudge the user, not its promise to automate difficult tasks. Experimentation with various new technologies shows that several key principles described below work best in building a choice architecture with amenable nudges.

## Personalization

Choice overload actually reduces participant motivation and satisfaction. Creating choices that are ostensibly personalized to an individual household is paramount in continuing user motivation and prompting action. Personalization needs to be pervasive and obvious throughout, even in what may seem superficial in the design. For example, simply using pictures that users took of their own devices reminded them that all the information is tailored around solving their particular situations. In addition, data collection from directly asking users relevant questions is not a nuisance, but instead a good way to establish an experience where an intelligent entity is personalizing a solution. Of course, the most important part of personalization is providing sound guidance based on the user's own electric advanced metering infrastructure (AMI) data.

### Participatory Education

Most residents are not aware of idle load and the affordable ways to reduce it. The most effective way to educate a user is through immersive education, which means empowering users to investigate and resolve their own real-world problems at hand. First, show users their home's actual idle load to set the motivation for the next part. Second, guide users through an interactive investigation of their own homes to identify where all this unnecessary waste is. Third, provide effective choices users can take in mitigating the identified idle loads. Finally, provide tracking of progress for continued positive reinforcement.

### Low Cost Choices

Unlike most behavior change problems in public health, the action steps to reduce idle load have three advantages responsive to nudging:

1. Only need to be done once
2. Require little to no changes in lifestyle
3. Do not incur high financial costs for vast majority of residents

Because idle load is an unnecessary waste, emphasizing the virtues of the fixes help nudge users to investigate and identify the idle loads in their homes. Outreach findings show that emphasizing the ease and simplicity of the solutions distinguished idle load reduction from other energy conservation initiatives usually associated with pain or a large hidden cost. Ironically, as mentioned before, public good will is necessary to avoid being dismissed as too good to be true.

## New Technologies

The application of new technologies focused on supporting two goals:

1. Make the participatory process of identifying home idle loads more accessible.
2. Automate tedious tasks that may become barriers to adoption.

New technology experimentation ranged from methods popular in other industries not yet applied to the field of energy efficiency all the way to cutting-edge technology still in research phase, such as deep learning. The research team assessed a wide variety of technologies, quickly culling those that are premature or inapplicable. An example of a premature technology that would be applicable when mature is the using deep learning to build computer vision that can recognize the make and model of a household device. Currently, computer vision using deep learning is too premature to accurately identify the large variety of devices in existing homes.

The study also delved into more mature technology such as mobile apps and home Internet of Things (IoT) to investigate the best way to apply them now and in the coming years. For instance, in building the RYPL platform that is mobile first, researchers found that responsive web design is just as effective as native mobile apps, but responsive web has the benefit of being widely available on mobile devices without the significant overhead of building apps for two additional operating systems: Android and iOS. Home IoT technologies, on the other hand, are mature but adoption is not widespread nor consistent enough to make good use of it for idle load reduction.

After numerous designs and experimentations, these technologies most effectively supported the two goals around accessibility:

- Artificial intelligence that is mature
- Mobile responsive web
- Home IoT around home monitoring

# User Acquisition and Outreach

The goal of scaling the solution to millions of Californian households made paid advertising, like search engine marketing, prohibitively expensive (more than $50 per user). Experiments were run on commonly practiced digital paid advertising first, as that would be the easiest way to scale. The challenge, then, becomes the high cost of user acquisition, especially through the last step of the funnel where users link with their utility accounts to grant data access.

While originally thought to be a key method to reach a large audience for Dr. Power, collaborating with utilities, the California Public Utilities Commission (CPUC) and the California Energy Commission (CEC), on outreach proved impossible.

Content marketing, a longer-term approach, proved more accessible and affordable, if the challenges of acquiring high enough search-engine optimization (SEO) could be surmounted. Efforts to generate high-quality content for SEO have to date produced good results and proved the economic viability of content marketing; however, the challenge of acquiring link authority requires that the content to be inside a website, such as one for a utility, the CPUC, or the CEC.

# CHAPTER 2: The Reduce Your Plug Load Platform

The RYPL platform consists of the app, Dr. Power, the plug load database (PLDB also referred to as idle load database [ILDB]), and the website AskDrPower.com. The Dr. Power app and PLDB were the primary focus of the original EPIC proposal. The website AskDrPower.com was developed as a method to increase use of Dr. Power. The RYPL platform provides a dependable public resource for California residents to learn how to reduce the idle load of their homes. The platform is branded around the theme of a doctor available to diagnose energy waste in a home that results in higher than necessary energy bills. Like a trusted physician, Dr. Power asks questions and relies on the users' answers to find inexpensive and easy ways to reduce their homes' idle loads.

## Participatory Education by Design

The RYPL platform is designed as an immersive educational experience that nudges users toward idle load reduction. The user starts out with a vague desire to cut her energy bills, but graduates as a self-taught tinkerer consistently saving energy. People learn most effectively by resolving real-world personal situations and then being rewarded for the effort with positive reinforcement.

Dr. Power is an expert guiding the user through an educational investigation of her electricity use and environment in the home. At each step, the user is nudged toward low-commitment choices or tasks with minimal cost. Throughout the process, the site reinforces that the RYPL platform is neither a marketplace nor a retailer, but a tool to identify a home's "energy hogs." This characteristic helps to maintain the platform's reputation for unbiased presentation of choices and personalized content.

### User Persona

The team crafted the user persona in Table 3 after studying the motivations of target users via prototype interviews and researching other energy efficiency products to best represent the major pain points the selected architecture must address.

**Table 3: User Persona Characteristics**

| Characteristic | Description |
|---|---|
| Gender | Female |
| Age | 40 to 60 years |
| Occupation | Full-time job in corporation during regular business hours. Feels stressed and overworked. |
| Family | Married mother of two children who live with her |
| Experience | Not too handy, but enough to know how to use most tools in a toolbox. Not knowledgeable about technicalities of a house or any of the appliances. |
| Finances | Money is a concern. The family is able to live a middle-class lifestyle by stretching every dollar, but unexpected expenses make it hard for the household to save more than 5% of disposable income per year. |
| Motivation | Worried about the future and wants to start saving money in a predictable way |
| Attitude | Not reluctant to engage in simple do-it-yourself (DIY) tasks. Agrees that climate change is a problem that society needs to tackle, but it is not her top priority in daily life. |

Source: Home Energy Analytics

## User Journey

Table 4 and Figure 2 explain the user journey through the RYPL platform, nudging users through six key scenarios as part of the participatory educational experience.

**Figure 2: User Journey through the Platform**


Source: Home Energy Analytics

**Table 4: User Journey Through the Platform**

| Scenario | Description |
|---|---|
| 1 | **Cut Bills.** The resident starts knowing little about idle loads and energy efficiency, in general. Her biggest pain point is figuring out a way to cut her bills quickly and inexpensively. She sometimes asks friends and coworkers for advice, but eventually resorts to searching online using her mobile phone. She suspects her monthly energy bill is higher than it should be. |
| 2 | **Q&A.** The resident begins asking questions using Google Search as her main guide. Her pain point now is finding something effective that she can trust without spending more than she can afford. She has learned to ignore or suspect most advertising. She wants free, relevant, and trustworthy answers to her questions. |
| 3 | **Investigate.** The resident becomes a user who has a verified idle load. She understands that she can identify the sources of idle load herself by simply continuing Q&A with an app and optionally with a support staff. Her biggest pain point now is to figure out quickly how much she can save per month reducing her home idle load. |

| Scenario | Description |
|---|---|
| 4 | **Take Actions.** The user wants to spend as little time and money as possible in shaving her monthly bills. The expense and time necessary to implement the options she has found outside of the RYPL platform are prohibitive. The user wants to take the lowest-cost actions with the biggest savings and the least sacrifice. |
| 5 | **Track Progress.** The user has forgotten about idle loads until she is reminded to check the latest idle load measurement from her most recent energy bill. She sees that her low-cost actions result in persistent savings. The user is eager to do the rest of the recommendations on the list. The positive reinforcement eventually encourages her to share with her neighbors and friends what she has saved by learning about home idle load. |
| 6 | **Contribute.** A small minority of users with interest in residential energy use and/or community action for climate change will contribute to society by helping measure idle loads for home devices, sharing user success stories, and answering questions from those in scenario #2. |

Source: Home Energy Analytics

## Knowledge Repository

At the center of Figure 2 is the knowledge repository, continuously capturing knowledge to be used by both humans and machines. As an ecosystem, the RYPL platform is designed to be self-learning, improving with each new data point or user interaction. The knowledge repository content type usable by humans and machines include:

- Electric household device catalog
- Device measurements
- Idle load estimation heuristics
- Device images
- Smart meter data
- Long-form articles

## Summary of Design Tenets

As covered in Chapter 1, research and the study's findings show that successful behavior change requires much more than understanding the user journey. For idle load reduction, personalization and self-service investigation are crucial to widespread adoption. In addition, principles from nudge theory help overcome the associated pain the general populace associates with energy conservation. Lastly, an unbiased reputation for public goodwill is necessary to overcome the cynicism and advertising fatigue people have toward the large hidden costs associated with home upgrades ("you will save energy if you pay us to add more insulation") and environmental programs ("you will save the world if you pay us to add solar panels and a battery"). The design of the RYPL platform adheres to the following tenets:

1. Personalization:  Content and choices specifically explain and resolve the user's own real-world problem in her home.
2. Participatory Education:  Self-service identification of home idle loads is experienced as an educational investigation of her home's surroundings.
3. Low-Cost Choices:  Choices are low commitment and low cost, including low financial cost as well as little to no sacrifice of the household's comfort and lifestyle.
4. Trust:  Unbiased personalized content is presented from a program not funded by the sale of products or services.

# The RYPL Nudge Experience

The RYPL platform was designed and developed from the ground up as a choice architecture following the principles of nudge theory. This section explains how nudges are applied to the user journey described in the previous section.

## Entry Points

The target user starts as a resident motivated to lower her bills. She will begin her journey using a search engine, predominantly Google, to do research. There are two entry points into the RYPL platform. One, if someone who is motivated to cut waste from household energy bills is already convinced that idle load reduction is worthwhile, then this user can start with the identification process immediately by using Dr. Power as a mobile app or web application. Two, content from the RYPL platform shows up in a search engine results page for queries about cutting bills or lowering energy costs. This entry point is the broader one and considered the starting point.

## Nudging through the User Journey

An effective nudge is an optimal choice to relieve the biggest pain point at each scenario. Figure 3 and Table 5 show the proper nudge for each of the six scenarios. For example, in the first scenario where the biggest pain point is not knowing how to cut bills quickly, the RYPL platform uses search engine results to nudge the user toward the concept of lowering energy bills as a quick and affordable method that, when resolved, can provide savings that accrue every month.

**Figure 3: Nudging User Journey toward Idle Load Reduction**


Source: Home Energy Analytics

**Table 5: User Journey Pain Points and Corresponding Nudges**

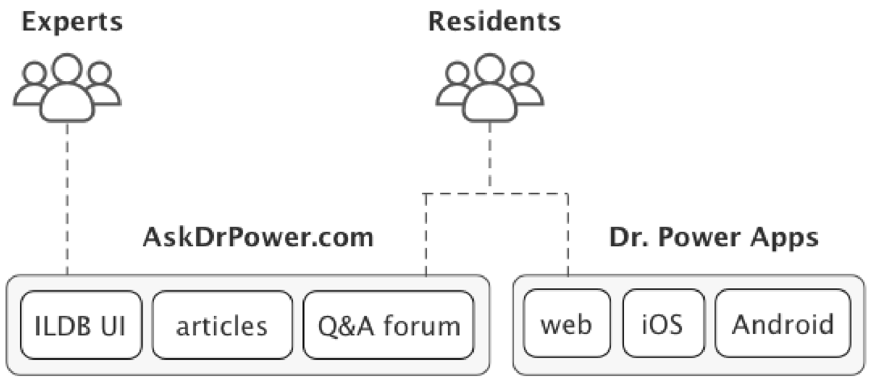
| | Scenario | Pain Point | Nudge |
|---|---|---|---|
| 1 | Cut Bills | Figure out a way to cut her bills quickly with little investment in time and money | Lower energy bill |
| 2 | Q&A | Find an affordable way that works with as little pain as possible. | Idle load is a good way |
| 3 | Investigate | Figure out how to reduce this annoying idle load. | Find the waste |
| 4 | Take Actions | Make sacrifices and compromises among myriad suggestions outside of RYPL. | Dr. Power's suggestions are easy and cheap |
| 5 | Track Progress | Figure out what is working and do more of that. | Idle load reduction works |
| 6 | Contribute | Help my friends and family do the same. | Share back in an online community |

Source: Home Energy Analytics

## Two Consumer Apps

Users interact with the RYPL platform primarily through two consumer apps: AskDrPower and Dr. Power. Table 6 provides an outline of what each app includes, and Figure 4 illustrates the high-level architecture for the user-facing part of the RYPL platform.

**Figure 4: User-Facing Subsystems**




Source: Home Energy Analytics

**Table 6: Two Consumer-Facing Apps of the Platform**

| App | Features |
|---|---|
| AskDrPower | AskDrPower.com is a web app dedicated to helping Californians lower energy bills and developed to show up in search engine results.<br>• Articles<br>• Q&A Forum<br>• Podcasts<br>• Idle load reference<br>• Device measurement submission |
| Dr. | Dr. Power pulls electricity bill data to guide users through the assessment and reduction of their homes' idle load.<br>• Access smart meter data<br>• Analyze idle load<br>• Identify idle load sources<br>• Chat with expert staff<br>• Choose remedies<br>• Track progress<br>• Device measurement submission |

Source: Home Energy Analytics

### AskDrPower

AskDrPower is an easily accessible and free public resource for learning about residential energy, including lowering energy bills. The website is designed "mobile first” and its content is structured to show up in search engine page results to nudge users at the starting point of their user journey. Its features and content are congruent with best practices in SEO (Clarke, 2019).

AskDrPower is optimized for search engines in the following ways:

1. Explanatory content match targeted keyword clusters
2. Q&A threads match long-tail distribution of questions
3. Podcasts for interviews and linkbacks
4. Idle load database available as faceted search

### Dr. Power

Dr. Power is a mobile app that uses AMI data to assess a user’s home idle load and then guide her through identifying and reducing that idle load. The app is designed as an educational investigation experience where the user participates actively in various ways:

- Investigates devices in the home
- Answers questions about the home and its contents
- Takes pictures
- Completes simple tasks
- Asks questions via text chat

The app is designed for mobile phones, but it also works well on a tablet or desktop computer via a browser. Our user research shows that a majority of people will be interacting with this type of app on their mobile phones. In the browser, the web app is responsive, which means that it will automatically detect the device screen size and conform its layout to it.

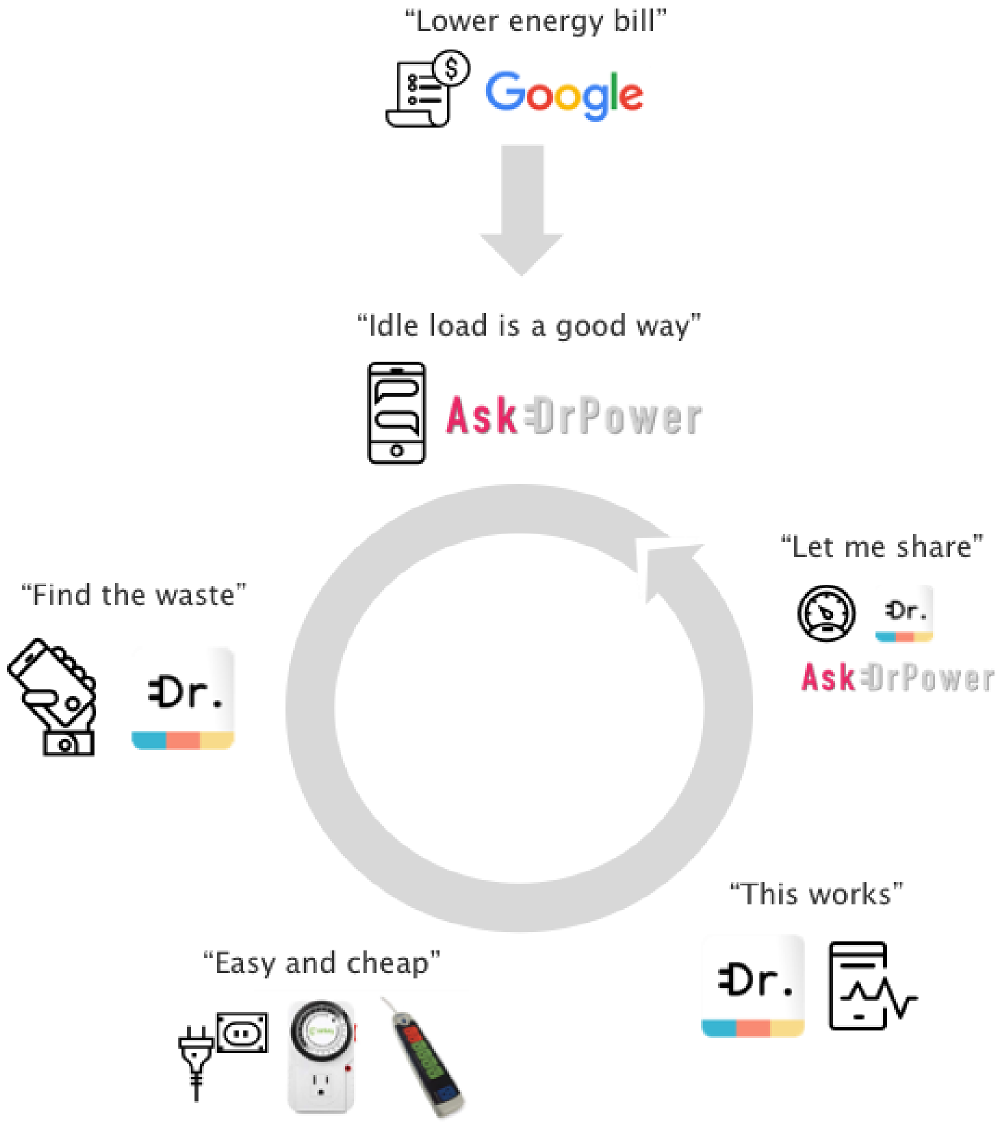
Dr. Power is available in the following ways:

- iOS native app downloadable from the Apple App Store
- Android native app downloadable from the Google Play Store
- Web browser on a mobile phone supporting Chrome, Safari, Firefox, and IE
- Web browser on a tablet or desktop computer supporting the same four browsers

## Nudging Toward Idle Load Reduction

The two consumer apps work together as a cohesive choice architecture. AskDrPower nudges the user at the beginning and the end, and is a complementary resource throughout the process as the user learns more about energy conservation and idle loads. Dr. Power is the personalized immersive education based on resolving a pressing problem: how to identify a home’s sources of idle load to persistently eliminate waste and cut down on monthly bills. Figure 5 illustrates how the two consumer apps provide nudges through the user journey toward idle load reduction.

**Figure 5: Consumer Apps Nudging toward Idle Load Reduction**




Source: Home Energy Analytics

## App Development

During the project, the research team designed and implemented more than thirty different user flows for AskDrPower and Dr. Power. This section will cover the user flows pertinent to the main function of the app for the typical user. Use cases to handle exceptions, though important, are not covered in this document.

## AskDrPower User Flows

Education and conversation start at AskDrPower.com. The user is first introduced to a public resource via search results, landing on diverse relevant content. Then, AskDrPower explains different topics, suggests idle load reduction, and directs the user to Dr. Power. This section now covers the main three user flows.

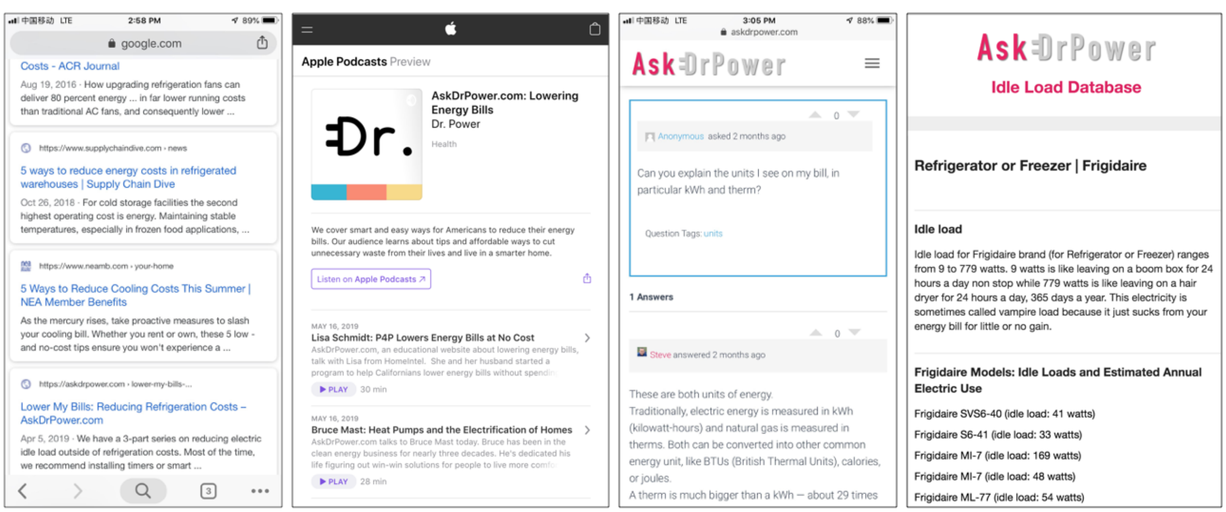
### Introduction to Trusted Public Resource

A user enters AskDrPower via search results in four typical ways:

1. Article snippets in search engine results page, such as Google
2. Podcast episodes in a number of sources, including Apple and Spotify
3. Answers showing up in search engine page results to long-tail distribution of questions
4. Electric use figures showing up in search engine results page

Figure 6 shows the screenshots of how a user may enter AskDrPower. The first one is an example of an article showing up in Google search engine results for the query "reducing refrigeration costs." The next three screenshots are landing pages introducing AskDrPower as a useful public resource. The first landing page shows AskDrPower in Apple.com's catalog of podcasts for the query "podcast lower energy bills." Podcasts allow AskDrPower to show up in search engines results, and is listed when more than ten different podcast broadcasters are searched. The second is an answer to a question about reading a utility bill. The third is idle load and electric use information about Frigidaire refrigerators.

**Figure 6: Screenshots for AskDrPower—Introduction to Public Resource**




Source: Home Energy Analytics

Trust is established and maintained throughout the web app in the following ways:

- Emphasis on this service as a public resource provided by the State of California

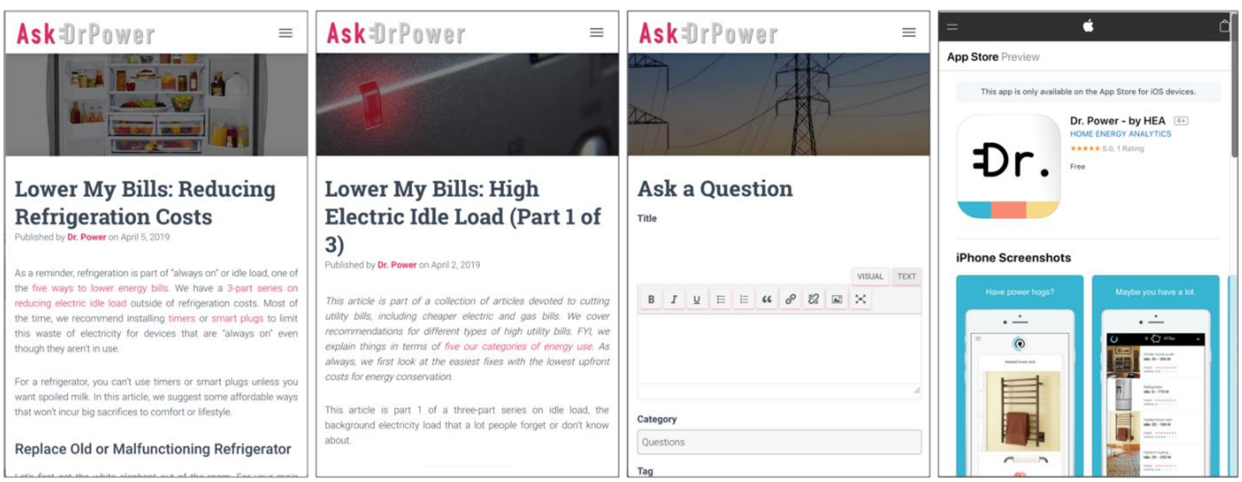
- Maintaining an open online community
- Topics expanded from idle loads to residential energy, in general
- Suggestions go far beyond idle load reduction and using Dr. Power
- No commercial products or services are promoted

### Educational Content Nudges to Dr. Power Trial

The educational content throughout the website not only explains, but also makes suggestions on how to lower energy bills. Articles and questions cross-reference each other so that the choice to try idle load reduction becomes an obvious "easy win." Figure 7 shows the main user flow of a resident using the educational content on AskDrPower. The screenshots correspond to the following interactions:

1. User comes from Google and reads an article about reducing refrigeration costs, which leads her to other content.
2. User reads about what idle load is and why eliminating waste is an easy and low-cost way to save money.
3. User asks the expert community a question about her situation.
4. User can try Dr. Power in a browser or download it from app stores.

**Figure 7: Screenshots for AskDrPower—Nudges to Dr. Power Trial**



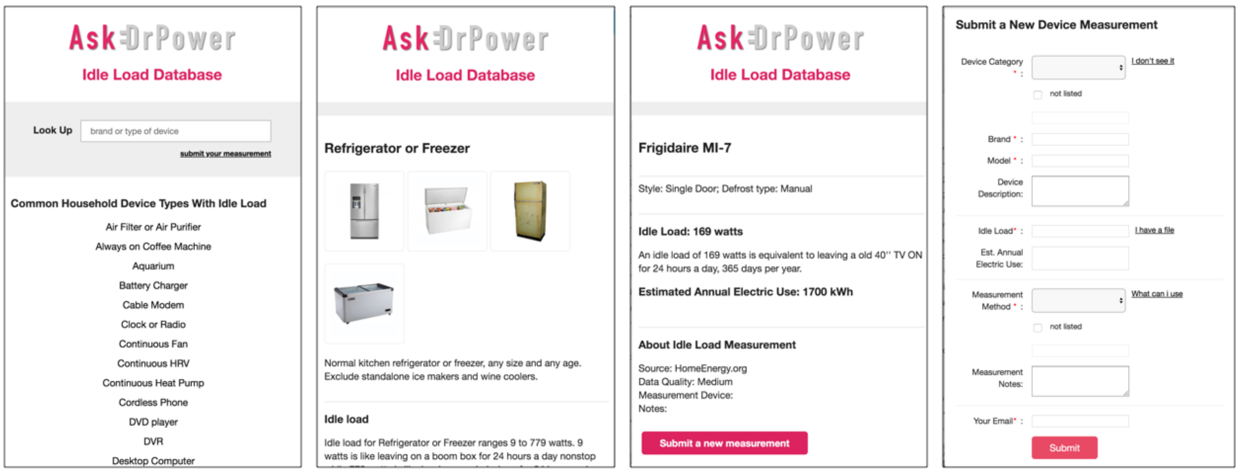

Source: Home Energy Analytics

### Looking Up the Idle Load Database

Some users will enter AskDrPower from researching electric use information for household devices. This subset of users may be technically savvy or are home improvement enthusiasts. They are nudged to contribute to content within the web app. Those who did not intend to look up technical information are directed to the articles and the Q&A forum. Figure 8 shows screenshots of the main user flow for looking up electric use information, as follows:

1. User searches or selects a device category.
2. User reads general information about a device category.
3. User finds exact make and model she is interested in.
4. User sees that she can directly measure idle load herself and contribute to the online community.

**Figure 8: Screenshots for AskDrPower—Looking Up the Idle Load Database**




Source: Home Energy Analytics

## Dr. Power User Flows

The Dr. Power app takes the user from linking to her utility account to tracking progress of her idle load reduction. The study's team designed the participatory educational experience to be conversational and engaging. The app asks users questions and enables them to text chat with Dr. Power anytime throughout the investigation. A dedicated chat service is built into the app and monitored by energy experts at HEA.

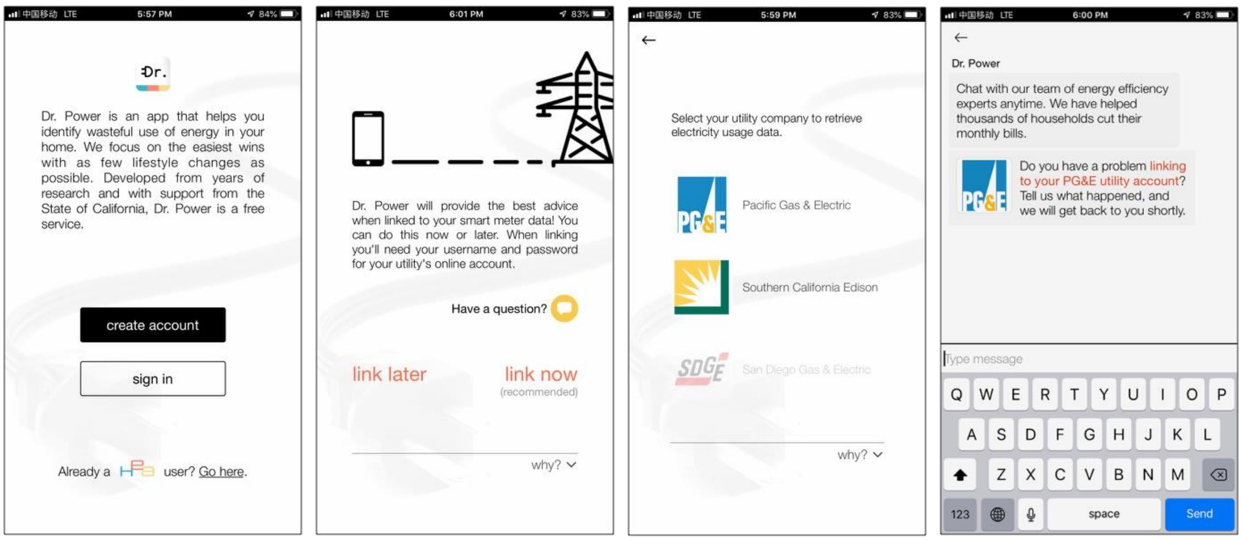
### Linking to Utility Account

After account creation, the user first links to her California investor-owned utility (IOU) account to retrieve her electricity use data. The most important aspect of this user flow is to avoid user drop-off. People introduced to new apps and new concepts tend to have little patience for tedious steps until they are rewarded with something of value. Because of poor data accessibility experienced during the project with the California IOUs, Dr. Power allows users to skip linking to their utility accounts and to begin immediately investigating idle load. This necessarily sacrifices personalization to minimize user drop off. Figure 9 shows selected screenshots highlighting the main steps of this user flow.

1. User chooses to create a new account or sign in. To reduce drop-off rate, numerous registration options were made available, including Facebook, Google, HEA, and email.

2. User can link to her utility account or do it later.
3. Two of the three utility companies in California are available. Access to SDG&E data is not available at this time, because the utility has not yet supported Dr. Power during the app's three years of operation.
4. A yellow chat button is available throughout the linking process for users to access support staff.

**Figure 9: Screenshots for Dr. Power—Linking to Utility Accounts**




Source: Home Energy Analytics

## Link Later: Estimating Idle Load

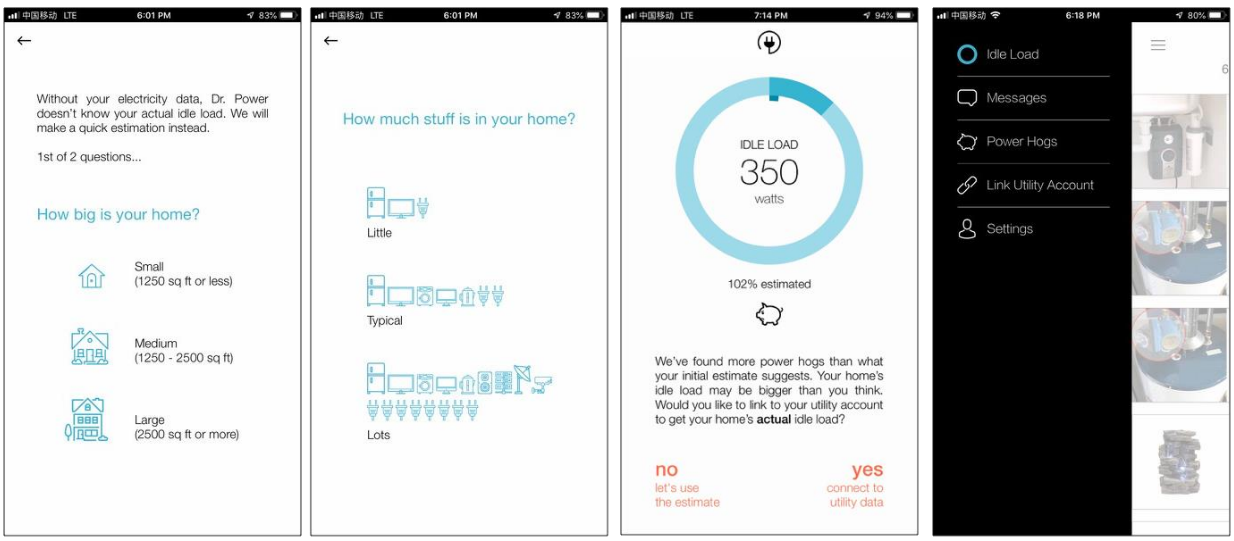
After initial public release, researchers added an option to "link later." Because linking to a utility account requires navigating the user to the utility company's website, the process was fraught with problems out of researchers' control, including:

- Residents not having an online utility account
- Residents not knowing their utility username and/or password
- Utility not providing secure open-protocol-based data access, such as SDG&E
- Utility company website functioning poorly in mobile web browsers
- The approval steps within the utility company website were confusing and too numerous, such as SCE requiring 14 clicks to grant data access approval
- Significant delays receiving AMI data (several days from SCE)
- Sporadic downtime for several days

As stated earlier, personalization is of utmost importance because of idle load's long-tail problem and because most people tend to be impatient with false positives, such as recommending LEDs when they have already done this conversion. Drop-off rates for linking to utility accounts exceeded 85 percent, so the study opted to sacrifice personalization to introduce the app to the user. Researchers created a quick two-step guide to estimate the user's home idle load, instead of assessing it directly from her electric use data. Figure 10 highlights the most important part of this user flow.

1. Dr. Power asks if the user's home is small, medium, or large.
2. Dr. Power asks if the quantity of "stuff" (household devices) in the user's home is considered small, typical, or large.
3. When Dr. Power detects that the user is actively investigating, the app will prompt the user to link to her utility account.
4. The user can also initiate linking to her utility account herself through the app's main menu.

**Figure 10: Screenshots of Dr. Power—Link Later**




Source: Home Energy Analytics

**What is My Idle Load?**

Education is most effective by showing, not telling. Presenting to the user exactly what is going on in her own home primes her for the investigation ahead. The team took great care to explain idle load and its impact on the user's electricity bill in visual and simple terms. This is done during the first use of the Dr. Power application. The team considered using video and audio production, but decided against it due to budget constraints.

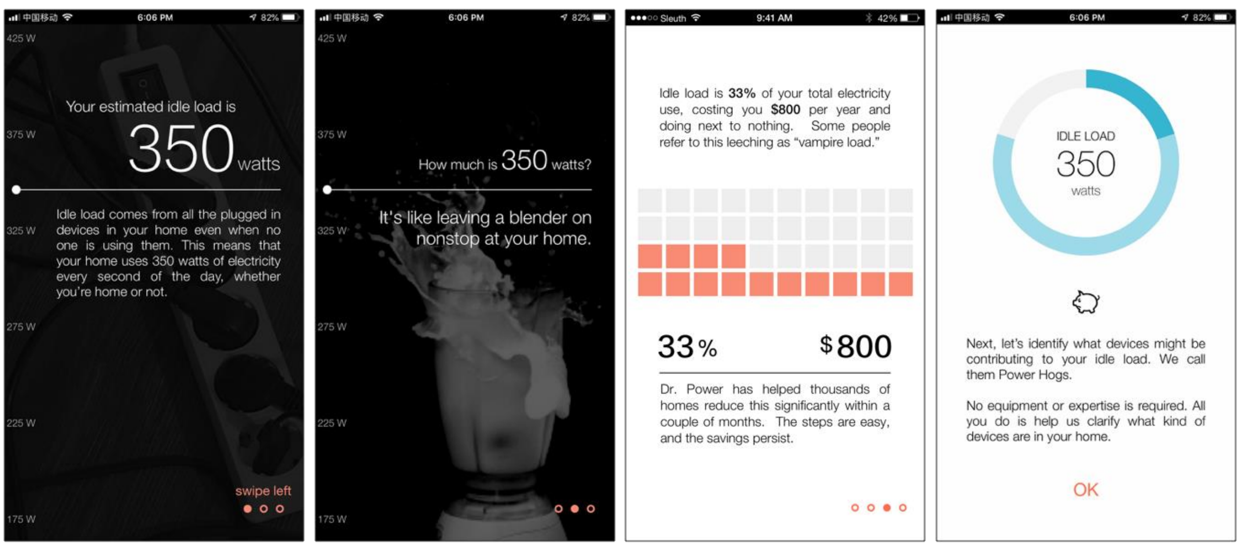
A common problem when educating people about electricity is the lack of understanding of how much a kilowatt-hour (kWh) is. One way is to equate a kWh to money, which the study does. However, comparing electricity to money alone does not convey the unnecessary wasted energy due to idle loads. The main concern with the idle load is that the load is "always on." To convey data about wasted energy, Dr. Power equates an idle load to allowing a common household device to run continuously.

Figure 11 shows the first four screens that explain the user's home idle load. During this process, the Dr. Power application:

1. Presents the home idle load as **X** watts with a concise explanation of what it is.
2. Helps the user understand how much **X** watts is by equating it with leaving a device using **X** watts turned on nonstop.
3. Shows the impact of the idle load on the user's monthly energy bill through explanation and visualization.
4. Incorporates an animated tutorial screen to encourage the user to begin the identification and reduction of her home's idle load.

After a quick introduction, the user is primed to begin a guided diagnostic of her home. Note that in screenshot #2 of Figure 11, the chosen device and background image change in relation to the detected idle load according to the reference table provided in APPENDIX A:
Dr. Power Representative Loads.

**Figure 11: Screenshots of Dr. Power—What is My Idle Load**



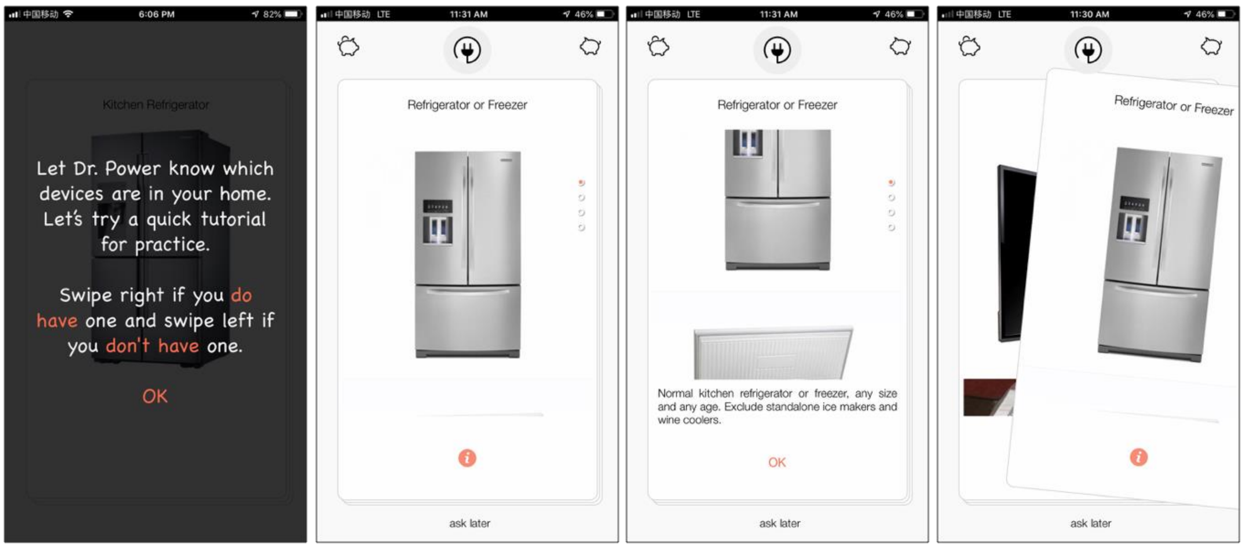

Source: Home Energy Analytics

## Sifting through Household Devices

In accordance with nudge theory, choices should be limited and obvious to reduce decision fatigue. The Dr. Power app was designed and built with interactions and animations that reward users for completing simple tasks. Investigation begins with the simplest task: recognizing if a household device is in the user's home. The process is as visual as possible to keep the user engaged. Users identify devices by swiping left or right, like dealing cards off a deck. User interviews revealed that they often found this part of the app "surprisingly fun swiping through devices that I never even thought of." Figure 12 highlights the main features of this user flow.

1. User begins with a tutorial where she practices swiping cards of devices left or right to indicate if she has one in her home or not.
2. The first card is a refrigerator, because it is the most common household device with a significant idle load. The order and the number of devices presented is optimized for each user to identify the biggest sources of idle load with as few swipes as possible until 100 percent of the idle load is identified.
3. Dr. Power can optionally display a brief description or more images for any given device type to clarify.
4. Swiping a card right means the user has at least one in her home. Swiping a card left means she does not have one.

**Figure 12: Screenshots of Dr. Power—Sifting through Household Devices**




Source: Home Energy Analytics

### Investigating Suspect Devices

When a user recognizes a device in her home, she has the option to begin immediately ascertaining the idle load of this device in her home or come back to it later. Dr. Power encourages the user to first answer basic questions she probably knows without further investigation. Each device category has a range of values for idle load. The specific idle load depends on the make, model, and settings of the device. For example, in the category "Refrigerator or Freezer," the idle load varies from 9W to 779W, an enormous difference. Just an approximation of its age and size can quickly help make the idle load estimate more precise by narrowing the range to a more reasonable 70W to 120W. If the user enters the make and model of a device, Dr. Power can sometimes retrieve the exact idle load in the ILDB.

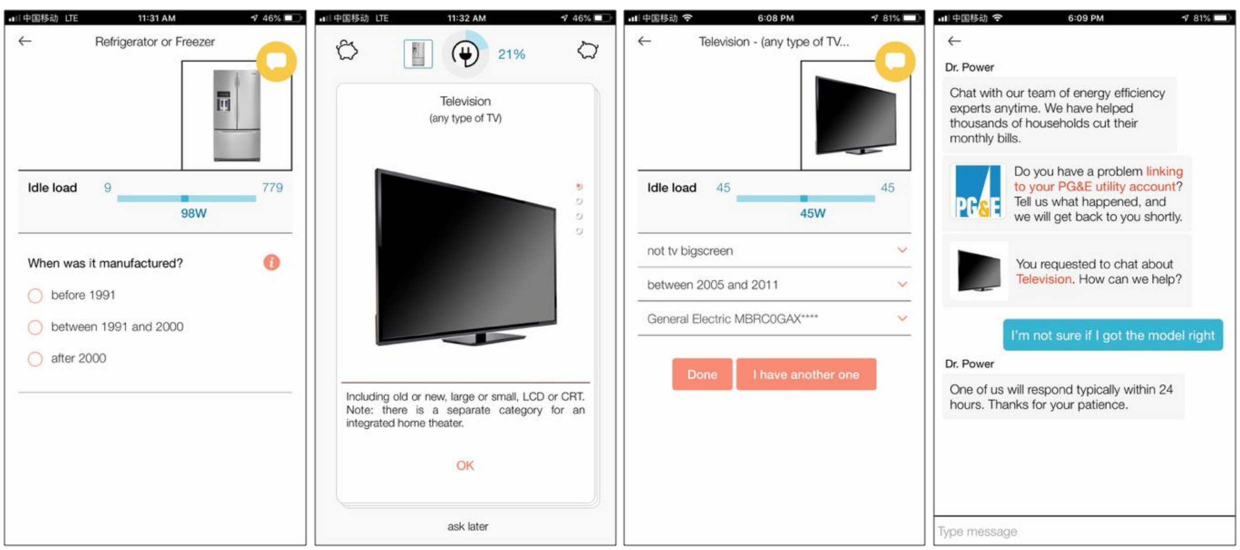
To make this investigation more engaging and rewarding, Dr. Power uses the following techniques throughout the user flow:

- Animation for most interactions
- Gamification to encourage completing the idle load identification
- Availability of text chatting with support staff

Interviews and feedback from users indicate that the use of these techniques provided an unexpectedly "fun and easy" experience. Figure 13 illustrates how the user experiences the flow.

1. User is presented the first question. If she needs help with the question, she can click on the "i" icon or tap on the bright yellow chat button that always floats at the top. The idle load estimate for the device will become more precise with each question answered.
2. When the next device card is revealed, the user sees an animation indicating what percentage of the idle load the last activity helped identify.
3. If the user has more than one device in a category, she has the choice to report it. In this example, the user entered the device's model to get the specific idle load for the device.
4. Chat is built-in throughout this user flow to allow conversational help from the staff. Dr. Power automatically inserts notes into the chat thread to facilitate discussion.

**Figure 13: Screenshots of Dr. Power—Investigating Suspect Devices**



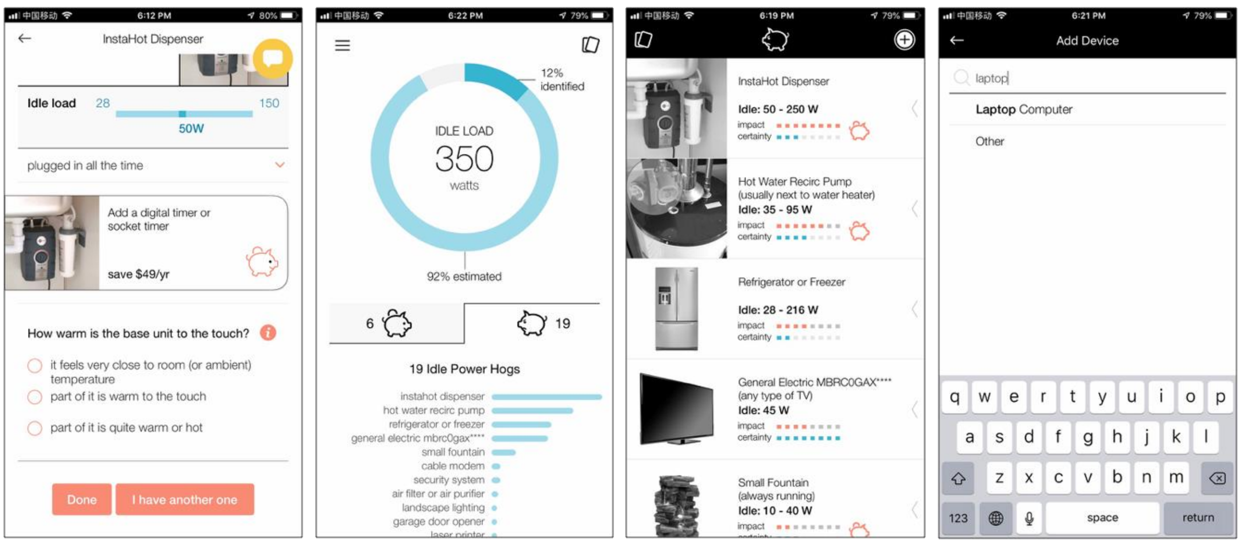

Source: Home Energy Analytics

## Identifying Idle Power Hogs

As the user investigates devices, she will soon find a few "hogs" contributing to her home's idle load. Hogs are devices with large idle loads and represent a significant portion of the overall idle load. Dr. Power has many features to draw attention to hogs when one is found during the investigation process. Figure 14 illustrates how hogs show up in the app.

1. A noticeably large animation highlights a hog once it is found while investigating a device. A recommended action and its estimated savings accompany the animation.
2. In the summary screen, hogs are listed with the worst at the top.
3. Hogs are at the top of the device list for high impact and often with piggy-bank icons to indicate possibilities for large and easy savings.
4. If a user thinks of a possible hog on her own, she can add it directly.

**Figure 14: Screenshots of Dr. Power—Identifying Idle Power Hogs, Part 1**

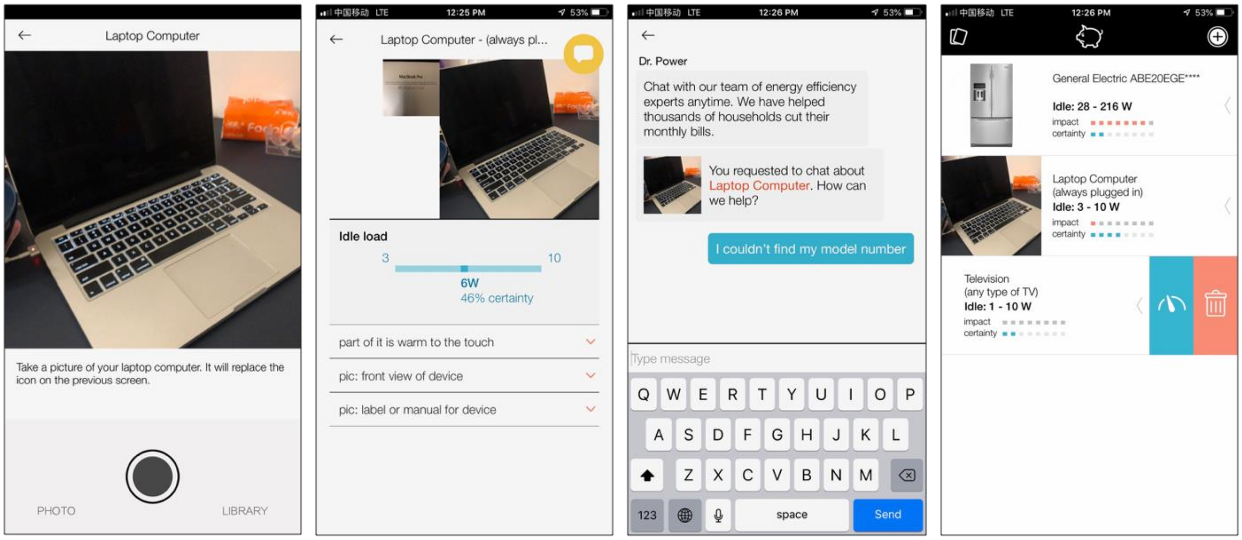



Source: Home Energy Analytics

Figure 15 illustrates how the app further helps users identify energy hogs, those devices with substantially higher idle loads.

1. Dr. Power encourages users to take pictures of the devices and of the nameplates showing make and model information.
2. Pictures provided by users are invaluable to RYPL's ILDB and can be used later to train artificial intelligence to recognize devices in pictures and videos.
3. Pictures taken by support staff helping users by providing more specific information.
4. Pictures submitted by users personalize the app and supplement the device list when there is more than one device in a category.

**Figure 15: Screenshots of Dr. Power—Identifying Idle Power Hogs, Part 2**



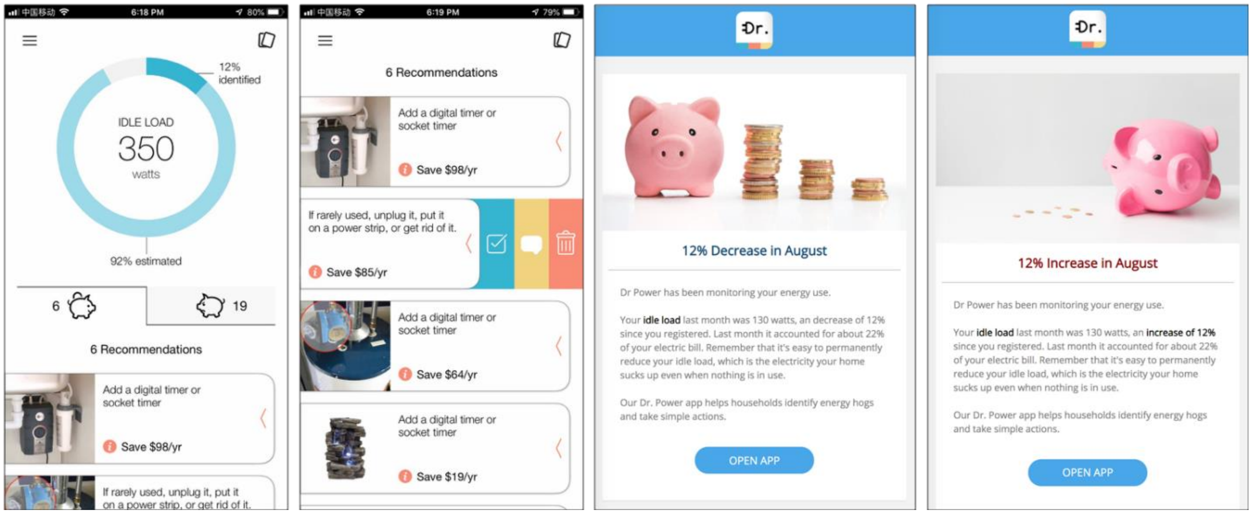

Source: Home Energy Analytics

## Take Actions and Track Progress

Although recommended actions are presented immediately during the investigation process, the app helps the user organize and track the actions. Actions are presented as a list of recommendations from which a user can choose. Each action can be marked complete or removed from the list. As always, users can tap the bright yellow button if they need help or have questions. Finally, the user receives a monthly email reminding her to check on the results of her idle load reduction. Figure 16 highlights the main interaction points of this user flow.

1. The list of recommendations first appears in the summary screen.
2. Each recommended action could be marked as completed, removed, or chatted about.
3. Each month, based on the most recent electricity bill, an active user receives a monthly progress report showing in her idle load.
4. Same as #3 above, except the idle load sometimes gets worse.

**Figure 16: Screenshots of Dr. Power—Take Actions and Track Progress**




Source: Home Energy Analytics

## Demo and Admin Modes

Dr. Power has three different operating modes to support the needs of different users. Table 7 shows the three different modes and their differences.

**Table 7: Dr. Power in Three Different Modes**

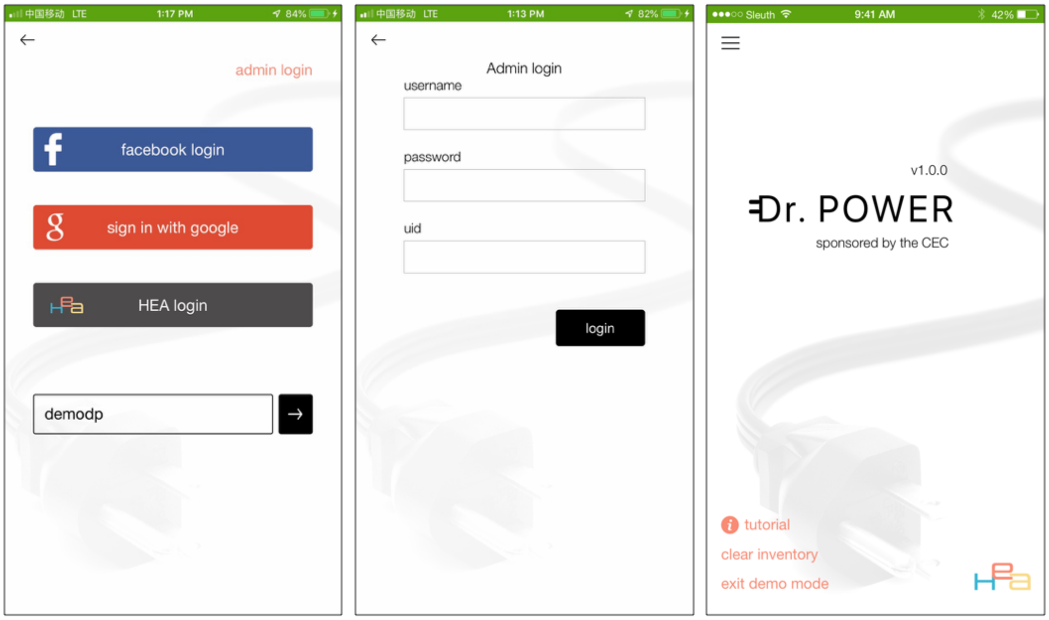
| Mode | User(s) | Features |
|---|---|---|
| Normal | Residents | The app works as usual. |
| Demo | Staff, Testers | • Enter arbitrary idle load<br>• Ability to "clear inventory" and start over |
| Admin | Administrator, Staff, Developers | Same features as Demo mode plus the ability to use the app as a typical user and debug problems with specific accounts. |

Source: Home Energy Analytics

Figure 17 illustrates how the modes work inside Dr. Power.

1. Enter the secret code word "demodp" as the email login. In demo mode, the status bar turns bright lime green, and the login screen now contains the "admin login" link.
2. Tapping on the "admin login" link displays the admin login screen.
3. In demo mode or admin mode, the About screen contains extra options.

**Figure 17: Screenshots of Dr. Power—Demo and Admin Modes**

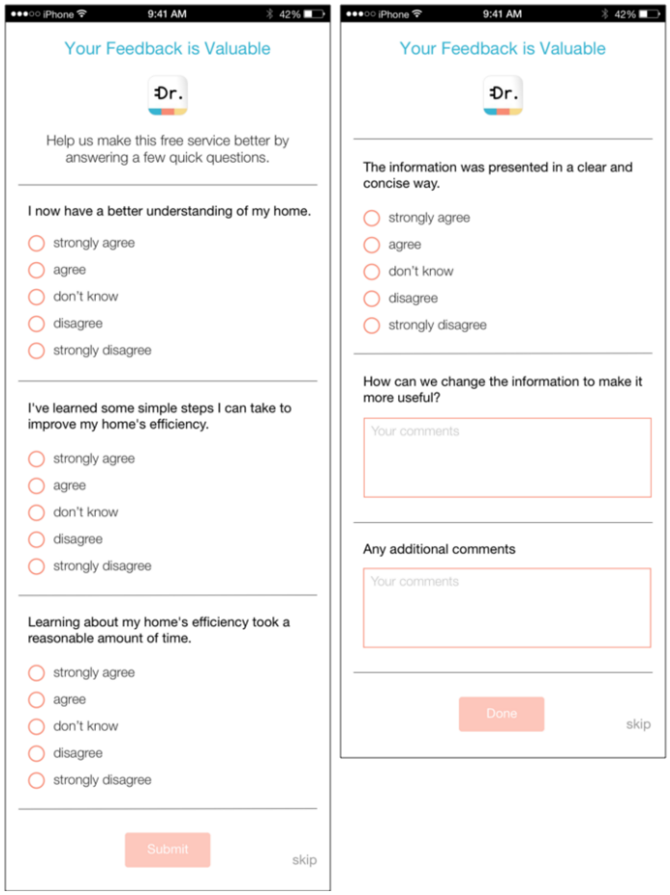



Source: Home Energy Analytics

## User Feedback Survey

After trying Dr. Power, the user receives a feedback survey containing six simple questions. Users can skip the survey if they wish. Figure 18 shows the contents of the feedback survey.

**Figure 18: Screenshots of Dr. Power User Feedback Survey**




Source: Home Energy Analytics

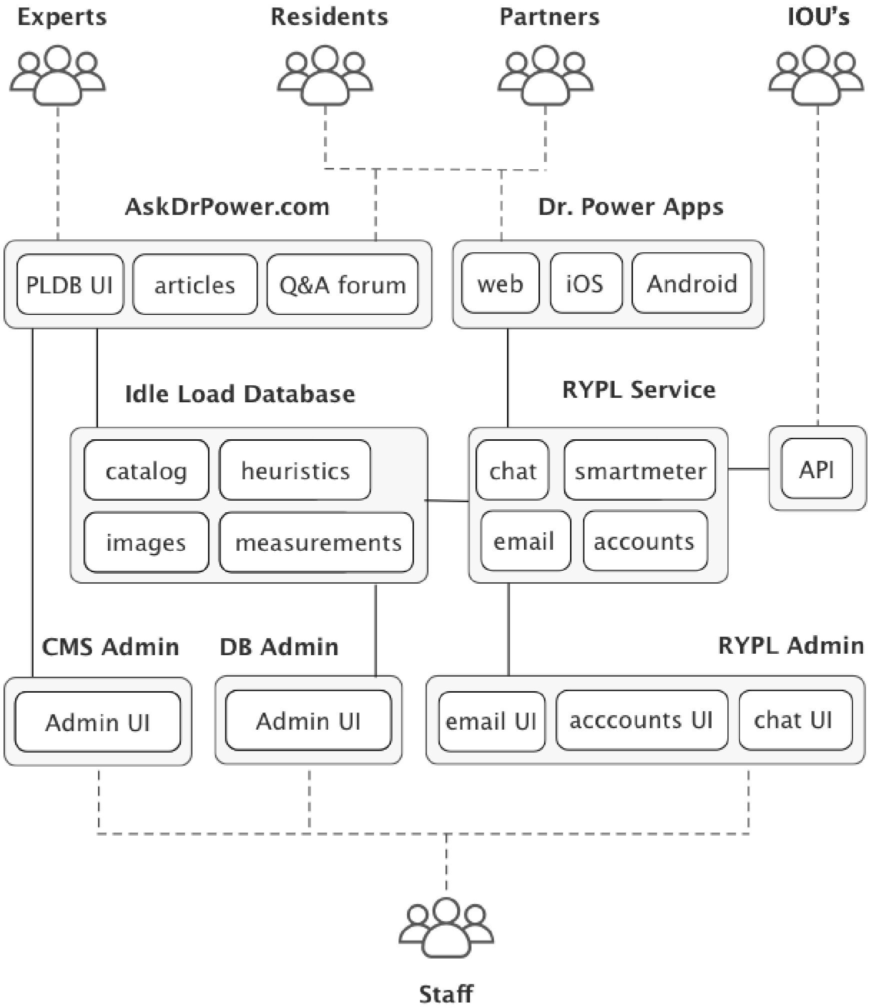
Below are the average feedback scores for each question (Range: 1=strongly disagree, 5=strongly agree), along with the quantity of responses:

1) I have a better understanding of my home: 3.5 (59 responses)
2) I've learned simple steps: 3.4 (59 responses)
3) Took a reasonable amount of time: 3.6 (58 responses)
4) Information presented clear and concise: 3.7 (57 responses)

# System Architecture

Behind the two apps, AskDrPower and Dr. Power, are five more subsystems. Figure 19 shows the system architecture for the RYPL platform, consisting in total of seven subsystems serving five different actors. Table 8 describes the five actors involved.

**Figure 19: Platform System Architecture**




Source: Home Energy Analytics

**Table 8: Actors of the Platform**

| Actor | Example | Description |
|---|---|---|
| Resident | | Any California resident |
| Expert | Energy Coach | A person who is very knowledgeable with residential energy, either as a researcher, administrator, or service practitioner |
| Partner | Enervee | An industry partner involved in the original proposal or added later |
| IOU | PG&E | Investor-Owned Utility |
| Staff | | Someone trained to administer the system and/or provide support to other actors in the platform |

Source: Home Energy Analytics

## Major Integration Challenges

The implementation of this system architecture faced two major challenges. First: integrating with IOUs' systems to access smart meter data was plagued by major delays and usability problems, causing severe user drop-off rates. Second: integration with IOU data systems increased the complexity of user account creation and linking across all systems involved. The second problem was eventually resolved, but the first problem remains a challenge.

### IOU Data Accessibility/Inaccessibility

In the team's September 2015 proposal, they indicated several times that the greatest risk to this project would be engaging with users. The researchers recognized that getting the word out about a free app to help with energy savings was going to be difficult. They did not identify data accessibility as a risk. All three IOUs had announced support of Green Button Connect, but their implementation has been lacking. The study's experience integrating with each of the three IOUs is described below.

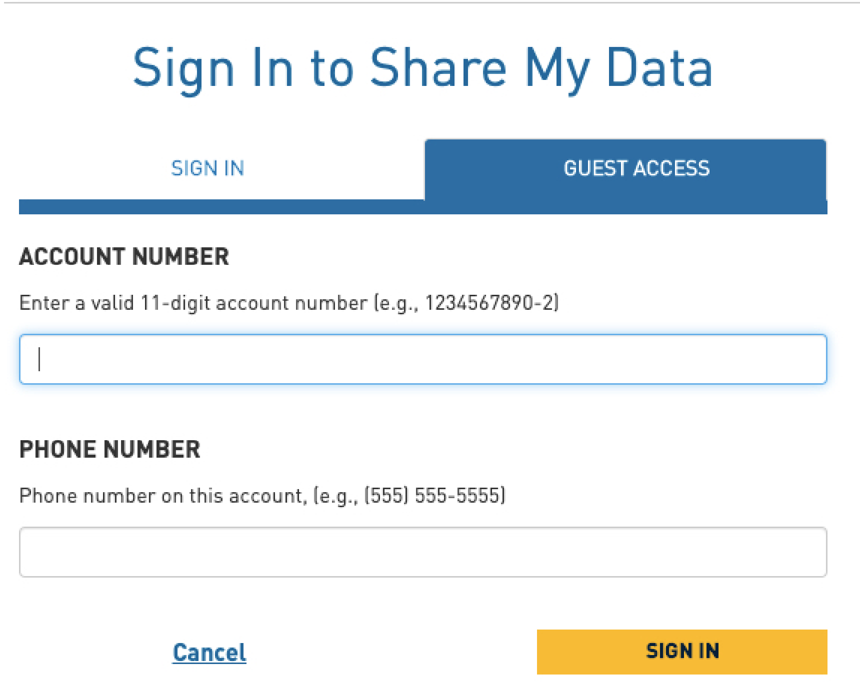
### PG&E's ShareMyData Platform; Grade: A+

Over the course of this project, PG&E has created an easy-to-use, reliable way for customers to grant access to their energy data. In their June 2018 update, the existing process[2] (which was already the best of the three at that time) was further updated[3] so it does not require the user to have an online account and can be completed in two screens as shown below in Figure 20 and Figure 21.

[2] Documented here: https://corp.hea.com/drpowerapppge

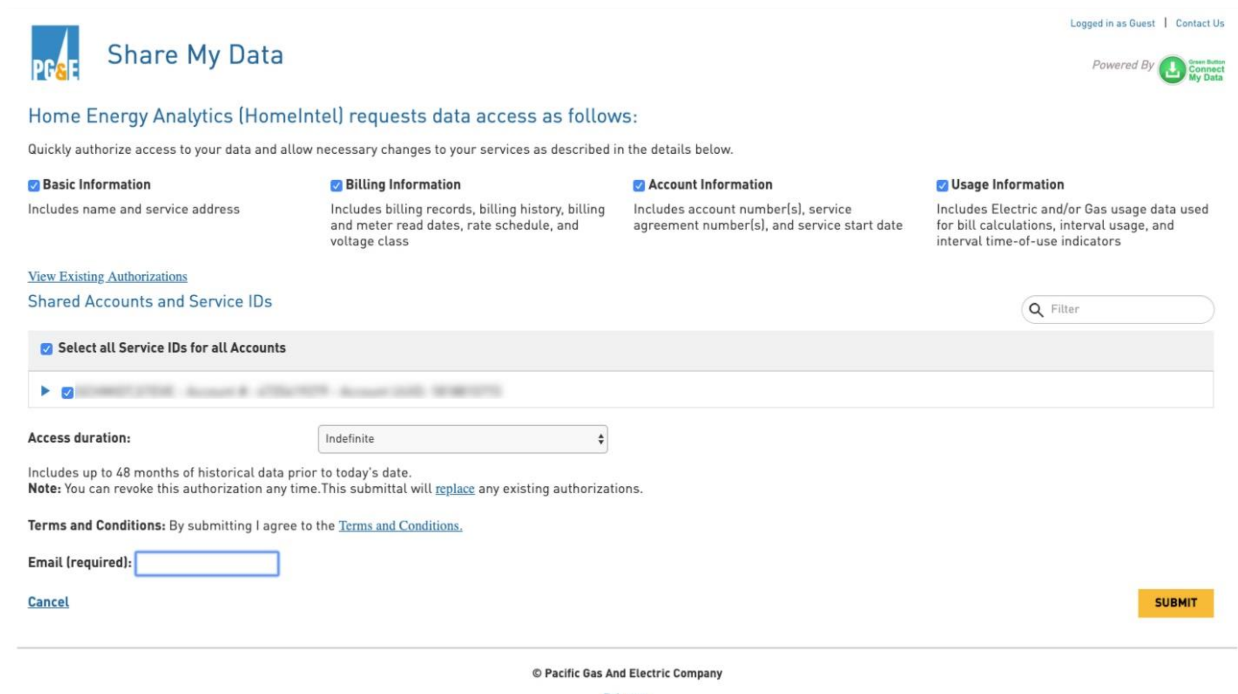
[3] Documented here: https://corp.hea.com/help-pge-share-my-data

**Figure 20: First Step in Linking Dr. Power with Pacific Gas & Energy**




Source: Home Energy Analytics

**Figure 21: Second Step in Linking Dr. Power with Pacific Gas & Energy**




Source: Home Energy Analytics

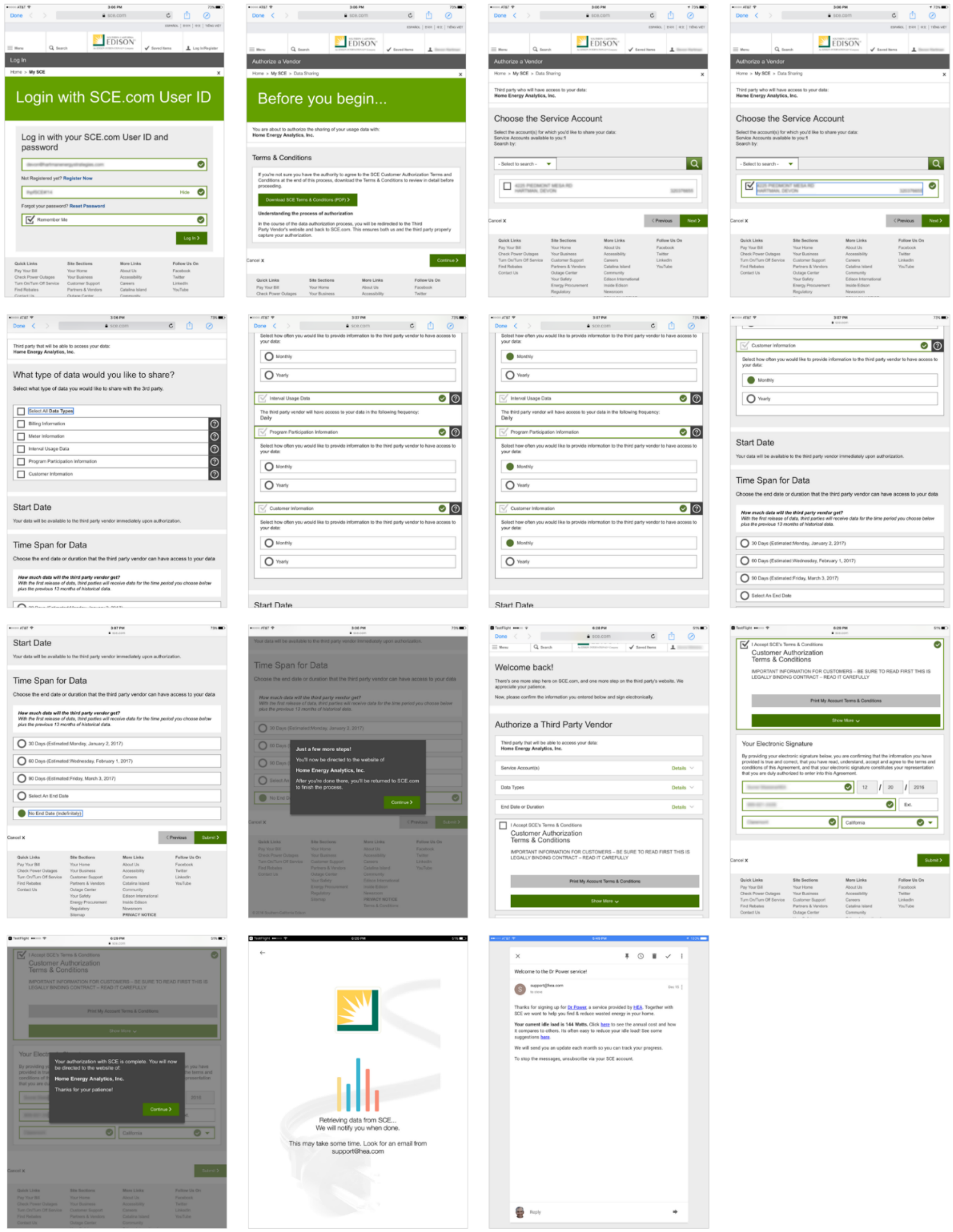
Once the PG&E customer completes the two screens shown above, data sharing occurs immediately. Dr. Power is able to access the data and share the analysis with the user in just a few minutes. This process is quick, easy, and stands in stark contrast to the other two systems.

**SCE's Green Button Connect System; Grade: F**

Until May 2019, a user was required to click through 15 screens[4] to authorize data access for an SCE account, and even after such a tedious authorization was completed, data frequently was not accessible for a day or longer. Few Californians will use an app with such a poor user experience. It is clear that SCE's implementation of Green Button Connect was not intended to be easy to use by either customers or third parties.

[4] Documented here: https://corp.hea.com/drpowerappsce

**Figure 22: Southern California Edison Registration Screens**




Source: Home Energy Analytics

## SDG&E's Open-Authorization-based Green Button Connect System; Grade: Incomplete

HEA integrated an early product (UnplugStuff) with SDG&E's original FTP-based system in October 2013. A more powerful and easy-to-use system based on Green Button

Connect (GBC) was announced by SDG&E via the following email to third parties on May 8, 2015, near the start of the RYPL project:

> "Good Day, Green Button Connect Team members!
>
> Over the past several months, the SDG&E Green Button Connect Team has been very busy! We have been working on upgrades to our Green Button Connect platform.
>
> During the last week of May (May 26), SDG&E will release those upgrades into production and go-live for both customers and third parties. The upgrades and enhancements include:
>
> - Filtering Tool on www.sdge.com that matches Green Button Connect tools to a customer's needs based on the customer's own input
> - Automated third-party registration process
> - Customized enrollment timeframes including additional historical data time periods
> - Compliance with Usability and Accessibility guidelines
>
> The system upgrades will impact all third parties. For example, the file formats have changed and will include meter numbers and account numbers in the subscription files."

To date, none of the events or services described in this email has come to pass.

HEA has been in contact with SDG&E regarding the Dr. Power integration to this new system since that date and has repeatedly been told by SDG&E that Dr. Power is "number two in the queue" for third party integration with this updated open authorization sometimes called "OAuth" to the GBC system. However integration delays on their part have been unending, and the integration to Dr. Power is still not complete.

SDG&E verbally promised support of improved data access from the very start of this project until their filing of A.18-11-017 on November 26, 2018, requesting that SDG&E not be required to support "click through," the proposed method for simplifying access to customer data. If they are successful in this request, SDG&E customers will never have easy access to GBC apps, such as Dr. Power.

The positions of both SCE and SDG&E have been in direct conflict with the goals of the 2015 CA Existing Buildings Energy Efficiency Action Plan and imposed severe constraints on the success of this program.

### Utility Data Link Rates

The project ended with 37 percent of Dr. Power users successfully linked to their utility account; however, only 3 percent came from users who were able to grant AMI data access inside the Dr. Power app. (Note: the app describes the process of granting data access via IOU web interface as "linking.") The vast majority of linked users came from the HEA system, where they had already granted access previously in HEA's other service. See Table 9 below for the breakdown of link rates.

**Table 9: Breakdown of Dr. Power Users Linked to Utility Account**

| Type of Users | Subtotal | Rate |
|---|---|---|
| All users | 817 | 100% |
| Linked to Utility | 305 | 37% |
| Already Linked from HEA | 280 | 34% |
| Linked within Dr. Power | 25 | 3% |

Source: Home Energy Analytics

As a result of IOU data inaccessibility, despite the fact approximately 50 percent of users attempted to link with their utility accounts inside the Dr. Power app, only 5 percent of users successfully granted access to their AMI data. Table 10 shows the breakdown of attempts and success rates for the three utility companies. Note that even with PG&E's better interface, only 10 percent of users successfully granted access, and none of the users from SCE managed to grant access; SDG&E did not have an interface, so none of its customers' 74 attempts were successful either.

**Table 10: Utility Account Linking Activity for Non-HEA Sourced Dr. Power Users**

| IOU | Subtotal | Attempted | Attempt Rate | Linked | Link Rate |
|---|---|---|---|---|---|
| PG&E | 263 | 125 | 48% | 25 | 10% |
| SCE | 98 | 46 | 47% | 0 | 0% |
| SDG&E | 137 | 74 | 54% | 0 | 0% |

Source: Home Energy Analytics

### Impact of IOU Data Inaccessibility

The impact of poor user web interface, especially on a mobile phone, in conjunction with other problems noted above resulted in only 3 percent of users able to properly use Dr. Power when user activity shows that 50 percent of users tried. This technical and usability hurdle informed the team to deploy two mitigation measures. One, the team implemented a "HEA social login" described in the next section, UtilityAPI.com

UtilityAPI.com is an integration hub that has worked with utility companies across the nation to make both billing data and AMI data available via a structured API. The team had considered using this service though it encountered two concerns. One, this service charged $15 for historical data and $2 per month for ongoing data. To support a user for two years would cost more than $60. The goals of this project aimed to provide a free service to Californians, so the team did not want to pass the cost to users. Two, at the time of consideration (near the beginning of the project), integration with

UtilityAPI.com would produce a collection process that would be inferior to directly connecting with the utility companies. The team did not anticipate the slow pace at which promised future development would be delivered. In hindsight, the team could have set aside a budget to at least experiment with integration with UtilityAPI.com.

Complexity of Handling All Accounts, to acquire Dr. Power users from the HEA system where data access can be transferred. Two, user acquisition costs must take into account that 90 percent to 97 percent of users may drop off or experience an unpersonalized and inferior experience at this step. Measures to manage affordable user acquisition are discussed in CHAPTER 4:
Scalable User Acquisition.

**UtilityAPI.com**

UtilityAPI.com is an integration hub that has worked with utility companies across the nation to make both billing data and AMI data available via a structured API. The team had considered using this service though it encountered two concerns. One, this service charged $15 for historical data and $2 per month for ongoing data. To support a user for two years would cost more than $60. The goals of this project aimed to provide a free service to Californians, so the team did not want to pass the cost to users. Two, at the time of consideration (near the beginning of the project), integration with UtilityAPI.com would produce a collection process that would be inferior to directly connecting with the utility companies. The team did not anticipate the slow pace at which promised future development would be delivered. In hindsight, the team could have set aside a budget to at least experiment with integration with UtilityAPI.com.

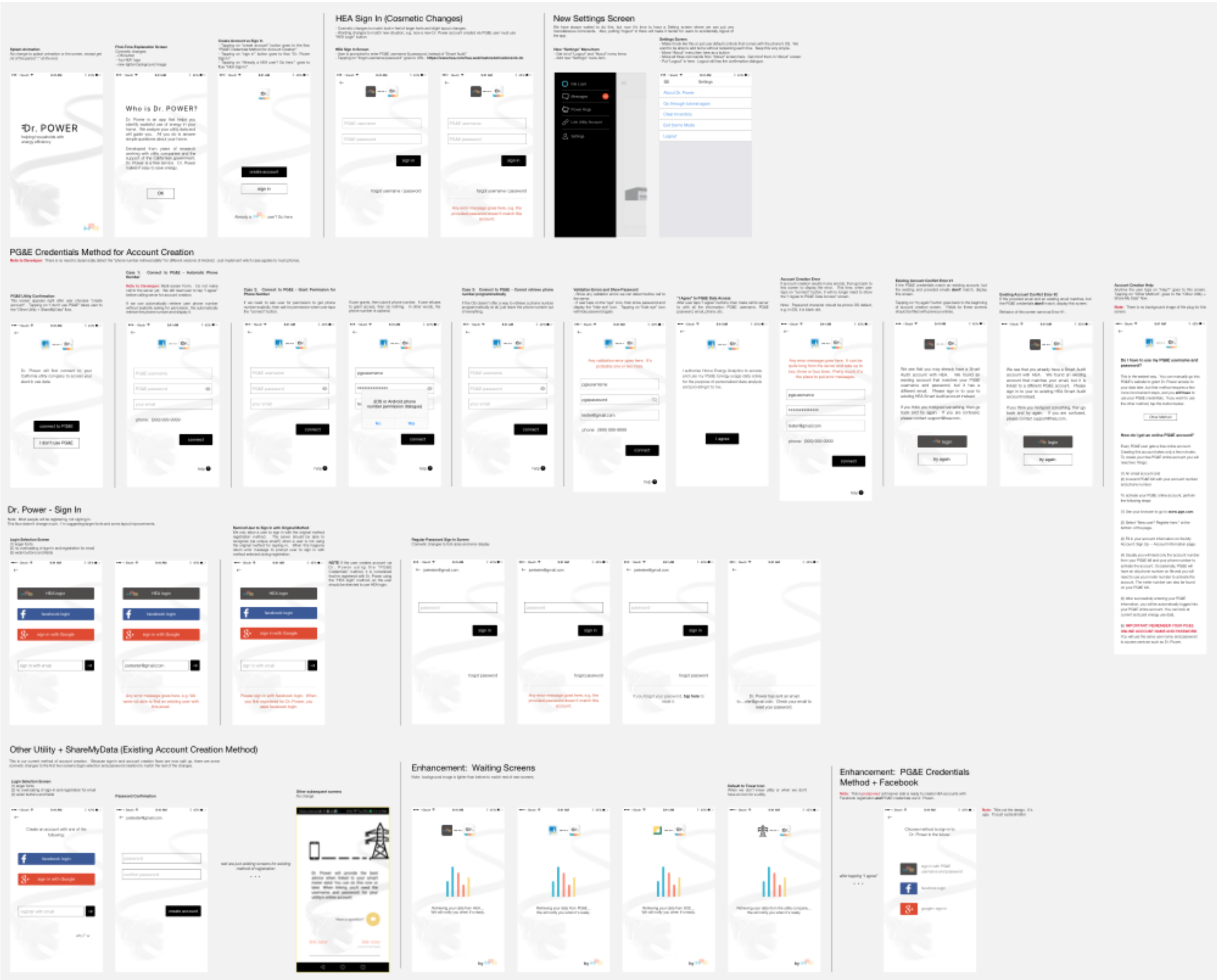
**Complexity of Handling All Accounts**

A user's first impression of Dr. Power, like any other mobile app, is when using account registration and linking. Linking is particularly important because personalization is crucial to immersive education and behavioral change. The different types of accounts and the data synchronization between them included the following:

- Social logins: Google, Facebook
- Partner login: HEA (to avoid relinking to IOU account)
- Utility account: PGE, SCE, SDG&E, or "unlinked"

Figure 23 shows the large number of screens necessary to handle account linking and syncing. It provides a glimpse of how the complexity quickly grew, requiring 13 iterations to resolve the problem to the team's satisfaction. Nonetheless, the challenge was overcome after two months of focused design and engineering helped to streamline the process as much as possible for the new user.

Figure 23: App Design for Handling Account Login and Registration




Source: Home Energy Analytics

# Cloud Service Development

To support the functionality required by the two apps (AskDrPower and Dr. Power), five additional subsystems were developed to enable the thirty-plus user flows. The "behind the scenes" subsystems consist of the following:

- ILDB
- RYPL Cloud Service
- Administrative Consoles
    - ILDB Admin
    - AskDrPower Admin
    - RYPL Cloud Service Admin

## Idle Load Database

The ILDB served as the main knowledge repository for Dr. Power and the ILDB portion of AskDrPower. Table 11 lists the knowledge stored in the ILDB. The data is used by both human and machine, including the expert system personified as "Dr. Power" that uses heuristics to quickly estimate idle loads for different device configurations.

**Table 11: Knowledge Content Type in Idle Load Database**

| Content Type | Description |
|---|---|
| Electric Device Catalog | Structured catalog of household electric devices in American homes<br>• Human: Browse and look up information<br>• Machine: Ontology used in heuristics and machine learning |
| Measurements | Directly measured or reported idle loads and annual electric use for make and model of a household electric device<br>• Human: Look up idle loads for brands, categories or exact make and model<br>• Machine: Numerical values used in heuristics and machine learning |
| Heuristics | The logic and agent interaction with users behind the heuristics are stored as structured metadata<br>• Human: Update heuristics or agent interaction without software programming<br>• Machine: Continuous improvement of the software agent and useful for future machine learning |
| Device Images | Images of devices for reference<br>• Human: Quickly verify a device category or a make<br>• Machine: Deep-learning improving quickly, but still requires a vast amount of data for object recognition inside images |

Source: Home Energy Analytics

### Object Entities

Eighteen tables in a relational database were created and populated to support eight object entities important to keeping a publicly available repository. The eight object entities are listed and described in Table 12.

**Table 12: Data Entities of Idle Load Database**

| Data Entity | Count | Description |
|---|---|---|
| Product | 169,440 | A product is a particular make and model of a household device using electricity. If available, each product contains the following information:<br>• Brand<br>• Model number<br>• Idle load<br>• Estimated annual electric use<br>• Measurement method |
| Category | 91 | A category is a user-friendly grouping of products with known idle loads that is displayed to the user, e.g., "Refrigerator or Freezer," or "TVs." |
| Category Image | 280 | A category image is a representative visual for a device category. Each category has two to four images to help users recognize the category immediately. |
| Subcategory | 499 | A subcategory is an internally used ontology to further group products by relevant features for estimating idle loads. |
| Product Type | 218 | A product type is the mapping of device ontology from Keewi's device classification system to each ILDB category. |
| Feature | 49 | A feature is a characteristic of a device or a user observation, e.g., "Is it warm to the touch?," determined by analysis to be important in estimating idle loads for that category. |
| User Action | 14 | A collection of recommended actions that can be applied to a device by a user in order to reduce its idle load. |
| Measurement Device | 5 | A measurement device is an instrument used to directly measure the idle load of a household device, e.g., a kilowatt meter. |

Source: Home Energy Analytics

### Initial Data Aggregation

Over the course of three years, idle load and annual electric use data were collected for more than 169,000 products (with specific make and models) in 91 device categories. A complete and detailed list of all device categories is available in APPENDIX C: Idle Load Database Device Categories of this document. The initial aggregation of device data required substantial design and engineering work to clean and organize various sources of data. Table 13 lists the sources of data used to first populate the database. Detailed data for appliances were downloaded from reliable public sources. Afterward, the database was designed to accommodate future user measurement submissions. But, most importantly, the metadata and data needed to be arranged to facilitate an expert system, the app's user experience, and the goal to reduce idle load.

**Table 13: Data Collection by Attributed Source**

| Attribution | Records |
|---|---|
| HomeEnergy.org | 87,587 |
| Energy.ca.gov/appliances | 59,842 |
| Data.energystar.gov | 74 |
| Keewi Inc. | 35 |
| Users | 20 |

Source: Home Energy Analytics

After data ETL (extraction, transformation, and load), the team performed an analysis to construct the most useful initial dataset for Dr. Power and AskDrPower. This work included first inserting idle load records for most common household devices that are the hardest for which to estimate idle loads. For example, nearly every household has a refrigerator accounting for a substantial portion of the idle load. Refrigerator idle loads vary from 10W to 800W and vary depending on a variety of characteristics (age, size, and so on). Thus, nearly 100,000 records were uploaded for refrigerators as the first use case. Table 14 lists other device categories that were loaded initially.

**Table 14: Database Product Records by Device Category**

| Category | Records |
|---|---|
| Refrigerator or Freezer | 107,982 |
| Battery Charger | 25,172 |
| Other Device | 10,376 |
| Furnace | 9,887 |
| Television | 7,473 |
| Stereo | 5,088 |
| Standalone Ice Maker | 1,545 |
| Instant Hot Water Dispenser | 985 |
| Undersized AC Unit | 906 |
| Other | 26 |

Source: Home Energy Analytics

### Initial Metadata Generation

Data aggregation from the sources listed above primarily organized and filled the product data type, which is only one of eight object entities in the ILDB. Following are six of the object entities considered metadata:

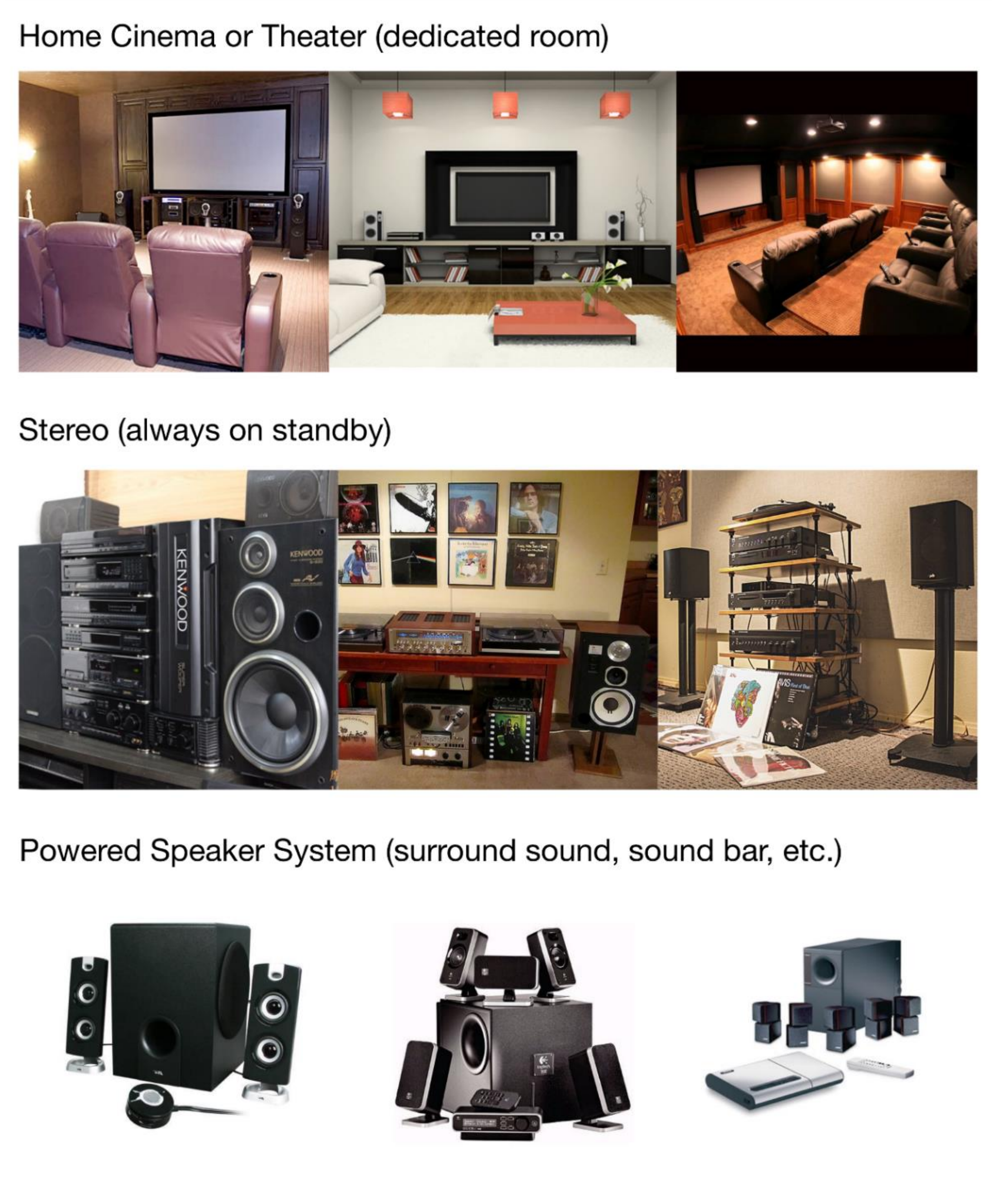
- 91 Categories: Manually generated based on statistical analysis and field experience to cover the most common high idle load devices.
- 49 Features: Manually generated based on statistical analysis and field experience for estimating idle loads most accurately with least amount of information presented to users.
- 500 Subcategories: Manually and automatically generated based on relationship between features and categories to encode heuristics for guided idle load identification.
- 14 User Action: Manually generated based on field experience and low-cost solutions validated before project initiation.
- Five Measurement Device: Manually and incrementally generated based on the most common electricity measurement devices in the market.
- 200+ Product Types: Loaded to map Keewi device types to ILDB categories.

The process of generating features and subcategories and related user actions was particularly painstaking, but turned out to be quite effective in building an expert system for idle load identification that can be flexibly altered and managed without software programming. Also, researchers believe this metadata and its structure make the knowledgebase ready for future developments in machine learning to automatically generate a conversational user interface.

**Category Image Aggregation**

Lastly, to wrap up data aggregation, 260 reference images for each category were manually procured and standardized for the 91 product categories. The product reference images were selected from thousands and then edited to best help users to understand what might be included in a device category by glancing through two to four photos. An unexpected benefit from this detailed work was the entertainment and engagement the user experienced sifting through pictures of devices, a pleasant surprise often reported in the user interviews. Side benefits aside, the reference images were especially useful in helping users decipher between device categories that can be ambiguous or that overlap. Consider the three categories in Figure 24. Without images, the distinction between a home theater versus a stereo or a powered speaker system is not as apparent; however, by just glancing at the images most users can easily make the correct categorization.

**Figure 24: Reference Images for Three Potentially Ambiguous Categories**



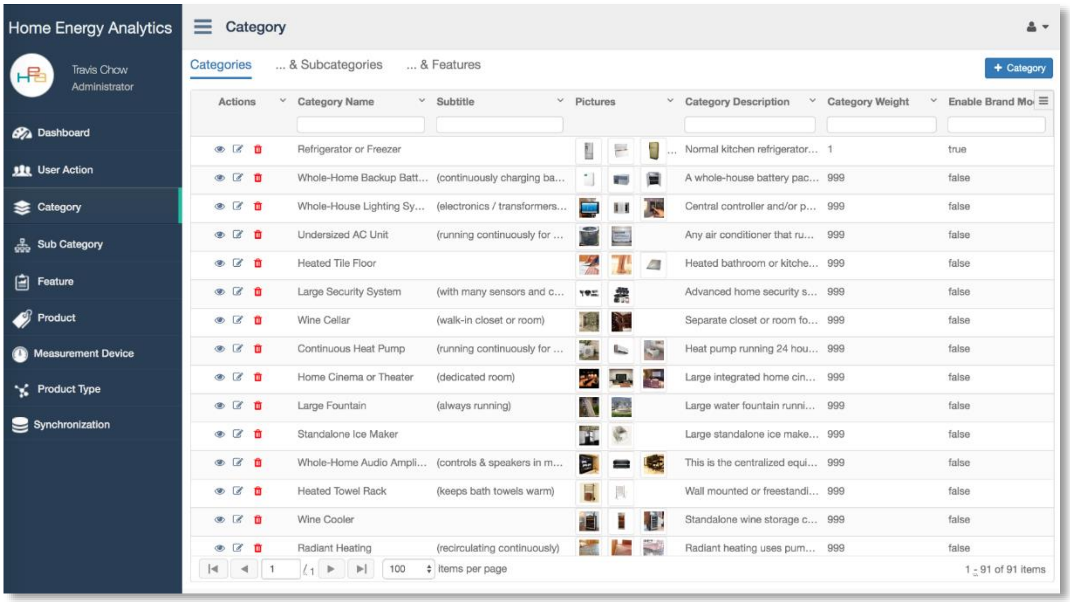

Source: Home Energy Analytics

The content generation for AskDrPower, including articles and ILDB faceted search, are covered in Chapter 4.

## Idle Load Database Admin Console

The admin console for ILDB (https://drpower.hea.com/pldb-web) is available as a secure online SaaS (Software-as-a-Service) from any desktop web browser. The tool is custom-built using JavaScript, HTML, and MySQL. The web application provides a control panel for each object entity to manage all the data and metadata in the ILDB. An administrator can search, lookup, add, edit, remove, import, and export records. Most importantly, the admin console follows secure protocols to authenticate users with special privileges. Figure 25 shows a sample screenshot of the admin console, and Table 15 highlights its most important features.

**Figure 25: Screenshot of Database Admin Console**




Source: Home Energy Analytics

**Table 15: Highlighted Features of Database Admin Console**

| Feature | Description |
|---|---|
| Dashboard | Users can monitor the database and outstanding alerts/ notifications. |
| Object Panels | Each object entity has a corresponding standardized user interface to browse, filter, and view what is in the repository. |
| Record Management | A user can add, edit, or remove records for all object entities. |
| Synchronization | Changes enacted in the admin console are not committed until synchronization between "sandbox" and "production" systems. |
| Security | Admin console uses standard high-level security protocols and practices to ensure data security, including SSL encryption and open authorization for authentication. |

Source: Home Energy Analytics

## AskDrPower Content Management System Admin Console

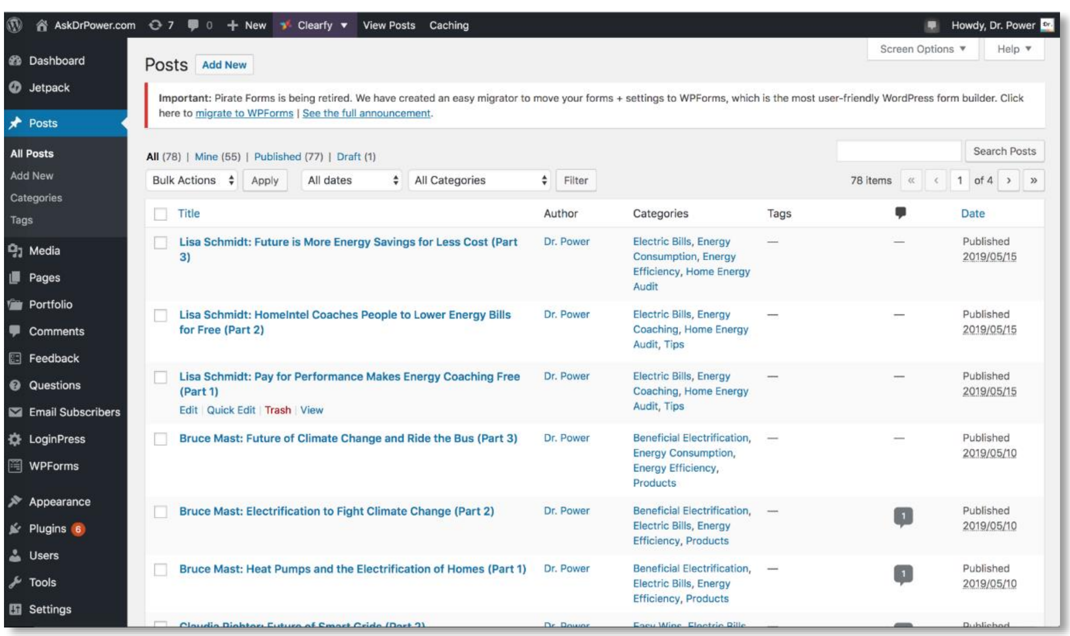
Behind AskDrPower is a content management system (CMS) built from WordPress, several third-party plugins, and a plethora of small software customizations. This admin console's main purpose is to manage content and user interface for AskDrPower. Besides managing content, the CMS handles user accounts, workflow, analytics, SEO, and app behavior settings. Table 16 lists the two types of content in AskDrPower and how both humans and machines use them. Figure 26 shows a sample screenshot of the admin console.

**Table 16: Knowledge Content Types Managed by AskDrPower**

| Content Type | Description |
|---|---|
| Articles | Explanatory prose covering various topics about residential energy, including energy bills and idle load.<br>• Human: Learn practical ways to save on energy bills<br>• Machine: SEO content to show up in search results |
| Question and Answers | Questions and answers posted by users and staff in both public online Q&A forum and chats between user and support staff.<br>• Human: Find answers to questions<br>• Machine: SEO content to show up in search results |

Source: Home Energy Analytics

**Figure 26: Screenshot of AskDrPower Admin Console**




Source: Home Energy Analytics

The CMS admin console is based on the standard WordPress dashboard interface. Enhancements included the installation and customization of several key plugins to enable better user experience, Q&A forum, subscribers, and SEO. Table 17 lists and describes features of the admin console beyond the standard WordPress installation.

**Table 17: Features of AskDrPower Admin Beyond WordPress Dashboard**

| Feature | Description |
|---|---|
| Q&A Forum | Guests or registered users can ask and answer questions, and the administrator can manage all aspects. |
| User Account Management | User registration, sign in, and privileges can be managed by the administrator without technical knowledge. |
| User Experience | Several plugins and a sophisticated WordPress theme were installed and heavily customized to improve the user experience and streamline the interactions. The administrator can continuously configure the user interface to reduce the number of user drop-offs. |
| Responsive Web | The layout of the user interface is further customized for the best reading experience on mobile phones. The administrator can alter and optimize the layout without technical knowledge. |

Source: Home Energy Analytics

## RYPL Cloud Service

Substantial software development work went into building the cloud services that enabled all the features in the Dr. Power app, in addition to the "behind the scenes" features necessary for administration and user support.

### RYPL Server API

The cloud services powering the RYPL platform is built as an API, so that not only the Dr. Power app can use the RYPL cloud services. Other developers can create apps using the same cloud services. At the core of the RYPL platform is the RYPL Server API, built on top of Amazon's virtualization backbone called AWS (Amazon Web Services), allowing for scalability. This API is built in accordance with industry standards such as Representational State Transfer (REST), OAuth, and SSL to ensure security and compatibility. The full documentation of the RYPL Server API is available at the following link: https://drpower.hea.com/swagger-ui. Table 18 lists all the components available to be a comprehensive API.

**Table 18: Server API Components**

| Component | Description |
|---|---|
| Auth | User authentication and security |
| User | User account management |
| Utility | Linking and analytics with IOU account |
| Picture | Efficiently retrieving reference photos of devices |
| Inventory | Tracking of user’s household devices |
| Measurement | New idle load measurement submissions |
| Event | Used for notification and handling events |
| Autocomplete | Auto-complete feature for all types of lookups |
| Test | Support features for demo mode |
| Admin | Miscellaneous for administration |
| Config | Settings |
| HEA | Integrate with HEA social login |
| Email | Send email to user |
| ILDB | Synchronization with knowledge repository |

Source: Home Energy Analytics

### RYPL Chat Service

The chat feature inside the Dr. Power app uses a separate cloud service to coordinate and handle potentially hundreds of concurrent chat threads. The chat service is implemented using the open source platform eJabberd deployed inside a Docker container, allowing it to be future compatible with other chat services. Only Dr. Power currently uses the RYPL Chat Service, but it can be accessed by any application in the RYPL platform that needs to implement a chat feature. Table 19 lists some of the features that this service enables.

**Table 19: Highlighted Features Enabled by Chat Service**

| Component | Description |
|---|---|
| Chat Threads | Provides expected features of popular chat apps that allow for concurrent peer-to-peer chat threads |
| Chat History | Chat threads are archived for reference |
| Staff Chat Window | Staff’s specialized chat window on the desktop can see and interact with all users |
| Chatbot | Simple chatbot that can auto-comment and auto-respond to certain queues |
| Notifications | Support for chat notifications for iOS and Android |
| Industry Compatibility | Use of industry standards allows for integration with other popular chat apps |

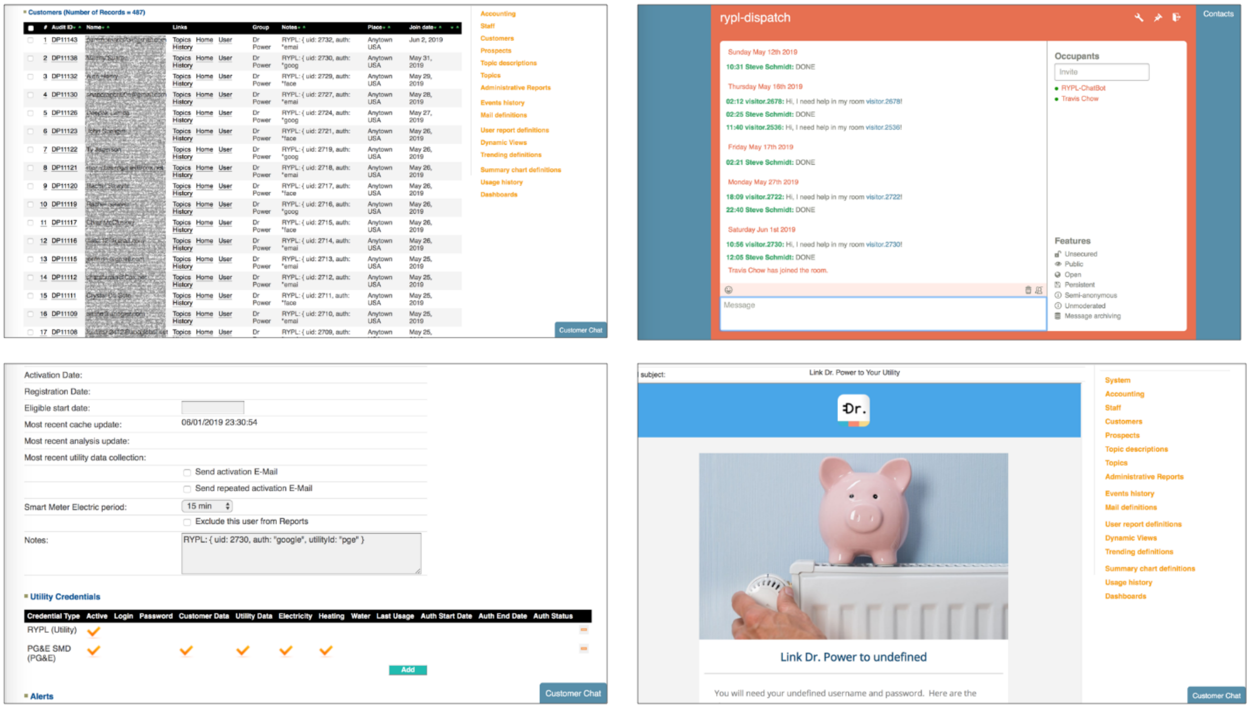
Source: Home Energy Analytics

## RYPL Cloud Service Admin Console

The admin console for RYPL Cloud Service was designed and built on top of the existing admin console for HomeIntel, the energy coaching service provided by HEA. Major extensions were necessary to manage and facilitate new features, including the chat service. Figure 27 shows four sample screenshots from the extended admin console.

1. Dashboard for account management and navigation to important functions
2. Online chat service facilitating concurrent real-time messaging custom-built just for the Dr. Power app
3. User account settings and details, including management of smart meter service
4. Secure email template management and creation

**Figure 27: Screenshots of Cloud Service Admin Console**




Source: Home Energy Analytics

The ongoing administration of the RYPL Cloud Service along with its users was non-trivial, so the feature set of the admin console is quite large. Table 20 highlights the console's most crucial features.

**Table 20: Highlighted Features of the Service Admin Console**

| Feature | Description |
|---|---|
| User Account Management | Manage both user and staff accounts, including each user's access and privileges |
| Reporting | User and system reports that can be exported to CSV or PDF. Reports can be custom-built for technically savvy staff users. |
| Integrated Chat Console | The chat console functions vary similarly to Google Hangout, but it is custom built for the Dr. Power workflow and user experience, and to keep the data private. The "customer chat" button is always available and implementing typical chat features, including the following threading, history, concurrency, and real-time response. |
| Idle Load Modeler | The administrator can define and alter idle load calculations or other analyses from the modeler. The modeler is custom built with its own scripting language to facilitate energy use analysis across a large number of accounts. |
| Smart Meter Account Management | IOU account credentials and the synchronization of smart meter data from IOU accounts can be complicated and require staff intervention. Staff can help users resolve issues through the admin console. |
| Emails | Emails can be created and sent via a custom-built email service. The console allows the administrator to use templates and merge data fields into email templates. An internal system was developed to maintain security and data privacy. |
| Systems Monitoring and Debugging | The console provides several tools to help monitor signs of technical problems in the system and debug them, if necessary. |
| Custom Script Language | Throughout the admin console, the administrator can use a scripting language to automate certain tasks or define reports and analytical models. |

Source: Home Energy Analytics

Note that in addition to the RYPL Cloud Service Admin Console, staff can also use the admin and demo modes available in Dr. Power, described in the Demo and Admin Modes section on page 35.

# Industry Partnerships

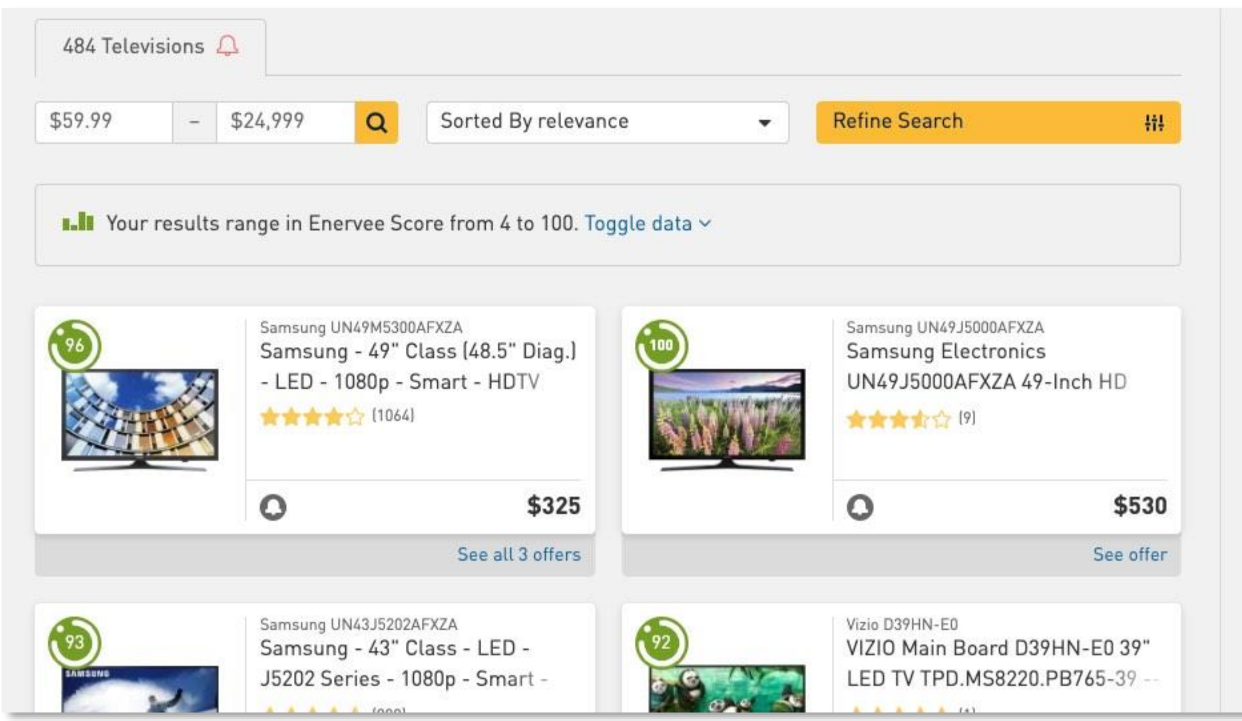
The project leveraged resources from three primary partners: Enervee, Keewi, and other project teams within Home Energy Analytics. These three are described below.

## Enervee

In our original proposal, Enervee was going to take the development lead on the ILDB, various aspects of the Dr. Power app, conducting in-home measurements, and integrating with the Enervee efficient-product marketplace. However, shortly after the project kickoff, its business changed and its resources were re-assigned. At that point, HEA took over all these tasks, except for integrating with Enervee's efficient-product marketplace.

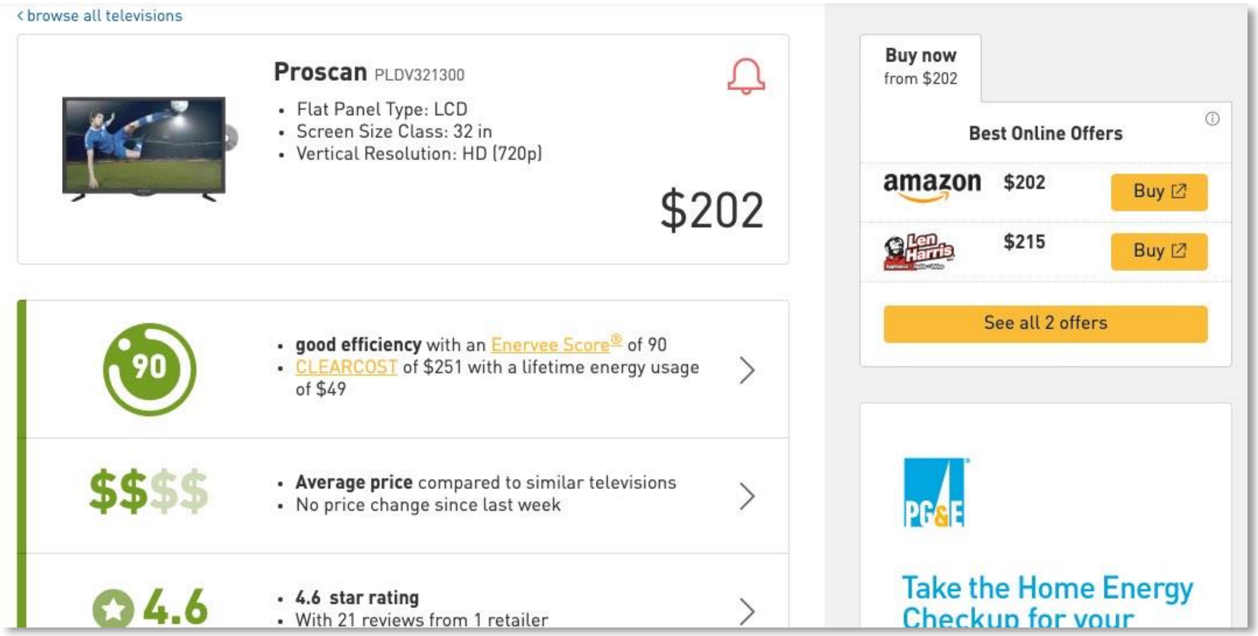
Enervee supported the Dr. Power integration with its online efficient products marketplace, including access to their proprietary EnerveeScore. This allows Dr. Power users to view details about more efficient versions of products identified by Dr. Power as contributing to their home idle load. In addition to viewing information about specific products and comparing different brands and models on their efficiency, the Enervee service also provides information on utility rebates, and links to purchase these replacement products. This offers users a simple and immediate action to reduce the known waste in their homes, directly from the app. Figure 28 and Figure 29 show sample screenshots from Enervee's website.

**Figure 28: Screenshot of Category Data Provided by Enervee**




Source: Enervee

**Figure 29: Screenshot of Individual Product Data Provided by Enervee**



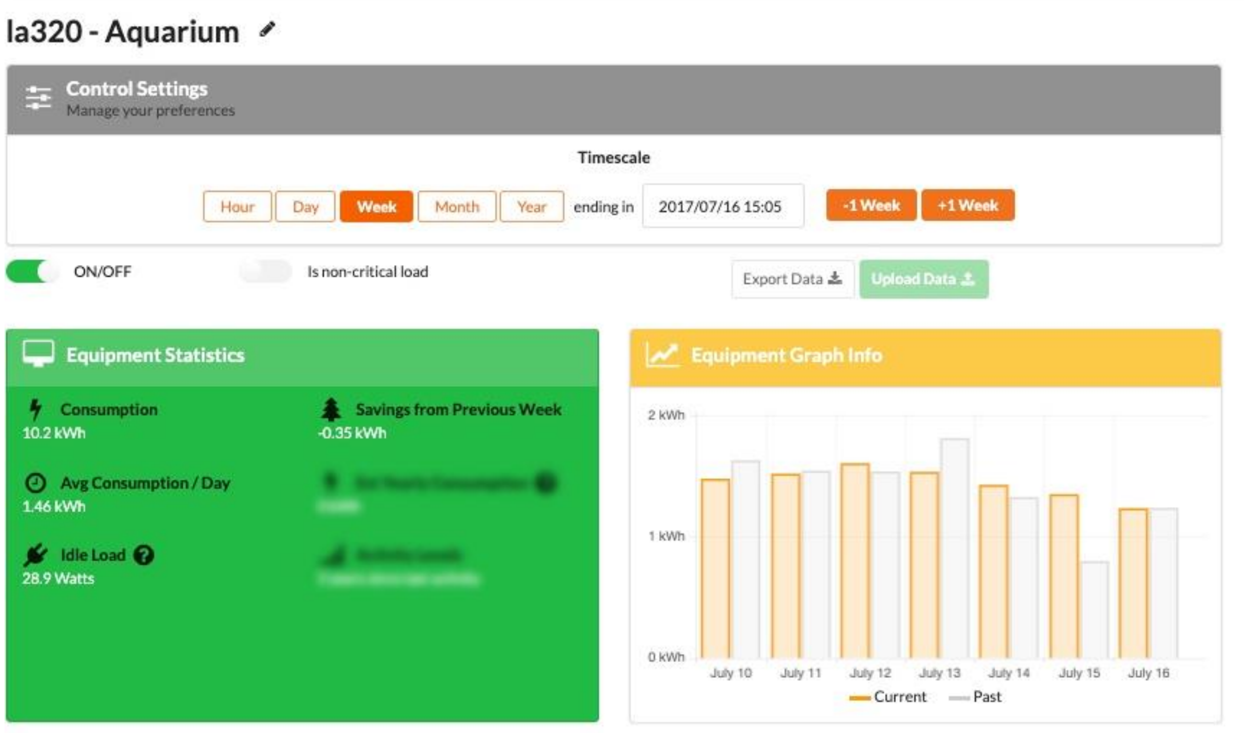

Source: Enervee

## Keewi

In this study's initial proposal, the team planned to purchase a large number of measurement devices to enable Dr. Power users to measure their plug loads and contribute to the ILDB. New technologies make this easier and cheaper, and this project's partnership with Keewi (a Stanford University-affiliated company that did not exist at the time of the proposal) allowed researchers to leverage a small number of device consumption monitors across a wider group of homes.

Keewi offers rental of monitoring devices along with remote administrative monitoring. This means the purchase of monitors is no longer required, and rented devices can be moved from one home to another using HEA's energy coaches and the Keewi administrative dashboard.

**Figure 30: Screenshot of Keewi's Administrative Console**




Source: Keewi

As shown in the green box above, Keewi added information about measured idle loads for devices being monitored and used HEA's idle load algorithm so it would match Dr. Power's analysis. This was important since the monitoring resolution was very different between the two approaches: the Keewi monitors record minute-level detail, while the Dr. Power analysis relies on hourly smart meter data.

In addition to adding the calculation and display of idle loads, HEA worked with Keewi in 2018 to streamline the movement of Keewi socket monitors from device to device and from home to home. This effort took longer than expected, and budget and schedule were expended before it was simplified sufficiently for customers and energy coaches. As a result, the team collected limited idle load data from the Keewi devices.

The data collection that was completed with Keewi devices was done as part of HEA's Pay for Performance project with PG&E, during which the project installed a number of Keewi devices in a variety of homes participating in that program. The monitoring devices remained with each customer for about a month, and then were recollected so they could be installed in other homes. As a result of these efforts, approximately 35 new devices were analyzed and added to the ILDB, as listed in the table above.

## Home Energy Analytics

HEA contributed to the project in a number of ways that leveraged other HEA projects and services, including the following:

1. Access to residential energy advisors: As mentioned above, HEA's energy coaches did some of the tasks Enervee originally intended to do, such as in-home device measurements). Energy coaches also encouraged existing HEA customers to try out Dr. Power whenever idle loads appeared as a major area of energy waste and wrote many articles for AskDrPower.com. These energy coaches are funded by PG&E's residential Pay for Performance (P4P) program.
2. As part of the RYPL marketing research, researchers used HEA's existing email platform to test various Dr. Power messages to different cohorts of HEA customers. Response rates from each message and from each target group were recorded and analyzed.
3. Since SDG&E was unable to support the integration of Dr. Power to their Green Button Connect system, the project used HEA's previous tool, UnplugStuff (see UnplugStuff.com), developed and integrated to SDG&E's early data transfer system in 2013, to analyze idle load values and savings from SDG&E customers in the San Diego area.
4. The idle load algorithm used in this project and provided to Keewi was developed by HEA in 2010.
5. Other HEA programs utilize PG&E's ShareMyData system. The team's familiarity with that service and its ongoing enhancements proved invaluable to stabilize and simplify the linking of Dr. Power to PG&E's system.

# Conclusion

Development of the RYPL Platform generally followed the normal software development process: with each release, the team learned a great deal from customer feedback, making course corrections to be implemented in the next version. Supported features and project partners changed over the course of the effort, and the team had some unrealistic expectations about adoption rates, however the resulting platform is extensive and of professional quality, delivers energy savings, and addresses the key research goals the project sought to explore.

# CHAPTER 3: Experimentation with New Technologies

This project experimented with using new technologies, as well as with trying innovative application of older technologies. Initially, artificial intelligence (AI) was of special interest. Experimentation showed that cutting edge AI, such as deep learning or computer vision, was too immature to be used effectively as part of Dr. Power. The innovative use of AI came from creating an expert system to guide users through idle load source identification and to recommend mitigating actions. Experimentation outside of AI included newer technology, such as IoT, or more mature technology, such as mobile platforms. The proper application of more mature technology proved most valuable.

## Artificial Intelligence

Some in the technical community believe that deep learning, a branch of AI, will be an enabling technology rivaling the Internet or electricity in its influence on society. Deep learning was still in its infancy for the duration of this project, but the team experimented with applying deep learning in an effort to create a more intelligent agent, affably called Dr. Power.

### Computer Vision

As an intelligent agent running on a smart phone, Dr. Power would have "eyes" to automatically recognize the make and model of all electric devices inside a residence. Several efforts have been used to identify devices through machine learning to recognize the electric usage pattern from high-resolution meter data[5]. To date, this approach has produced very poor results and low adoption. If device identification with a phone's camera could be automated with computer vision, more than 80 percent of user tasks within Dr. Power could be automated. Though speculative, such an innovative application of deep learning to residential energy efficiency could produce huge gains and dramatically lower barriers to wide adoption. The resulting app would be fun, useful, and have a high "wow" factor.

At the beginning of this project, computer vision seemed promising, considering the impressive results from facial recognition, autonomous vehicles, and medical imaging. For this project, research and experimentation with deep learning were focused on creating a convolutionary neural network (CNN) to identify household devices. If successful, computer vision powered by a CNN would use a smartphone camera to automatically identify the following:

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[5] Examples include Bidgeley, Sense, Smappee, Curb and Neurio.

- Type of household device
- Relevant features of the device
- Make and model of the device

### Training a CNN from Scratch

Expert opinions were mixed on the applicability of CNN to this project. Some experts believed that device type and feature recognition should be quite easy with a CNN. An overly optimistic opinion suggested that collecting only 100,000 images from an online marketplace like Amazon or eBay would be enough to train a CNN from scratch to accurately recognize most household electric devices. As other opinions were less optimistic, the team consulted with a computer scientist to gauge feasibility.

A quick study and experimentation with Google's deep learning cloud service called TensorFlow indicated that training a CNN from scratch was well beyond the scope of this project because of the following reasons:

- Training techniques are too immature and not well understood.
- Expertise to accomplish such training was (and still is) prohibitively expensive.
- The required training dataset is too difficult to aggregate or generate.
- Accuracy of object recognition, such as facial recognition, requires years of developing rules-based geometric feature extraction before deep learning can be applied effectively to recognize details.

### Application of Out-of-the-Box Visual Search

An alternative was to apply an existing computer vision service that can recognize household objects. The hope was that a mature enough service built for "visual search" already existed in the e-commerce sector. Visual search was a feature that allowed a user to take or upload a picture to initiate a search, instead of typing in a phrase.

A quick test of about twenty images casually taken with a smartphone showed that Google Image Search was able to accurately identify less than half of the images correctly, which was already much better than Amazon or Microsoft at the time. A subsequent test with a larger sample of various devices showed that three problems made ready-to-use cloud services unusable:

1. Too much variability within a device category yielded unworkable accuracy rates. For example, a refrigerator with too many magnets and pieces of paper on it could throw off the service. Likewise, a shiny, red four-slot toaster did not look enough like a standard two-slot toaster. Further, the service had trouble identifying combinations of things, such as a picture of a stereo system, a computer system, or an entertainment system would easily mislead the service.
2. Google Image Search could only identify a device type with tens of thousands of photos it had crawled. Otherwise, the picture of the object had to be taken at

the proper distance, angle, and lighting in order to match limitations of smaller training sets.

3. Even if users were instructed to take pictures in very restricted ways, and the service could recognize the fifty most popular device types, the automated identification of a device type alone does not provide enough value to merit automation. Taking a picture of a device is arguably more troublesome than just answering yes or no to the question "Do you have a toaster?" This was especially true if the service occasionally called the toaster a golf cart.

Lastly, the long-tail distribution of idle load sources demanded object recognition capabilities that have not been built yet for household devices. Computer vision needs to accurately recognize both device type and its features to be useful. Unlike facial recognition, which has benefited from a 30-year history and millions of dollars invested in research and development, object recognition of household devices is not yet mature enough.

**Final Layer Training**

A last possibility to explore was to custom train on top of a CNN that can already accurately recognize features of household objects. The objective of the custom training would be to further refine the capabilities of a strong computer vision foundation to specialize it for household electric devices. This practice of "last layer" or "final layer" training in CNN was (and still is) quite new and not well understood, but success in other niches show that it could cut down the size of necessary training sets by tenfold to a hundredfold. The primary concern was the risk of committing significant project funds to such a speculative endeavor in an immature field.

The design and engineering team conducted research on CBInsights, a SaaS that tracked innovative startups all over the world. Filtering through a listing of more than 500 startups working in the field of machine learning and AI, the team selected six potential partners listed in Table 21 that might have a computer vision cloud service that could be extended to accurately recognize device types and features.

**Table 21: Six Potential Partners for Computer Vision Custom Training (Nov 2016)**

| Company | Company Provided Description |
|---|---|
| Clarifai | Clarifai provides advanced image recognition systems for customers to detect near-duplicates and visual searches. |
| Blippar | Blippar is an image-recognition platform and visual browser for mobile targeted specifically at customer-brand interaction. |
| CloudSight | CloudSight's mission is to make AI see. |
| Deepomatic | Deepomatic helps companies and scientists build massive, high quality, image-based datasets to unlock the new generation of AI. |
| Catchoom | Catchoom is an award-winning image and object recognition provider, powering CraftAR, the ultimate Augmented Reality (AR) toolbox. |
| Clevapi | Clevapi provides real-time object recognition powered by artificial intelligence. |
| Pixuate | Pixuate is a cloud-based image-processing platform that offers APIs for developers and helps them build cross platform applications. |

Source: Home Energy Analytics

Discussions with the research and development teams of these six companies resulted in the following:

- Only two companies, Clarifai and Deepomatic, would consider collaboration for last-layer training, but their existing CNN performance was poor. In addition, Deepomatic would be prohibitively expensive as the company functioned like a consulting service.
- Only one company, CloudSight, had a CNN that was speculatively good enough for last-layer training to meet the requirements for Dr. Power. CloudSight's image recognition for household devices significantly outperformed Google Image Search. Further, its computer vision cloud service combined optical character recognition (OCR) and pattern recognition to read brand names on devices if a logo was visible.

CloudSight seemed to have the technology, but training on top of their CNN would not be a collaborative effort with CloudSight as a partner. Final-layer training without substantial contribution from an expert partner was determined to be outside the scope of this project in terms of both budget and goal of applying new technology. In the end, final-layer training was not a viable option. Optical Character Recognition

Object recognition is too immature and costly, but OCR is mature technology benefiting from decades of AI research and development. OCR is considered by computer scientists to be a subfield of computer vision; however, OCR is based on supervised programming and is well understood. Also, OCR is cost effective with numerous commercial cloud services. The problem is figuring out how to apply it effectively to idle load reduction.

After a few iterations of design, the team considered two viable use cases:

1. Use OCR to read brand and model information from name plates or labels often printed on the back of devices.
2. Use OCR to read brand and model from covers of instruction manuals.

Simple research and experimentation showed that OCR could technically handle both cases with a smartphone camera. Once the app matched brand and model numbers to the label text, it can access information from a database like the ILDB, including electric use measurements. The problem with these two use cases is that both required the user to take a picture of something that is hard to find or even inaccessible, such as the nameplate on a dishwasher or the back of a TV. While OCR is mature and cost effective, the team did not find a way to apply it meaningfully.

## Speech Recognition

Speech recognition has improved dramatically in the past decade from advances in deep learning. This form of AI is also commercially available, cost effective, and mature.

### Voice Input

Using speech recognition and vector matching to replace touchscreen gestures with spoken commands is a very mature technology; however, there is little value in applying voice input to Dr. Power. For Dr. Power's use cases, tapping and swiping on screens of smartphones are much easier than speaking into them—even with a wireless earpiece. The team concluded that voice input would be a tactic providing minimal value for the project's purposes.

### Conversational Agent

Sometimes derogatively referred to as "chatbot," a conversational agent combines speech recognition and natural language processing to enable conversational human computer interface (HCI) that is more sophisticated than voice input. Voice input uses spoken words to replace hand movements, such as typing as input to a computer, but a conversational agent seeks to mimic the two-way interaction of human dialog. Each year since 2016, platforms and API for developing conversational agents known commercially as "assistants" have been improving significantly. In 2018, Amazon released "Lex", a service for building conversational interfaces for applications using voice and text that is the underlying engine that powers Alexa. As of mid-2019, Google became close to offering a platform for third parties to develop conversational agents with the ability to understand conversation context. In the near future, software developers with no deep experience in the field will be able to program agents that understand what was previously said in a conversation similar to natural speech.

Since Dr. Power was designed as an educational app, conversational agent remains a promising technology. However, for the duration of this project, this technology still required laborious supervised programming to enable a two-way conversation that would be better than the much simpler touchscreen gestures. Furthermore, before making the app conversational, the agent must first be an expert in diagnosing or resolving a problem. The best method to guide a user through the identification of idle load sources is still under research and development. Dr. Power needs to be an effective diagnostic agent first before enhancing it with a conversational HCI, which itself is not yet a mature technology.

### Automated Transcription

Transcription is probably the first widely used commercial application of speech recognition. There was no need for transcription in Dr. Power, but the automatic transcription of podcasts into articles for AskDrPower using Rev.com (an MIT spinout) saved time and money, and provided a new scalable way to add SEO-enabled content to the website. This application of AI is not particularly innovative, but it proved to be scalable and convenient.

## Expert System

An expert system is a form of AI that gives advice or emulates decision-making with a data repository of expert knowledge. Unlike deep learning, an expert system is essentially supervised programming, with the biggest challenge being the proper structuring and encoding of knowledge to allow for "learning" as more data and metadata are loaded.

Expert system technology is quite mature and has been applied effectively for decades to business workflow, chess engines, video game AI, autonomous vehicles, diagnostic software, manufacturing control systems, healthcare, and motion planning. In fact, most systems that are considered artificially intelligent today still use a form of expert system at their core.

### Expert System as Structured Foundation for Deep Learning

Many computer scientists characterize expert system's "top down" approach as the exact opposite of deep learning's "bottom up" approach. The biggest advantage of an expert system is that the entire system is transparent to human understanding and manipulation, allowing for rapid prototyping, incremental improvement, debugging of mistakes, and maintenance. The main benefit of expert system is the complete opposite of the "black box problem," which is the biggest drawback of relying on deep learning. The weights of a neural network used in deep learning are opaque to human understanding; thus, even computer scientists cannot directly fix or modify any particular part of a neural network. On the other hand, expert systems' biggest drawback is the knowledge acquisition problem. Unlike deep learning, structured data alone is useless. Humans must encode the knowledge as data and metadata for the expert system, a process often called knowledge engineering.

The most successful applications of AI thus far started with supervised programming, knowledge engineering, and statistical algorithms that extract features. The subsequent addition of deep learning to these systems that have already structured the knowledge was able to increase the system's accuracy from over 90 percent to over 99 percent, beating human experts. These successes included speech recognition, facial recognition, natural language process (NLP), text-to-voice, and autonomous vehicles.

In the case of Dr. Power and idle load source identification, expert system and knowledge engineering provided the best short-term and long-term value. In the near term, an expert system is still the best way to build agents and assistants for the vast majority of problem domains. This is a form of AI that can be applied meaningfully and immediately. In the long term, when deep learning is mature and cost-effective enough, knowledge engineering will have provided a foundation on which deep learning can effectively train.

### Application of Expert System

Expert system technology and methodology were applied to the RYPL platform in several ways. Most importantly, nearly all of the rules, analytical models, and knowledge in the entire platform persisted as a knowledge repository structured specifically for incremental improvement as the team gains further expert knowledge of the domain. Table 22 highlights the application of expert system technology to the RYPL platform.

**Table 22: Application of Expert System to RYPL Platform**

| Technology | Application |
| --- | --- |
| Rules Engine | The RYPL cloud service represented all calculated variables and various analytical models such as metadata, including the time series analysis used to determine a home's idle load from smart meter data. Also, the heuristics that drive Dr. Power's idle load source investigation was based on a rules engine with metadata residing in the ILDB. |
| Inference Engine | Dr. Power's recommended user actions and idle load estimation for a suspect device used a simple but effective form of inference engine to diagnose and suggest quickly. |
| Decision Tree Analysis | Most of the encoded knowledge for Dr. Power for idle load estimation and source identification was derived through the construction of decision trees. |
| Knowledge Repository | The ILDB is a repository designed for knowledge engineering; it powered the expert system inside the Dr. Power app. |

Source: Home Energy Analytics

# Other Technologies

Although technology experimentations focused on artificial intelligence, at the beginning of the project there were several other technologies on the horizon that were deemed promising. This included mobile platform and IoT. While mobile devices were already widely adopted, IoT in the home was just beginning to gain traction. Efforts to apply both technologies in reducing home idle loads proved that delivering the educational experience on mobile was very effective, but the team discovered during the project duration that a simpler approach of responsive web made more sense than investing in native app development. Home IoT did not become widely adopted enough during the duration of this project, and its application was limited to connecting electric use monitoring devices for a small group of enthusiasts in helping measure idle loads for a limited set of home appliances.

## Internet of Things

The IoT promised to connect home appliances and devices to the Internet, sharing data and coordinating with each other. Despite the lofty vision, consumer reception in the past five years to smart and connected home devices has been tepid. The benefits of a connected home device (other than the new category of smart speakers) never became convincing enough to merit upgrades with costlier but similar devices. IoT as a disruptive technology platform shifted its focus to industrial applications, such as factories, cities, and offices.

The team considered several applications of IoT, including the following:

1. Discover from the IoT network the collection of devices present in the home.
2. Directly measure and discover idle loads of devices present in the home through connected metering services.
3. Integrate with smart speakers, such as Amazon Alexa, to allow for smarter power management.

First, Home IoT never got enough adoption to allow an API where software, such as Dr. Power, could read a registry of devices inside a home. Even though this vision has existed since the 1980s (including the ITRON demonstration home created in Tokyo during that period), the adoption of connected IoT devices was so low across all of California, even in the Silicon Valley, that the concept of identifying devices through an IoT network registry never came close to materializing.

Second, high-resolution electric use monitoring devices, such as Rainforest or Sense, also suffered from very low user adoption. The small number of installations made the cost of developing features within Dr. Power to work with electric use monitoring devices not worthwhile. Instead, the team's experimentation with IoT was limited to collaboration with Keewi, a home IoT platform for measuring and managing electric use, as mentioned in the section Industry Partnerships of this document.

Lastly, using smart speakers to manage power to electric devices around the home also suffered from the lack of home IoT adoption. Though home IoT in general gained little adoption, smart speakers penetrated about 25 percent of American households by the end of 2018 (Nielsen, 2018). A smart speaker enabled a conversational interface with the home IoT network; however, the electric outlets and switches around the home were rarely connected to the smart speaker, or, more frequently, homes were not equipped with such outlets connected to any network.

Because this project's goal was to find solutions that can reach millions of California households, the application of IoT to idle load reduction was limited to partnership with Keewi in helping enthusiasts measure idle loads and electric use of specific devices in their homes. Home IoT did not get traction in California, much less in America, in the past five years. Without a network of IoT devices, IoT remains a promise in the home and provides minimal value to idle load reduction.

## Mobile Platform

More than 95 percent of Americans own a smartphone (Pew Research Center, 2019), but previous efforts to reduce home plug loads or idle loads rarely used a mobile-only solution. In other words, the RYPL platform does not require residents to buy or install any hardware to begin identification of idle load sources. By integrating with IOU data sources, RYPL only needs lower resolution AMI data obtained with approval from the resident.

At the beginning of the project, unlike other approaches, the team reduced the barriers to adoption to simply downloading a mobile app. Both an iOS and Android version of the mobile app were developed and released to the marketplace. The mobile app form factor proved well suited for an educational app such as Dr. Power. Users could walk around the home with their smartphones, and because no additional hardware was required, Dr. Power enjoyed much better trial rates than other electric use disaggregation solutions. However, the team developed a third version of the app that worked across all web browsers, including those on mobile or desktop computers. This "responsive web" version, though it did not work as smoothly as native apps in the iOS and Android operating system, afforded several benefits that made it a better approach:

1. Users could start the app immediately, using any browser on the smart phone without downloading an app, which decreased signup drop-off rates.
2. User engagement and activity with the app did not change, but the cost of development and maintenance of a responsive web app was much less than that of the native apps.

The team recommends future mobile app efforts to first start with a responsive web application that works well with smart phone screens (utilizing responsive web platforms, such as Angular and React), and to only develop native apps if entirely necessary due to some specialized user experience requirement not supported by responsive technologies.

### Game Mechanics

Game mechanics, which is sometimes referred to as gamification, is not technology per se, but a systematic method of motivating users using well-practiced principles in game design. At the beginning of the project, the energy industry and behavior change scientists still saw promise in applying game mechanics. Since then, game mechanics has lost a lot of support after being overused in the past decade, and after the backlash from studies that show how the overuse of some game mechanics may damage the human nervous system[6].

The team shifted away from game mechanics shortly after the beginning of this project and designed the RYPL platform around principles of nudge theory and choice architecture, as described in the section Keys to Nudging of this document. The only game mechanic the RYPL platform uses is the principle of variable reward in motivating users to get through the list of suspect devices in the Dr. Power app. Rewards were periodically given to the user as animations and progress chart updates.

# Conclusion

Experimentation with applying AI to idle load reduction showed that only one mature technology was applicable and effective. Most of the cutting-edge AI technologies, such as deep learning, were too immature or too expensive to try, and for those that were mature enough, no good use cases beyond gimmick were found. In the end, techniques in expert systems, a form of AI with supervised programming, were the most useful and effective in building a smart assistant that continuously improved with more structured knowledge. The expert system and its knowledge repository may serve as a necessary foundation for future application of AI with unsupervised programming. Artificial intelligence such as computer vision for automated identification of objects and its details are promising, but they are not yet mature enough.

Experimentation with technologies outside of AI showed that responsive web apps on mobile devices was a very cost-effective form factor to deliver the immersive education experience and to reach millions of California households. The IoT in the home never got enough adoption in California residences during the duration of this project to merit serious experimentation.

[6] See related articles https://www.sciencedaily.com/releases/2017/06/170622103824.htm and https://www.iamwellness.com/video-games-affect-the-nervous-system/

# CHAPTER 4: Scalable User Acquisition

As noted in the The study "Home Idle Load: Devices Wasting Huge Amount of Electricity When Not in Active Use" estimates that the idle load represents one-third of the yearly electric use in the average home. The potential for statewide savings is high with widespread participation, even from modest idle-load reductions. The premise of this research is that residents can reduce their idle load easily, with little investment in time or money when given access to accurate information and a customized list of actions.

The biggest challenge is that residential plug loads encompass a diverse set of energy-consuming devices. Starting in 1977, California set its first efficiency standards for refrigerators. The different types of appliances falling under efficiency standards have continued to grow; however, the variety of plug-load devices is expanding faster than standards can be set. New categories of appliances that do not have efficiency standards are proliferating pet water fountains, heated baby wipe dispensers, Wi-Fi-enabled BBQs, heated towel racks, and many others.

It is not possible to rely on device standards alone to reduce idle loads. Unregulated devices often have high standby loads, and in some cases—such as most heated towel racks—do not even have an "off" switch. Appliance standards are a cornerstone in the effort to reduce per-capita energy consumption but are not capable of expanding fast enough to keep up with new devices as they come onto the market. Instead, residents need a simple way to learn about devices with high idle loads so they can take action.

Project Purpose section of this document, developing an innovative and effective solution is not enough. The solution needs to be scalable to reach millions of Californian households. The RYPL platform is a self-service application with very low incremental cost with each additional user. The remaining challenge was to find a way to acquire thousands of users with equally low incremental costs.

Digital advertising and the digitization of content have made attention quite expensive. Given the poor engagement and signup rates in the residential energy sector, user acquisition through conventional paid advertising channels proved to be too expensive to be scalable. In addition, the extremely high drop-off rates from poor IOU data accessibility during the signup process made paid advertising prohibitively expensive.

Instead, the team experimented with the long-term approach of content marketing and SEO, and built a promising asset for unpaid outreach through the State of California. Our user acquisition experiments show that representation from the State dramatically increased trust and public goodwill, considerably increasing open rates and response rates of any channel. Also, the trust and credit search engines such as Google grant the websites run by the State of California, often referred to as "link authority," can strongly accelerate the effects of SEO to reach users in search engines for topics around energy conservation, energy efficiency, and lowering utility bills.

## Cost as Barrier to Scalability

The biggest barrier to scalability is the financial cost necessary to acquire and service users all the way from first impression to idle load reduction. The financial cost can be broken down into three phases of the entire user funnel:

1. Platform's cost to acquire a user
2. Platform's cost to service a user
3. User's cost to take recommended action(s)

Note that the incremental costs of phases #1 and #2 have to be multiplied by many thousands to assess the cost from the platform's perspective while individual users bear the cost in phase #3. For the user in phase #3, the cost of unplugging devices or installing one or several smart strips or timers ranges from $0 to $100. This range is within reach for a vast majority of Californian households, especially considering in many cases the savings can pay back the initial cost within three months. Even in cases where the resident needs to hire a service provider or purchase a new household appliance, the upfront investment is minimal compared to most home improvement projects, and for the majority of cases the savings from idle load reductions quickly recoups the upfront cost. Furthermore, field experience shows the self-installation of smart strips and timers or free changes to device settings cover the vast majority of cases. Therefore, the incremental cost incurred by each individual user in phase #3 is not a barrier to scalability.

In order to service the user in phase #2, because the RYPL platform was built on top of all open source software, no additional licensing cost per user is required. Incremental cost to administer and operate user support on an annual basis should not exceed $2 per user and can reasonably be capped at $1 per user. Dr. Power and AskDrPower were both designed to be self-service apps where the immersive education has been mostly automated. Through the duration of this project, the user support required was minimal and researchers do not anticipate that the platform's operational cost per user would change going from 1,000 to 1 million users. In fact, operational costs could benefit from economies of scale. Thus, the incremental cost of phase #2, servicing users through the RYPL platform, was also not a barrier to scalability.

The incremental cost of phase #1, however, was too costly to rely primarily on paid advertising channels and marketing practices. In order to successfully acquire a user in phase #1, the platform must not only get a resident's attention, but also lead her to sign up for Dr. Power and then link with her IOU account. Several factors outside the team's control, including market forces and lack of IOU data accessibility, set the incremental cost for phase #1 in the range of $30 to $70 per user acquisition.

## User Acquisition Funnel

Whether it begins as a Google advertisement or a flyer at the library, the user acquisition funnel is the following:

1. Get permission to message to a target group.
2. Make an impression on the group.
3. Some impressions respond to become leads .
4. Some leads download the app or try the web version.
5. Some leads register as users.
6. Some users link to their IOU accounts.

The challenge is to usher people through these six steps cost-effectively in the highly competitive landscape of capturing people's attention. Further, drop-offs at each step must be minimized to make the investment in earlier steps worthwhile and its return on investment (ROI) more predictable. In other words, it is important to know how many users are needed at step #1 in order to produce one user at step #6. This ratio may be 5 to 1 or 500 to 1 depending on the drop-off rates at each step.

## Cost Barrier of IOU Data Accessibility

The most crucial barrier encountered in lowering the cost of acquisition per user was the drop-offs at step #6. Because only 10 percent of users were able to link to their utility accounts as discussed in section IOU Data Accessibility/Inaccessibility, a 10 percent conversion rate at this step makes user acquisition economically nonviable. Without achieving step #6, Dr. Power is no longer a personalized and participatory education experience, greatly reducing its effectiveness as an app for behavioral change.

For comparison, in another HEA project outside of RYPL called HomeIntel, the team has been able to maintain a conversion rate of approximately 60 percent for the utility account-linking step for a specific channel that involved direct mailing. Note that HomeIntel is a different service with high-touch human support, including in-home visits by expert energy advisors. This conversion rate of 60 percent has been achieved under the following conditions:

1. Only for PG&E (no other IOUs) through a new integration point rolled out in second half of 2018 called Guest Access, an enhancement to their Share My Data system.
2. Only for highly targeted users whose permission for marketing, contact information and known high idle loads were provided directly by PG&E.
3. A human coach actively communicates and supports a user, dramatically increasing the incremental cost of service to several hundred dollars per user.
4. The cost of user acquisition required $50 to $70 per user.

Investigation into this problem showed that Dr. Power drop-offs at this step are unavoidable, and mitigation is out of the team's control. Discussions with industry partners reveal that IOU data accessibility is a problem across many residential energy efficiency programs, and the 60 percent conversion rate from HomeIntel for authorizing IOU account access is considered difficult to achieve. Outside of user motivation, the key factors only the IOUs can control include:

- Some people do not have IOU online accounts or have rarely used them, so they do not recall their access credentials.
- Uneven technical support from the IOUs:
  - PG&E now provides reliable and well-supported data access through a customer friendly authorization portal.
  - SCE offered a laborious process for data access approval.
  - We have been unable to integrate with SDG&E due to lack of support from them.

Through April 2019, nearing the end of this project, these conditions remained the same, so any future planning for scaling Dr. Power to thousands of California households should have assumed a step conversion rate (going from step #5 to step #6) of 10 percent to 50 percent. Using a very optimistic estimate that 25 percent of users would successfully link to their IOU accounts, if it took $10 to acquire a user, the IOU data accessibility problem would quadruple that cost to $40 since 75 percent would drop off for all the reasons stated above. If conditions do not change, but only 10 percent of users successfully link to their utility accounts, then the cost of user acquisition would be $100. The problem would be that the team's application of the very best practices in paid advertising showed that it would take more than $10 to sign up a single user. Others validated this user signup cost in the residential energy sector.

## Avoiding App Download

Even if the data accessibility problem would be fixed at step #6 to an optimistic step conversion rate of 50 percent, figuring out scalable user acquisition would require cost effectiveness at each step, especially in steps 1-5. One key performance indicator (KPI) that the digital marketing industry uses for measuring effectiveness of user acquisition is the cost per mobile app download. These metrics map to step #4 in the user acquisition funnel described above.

The national average cost was about $2 per app download at step #4 (BusinessofApps.com, 2018); however, the cost per app download for an energy efficiency app was closer to $5 to $7, which was validated by this team's experimentation with paid advertising discussed in section Experiments with Paid Advertising of this document. In addition, consultation with marketing professionals in the residential energy sector validated that these were accurate cost ranges.

Mobile app downloads are notoriously competitive and costly in the technology industry. Mobile app revenue is dominated by gaming, media subscriptions, social media, and dating services. The channels for acquiring app downloads are controlled by a duopoly comprised of Google and Facebook. Consequently, the return on investment (ROI) of an app download can only be obtained if a download drives substantial revenue to pay for getting attention of users via Google's and Facebook's choke points.

For the residential energy sector, the economics make app downloads a prohibitively expensive step in the user acquisition funnel. This incremental cost is in addition to building and maintaining a version for both iOS and Android. In 2019, OhmConnect, the most popular residential energy mobile app to date, withdrew their Android and iOS apps. The company now relies on text messages and a responsive website on mobile phones to avoid the insupportable ROI of acquiring app downloads. Even with significant revenue per user, OhmConnect withdrew their apps.

For the RYPL platform, experiments with user acquisition revealed costs that also forced this project to avoid app downloads. Because the parameters of this project did not allow for revenue per user, avoiding the drop-offs caused by app downloads became even more critical. Usage reporting revealed that switching from a mobile app to a mobile-first website incurred user experience degradation, but not by much. User rating of the app experience went down slightly, but their activity (indication of engagement) in the app only marginally reduced. In the later user acquisition experiments, contacts were presented with a link to the responsive web app, instead of links to the Apple App Store or the Google Play Store.

For any future paid advertising campaigns for Dr. Power, the team recommends skipping app download, but providing links to the responsive web app instead.

# Experiments with Paid Advertising

Even an incremental cost of $25 per user rendered the RYPL platform unscalable to thousands of California households. The user acquisition cost must be dramatically driven down to a few dollars per user to make the solution scalable. The team engaged in several user acquisition experiments to validate what it learned from industry research and field experience before resorting to a different user acquisition strategy.

## Search Engine

The team tested user acquisition with Google Adwords for keyword clusters around utility bill reduction, idle loads, and energy conservation. As expected, the best performing keyword cluster was the one around utility bill reduction. Table 23 shows the cost of user acquisition for search engine marketing with the best keyword cluster.

**Table 23: Costs through User Acquisition Funnel for Search Engine Advertising**

| Step | Conv Rate | Step Conv Rate | Cumulative Cost per User | Description of Each Step in User Acquisition Funnel |
|---|---|---|---|---|
| 1 | | | | Google user searches for information |
| 2 | | | | Google ad is displayed in search results |
| 3 | 6% | 6% | $1.40 | Clicks on Google ad |
| 4 | 0.4% | 6% | $21.90 | Downloads iOS app from landing page |
| 5 | 0.2% | 60% | $36.50 | Signs up as user |
| 6 | 0% | 0% | | Links to IOU account |

Source: Home Energy Analytics

In this experiment, no residents ended up linking to their utility account. The team quickly stopped experimentation after realizing that $36 per user is too high to be tenable. Search engine traffic was notoriously hard to convert into app downloads, as validated for the residential energy sector once again.

## App Downloads

Google provides a seamless Android App Download advertising channel that presents app recommendations throughout its media properties for all its mobile users. Its service reduces the number of interactions necessary before an app is downloaded, appreciably lowering average cost of download per user. Table 24 shows the cost of user acquisition for an app download campaign run through Google's media properties, including YouTube and its mobile ad network.

**Table 24: Costs through User Acquisition Funnel for App Download Advertising**

| Step | Conv Rate | Step Conv Rate | Cumulative Cost per User | Description of Each Step in User Acquisition Funnel |
|---|---|---|---|---|
| 1 | | | | Mobile phone user on Google property or network |
| 2 | | | | Shows app download suggestion |
| 3 | 8% | 8% | $0.06 | Interacts with app download suggestion |
| 4 | 0.08% | 1% | $5.90 | Downloads Android app directly |
| 5 | 0.03% | 36% | $16.50 | Signs up as user |
| 6 | 0.01% | 20% | $82.50 | Links to IOU account |

Source: Home Energy Analytics

Compared to search engine marketing, the cost per download decreases by a factor of four while the cost of signup is halved. Notice that with search engine marketing, 60 percent of people who download end up registering, while with app download advertising only 36 percent of those who download actually sign up. This implies that although it is easier to get people to tap download, they do not take it as seriously, and user acquisition from app download ads are generally less precisely targeted, because Google or Facebook has made it so much easier for a person to download an app and forget about it. In any case, $16.50 per signup is still much too high, especially for untargeted and unengaged traffic.

## Affiliate Marketing

Affiliate marketing has traditionally worked well with niche services, because affiliate channels have already filtered for users or followers who are actively interested in certain topics. In practice, affiliate marketing can work with a variety of formats, including email, editorials, recommendations, endorsements, postings, blog articles, and the like. The most important factor to success is matching the service with the right affiliate.

For energy conservation, the choices of affiliates were limited. The best affiliate would, of course, be the IOUs themselves, especially inside paper or digital bills, but that channel proved inaccessible. Another option was to find affiliates who have an audience of readers interested in budgeting and figuring out ways to save money, such as NerdWallet. Unfortunately, Dr. Power did not have the budget to reach a deal with an affiliate partner like NerdWallet, nor would the fees to get to such a valuable audience be affordable, even if user acquisition rates proved to be very good with strong targeting.

Instead, experiments with affiliate marketing were conducted with two online properties run by Home Energy Analytics. Both online properties were able to allow the team to test affiliate marketing for 5,500 subscribers under ideal conditions, with no use of project funds. The team ran three experiments comprised of two affiliate email campaigns and one affiliate content campaign.

### Unplugstuff.com

Unplugstuff.com is a small web app developed by HEA in 2012 that has accrued about 1,100 subscribers. These users have actively expressed interest in learning more about idle loads over the past seven years. Despite the fact that the email list was not fresh, there was no better targeted affiliate partner in the market that the team could identify. Further, since HEA owned the email list, the team was able to send multiple emails with complete creative freedom to test using the best-known email marketing practices in the industry. Table 25 shows the results of three rounds of emails to all Unplugstuff.com subscribers under those ideal affiliate marketing conditions.

**Table 25: Costs through User Acquisition Funnel with Unplugstuff.com**

| Step | Conv Rate | Step Conv Rate | Estimated Cost per User | Description |
|---|---|---|---|---|
| 1 | | | $0.50 | Email sent to highly targeted resident with permission |
| 2 | 33% | 33% | $1.50 | Resident opens email |
| 3 | 7% | 22% | $6.80 | Resident clicks on link in email to become lead |
| 4 | | | | (app download not applicable) |
| 5 | 5% | 65% | $10.50 | Signs up as user |
| 6 | 0.1% | 2% | $525.00 | Links to IOU account |

Source: Home Energy Analytics

Assuming a cost of $0.50 per email address, which is reasonable for such a highly targeted list and that the team acquired the permission to email each three times, the average cost per sign up was $10.50. This is the best performing of all user acquisition experiments. Unfortunately, only 2 percent of users were able to link to their IOU account because the vast majority of them were serviced by SDG&E, from which Dr. Power could not access AMI data for its users, as discussed earlier.

Besides the cost, this affiliate marketing experiment also yielded impressive performance compared to industry averages. The open rate was 33 percent as compared to the email marketing average of 21 percent, but what was even more impressive was the 7 percent click rate, compared to the industry average of 2 percent (MailChimp, 2018). Factors that yielded such impressive results included the following:

- Subscribers had previously expressed interest in idle load reduction.
- Messaging emphasized support and funding from the State of California.
- Messaging focused on reducing the energy bill, rather than on sustainability.
- Messaging emphasized the low cost of solutions.

The most significant factor after exceptional targeting was the trust the State of California generated. The team speculated that the trust and reputation for goodwill alone doubled click rates and subsequent signup rates. The average cost of $10 per user acquisition was still too high, and because such exceptionally targeted affiliate channels were practically nonexistent, paid affiliate marketing would likely not scale and would be too expensive.

Refer to Appendix D for an example of how the reputation from CEC was used in affiliate email marketing.

**HEA.com**

Another experiment the team conducted tested a more likely scenario. Instead of relying on a website with subscribers interested in idle loads, the team ran an email campaign to 2,000 users of a complementary service like HEA's Smart Audit. Other potential affiliate partners were among service providers in the residential energy sector with similar users. The problem would be that getting permission to market to their users remained a challenge, and then doing so within a reasonable cost range would be even harder.

In any case, experimentation with an online property under HEA's control created an opportunity to test under optimistic but realistic conditions. Also, because most HEA.com users already had linked to PG&E accounts and had granted data access, the team could run a test without the usual detrimental drop-off at step #6 of linking to an IOU account. Table 26 shows the results of sending multiple emails to about 2,000 HEA.com users who were identified as having a need for an app such as Dr. Power.

**Table 26: Costs through User Acquisition Funnel with HEA.com Users**

| Step | Conv Rate | Step Conv Rate | Estimated Cost per User | Description |
|---|---|---|---|---|
| 1 | | | $0.50 | Email sent to highly targeted resident with permission |
| 2 | 49% | 49% | $1.00 | Resident opens email |
| 3 | | | | (signup via HEA already completed) |
| 4 | | | | (app download not applicable) |
| 5 | 1.8% | 4% | $27.50 | Signs up as user |
| 6 | 1.5% | 85% | $32.50 | Links to IOU account |

Source: Home Energy Analytics

Notice that the open rate was very high at 49%, which was expected given that users of the HEA system regularly opened emails from their service provider. However, the signup rate of 1.8 percent was much lower than the 5 percent for the campaign for Unplugstuff.com subscribers. This lower signup rate yielded an estimated cost of $27.50 per user via affiliate email marketing, which was more realistic than the $10 from Unplugstuff.com campaign. While many service providers were related to residential energy efficiency, there were very few websites about idle loads with a high volume of subscribers.

Most importantly, because the majority of HEA.com users were already linked to PG&E, 85 percent of users made it to step #6, yielding a cost of $32.50 per complete user acquisition. This is the lowest figure the team was able to achieve, but it was only because Dr. Power was integrated with HEA.com, easily allowing the transfer of data access rights without going through IOU linking like the previous funnels. This special condition, however, was unrealistic for other affiliate partners outside of HEA.com.

### HomeIntel

To experiment with another form of affiliate marketing that had proven to work better than emails, Dr. Power was added as a suggestion inside the user interface for HomeIntel, an online energy coaching service, when idle load is specifically mentioned. Of all the user acquisition experiments conducted, this afforded the most ideal conditions since the affiliate channel was the timeliest, deeply integrated, and most targeted. In addition, HomeIntel users also were already linked to their PG&E accounts and could transfer data access to Dr. Power, skipping the problematic IOU account linking step. This experiment ran for 19 months from December 2017 to June 2019, suggesting Dr. Power to about 2,500 HomeIntel users. Table 27 shows the results of this experiment.

**Table 27: Costs through User Acquisition Funnel with HomeIntel**

| Step | Conv Rate | Step Conv Rate | Estimated Cost per User | Description |
|---|---|---|---|---|
| 1 | | | $1.00 | Be included to every user in HomeIntel |
| 2 | 79% | 79% | $1.30 | Content about Dr. Power is displayed to HomeIntel user |
| 3 | | | | (signup via HEA already completed) |
| 4 | | | | (app download not applicable) |
| 5 | 6.7% | 8.5% | $14.90 | Signs up as user |
| 6 | 6.1% | 91% | $16.40 | Links to IOU account |

Source: Home Energy Analytics

With an estimated cost of $1 per impression, this method yielded the most impressive results with signup rate of 6.7 percent and reaching step #6 at an average cost of $16.40. However, the ideal conditions of this experiment cannot currently be repeated elsewhere, so it is not a scalable method of user acquisition. The results validated that under ideal conditions, Dr. Power can attain a total user acquisition cost of about $15 per user through paid advertising with highly qualified affiliate marketing.

More importantly, user acquisition costs aside, experiments with affiliate marketing revealed very impressive response rates and conversion rates if a reliable method was available to reach at scale the California households who were actively interested in saving on energy bills. Although paid affiliate marketing may be too expensive, unpaid affiliate marketing, if pursued by IOUs or the CEC, could enable Dr. Power to reach millions of California households with content that naturally filter those who are actively interested in saving on energy bills. Within this filtered audience, simple and direct educational messaging from a trusted entity with public goodwill could yield engagement rates up to four times that of industry average.

# Other Outreach Methods

Early assessment quickly ruled out experimentation with other known outreach methods practiced by other groups in the residential energy sector or local governments. These channels were obviously too expensive and/or not at all scalable.

## Direct Mail

Direct mail is sending letters or post cards to an address list. The cost of contact list acquisition, postage, and production of mailouts came to $2 to $3 for a simple letter or postcard. With an industry average response rate of 2 to 3 percent, which has been corroborated by field experience in other HEA projects, the signup rate was estimated to exceed $100, and this was before resolving the IOU data access issue, which was expected to drop 80 percent of users. Even assuming a very optimistic 5 percent response rate and assuming 50 percent of people who responded by typing in the URL signed up, the lowest cost for a registered user before linking to IOU account was more than $80 per user.

### Print Advertising

Print advertising included flyers, posters, and handouts in different community centers or corporate offices. The response rate was known to be so low from previous HEA experience and further validation from partners in the field that no optimistic model would justify the initial cost of working with print advertising. Further, even if the cost of acquisition turned out to be reasonable, this method would not be scalable.

### Events

Considering the labor, planning, and time involved in participating in events such as farmers markets, art and wine festivals, and other community events, this outreach method produced perhaps the worst ROI of all promotions for a free service like Dr. Power. Because of the human resources and logistics involved, this was only good for branding and relationship building within communities, not user acquisition, especially for a free app.

## Problem with Paid Advertising

Paid advertising was too expensive for the scalability goal of this project. Common scalable practices such as search engine marketing or app marketing yielded unaffordable user acquisition costs over $35, even assuming the most optimistic scenario that 50 percent of the users would successfully link to their IOU accounts. However, because of the problems with IOU data accessibility, user acquisition efforts show that only 10 percent of users ended up successfully linking, driving user acquisition costs up to $175. Under the best conditions with affiliate marketing, user acquisition cost with paid advertising would not improve much unless the team had special access to systems with millions of users who were already granted access to their PG&E accounts.

Throughout the user acquisition experiments with paid advertising, the team generated several hypotheses why scalable paid advertising was too expensive for the RYPL platform.

### Ad Fatigue Precipitated High Costs

Americans have been inundated with digital ads in all kinds of format, and the ads often went ignored even if delivered straight to their email inbox. Getting attention required content that was obviously different from typical ads. For example, emails from the government had double the open rates to those in e-commerce (MailChimp, 2018). In this project’s own email campaigns, the team speculated that the following could double response rate:

- Lead with the logo from a noncommercial entity, such as a department within the State of California or the utility company itself
- Emphasize funding and support from local, state, or federal government
- Emphasize new, low-cost ways to save energy

Dr. Power email campaign results validated the conclusion that noncommercial emails were more than twice as likely to be opened and read by Californians when compared to a typical commercial email. Even with this advantage, search engine marketing or app download marketing would be too expensive, because commoditized advertising channels like these are ignored.

### Reputation for Greenwashing

In the past decade, too many commercial players in the home improvement and residential energy industry have been aggressively marketing complex installations and upgrades costing thousands of dollars purporting to yield fast return on investment while being "green." This practice is often referred to as "greenwashing." In addition, service providers who sell solar installations, HVAC improvements, or even managers of awareness campaigns, have made unrealistic claims about the positive environmental impact their solutions provide. User acquisition experiments also showed Californians' aversion to overreaching claims about sustainability, especially when it was related to home improvement and residential energy. Messaging around saving on energy bills far outperformed messaging around positive environmental impact. This phenomenon was so consistent early on that nearly all messaging in user acquisition experiments revolved around savings on energy bills. Worse yet, complex and expensive home upgrades have masked themselves as free diagnostic services so frequently that Californians assumed that Dr. Power was another e-commerce advertising pitch until the goodwill reputation of the State of California was applied.

### Trust is Tantamount

Simply put, even with superior targeting, any form of outreach or marketing to Californians requires a reputation for goodwill and some distinction from regular advertising. Traditional scalable paid advertising channels, like search engine marketing, were too expensive and ineffective even with a good reputation, because these messages were currently being treated as home upgrade advertising. Simple educational content around energy bill savings through a trusted channel was the key to effective and scalable user acquisition.

## Content Marketing

During the last year of the project, the team pivoted to content marketing, which was usually considered a long-term approach. Content was developed as an asset that garnered attention and through useful information generated a following. Instead of spending advertising dollars to directly buy attention, budget was spent on content development for two channels:

1. Content discovered in social media
2. Content discovered in search engine results

Of these two channels, search engine results were much more appropriate for the RYPL platform because Americans predominantly used Google to ask questions or to research about personal finances and home maintenance. Content marketing to acquire users for Dr. Power became a process of nudging visitors to become Dr. Power users as described in section The RYPL Nudge Experience of this document.

## Scalable Economics

Instead of reducing incremental costs through a funnel, content marketing shifts budgeting to investing in the development of media assets that are useful on their own and can also automatically acquire attention in search engines results. The challenge of this project was that SEO was a long-term approach, requiring the development of link authority and well-targeted content ranking well in Google search results over a long period of time, such as a few years (Clarke, 2019).

Considering the best-case cost of $15 per signup in paid advertising, 100,000 signups would cost $1.5 million, but because only 10 percent would go through the last step, this budget would only yield 10,000 fully active users who had linked to their IOU accounts. With scalable paid advertising, this would equate to an acquisition cost of $150 per user.

Because Google users trust organic search engine results much more than paid advertising, these acquired users could be retained more easily and led through the IOU data access barrier. The team estimates that 25 percent of users would successfully link to their utility accounts if Google users discovered AskDrPower content in the following manner:

1. Within the top half of the first page of organic search results, and
2. Within State of California or their IOU's website

If these two conditions were true, conservative estimates suggested that a $750,000 investment could build and maintain content that would yield 20,000 Dr. Power users with linked IOU account per year for five years. Over five years, this estimate translated to a user acquisition cost of $5 per user with content marketing, versus a $150 with paid advertising.

The initial challenge was to build enough content to get started and to determine what kind of content would work best for the RYPL platform. AskDrPower.com became a testbed for generating content that could show up in Google search results to match the long-tail of questions and topics related to energy bills, residential energy, and home improvement.

## Medium-Form Articles

Articles form the backbone of any website building for SEO. Because of the fierce competition, high quality medium-length articles of at least 700 words performed much better than a higher volume of low-quality and short articles. The original goal was to produce 200 articles at $100 per article by outsourcing the copy to writers available in job marketplaces, such as Upwork. By the end of this project, 79 high-quality articles of medium length were created at a cost that was closer to $400 per article. To generate 120 more articles to reach the critical mass of SEO significance would take a budget of about $50,000.

### Ineffectiveness of Outsourced Writers

The team found fourteen remote writers from three different job marketplaces, including Upwork, Hubstaff, and Freelancer to author 25 articles. The deliverables were extremely poor across the board. Articles were not targeted, accurate, useful, nor interesting, so only three articles after severe editing were usable. In the end, high-quality articles about energy bill savings and residential energy requires experts who have experienced doing just that for Californian residents. Articles for AskDrPower.com were mostly written by HEA with a few written by hired experts.

Future content development would require investment in article content development closer to $400 per article, considering that an article takes more than four hours to research, write, edit and post, and required a field expert.

### Podcast Interviews

Recording interviews with field experts became an effective way to simultaneously generate articles and podcast episodes as effective content for SEO. Plus, podcasts offered another channel through which to get discovered. AskDrPower podcast was available in more than seven podcast publishing platforms, including the two most popular ones: Apple and Spotify. The process for content generation worked in the following manner:

1. Setup interview with a field expert.
2. Conducted and recorded the interview for 45 minutes.
3. Transcribed the interview into text using automated service.
4. Heavily revised and proofread the transcript into three to four articles.
5. Published podcast episode and articles.

The team generated six podcast episodes and twenty articles, validating that this was a scalable process to generate content with high SEO value. In addition to strong content that naturally matched target key phrases, the podcast episodes provided additional ways to discover AskDrPower, as well as linkbacks to the website. Interviewing field experts also helped engage the residential community for participation in other features of AskDrPower, such as the Q&A forum described next.

## Question and Answers

People type many questions into Google Search, so Q&A forums often perform very well in search engine results. A Q&A forum provided value to AskDrPower.com in the three following ways:

1. Content with SEO value perhaps higher than articles for residential energy
2. Reputation as a place for useful information
3. Reason for visitors to sign up as users providing an email address

The Q&A forum was built in AskDrPower.com, but the team had neither the time nor the budget to seed content in the Q&A forum, which would require paid advertising to promote it to acquire initial visitors who posted questions. Development of the Q&A forum with plugins was nontrivial, because the team wanted it to work a certain way, that is more like Quora.com and less like an unstructured discussion forum that was vulnerable to internet trolling and poor content. Features of the Q&A forum included the following:

- Support for registered users and individual profiles
- Both guests and users could post questions
- Each question was a thread optimized for SEO
- Only certain users could answer questions
- Question and answers could be voted upon like Reddit
- Permission and access management for different roles
- Questions and answers were subject to approval
- Spam protection with "are you human" challenge
- Support for management of a network of field experts
- Email notifications

The next step would be to promote the Q&A forum with partnerships and ads that answer the long tail of matching questions within Google search results. A seed of at least 100 questions would get it started, but a target of 500 questions each with at least two follow-up snippets would ensure that the Q&A content reached the critical mass needed to get SEO significance.

## Idle Load Database Faceted Search

Faceted search is also another well-practiced method to build SEO for a website. Unlike article writing or Q&A forums, faceted search was not as common a practice during this project, because implementing it required a large database with relevant data and software development to create a network of cross-referenced pages specifically for SEO. The RYPL platform already had the ILDB with detailed information, including idle load, for more than 160,000 devices. The team decided to implement faceted search for the ILDB, instead of having a simple look-up user interface for the listings in the ILDB.

Faceted search implementation yielded more than 160,000 search engine optimized web pages that tightly cross-referenced each other. The breakdown of new content is listed below:

- 91 category pages
- 2,955 brand pages
- 3,282 category+brand pages
- 105,544 brand+model pages

This network of pages was designed to capture search engine results around idle load and electric use, as well as the long tail of household device brand names and categories. In addition, as the ILDB gets bigger, SEO results for AskDrPower would continue to improve.

## Link and Domain Authority

Google Search ranks its search results based on trust and authority. A website with the most proven content to answer the user's query came first, and Google looked for proof of authority and trust based on how others have referenced a website. Websites with the most useful and trustworthy information came first. High quality content was not enough; the SEO content must have been inside a website with high trust and authority for energy bills and residential energy.

Most content marketing experts regarded acquiring link authority as much harder than publishing high quality content. The biggest challenge was that link authority took a long time unless something unusual happened or viral content quickly spread related to very popular topics. The topics that the RYPL platform targeted was a long-tail that is not considered popular. Virality was not a promising method in getting link authority.

Community engagement was another option in acquiring link authority for this vertical, including related links, information, and terminology  Given that the residential energy sector was not that active and moved quite slowly in online communities, this was a very slow path, even with a larger budget.

The third method was to put the high-quality content at AskDrPower.com inside a website that already had high trust and authority, but did not have much relevant content. This method would save a tremendous amount of time and money, plus lower the risk of failure by creating synergy between too complementary situations. The team believed that AskDrPower SEO content belonged inside a website related to residential energy within the State of California umbrella, such as Energy Upgrade CA or a utility company. Developing content under such a website not only accelerates SEO dramatically, but it introduces the entire RYPL platform as a public service supported and funded by the State of California. User acquisition experiment results, user interviews, and expert knowledge all confirmed the importance of a reputation for public goodwill, especially in the residential energy sector.

## Notable Findings

The goal of user acquisition experiments was to find a way to scale the RYPL platform to tens of thousands of households. Both scalability and cost were of high concern. An outreach method, such as leaving flyers at community centers, might have cheap production costs and no advertising costs, but the method was not scalable. Scalable paid advertising proved to be cost prohibitive, especially for a service producing no revenue. More importantly, the IOU data accessibility problem resulted in the drop-off rates of 75 percent to 90 percent, ruling out the possibility of any affordable way to acquire linked users via paid advertising. The scalable economics that content marketing provided was the only alternative the team found that would be both scalable and cost effective. Though content marketing was a long-term user acquisition tactic that would usually be very slow, time and budget could be dramatically reduced if proven techniques and seed content from this project was put inside a website regarded by Californians to be trustworthy and not full of advertising, such as Energy Upgrade California or PG&E.

Other notable findings were discovered or validated while conducting experiments with user acquisition during the two years when Dr. Power was available. The most crucial findings are summarized in priority order in Table 28.

**Table 28: Notable Findings for Scalable User Acquisition**

| Finding | Comments |
|---|---|
| Content was the way to scale. | The economics of paid advertising in its various forms made it unaffordable. In addition, advertising especially related to residential energy was often mistrusted or ignored by residents. |
| The State of California had the trust. | The content should have been from the State of California or utility companies for three reasons. 1: public trust separated content from advertising, doubling or tripling interaction and conversion rates. 2: link and domain authority dramatically accelerated SEO. 3: user retention rates helped lower drop-offs, especially in the more difficult last step of linking to IOU accounts. |
| IOU data access had to be improved. | IOU data access problems severely hampered registration completion and blocked the personalization of the app necessary for immersive education. Also, because of high drop-off rates, lack of data access increased cost by 2 to 5 times. |
| Focused messaging on savings. | Messaging in communication or promotions should have introduced the RYPL platform as a new way to save money by reducing high energy bills. Limited suggestions about positive environmental impact or social good. |
| Promoted low-cost solutions. | In the residential energy sector, residents were familiar with free services that sell complex, expensive upgrades. Emphasized early that the program was about cutting unnecessary waste, and that the solution was based on buying $20 devices anyone could setup and understand. |
| Got rid of vampires and hogs. | Emphasized in messaging and educational content that this program was focused on large unnecessary wasting of energy around the home. Stopping waste would not have required sacrifice in comfort or lifestyle. |
| Education was first impression. | People distrusted advertising and suffered from ad fatigue, so the first impression was important. Emphasized education, not advertising, for any product or service. |

Source: Home Energy Analytics

# Conclusion

It was difficult to get people to care about energy reduction. The team speculated about the reasons: residents were too busy; were already drowning in a flood of advertising and information; thought energy reduction was difficult and expensive; did not think it was important; the amount of money saved was not sufficient to engage; and did not connect energy reduction to reducing their carbon footprints. Researchers determined that users were more likely to engage with Dr. Power if they viewed it as a noncommercial service. Branding Dr. Power as an app provided by California without any commercial connections had the most promise.

# CHAPTER 5: Conclusion

HEA and the project's partners have developed a commercial quality app that would have great benefit to California ratepayers and support aggressive energy and greenhouse gas reduction goals, but it is unclear if the ratepayers would see these benefits.

There are 2 issues that must addressed:

- Easy data access for both SCE and SDG&E customers

  This issue is being addressed in CPUC proceedings A.18-11-016 and A.18-11-017. HEA is a party to both proceedings and filed a protest to A.18-11-017. The latest ruling will be available in Q1 2020, and then if the utilities are required to provide the appropriate data access it will still require time to deliver the capability. It seems unlikely that customers will see easy data access from SCE and SDG&E until 2021 at the earliest. Dr. Power is not the only app that would be enabled by improved services: several parties are advocating for greater data access through these proceedings.

- Promotion of Dr. Power to ratepayers

  It will take active promotion for ratepayers to learn about and take advantage of Dr. Power. There are two vehicles for this promotion: Energy Upgrade CA and utility websites. The state can require both to promote Dr. Power.

The RYPL platform was a unique EPIC project because the goal was to deliver a customer-ready service, and except for the data access limitations discussed above, Dr. Power and the underlying RYPL platform are customer ready. However, there is no economic model that will support Dr. Power as a commercial app at this time. Users will not pay to use it and the team's experience shows that having Dr. Power promoted as an app from a little-known software firm with no brand recognition will not get much traction, even if it is free and useful. To achieve the maximum benefit for ratepayers, Dr. Power should be rolled into the public-funded promotion of energy savings conducted by the state. A natural place for it would be the EnergyUpgradeCA.org, the IOU websites or websites of municipally owned utilities, pending that smart meter data becomes available. Only a modest investment would be required to promote and maintain Dr. Power since the investment has already been made to develop it.

# CHAPTER 6: Benefits to Ratepayers

As described above, one of the goals of this project was to develop a commercial quality app, Dr. Power. To achieve maximum ratepayer benefits requires promoting and deploying Dr. Power. The benefit in terms of watts (demand) reduced or kWhs (energy) saved can be extrapolated from the sample of users who were able to connect Dr. Power to their PG&E MyEnergy account, engage with the app, and then allow their energy use to be tracked. If every user reduced their idle load by 5.4 continuous watts (which equates to 47 kWh/year) as seen in the sample group, the benefit can be calculated:

$$\frac{Number\ of\ users\ \times ValueOf(5.4\ watts + 47\,\frac{kWh}{year}\,per\ user)}{\$\ for\ promotion + \$\ for\ maintenance}$$

The result is a ratio of the value of reducing residential energy use through Dr. Power relative to the cost. Simplistically, if the calculated value of the energy saved (the cost to generate the avoided energy) is more than the cost to do so, ratepayers will benefit from continued investment. If the value is less, further investment in Dr. Power is not warranted. The avoided cost is not a static number and varies based on many factors, including location, time of use, and so on. But with this rough calculation, it is possible to make an informed decision on promoting and supporting Dr. Power to achieve energy savings.

A possible scenario for a test calculation:

- Assume: $100,000 of funding per year for Energy Upgrade California to promote Dr. Power throughout California
- Assume: $50,000 per year for RYPL platform maintenance
- Assume: SCE and SDG&E AMI data linking is improved and user-friendly
- Assume: The above results in 20,000 new linked Dr. Power users per year
- Analysis: Using placeholder values of $1 per watt and $0.12 per kWh saved, the equation above results in a figure of 1.5, which indicates a positive return, and would justify such an investment.

$$\frac{20{,}000 \times (5.4 * 1.00 + 47 * 0.12)}{\$100{,}000 + \$50{,}000} = 1.5$$

The value of promoting Dr. Power exceeds the cost, the goal of all energy reduction programs overseen by the CPUC. The above calculation uses conservative values for the cost of a kWh and therm. In the PG&E E-1 residential rate plan, baseline kWh cost is $0.22 and therm cost is $1.27, both values higher than used above. With the cost of both kWh and therms expected to rise, the value of Dr. Power increases. For a modest yearly investment, the state would see significant savings.

Dr. Power is perhaps dissimilar from other EPIC projects in that it could be deployed immediately with this modest funding. In addition, it may be unique because there is no monetary incentive for a private company to deploy it, given that the commercial potential does not currently exist. There is no sufficient market for selling an app like Dr. Power. The difficulty encountered to convince people to download a free app indicates there is no market for an app that people must purchase. The value is in helping to achieve California's energy reduction goals through a budget of approximately $400M to achieve residential energy reduction.

To reap the benefit from this research and development, the team encourages the CEC to work with HEA to find an appropriate funding mechanism, perhaps from the IOU EE funding described above, to pay for the promotion and maintenance of Dr. Power. Researchers also strongly encourage the state to enforce energy data access standards. Poor support from both SCE and SDG&E is depriving residents in their jurisdictions of access to innovative software tools supporting energy reduction.

# LIST OF ACRONYMS

| Term | Definition |
|---|---|
| AC | Air Conditioning |
| AI | Artificial Intelligence |
| AMI | Advanced Metering Infrastructure |
| API | Application Programming Interface |
| AWS | Amazon Web Services |
| AR | Augmented Reality |
| CAGR | Compound Annual Growth Rate |
| CEC | California Energy Commission |
| CMS | Content Management System |
| CNN | Convolutionary Neural Network |
| ETL | Extraction, Transformation and Load |
| FTP | File Transfer Protocol |
| GFCI | Ground Fault Circuit Interrupter |
| HCI | Human Computer Interface |
| HEA | Home Energy Analytics, Inc. |
| HTML | Hypertext Markup Language |
| HVAC | Heating Ventilation Air Conditioning |
| IE | Internet Explorer |
| ILDB | Idle Load Database, aka PLDB |
| IOU | Investor Owned Utility |
| IoT | Internet of Things |
| kWh | kilowatt-hour |
| NLP | Natural Language Processing |
| OAuth | Open Authorization |
| OCR | Optical Character Recognition |
| PG&E | Pacific Gas and Electric |
| PLDB | Plug Load Database (original name of ILDB) |
| Q&A | Question and Answer |
| NRDC | Natural Resources Defense Council |
| REST | Representational State Transfer |

| Term | Definition |
| --- | --- |
| ROI | Return on Investment |
| RYPL | Reduce Your Plug Load |
| SaaS | Software as a Service |
| SCE | Southern California Electric |
| SDG&E | San Diego Gas and Electric |
| SEO | Search Engine Optimization |
| SSL | Secure Sockets Layer |
| URL | Universal Resource Locator |
| W | Watts |

# REFERENCES


Bertoldi, P. (2002). Standby Power Use: How Big is the Problem? What Policies and Technical Solutions Can Address It? *ACEEE*.

BusinessofApps.com. (2018). *CPI Rates 2018.* Retrieved from BusinessOfApps.com: http://www.businessofapps.com/ads/cpi/research/cost-per-install/

CEC. (2015). Status_of_PlugLoad_Efforts.ppt. *CEC presentation (15-IEPR)*.

Clarke, A. (2019). *SEO 2019: Learn search engine optimization with smart internet marketing strategies.*

Delforge, P., Schmidt, L., & Schmidt, S. (2015). *Home Idle Load: Devices Wasting Huge Amounts of Electricity When Not in Active Use.* NRDC.

MailChimp. (2018, March). *Email Marketing Benchmarks.* Retrieved from Mailchimp.com: https://mailchimp.com/resources/email-marketing-benchmarks/

Nielsen. (2018, Sep). *(SMART) SPEAKING MY LANGUAGE: DESPITE THEIR VAST CAPABILITIES, SMART SPEAKERS ARE ALL ABOUT THE MUSIC.* Retrieved from www.neilsen.com: https://www.nielsen.com/us/en/insights/news/2018/smart-speaking-my-language-despite-their-vast-capabilities-smart-speakers-all-about-the-music.html

Pew Research Center. (2019, Jun). *Mobile Fact Sheet.* Retrieved from PewInernet.com: https://www.pewinternet.org/fact-sheet/mobile/

Scrapehero.com. (2018, January 10). *How many products does Amazon sell?* Retrieved from Scrapehero.com: https://www.scrapehero.com/many-products-amazon-sell-january-2018/

Thaler, R. H., & Sunstein, C. R. (2009). *Nudge.* Penguin Books.

# APPENDIX A:
# Dr. Power Representative Loads

| Idle Load Range | Associated Device on 24/7 |
|---|---|
| 0-10 watts | Tent |
| 10-25 watts | Boombox |
| 25-50 watts | Electric Fan |
| 50-75 watts | 32-inch Television |
| 75-100 watts | Desktop Computer |
| 100-150 watts | 100-watt Lightbulb |
| 150-200 watts | Big Analog Television |
| 200-250 watts | Electric Blanket |
| 250-300 watts | Washing Machine |
| 300-400 watts | Blender |
| 400-500 watts | Garage Door Opener |
| 500-550 watts | Power Drill |
| 550-700 watts | Vacuum Cleaner |
| 700-800 watts | Hair Dryer |
| 800-900 watts | Waffle Iron |
| 900-1000 watts | Angle Grinder |
| 1000-1100 watts | Electric Deep Fryer |
| 1100-1200 watts | Burning Toaster |
| 1200-1300 watts | Electric Chainsaw |
| 1300-1400 watts | Circular Saw |
| 1500-2000 watts | Electric Lawn Mower |
| 2000-2500 watts | Large Pool Pump |
| 2500-3000 watts | Electric Jack Hammer |
| 3000+ watts | Electric Clothes Dryer |

Source: Home Energy Analytics

# APPENDIX B:
# AskDrPower.com Organic Traffic Growth

Table B-1 below lists the number of visitors per month to AskDrPower.com as provided by the tracking service from WordPress.com (https://wordpress.com/stats/month/askdrpower.com). Rolling three-month average was used to smooth out the number of visitors. The month-over-month growth rate from organic traffic is 14%, translating to a CAGR of nearly 500%.

**Table B-1: AskDrPower.com Monthly Organic Visitors**

| | **Visitors** | **m-o-m%** | **Visitors (3 mo. rolling)** | **m-o-m % (3 mo. rolling)** |
|---|---|---|---|---|
| Mar 2018 | 8 | | | |
| Apr 2018 | 18 | 125% | | |
| May 2018 | 41 | 128% | 22 | |
| Jun 2018 | 22 | -46% | 27 | 21% |
| Jul 2018 | 16 | -27% | 26 | -2% |
| Aug 2018 | 56 | 250% | 31 | 19% |
| Sep 2018 | 48 | -14% | 40 | 28% |
| Oct 2018 | 22 | -54% | 42 | 5% |
| Nov 2018 | 31 | 41% | 34 | -20% |
| Dec 2018 | 91 | 194% | 48 | 43% |
| Jan 2019 | 83 | -9% | 68 | 42% |
| Feb 2019 | 64 | -23% | 79 | 16% |
| Mar 2019 | 87 | 36% | 78 | -2% |
| Apr 2019 | 99 | 14% | 83 | 7% |
| May 2019 | 115 | 16% | 100 | 20% |
| Jun 2019 | 94 | -18% | 103 | 2% |
| Jul 2019 | 142 | 51% | 117 | 14% |
| *Average* | | | | 14% |
| *2019 Average* | | | | 14% |

Source: Home Energy Analytics

# APPENDIX C:
# Idle Load Database Device Categories

| Category | Description |
|---|---|
| Refrigerator or Freezer | Normal kitchen refrigerator or freezer, any size and any age. Exclude standalone ice makers and wine coolers. |
| Television (any type of TV) | Including old or new, large or small, LCD or CRT. Note: there is a separate category for an integrated home theater. |
| Desktop Computer (not a laptop) | Desktop or tower computer, including gaming machines and servers. |
| Whole-Home Backup Battery (continuously charging batteries) | A whole-house battery pack provides backup power during outages. The batteries are not the problem; it's the battery charger which can be very wasteful. |
| Whole-House Lighting System (electronics / transformers always on) | Central controller and/or power transformer(s) for an advanced whole-house lighting system. |
| Undersized AC Unit (running continuously for weeks) | Any air conditioner that runs 24 hours per day for weeks at a time. Note: this usually only happens if the AC unit is undersized or old. |
| Heated Tile Floor | Heated bathroom or kitchen tile flooring. Some of these units stay on continuously, no matter how low the thermostat is set. |
| Large Security System (with many sensors and cameras) | Advanced home security system with cameras |
| Wine Cellar (walk-in closet or room) | Separate closet or room for wine storage with climate control |
| Continuous Heat Pump (running continuously for weeks) | Heat pump running 24 hours per day for at least three weeks at a time. Note this should only happen if the heat pump is either undersized or old. |

| Category | Description |
| --- | --- |
| Home Cinema or Theater (dedicated room) | Large integrated home cinema or home theater |
| Large Fountain (always running) | Large water fountain running continuously (24x7) |
| Standalone Ice Maker | Large standalone ice maker, always on |
| Whole-Home Audio Amplifier (controls & speakers in many rooms) | This is the centralized equipment (a rack of devices or individual amplifier) that powers a whole-house audio system. |
| Wine Cooler | Standalone wine storage cooler |
| Radiant Heating (recirculating continuously) | Radiant heating uses pumps to move heated water, and some of these pumps run continuously |
| Hot Water Recirc Pump (usually next to water heater) | Continuous hot water recirc pump that provides instant hot water to all faucets |
| Continuous HRV (heat recovery ventilator) | Some modern and extremely efficient homes use Heat Recovery Ventilators to circulate fresh air. Most run continuously. |
| Video Game Console | Electronic game console like PlayStation, Xbox 360, Wii, etc. |
| Stereo (always on standby) | At least one stereo amplifier with other components that are always plugged in. |
| InstaHot Dispenser | Instant hot water dispenser, usually in kitchen, provides steaming water immediately. |
| Aquarium (with pumps, lights, filter, etc.) | Any type aquarium that has a filter pump, lighting and/or heater. |
| Fish Pond (with electric pump) | A pond for fish or aquatic plans with a recirculating pump or fountain. |
| Mini Fridge | Dorm fridge, small fridge, compact fridge. |

| Category | Description |
|---|---|
| Light - Always On (larger than a nightlight) | Any type of light (indoor or outdoor) which is always on. |
| Security System (with central controller) | Typical home security system with backup battery and multiple sensors connected to a central controller. |
| Continuous Fan (always running) | Any continuous fan for cooling, drying, ventilation, exhaust, comfort, air circulation, etc. Including furnace fans if always on. |
| Cable Modem (always on) | Cable modem for TV, internet or phone service. |
| Radon Mitigation System | Radon gas ventilation system. Usually includes a blower in or near the basement/crawlspace or beside the home connected to a round plastic exhaust duct. |
| Small Fountain (always running) | Small indoor or outdoor fountain running continuously. |
| UPS Backup Device | Uninterruptible Power Supply for electronics |
| Network Hard Drive | Network storage device on a home area network. |
| Home Medical Device (always running) | Medical equipment running continuously (ventilator, CPAP, dialysis, etc.) |
| HandVac (always plugged in charging) | Rechargeable handheld vacuum cleaner |
| DVR (always on standby) | Digital Video Recorder, always on, ready to record video programs. |
| Powered Speaker System (surround sound, sound bar, etc.) | Surround sound system, sound bar, or any other powered audio system used to improve sound from TV, computer, CDs, tuner, or other input device. |
| VCR (always plugged in) | Video Cassette Recorder left in standby mode |
| Air Filter or Air Purifier | HEPA air cleaner or other air filter, always on. |

| Category | Description |
|---|---|
| Smart Dishwasher (electronics & display always on) | High end dishwasher with advanced electronics, always on. |
| EV Charger | Electric Vehicle Supply Equipment (EVSE). Some consume energy all the time, even when not charging a vehicle. |
| Fax Machine (always on) | Fax machine, always on for incoming faxes. |
| Laser Printer (always on) | Computer laser printer (not an inkjet). |
| Smart Cooking Device (internet enabled) | Smart (connected) slow cooker, BBQ grill, etc.; always on |
| Battery Charger (always plugged in) | Battery charger for drill-driver or other handyman tool, always plugged in. |
| Digital Picture Frame | Digital picture frame continuously showing photos |
| Networking Device (always on) | Networking equipment including routers, Wi-Fi, switches, hubs. Always on. |
| Smart Water Heater (electronics always on) | Advanced electric water heater, with electronics always on. |
| Paper Shredder (always plugged in) | Mechanical paper shredder, always ready to shred. |
| Power Conditioner | Power conditioner for sensitive electronics, computers or audio equipment. |
| Garage Door Opener | Garage door opener with remote control. |
| Landscape Lighting | Landscape lighting controller, always on |
| Water Softener | Water softeners are plumbed into the main water line, and remove hard" minerals from the water supply." |
| Pool Controller | Pool equipment controller, always on. Used to schedule filter pump run times and other pool equipment. |

| Category | Description |
|---|---|
| DVD player | DVD player used with either a TV or computer |
| Smart Washing Machine | High end washing machine with advanced electronics which is always on. |
| Smart Clothes Dryer | High end clothes dryer with advanced electronics which are always on |
| Smart Furnace, AC or Heat Pump (electronics always on) | Modern furnace or air conditioning system with advanced electronics which are always on. |
| Always on Coffee Machine (always warm, or smart")" | High end coffee or espresso machine with advanced electronics or always warm |
| Emergency Lighting | Emergency lights always plugged in (not necessarily on) |
| Irrigation Controller | Automated landscape irrigation system |
| Invisible Pet Fence | Invisible pet fence with electronics, always on |
| Exercise Machine (always plugged in) | Treadmill or other exercise device with electronics, always on |
| Multifunction Inkjet | Copier/Printer/Scanner/Fax machine, always on |
| Microwave Oven | Microwave oven with electronics and clock, always on |
| Laptop Computer (always plugged in) | Portable laptop computer (not a tablet or phone) |
| Furnace | Traditional furnace with electric plug (often for thermostat) |
| Electric Toilet Seat | Toilet seat with electronics and heater, always on |
| Tankless Water Heater | Tankless water heater with electronics, always on |
| Weather Monitor | Weather station and monitor, always on |
| Electronic Instrument (always plugged in) | Electric piano or other electronic musical instrument, always on |

| Category | Description |
|---|---|
| VOIP Device (always on) | Skype hardware or other electronic Voice Over IP phone system |
| Inkjet Printer (always on) | Printer and/or copy machine, inkjet, always on |
| Electric Toothbrush (always charging) | Rechargeable or electric toothbrush, always plugged in |
| Smart Thermostat | Internet enabled thermostat |
| Home Energy Monitor (always on) | Energy monitoring device, always on |
| Electronic Charger (always plugged in) | Charger always plugged in, for mobile electronic devices |
| Clock or Radio | Electronic alarm clock or radio, always plugged in |
| Cordless Phone (always plugged in) | Cordless phones, always plugged in and charging |
| Smart Light Switches | Electronic light switches that can be remotely controlled |
| Digital Water Faucet | Digital water faucet, always plugged in |
| Doorbell | Electric doorbell with transformer |
| Smart Outlet (always plugged in) | Home automation smart outlet or other device (X10, Control4, Wi-Fi, zigbee) |
| Motion Sensor Lighting | Outdoor light controlled by motion sensor |
| Electric Wine Opener (always plugged in) | Electric wine opener, always plugged in |
| Smart LED Light | Bluetooth or other wireless enabled LED light bulb |
| Surge Protector (always plugged in) | Surge protector for sensitive electronics, always on |
| GFI Outlet | Ground Fault Interrupt outlets, usually near sinks |
| Smoke or CO Detector | Smoke alarm or Carbon Monoxide (CO) detector |
| Nightlight (always on) | Nightlight, always on (24 hours/day) |

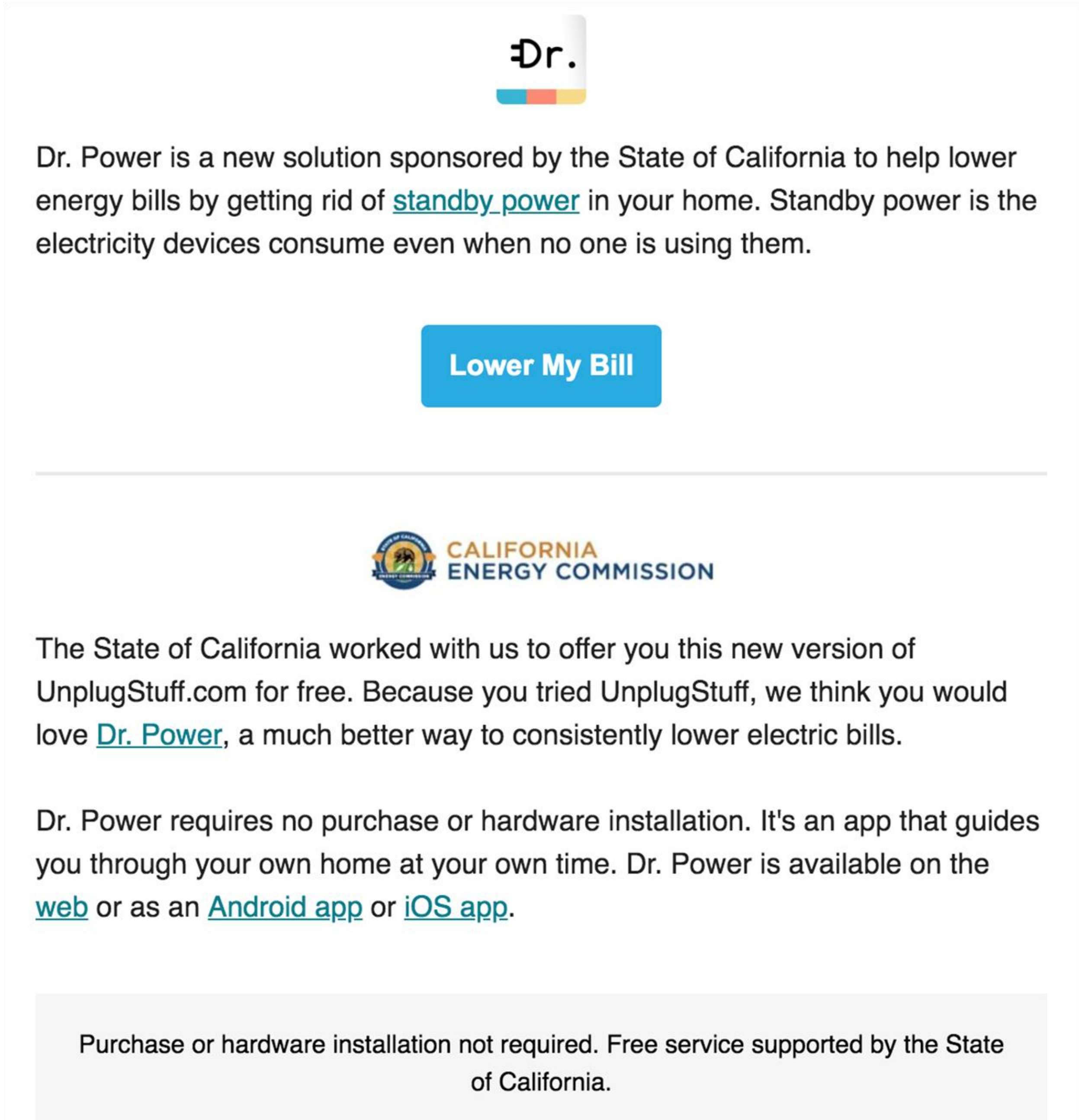
| Category | Description |
|---|---|
| Other Device | Any other electrical device that we haven't mentioned that is plugged in all the time and feels warm when not in use. |

Source: Home Energy Analytics

# APPENDIX D:
# CEC Affiliated Emails for UnplugStuff.com

Included are two email templates used for the affiliate email campaign with UnplugStuff.com.

**Figure D-1: Email for First Unplugstuff.com Mailing**



Dr.

Dr. Power is a new solution sponsored by the State of California to help lower energy bills by getting rid of standby power in your home. Standby power is the electricity devices consume even when no one is using them.

Lower My Bill

CALIFORNIA ENERGY COMMISSION

The State of California worked with us to offer you this new version of UnplugStuff.com for free. Because you tried UnplugStuff, we think you would love Dr. Power, a much better way to consistently lower electric bills.

Dr. Power requires no purchase or hardware installation. It's an app that guides you through your own home at your own time. Dr. Power is available on the web or as an Android app or iOS app.

Purchase or hardware installation not required. Free service supported by the State of California.

Source: Home Energy Analytics

**Figure D-2: Email for Second Unplugstuff.com Mailing**

CALIFORNIA
ENERGY COMMISSION

The California Energy Commission (CEC) wants to lower your electric bills. The easiest way is to locate your home's devices wasting electricity for no good reason. Dr. Power is a free online utility to help Californians find these "power hogs." We at HEA.com are proud to help the CEC.

What is an example of a power hog sucking your bills dry for not much to show for?

The hot water recirculation pump that keeps on running 24/7 when it's used for maybe 2-3 hours per day costing **$50 per month.**

Buy a $25 timer once to keep saving $50 per month? It's a good deal for you, helping both your state and the planet, too. There are lots of other examples, and this new online service from CEC will guide you.

**Find My Waste**

Source: Home Energy Analytics