Display of Smart Meter Information Via Set-Top Box Systems

ET13SCE7160 Report

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Disclaimer

EXECUTIVE SUMMARY

The Smart Meter Data on TV via Set-Top Box project aims at collecting real-time energy consumption data and displaying it on household TV screens through commercial pay TV service.

According to the United States Energy Information Administration (EIA), in 2012, the average annual electricity consumption for a U.S. residential utility customer was 10,837 kilowatt hours (kWh) [1]; much of this consumption can be cut down by reminding the home owners to turn off idling electronic appliances. A Nielsen study shows that on average, there are 2.73 TV sets per household and the average American spends approximately 8 hours per day watching TV [2].

This work aims at collecting real-time energy consumption data and displaying it on an easily accessible medium for the public, on TV screens through TV set-top-boxes. Displaying this data will provide home owners with sufficient information that will help them manage their energy consumption. The user friendly interface has been designed to display customer's energy usage and cost information on their TV screen while they are watching TV. The midterm and final demo were performed in order to demonstrate a proof-of-concept system design and to collect feedback on its functionality and interface design for further improvements. The Smart Meter Data on TV via Set-Top Box project is a collaboration between Southern California Edison (SCE) and California Plug Load Research Center (CalPlug). This report summarizes the work completed through phase 1 and 2 of the project, and includes the midterm and final demonstrations.

The system used in this project consists of an information delivery channel from SCE deployed Smart Meters to a consumer-premises gateway system, to a connected home set-top box as shown in Figure 1. Raw energy consumption data is collected by Itron Smart Meters, which are installed in most SCE customer households. The Itron meters are equipped with a ZigBee® radio, which enable this data to be transmitted to a gateway device through a ZigBee network. The gateway then sends the data to a cloud/server. Finally, the real-time data can be accessed by a set-top box and displayed on a TV screen via display web services.

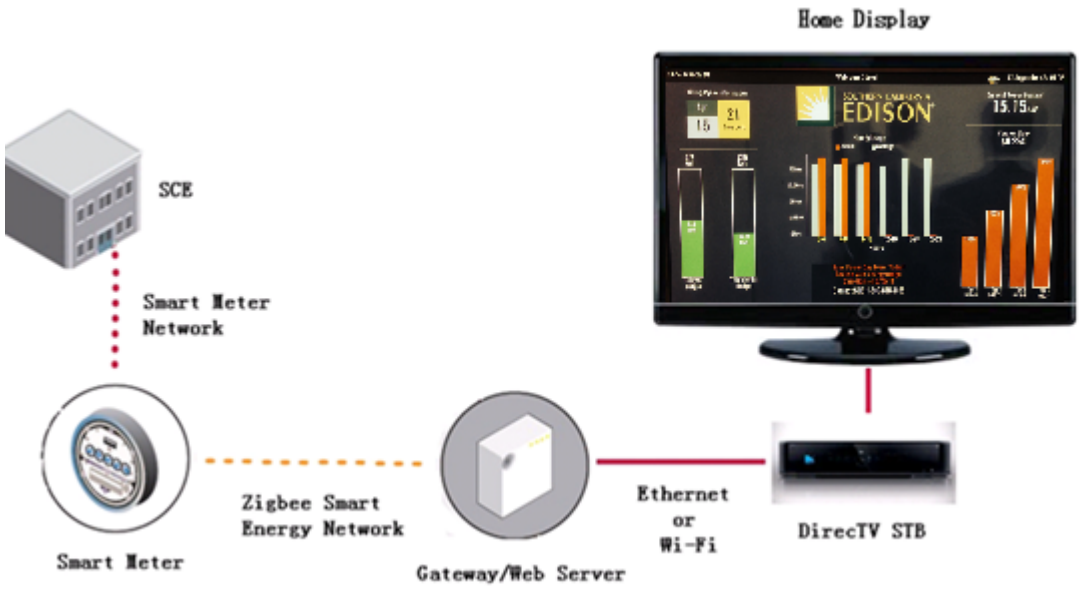

FIGURE 1. SMART METER INFORMATION DISPLAY SYSTEM OVERVIEW

The midterm and final demonstrations were performed at DIRECTV laboratories. The energy consumption data from a Smart Meter installed in the CalPlug lab was successfully displayed on a TV screen via DIRECTV's set-top box. Feedback was collected during the demo and will help the design team to further optimize their design.

ACRONYMS

C	Celsius
Calplug	California Plug Load Research Center
dBm	Decibal Miliwatt
EIA	United States Energy Information Administration
F	Fahrenheit
FT	Feet
GHz	gigahertz
M	Meters
SCE	Southern California Edison
STB	Set-Top Box

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INTRODUCTION

This project, with the California Plug Load Research Center (CalPlug), aims to demonstrate the concept of distributing Smart Meter information through compliant home set-top box systems. Real-time information, such as kWh usage and kW demand, will be relayed from an end-point Smart Meter to a multi-access gateway. The gateway, or dedicated web server device, will embed the consumer home energy usage in a web-based platform already developed by CalPlug that can be accessed through a standard web browser built into a user terminal such as a set-top box.

ZIGBEE SMART ENERGY GATEWAY DEVICES EVALUATION

The first step of this project seeks to identify and utilize gateways to read energy data from Smart Meters. After a solid data communication is established with the gateway, real-time data is read and integrated in the web server, which will then link to the Set-Top Box (STB) for display.

Currently, three gateways are being tested for ZigBee® network analysis and system development: Rainforest Automation™, Harmony Platinum, and Digi ConnectPort X2e®. These gateways are in compliance with industry standard software and network protocols. By sampling a variety of gateways, we are able to identify the most suitable one for data gathering and software integration. Additionally, affordability and user-friendliness of APIs are also considered.

The criteria for selecting gateways are: Southern California Edison (SCE) Smart Meter compatibility, socket interface, and cloud service robustness. The gateway must be able to read SCE Smart Meter via ZigBee Smart Energy profile 1.1. The physical layer and MAC sub-layer must be defined by IEEE 802.15.4 and operate in the 2.4 gigahertz (GHz) frequency band.

GATEWAY CANDIDATES

Figure 2, Figure 3 and Figure 4 are pictures of the three candidate gateways from Rainforest Automation, Harmony Platinum and Digi. Their specifications are listed in Table 1, Table 2 and Table 3, respectively.

FIGURE 2. RAINFOREST GATEWAY - RFA-Z109 EAGLE

TABLE 1. RAINFOREST GATEWAY - RFA-Z109 EAGLE SPECIFICATION

SPECIFICATION	DESCRIPTION
Wireless Link	IEEE 802.15.4 MAC, 2.4GHz ISM Band Receiver sensitivity: -99 decibal miliwatt (dBm), Transmit Power: +20dBm
Wireless Range	Up to 50 meters (m) (150 feet (ft) (highly dependent on usage environment
Standards	ZigBee Smart Energy Profile 1.1; HTTP/TCP/IPv4/Ethernet
Provision	Factory/warehouse pre-pairing based on installation code, or user pairing through phone/web based automated activation.
Operating Temperature	0° Celsius (C) t0°C to 50°C (indoor use only)
Price	$99.00

FIGURE 3. HARMONY GATEWAY – MODEL #6005B

TABLE 2. HARMONY GATEWAY - MODEL #6005B SPECIFICATION

SPECIFICATION	DESCRIPTION
Wireless Link	JN5148 IEEE 802.15.4 radio transceiver; available with either ZigBee PRO, JenNet or 6LoWPAN
Wireless Range	150ft (indoor)
Standards	ZigBee Smart Energy Profile 1.1
Provision	Factory/warehouse pre-pairing based on installation code
Operating Temperature	32° Fahrenheit (F) to 122°F (indoor), up to 85% relative humidity
Price	$279.99

FIGURE 4. DIGI GATEWAY - CONNECTPORT X2E ROUTER WIFI

TABLE 3. DIGI GATEWAY - CONNECTPORT X2E ROUTER WIFI SPECIFICATION

SPECIFICATION	DESCRIPTION
Wireless Link	UDP/TCP, DHCP; IEEE 802.15.4/Zigbee XBee ZB SMT transmit power 6.3 mW (+8 dBm) Receiver sensitivity (1% PER) -102 dBm
Wireless Range	200ft (indoor) 4000ft (outdoor within line of sight)
Standards	Smart Energy Profile 1.1
Provision	Factory/warehouse pre-pairing based on installation code
Operating Temperature	0 to 40°C (32 to 104°F) Relative humidity 5% to 95% (non-condensing)
Price	$120.00

ZIGBEE PROTOCOL AND APIS

ZigBee key features include:

- Multiple network topologies supported
- Low duty cycle (long battery life)
- Low latency
- Direct Sequence Spread Spectrum
- Up to 65,000 nodes per network
- 128-bit AES encryption symmetric encryption key
- Collision avoidance, retries, and acknowledgements

In conjunction with evaluating gateways, the team is also researching ZigBee wireless networks, specifically the IEEE 802.15.4/ZigBee standard. Since the IEEE

802.15.4 is well-known for its low-data-rate wireless personal area network (LR-WPAN), it is the ideal network to serve as an imbedded system for applications such as remote controls and home automation. As we enter the realm of home automation, the IEEE 802.15.4 standard allows us to maximize the energy efficiency by operating at a very low cost wireless network and low power consumption.

A major underlining concern about wireless network is security and reliability. Hence, the importance of the consumers' privacy and security must be safeguarded and all the gathered energy data have to be kept confidential. Therefore, having a secure wireless sensor network is fundamental. ZigBee is a huge enhancement to the IEEE 802.15.4 because it adds more sophisticated layers to the system by improving the network security with valid nodes and encryption and enables mesh networking with data routing and forwarding capability. This is also known as mesh topology, in which any node can communicate directly with any other node even if one is disabled. With this enhancement, the ZigBee network will provide the necessary security and reliability to gather and store data from the Smart Meter.

Specifically, Zigbee Smart Energy and Home Automation are two sets of protocol profiles that interface home energy monitoring and controlling devices. While Home Automation (HA) focuses on individual appliances inside a home, Smart Energy (SE) is more about regulating the usage in a home. So it was designed to act as the bridge between Advanced Metering Infrastructure (AMI) and Home Area Network (HAN). Because of the sensitive nature of the information being transmitted between the utility and the consumers, SE emphasizes security issues with more layers of encryption and key installation. Therefore, interoperability issues do exist among HA and SE compliant devices. However the scope of this energy display project only includes SE communication between a smart meter and a gateway, and HA integration is not relevant in this case.

In regards to an overcrowded network of ZigBee applications (refrigerators, TVs, washers, and dryers, etc.), the mesh network provides a solid solution to keep the network alive by relaying transmission either directly or indirectly (if not within range) with multiple nodes and connection paths. Additionally, transmission range is another factor that must be taken into consideration. Transmit power level and receiver sensitivity are the two major factors that determine the amount of packet loss, that can lead to faulty transmission and inaccurate data. To achieve minimum packet loss, logistic applications should be in the line of sight (LOS), but with the most up-to-date IEEE 802.15.4/ZigBee standard; most applications can cover a range up to 100 meters LOS. Effective range will be affected by objects in the way and interfering RF signals. This is relatively perfect for the majority of in-home applications. However, in the case of optimizing the range, using multi-hop network and high density nodes will help with expanding the network. Tweaking and implementing the algorithm to the system can also help enhance the connection as well as reduce packet loss. These features will be further explored as we progress to other stages of the project.

BENCHMARKING AND TESTING MULTI-ACCESS GATEWAYS

The gateway candidates have been connected with Itron meters and tested for ZigBee communication. One Rainforest Eagle gateway and one Digi gateway have been installed and provisioned with a residential SCE commercial Smart Meter. Another Digi gateway and a Harmony gateway have been connected and provisioned with the SCE Test Meter installed in the CalPlug Center. Their communications have been tested and each of their user APIs and interfaces have been evaluated.

GATEWAY EVALUATION CONCLUSION

The preliminary product of this grant project will be a fully functional ZigBee network connection between the Itron meter and the gateways. At this point, the team at CalPlug compared gateways in Table 4 and chose to work with the Digi ConnectPort X2e gateway for the next phases of the project. We made the choice based on the following reasons:

- Digi provides a powerful and reliable cloud service for data storing and network analysis.
- iDigi Appspot and Ethrios cloud both enable easy-to-use API debugging consoles.
- Digi built and categorized its multiple gateway APIs in an organized way, that is convenient for developers who are seeking to master this knowledge.
- Digi ConnectPort X2e has the longest communication range of all three candidates (200ft).
- The Digi gateway is reasonably priced given its wide range of capabilities.

While the gateways continue to run simultaneously under the testing mode, energy data will be collected and analyzed during phase two of the project. In the second phase, Calplug's Wall of Power server will be modified to be compatible with the Smart Meter and the set-top box. Once we establish the foundation of a web server interface, real-time energy consumption data will be displayed on a STB. With the support from SCE, the team at California Plug Load Research Center is confident to deliver a product that will help both the consumers and the industry optimize energy efficiency and reduce electricity cost.

TABLE 4. GATEWAY COMPARISON

PRODUCT	CLOUD SERVICE	API DEBUGGING CONSOLE	API POTENCY	API FRIENDLINESS	ZIGBEE RADIO RANGE	PRICE
Rainforest Eagle	No	No	No	Yes	150ft.	$99.00
Harmony Platinum	Yes	No	Yes	No	150ft.	$279.99
Digi ConnectPort X2e	Yes	Yes	Yes	Yes	200ft.	$120.00

SCE SMART METER DISPLAY USER INTERFACE

The Smart Meter display user interface is designed to make users aware of their energy usage (kilowatt hours) and energy cost ($), in order that they may consider more efficient ways to use energy. Three on-screen views of the user interface including full screen, overlay widget, and menu widget were designed during this phase of the study. The menu widget is a small window at the top of the menu screen of the TV program that displays a brief overview of current energy usage data. The user can press a predefined button on the remote control to see more detailed information via the full screen view, if interested. The overlay widget has a little more information than the menu widget. It displays periodically throughout the TV program. The user can chose to see the full screen in order to view detailed information or close the overlay widget by pressing the predefined button on the remote control or let it close on its own. The full screen view shows detailed information related to energy consumption gathered from the Smart Meter. The user interface design of the menu widget, overlay widget, and full screen view developed for the midterm demo are shown in **Error! Reference source not found.**Figure 6, and Figure 7, respectively.

FIGURE 5. SMART METER DISPLAY USER INTERFACE - MENU WIDGET

FIGURE 6. SMART METER DISPLAY USER INTERFACE - OVERLAY WIDGET

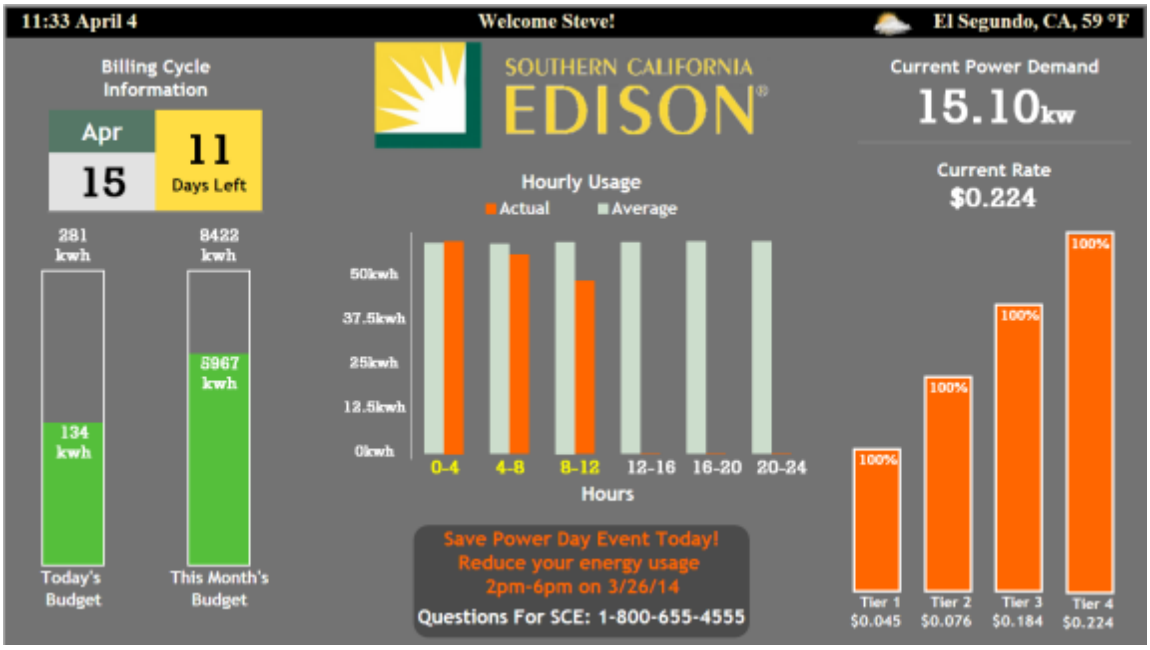

FIGURE 7. SMART METER DISPLAY USER INTERFACE - FULL SCREEN VIEW 1

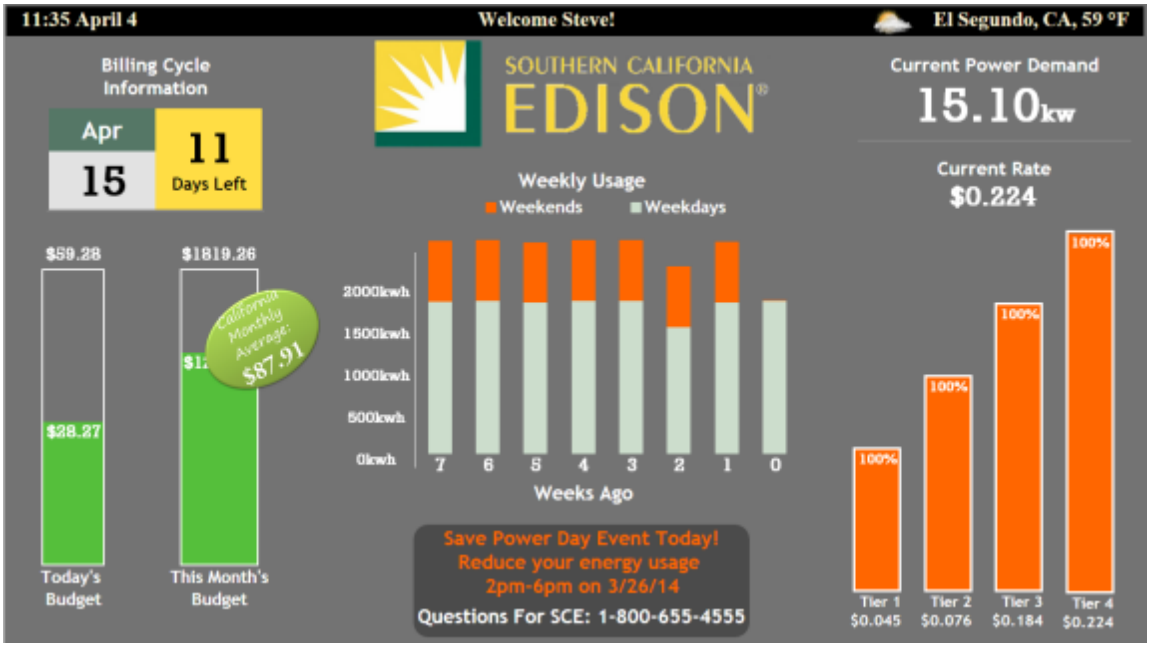

FIGURE 8. SMART METER DISPLAY USER INTERFACE - FULL SCREEN VIEW 2

DISPLAY ZONES DEFINITION AND BASIC INFORMATION

In the full screen design, the interface is divided into several zones. A "zone" is a term used to describe an area of the display that contains specific information unique to that area. The zones defined on the full screen are named by their identifying numbers as shown in Figure **9** and Table 5.

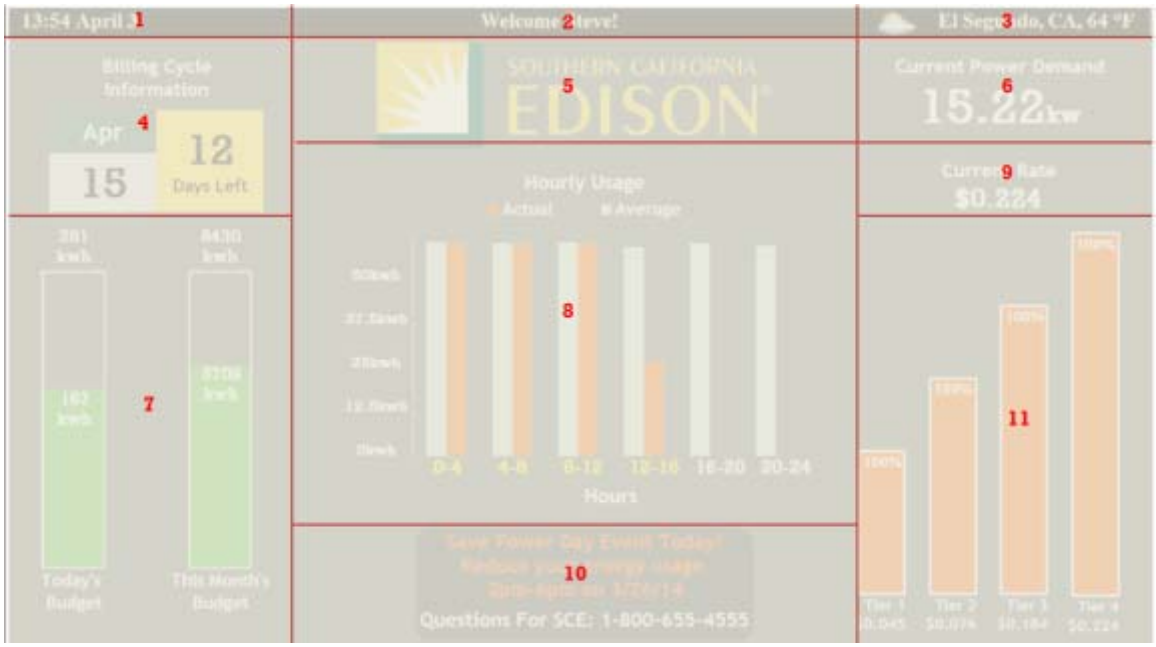

FIGURE 9. FULL SCREEN VIEW DESIGN ZONE DEFINITION

TABLE 5. SCREEN VIEW DESIGN ZONE DEFINITION

ZONE NUMBER	CONTENTS	TOP-LEFT COORDINATES
1	Time/Date	0, 0
2	Welcome Message	1/4, 0
3	Weather	3/4, 0
4	Billing Cycle	0, 1/18
5	Logo Space	1/4, 1/18
6	Power Demand	3/4, 1/18
7	Accumulated Bill & Usage	0, 1/3
8	Hourly & Weekly Trend	1/4, 4/18
9	Current Rate	3/4, 4/18
10	Message & Warning	1/4, 15/18
11	Tier & Rate Information	3/4, 1/3

The coordinates given here are for the top-left corner of the area and are of relative scale to accommodate varying displays. The format used is: (fraction of total width), (fraction of total height), where the top-left corner of the display is (0, 0). It is important to note that the ratios are deliberately chosen based on the current standard aspect ratio for televisions, 16:9, and all dimensions of the zones are whole numbers, down to 720p (1280x720).

CONTENT FUNCTIONALITY

The contents of each zone are described in Table 6.

TABLE 6. CONTENT FUNCTIONS

ZONE NUMBER	CONTENTS
1	Time/Date
2	Welcome Message
3	Location and Weather
4	The “Billing Cycle Information” displays the date the billing cycle is over on the left and the days remaining in the billing cycle on the right side of this zone.
5	Utility Logo
6	“Power Demand” refers to the difference between the most recent power reading and the preceding reading, divided by the time between pings.
7	“Accumulated Usage” provides the cost and energy consumption till date in the current billing cycle or till this hour in the day, as well as the projected budget for both time frames. These bar graphs represent the total accumulated usage for the day, and the month. The top of the bar represents the average total usage (daily/monthly). In the event that the total usage exceeds the average, the “full” bar will change color.
8	The central graph space contains two alternating graphs. Graph 1 is a stacked bar graph that displays the energy usage by week. The grey region (bottom) of the graph represents usage during weekdays and the orange region (top) represents usage during weekends. The second/alternate graph shows hourly usage that compares the current hours’ usage with the average usage (computed by averaging the last 6 weeks minus the highest and lowest usage periods).
9	Current tier rate based on the tier the user is in.

10 Alert message and utility contact information

11 The bar graph shows the progress toward the next tier, and the price at that tier.

CONTENT SPECIFICS

GENERAL INFORMATION

The following outlines some of the user interface (UI) formatting specifics.

- Text fonts
  - All text in zone1, 2 and zone 3 are in font “Technic”.
  - All non-numeric text thereafter is in font “Trebuchet”.
  - All numeric text thereafter is in font “Rockwell Bold”.

- Colors
  - Green: #24B515
  - Dark Green: #557766
  - Orange: #FF6600
  - Yellow: #FFDD44
  - Tan: #CCDDCC
  - Grey (background): #696969
  - Grey (otherwise): #E2E2E2

WEB UI OPTIMIZATION

The usage data displayed includes real-time (daily/monthly consumption, power demand, tier and price), historical (past week/hour trend) and forecast (estimated daily/monthly budget). The latest power and consumption data is retrieved directly from the meter, pricing tier is determined by comparing these real time numbers with thresholds stored in JavaScript Object Notation (JSON) format; non-aggregated historical data is stored in CalPlug’s database which fetches a data stream from the gateway’s commercial cloud; budget forecasts are simply statistical estimations based on historical data. In summary, the data being displayed is derived from meter reading; no access to the SCE database is needed.

The Smart Meter Display UI implements the latest Web 3.0 technologies. JavaScript, JSON, HTML5, CSS3, PHP, MYSQL, and other languages make up the webpage run on the DIRECTV Set-Top-Box’s built-in HTML5 platform. Like all other webpages, latency issues need to be taken into consideration for our UI.

In terms of web performance, “latency” is the amount of time it takes for the host server to receive and process a request for a page object. The following common latency optimization methods were used to make then web UI more responsive:

- Reduced number of source files requested and minimize each file;
- Shortened the distance of the network roundtrip of each request; and

- Leveraged browser cache.

In the context of this project, there are no network structure privileges to shorten the roundtrip distance. The only static and re-occurring image in the UI is the SCE logo and it will be automatically stored locally in the browser because of the advanced cache configuration capabilities of the browsers available.

Conversely, the size of the webpage file and data retrieving efficiency can be optimized. In an effort to consolidate the source code, CSS, PHP, HTML, and JavaScript files have been cleaned up and merged into a single file in order to minimize bandwidth.

Retrieving data from the server database must be performed prior to calculating the consumption and bill report and estimation. Algorithms for these purposes have been optimized to not only depend on critical data, but also produce accurate projections. This can save up to 70% of loading time leaving the less relevant data un-retrieved.

SMART METER DATA ON TV VIA SET-TOP BOX MIDTERM DEMO

The Smart Meter display midterm demo was held successfully on Feb 26, 2014 at the DIRECTV's lab. During the midterm demo, the full-screen view, the overlay widget, and the menu widget were displayed on TV via DIRECTV Set-Top box. Figure 10 and Figure 11 show the full-screen view solution 1 and 2. The overlay widget is shown in Figure 12 and the menu widget is shown in Figure 13.

FIGURE 10. MIDTERM DEMO - FULL-SCREEN VIEW SOLUTION 1

FIGURE 11. MIDTERM DEMO - FULL-SCREEN VIEW SOLUTION 2

FIGURE 12. MIDTERM DEMO - OVERLAY WIDGET

FIGURE 13. MIDTERM DEMO - MENU WIDGET

FEEDBACK

During the midterm demo, valuable feedback was collected for improving the display interface design. Overall, feedback included suggestions to modify the interface design such that it draws home owners' attention to their energy usage and the money they spend on their electricity bills, in an effort to help them reduce energy usage. Therefore the dollar amount of energy cost should be the most prominent metric. Also, the interface should form a layered combination, starting from the basics, and dive deeper into more details. The detailed feedback is listed in the following sections.

FEEDBACK ON MENU WIDGET

The menu widget is a small screen displayed on menu view. The following information should be displayed:

- Energy charges for today ($ amount)
- Energy charges for current month ($ amount)

FEEDBACK ON OVERLAY WIDGET

The overlay widget is displayed periodically on the side of TV screen over the program when users are watching TV. This widget is designed to draw users' attention with simple and useful data and graphics. Feedback received to improve this view is to display following information:

- Energy charges for current month ($ amount)

- Billing cycle information
- Current demand (kW)
- A bar graph that displays daily budget information such as:
  - An estimate of energy cost for that day or total demand at top of the bar
  - Energy cost in dollars for that day
  - Total energy used in kWh for that day
- A bar graph that displays monthly budget information such as :
  - An estimate of energy cost for current month or total demand at top of the bar
  - Energy cost in dollars for current month
  - Total energy used in kWh till date during current month

FEEDBACK ON FULL SCREEN

The full screen is displayed when a user selects the predefined button on the remote control when a menu widget or overlay widget is displayed. This display option provides more detailed data regarding users' energy usage and costs. Feedback received to improve this view is listed below:

- Move the billing cycle information from right side to left.
- Move the current power consumption from left side to right.
- Modify today's and this month's budget bars as described above in the overlay widget section.
- Add account holder's name and greeting message.
- SCE logo should be changed to the other utility's logo according to the location/service territory.
- Add the utility's customer service contact information.
- Add the comparative data for the average energy usage within the stat from Energy Information Agency
- Add an alert message; for example, a message for DR program participation etc.
- Use a bar graph format to display tier information.
- Provide a predictor for tier change in percentage use of electricity.
- Add help or tips for terminology,

SMART METER DATA ON TV VIA SET-TOP BOX FINAL DEMO

According to the valuable feedback collected during the Midterm Demo described in the Midterm Demo section, the CalPlug team optimized the user interface design and demonstrated it during the Final Demo. The Smart Meter data on the TV via Set-Top Box Final Demo was held successfully on March 26, 2014 at DIRECTV's lab. During the demo, the menu widget, overlay widget, and full-screen view were displayed on TV via Webkit enabled Set-Top Box. The menu widget consists of brief energy cost information for the current day and current month. This widget may be displayed on the program guide screen or on top of the TV program as shown in Figure 14. The overlay widget contains more detailed energy consumption data and is displayed on top of the TV program. When the overlay widget is on display, the two bars will alternatively show the current day and month energy costs and energy consumption as shown in Figure 15 and Figure 16. It is user's choice at any time to evoke the full-screen view for complete energy data. Users can choose whether to close it or wait for it to timeout and close automatically. Remote control buttons can be designated for viewers to trigger full-view from either widget. Some sections within the full-screen view alternatively display with different data as shown in **Error! Reference source not found.** and **Error! Reference source not found.**18.

FIGURE 14. FINAL DEMO - MENU WIDGET VIEW

FIGURE 15. FINAL DEMO - OVERLAY WIDGET VIEW 1

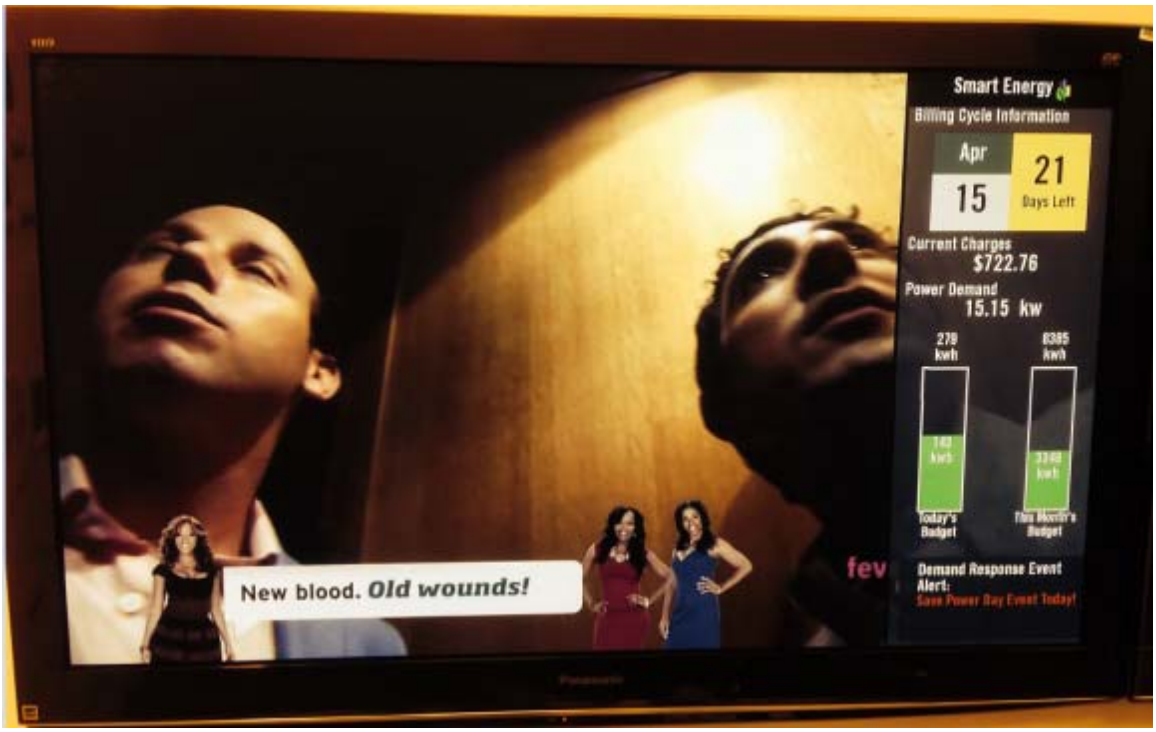

FIGURE 16. FINAL DEMO - OVERLAY WIDGET VIEW 2

FIGURE 17. FINAL DEMO - FULL-SCREEN VIEW 1

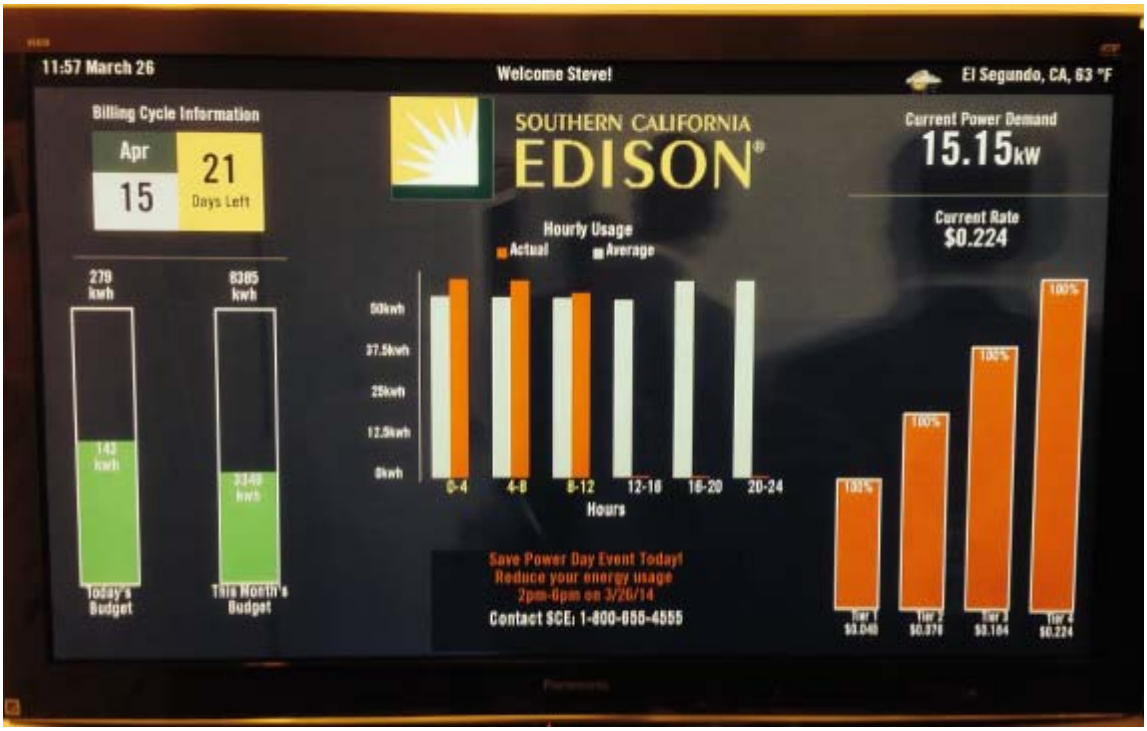

FIGURE 18. FINAL DEMO - FULL-SCREEN VIEW 2

FEEDBACK

During the Final Demo, the following feedback from both SCE and DIRECTV participants was collected:

- The Menu Widget is better with transparency.
- On the Overlay Widget and Full-Screen View, use the dash line across the monthly cost bar to show the average monthly cost in California instead of using the pop-up button.
- The pop-up button may be used to show special event messages.
- On the Full-Screen View, use an arrow tag to indicate the current tier and price rate and consider merging tiers.
- On the Full-Screen View, change “Contact SCE: 1-800-655-4555” to “For questions on billing, contact SCE: 1-800-655-4555 or www.sce.com”.
- On the Full-Screen View, make the SCE logo smaller and move the logo to top bar; make the greeting message bigger at where SCE logo was previously located.
- On the Full-Screen View, move the alert message or special event message to the top.
- Add tips that are adaptive to SCE customers’ profile.
- After SCE launches Green button in Q4 of 2014, directly collect data from SCE instead of using a gateway device to obtain data from Smart Meters.
- Make the UI scalable on mobile devices.
- Possibly integrate the customer's Facebook profile into the UI.

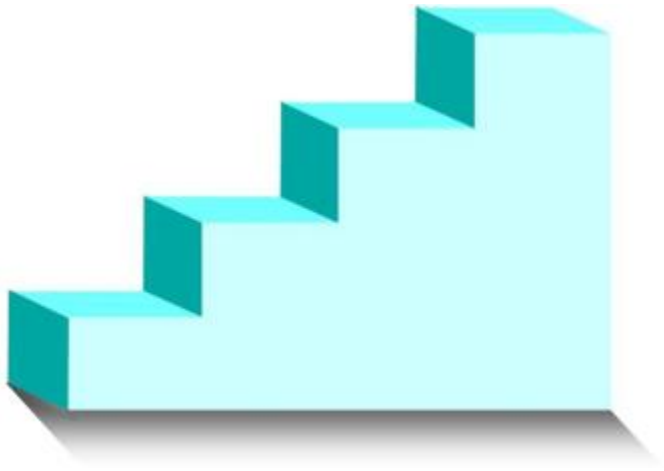

FIGURE 19. MERGED TIER BARS INTO A STEP-LIKE SHAPE

FUTURE WORK

The Final Demo successfully demonstrated the concept of distributing Smart Meter information on a TV through Set-Top Box. In order to promote this concept for users to easily access their energy information and increase public awareness in energy savings, recommendations for the future steps are addressed in the following section.

USING SCE GREEN BUTTON DATA

The Green Button initiative allows utility customers to easily access their electricity usage data. This data can then be shared with third party developers who can provide valuable context, analysis, and other functions based on their specific usage data. SCE is aiming to launch the Green Button function by the end of 2014. By using the Green Button data from SCE, a gateway device can be removed from the system and the Smart Meter data can be collected directly from SCE Green Button initiative. This will greatly simplify the set-up process and be more convenient for the users.

FIELD DEMONSTRATIONS & PILOT PROGRAMS

Utility administered field demonstrations and pilot programs can help to advance the value and functionality of displaying Smart Meter data via Set-Top Boxes. Field demonstrations provide an avenue for testing technologies in real-world applications and ensure that they are technically sound before they are assumed to be considered proven technology. Pilot programs test proven-technologies in specific applications to test market-readiness. These pilot programs are intended develop the basis for operational energy efficiency programs. Leveraging these two utility programs, as well as other programs, is highly recommended.

DEVELOPING SMART METER DISPLAY MOBILE APPLICATION

Developing a mobile application to display Smart Meter data will allow users to access their energy usage information anywhere. If the home automation solution is integrated into the system, users may have real-time control over their appliances and manage their energy usage while they are away from home. Furthermore, alert messages or energy usage tips may be sent through mobile devices. This serves the purpose of changing the users' behavior toward a more eco-friendly fashion.

SOCIAL NETWORK INTEGRATION

DIRECTV has an existing Facebook integration that can be utilized to personalize the interface. An advanced option could be to develop an API to link Facebook profiles with customers' energy info by users' permission.

ADDING HOME AUTOMATION TO THE CURRENT SYSTEM

In the future we may consider introducing home automation solutions for Home Area Network into the Smart Meter Data display system so the interface will provide not only energy usage information from the Smart Meter, but also provide detailed

power demands, load control and control access for individual appliances. This will provide homeowners the opportunity to better manage their energy usage through smart energy management.

INTEGRATING GATEWAY DEVICE FUNCTION INTO SET-TOP BOX

In our Smart Meter display system, one of the key components is the multi-access gateway that collects Smart Meter data via a ZigBee network and then sends the data to a cloud/server for the web service. If we can integrate the gateway device function into STB, it will free users from the burden of purchasing a gateway device and paying for cloud services. To integrate the gateway device function into STB, a STB box needs to meet the following hardware and software requirements:

- Hardware requirements:
  - ZigBee communication physical channel
  - Data storage for Smart Meter data for a specific period of time (e.g., 2 months)
- Software requirements:
  - ZigBee communication protocol 802.15.4
  - ZigBee Smart Energy Profile SEP1.1/2.0
  - Wi-Fi/Ethernet communication protocol

Integrating the gateway device function into STB requires collaboration from STB manufactures and TV service providers. Certain STB hardware and software designs need to be modified in order to facilitate this; much effort will be required but technically this is a possible path.

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