Practical Web Based Visualization for Comparative Energy Usage Analysis

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ABSTRACT

The Citizen Engagement for Energy Efficient Communities project at Oak Ridge National Laboratory aims to help energy consumers visualize, better understand, and become more aware of their energy consumption in order to lower their consumption and reduce their carbon footprint. The easiest way for the greatest number of users to be able to access their consumption data is via an easy to use, easily accessible web-based application. Through a combination of HTML5, PHP, MYSQL, JSON, and Javascript we were able to create such an application and create compelling visualizations that combines user's energy consumption data, climate data, and the usage of a user's peers to help consumers better understand their own energy usage.

Keywords: Visual Knowledge Representation, Data Aggregation, Focus + Context Techniques, Mobile and Ubiquitous Visualization

Index Terms: Energy efficiency, energy apps, energy consumption analysis, smart home, visual analytics

1 INTRODUCTION

Residential consumers are responsible for a large share of the nation's energy consumption. Despite increasing access to more energy efficient building technologies, appliances, and lighting, residential power usage can often differ by up to 300% between identical homes with a similar number of residents [1]. Two of the largest factors in differing power consumptions are the habits of the consumers and equipment available. Unfortunately, consumers are rarely able to adequately observe how their changes in habits and equipment have affected their energy consumption. When a consumer receives a bill, they may be shown their last month's usage in terms of kilowatt-hours or they may see their usage compared to other months of the same year, but neither of these comparisons gives the user a complete picture of their usage. A utility bill doesn't allow the users to relate their climate to increases or decreases in their usage. In order to arrive at a sensible conclusion, the user must be shown what their usage was like in previous years, what the weather was like in previous years, and how well their peers are doing with their energy consumption. This is the motivating factor behind our development of Citizen Engagement for Energy Efficient Communities (CoNNECT)

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2 CONNECT

CoNNECT was created to solve the problem of the under-informed energy consumer. More specifically, the goal of the CoNNECT project is to allow users to observe their trends in power usage over time, compare their usage with themselves in previous years, and compare themselves against the usage of their peers. CoNNECT also links usage data and climate data together to give the consumer a better understanding of any fluctuations in energy usage whether it is due to normal seasonal changes or changes in average monthly temperature from year to year. CoNNECT is made available to customers by an intuitive, web application that offers rich, interactive visualizations of historical energy usage data and environmental conditions. By adequately informing and engaging the user with their consumption data it could be possible for users to reduce their energy consumption by an average of 10% [2-3].

2.1 Technologies Used

The deployment of CoNNECT via a web application facilitated the application in being easily accessible, easy to use, and being easily ported to a broader platform. The climate and usage data are both normalized and stored in a MySQL database. The data is then served to the user with a combination of PHP and JSON. HTML5 and Javascript were used to handle the display of the information in lieu of Flash due to the native browser support. The use of these technologies also greatly simplifies the user experience because they are not required to update or install any additional software to use the application. To handle the creation and rendering of the visualizations, the Protovis Javascript [4] library was used. Using Javascript along with HTML5 not only allows the application to make cross browser compatible visualizations that work on all modern browsers, but also allows CoNNECT to be more easily ported to other platforms such as mobile devices. This is becoming even more important due to the increasing share of mobile devices that are being used; in 2010 mobile devices already made up for 11% of all web traffic worldwide and with many more devices being sold since then, this share of the traffic will only continue to grow [5].

2.2 Visualizations

Using the Protovis visualization library, CoNNECT is able to create compelling visualizations that not only show the user their usage habits over a period of time, but also allows users to relate their usage habits to yearly climate changes, seasonal climate changes, and the consumption of other users.

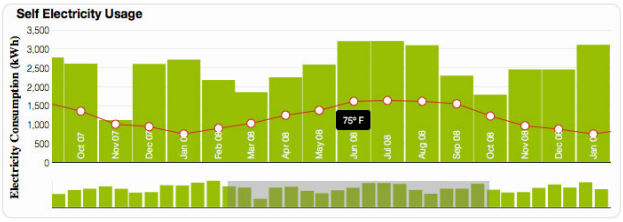

Figure 1: A detailed view of power usage over a user select course of 18 months using the focus+context component, with an overlay of average monthly temperatures.

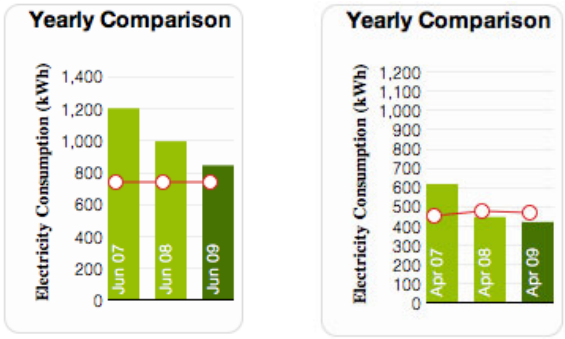

Figure 2: Column graphs with tempuratrue overlays showing the users whether or not they are making significant improvements to their power consumption from year to year.

Power consumption is shown in a focus+context type column chart where each column represents a billing month's worth of energy consumption. The user has the ability to select several months for a closer look by dragging a box around a range of dates (Fig. 1). This provides the user with a way to see the big picture, such as a multi-year comparison and the smaller more detailed portions like seasonal changes in power consumption. This graph can also be overlaid with monthly average temperature data (shown in red) and monthly precipitation data (shown in blue). These overlays show the user the relationship between their power usage and the weather for that month. When a user hovers over any one of the nodes on the line graph, a popover will show the user the average temperature or amount of precipitation for the corresponding month. When a user clicks on any single month the column for that month will change to a darker green than those around it, and the corresponding yearly usage, zip code comparison, and county comparison graphs are updated accordingly. With the yearly usage comparison (Fig. 2), the user is shown the previous years' usage side by side along with having the option to view the temperature and precipitation data overlays for those previous years.

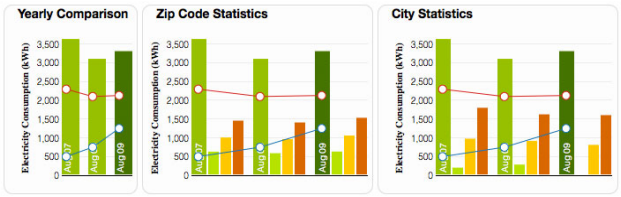

Figure 3: A view of the Zip Code area statistics and City area statistics with an overlay of monthly average temperature (red) and monthly precipitation (blue).

This allows the user to gain a better perspective on why their usage is either increasing or decreasing; whether it is due to yearly climate changes such as that month being hotter/cooler than in previous years, if it is due to habit changes such as not setting the their cooling below 74 degrees during the summer months, if it's due to a change in equipment such as an upgrade to the user's insulation, or if is due to the purchase of newer more energy efficient appliances.

The county and zip code comparisons give the users a better perspective on where their energy consumption lays given the aggregate of other users in the same region with a similar climate. The user is able to examine how they compare to other users in their vicinity whether at a zip code or city level. The comparisons at either level are structured the same (Fig. 3). The user's current usage is highlighted in green and labeled with the month it represents. The bottom 25% of users are highlighted in a much brighter green to give the users a sense that the less power they use the more "green" they are. The next 25% (25-50) are highlighted with a yellow color, while the next 25% (50-75) are highlighted in orange, the final 25% (75-100) is implied as anything above the 75% mark. Each of these statistics is updated every time that the user clicks on a month of interest in the focus view. This gives the user the ability to examine any month of interest that they choose. The statistic views also show the previous years statistics as with the focus+context component there is an option to overlay temperature and precipitation data. This also allows the user to see how other people responded to the same changes in climate from year to year.

3 Conclusion

Many factors drive energy consumers to try to lower their energy usage ranging from the desire to reduce their carbon footprint to the need to reduce their monthly bill. The CoNNECT application helps users reduce their usage by showing them any place they might have for improvement or giving the user useful feedback about the effect of any changes made whether the changes are in habit, equipment, or upgrades to existing structures.

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