Using ICT & Analytics to Build Demand for Sustainable Power Consumption in a Rural Mountain Community

Emergent Research Forum

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Abstract
This paper develops a model and implementation plan for using ICT (Information and Communication Technology) combined with Predictive and Behavioral Analytics to build demand for more sustainable power consumption in the community as a small 100-year-old power company upgrades to using consumer level smart meters in its geographically isolated rural mountain town. With the upgrade to smart meters, the power company hopes to be able to predict power consumption, particularly system wide peak loads in conjunction with individual usage, and use ICT and incentives to encourage users to lower their power consumptions. The plan includes using both financial and psychological methods to help reach these goals. The models, planned implementation and process are outlined in this prospective case study.

Key Words: Sustainable Electrical Usage, Rural Development, ICT, Analytics, Smart-Meters

Introduction

There is a distinct need in the world to reduce energy consumption, due to pollution, population growth, and the coming water shortage. According to the U.S. Energy Information Administration, fossil fuel was burned to provide 37% of America’s energy in 2013, the largest source of energy (eia.gov, 2014). Another factor that dictates a necessary reduction in energy usage is expected population increase. After all, “population projections show that the earth will need to sustain another billion people in the next decade let alone another 25 billion in the next century” (AMCIS).

Also, water may be in short supply in coming years (Dimick, 2014), and water is used in large quantities to produce electricity, which is a growing concern (Hightower, 2014). Finally, concerning carbon dioxide emissions, the “total U.S. energy-related emissions of carbon dioxide (CO2) by the electric power sector in 2013 were . . . about 38% of the total U.S. energy–related CO2 emissions” (eia.gov, How much of U.S. carbon dioxide emissions are associated with electricity generation?, 2015). Obviously, by reducing electricity usage, even in small ways, this can be reduced. By using information communication technologies (ICT) in conjunction with Predictive and Behavioral Analytics, this project attempts to reduce overall energy usage by encouraging consumers to use less energy.

The electric company that provided the data used to develop the analytics and predictive models, and in the short-term will garner the most benefit from this research, is a small non-profit university-owned company in a rural mountain area. The rural setting, and thus smaller population, allows for
improvement of the analytics and predictive models and, in the future, the ICT that will be used to implement the proposed strategies in this study. It buys power from a major power generating company and provides it to its approximately 7,500 customers. The university that owns the rural electric company has many incentives to run more efficiently and increase sustainability. Being university-owned allows for more freedom of information, as well as a platform with which different energy-saving strategies can be tested as the project proceeds.

In terms of efficiency, approximately 50% of the electric company’s costs are determined by its energy usage during peak hours. So, if the company can predict and take steps to reduce its peak load, it can drastically reduce its costs. Any profits the company does earn goes towards scholarships, and it truly is a company that wants the best for all of its customers.

In terms of sustainability, the university is constantly striving to reduce its carbon footprint, and rise in national sustainable rankings. As part of the bigger picture, the university encourages students to learn all they can in this field while in school, and it wants all of its students to be well informed and sustainability focused when they become a part of the work force after they graduate.

Additionally, the governing structure of the power company, in reporting to a university with a strategic goal of building sustainability into a core competency and distinctive advantage, gives added motivation to moving into this direction. In addition to the need to make a profit, prestige, student engagement, sustainable footprint and academic progress also play a role and provide additional reason and ways to move in a more sustainable direction and can lead to additional resources being made available to accomplish this purpose.

Consequently the university has authorized the power company to install smart meters throughout its coverage area. Together these goals and practices open up the doors to a unique situation that may create the ideal environment to test these theories and see which methods work best to promote greater sustainability activities.

**Literature Review**

Smart meters are an up-and-coming technology, affording power companies and users real-time information regarding energy consumption (Cook, et al., 2012). The collection of smart meter data over time will allow for predictions to be made regarding peak load hours specific to weather conditions and time of year (Kavousian, Rajagopal, & Fischer, 2013), while also allowing the user to make more responsible use of power and witness the immediate benefits, instilling more efficient tendencies into their daily routines.

While implementing smart meters and collecting data is rather straight forward, using the data to persuade local power consumers to make more efficient use of their power is more complicated. This issue is compounded when considering the diversity of the power consuming population in this region and also that a significant portion of the population resides in university residence halls, and thus are charged a flat rate for their energy consumption.

In order to influence a positive change in power consumption and efficiency throughout the entire population, three main behavior change theories will be used: operant conditioning, social learning theory, and the transtheoretical model for behavior change. Operant conditioning, simplistically, involves rewarding a desired action and/or punishing a non-desired action. Operant conditioning, negatively exemplified by addiction, has been utilized in influencing behavior change in many areas ranging from marketing to injury rehabilitation (Manella, Roach, & Field-Fote, 2013; Peter & Nord, 1982). Social learning theory suggests that behavior change can be induced through observation and/or instruction as opposed to action/reinforcement, as is the case in operant behavior change. Social learning theory has been employed in various fields, ranging from analyzing social anxiety and drinking in college students to decreasing tobacco consumption in young adults (Spigner, Shigaki, & Tu, 2005; Reynolds, Hinton, Shewchuk, & Hickey, 1999). Transtheoretical model for behavior change involves a five-step process of change and also provide strategies and processes for guiding individuals through change. The transtheoretical model has been used for influencing change in diet, promoting fruit and vegetable consumption, as well as influencing an increase in exercise among students (Horwath, Schembre, Motl,
Table 1 demonstrates some previous locations and projects that have utilized these theories.

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<td>Operant Conditioning</td>
<td>University of Hawaii (Brewer, Lee, &amp; Johnson, 2011)</td>
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<td>3. Implementing social media to encourage efficiency</td>
<td>Social Learning Theory</td>
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<td>4. Designated Energy Delegate</td>
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<td>5. Interactive web interface</td>
<td>Transtheoretical Model</td>
<td>Oberlin College (Petersen, Shunturov, Janda, Platt, &amp; Weinberger, 2007)</td>
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Table 1: Behavior Change Proposals

Example 1 from the table above involves decreasing the charges on power consumers with variable power rates. The method implemented in this example has been analyzed in studies throughout the United States and across Europe, bringing positive results.

In example 2, the University of Hawaii held an energy consumption competition, providing positive feedback to those operating efficiently and negative feedback to those that need to improve efficiency.

In example 3, Indiana University utilized the social learning theory by relying on Facebook to update and motivate their campus hall residents.

For example 4, the University of Kent utilized both the social learning theory and the transtheoretical model by designating an “energy delegate” to encourage and enforce the efficient use of energy within their respective halls. These delegates influence residents through observing their efforts, as well as raising their awareness of the objectives importance. Direct updates through mail or email from the power company would be added to this, not limiting it to social media, so that target demographics besides young people could be included in this and encourage friendly neighborhood rivalry.

Lastly, in example 5, Oberlin College recently utilized a real-time website informing residents within specific halls of their impact on the halls energy consumption and providing different metrics demonstrating the magnitude of their impact. In providing this information, Oberlin utilized the consciousness-raising and environmental re-evaluation processes for transtheoretical behavior change.

Each of these methods should positively impact our region due to the similarities in the test subjects and the demographics of the individuals within the previously discussed studies and our own.

Research Questions

Our tasks in this project are mainly to 1) use Analytics to predict system wide power usage based on temperature, humidity, wind, weather, special events, and other relevant factors, and 2) use analytics to predict power consumption for each individual home place, based upon smart meter data over time.

If the small power company could track and predict energy usage for each individual home place, it would be able to more accurately target groups that might be able to reduce power consumption. Then peer and economic incentives will be used to lower power usage, by making available information about a user’s energy usage compared to their neighborhood average, or the same time last year for them. Having this data would also allow us to offer financial incentives to reduce energy usage during predicted peak times. For example, the company could offer $10 off a customer’s power bill if they reduced their energy usage by 5% for the next day.
Additionally, with the adoption of smart meters throughout most of its service area, the power company will finally be able to move to a pre-payment model where customers pay in advance for power used. It has been shown that power usage drops when a customer is on a prepayment plan (Martin, 2014). This could be tracked much more easily with individual household data available, and incentives could likewise be offered to encourage customers to use a prepayment plan. This will further add to the sustainable stance of the power company and its owners the university.

As discussed in the Literature Review section of this paper, the goals will be accomplished using five different methods utilizing based off of different theories: 1) the Operant Conditioning Theory through financial reinforcement, 2) the Operant Conditioning Theory through competitions, 3) the Social Learning Theory through social media and direct updates from the power company, 4) the Social Learning Theory and Transtheoretical Model for Behavior Change Theory through designated energy delegates, and lastly, 5) the Transtheoretical Model for Behavior Change Theory through an interactive web interface. While acknowledging that method 1 (financial reinforcement) is not an ICT based incentive, it should well complement the other ICT based suggestions above. This is our toolkit, now, let us look at how these will work to the consumers’ advantage and the planet’s advantage at the same time.

There are also three primary customer markets that must be considered as these different tools are used: 1) Well-Educated Professionals, 2) Low Income/Fixed Income Seniors, and 3) Students. Each segment exhibits different behavioral patterns, and views different incentives and perks as valuable, and so, each must be viewed completely separate from each other, and the proper theories and methods must be discovered that will most effectively reach each different customer segment. The ultimate goal of this project is to incentivize the three different types of consumers to help themselves by reducing their electricity usage, thus reducing their electric bill and helping their community and planet in the process.

**Students**

When these theories are tested, students should be much more incentivized to reduce their electricity by method 2 (competitions), method 4 (energy delegates), and method 5 (interactive web interface) than the other groups. This is based on knowledge of university students today. Students are very motivated by competitions, and if these competitions could be set up between dormitory buildings, or even, individual rooms, there should be a drastic decrease in energy usage. This competition will be run and managed using method 5, which would provide real-time feedback for residents of the campus buildings. Also, if students have a knowledge expert among their peers who keeps everyone driven and working towards a common goal, they also are very motivated by this. These methods should motivate students more than financial incentives since many students are funded by their parents, and currently the university charges a flat energy rate, and that is not expected to change in the near future.

**Well-Educated Professionals**

Well-Educated Professionals should find the most incentives to change by using method 1 (financial compensation), and method 3 (social media and direct updates from power company). This more mature market should be willing to make some changes to their energy consumption habits, if they are provided financial motivation for doing so. Also, these professionals are typically connected to social media, and have relationships in their community. This is why social media updates on the community’s performance and direct updates from the power company concerning their neighborhood’s average energy usage and how they compare to it would work so well. This would give them conversation topics with neighbors, help forge friendships and more relationships, and of course, give them bragging rights concerning their energy usage.

**Low Income/Fixed Income Seniors**

Lastly, for the Low Income/Fixed Income Seniors, method 1 (financial compensation), and method 4 (energy delegates) will be implemented. This is likely to be the most difficult, slow-to-change group of any that have been discussed thus far. Financial compensation should help this group of people, and provide sufficient motivation to reduce their energy usage some. However, instead of providing pure discounts on their bills, it would be good to see if they would prefer gift cards, or other such benefits, instead. Also, if leaders of certain of these groups could be found, or assisted living community clubs
could be encouraged to help residents find ways to reduce energy usage, this may also help reduce energy usage.

**Conclusion**

Information and Communication Technologies (ICT) can help build a more sustainable livelihood in rural and underdeveloped regions such as the one described in this paper. In particular around the area of sustainable power consumption, which can not only reduce electrical consumption, but also reduce water usage, CO2 generation, fossil fuels burned and spur economic development through right sizing electrical prices and consumer bills through optimal power usage.

In addition this project, with a university owned power company with multiple sustainable motivations, provides the ideal candidate to test various theories for encouraging more sustainable behaviors among their clients. In particular the rollout of smart meters among students, well educated professionals and the low income groups allows for an ideal environment to test theories of sustainable behavior change, including Operant Conditioning, Social learning Theory and the Transtheoretical Model of Behavioral change.

The project has begun, and data is already being analyzed to figure out the best model to predict the peak hours. Once this is done, and the smart meters are installed in our community, it is our hope to encourage community members help themselves by helping the planet as a whole. If a rural mountain community can be convinced to make these changes, there is no reason it cannot be spread to other communities as well, and make for a wide-reaching positive impact on the United States, and the world as a whole. A positive impact on the global community is our long-term aspirations for this project. Preliminary results will be presented at the conference if accepted.

**References**


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