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REDUCING ENERGY CONSUMPTION IN THE UNL RESIDENCE HALLS
A CASE STUDY OF UNL'S PARTICIPATION IN THE 2015 CAMPUS CONSERVATION
NATIONALS

by
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AN UNDERGRADUATE THESIS

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Abstract

Energy conservation has become an increasingly discussed topic in recent years as climate change marches onward and energy prices fluctuate. In response to the ever-present problem of energy cost rises, Campus Conservation Nationals was created to promote energy-saving behaviors in universities throughout the United States. UNL has participated in CCN before, but due to several external factors, failed to produce significant improvements to its energy consumption. The purpose of this project was to monitor their 2015 participation in an attempt to identify methods of increasing energy conservation in the future.

Introduction

The benefits of energy conservation are numerous. Lowering power consumption decreases pollution by power plants, improves the longevity of energy sources, and saves consumers money. Energy consumption is generally divided into four categories by use: transportation, industrial use, commercial use, and residential use. Of the four, residential use is one that consumers have the most control over, so it is an excellent target for conservation efforts.

Arguably the most important source of residential power savings comes in the form of behavioral changes. While green construction methods allow for impressive results, it is much more difficult to attain similar results from existing buildings, for a variety of reasons (Annunziati et al 2014). In contrast, while not always easy to do, convincing people to adopt green behaviors can provide significant efficiency improvements for significantly lower costs. To this end, an annual energy- and water-saving competition called Campus Conservation Nationals (CCN) was created.

The purpose of this project was to analyze the energy consumption of several UNL dorms during CCN 2015 in order to determine the effectiveness of various aspects of the competition. Its goal is to monitor the decrease personal energy use by student residents as much as possible over a three-week period during the spring semester.

Project Description

This project was an analysis of UNL's participation in Campus Conservation Nationals 2015. Campus Conservation Nationals (abbreviated as CCN) an annual competition whereby universities from throughout the United States compete to see who can improve their

environmental sustainability by reducing their energy and water consumption. The University of Nebraska-Lincoln participated in CCN for the first time in the spring of 2014, but failed to reduce energy consumption overall in the participatory dorms. This project is intended as a follow up to the prior attempt, and will analyze the effectiveness of UNL's 2015 CCN bid.

This project was primarily observational- CCN's effectiveness was monitored as detailed in the "sampling methods" section below. Once the competition has concluded, an effort was made to identify what conservation methods were especially effective or ineffective.

Energy Conservation Background

Energy conservation, and on a broader level, energy sustainability, is an incredibly large and varied subject matter. There are several ways to approach it- improving production and distribution, improving transportation efficiency, etc. However, the aspects of energy conservation most pertinent to this project are those related to end-use fixes.

End use fixes differ from production and distribution in that consumers have control over them, whereas changes to the energy production and distribution system are only possible for those who run it. While too numerous to list, methods of reducing end-use energy consumption generally fall into one of three categories: constructing new energy-efficient buildings, renovating existing buildings, and changing the habits of consumers (Annunziati et al 2014). Done properly, new construction provides extremely impressive energy savings, although the extent to which this is true will vary immensely on a case-by-case basis. Renovating existing construction is virtually always more cost-effective, but has its own problems that will be discussed below (Annunziata et al 2014). Changing habits will vary wildly in terms of how effective it is, but has the distinction of being the only method of saving energy that doesn't

require extensive work up front in order to produce results- in many cases, all that is needed is a change in behavior.

In theory, energy-saving behaviors are beneficial to consumers in the long term, since it decreases the consumption of fossil fuels and cuts back significantly on pollution. However, in most cases, there is a sacrifice associated with energy-saving measures. These costs can be financial, such as adding more insulation to a house or buying a more efficient refrigerator; they can also take the form of personal quality of life sacrifices, such as not using climate control as much, or using a clothesline instead of an electric dryer. Many actions can classify as both, such as buying a more fuel-efficient car. Regardless, virtually every energy-saving measure will have a cost associated with it, which will frequently discourage adoption (Hamamoto, 2013).

There are numerous ways to encourage people to conserve energy, and they generally fall into one of two categories: financial motivation and social pressure. Financial motivation is a proven method of influencing energy-efficient behavior (Cebula 2012) as human behavior is highly responsive to economic feedback. Social pressure is also proven to be successful (Gulbinas et al 2014), although using social manipulation to facilitate energy-saving behavior requires significant effort to accomplish.

Financial motivation is slightly complex, as it can be internal or external. In many cases, energy-saving measures can actually provide a tangible financial benefit in the long term, by saving enough energy to become cost-effective. However, many times the savings associated with lower energy consumption simply cannot compare to the prohibitively high initial costs. In these cases, the only people who will accept the financial burdens of such solutions are those who feel the relatively intangible benefits outweigh the financial detriments. However, this can be changed with external pressure.

It is a relatively common practice for governing bodies to provide financial incentives for energy-saving behaviors. While in rare cases these incentives will be direct, such as the Cash for Clunkers program (which, while primarily a financial stimulus program, still produced environmental benefits), these incentives usually take the form of tax breaks and subsidies. The problem with providing tax breaks for energy-conscious changes is that in many cases, sub-optimal fixes are made. Due to the varied nature of residential construction, there tends to be a certain amount of flexibility in the standards to qualify for tax incentives. Unfortunately, this tends to result in the so-called “plucking of low-hanging fruit,” whereby the relatively cheap, easy fixes are made, but no long-term pattern of sustainability is actually established (Annunziata et al, 2014).

A slightly more direct way in which organizations can regulate energy consumption is to simply make it more expensive. This has historically been the most common method by which utilities have decreased consumption (Sweeny et al 2014), but has the downside of promoting resentment and negativity towards the utility. It also fails to promote any sort of long-term behavioral changes, since it is largely disconnected from consumers’ actions.

By far the least resource-intensive way to conserve energy is by promoting behavioral shifts. This has the advantages of requiring little or no authority or financial resources to be effective, as it relies more heavily on social engineering than on directly changing the scenario. It also doesn’t require significant preparation or infrastructure, so it is much less knowledge-intensive. Social research is also highly scalable, so successful methods can easily be transferred between different applications.

The process of motivating people to conserve energy through behavioral shifts is seemingly simple, but is actually a fairly complex process. The first step is to allow them access

to a tool to monitor their energy consumption. There are several factors that determine how effective providing feedback is (Loock et al 2013). The most important of these is how immediately the feedback is provided, but how much data is provided is also important. Further, actively comparing two or more peoples' results will produce superior results to simply providing them with their own data without context.

One of the most powerful tools for promoting energy efficiency is social networking. It is a very potent tool for distributing information, since it allows very rapid updates, and it allows large groups to compare how they are doing. This has the twofold effect of 1) promoting competition and 2) providing a large test group against which participants can compare their progress (Gulbinas et al 2014).

There are certain factors that will help determine how successful social networking is in improving energy conservation. High-profile individuals have a disproportionately large impact on other peoples' behavior (Anderson et al 2014), so focusing on people such as RAs and other individuals with greater social presences could be effective.

A way to expand on peoples' tendency to become competitive when it comes to energy efficiency is to provide some sort of tangible reward for success. This can take the form of directly incentivizing participants, or offering prizes for success. When specific results are desired, it is very effective to simply offer some sort of prize to whoever achieves the best results (Gulbinas et al 2014). Depending on the nature of the project in question, it may be more apt to include a prize for lowest total energy consumption, or for most decreased consumption- this will generally be a function of how equal contestants' living situation are, since some may simply have lower energy needs.

Competition details

Data was collected in two sections. First, baseline data was collected for 2 weeks starting on February 11th and ending on February 25th. Since the purpose of this period was to determine what the average dorm energy consumption would be during normal operation, no efforts were made to promote conservation during this time. Following the completion of the baseline period, a 3-week period stretching from February 25th to March 18th began. During this second period, Sustain UNL actively attempted to convince residents to reduce their energy consumption.

The city campus dorms selected for this test are Harper, Schramm, Smith, Abel, Sandoz, Pound, Neihardt, Selleck. Additionally, three dorms on east campus- Burr, Fedde, and Love Halls- will be sampled, but will be analyzed as a single dorm to correct for their smaller size. Because Selleck hall does not have separate monitoring equipment for its dining hall, the Harper-Schramm-Smith dining hall was used to approximate the consumption in the Selleck hall. The logic behind this was that campus dorms are fairly consistent in operating hours and in what equipment they have access to, so consumption should be reasonably consistent.

UNL Unplugged promoted CCN in a few different ways. Daily updates were posted in dorms and residence halls showing how well each dorm was doing, with links to a more detailed stat-tracking website. Resident Assistants were approached to promote conservation among their student base. Additionally, two events- a game night was held on the first day of the competition to promote initial awareness, and a dodgeball game was organized mid-way through the competition to attempt to produce a flat reduction to energy consumption. As an incentive to conserve energy, the winning dorm was promised a desert party.

When analyzing how significantly a given dorm had reduced its consumption on a given day, the average daily consumption for that dorm from the baseline period was compared to the

consumption for that day. This allowed the improvements of each dorm to be compared to each other dorm, as directly comparing raw consumption data would be rendered useless by the very different designs of the various campus dorms.

Results

Of the 9 teams participating in CCN 2015, 8 managed to reduce their overall energy consumption. The magnitude of this reduction ranged from a .4% reduction in Harper Hall to a 8.8% reduction in Abel Hall. The only group that failed to reduce consumption was the Burr-Fedde-Love co-operative team, which increased its total consumption by 7.4%. For a complete breakdown of energy consumption by hall, see figures 1 and 2.

Discussion

Overall, CCN was quite successful. A total of 127,368 kilowatt-hours of electricity were saved during the competition period, saving UNL \$7769.45. However, consumption reductions were not universal, and were fairly inconsistent, so there is room for improvement.

While UNL Unplugged was successful in reducing energy consumption overall, certain aspects of their campaign were more successful than others. In particular, the dodgeball event held on March 14th appears to have failed to promote any behavior shifts. Power consumption on the 14th was lower than on either of the preceding days, but increased significantly the following day in every dorm except Burr-Fedde-Love (figure 3).

Burr-Fedde-Love

The failure of the Burr-Fedde-Love team to reduce their consumption warrants a certain degree of additional scrutiny. BFL was initially reasonably successful at conserving energy, and in fact Love was one of the most successful individual dorms in the competition, reducing their average daily consumption by 7.4% during the competition. However, on March 11th, a period of abnormally warm weather began. This rise in temperature was associated with an increase in energy consumption in both Burr and Fedde, although the magnitude of Burr's consumption increase was much greater than that in Fedde Hall.

Tracking the effects of the temperature increase is difficult. Burr Hall accounted for a majority of BFL's total consumption during both the baseline and competition portions of this study, but because Burr hall has a relatively old power meter that monitors power consumption in ticks, with each tick representing 120 kilowatt-hours. Monitoring in discrete intervals like this is adequate for measuring total monthly consumption, but because a single tick generally represented more than 10% of the dorm's total daily consumption, it makes day-to-day comparisons inherently inaccurate. However, above, 70°F, energy consumption increased fairly consistently in conjunction with temperature increases (figure 4).

The presumed reason for Burr's increase in energy consumption during the competition period is that its dorms have relatively inefficient window-mounted air-conditioning units. Most of the other dorms use the campus's thermal water exchange system, so the only energy consumption associated with cooling comes from circulation. Abel and Sandoz halls are the exception to this- the combined Abel-Sandoz facility uses on-site heating and cooling systems, but there are certain technical differences. Abel-Sandoz uses much more modern centralized cooling, and has a heat pump, which is ideal for small-magnitude temperature corrections (Perera et al 2014).

Recommendations

There are several approaches that could potentially improve UNL's results in future CCN participation. Depending on how future CCN participation is handled, some methods may prove more viable than others. Trialing different methods would ultimately be best, but this could take several years to do properly. It is possible that different approaches will work better in different dorms due to different demographics, population sizes, social structures, etc. (Manika et al 2015)

First, the most basic way to improve the overall results of the competition would be to simply hold it earlier in the year. March 2015 was abnormally warm- the middle of march was consistently 10 degrees higher than average- so it is possible that in other years this wouldn't cause complications, but that doesn't remove the risk. The biggest problem with this is that there are a number of factors that can influence when the competition is held- the timing of other schools' participation, the availability of certain staff members, the timing of student breaks, etc.

Second, emphasizing the competitive nature of the competition could prove very helpful. The general rhetoric of the competition was simply "do well." In particular, the inter-school competition between the Big 10 schools was almost entirely ignored in the promotional material for CCN. The only downside to emphasizing the inter-school rivalry is that it could potentially make scheduling the competition more difficult. Playing up the competitive nature of CCN could potentially produce improvements to energy consumption (Sweeney et al 2014).

Third, reducing the emphasis on conservation-promotion events might free up resources for other things. While Dodgeball in the Dark appears to have produced flat consumption decreases in the dorms, it does not appear to have caused any behavioral shifts. Because behavioral shifts are the primary intent of CCN, it may be a better to focus on changing

residents' habits, rather than expending limited resources to produce flat reductions with now long-term effects.

Fourth, some sort of goal structure beyond simply reducing consumption might prove useful. The 2015 competition was organized with a binary success/failure goal- providing incremental goals might prove useful, since they provide periodical success feedback (Loock et al 2014). This could be handled a few different ways- flat reduction goals, daily/weekly reduction quotas, targeted goals of beating another dorm by a certain amount, etc.

Fifth, providing more direct incentives for success might be useful. The winning dorm was given a dessert party, but this was hardly mentioned in most of the promotional materials. There are a number of ways to handle this, some of which could potentially synergize well with an overhaul of how the goals for the competition are handled and how aggressively the competitive aspect of CCN is promoted. Incentives are a powerful tool for promoting conservation, and it would be interesting to see how different systems would end up working out in future CCN participation (Gulbinas et al 2014).

In addition to these possible solutions, there are already new systems for promoting conservation already being implemented. A trial of a peer-to-peer conservation program called Eco Reps was originally going to be implemented in Harper, Schramm, and Smith halls during the Spring 2015 semester at UNL, but this fell through due to now-resolved complications. Similar programs have been shown to be effective in the past, so it is likely that Eco Reps will be successful in improving UNL's environmental profile (Anderson et al 2014)

Conclusion

UNL's CCN Participation can ultimately be considered successful. All but one participating team managed to reduce their energy consumption, saving UNL over \$7000. The only group that failed to reduce their consumption had to deal with external factors beyond their control, and it is likely that with future modifications to how UNL approaches the competition, significant improvements can be made.

Figures

Figure 1

Average Daily Energy Consumption (kWh)					
Dorm	Baseline	Competition	Percent decrease	Energy saved (kWh)	Money saved
Abel	39517	36006	8.88%	71,306	\$4349.66
Sandoz	44151	41788	5.35%	47,870	\$2920.07
B/F/L	1380	1485	-7.64%	-665	-\$40.56
Pound	1112	1092	1.80%	669	\$40.81
Harper	4476	4457	.433%	297	\$18.12
Neihardt	2117	1948	8.00%	3,504	\$213.74
Schramm	3410	3340	2.04%	1,152	\$70.27
Selleck	3706	3589	3.17%	2,455	\$149.755
Smith	3193	3143	1.54%	780	\$47.58
			Total	127,368	\$7769.45

Figure 2

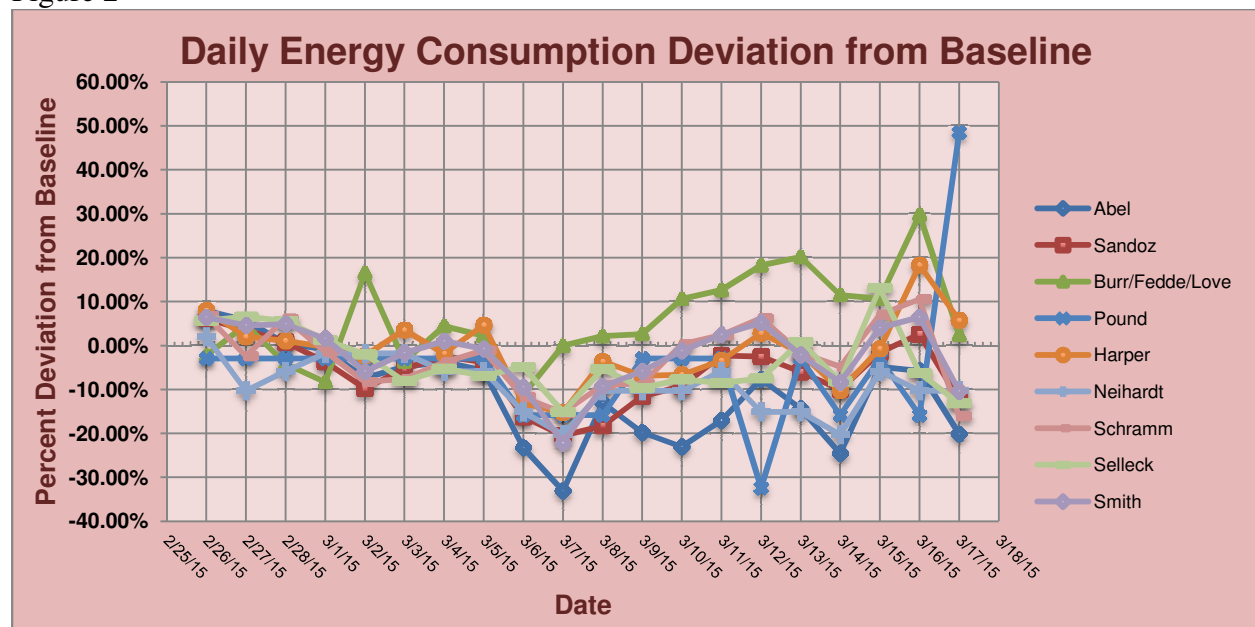


Figure 3

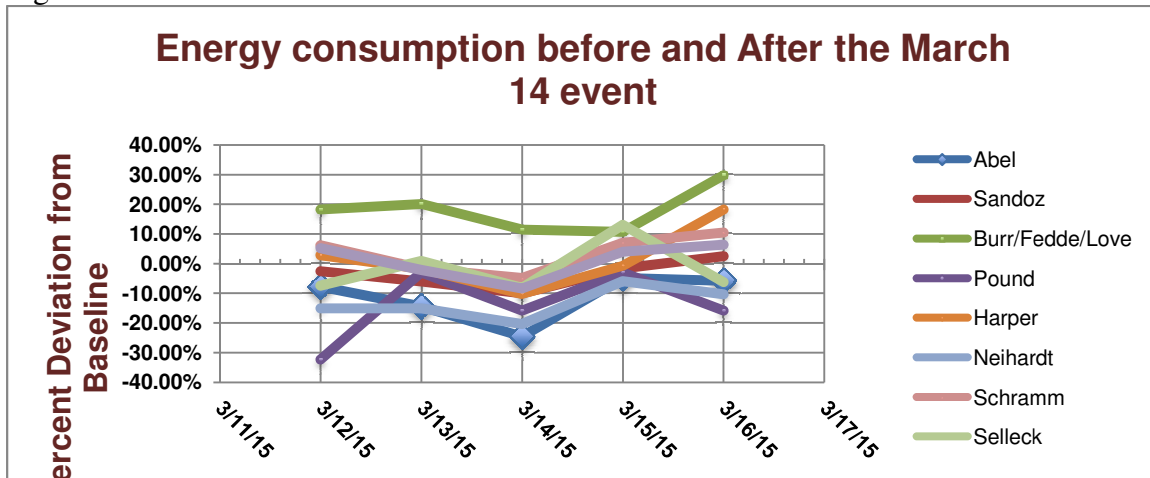
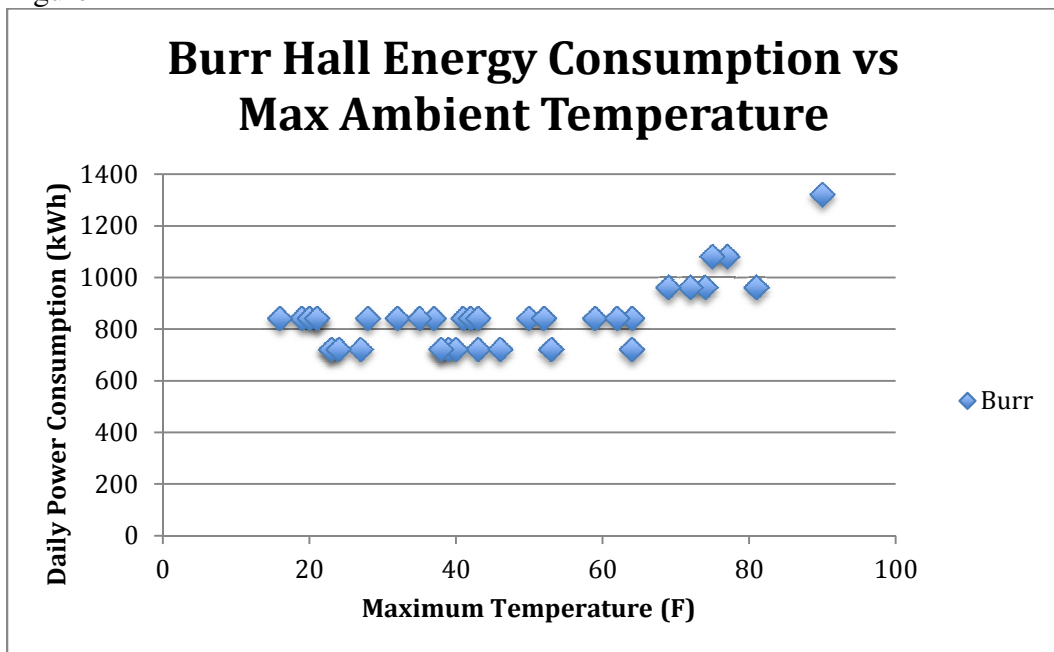


Figure 4



Weather data acquired from the High Plains Regional Climate Center

Sources

Anderson, K., Lee, S., and Menassa, C. 'Impact of Social Network Type and Structure on Modeling Normative Energy Use Behavior Interventions' 2014, *Journal Of Computing In Civil Engineering*, 28, 1, pp. 30-39, Academic Search Premier, EBSCOhost, ASCElibrary. viewed 10 October 2014.

Annunziata, E, Rizzi, F, & Frey, M 2014, 'Enhancing Energy efficiency in public buildings: The role of local Energy audit programmes', *Energy Policy*, 69, pp. 364-373, Business Source Complete, EBSCOhost, viewed 17 September 2014.

Cebula, RJ 2012, 'US residential electricity consumption: the effect of states' pursuit of energy efficiency policies', *Applied Economics Letters*, 19, 15, pp. 1499-1503, Business Source Complete, EBSCOhost, viewed 15 October 2014.

Gulbinas, R., Jain, R., Taylor, J., Peschiera, G., and Golparvar-Fard, M. 'Network Ecoinformatics: Development of a Social Ecofeedback System to Drive Energy Efficiency in Residential Buildings' 2014, *Journal Of Computing In Civil Engineering*, 28, 1, pp. 89-98, Academic Search Premier, EBSCOhost, viewed 24 September 2014.

Hamamoto, M 2013, 'Energy-saving behavior and marginal abatement cost for household CO2 emissions', *Energy Policy*, 63, pp. 809-813, Business Source Complete, EBSCOhost, viewed 16 October 2014.

Loock, C, Staake, T, & Thiesse, F 2013, 'Motivating Energy-Efficient Behavior With Green Is: An Investigation of Goal-Setting and the Role of Defaults', *MIS Quarterly*, 37, 4, pp. 1313-A5, Business Source Complete, EBSCOhost, viewed 17 September 2014.

Manika, D., Wells, V., Gregory-Smith, D., & Gentry, M. (2015). The Impact of Individual Attitudinal and Organizational Variables on Workplace Environmentally Friendly Behaviors. *Journal Of Business Ethics*, 126(4), 663-684. Academic Search Primer, EBSCOhost, viewed 26 April 2015

Perera, D. U., Pfeiffer, C. F., & Skeie, N. (2014). 'Control of temperature and energy consumption in buildings - A review'. *International Journal Of Energy & Environment*, 5(4), 471-484. Academic Search Premier, EBSCOhost, viewed 23 April 2015

Sweeny, JC, Webb, D, Mazzarol, T, Soutar, GN. 'Self-Determination Theory and Word of Mouth about Energy-Saving Behaviors: An Online Experiment' 2014. *Psychology and Marketing*, 31, 9, pp. 698-716, Wiley Online Library, viewed 11 October 2014.

University of Nebraska High Plains Regional Climate Center (2015) Lincoln, NE, February 2015 Weather and Climate Data. Retrieved from:
<http://snr.unl.edu/lincolnweather/data/February2015data.asp>

University of Nebraska High Plains Regional Climate Center (2015) Lincoln, NE, March 2015
Weather and Climate Data. Retrieved from:
<http://snr.unl.edu/lincolnweather/data/March2015data.asp>

Vijayakumara, D and Malathi, V. 'A real-time management and evolutionary optimization scheme for a secure and flexible smart grid towards sustainable energy' 2014, *International Journal of Electrical Power & Energy Systems*, volume 62 pp. 54-548, Sciencedirect, viewed 11 October 2014

Vieira, A. S., Stewart, R. A., & Beal, C. D. (2015). Air source heat pump water heaters in residential buildings in Australia: Identification of key performance parameters. *Energy & Buildings*, 91148-91162 EBSCOhost, Viewed 24 April 2014