Alex Hovet, Evan Braun, Nora LaCasse

# Energy Conservation Through Behavioral Changes and Smart Meters

## Introduction

In recent years and through close collaboration and business with Efficiency Vermont, Bennington College has been active in making strides towards sustainability and energy conservation through restoration of campus buildings and in educating students about sustainable methods in their lives on and off campus. While visible improvements have been made in conserving energy in campus buildings such as VAPA, one aspect that could be further improved upon is that of monitoring energy use in campus houses. Currently, Bennington has no way of quantifying individual houses' energy consumption, making it difficult to implement further improvements in specific areas of use, such as water, heat, appliances, and lighting. This could be solved by having a metering system installed in houses which then provide real-time feedback to students and staff about the energy used in each house. We propose beginning by installing a meter in two campus houses and dividing our initial data collection into three approximately two-week periods. The first would be to collect data from the two metered houses without informing the residents about the meters. Next, both houses would be informed about the meters and encouraged to compete to reduce their energy usage followed by a survey about residents' continuance of habits. Finally, another period of data collection would follow to determine the impact of the metering system after the competition period as we would continue to educate students about their energy

consumption in their houses. The feedback received, coupled with more education about daily sustainable practices, would inspire students and staff to be more proactive about reducing their energy consumption. Through examples on the part of other small colleges that have successfully implemented a sub-metering system in their campus housing, we will prove that monitoring energy consumption within student houses is an effective way to reduce energy use and costs.

## Methods

With the installation of sub-meters in two campus houses, we would initially begin collecting data while keeping the respective houses uninformed about the presence of these meters. In doing so, we expect to see that the energy use in these houses are relatively high and energy-saving habits on the parts of the residents are typically inconsistent or ignored altogether. Areas of high usage of energy which we expect to see include lights, water, heat, and appliances. This is likely as a result of students not seeing any type of feedback in the form of information or an energy bill to motivate them to reduce their energy consumption; rather, they are able to remain ignorant of the consequences of excessive energy use. Toward the end of this period, we propose distributing a survey through an online collection survey site to all of the campus' students about their energy habits and how much energy they believe they use. With this is mind, we would look for any sign that students reduced their energy use over the remaining period. This would allow us to know how much education and motivation students may need about their energy habits.

After the initial period of data collection, the houses equipped with meters would

be informed and a period of competition would begin. Students would be first educated about the meters, their functions, and their purpose. With incentives to be determined, the two houses would be encouraged to reduce their energy consumption. During this time, we would begin programs to educate students throughout the campus on ways in which to reduce their energy use and how it is beneficial to them and the community as a whole now and in the future. The purpose in doing this would be to prove that education has great power in affecting habits such as these for the better. Studies at other colleges have shown that half of the energy used in buildings is controlled by activities and habits on the part of students and that this can be changed to reduce energy consumption. This change can only occur through instantaneous feedback from the sub-meters to students so a comparison in progress and energy use is constantly available to motivate. Additionally, we would begin announcing our data and displaying it for the entire student body to begin motivating them as well.

When the period of competition is concluded, we will continue to make the data available to the houses and the rest of the campus without the use of a physical reward, but rather with the expectation of a continued moral incentive. Directly following the period of competition, another survey will be distributed to the houses with the meters as well as the rest of the student body asking about what, if any, habits were changed purely as a result the competition and which habits they will continue to maintain as their own lifestyle choices. Results from the students of the two metered houses will allow us to interpret the effects of feedback combined with education and incentive. Data collection would continue throughout this last period of time and would be used to compare the amount of energy consumption before, during, and after the initial stages of the metering

system. We expect to find that having meters and their feedback available to students will significantly reduce their energy consumption. This will be supported by the data collected in all three stages and will include exact figures of energy usage and reduction.

## Discussion of Outside Literature

Previous studies have discussed the definite reductions of energy consumption after installing sub-metering units in collegiate dormitory settings. Four papers in particular have been highlighted to demonstrate, through empirical and philosophical support, how the proposed sub-metering plan can best emulate their successes and produce a significant reduction in campus consumption. The first of these, "Sub-Metering Energy Use in Colleges and Universities: Incentives and Challenges," focuses on technological and ecological aspects of sub-metering individual campus buildings, which is quite applicable to the proposed Bennington sub-metering project, as that is the exact area that the initial sub-meters would be tested in.

Of particular interest to our proposal is the way that "Sub-Metering Energy Use" describes the benefits of sub-metering: "[sub-metering] identifies performance improvements and guides preventive maintenance... [and] enables quick responses to failures of system components." In this manner, sub-metering can provide a definite reduction in consumption, regardless of community responsiveness (which, presumably, would also result in a marked reduction in consumption). By allowing Maintenance staff the diagnostic capability of assessing any failures in equipment or system operations, a sub-metering system would result in significant reductions in energy consumption. A member survey of a university group conducted by the authors of "Sub-Metering Energy

Use" indicated that, in a general sense, nearly 80% of campus energy costs could be attributed to electricity consumption, meaning that any reduction in electricity consumption would drastically reduce Bennington College's overall energy consumption and, by extension, its average carbon emissions.

Another survey paper, "Dormitory Residents Reduce Electricity Consumption When Exposed to Real-Time Visual Feedback and Incentives," focused on the impacts of sub-metering on student dormitories at Oberlin College in Oberlin, Ohio. Though the focus of this particular paper tracked the overall consumption reductions of an electricity-conservation competition, the paper itself still highlights the value and effectiveness of sub-metering in significantly reducing electricity consumption. In particular, the paper focused on the importance of 'higher-resolution' sub-metering feedback systems - systems that could "essentially [allow] building users to teach themselves how to conserve resources by trial and error." The actual, mechanical components of 'high resolution' feedback systems provided "total real-time electricity use... for both dormitories and for two of the three floors within each of these dormitories. Electricity data for the third floor were collected, but not displayed so that this floor could be used as a control with which to assess the effect of supplying information at the level of individual floors." In comparison, 'low resolution' feedback systems were systems in which "utility meters... were read on a weekly basis throughout the study."

The study found that, in the course of the highlighted competition, high resolution dorms reduced their electricity consumption by 55 percent; whereas the low resolution dorms reduced their electricity consumption by a (still significant) 31 percent. Thus, we can see two essential take-away points from this study: one, that high resolution

sub-meter feedback systems are vastly preferable to low resolution feedback systems; and two, that any type of feedback system will result in a reduction in energy consumption - although the Oberlin paper focused on a competition event, compelling post-competition survey data showed that a majority of students would "continue conservation practices developed during the competition and that they would view web-based real-time data even in the absence of competition." This implies that, regardless of competition, sub-metering feedback systems will result in higher student awareness of consumption practices and, summarily, a significant reduction in energy consumption, provided that sufficient educational measures are taken to instruct students as to the practices of reducing energy consumption.

A third paper, "Learning Systems for Electric Consumption of Buildings," focused on a different methodology to providing energy consumption feedback - called Non-Intrusive Load Monitoring (or NILM). Though NILM is applied quite differently to sub-metering (it focuses much more on the micro-scope of individual appliances and outlets, rather than on the macro-scope of singular buildings), it renders a similar service to those who choose to use it - it provides detailed information on where, exactly, energy is being spent and thus allows consumers to reduce their emissions by addressing areas of highest need. Both methods focus on creating "a decision support system that would help users address their energy saving needs more effectively." While precise numbers for the total reduction of energy consumption by NILM are unavailable (the technology is still being tested) the example provided by "Learning Systems" is another demonstration of the value of specific, granular, diagnostic knowledge of present energy consumption in helping to reduce total consumption at the individual-building level. Though NILM is

likely not viable in a dormitory setting, one would expect its application to be equally-valuable to sub-metering in domestic situations.

Sub-metering has been shown to be the causal factor in producing concrete, significant reductions in energy consumption at the college dormitory level. The discussed papers provide reasons empirical, philosophical, and logical as to why a sub-metering program at Bennington College would directly lead to on-campus energy consumption reductions - a valuable pursuit as a component of the College's efforts towards carbon-emissions neutrality.

Literature Cited:

Berges, Mario, Goldman Ethan, Matthews Scott H., and Soibelman Lucio. *Learning Systems for Electric Consumption of Buildings.* Tech. Austin, 2009. Print. Proceedings of the 2009 ASCE International Workshop on Computing and Civil Engineering.

Peterson, John E., Shunturov Vladislav, Janda Kathryn, Platt Gavin, and Weinberger Kate. "Dormitory Residents Reduce Electricity Consumption When Exposed to Real-time Visual Feedback and Incentives." *International Journal of Sustainability in Higher Education* 8.1 (2007): 16-33. Print.

*Sub-Metering Energy Use in Colleges and Universities: Incentives and Challenges.* Rep. Energy Star. Print. U.S. EPA.