UMass Clean Energy Extension
(formerly Massachusetts Energy Extension Initiative (MAEEI))

Progress Report to MA Department of Energy Resources
Period ending September 30, 2015

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In this report we provide an update made by MAEEI through the period ending September 30, 2015. MAEEI has gone through a re-branding exercise and is now formally called UMass Clean Energy Extension, which provides a clear indication of its mission to the public and also fits better into the UMass Extension portfolio. For the purposes of reporting to DOER, we may use both names, but externally, MAEEI will be known as the Clean Energy Extension going forward.

The three member PI team comprising Shenoy, Weil and Kosanovic continued to lead this effort during this reporting period. They have now been joined by the new Director of the initiative, Dwayne Breger, as noted below.

1. Update on Managing Director Search for MAEEI

The managing director search for the MAEEI/Clean Energy Extension was successful and we are pleased to report that Dr. Dwayne Breger has accepted our offer to join as the Director of this effort. He will officially join on October 13, 2015. His contact details have been listed above.

2. Annual Conference

In September 2015, we held the annual conference of the Clean Energy Extension titled the "Municipal Energy Symposium" with 45 invited key municipal decision-makers from towns randomly selected and stratified by population size, region in the state, and evenly divided between Green Communities and others. We provided updates about the Green Communities program and several other DOER programs, but the main activity was a series of intensive, facilitated roundtable discussions to ascertain the current state of energy planning, opportunities and challenges across these different groups. Each group discussed their current understanding of their town's energy situation, projects they are working on and hope for, and what extension services they could most benefit from. Student volunteer scribes recorded all of these conversations, and the transcripts are being analyzed now. We also presented this group with examples of energy extension projects. For each type of project we used instant i>Clicker polling to ascertain the perceived value and likelihood of a similar project in their own communities. The projects with the highest perceived value and need were the "consulting on specific municipal building issues" (similar to earlier school building projects with Sunderland, Warwick and Greenfield) and "early stage transformational planning" (similar to work with Holyoke and Rowe). We are in the process of analyzing the polling data to identify differences by region, population, and Green Communities status. The event itself was successful, with an average

rating of the symposium of 3.38 (5-point likert scale, 0 - 4); 92% of attendees were "likely" or "highly likely" to attend a future similar workshop. We will use the information gained from this event to guide our focus going forward.

3. Extension Activities

Over the summer and early Fall, the energy extension took on several initial projects in surrounding communities. We continue to field calls from local towns and cities to take on new projects. The Manager Director will be responsible to further expand our offerings.

Some example projects that have been completed or initiated over the summer include:

Holyoke Renewable Energy Development Fund
The City of Holyoke contracted with us to develop an implementation plan to most cost-effectively subsidize renewable energy development while leveraging that investment to generate redevelopment investment in the City. This required an assessment of the photovoltaic production potential and system size for 300 buildings with roof areas larger than 1000 m^2. This information then informs a ranking system to optimize the incentive design. Draft reports on the PV potential and incentive design written by Ben Weil and Christine Crago, respectively, have been supplied to the City.

This project has resulted in research and the development of new techniques for finding solar PV sizing using GIS. Part one of the project was to identify the roofs in Holyoke with the greatest PV production potential. This is not a simple matter of finding roof surface areas. Orientation, slope, shading from other buildings, and other practical implications of roof geometry and standard PV panel sizes all must be considered. Where LIDAR is available, it is possible to find all of these factors through an automated process in ArcGIS. However, there is only one small strip of LIDAR for Holyoke, so we had to devise an alternate approach. We manually sized a stratified sample of the buildings, fit a curve to the size v. perimeter to roof area ratio adjusted for proximity to other buildings and applied this model to the other buildings. Manual checks of a second sample showed that we were within 3%. This finding will be written up for publication, but also provides a rapid assessment tool that can be applied to other urban areas with large roofs. We will be working with colleagues in Computer Science, Prashant Shenoy and his grad students, to make this into a publicly usable stand-alone tool. Our colleague in Resource Economics, Christine Crago, will work to automate a benefit-cost analysis for each potential site and incorporate that into the implementation plan for the city.

North Quabbin Harvest Food Coop
The food coop is a community group that support local agriculture while providing a source of healthy food in an area of central Massachusetts known as a food desert. They occupy an historic bank building and have converted it into a food store – the most energy intensive building type according to the EIA CBECS database.

Prior work by the energy extension faculty included hygrothermal modeling and recommendations to allow insulation of the building without compromising building durability

or occupant health. In March, we performed thermographic and pressure testing and diagnostics, power and temperature data analysis. We have worked with Guardian Energy Services over the summer and fall to provide engineering and design advice for envelope improvement, HVAC design, and heat recovery from the refrigeration system. The Coop have already acted on our advice on insulation, air sealing, free cooling economizer operation, simple heat recovery, ventilation and safety measures, night-flush cooling, and improved refrigeration operation. Over the past year they used 60% less energy than predicted by Guardian Energy's code-compliant model. The collaborative design process has resulted in a grant application to complete the new HVAC systems, install PV and make this 1860s bank building into a Zero Energy modern food store.

Green Communities Case Studies
Lauren Mattison is working with DOER to create a two-page case study on each of the seven municipalities that has achieved a 20% municipal energy reduction in the Green Communities program: Arlington, Belchertown, Cambridge, Natick, Palmer, Springfield and Sutton. On June 26, she met with Lisa Capone and Emma Krause at DOER to kick off the project. She did background research on each community, using materials provided by DOER, the municipal websites and the websites of local newspapers. Then she visited each community and met with the staff who led the energy reduction efforts. She has been working with DOER to develop graphs depicting energy savings for each community. The case study about Sutton was completed on October 2 and is shown in the appendix. The case studies on the six other communities are in progress.

Wood Pellet Boiler Case Study
In July, Lauren Mattison completed a two-page case study on the wood pellet boiler in Briggs Elementary School in Ashburnham. She worked with Elise Anderson and Rob Rizzo at DOER to develop this case study, building off of a short rough draft that they provided. She contacted the school superintendent, the system installer, and the fuel supplier to get additional information and photographs to expand and complete the case study, which is shown in the appendix.

Greenfield Community College Case Study
Lauren Mattison continued to work on a case study on the use of renewable energy including a wood pellet boiler at Greenfield Community College. She began the case study in the spring and has been waiting for the facilities director at GCC to respond to a few follow-up questions. In July, Rob Rizzo reviewed and gave positive feedback on a draft that has placeholders for responses to those questions. She is still waiting for the additional information from GCC, and will continue to follow up with them so she can complete the case study.

4. Update on Funded "Seed Grant" Projects

In this section, we provide updates on the progress made by the three "seed grant" projects provided by the extension to UMass faculty.

Seed Grant Project 1: *Improved Efficiency through Environmental Control*, PI Simi Hoque, Environmental Conservation

Project goals: Since poorly performing buildings are not only uncomfortable, energy intensive and more expensive to operate, this project will promote energy efficient operations and management practices in educational and public/commercial buildings in Massachusetts by improving and calibrating control strategies for heating, ventilation, and air conditioning systems. The project will conduct user studies to establish a set of guiding principles and control strategies about thermal comfort perceptions and performance that will be applied to a broad range of building types across Massachusetts. Finally, in the context of educational and public buildings, the potential to use renewable thermal technologies for HVAC operations will be also be considered.

Progress report: Since getting funded, we were able to complete the following objectives in the MAEEI-funded project: During the academic year, we collected environmental data using data loggers that were installed in two university classrooms: Hasbruck Lab extension (room 126) and Goesmann (room 20). We solicited thermal comfort data from students in two university classrooms every three weeks for the entire semester. Each class had 120-160 students. In the summer, we began collecting thermal comfort data from office workers in the University. This involved visiting 11 different buildings on campus and soliciting thermal environmental data and conducting occupant comfort surveys from over 100 employees. The environmental data was measured using a Kestrel environmental weather meter and a using a Google document to anonymously collect the human subjects' data. The data collected was cleaned and organized for further analysis. We trained a student (high school intern) from the summer informal STEM program, Project Eureka!, who worked with us on data collection and organization. We made arrangements for developing further protocols to collect data during the academic year. Finally, we revised a paper about our preliminary results that will be published in the Journal of Green Building in the forthcoming year.

Seed Grant Project 2: *Solar Policy Effectiveness*, PI Prof. Christine Crago, Resource Economics

Project goals: The study will utilize statistical/econometric modeling tools to estimate the impact of individual state-level policies on the growth of solar PV capacity at the commercial scale. An analysis of the cost of each policy relative to benefits from reduced GHG emissions as solar power displaces electricity from fossil fuels will also be conducted. Results should identify for policymakers the most cost effective PV adoption policies. This should enable "optimizing" solar adoption policies to accelerate the adoption of Solar PV renewable energy, and expand the solar PV industry in Massachusetts.

Progress report: As of early Fall 2015, the data collection phase is almost complete. We have collected county-level data on commercial-scale PV installations in the Northeast from 2005 to 2014. We have also collected county-level demographic information for the different states included in the study. We are in the process of assembling a database of solar incentive programs in the Northeastern states. These incentives include rebate programs, tax exemptions, performance based incentives, availability of loan programs, and other market support policies. We expect to be running statistical analysis in the coming months to examine the relationship between commercial scale PV growth and solar incentive programs, and identify policies that are most impactful to the growth of commercial-scale PV installations.

Seed Grant Project 3: *Green, Energy Efficient Data Centers*, PI Prof. David Irwin, Electrical & Computer Engineering

Project goals: The goal of this project is to motivate the use and development of data center facilities, in the Commonwealth of Massachusetts, to support the IT and knowledge economies, by quantifying the energy savings from using newer data center technologies that are emerging. Massachusetts has, until now, not been a cost-effective state to deploy data centers due to higher relative real-estate and energy costs; emerging green and renewable technologies have the potential to be game changers for Massachusetts and the project will focus on such techniques. The study will particularly focus on the use of renewable solar, renewable open-air cooling and thermal energy storage in data centers.

Progress report: Over the summer, we gathered energy data from several thousand points of instrumentation from MGHPCC (a green data center in Holyoke). We carried out a detailed energy usage analysis of this data center. The main finding was that the use of renewable cooling technologies used by the data center can yield a 0.1 reduction in the Power Usage Effectiveness of a data center – a significant reduction. Since the data center uses significant clean hydro power from Holyoke, our study also showed that the carbon footprint (carbon usage effectiveness) of the facility is among the lowest in the country – which points to the attractiveness of using Commonwealth towns such as Holyoke as possible sites for data center deployments. An early technical report outlining these findings has been written up for dissemination.

Town of Sutton

Municipal Energy Efficiency

CASE STUDY

BACKGROUND

In 2008, Selectman Michael Chizy set a goal to reduce energy consumption and pursue renewable energy options in Sutton, a town on Route 146 in the Blackstone Valley. The town began to identify projects that they could invest in to lower long term operating costs and benefit the environment, and the school department kicked the effort off by upgrading to energy-efficient lighting and planning its first solar energy project.

AT A GLANCE:

- Population: 9,600
- Size: 33.9 square miles
- Reduction of municipal energy consumption: 21%
- Annual energy cost savings: $114,000

LEARN MORE:

- http://suttonma.org/pages/SuttonMA_Green/index

The Board of Selectmen voted to pursue designation as a Green Community in 2011. One of the criteria to earn designation in the Green Communities program is to establish an energy use baseline and develop a plan to reduce energy use by 20% within five years. Initially the Town Administrator managed this effort, and then it was taken over by the Planning Director. Both have worked closely with the School Business Manager, who is focused on reducing operating costs for her department, which accounts for the majority of the town's budget and energy use. In 2014, the Planning Director collaborated with her peer in the neighboring town of Millbury to apply for DOER's energy manager grant program, which has provided funding to hire a part-time Energy Manager who splits her time between the two towns.

ACTIONS

Sutton has taken a multipronged approach to reducing its energy consumption, and in a short time energy efficiency has become an integral part of the town's operations and planning.

Energy audits – Sutton took advantage of free energy audits provided through its electric utility company, National Grid. Audits were conducted in all town facilities, and staff found them very helpful for identifying energy efficiency measures and providing documentation necessary for grant applications.

Energy efficiency measures

Sutton has implemented energy efficiency measures in every town facility. These were funded through a combination of municipal funds, two Green Communities grants from DOER, and utility rebates. The town prioritizes measures with a simple payback period of less than five years.

- **Exterior lighting upgrades** – The town converted its street lights to high pressure sodium technology in 2011 through a utility program, and Town Meeting voted unanimously to further upgrade to LED lighting in 2015. Lighting was also upgraded to LED lighting in the parking lot of the school complex, which includes all of Sutton's schools on one site.
- **Interior lighting upgrades and controls** – In most town facilities, Sutton has upgraded to energy-efficient lighting and installed occupancy sensors to automatically turn lighting on and off based on occupancy. The school complex also has daylight dimming sensors to take advantage of natural light when possible.
- **Efficient equipment selection** – Sutton chose high efficiency models when replacing the aging water heater and boiler at the Municipal Complex, which includes Fire, Police and Administrative Offices.
- **HVAC controls** – Several measures have been taken to reduce electricity and oil use in Sutton's heating, ventilation and air conditioning (HVAC) systems:
  - Variable frequency drives in the school complex adjust motor speeds to match output requirements.
  - A heat recovery system in the Municipal Complex preheats incoming fresh air in the winter by transferring heat from the outgoing exhaust air.
  - Demand control ventilation in the school complex automatically adjusts the amount of outside air let into the building to ensure that occupants are provided with the right amount of fresh air and optimize energy use.

Sutton's Board of Selectmen displays Green Communities sign

Removal of unnecessary equipment – Sutton removed the soda machines in the Municipal Complex. Staff now bring drinks in and store them in the existing refrigerators.

Efficient vehicles – Sutton purchased its first hybrid vehicles and adopted a policy requiring town departments to consider fuel efficiency for all vehicles, even the larger vehicles that are exempt from the Green Communities requirement. The town has also made efforts to reduce fuel use by avoiding idling vehicles.

Energy awareness program – Sutton has reduced wasted energy in town facilities by reminding staff to take basic steps such as turning lights off when rooms aren't occupied, using energy saving mode on equipment, and turning computers off over the weekend. Educational materials have been distributed to employees and the Town Administrator regularly emphasizes the importance of this effort at staff meetings. Signs are posted near light switches and on copy machines, and people remind each other when they see lapses. These efforts have been successful in making energy-efficient behavior a part of the culture for town employees.

Community engagement – Staff continuously work on educating residents about the town's energy efforts and successes, through the local access television station, press releases in the local newspaper, and presentations at the senior center and the high school environmental club. These efforts have helped gain public support for energy projects and funding from Town Meeting.

Department budgets – Town staff understand that cost savings from reducing energy use can make room in their operating budget for other uses, so they look for energy efficiency opportunities throughout the year and bring ideas to the Planning Director or Energy Manager.

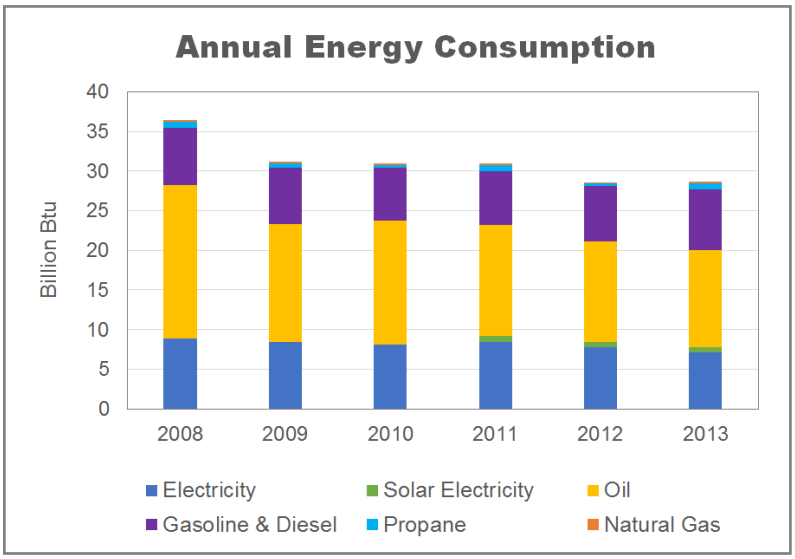
Energy efficiency fund – To assure an ongoing source of funding for these efforts, in 2013 Sutton committed at least 3% of future annual capital plans to energy efficiency projects.

Capital planning – Sutton has added a question about energy efficiency to the form that department heads use to submit their capital planning requests each year, and that information is considered when prioritizing projects.

RESULTS

Sutton reduced municipal energy consumption by 21% from 2008 to 2013. The town's annual energy savings is approximately $114,000 to date. After Green Communities grants and utility incentives, the payback period was less than two years for most of the energy efficiency measures taken.

To date, Sutton is the smallest community and the only one in central Massachusetts to achieve the program's goal of reducing energy use by at least 20%. The town has committed to energy efficiency as an ongoing priority, so after reaching that goal, they are looking to what they can do next.



RECOMMENDATIONS

Emphasize leadership's support. Strong leadership has been a key factor in Sutton's success as a Green Community. The Town Administrator and Board of Selectmen have made energy efficiency and renewable energy a priority, and staff understand that they are expected to contribute to these efforts.

Communicate with the community. Resident support of energy projects and associated funding requests has been bolstered by outreach about the benefits of these efforts and the town's successes to date.

> "Energy efficiency is now a part of everything the town does."
>
> - Jennifer Hager, Planning Director

Use all available resources to achieve cost-effective energy savings. By prioritizing cost-effective measures and using technical support and funding provided by DOER and their utility, Sutton saw a payback of less than two years for the many of the investments they have made in energy efficiency. The town also achieves some energy savings from behavioral measures that have no implementation cost.

Integrate energy efficiency into operations and planning. Sutton has included energy efficiency as a consideration in their capital planning process, committed to investing a portion of their annual budget in energy efficiency, and encouraged staff to consider the impact of their daily actions and purchasing decisions on the town's energy consumption.

Briggs Elementary School, Ashburnham

Wood Pellet Boiler

Massachusetts Department of Energy Resources

CASE STUDY

Overview

The John R. Briggs Elementary School in Ashburnham is the first public elementary school in Massachusetts to use a wood pellet boiler as its primary method of heating.

With approximately 525 students in preschool through fifth grade, Briggs is one of three elementary schools in the Ashburnham-Westminster Regional School District in north-central Massachusetts. The new 87,000 square foot school opened in the fall of 2013 to replace an overcrowded 1960s building. To reduce the school's operating costs and reliance on fossil fuels, the John R. Briggs School Building Committee selected a wood pellet boiler. The choice was supported by members of the Ashburnham-Westminster Regional School Committee and other local residents who had experience using wood boilers and other forms of renewable energy in their homes.

The boiler is now operating successfully and serving as a model for other projects. While the new building is over one and a half times larger than the one it replaced, the annual cost of fuel to generate heat and hot water has remained consistent, with the help of the wood pellet boiler.

AT A GLANCE:

- New 87,00 square foot building opened in 2013
- Wood pellet boiler provides space heating and domestic hot water, supplemented by a propane boiler
- Pellets are automatically fed into the boiler from a silo behind the school
- Fuel costs are consistent with the previous building, while the new school is one and a half times larger

LEARN MORE:

- Briggs Elementary School: http://jrb.awrsd.org
- Renewable heating and cooling in Massachusetts: http://bit.ly/renewablethermal

Briggs Elementary School

Wood pellet boiler

System Design and Operation

One Viessmann Pyrot 540 boiler was installed to heat water for space heating and domestic hot water. The boiler heats the water to approximately 180°F and uses a 1,500 gallon tank for thermal storage. It is fueled by wood pellets, which are made by compressing sawdust and wood shavings under high pressure. The pellets are stored in a 28 foot tall metal silo outside the school and automatically fed into the boiler on demand. An indicator on the silo shows when the level of pellets is low. Sandri, based in Greenfield, delivers pellets to the school every five weeks on average during the heating season. The boiler uses approximately 169 tons of pellets per year.

Student artwork celebrating the new heating system

The wood pellet boiler runs from October through April. During the rest of the year, a propane boiler provides hot water and any heating needed. The propane boiler also serves as backup during maintenance of the wood pellet boiler. There were issues early on with the interaction between the wood pellet and propane boilers, and they were addressed by modifying the programming of the building management system.

Ash that results from the combustion process gets injected by an auger into a bin near the boiler. The ash can serve as a substitute for lime, a supplement used to balance the pH of soil, so about once a month during the heating season, school custodians empty the ash bin and mix it into their loam pile for use in landscaping.

To keep the wood pellet boiler running smoothly, it receives a full cleaning after approximately every 500 hours of operation. During the first year, the installer did the cleanings and trained school custodians, and now the custodians clean the boiler themselves.

Other elements of the new school were also designed to use resources efficiently. The building was designed to take advantage of natural light and includes energy-efficiency measures such as an automated lighting system with dimmers. Many of the building materials, such as the ceiling tiles, were made from recycled materials. Water-efficient plumbing fixtures were used throughout the building.

Pellets are stored in a silo behind the school

A truck delivers pellets about every five weeks

Results

Ashburnham-Westminster Regional School District superintendent Ralph Hicks reports that the wood pellet boiler ran very smoothly in its second season, after working out some issues during the first year. The boiler has been publicized to the community, and it contributed to the school's national recognition as a Verified Leader through the Collaborative for High Performance Schools, which was celebrated in a community ceremony in June 2015.

In the 2014-2015 heating season, the total annual fuel cost (wood pellets and propane combined) to generate heat and hot water at Briggs was approximately the same as the oil bills of $60,000 for the last year in the old building, though the new building is 74% larger in square footage.

Following this success at Briggs, the school district is planning to replace the aging oil boiler at their middle school with a wood pellet boiler.

An auger injects pellets into the boiler

Lessons Learned

To ensure a smooth startup process for new wood pellet boiler installations, school staff and the system installer have several recommendations:

- Seek an experienced team – Wood pellet boilers are relatively new to the United States, though the industry is well developed in Europe. Because of key differences in operation between wood pellet and fossil fuel systems – such as longer startup and shutdown times and the importance of thermal storage – people with relevant experience should be involved from design through installation. Boiler manufacturers, mostly based in Europe, can be a valuable resource when local expertise is limited.
- Carefully consider any changes – After construction began at Briggs and piping was laid, the contractor selected a different brand of boiler than had been included in the initial design. It is important to revisit and update the system design and commissioning plan if any changes are made to the equipment.
- Be patient the first year – It can take some time to optimize operation of a new system and adapt to a new technology. Investing time in training staff and refining system controls will contribute to long term success with a wood pellet boiler.

Ash is injected into bin and emptied monthly