Problem Statement

The existing boilers at the Central Utility Building (CUB), 55 New York Ave. in Framingham, MA currently operate with outdated burners, controls, and linkages. There are newer available burners and controls systems that will enable the CUB to operate with greater efficiency. In addition, the Framingham campus is reaching its’ potential NOx limit and FSS has established a carbon reduction goal for 2013. Both CO2 and NOx emissions will be reduced with the installation of the new equipment. Due to the increased efficiency of the boilers, energy use will decrease which will reduce the annual operating costs of the boilers significantly.

Project Charter

The objective of the 55 NVA Burner energy conservation measure (ECM) project is to reduce operating costs and lower CO2 and NOx emissions. These energy goals will be accomplished through the installation of two new Limpshire low O2 burners, which will replace two of the four existing Cleaver Brooks boilers at the CUB. The cost for the replacement boilers and installation are $220,013. However, there is also a $164,454 NSTAR incentive for performing this energy efficiency measure, which will bring the total cost of the project to $55,559. The project timeline is being finalized, but work should be completed as soon as possible to ensure that the NSTAR incentive is obtained. The benefits of project completion will be user friendly boilers, decreased fuel use (and therefore a decrease in annual fuel costs), and lower CO2 and NOx emissions.

Project Description

An energy conservation measure (ECM) has been identified at the Central Utility Building (CUB), 55 New York Ave. in Framingham, MA. The existing boilers currently operate with outdated burners, controls, and linkages. Wilkinson has performed an on-site study and is proposing to remove and replace the existing Cleaver Brooks burners and associated controls and install Limpshire low O2 natural gas firing burners as well as the AutoFlame Combustion Management System.

Two options were presented in the Wilkinson proposal – to replace two of the boilers or all four. The current path forward is to replace two of the burners. For more information on the options, see Section 4 below. Regardless of either option chosen, there is an NSTAR incentive of $164,454 for performing the energy efficiency measures. Through a reduction in energy usage Wilkinson estimates a total annual savings associated with operation of the boiler of $160,665. Other benefits of the project include a reduction in CO2 and NOx emissions by the boilers. The benefits of the project are outlined in detail below in Table 1. All BMS work will be completed in house with guidance from the project team.

Project Measured Savings

Actual savings exceeded anticipated savings by 168%. Anticipated savings was 131,323 therms while metered savings suggest 352,715 therms, and 8,233.5 Mtcde.
Summary

Boiler efficiency curves were developed (see Chart-2) for Pre and Post retrofit boilers and applied to the Annual Load Profile (Chart-1) yielding annual savings of 25% or 352,715 therms per year and 8,233.5 Mtcde per year; typical annual therm usage is approximately 1,401,321 therms consumed per year (136,300 MCF). The therm savings represent only 8394 hours (96%) of a full year due to limited Post-retrofit test data at higher boiler load, however, we have estimated that additional natural gas savings would not more than be no more than 10,000 additional therms.

One interesting aspect of the NSTAR hourly gas data is that the combined process & non-process loads can always be theoretically met with a single boiler, i.e., the maximum annual NSTAR Gas Input value was only 30,180,000 BTU per hour, and the boiler max gas input rating is 32,689,000 BTU/hour.

Chart-1

% Output Load Profile

Hours per year vs. % Single Boiler Output Load
## Table-1

### Saving Analysis

<table>
<thead>
<tr>
<th>%LOAD</th>
<th>Hours</th>
<th>Pre-retrofit Boiler Effic.</th>
<th>Post-retrofit Boiler Effic.</th>
<th>Therms Saved</th>
</tr>
</thead>
<tbody>
<tr>
<td>15%</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>23%</td>
<td>55</td>
<td>38%</td>
<td>48%</td>
<td>1,812</td>
</tr>
<tr>
<td>26%</td>
<td>327</td>
<td>42%</td>
<td>54%</td>
<td>11,550</td>
</tr>
<tr>
<td>28%</td>
<td>726</td>
<td>44%</td>
<td>58%</td>
<td>29,246</td>
</tr>
<tr>
<td>31%</td>
<td>984</td>
<td>47%</td>
<td>62%</td>
<td>40,575</td>
</tr>
<tr>
<td>33%</td>
<td>985</td>
<td>49%</td>
<td>65%</td>
<td>42,941</td>
</tr>
<tr>
<td>36%</td>
<td>891</td>
<td>52%</td>
<td>69%</td>
<td>39,454</td>
</tr>
<tr>
<td>38%</td>
<td>712</td>
<td>53%</td>
<td>71%</td>
<td>34,103</td>
</tr>
<tr>
<td>41%</td>
<td>655</td>
<td>56%</td>
<td>74%</td>
<td>30,368</td>
</tr>
<tr>
<td>42%</td>
<td>646</td>
<td>58%</td>
<td>76%</td>
<td>29,936</td>
</tr>
<tr>
<td>46%</td>
<td>652</td>
<td>60%</td>
<td>78%</td>
<td>30,132</td>
</tr>
<tr>
<td>49%</td>
<td>599</td>
<td>64%</td>
<td>80%</td>
<td>23,742</td>
</tr>
<tr>
<td>51%</td>
<td>547</td>
<td>66%</td>
<td>81%</td>
<td>20,768</td>
</tr>
<tr>
<td>54%</td>
<td>372</td>
<td>71%</td>
<td>84%</td>
<td>11,367</td>
</tr>
<tr>
<td>56%</td>
<td>242</td>
<td>74%</td>
<td>86%</td>
<td>6,702</td>
</tr>
<tr>
<td>59%</td>
<td>147</td>
<td>Limited test data</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>61%</td>
<td>90</td>
<td>Limited test data</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>64%</td>
<td>50</td>
<td>Limited test data</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>66%</td>
<td>26</td>
<td>Limited test data and low frequency load</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>69%</td>
<td>17</td>
<td>Limited test data and low frequency load</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>71%</td>
<td>8</td>
<td>Limited test data and low frequency load</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>74%</td>
<td>1</td>
<td>Limited test data and low frequency load</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>77%</td>
<td>3</td>
<td>Limited test data and low frequency load</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>8304</td>
<td></td>
<td>Total Est's Savings</td>
<td>352,715</td>
<td>25%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annual Usage</td>
<td>1,401,321</td>
<td>Usage/Savings</td>
</tr>
</tbody>
</table>
Chart-2
28 days of Hourly Test Data - Boiler Efficiency versus % Boiler Output Process & non-Process Loads

---

Annual Savings Methodology
To develop % Load Profiles (Chart-1) from gas CF figures we used 1027 BTU per CF to convert hourly cubic feet (CF) natural gas to hourly BTUs, multiplied by its Pre-retrofit assumed 4-season boiler efficiency (65%) and then divided this figure by the boiler's nominal gas input rating at its nominal boiler efficiency rating (32,689,000 BTU/hr x 80%). Then we performed a look-up of boiler thermal efficiency for pre-retrofit and post-retrofit, where

\[
\text{Therm savings} = \frac{\text{Output Load} \times \#\text{Hours} \times 32,689,000 \times 80\% \times [1/\text{Pre.Effic.} - 1/\text{Post.Effic.}]}{100,000 \text{ BTU} / \text{Therm}}
\]

As stated above we assumed a "4-season" boiler efficiency of 65% in order to determine boiler output Load Profiles [see Chart-1]. This may seem somewhat arbitrary; however, there is no Pre-retrofit correlation (see Chart-3) between NSTAR Gas usage and Boiler efficiency as can be seen by Chart-3 (below) therefore it was left to us to assume a reasonable boiler efficiency in order to create a Load Profile, necessary to calculating full year savings.

In a separate analysis we came up with **312,387 (22%)** **annual therm-savings** by developing a slightly different Load Profile using an assumed boiler efficiency of 75% for the winter months (1964 hours) and 65% boiler efficiency (5814) for the balance of the year.
Chart 3
Pre-retrofit - used in the development of Load Profiles

NSTAR Gas BTU/Hr vs Boiler Efficiency

Chart 4
Post-retrofit

NSTAR BTU/Hr vs % Output Load
Precision & Accuracy
We believe the precision of the metering was adequate; however, the accuracy was off due to possible calibration issues. That said, the Pre-retrofit strap on feed water flow meters were re-installed for the Post-retrofit testing period, therefore we feel that the ill effects of any inaccuracies were at least partially negated. A formal error analysis evaluation has not been performed at this time so we cannot state the +/- error in the above savings analysis.

Metering Enhancements for Future testing
- Add permanent steam meter and/or feed water Mag-Meters in lieu of temporary strap on Doppler ultrasonic feed water meters
- Boiler #1, #2, #3, #4 individual natural gas meters do not reconcile against NSTAR meters, and therefore suggest that these recently installed meters be re-commissioned
- Longer testing periods, perhaps continuous testing should be considered. We had only 14 days of pre-retrofit hourly data and 14 days of post retrofit hourly data.

Sources of Savings
- Improved stoichiometry
- Reduced standby / purge losses due to less boiler cycling achieved via higher turndown ratios

Conclusions
- Limpfield combustion technology saves at least 6% annually or more. In our case it was 25% due to over-sized boilers
- With Limpfield Combustion technology, a summer (smaller) boiler is not economically justifiable because of improved boiler efficiencies at low load

Disclaimer - this report analyzes meter readings, and performs some basic analysis. This is not an endorsement of this product by EMA. The savings are indicative; additional monitoring periods over wider load ranges as well as the addition of a steam meter would provide more valuable / additional support and more concrete savings-validation.

Very truly yours,
Energy Management Associates, Inc.

Stephen Di Giacomo, PE, CEM, CPMP
Principal Design, Commissioning & Energy Engineer
ADDITIONAL CHARTS

Charts 5 & 6 represent Raw Hourly Data Points that comprise Chart-2

Chart-5
Pre-retrofit Hourly Data

Chart-6
Post-retrofit Hourly Data
To: Geoff Wilkinson  
   President - Wilkinson  

From: Steve Di Giacomo, PE, CEM  
      Principal Engineer  

Subject: Tufts Building-20 Controls Energy Analysis  

Date: February 22, 2008  

Savings  
Annual Energy savings of 6556 therms or 7.2% were found via statistical regression models for the period of January 25th, 2003 through November 18th, 2005 for the base year and November 19th, 2005 through July 19th, 2007 for the post-retrofit period.  

An overall 7.3% or 6869 annual therms savings was calculated using 30-year heating degree dat averages (HDD30) for Boston.  

Methodology  
Gas consumption was analyzed for the 3 preceding heating seasons prior to when we were told of a retrofit and two season following the retrofit. I normalized for heating degree days in order to take into account weather fluctuations; also, I normalized for calendar days in order to account for some months with more days than other months. I plotted therms per day versus heating degree-days per day. The before-retrofit model has a least squares regression coefficient of determination of (R^2) 91%; the after-retrofit model has a least squares regression coefficient of 95%.  

Disclaimer  
While statistically significant, this is not considered a scientific study does not investigate additional operational changes that may have occurred during the time period involved that in theory may have either increased, or decreased the statistically reported energy savings reported.  

Please don't hesitate to call me with any questions at 508.533.1128.  

Submitted by  

[Signature]

Stephen M. Di Giacomo, P.E., CEM  
Massachusetts Professional Engineer – Mechanical  
No. 37749