Plant Utility Systems Optimization Through Energy Controls

Summary Report

Stonyfield Farm, Inc.

January 2011

Table of Contents

Questions regarding this study should be directed to:

Jeff Shuman
10 Burton Drive
Londonderry, NH 03036
(603) 437-4040
jshuman@stonyfield.com

Introduction

This report presents a summary of the program entitled "Plant Utility Systems Optimization through Energy Controls", conducted by Stonyfield Farm, Inc. with the assistance of funds from the Greenhouse Gas Emissions Reduction Fund. The project was conducted from November 2009 through December 2010. Jeff Shuman., Sr. Engineer for Stonyfield Farm Inc. was the project manager. The pre and post project data was gathered using an energy monitoring system, "Barexpert", which was installed at Stonyfield prior to the commencement of this project (December 2007).

This report discusses the outcomes of the tasks proposed in Stonyfield's revised proposal dated September 8, 2009.

On a summary level, the work plan for this program consisted of 4 tasks as follows:

- Task 1 - Steam System Modifications
- Task 2 - Refrigeration System Modifications
- Task 3 - Compressed Air Tuning
- Task 4 - HVAC System Modifications

During the course of the project, our business experienced a number of changes in production and processes that cannot always be separated from changes that are directly attributable to the energy savings of this project. Weather variability also plays a factor, particularly in refrigeration, with higher exterior temperatures requiring more cooling in our process. These variabilities have an impact on the analysis of the project data and are discussed more specifically in the sections that follow.

The actual measured energy savings were greater than the anticipated energy savings. From the sum of all tasks, electrical energy savings were **66%** greater than anticipated at **1,557,948 kWh/year** and the natural gas energy savings were **154%** greater than anticipated at **91,200 Therms/year**.

The project work plan consisted of four energy efficiency tasks. The realized savings associated with each measure are listed below. The savings that were expected from the program as stated in our original proposal are shown below as "Proposed". The savings realized based data verification post project are shown below as "Actual". The "Actual" savings are shown on an annual basis although less than a year of data has been collected at this point. The savings were calculated using a utility data collection system that measures various points of pressure, temperature, flow, and kW in the utility system. From this data, electrical savings are expressed as kWh and gas savings expressed as therms. Data was extrapolated over the course of 1 year to determine the annual savings as there is currently not 1 year of data to provide. The charts presented in this report are generated from data obtained from the BarExpert system.

Annual Savings Summary				
	ACTUAL	PROPOSED	ACTUAL	PROPOSED
Action	Annual Savings Electrical (kWh)	Annual Savings Electrical (kWh)	Annual Savings Gas (Therms)	Annual Savings Gas (Therms)
Task 1 - Steam System Modifications	0	0	83,580	34,120
Task 2 - Refrigeration System Modifications	1,473,096	878,125	0	0
Task 3 - Compressed Air Tuning	84,852	59,375	0	0
Task 4 - HVAC System Modifications	0	0	7,620	1,813
Totals	1,557,948	937,500	91,200	35,933

Monthly Savings Summary		
Action	Monthly Savings Electrical (kWh)	Monthly Savings Gas (Therms)
Steam System Modifications	0	6,965
Refrigeration System Modifications	122,758	0
Compressed Air Tuning	7,071	0
HVAC System Modifications	0	635
Totals	129,829	7,600

Task 1– Steam System Modifications

Completed April 26, 2010

Proposed Savings Per year	**34,120 Therms**
Actual Savings Per Month	**6,965 Therms**
Actual Savings Per Year	**83,580 Therms**

Task 1: Steam System Modifications Proposed
Install orifice plate in DA vent to atmosphere.
Install circuit setters on CIP fresh water make-up.
PLC programming to modulate steam valves to open slowly.

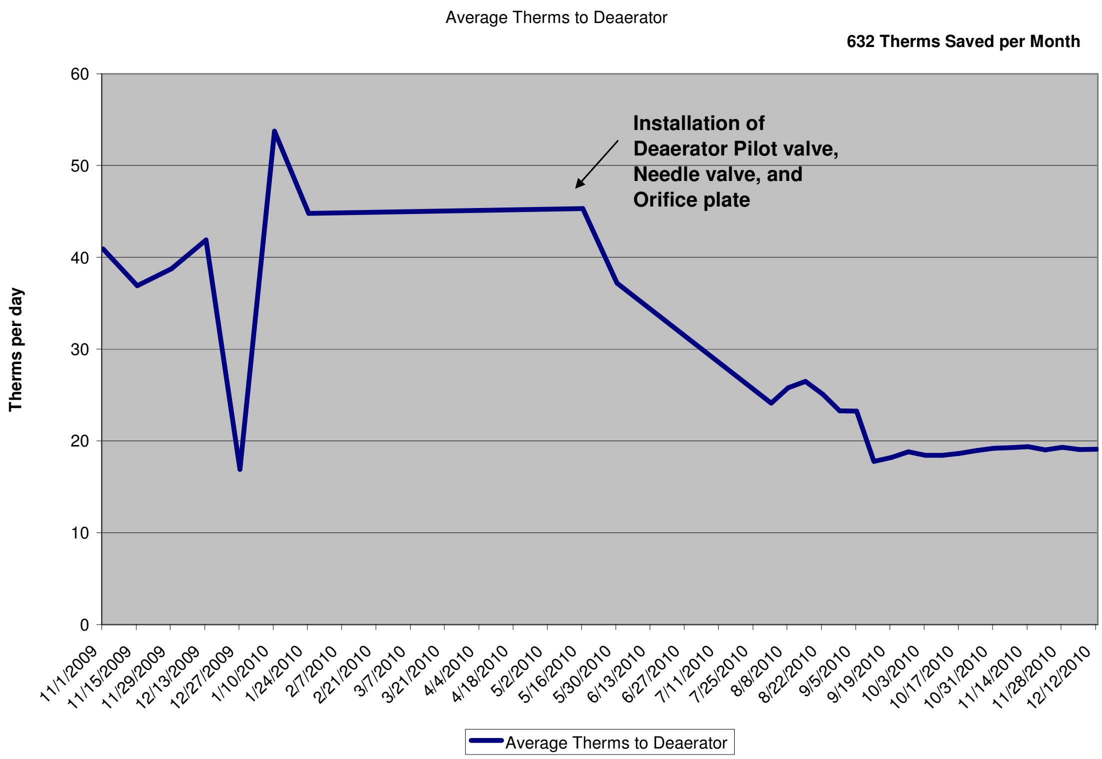
Our process heating needs are met primarily with a natural gas steam boiler. On the steam system task, the primary objective was to reduce peak steam loads by installing circuit setter valves, and programming flow valves to open slowly rather than quickly opening 100%. The project also included system adjustments that would practically eliminate steam loss to the pressure relief.

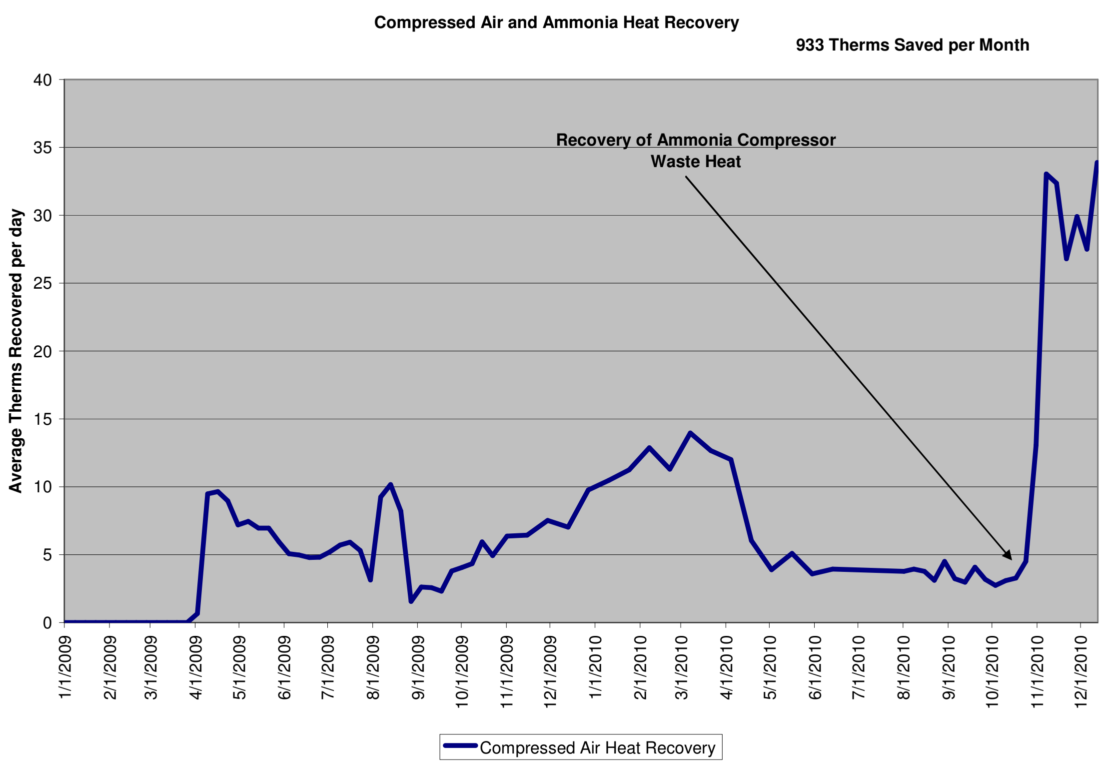
Steam system modifications completed included:

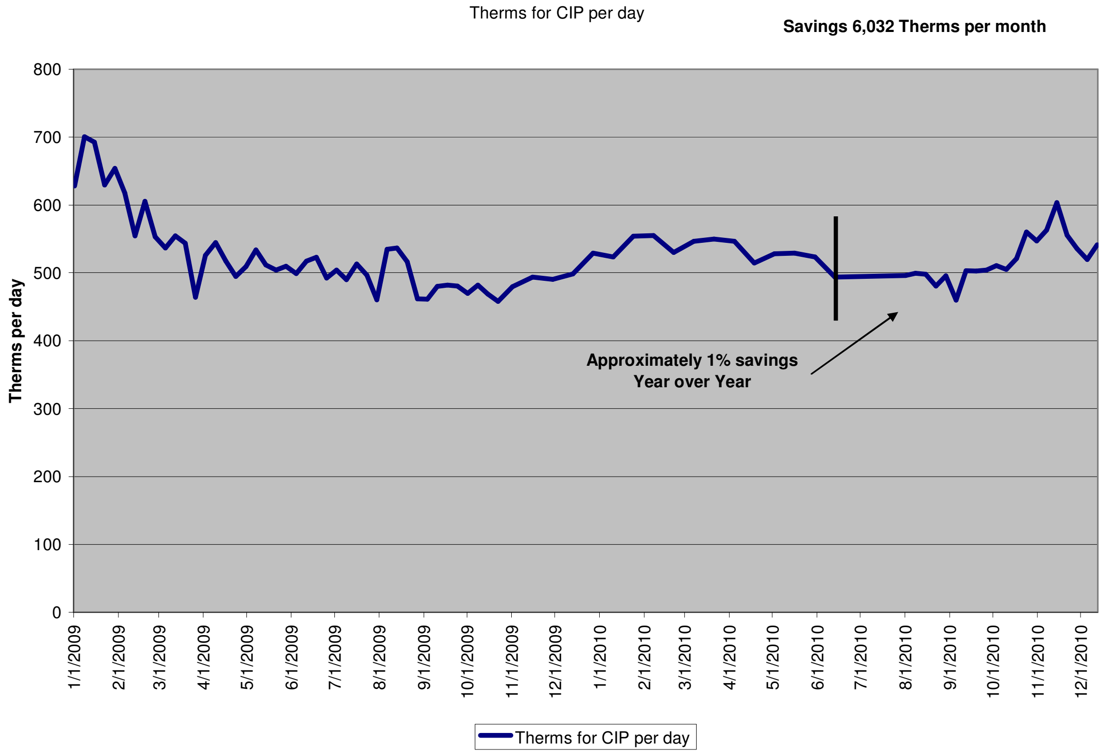
- Installation of a control valve on the deaeration tank to control the pressure at 1 psi vs. 5-7 psi. See savings next bullet.
- Installation of a needle valve on the steam discharge line from the deaeration tank to prevent unnecessary steam from escaping to atmosphere. Savings of 632 therms per month.
- Installation of three circuit setter valves on the Clean-In-Place water make-up lines to prevent excess cold water make-up from triggering sudden large steam load demands. Due to many manufacturing changes during this same time period, savings are difficult to calculate. Savings realized are no less than 6,032 therms per month, and are likely to be greater.
- Adding piping to capture waste heat from the ammonia compressor through an existing heat exchanger to pre-heat the domestic hot water make-up. Note: this task was added to the project. Savings of 933 therms per month.

These modifications have made a significant reduction in steam consumption and steam boiler fire rates during water make-up events. The data of the individual task items was difficult to interpret due to an increase in make-up water frequency due to changes in production coinciding with the completion of Task 1. These changes in make-up water frequency, upon data review, appear to negate some of the Task 1 savings, however the true savings compared to a no change scenario, are even greater than being reported. The heat recovery is the only task item with a direct measurement that is not impacted by these other factors and is presented in graphical form below.

Data collection for ammonia heat recovery was accomplished using Barexpert sensor Cal [200] “AC Power heat recovery”, this sensor consists of flow measurement and water temperature before and after the heat exchanger in which the ammonia compressor waste heat was added.







Deaerator pilot valve

Task 2– Refrigeration System Modifications

Completed October 12, 2010
Proposed Savings Per Year 878,125 kWh
Actual Savings Per Month 122,758 kWh
Actual Savings Per Year 1,473,096 kWh

Task 2: Refrigeration System Modifications Proposed
Install VFDs on Ammonia Condenser Fans and program compressors.
Install electrical conditioning equipment on large motors.
Install bypass on ice water and glycol water loops to cooling tunnels.
Install pressure sensors and control the pressure using PLC and VFD.
Balance glycol networks.
Balance ice water networks.
Modify PLC program to control pressure at the end of ice water network.
Programming for cooling tunnel operational improvements.

An ammonia refrigeration system with glycol and ice water networks provides process cooling throughout the facility. Prior to this work, a series of condenser fans responded to cooling demand in the facility by turning on and off. This created unnecessary spikes in electrical demand. Similarly, large ammonia compressor motors run long hours in our facility and cycled on and off based on cooling loads. By installing variable frequency drives (VFDs), the system can better modulate in response to cooling tower loads, ensuring that the minimum amount of energy is used to meet demands.

Power conditioning equipment, or KVAR units, were installed to optimize the power factor of individual inductive motor loads. We installed KVAR units on 7 motors.

Through use of BarExpert, we had also identified opportunity to improve the efficiency of how we operate the glycol and ice water loops within the refrigeration system. By installing a bypass loop, adding pressure sensors, and controlling pumps by the pressure sensors, chilling fluids would only be pumped when and where needed rather than constantly pumped through the loops.

Modifications to the refrigeration system accounted for the greatest energy savings of all the tasks and constituted the major focus of the overall project. Savings from this task were verified as follows:

- Installation of VFD duty motor and VFD on one large Ammonia compressor and PLC/SCADA programming. Savings of 78,000 kwh per month.
- Installation of VFD duty motors and VFD's on Ammonia condenser fans and PLC/SCADA programming. Savings cannot be verified as there are no watt meters on these fans. Savings are believed to be significant.
- Installation of power conditioning equipment. No kwh savings were realized.

- Balancing of Glycol Water flow to meet demand. Including installation of valves and controls. Savings of 24,000 kWh per month.
- Balancing of Ice Water flow to meet demand. Including installation of valves and controls. Savings of 17,000 kWh per month.

The summer temperatures in 2010 were higher than the baseline year and likely negated some of the actual savings. Outside temperature were recorded but cannot readily be adjusted for in this study.

Data collection for the VFD duty on the ammonia compressor was accomplished using Barexpert sensor Grd[053] which is a wattmeter measuring kW consumed by the ammonia compressor.

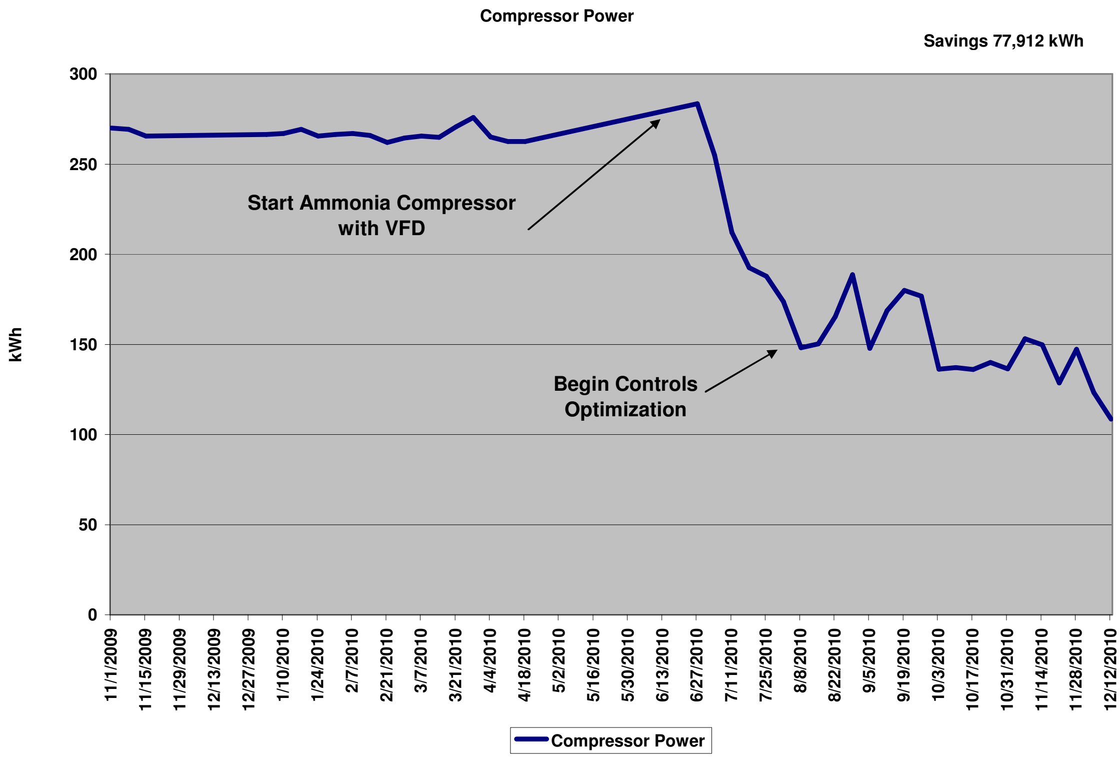
Data collection for the balancing of the Glycol Water was used using Barexpert sensor Grd[147] which records the % of maximum that the glycol pump is running. The kW of the pump is known from the pump and motor name plate. This allowed the calculation of kWh savings.

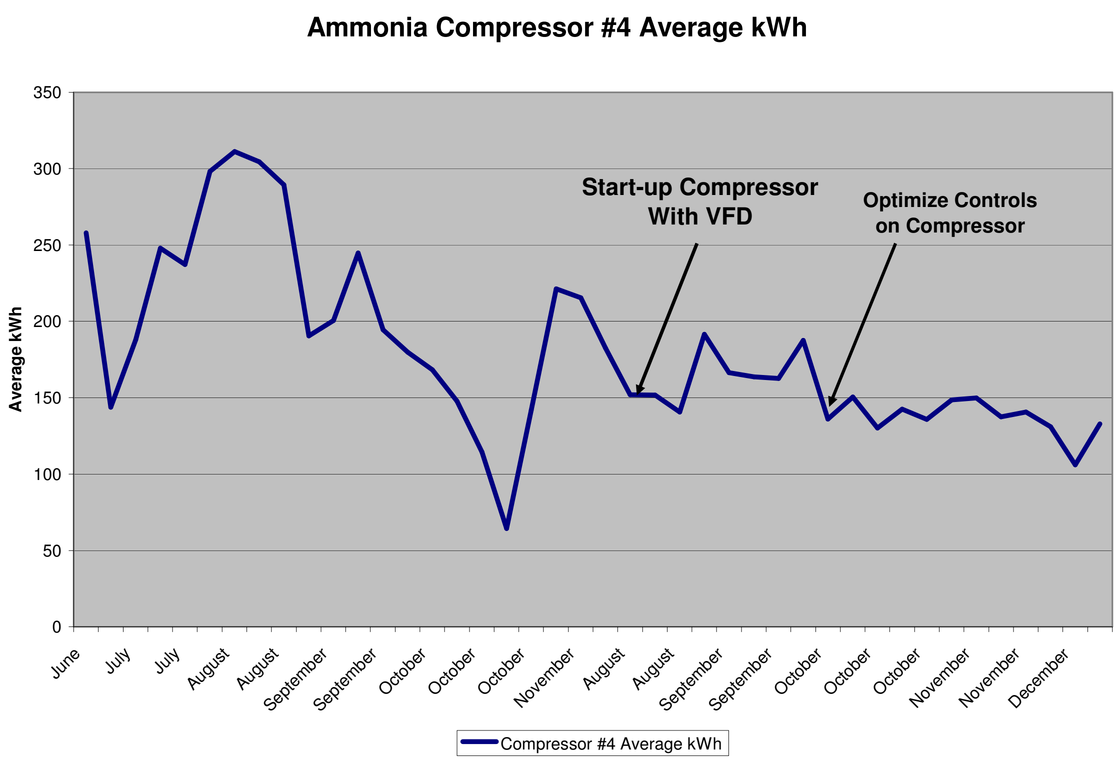
Data collection for the balancing of the Ice Water system was accomplished using Barexpert sensor Grd[165] and Grd[166] which measure the ice water pump VFD % of maximum. The kW of the pumps are known from the pumps and motor name plate. This allowed the calculation of kWh savings.

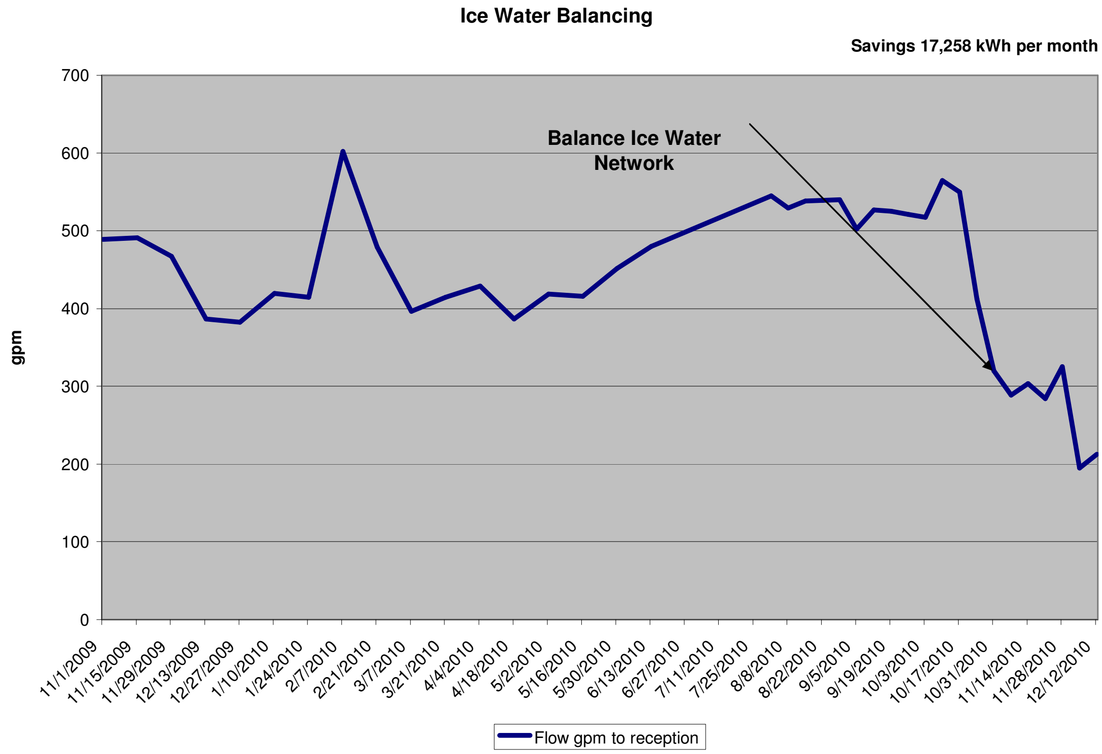
Ammonia Compressor VFD

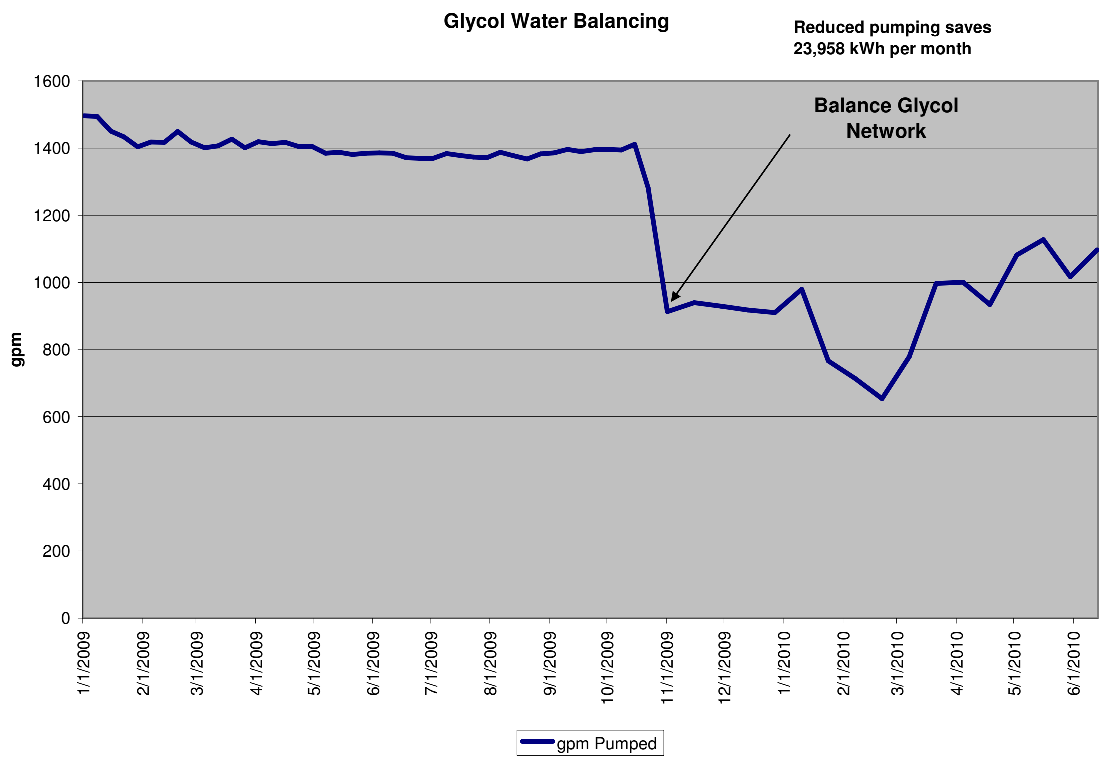
Ammonia Compressor with VFD duty motor.

Condenser Tower VFD's


Compressor Power
Savings 77,912 kWh
kWh
300
250
200
150
100
50
0
Start Ammonia Compressor with VFD
Begin Controls Optimization
11/1/2009
11/15/2009
11/29/2009
12/13/2009
12/27/2009
1/10/2010
1/24/2010
2/7/2010
2/21/2010
3/7/2010
3/21/2010
4/4/2010
4/18/2010
5/2/2010
5/16/2010
5/30/2010
6/13/2010
6/27/2010
7/11/2010
7/25/2010
8/8/2010
8/22/2010
9/5/2010
9/19/2010
10/3/2010
10/17/2010
10/31/2010
11/14/2010
11/28/2010
12/12/2010
Compressor Power


Ammonia Compressor #4 Average kWh
Average kWh
350
300
250
200
150
100
50
0
Start-up Compressor With VFD
Optimize Controls on Compressor
June
July
July
August
August
September
September
October
October
October
November
August
August
September
September
October
October
October
November
November
December
Compressor #4 Average kWh


Ice Water Balancing
Savings 17,258 kWh per month
Balance Ice Water Network
gpm
700
600
500
400
300
200
100
0
11/1/2009
11/15/2009
11/29/2009
12/13/2009
12/27/2009
1/10/2010
1/24/2010
2/7/2010
2/21/2010
3/7/2010
3/21/2010
4/4/2010
4/18/2010
5/2/2010
5/16/2010
5/30/2010
6/13/2010
6/27/2010
7/11/2010
7/25/2010
8/8/2010
8/22/2010
9/5/2010
9/19/2010
10/3/2010
10/17/2010
10/31/2010
11/14/2010
11/28/2010
12/12/2010
Flow gpm to reception


Glycol Water Balancing
Reduced pumping saves
23,958 kWh per month
Balance Glycol Network
gpm
1600
1400
1200
1000
800
600
400
200
0
1/1/2009
2/1/2009
3/1/2009
4/1/2009
5/1/2009
6/1/2009
7/1/2009
8/1/2009
9/1/2009
10/1/2009
11/1/2009
12/1/2009
1/1/2010
2/1/2010
3/1/2010
4/1/2010
5/1/2010
6/1/2010
gpm Pumped

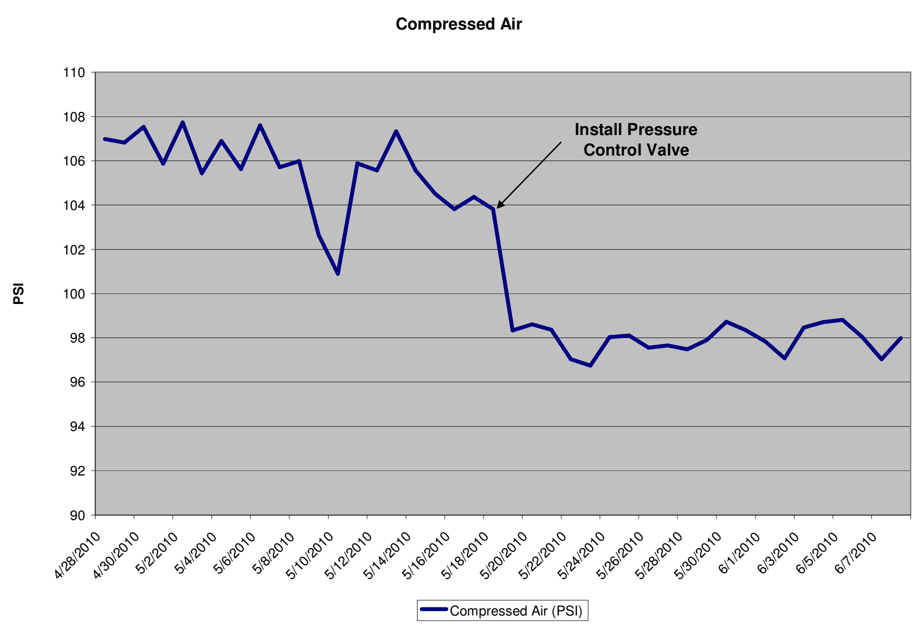
Task 3 – Compressed Air Tuning

Completed October 1, 2010

Proposed Savings Per Year	**59,375 kWh**
Actual Savings Per Month	**7,071 kWh**
Actual Savings Per Year	**84,852 kWh**

Task 3: Compressed Air Tuning
Tune Air compressors so that VFD controls pressure to +- 1.5 psi and not on/off.
Adding sensors and completing programming to tie into PLC.
Complete a targeted audit to identify additional improvement opportunities.

The air compressor system was improved by tuning the existing VFD to control pressure to +/- 1.5 psi. Additional improvements resulting from the audit consisted of installing a compressed air control valve and additional air surge tank. The compressed air controller was installed as originally planned. The compressed air control valve enabled the average plant pressure to be reduced from 108 psi to 98 psi. For every two psi reduction in system pressure 1% less energy is consumed. The air surge tank dampened large events and small events to allow a second air compressor to either ramp up or reduce short cycling. The compressed air controller controlled the air compressor with the VFD to ramp and down until it was at maximum output, then called for a second air compressor to turn on and controlled the air compressor with the VFD to control as a trim compressor. The savings reported are likely higher than reported because the implementation of this work coincided with various expansion projects consuming additional compressed air in the plant. The impact of one vs. the other is difficult to differentiate. The savings are therefore estimated based upon the 10 psi reduction.



Compressed Air Controller


Compressed Air Global control Valve

Task 4 - HVAC System Modifications

Complete May 30, 2010

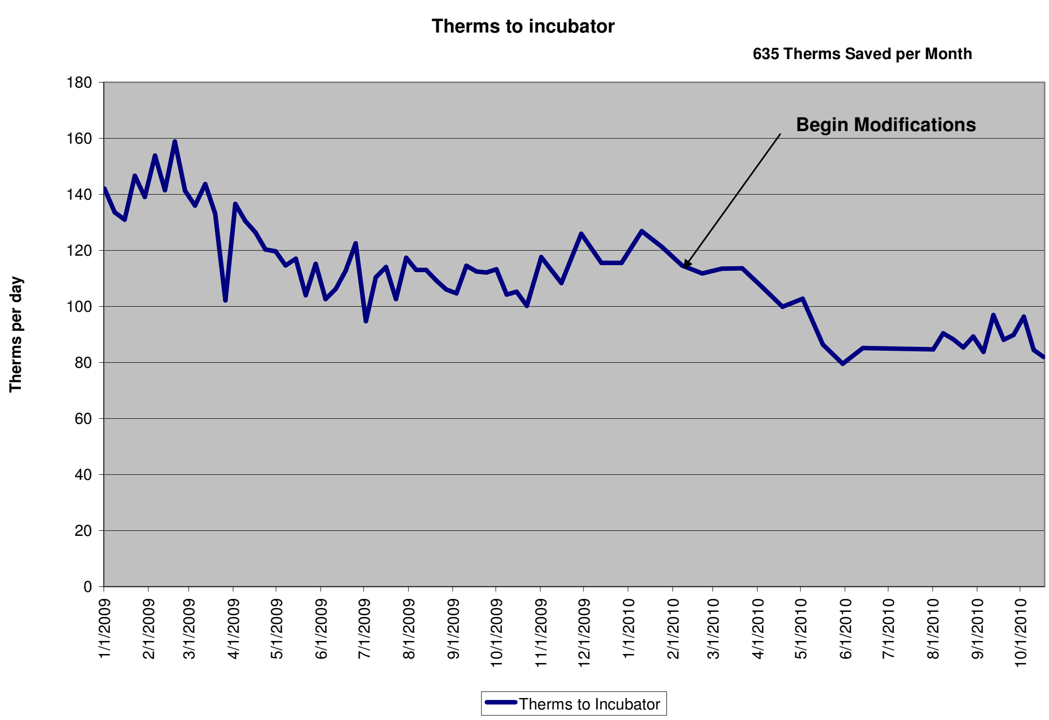
Proposed Savings Per Year	**1,813 Therms**
Actual Savings Per Month	**635 Therms**
Savings Per Year	**7,620 Therms**

Proposed Task 4: HVAC System modifications
Block opening between incubator room and cooling tunnels.

Task 4 was a specific improvement to the interface between the hottest and coldest areas of our plant to eliminate air flow and/or infiltration between neighboring heated and cooled areas.

The modification was done to the incubator, which is a room that is kept at a high temperature. The modifications included adding insulation, insulated walls, modification to duct work and installation of an air break for movement of pallets between the heated incubator and the cooled cooling tunnel area.

Data was collected using Barexpert sensor Cal[082] which measures the pounds of steam delivered to the incubator. The pounds of steam were converted to therms. Savings are known to be at least 635 therms per month.



Above: Before Project Changes

Above: New Air break for pallets vs strip curtain, two new doors vs strip curtain, insulated panel.