Rowan University
Energy Management
Optimization of our Central Chilled Water System

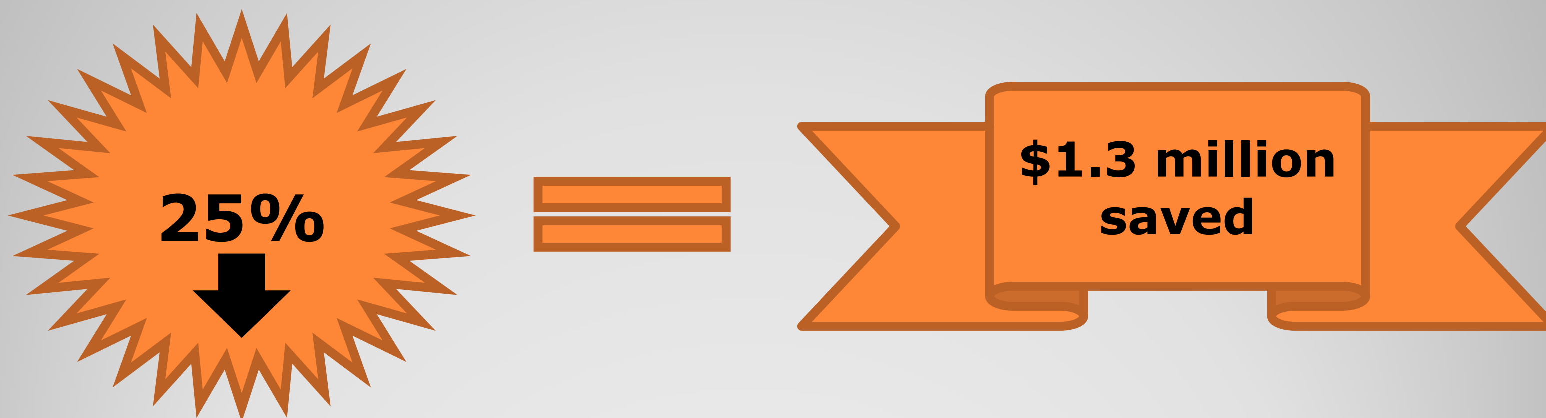
Presented at the 2014 IDEA Annual Campus Energy Conference
Atlanta, GA

FOUR PILLARS OF ROWAN ENERGY MANAGEMENT:

- **G**ENERATION
- **R**EDUCTION
- **I**NNOVATION
- **P**ROCUREMENT

Purpose

To illustrate how Rowan University REDUCED energy consumption & cost approximately 25% over 2-years with a focus on **Optimizing** our Chilled Water distribution and operating business rules.



Students
13,000+

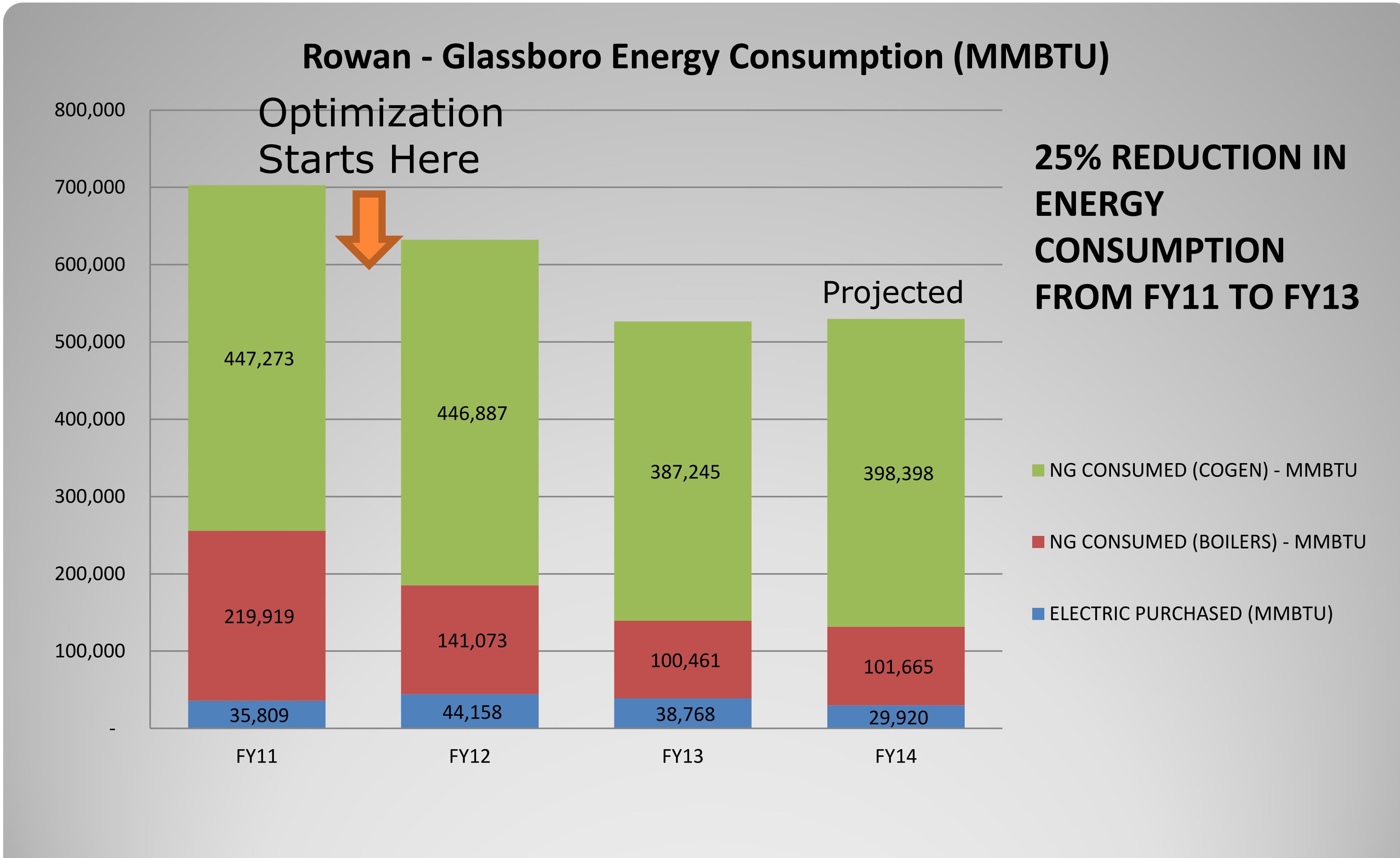
Space
2.1 million g.s.f. served from the Central Utilities Plant

Campus
225 Acres

FY13 EUI:
243 kbtu/sf

FY13 Avg Cost:
$2.05/sf/yr

Rowan University
Glassboro, NJ (20 miles from Philadelphia)



Downward Trend

Chiller/Cogen Addition, since 2006/ CMX 2009
2600 Tons Peak Demand

Heat Plant, since 1961

Rowan University's
Combined Heat, Power, and Cooling Plant

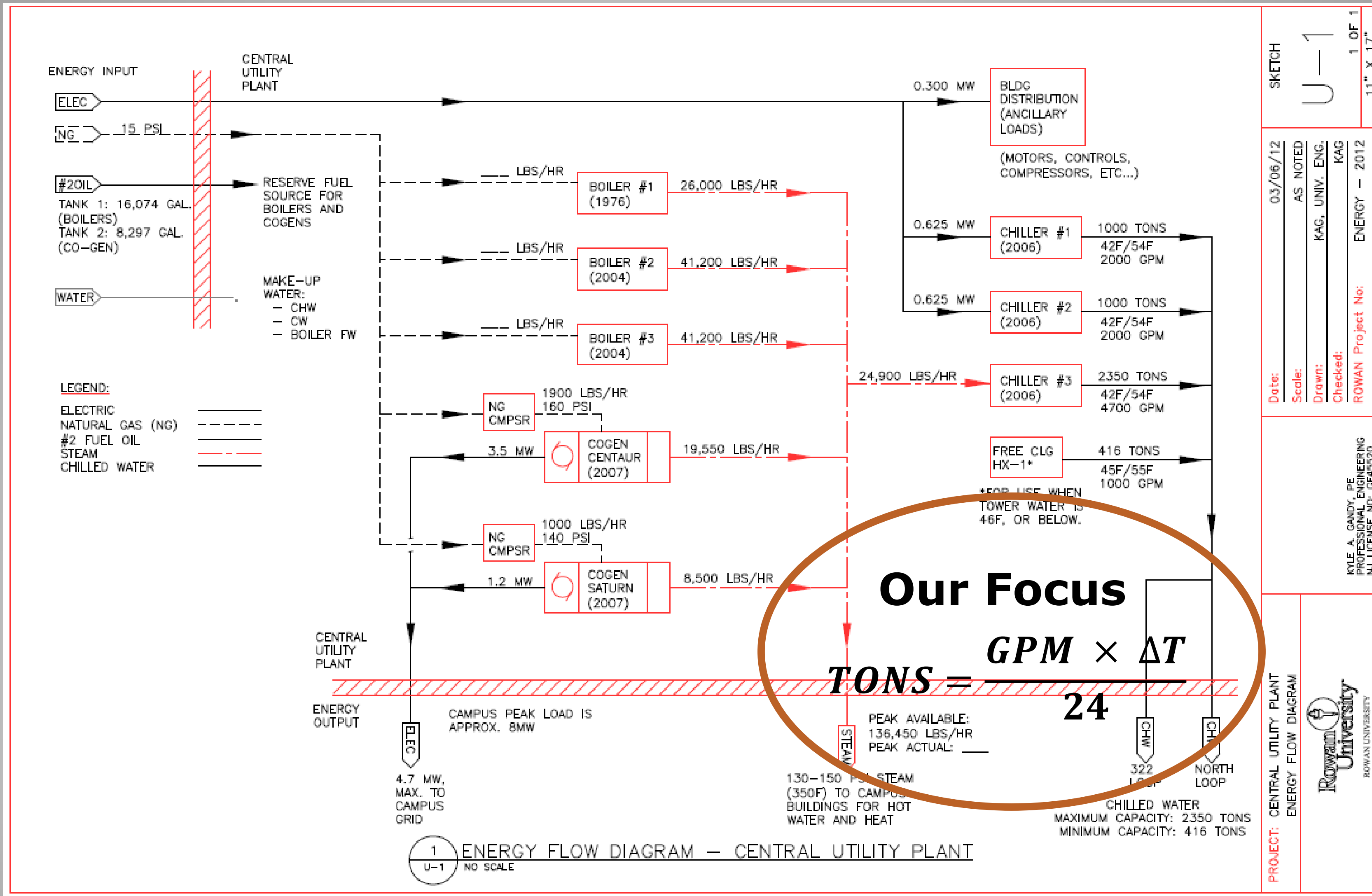
Main Assets

Rowan University - Central Plant - Existing System Summary

Plant Type	Equipment*	Installed Capacity	Firm Capacity
Boiler Plant	1 - 26,000 lb/hr dual fuel Steam Boiler (1976)	108,400 lb/hr Steam	67,200 lb/hr Steam
	2 - 41,200 lb/hr dual fuel Steam boiler (2004)		
Chiller Plant	2 - 1,000 ton electric centrifugal chillers (2005)	4,350 Tons	2,000 Tons
	1 - 2,350 ton steam turbine centrifugal chiller (2005)		
Cogeneration Plant	1.2 MW Solar Saturn 20 daul fuel combustion turbine generator w/ 8,500 lb/hr unfired HRSG (2007)	4.8 MW	1.2 MW
	3.6 MW Solar Centaur 40 dual fuel combustion turbine generator w/ 19,500 lb/hr unfired HRSG (2007)	28,000 lb/hr Steam	8,500 lb/hr Steam

* *Does not include misc. ancillary equipment (e.g. pumps, compressors, cooling towers, etc.)*

Table extracted from 3/2013 Asset Evaluation Report prepared by Concord Engineering.



CUP Energy Flow Diagram

2007:

Rowan's Chilled Water Distribution system, in operation since 2007, relied on a basic operating sequence that ensured adequate chilled water flow 12-months per year.

2012:

Starting March of 2012, we started the process towards improving operational efficiencies focusing on our chilled water distribution and associated pumping energy.

2013 - Current:

Reduced pumping energy and less steam demand, creating energy savings and new spare capacity.

Timeline

Automated Control of our Central Chilled Water distribution system

- Automated Control = safe, no HVAC complaints from end users.
- Delivered more than required and as a result consumed more electrical pumping energy than necessary.
- Very little human interaction.

Automation

Automation

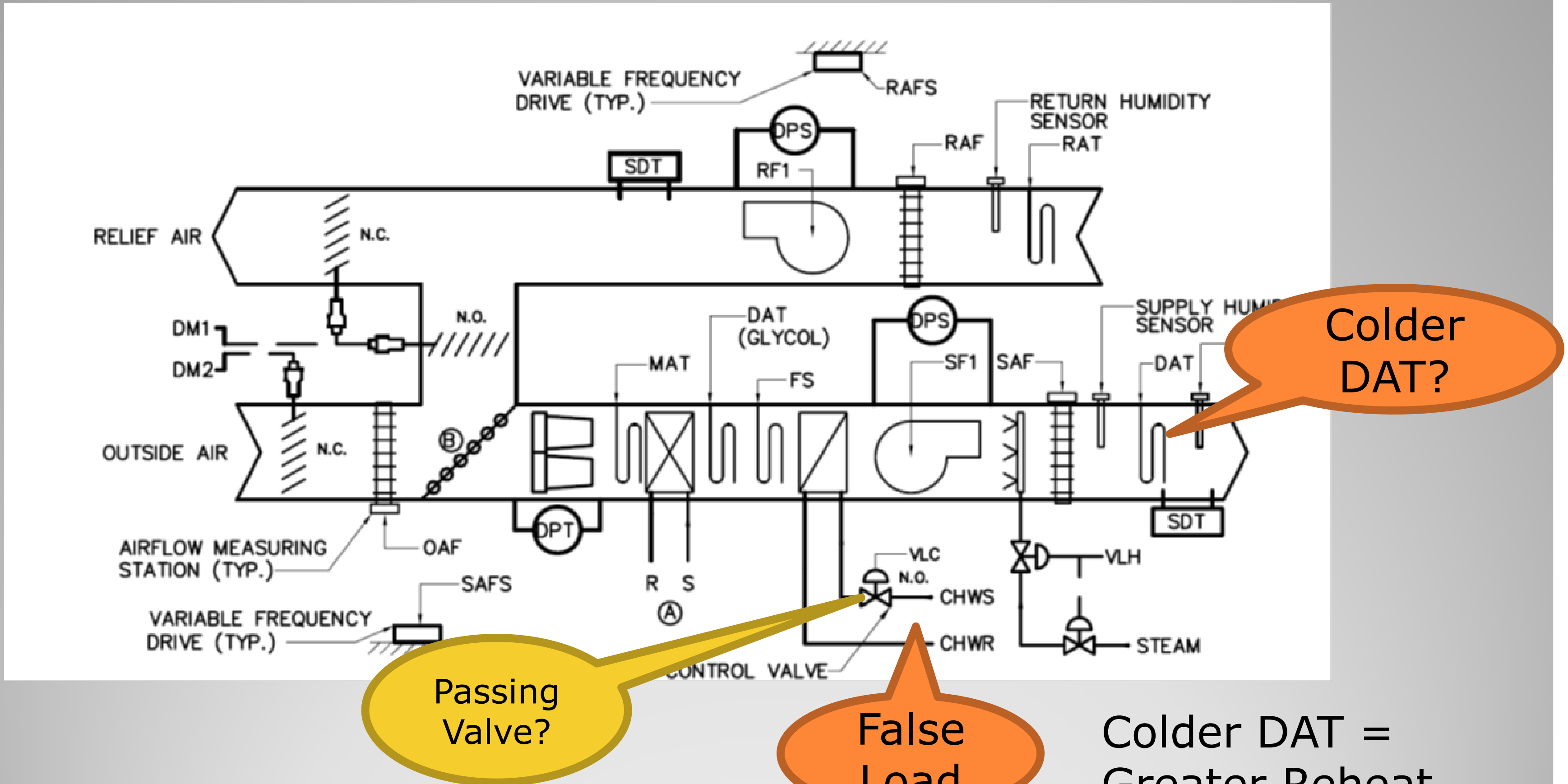
2007-2012 Automated Control (Summer)

- Summer Mode: Operated Primary variable flow 400 HP pump based on building differential temperatures, or maximum return temperature. If 2 or more buildings exceeded the parameters, our 400 HP vfd would increase output until parameters were satisfied. Over-pumping warmer water offered no benefit to building comfort.

2007-2012 Automated Control (Winter)

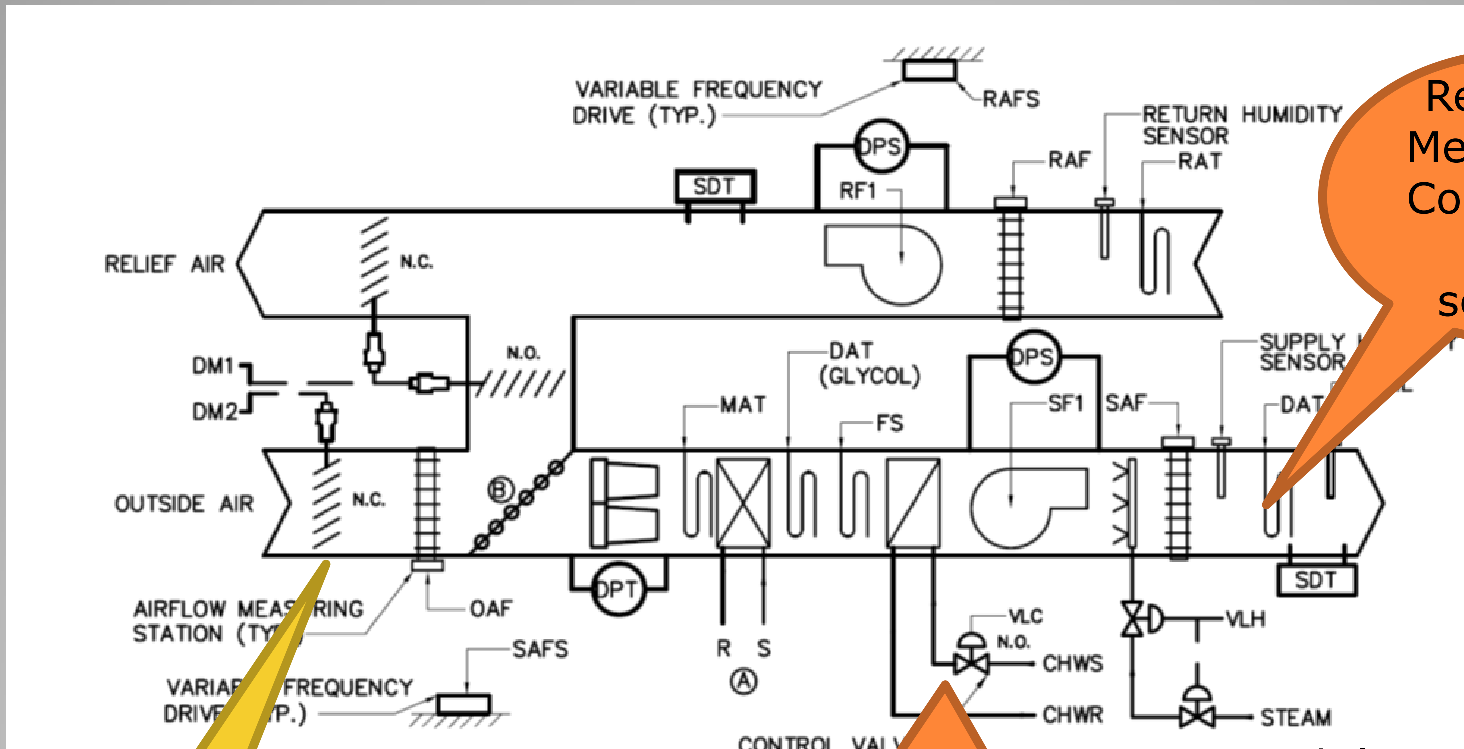
- Winter Mode: Free cooling enabled at 43 degF OA with a “Free Cooling” plate and frame using 200 HP variable flow pump at set speed of 50% and CHWS @ 45 deg. F.
- Free cooling in the Fall/Winter/Spring months with automated setpoints was causing 2 major issues:
  - Excessive pressure on building valves calling for 0% chilled water, especially those closer to the plant. CHW passing?
  - Supply water temp was 10 to 15 deg.F lower than our AHU’s supply air temperature. Passing control valves created colder supply air that would require greater reheat energy. At the same time, it added an artificial load to our chilled water and steam supply systems.

Automation



Colder DAT = Greater Reheat Energy (steam) Consumed

Overpumping Issue Winter Months



Relied on Mechanical Cooling for DAT setpoint

Bad OA Damper?

Unnecessary Load

Overpumping Issue Spring & Fall

By delivering CHW at 45F allowed bad dampers to go unnoticed, requiring more pumping energy to satisfy DAT.

DELIVER

only

WHAT IS NEEDED

to

MAINTAIN HVAC COMFORT

and

MINIMIZE COST

Optimization, or “Just Enough”

Our Process of Optimizing the CHW system:

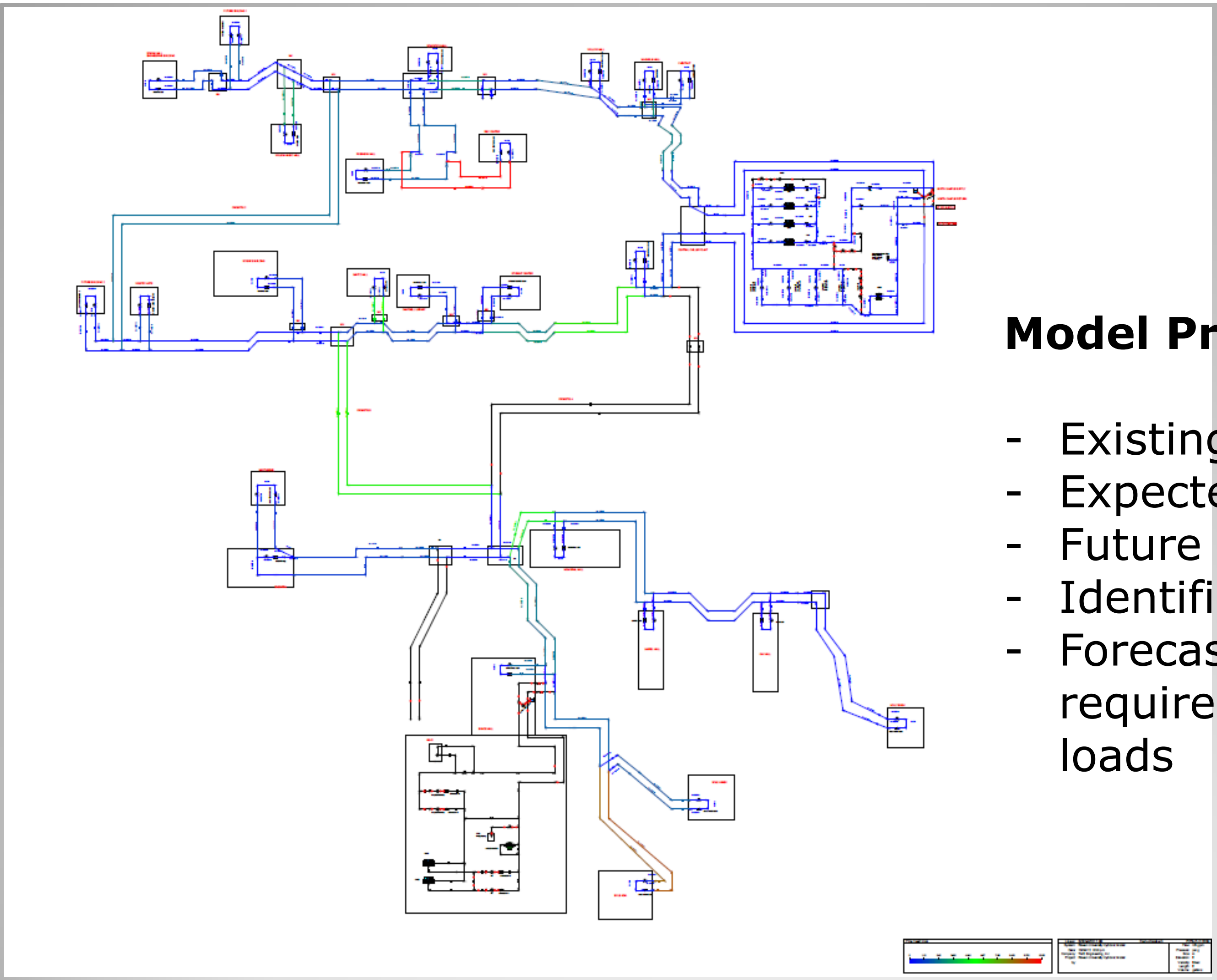
- **Step 1:** Understand the loads being served and the actual seasonal needs. Are there any real winter chilled water needs, and if so, why?
- **Step 2:** Be aware of the constraints of your central equipment; minimum and maximum flow rates of equipment.
- **Step 3:** Know your underground distribution system. Find the bottlenecks/choking points in the piping system. How? Conduct a Hydronic Model of the system (model utilized Pipe-Flo software).
- **Step 4:** Based our variable pump control on required differential pressure at the worse case point-of-use as identified by the Hydronic study.
- **Step 5:** Adjust, monitor, and validate…repeat.

Optimization - Our Process

Our Winter Load

- Only (1) real load requiring CHWS during the winter months, our Recreation Center, which uses water source heat pumps and rejects the heat to our chilled water via a plate and frame.
- Our smallest primary variable flow CHW pump operates at minimum speed (20 HZ) during most of the Fall/Winter/Spring, generally when OAT is 50F and below. Running colder water provides no greater pumping savings.
- Our Cogen units utilize condenser water for lube oil and NG Compressor cooling year-round.

Understanding our Loads



HYDRONIC MODELING

Model Provided:

- Existing Conditions
- Expected Pressures
- Future Connections
- Identified bottlenecks
- Forecasted plant DP required for future loads

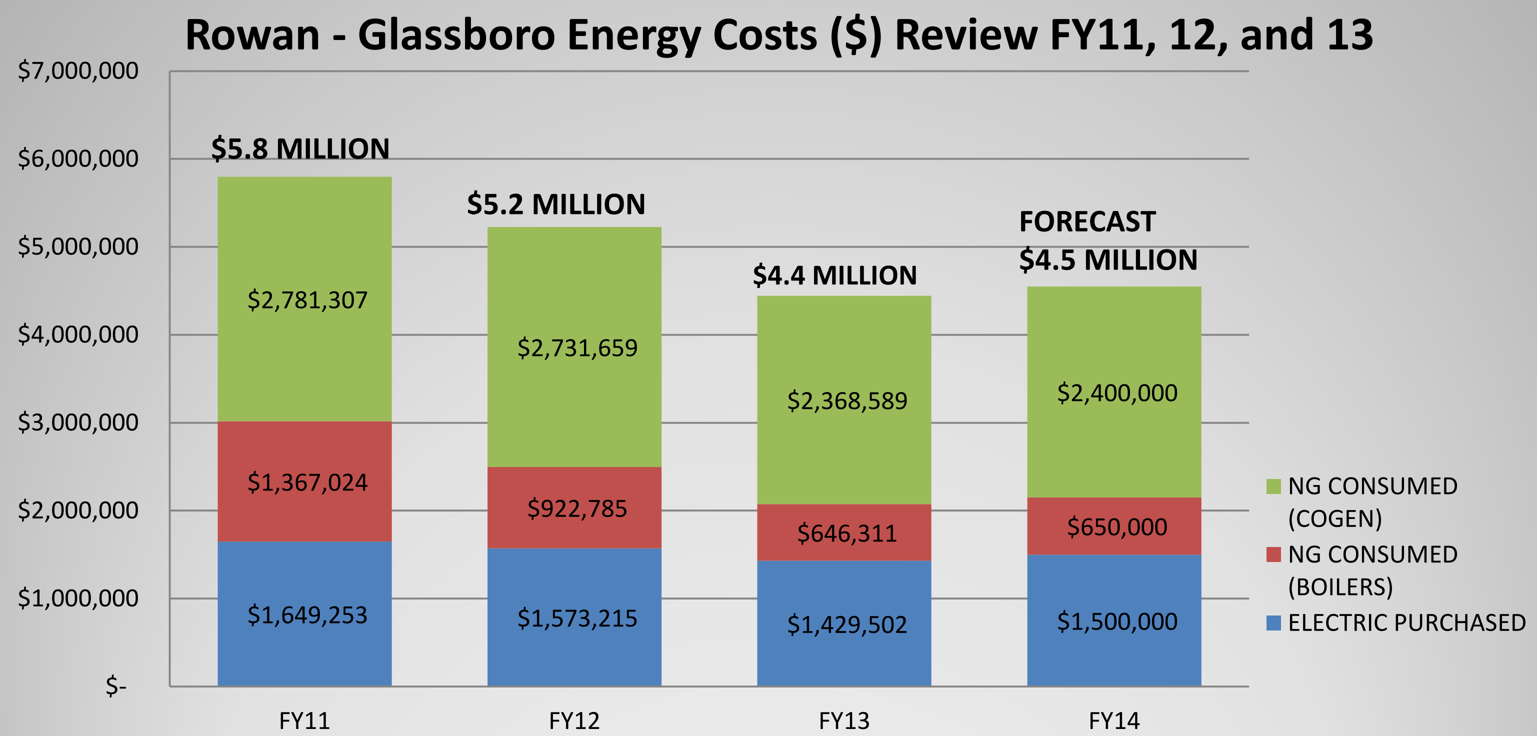
Extracted from Trefz Engineering Final Report dated 4/1/13

Description	2012	2013	% Reduction	$ Saved (2 months)
Free Cooling Enable Setpoint and CHW Supply Setpoint	43F, OAT 45F CHWS	55F, OAT 50-60F CHWS		
Average CHW Flow from CUP when OA is less than 55-degF, GPM	1000 GPM	533 GPM	46%	
Average Pressure Differential at CUP when OA is less than 55-degF	7 psi	2 psi	71%	
CUP kwh's consumed, February and March	542,250 kwh	242,221 kwh	55%	$45,000
Steam Production, same period	47,423 klbs	40,183 klbs	15%	$51,548

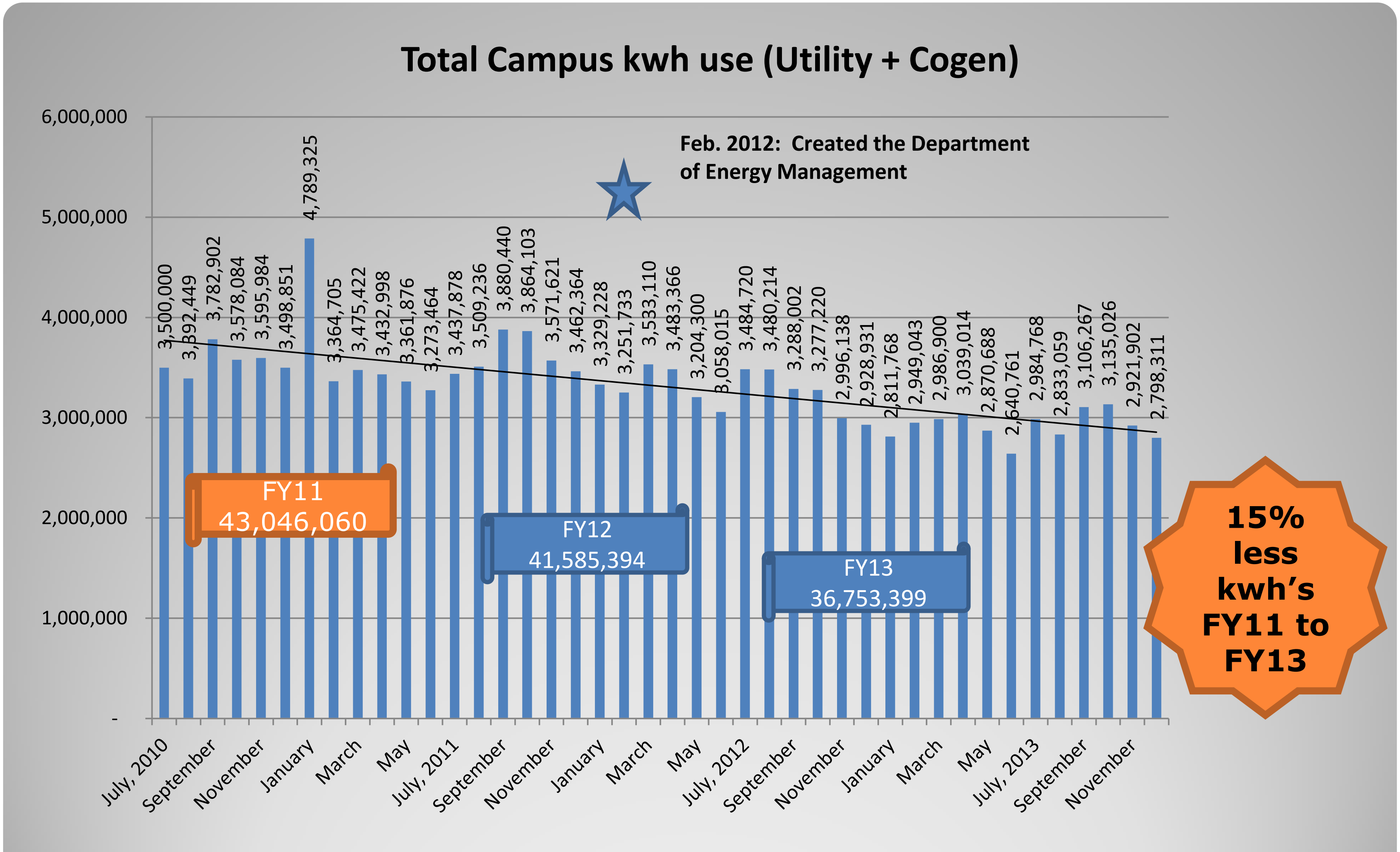
Realized savings of **$96,548 over 2 months** attributed to Optimization Changes. Less than a 1-month payback on Hydronic Study.

Optimized Changes

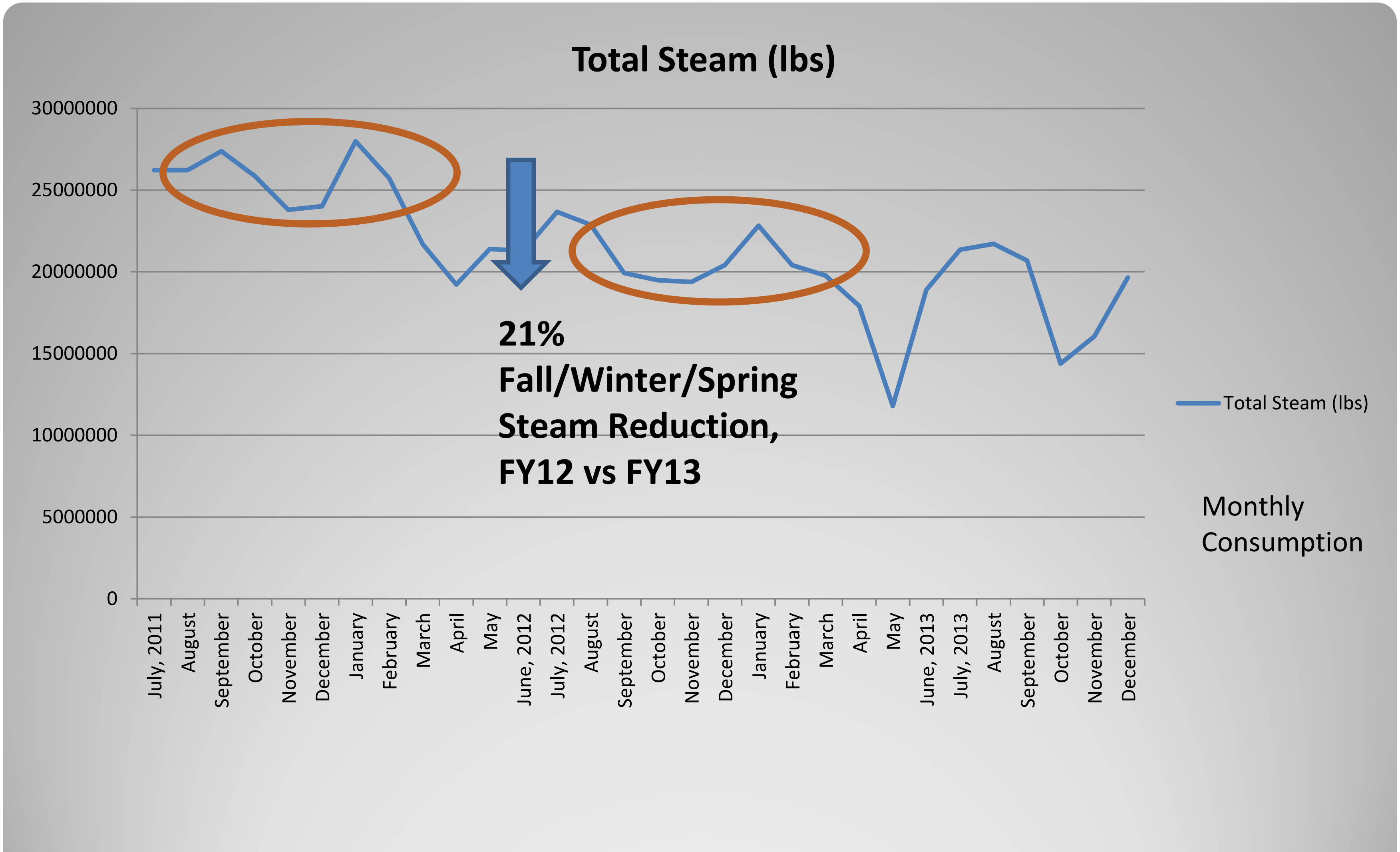
The Chilled water optimization initiative is the primary reason for our year-to-year energy cost savings.



RESULT$ - Annual Spend



Campus KWH Downward Trend



Campus Steam Downward Trend

Central Utilities Plant

Cooling Guidelines for Operation based on Outside Air conditons

Central Chilled Water flow is available year round and will be controlled based upon ambient temperatures as follows:

Ambient (Outside Air)	**CHW Supply Temp. °F.**	**Diff. Pressure at CUP**	**Cooling Mode**
80°F and Above	42-45F	Approx.. 12-16 PSIG	Mechanical
60°F to 79F	46 - 50°F	Approx. 5-7 PSIG	Mechanical
55°F to 59F	55 - 60°F	Approx. 3 - 5 PSIG	Free Cooling, maybe Mechanical (Note 3)
Below 55°F	62°F	Approx. 2 PSIG (for Rec Center Heat Pumps)	Free Cooling with Tower Temp. Set at 60F

New Rules

- New Rules, New Issues:
  - HVAC units on campus with inoperable Outside Air Intake dampers were now generating hot complaints in the Winter. Dampers Repaired.
  - Warmer discharge supply air temps from AHU's meant less reheat required, thereby reducing our steam demand. This has created Cogeneration utilization issues where we are unable to operate due to a substantial decrease in thermal demand. New spare capacity for future growth.
  - Less work required by cooling towers with higher CHWS temps (Fall/Winter/Spring). Note: We reset our CHWS temps because we are at our minimum pumping setpoint of 20 HZ, 24/7 operation.

Good Issues

Opportunity Cost

Def.: opportunity cost of a choice is the value of the best alternative forgone.

Question: What is the next initiative that is costing us money by not implementing?

- Implement central plant equipment dispatch control system (Spring 2014)
- Participate in FERC 745 – Economic Load Response (Summer 2014)
- Participate in FERC 755 – Frequency Response (Summer 2014)
- Retire larger 20 klb/hr boiler and replace with smaller modular boiler array for better steam following capacity at greater efficiencies. (Summer 2015)

Future Central Plant Initiatives

Rowan reduced energy consumption 25% by making what are now considered simple decisions on how we deliver Chilled Water.

We discovered, with the help of an engineered analysis and trial & error, the optimal setpoints that meet the NEEDS of our campus for each season.

Conclusion

Thank you

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Rowan University