Sustainable Energy Management

Case Study: Monroe County, FL Energy Retrofit Project

New Partners for Smart Growth
February 7, 2013

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Agenda

- Sustainable energy management
- Management systems
- Overview of ISO 50001 *Energy Management Systems*
- Case study: Monroe County, FL energy retrofit project
  - Examples of data analysis and monitoring using ISO 50001 methodology

Energy Management Issues

Fixed & uncontrollable overhead

Price Volatility

Not core business/mission

Crisis management

Technology is silver bullet

Short term perspective

Management systems are tools used to address these, and other issues

Sustainable Energy Management – Management System Perspective

Sustainable energy management is ***not*** a destination…..

it is a ***process***!

Management Systems

Quality – QMS
ISO 9001:2008 ***Quality Management Systems – Requirements***

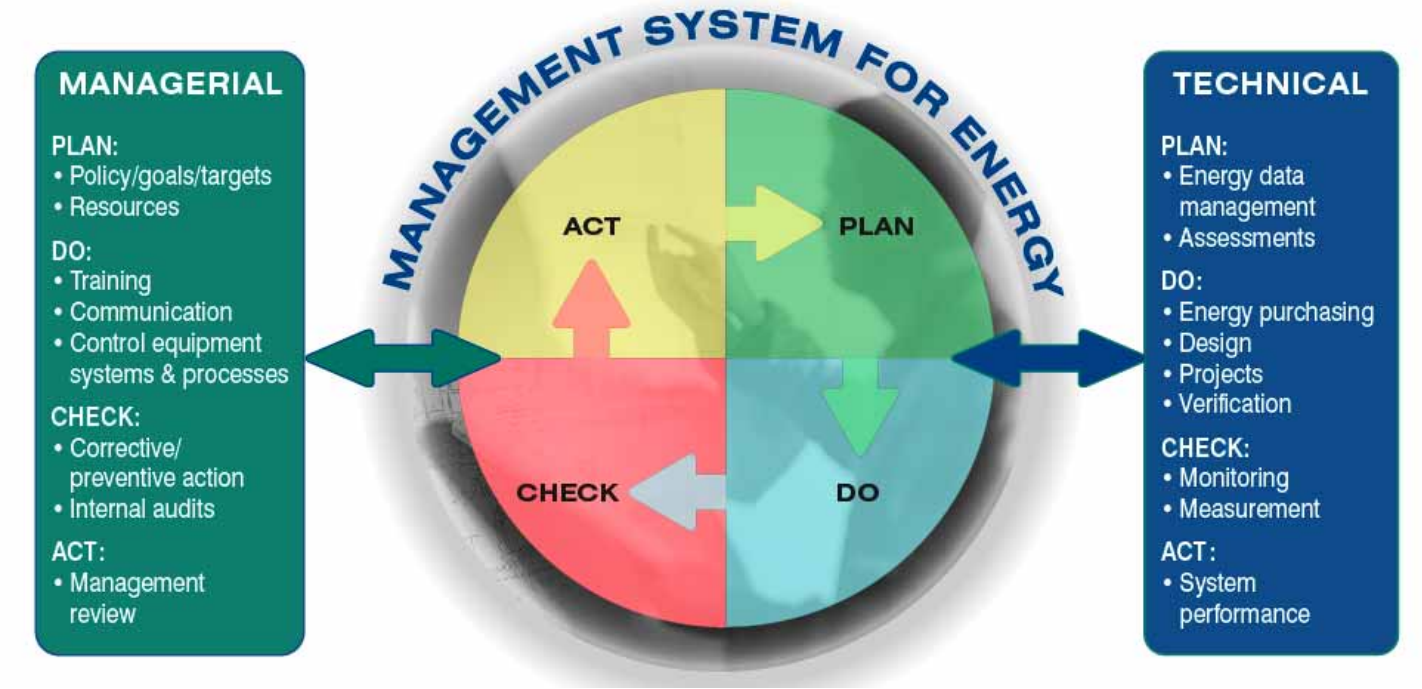
Environmental – EMS
ISO 14001:2004 ***Environmental Management Systems – Requirements with guidance for use***

Energy – EnMS
ANSI/MSE 2000:2008 ***Management System for Energy***

ISO 50001:2011 ***Energy Management Systems – Requirements with guidance for use***

Energy Management Systems – ANSI/MSE 2000, ISO 50001, others

A Management System for Energy provides an organized structure to incorporate Managerial and Technical elements to maximize benefits using the PLAN-DO-CHECK-ACT continuous improvement model.



Development of ISO 50001

- ISO appoints project committee PC 242 to develop standard
- The United States and Brazil are the Secretariat of PC 242
- There are 48 participating nations and 17 observing nations
- ISO 50001 published in June 2011
- PC 242 transitioned to a technical committee – TC 242

ANSI American National Standards Institute

BSI

First international meeting
September 2008 in Washington, DC

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ISO 50001 - Definitions

Boundaries – physical or site limits and/or organizational limits as defined by the organization

Energy Baseline – quantitative reference providing a basis for comparison of energy performance

Energy Use – manner or kind of application of energy

Energy Consumption – quantity of energy applied

Energy Efficiency – ratio or other quantitative relationship between an output of performance, service, goods or energy, and an input of energy

Energy Performance – measurable results related to energy efficiency, energy use and energy consumption

Energy Performance Indicator (EnPI) – quantitative value or measure of energy performance, as defined by the organization

Key Elements of an Energy Management System (EnMS)

- ***Energy policy*** top management's official statement of the organization's commitment to managing energy

- ***Cross-divisional management team*** led by a representative who reports directly to management and is responsible for overseeing the implementation of the energy management system

- ***Energy review*** to assess current and planned energy use, energy sources and consumption and identify *significant energy uses* and opportunities for improvement

- ***Baseline(s)*** of the organization's energy use

- ***Energy performance indicators*** **(EnPIs)** that are unique to the company and are tracked against the baseline to measure progress

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Key Elements of an Energy Management System

- ***Energy objectives and targets*** for energy performance improvement at relevant functions, levels, processes or facilities within an organization

- ***Action plans*** to meet those targets and objectives

- ***Operating controls and procedures*** for *significant energy uses*

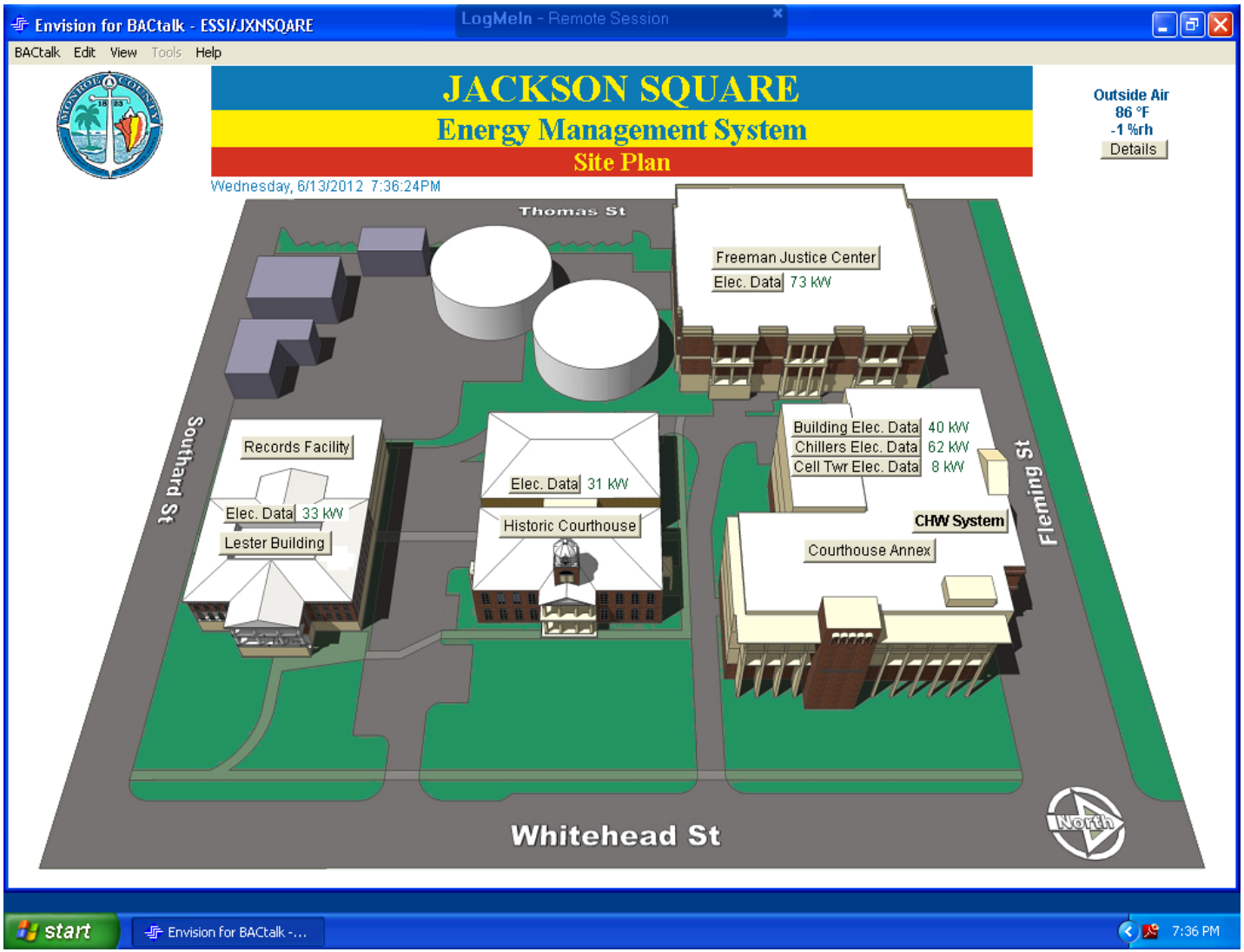
- ***Measurement, management, and documentation*** for continuous improvement for energy performance

- ***Internal audit of progress*** reported to management based on these measurements.

- ***Management review*** to determine the effectiveness of the EnMS and resulting energy performance improvements

Monroe County, FL - Energy Retrofit Project

- **Jackson Square, Key West**
- **4 buildings with an area of approximately 200,000 sq ft**
- **3 of the buildings are served by a central chilled water plant**
- **5 electric meters**
- **all systems operate 24/7**


Envision for BACtalk - ESSI/JXNSQARE
LogMeIn - Remote Session
BACtalk Edit View Tools Help
JACKSON SQUARE
Energy Management System
Site Plan
Wednesday, 6/13/2012 7:36:24PM
Outside Air
86 °F
-1 %rh
Details
Thomas St
Freeman Justice Center
Elec. Data 73 kW
Building Elec. Data 40 kW
Chillers Elec. Data 62 kW
Cell Twr Elec. Data 8 kW
CHW System
Courthouse Annex
Records Facility
Elec. Data 33 kW
Lester Building
Elec. Data 31 kW
Historic Courthouse
Southard St
Fleming St
Whitehead St
North
start
Envision for BACtalk -...
7:36 PM

Energy Sources - electricity

The chilled water plant accounts for 30% of the total consumption

Cooling (the chilled water plant) identified as a *significant energy use*

Building	Average Demand (kW)	Peak Demand (kW)	Energy (kWh)	Cost	Account Number	Meter Number
Chiller Plant	228	328	981,960	$ 131,826	1065003-00	E000069849
Jefferson Annex	78	90	467,680	$ 60,170	1065802-13	E000061561
Freeman Justice Center	145	150	752,760	$ 97,650	1065002-00	E000061558
Lester Building	143	160	653,520	$ 87,015	1065793-02	E000061504
Old Courthouse - Addition	95	108	468,840	$ 61,814	1065797-10	E000061559
Totals for Jackson Square			3,324,760	$ 438,474		

Project Selection Tool – (ECMs identified during audit - bundle ECMs to reach *target*)

Shaded cells are user input

Energy Conservation Measure	Demand Savings (kW)	Energy Savings (kWh)	Electric Cost Savings	CHW Savings (ton-hours)	CHW Cost Savings	Total Cost Savings	ECM Cost	Simple Payback (yr)
Lighting	17.9	140,228	$ 17,473	-	$ -	$ 17,473	$ 66,999	3.8
Chilled water plant	24.0	263,996	$ 32,668	-	$ -	$ 32,668	$ 285,000	8.7
Retro-commissioning-Controls	10.0	211,930	$ 24,885	231,832	$ 10,471	$ 35,356	$ 170,500	4.8
Motors - VFDs	13.0	34,598	$ 4,498	10,958	$ 495	$ 4,992	$ 28,338	5.7
Envelope	-	1,940	$ 220	8,650	$ 391	$ 610	$ 4,600	7.5
TOTALS	***64.9***	***652,692***	***$ 79,743***	***251,440***	***$ 11,357***	***$ 91,100***	***$ 555,437***	6.1

Ref No.	x	Building	Energy Conservation Measure	Description	Demand Savings (kW)	Energy Savings (kWh)	Electric Cost Savings	CHW Savings (ton-hours)	CHW Cost Savings	Total Cost Savings	ECM Cost	Simple Payback (yr)
1	x	Lester Building	Lighting	Lighting Retrofits	3.4	13,908	$ 1,882	-	$ -	$ 1,882	$ 7,873	4.18
2	x	Jefferson Annex	Lighting	Lighting Retrofits	13.0	120,578	$ 14,816	-	$ -	$ 14,816	$ 58,085	3.92
3	x	Freeman Justice Center	Lighting	Lighting Retrofits	1.4	5,741	$ 775	-	$ -	$ 775	$ 1,042	1.34
4		Old Courthouse	Lighting	Lighting Retrofits	-	-	$ -	-	$ -	$ -	$ -	-
5	x	Freeman Justice Center	Motors - VFDs	Prem motors & VFD	10.0	16,538	$ 2,319	10,958	$ 495	$ 2,814	$ 11,500	4.09
6	x	Freeman Justice Center	Retro-commissioning-Controls	Minimum OA schedule	-	1,420	$ 161	86,450	$ 3,905	$ 4,065	$ 7,500	1.84
7	x	Lester Building	Motors - VFDs	Prem motors & VFDs	3.0	18,060	$ 2,178	-	$ -	$ 2,178	$ 16,838	7.73
8	x	Chiller Plant	Chilled water plant	VFD on cooling tower fan	1.0	29,166	$ 3,599	-	$ -	$ 3,599	$ 8,950	2.49
9	x	Chiller Plant	Chilled water plant	VFDs on CHW pumps	2.9	58,332	$ 7,199	-	$ -	$ 7,199	$ 8,950	1.24
10		Chiller Plant	Retro-commissioning-Controls	Other ECM savings	-	-	$ -	-	$ -	$ -	$ -	-
11		Chiller Plant	Chilled water plant	Replace both chillers	-	-	$ -	-	$ -	$ -	$ -	-
12	x	Courthouse Annex	Retro-commissioning-Controls	Schedule AHU-1	-	13,286	$ 1,504	57,312	$ 2,589	$ 4,093	$ 1,000	0.24
13	x	Lester Building	Retro-commissioning-Controls	Demand controlled vent	-	36,450	$ 4,126	-	$ -	$ 4,126	$ 8,000	1.94
14	x	Lester Building	Retro-commissioning-Controls	Setback (6hours)	-	63,370	$ 7,173	-	$ -	$ 7,173	$ 7,000	0.98
15	x	Jefferson Annex	Retro-commissioning-Controls	Setback (6hours)	-	17,530	$ 1,984	26,220	$ 1,184	$ 3,169	$ 10,000	3.16
16	x	Old Courthouse	Retro-commissioning-Controls	Setback (6hours)	-	17,530	$ 1,984	21,850	$ 987	$ 2,971	$ 10,000	3.37
17	x	Old Courthouse	Retro-commissioning-Controls	Recommission water pumps	-	8,333	$ 943	-	$ -	$ 943	$ 2,000	2.12
18	x	Freeman Justice Center	Retro-commissioning-Controls	Setback (6hours)	-	19,011	$ 2,152	-	$ -	$ 2,152	$ 10,000	4.65
19	x	Freeman Justice Center	Envelope	Window film on west side	-	1,940	$ 220	8,650	$ 391	$ 610	$ 4,600	7.54
20		Jackson Square	Retro-commissioning-Controls	Additional controls-dashboard	-	-	$ -	-	$ -	$ -	$ -	-
21	x	Chiller Plant	Chilled water plant	Replace one chiller	20.2	176,497	$ 21,871	-	$ -	$ 21,871	$ 267,100	12.21
22	x	Lester Building	Retro-commissioning-Controls	Additional controls-dashboard	4.5	14,000	$ 1,987	-	$ -	$ 1,987	$ 46,000	23.15
23	x	Freeman Justice Center	Retro-commissioning-Controls	Additional controls-dashboard	4.5	8,750	$ 1,393	16,000	$ 723	$ 2,115	$ 23,000	10.87
24	x	Old Courthouse	Retro-commissioning-Controls	Additional controls-dashboard	-	3,500	$ 396	8,000	$ 361	$ 758	$ 17,250	22.77
25	x	Jefferson Annex	Retro-commissioning-Controls	Additional controls	1.0	8,750	$ 1,080	16,000	$ 723	$ 1,803	$ 28,750	15.95

Life Cycle Cost Analysis – NIST Handbook 135

Also calculates the greenhouse gas emissions reduction resulting from energy savings

Location:	Jackson Square - Key West, FL
ECMs:	Lighting retrofits - chilled water plant retrofits - retro-commissioning motors and VFDs - envelope modifications
Bldgs:	Lester Building - Jefferson Annex - Freeman Justice Center - Old Courthouse - Chiller Plant

INVESTMENT COSTS

Construction:	$ 555,437	
Supervision:	$ -	0.0%
Design - Contingency:	$ -	
Salvage		
Total Investment:	**$ 555,437**	

Economic Parameters

Base Year:	2,011
Discount Rate:	3.0%
Region:	3
Project Life:	15

ENERGY SAVINGS (COSTS)

	Units	Average Cost per Unit	Annual Reduction	Annual Energy Savings (MMBtu)	Annual Cost Savings	Discount Factor	Life-Cycle Discounted Savings
Electricity	kWh	$ 0.1210	753,016	2,570	$ 91,100	11.610	$ 1,057,668
Gas	ccf	$ -	-	-	$ -	-	$ -
Fuel Oil	gallon	$ -	-	-	$ -	-	$ -
				2,570	$ 91,100		$ 1,057,668

ECONOMIC METRICS

Total Investment	$ 555,437	*Total Investment*	$ 555,437
Annual Energy Savings:	$ 91,100	Discounted Energy Savings:	$ 1,057,668
Annual Non-Energy Savings:		Discounted Non-Energy Savings:	$ -
Total Annual Savings:	$ 91,100	*Total Discounted Savings:*	$ 1,057,668
Simple Payback (years):	***6.10***	***Savings To Investment Ratio:***	***1.90***

Total Site Annual Energy Savings (MMBtu): 2570

Energy Savings to Investment: ***4.63*** ***MMBtu/($1,000)***

Adjusted Internal Rate of Return

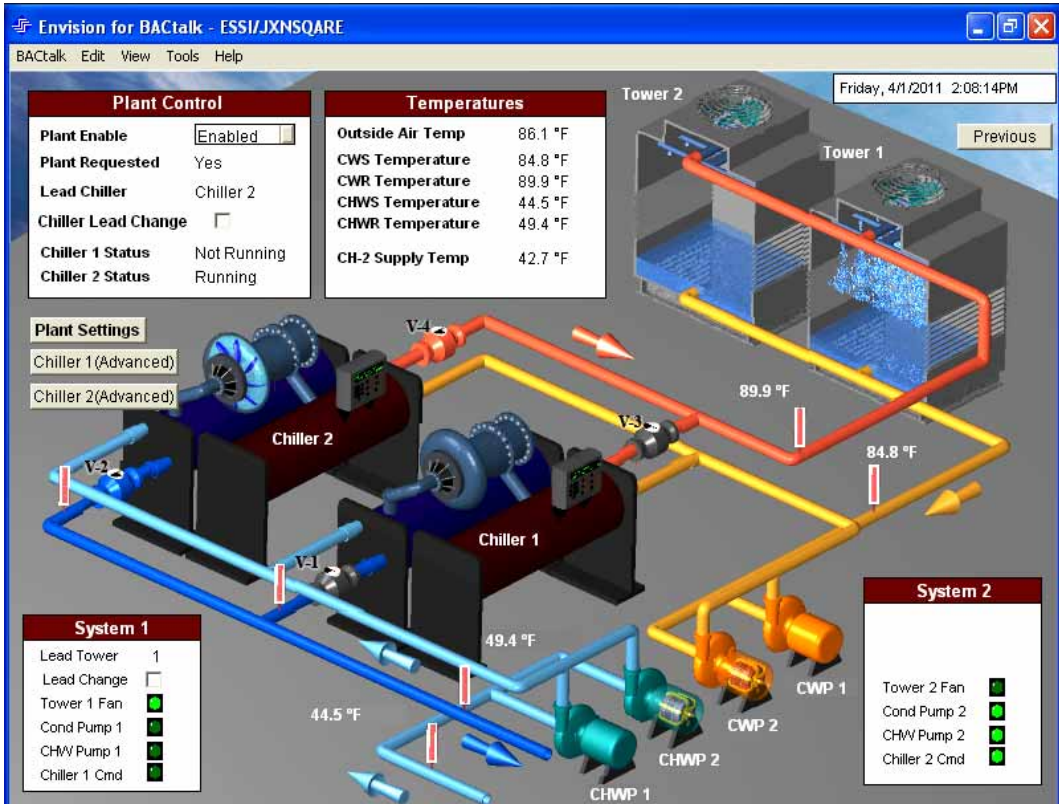
AIRR: **7.5%**

Baseline Greenhouse Gas Emissions

Energy Type	Unit	Quantity	Energy (MMbtu)	MT CO2	kg CH4	kg N2O	MT CO2e
Electricity	kWh	753,016	2,570	450	16	6	453
Natural Gas	ccf	-	-	-	-	-	-
Fuel Oil #2	US gall.	-	-	-	-	-	-
Propane	US gall.	-	-	-	-	-	-
	Totals		2,570	450	16	6	453

Example ECM – Central Chiller Plant

During an interview with the Director of Public Works, he expressed his primary concern was the sustainability of the chilled water system during a power outage.



Existing Situation

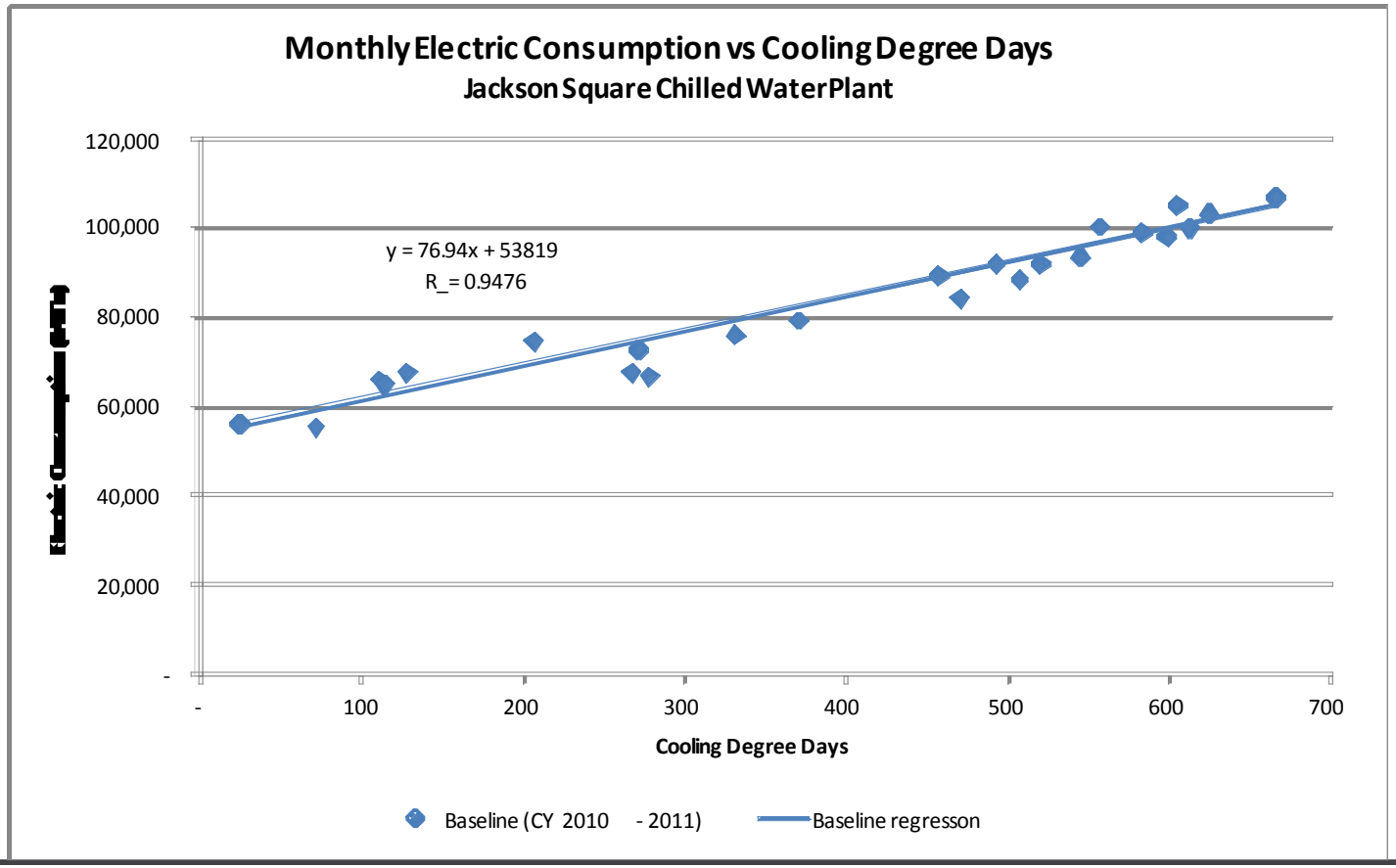
- 24/7 operation
- Serves key buildings
- Reliability critical
- Constant speed chillers, pumps, tower fans
- *Emergency generator not able to start system*

Measurement & Verification – Monitoring Performance

Energy Baseline is a linear regression model with independent variables:

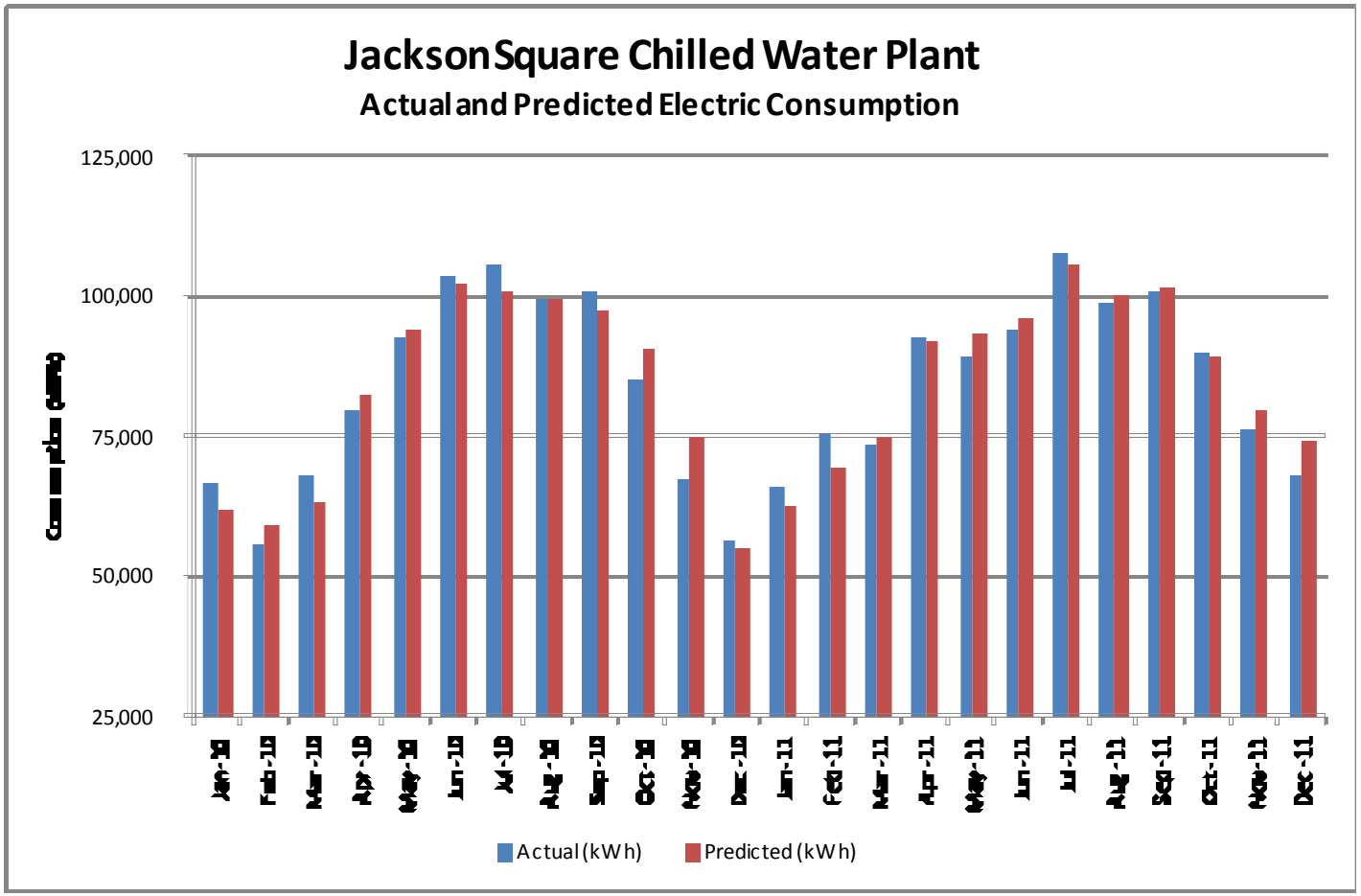
CDD – Cooling Degree Days

NOD – Number of Days in billing cycle



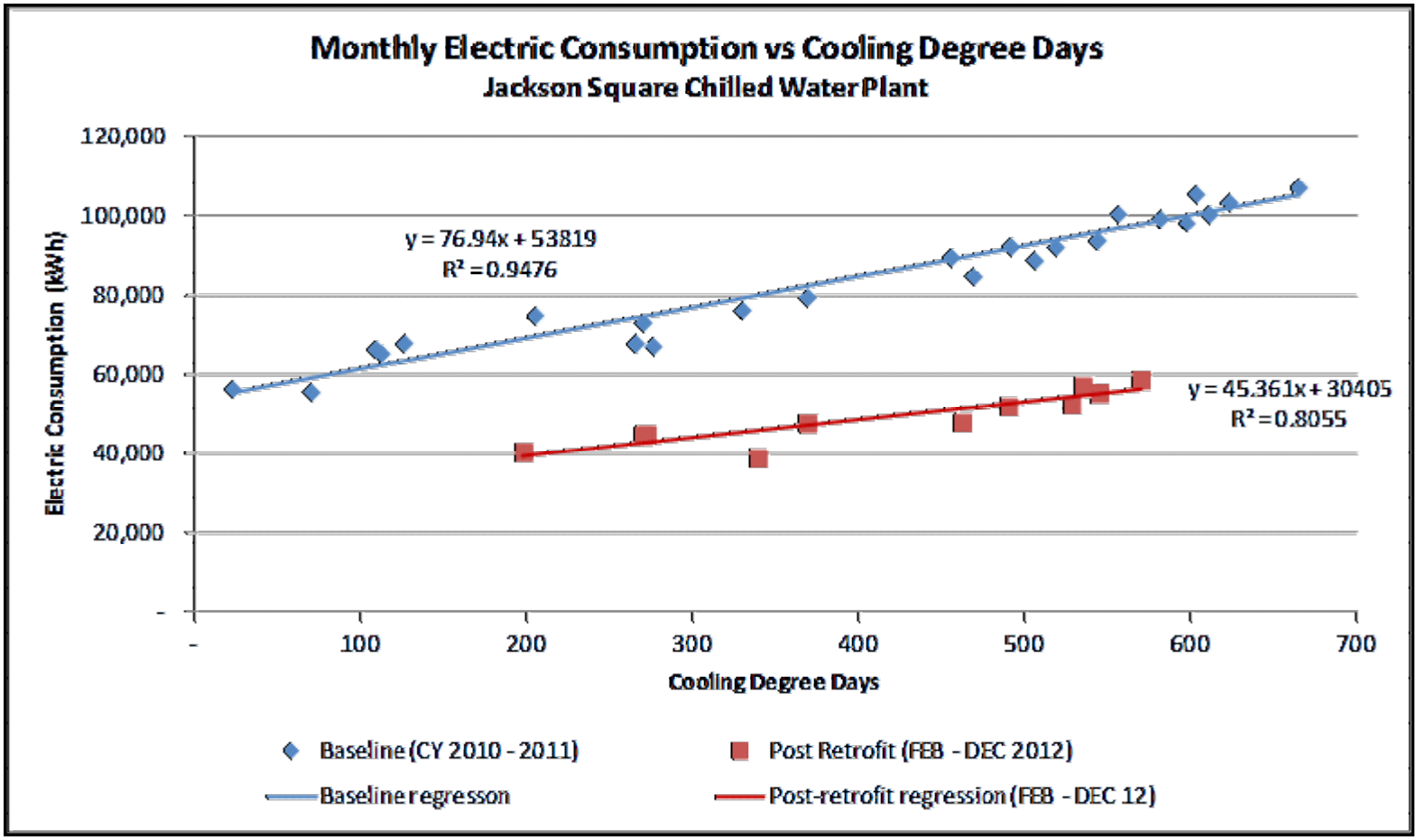
Measurement & Verification – Baseline Period

Trend plot of Actual and Predicted energy consumption



Measurement & Verification – Option C, Whole Building

Post retrofit performance

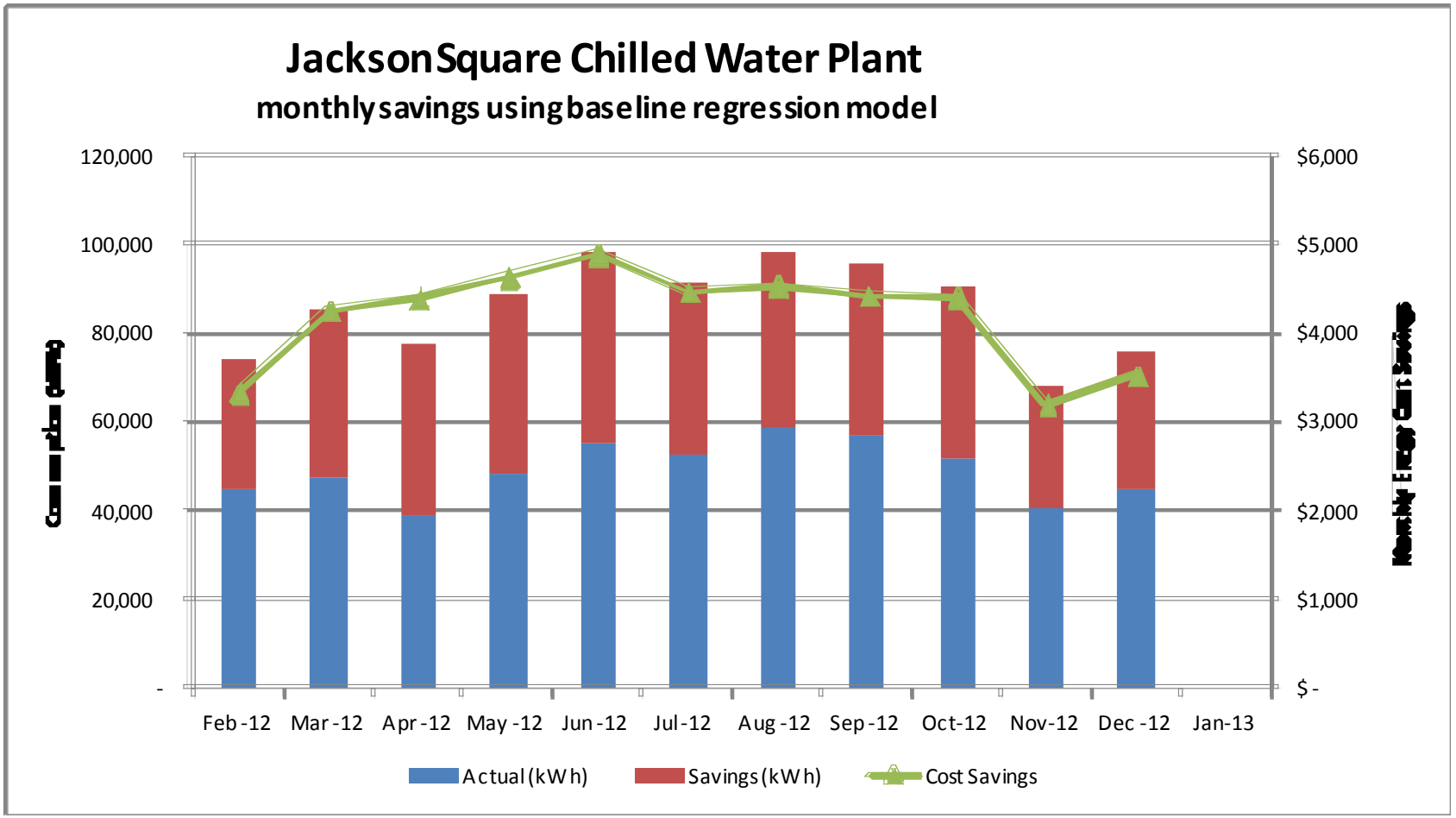


Baseline Model Used to Calculate Savings from Project

Jackson Square Energy Project Savings at CHW Plant

Month	NOD	CDD	Predicted *Baseline* (kWh)	Actual (kWh)	Savings (kWh)	Cost Savings	Percent Savings
Feb-12	30	272	74,197	45,000	29,210	$ 3,337	39%
Mar-12	32	369	85,110	47,880	37,244	$ 4,255	44%
Apr-12	29	339	77,488	39,000	38,501	$ 4,399	50%
May-12	30	462	88,620	48,120	40,512	$ 4,629	46%
Jun-12	32	545	98,465	55,680	42,798	$ 4,890	43%
Jul-12	29	528	91,822	52,680	39,142	$ 4,472	43%
Aug-12	31	570	98,578	58,920	39,658	$ 4,531	40%
Sep-12	31	535	95,921	57,240	38,681	$ 4,419	40%
Oct-12	30	490	90,721	52,200	38,521	$ 4,401	42%
Nov-12	30	198	68,552	40,560	27,992	$ 3,198	41%
Dec-12	31	270	75,802	44,880	30,922	$ 3,533	41%
Jan-13							
To Date	***335***	***4,579***	***945,277***	***542,160***	***403,181***	***$ 46,064***	***43%***

Baseline Regression Mode – Determining Energy Savings



Post-Retrofit Regression to Monitor System Performance –

Introduce Energy Performance Indicator (EnPI)

EnPI = (Actual/Predicted) consumption

Jackson Square CHW Plant Post-Retrofit EnPI

Month	NOD	CDD	Predicted *Post-retofit* (kWh)	Actual (kWh)	EnPI *(post-retrofit)*
Feb-12	30	272	42,625	45,000	1.06
Mar-12	32	369	48,863	47,880	0.98
Apr-12	29	339	44,485	39,000	0.88
May-12	30	462	50,834	48,120	0.95
Jun-12	32	545	56,463	55,680	0.99
Jul-12	29	528	52,642	52,680	1.00
Aug-12	31	570	56,514	58,920	1.04
Sep-12	31	535	55,002	57,240	1.04
Oct-12	30	490	52,029	52,200	1.00
Nov-12	30	198	39,413	40,560	1.03
Dec-12	31	270	43,552	44,880	1.03
Jan-13					
To Date	***335***	***4,579***	***542,423***	***542,160***	***1.00***

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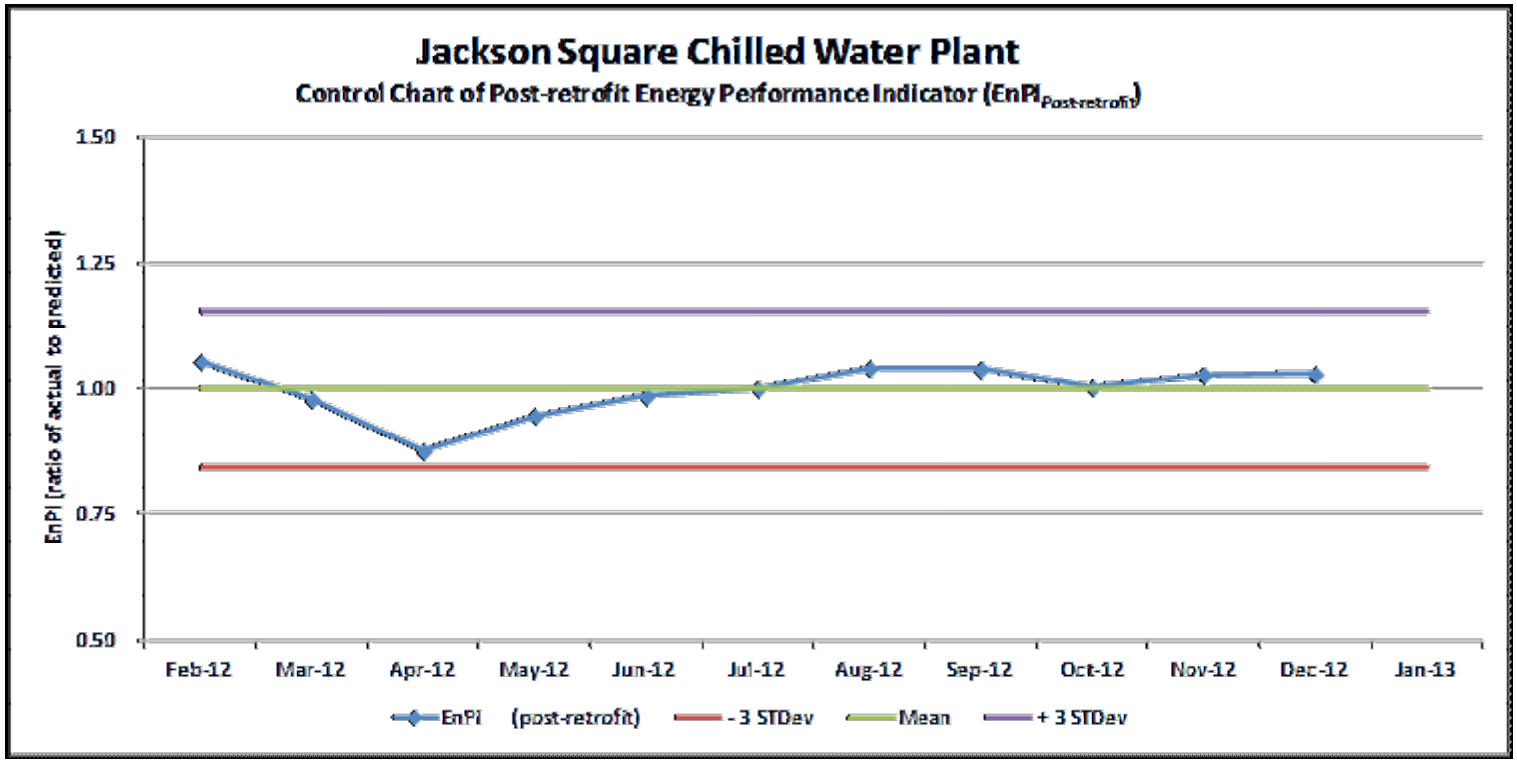
Monitor Performance with EnPI Control Chart



Summary

- **Sustainable Energy Management is a continual process**

- **Management Systems provide a framework using the Plan-Do-Check-Act process**

- **Quantitative tools provide a means to ensure continued *energy performance***

Thank You!

Questions

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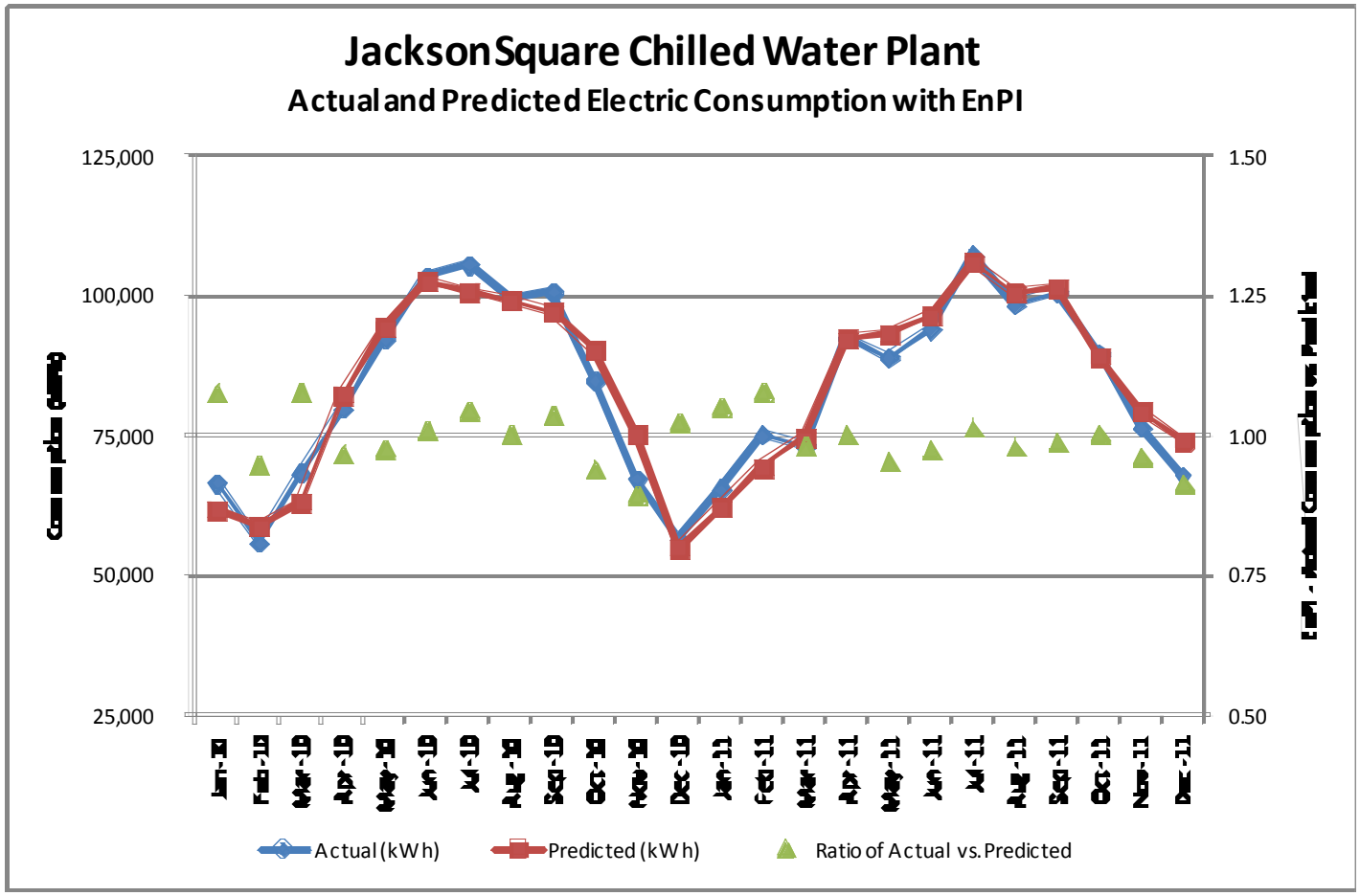
CEM, CP EnMS-Industrial
Energy Services Technical Director – EB
816-360-2739

BACKUP SLIDES

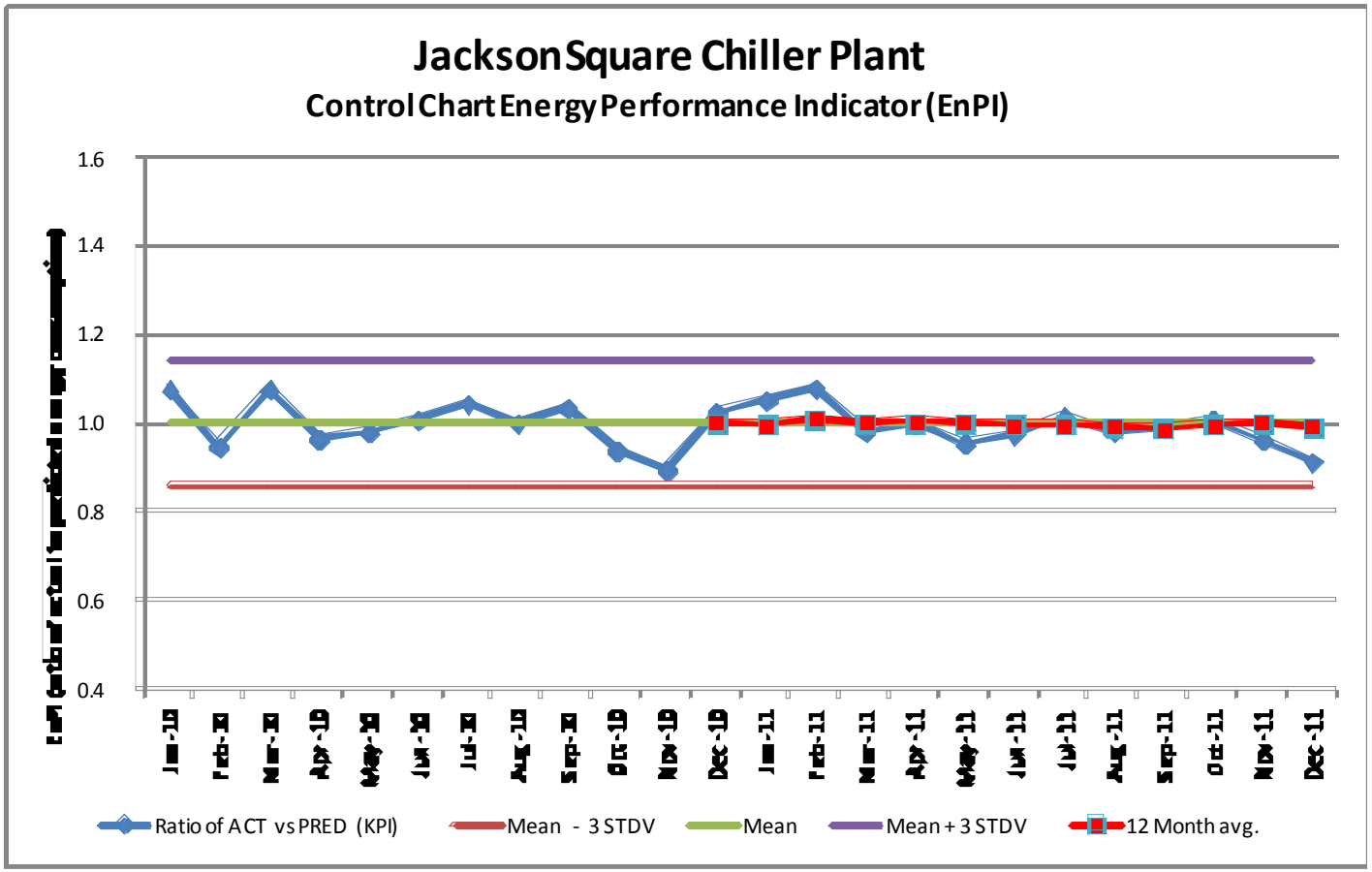
Baseline Period Trend Plot

Addition of Energy Performance Indicator (EnPI) – (Actual/Predicted)



Measurement & Verification – Baseline Period

Control chart of EnPI



Solution

Replace chiller with unit using frictionless compressors

•Technology uses magnetic bearings which eliminates friction

- System is run without oil in the refrigerant
- Very good efficiency over a range of loading – low NPLV
- Quiet operation
- Multiple chiller manufacturers incorporate these compressors

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Energy Project Implementation

Investment Grade Audit
(identify ECMs)

Project Development
(bundle ECMs into project)

Measurement & Verification

Investment Grade Audit – Project Development

Collect and review background information

Site investigation

Analysis of Energy Conservation Measures (ECM)

Develop list of viable ECMs

Develop energy project within budget constraints

Background Information

Building plans

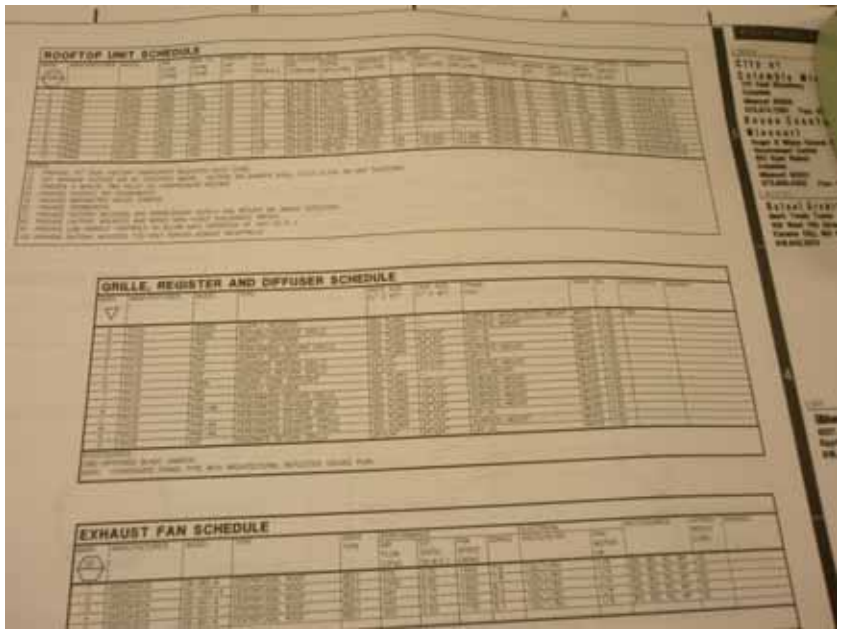
Past energy studies

Bing.com/maps views

Master plan information

Utility bills

Utility tariffs



Utility Rate Analysis

- **Time of use - Demand vs. Energy Charge - Ratchets**
- **Identify Proper Rate** ***(Is there a minimum demand charge, ratchet, power factor penalty, declining block, etc.?)***

What is the annual cost to run 10, 100 watt lighting fixtures?
It depends on <u>when</u> and <u>where</u>.

Incremental Cost of 1 kW
(10 hours per weekday)

Utility	Daytime	Nighttime
KCPL	$ 156.39	$ 98.97
SCE	$ 483.24	$ 171.43

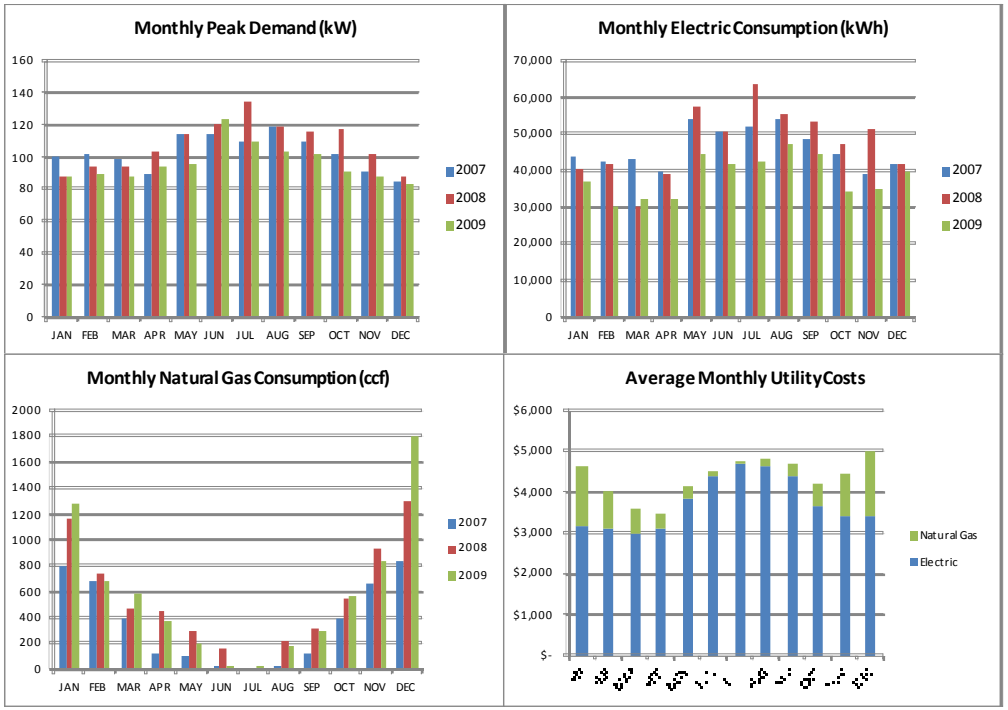
Sample Utility Bill Analysis

HDR's Analysis Includes:

- Energy consumption by by units of billing
- Energy consumption in in common units of energy
- Energy costs
- Index of energy consumption and energy cost by area
- Baseline development (by averaging or regressions)
- Green house gas baselines
- Weather correlations

Health Department 29,740 sq ft

Year	Peak Demand (kW)	Electric (kWh)	Natural Gas (ccf)	Electric (kBtu)	Natural Gas (kBtu)	Total Energy (kBtu)	Electric Cost	Natural Gas Cost	Total Cost	ECI (kBtu/sqft/yr)	Cost Index ($/sqft/yr)
2007	118.8	554,760	4,197	1,893,396	432,291	2,325,687	$ 42,862	$ 5,207	$ 48,069	78.20	$ 1.62
2008	134.4	575,040	6,620	1,962,612	681,860	2,644,472	$ 48,078	$ 9,197	$ 57,275	88.92	$ 1.93
2009	123.6	462,840	6,908	1,579,673	711,524	2,291,197	$ 43,690	$ 8,316	$ 52,005	77.04	$ 1.75



Three year averages

Month	Demand (kW)	Energy (kWh)	Natural Gas (ccf)	Electric Cost	Natural Gas Cost	Total Cost
JAN	92.4	40,480	1,081	$ 3,201	$ 1,421	$ 4,621
FEB	95.6	38,520	708	$ 3,124	$ 931	$ 4,055
MAR	93.6	35,440	488	$ 2,979	$ 637	$ 3,615
APR	96.4	37,200	319	$ 3,109	$ 399	$ 3,508
MAY	108.4	52,160	197	$ 3,874	$ 262	$ 4,136
JUN	120.0	47,800	68	$ 4,401	$ 123	$ 4,524
JUL	118.4	52,680	21	$ 4,690	$ 53	$ 4,743
AUG	114.0	52,480	147	$ 4,624	$ 218	$ 4,842
SEP	109.2	48,960	252	$ 4,379	$ 343	$ 4,721
OCT	103.6	42,080	501	$ 3,657	$ 578	$ 4,235
NOV	94.0	41,840	813	$ 3,440	$ 1,020	$ 4,460
DEC	85.6	41,240	1,314	$ 3,399	$ 1,590	$ 4,989
TOTALS		530,880	5,908	$ 44,876	$ 7,573	$ 52,450

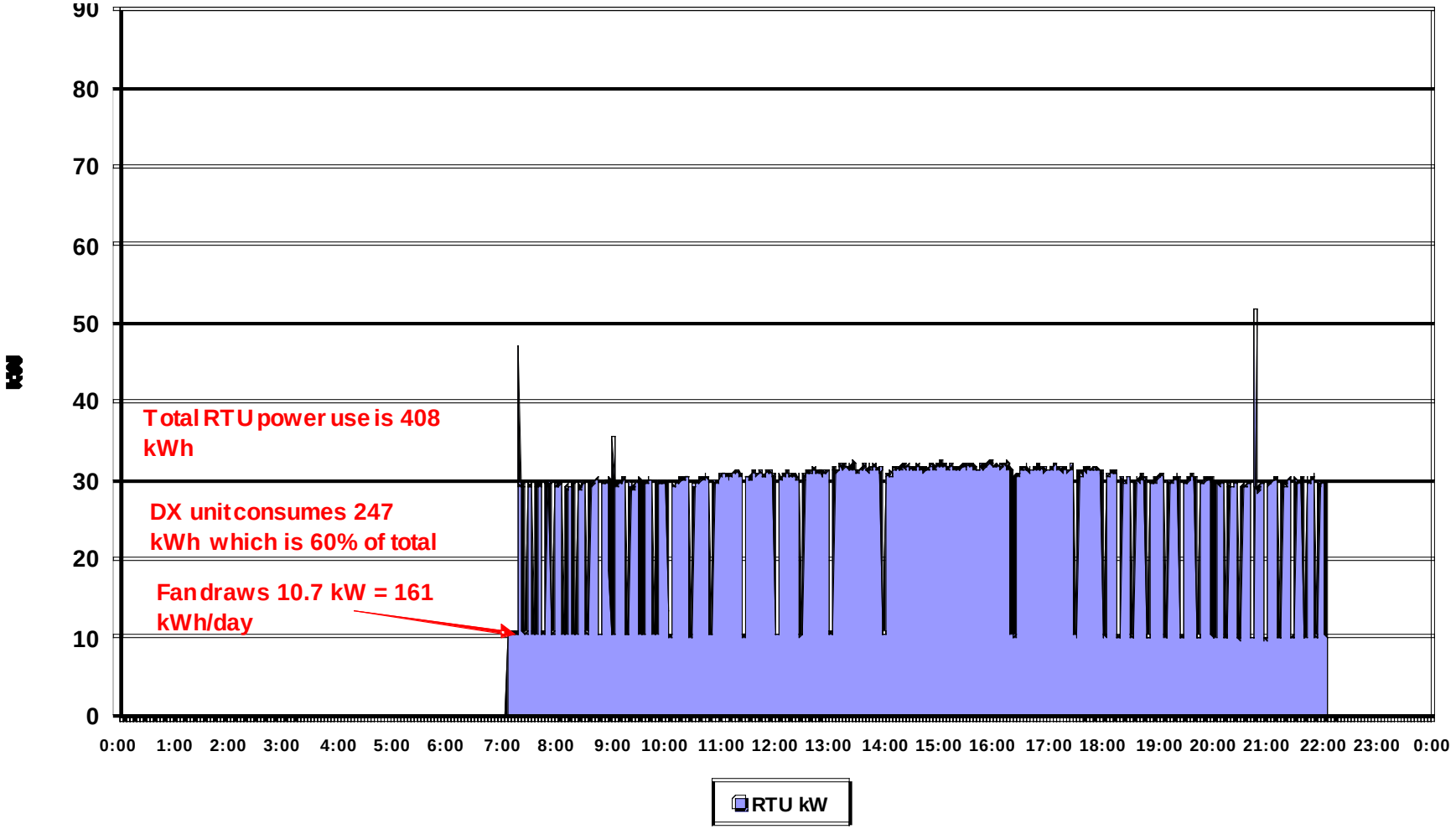
Greenhouse Gas Emissions
475.3 MtCO2e/year
472.8 MtCO2/year
8.3 kg CH4
7.5 kg N20

Weather Correlations
Natural Gas Use vs. HDD (base 65 F)
Rsquared = *0.838*
Electric Use vs. CDD (base 65 F)
Rsquared = *0.421*

Site Investigation

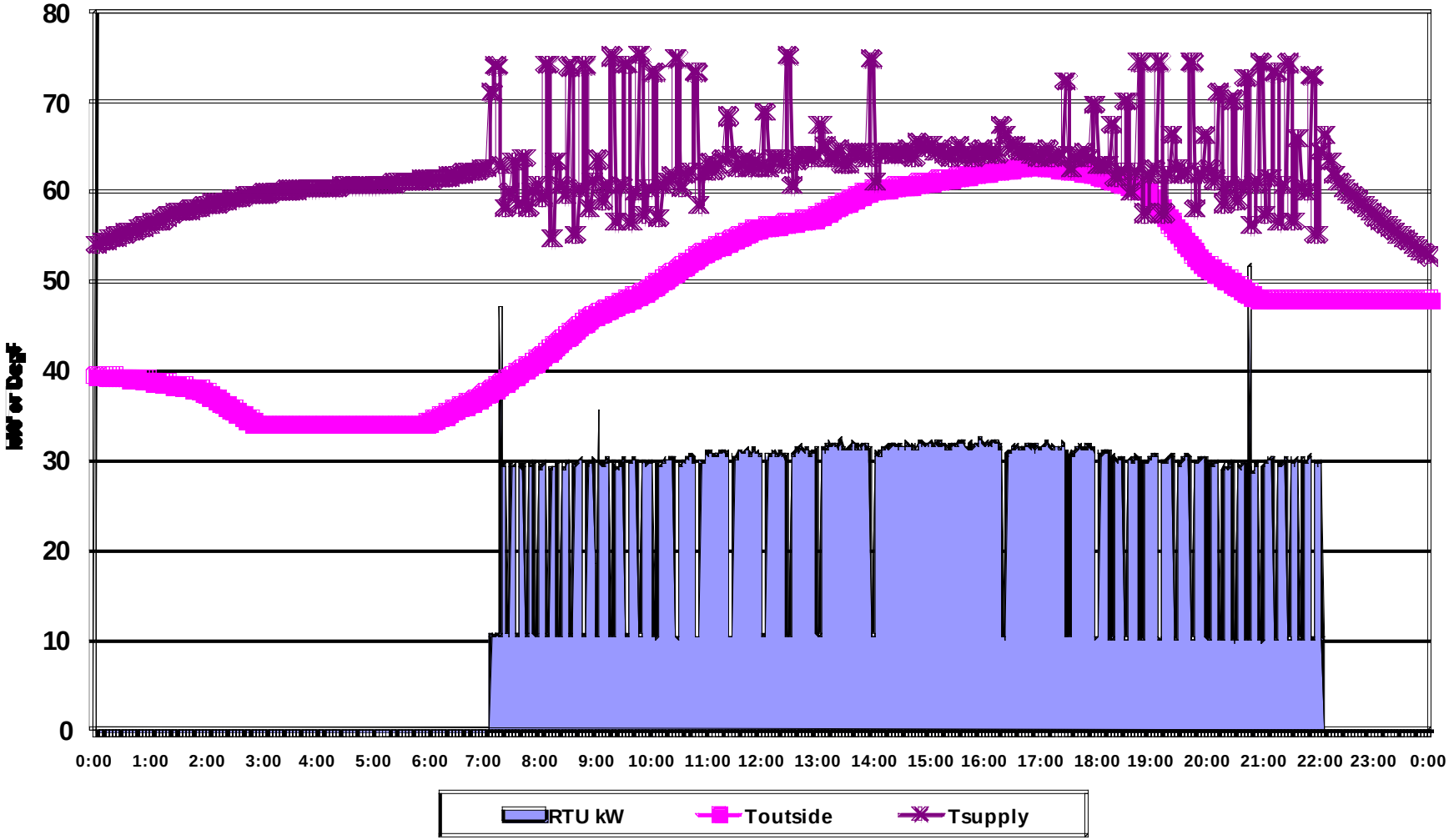
- **Interviews with building occupants – facility staff**
  - Determine proper schedules and operating conditions
  - Identify chronic problems
- **Gather information on relevant systems**
  - Envelope
  - Mechanical and electrical
  - Lighting
- **Measurements (light levels, amp draw, temperature, etc.)**
  - One time – trend logging

Trend Data Example – Rooftop unit with variable air flow & economizer

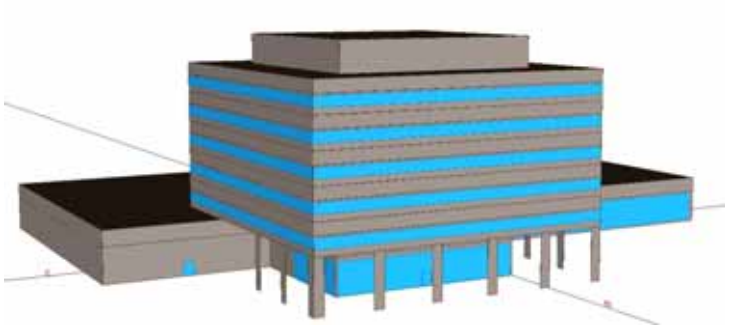


Trend Data Example – Rooftop unit with variable air flow & economizer

The RTU consumed 408 kWh at a cost of $27.52. This consisted of $10.83 for the fan and $16.69 for the DX unit.



Energy Conservation Measure Analysis



Varying levels of analysis available based on the complexity of the ECM

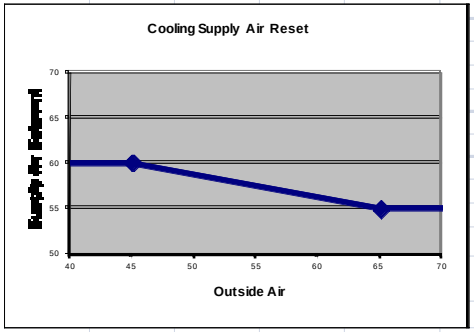
- Engineering calculations (lighting, constant loads, etc.)

$kWh_{saved} = (kW_{old} - kW_{new}) * (hours\ of\ operation)$

- Bin calculations (simple calculations that vary by outside temperature)
- Whole building energy simulation (eQUEST - FEDS)

Sensible Cooling Savings from Dry-Bulb Economizer

input cells

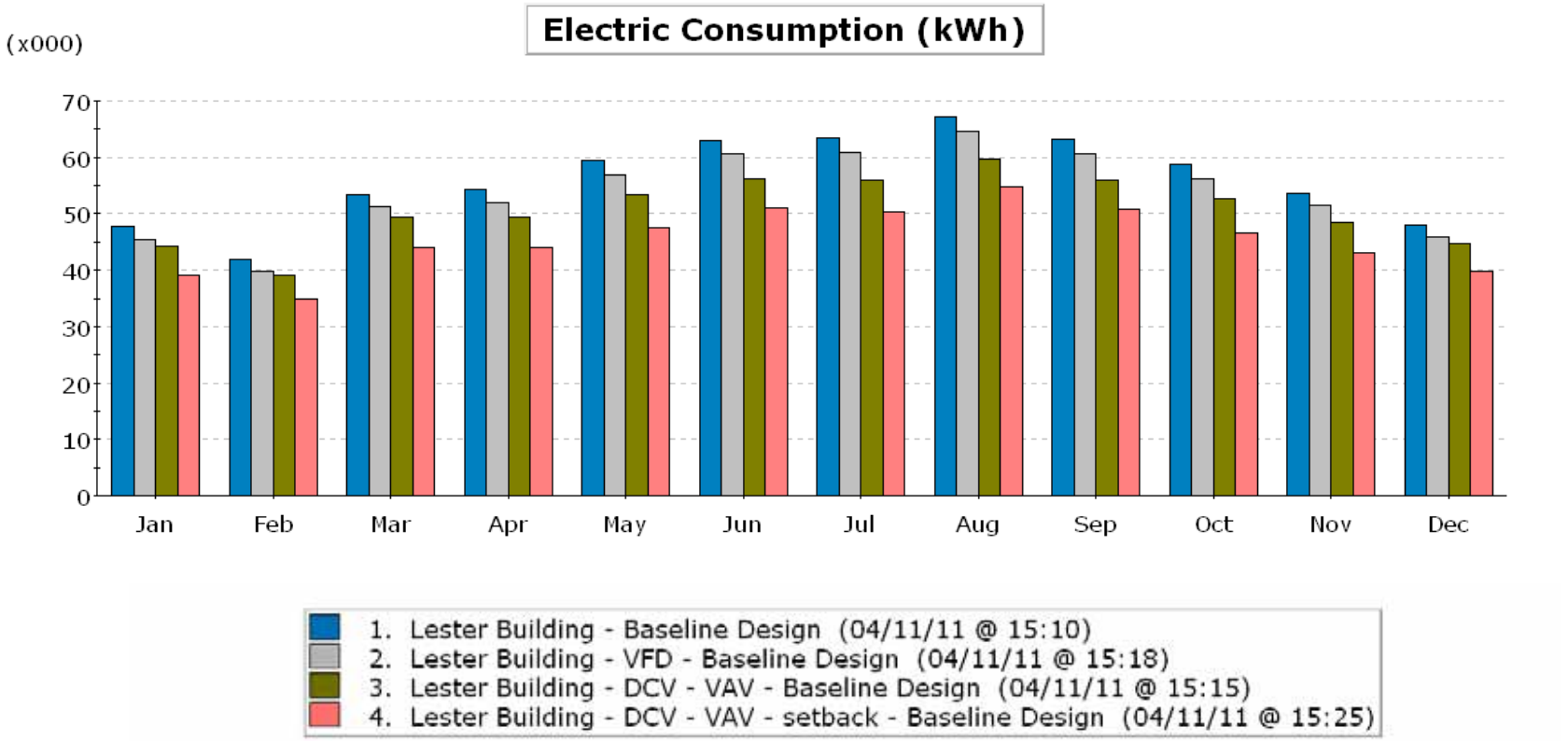


INPUTS	
OA	SA
45	60
65	55
10%	Fixed OA Flow
75	Return Air Temperature
10,000	CFM
1.1	Cooling kW/ton
$ 0.09	Avg cost per kWh

RESULTS		
Saved Ton-hr	Saved kWh	Saved kWh Cost
68,793	*75,672*	*$ 6,810*

Mid-Bin Temp	Hours	MAT w/ Fixed OA	MAT w/ Econ	MAT difference	Saved Sensible Cooling (Btuh)	Saved Total Sensible (ton-hr)	Saved kWh for Cooling	Saved kWh Cost
112.5	5	78.8	78.8	0.0	0	0	0	$ -
107.5	75	78.3	78.3	0.0	0	0	0	$ -
102.5	206	77.8	77.8	0.0	0	0	0	$ -
97.5	351	77.3	77.3	0.0	0	0	0	$ -
92.5	415	76.8	76.8	0.0	0	0	0	$ -
87.5	488	76.3	76.3	0.0	0	0	0	$ -
82.5	796	75.8	75.8	0.0	0	0	0	$ -
77.5	757	75.3	75.3	0.0	0	0	0	$ -
72.5	824	74.8	74.8	0.0	0	0	0	$ -
67.5	646	74.3	54.4	19.9	218,625	11,769	12,946	$ 1,165
62.5	1,000	73.8	55.6	18.1	199,375	16,615	18,276	$ 1,645
57.5	848	73.3	56.9	16.4	180,125	12,729	14,002	$ 1,260
52.5	884	72.8	58.1	14.6	160,875	11,851	13,036	$ 1,173
47.5	674	72.3	60.0	12.3	134,750	7,568	8,325	$ 749
42.5	397	71.8	60.0	11.8	129,250	4,276	4,704	$ 423
37.5	261	71.3	60.0	11.3	123,750	2,692	2,961	$ 266
32.5	98	70.8	60.0	10.8	118,250	966	1,062	$ 96
27.5	31	70.3	60.0	10.3	112,750	291	320	$ 29
22.5	4	69.8	60.0	9.8	107,250	36	39	$ 4
		0.0	0.0	0.0	0	0	0	$ -

Energy Modeling



Project Development

Live demonstration of Project Selection Tool with Life Cycle Cost

Measurement and Verification

International Performance Measurement and Verification Protocol IPMVP

Identifies 4 M&V Options

Option A – Partially Measured Retrofit Isolation

- Used when savings can be determined by short-term data collection, engineering calculations and stipulated factors.
- Usually pre- and post- retrofit measures
- Good application are loads that are constant and have a defined schedule
- Examples include:
  - One for one lighting retrofits
  - Replacing standard efficiency motors with premium efficiency

Measurement and Verification

Option B – Retrofit Isolation

- Generally done at the system level
- Requires continuous measurement to provide long term savings verification
- Best practice is to monitor before and after retrofit
- Examples include:
  - Replacement chiller (monitor the performance metric of kW/ton)
  - Variable frequency drive on pump or fan motors
  - Boiler replacement (monitor efficiency – output versus input)

Option C – Whole Facility Energy Usage

- Savings based on actual consumption as measured by the utility meter
- Savings determined from utility bills and/or regression models
- Used when multiple ECMs are present with high interaction

Measurement and Verification

Option D – Calibrated Simulation

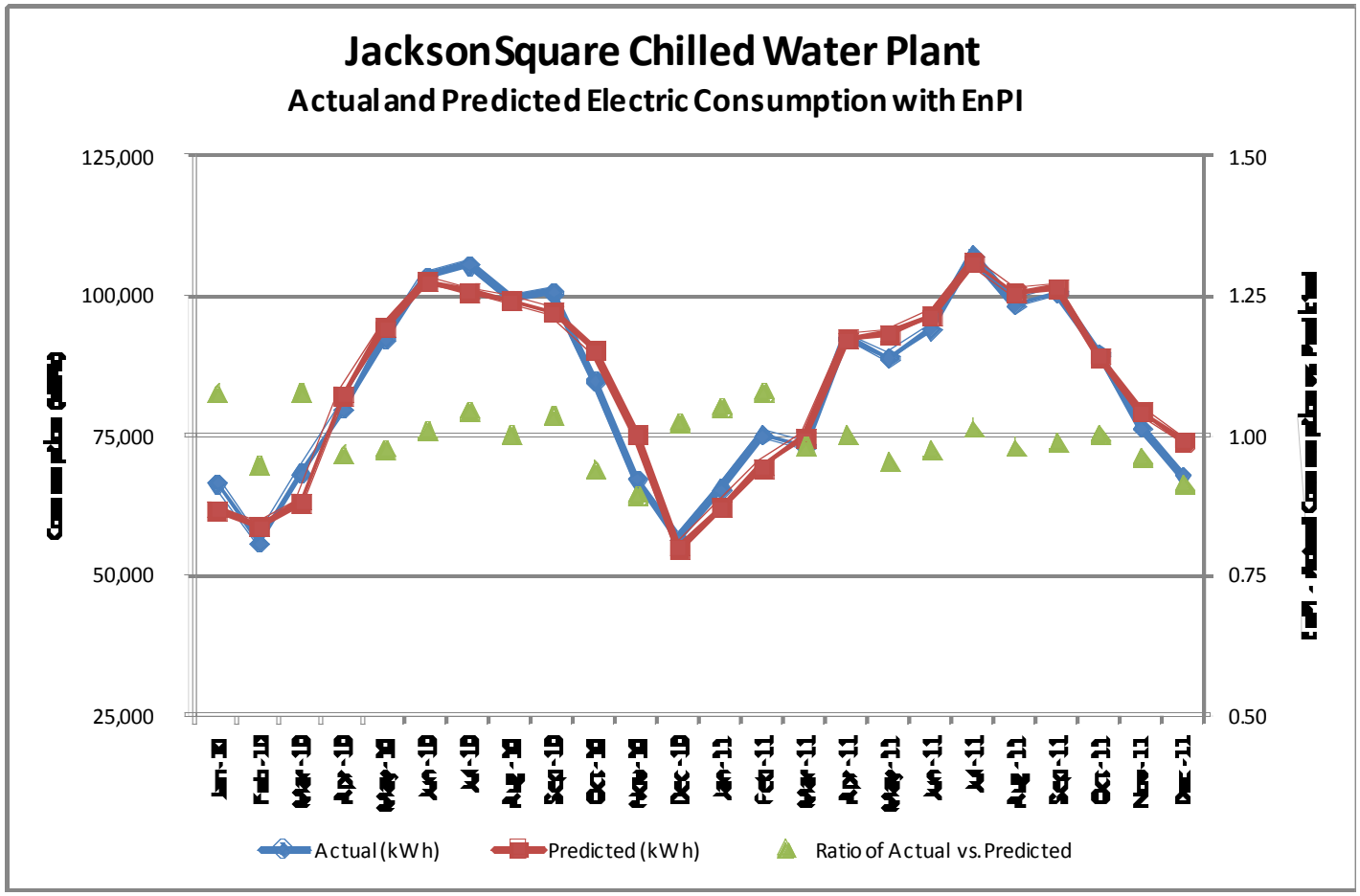
- Primarily a whole-building method but can be used at the system level
- Savings based on the results of a calibrated model
- Linking simulation inputs to baseline and post-installation conditions completes the calibration
- Requires considerable expertise to calibrate models

We will now take a look at some of the energy analysis and M&V used for the Monroe County, FL project. Although calibrated models were used to determine the savings for some ECMs, the M&V methodology chosen was Option C – Whole Facility Energy Use

HDR

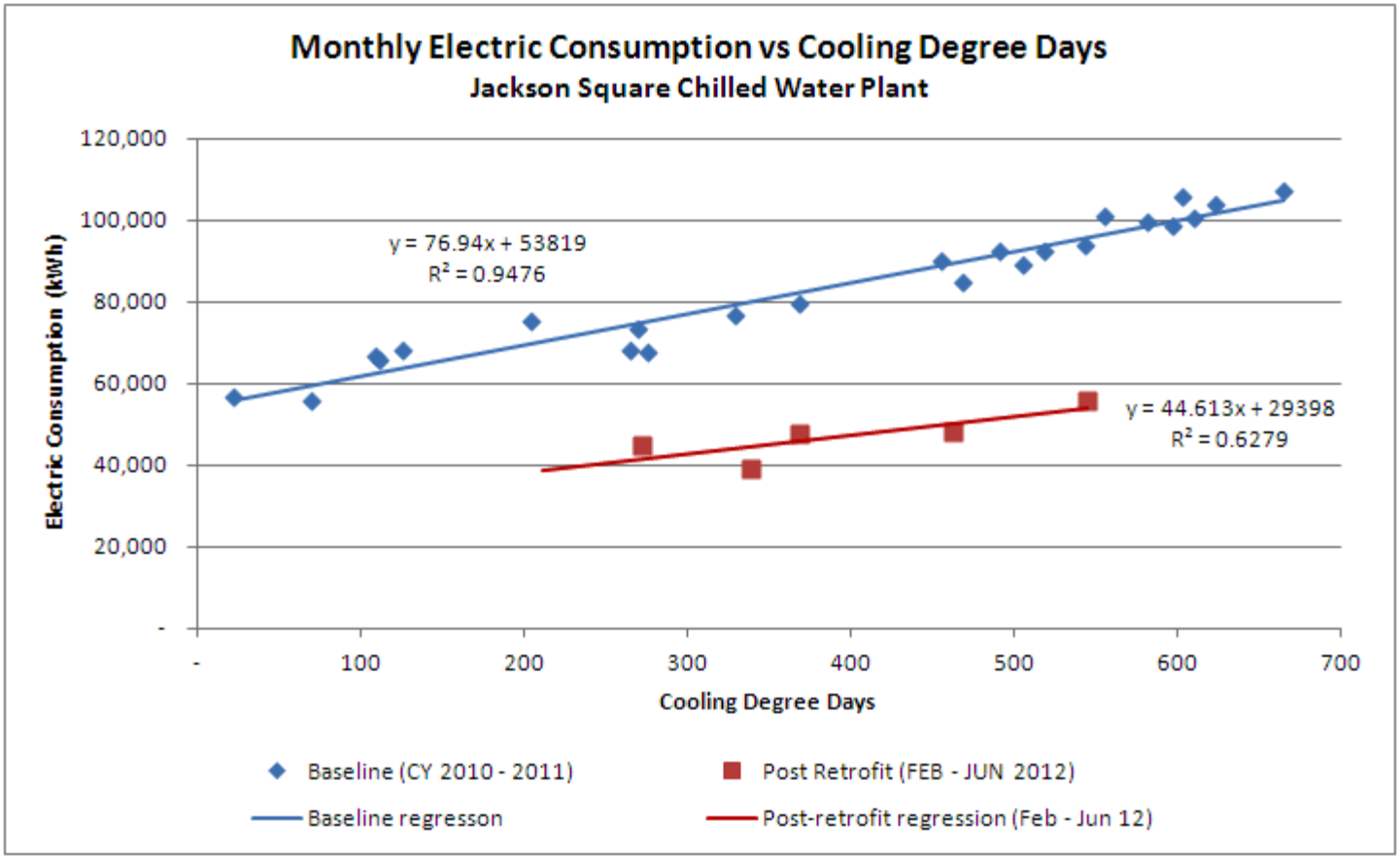
Measurement & Verification – Baseline Period

Trend plot of Actual and Predicted energy consumption with EnPI

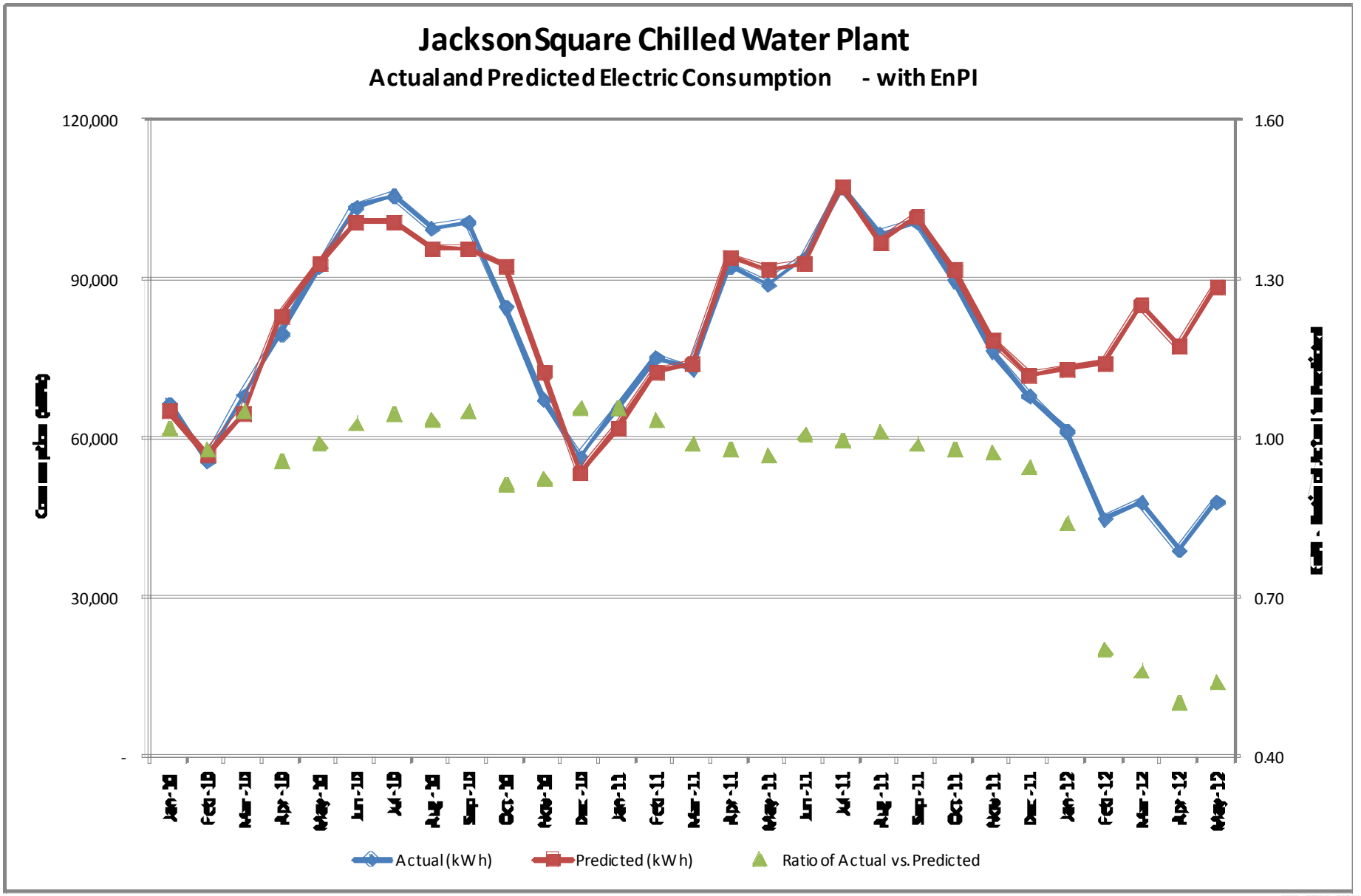


Monitoring Future Performance

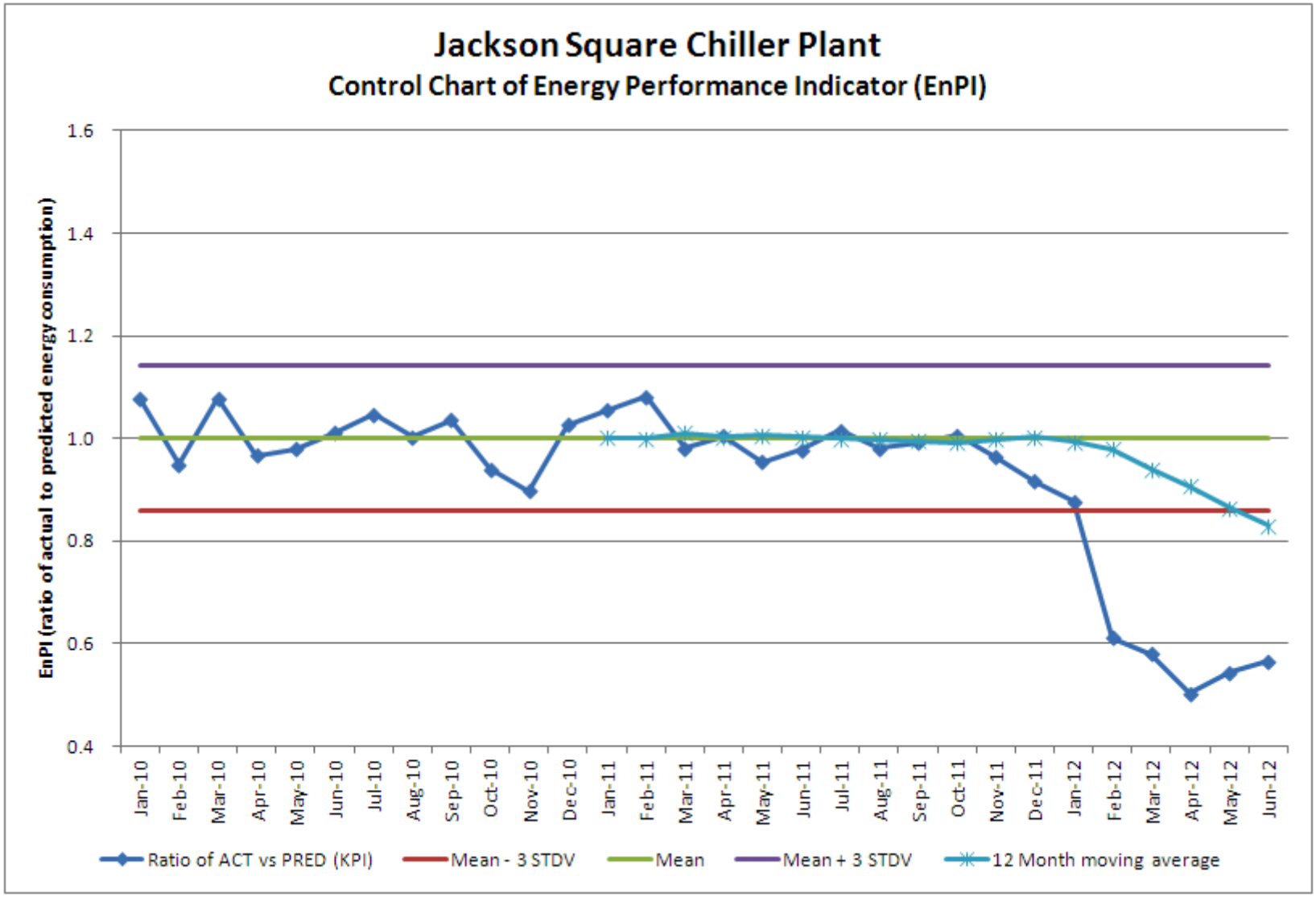
- **Continue to use the original baseline model to track savings attributed to the project**
- **The Post-retrofit baseline model can be used to monitor performance**



Incorporating an Energy Performance Indicator (EnPI)



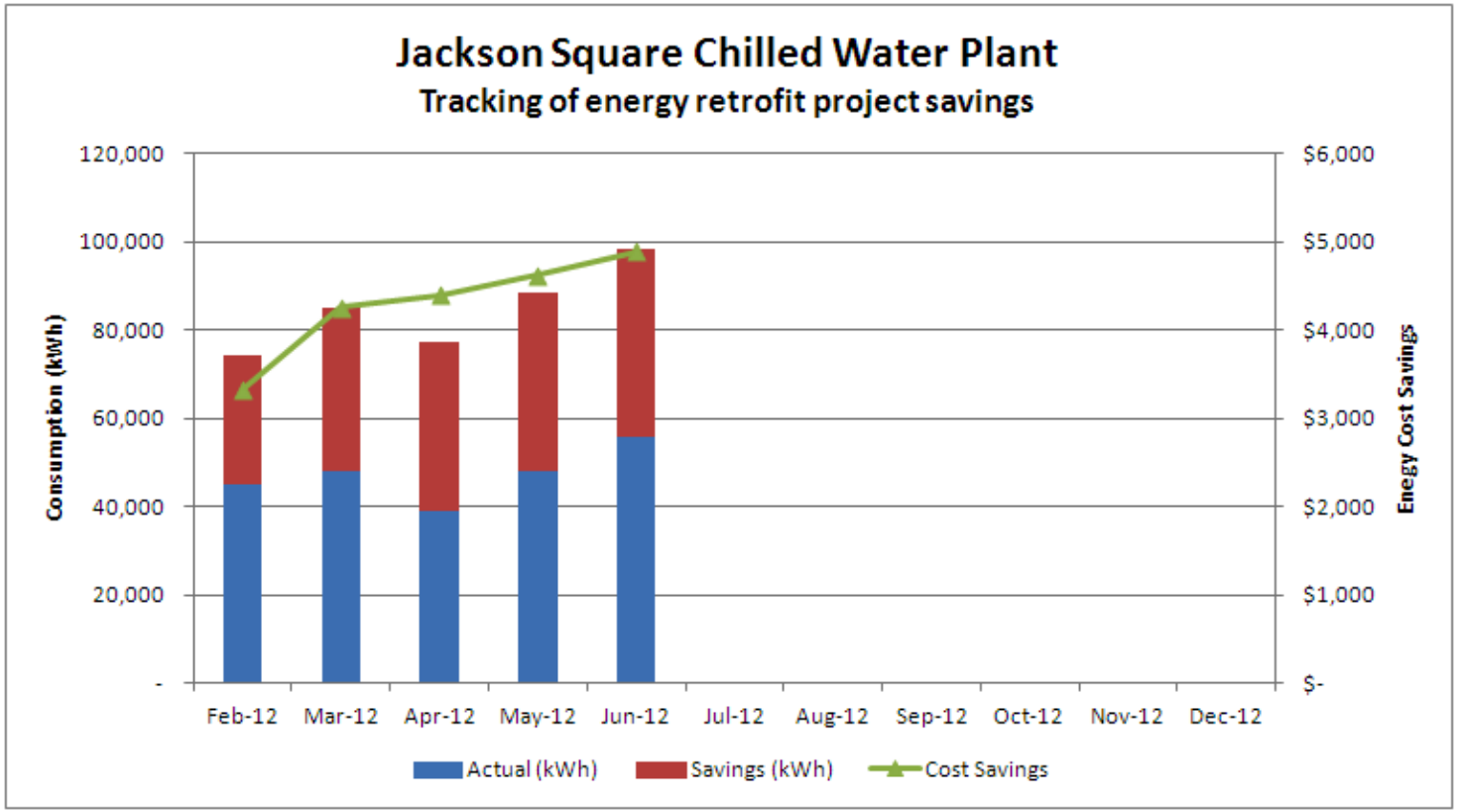
Control Chart for Monitoring EnPI



Pre-Retrofit Baseline Used for Savings Calculations

Energy Project Savings

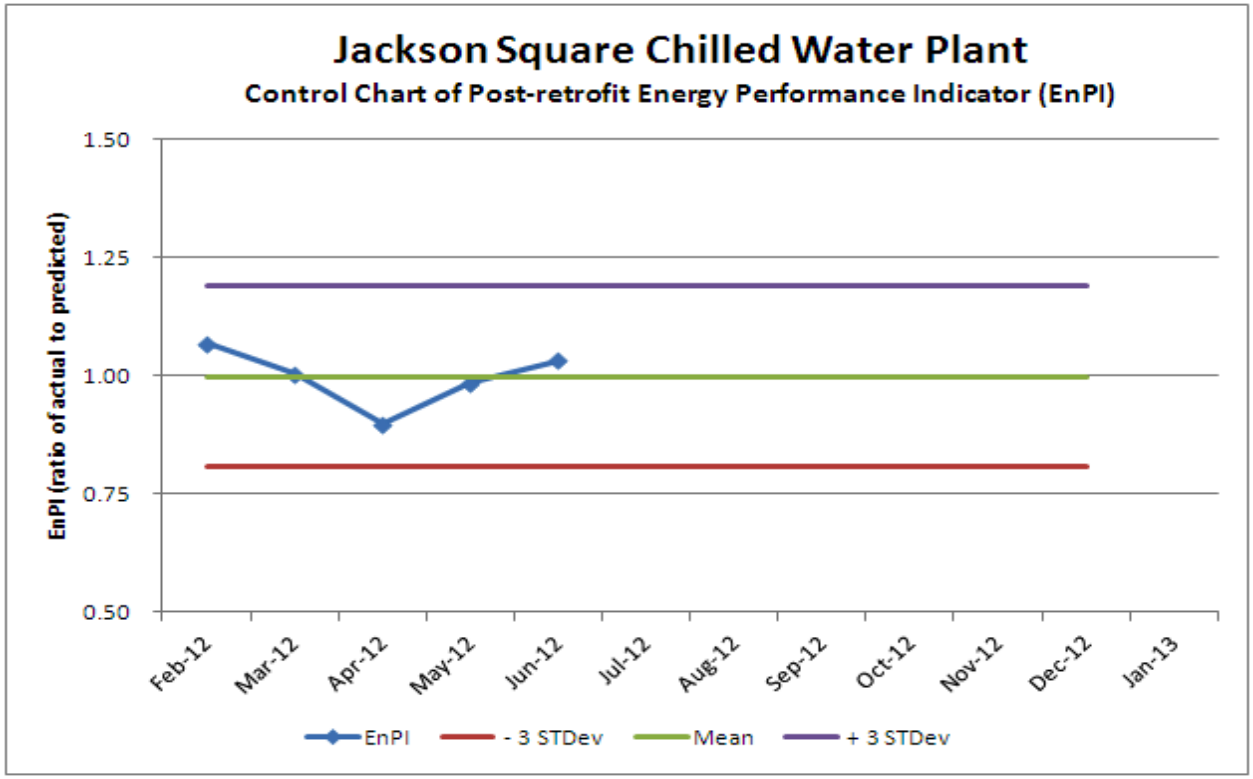
Month	NOD	CDD	Predicted (kWh)	Actual (kWh)	Savings (kWh)	Cost Savings	EnPI
Feb-12	30	272	74,210	45,000	29,210	$ 3,337	0.61
Mar-12	32	369	85,124	47,880	37,244	$ 4,255	0.56
Apr-12	29	339	77,501	39,000	38,501	$ 4,399	0.50
May-12	30	462	88,632	48,120	40,512	$ 4,629	0.54
Jun-12	32	545	98,478	55,680	42,798	$ 4,890	0.57
To Date	***153***	***1,988***	***423,944***	***235,680***	***188,264***	***$ 21,510***	***0.56***



Continuous Monitoring of Post-Retrofit Performance

Post-Retrofit EnPI

Month	NOD	CDD	Predicted (kWh)	Actual (kWh)	EnPI
Feb-12	30	272	42,132	45,000	1.07
Mar-12	32	369	47,707	47,880	1.00
Apr-12	29	339	43,400	39,000	0.90
May-12	30	462	48,819	48,120	0.99
Jun-12	32	545	53,899	55,680	1.03



Monroe County, FL - Energy Retrofit Project

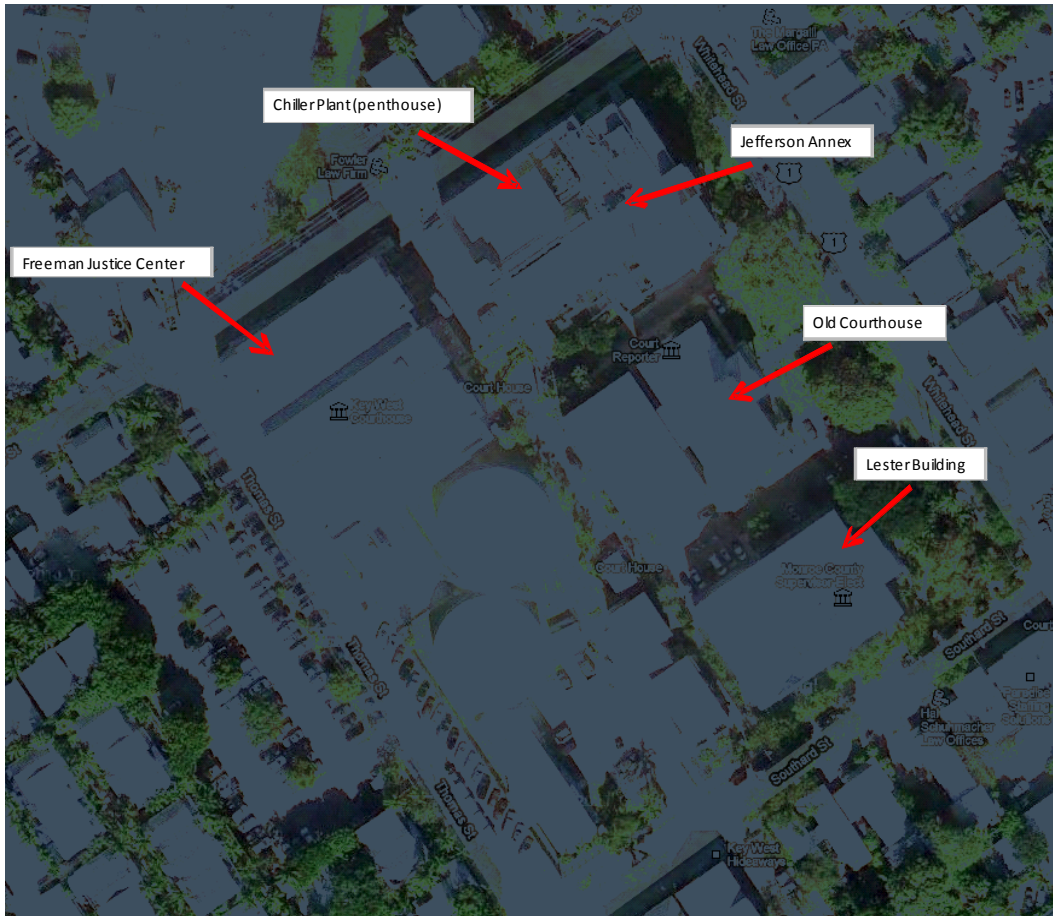
Four buildings with a total area of approximately 200,000 sq ft

Three buildings served by a central chilled water plant

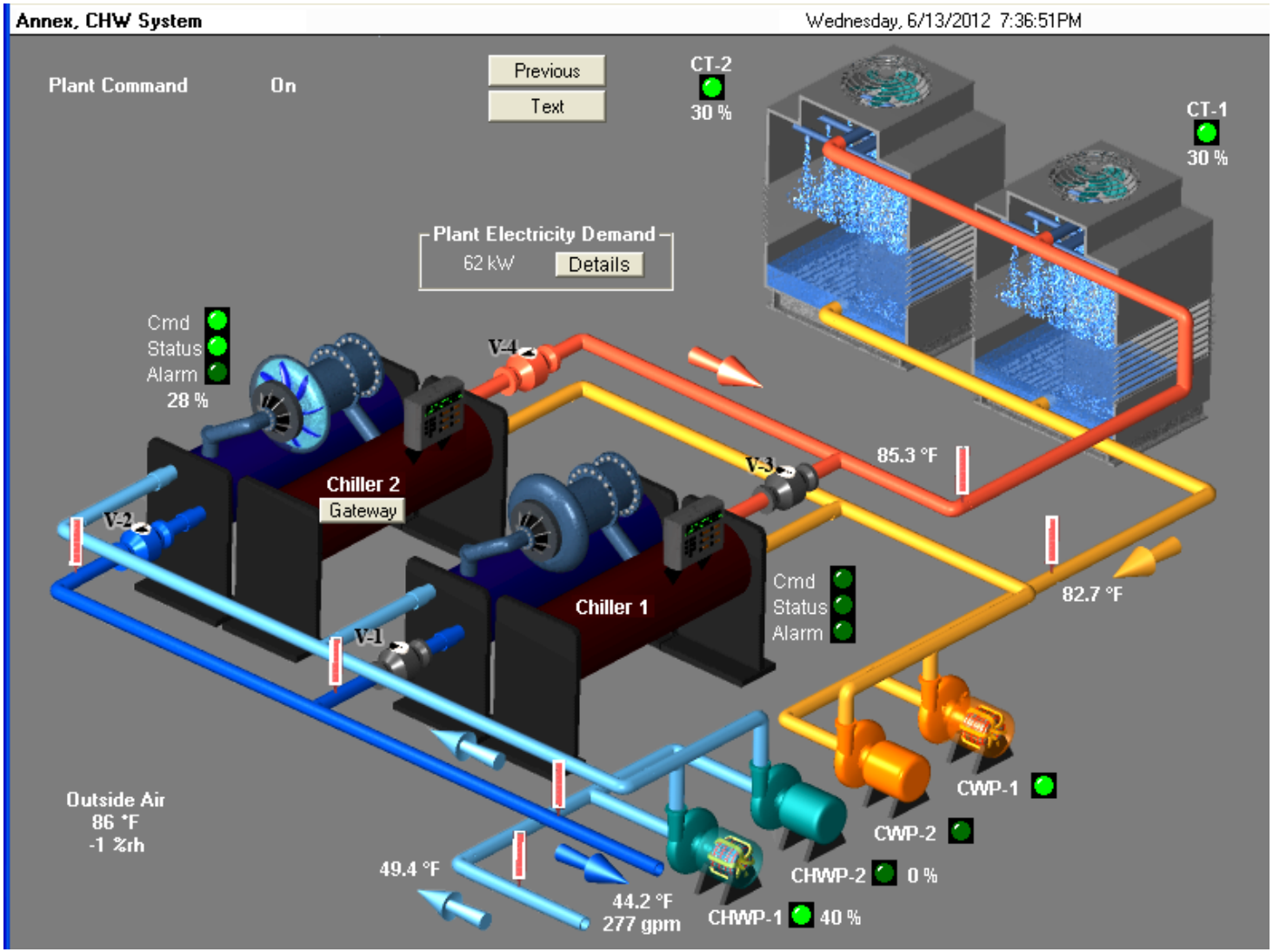
Five electric meters (each building and the chilled water plant)

Most of the HVAC systems were on a central building automation system

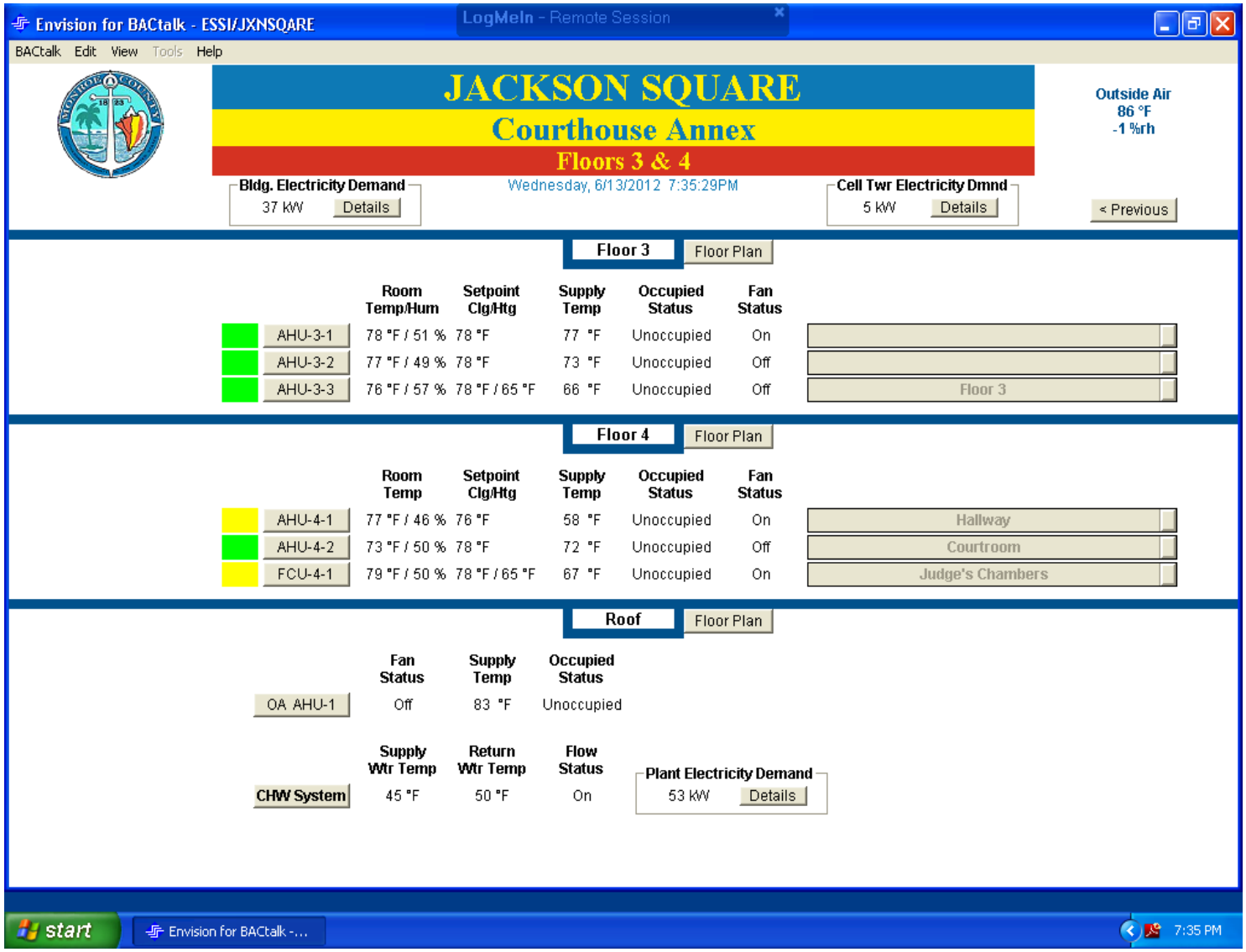
All HVAC systems operated in a continuous manner – no scheduling



Post-retrofit Operation



Post-Retrofit Operation



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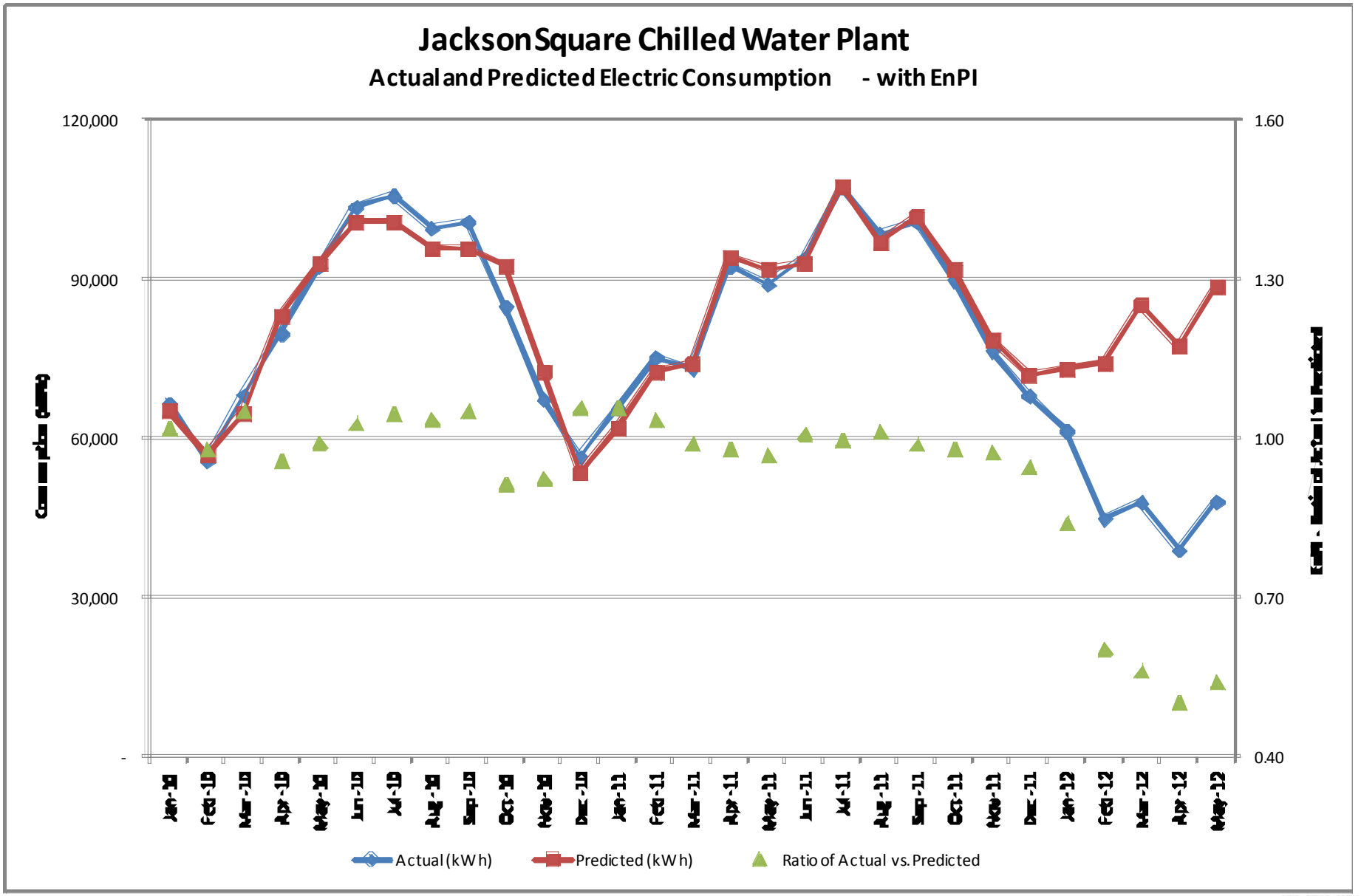
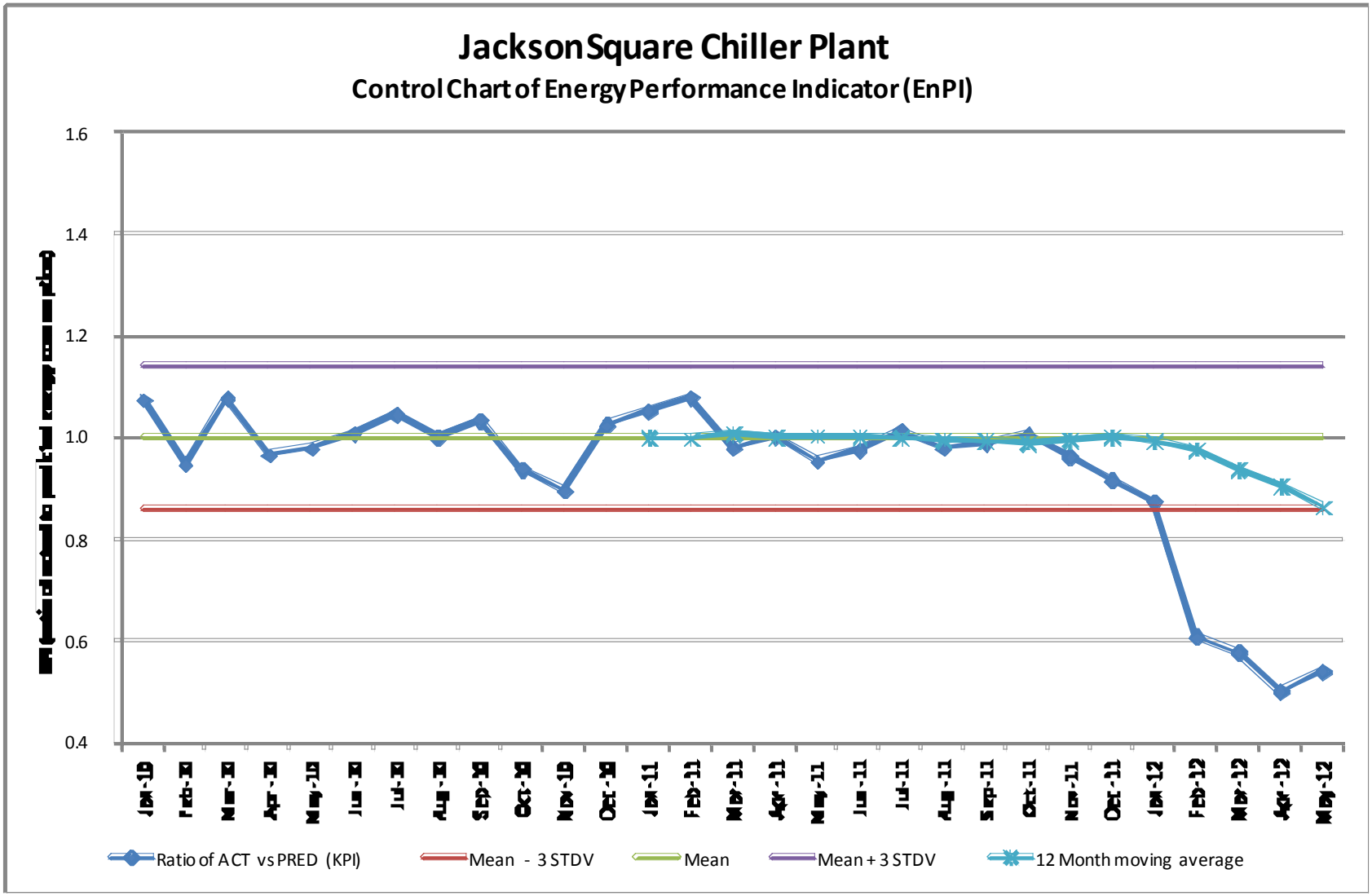


Control Chart for Monitoring EnPI



Monroe County – Measurement & Verification

Chiller plant post-retrofit performance

Month	Predicted (kWh)	Actual (kWh)	Savings (kWh)	Savings (kW)	Cost Savings	EnPI
Feb-12	74,210	45,000	29,210	-	$ 3,337.26	0.60
Mar-12	85,124	47,880	37,244	-	$ 4,255.14	0.56
Apr-12	77,501	39,000	38,501	32.0	$ 4,637.04	0.50
May-12	88,632	48,120	40,512	43.0	$ 4,948.78	0.54
Total	325,466	180,000	145,466	75.0	$ 17,178.22	0.55