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Energy Strategies

Cull & Associates

RETROCOMMISSIONING

Challenges & Opportunities

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Bio for Stephany L. Cull, BEP, CBCP, CSDP

Ms. Cull is the Founder of RetroCom Energy Strategies and Cull & Associates, independent consulting firms focused on Building Systems Commissioning, Ongoing Commissioning, Green Building Services and Energy Efficiency Program Development.

Stephany has been involved in the energy & technical services industry for more than twenty-five years. She has direct experience in facility operations & maintenance, HVAC & lighting control systems, and demand side energy efficiency applications, in both the United States and Canada. Ms. Cull holds designations as a Certified Business Energy Professional, as a Certified Building Commissioning Professional and as a Certified Sustainable Development Professional, from the Association of Energy Engineers.

Ms. Cull is a sought after speaker and recognized subject matter expert on the topics of Energy Retrocommissioning and Ongoing Commissioning. She has presented papers at events across the U.S. including the World Energy Engineering Congress, IFMA Industries Forum, IFMA California Sustainability Mayday, at the Pacific Energy Center, the Bay Area Sustainable Buildings Conference, the Green Action Summit, Facility Decisions Conference, at the National Facility Management & Technology Conference, at the California Society for Healthcare Engineering Annual Institute, at the Institute of Real Estate Management, and others.

Stephany is the author of the Retrocommissioning section in the Encyclopedia of Energy Engineering & Technology and she has published articles appearing in the BOMA San Francisco Bulletin, the California Society for Healthcare Engineering News and Facility Care Magazine. Ms. Cull is a member of the BOMA California Energy Committee and the BOMA International Energy & Environment Committee. Ms. Cull has represented BOMA on energy legislation issues in Washington, DC and she is an active and supportive voice for energy efficiency and sustainable operations in public and private sector facilities.

Basic Definitions

- **Commissioning (Cx)** performed during original project design and construction

- ***Re*Commissioning (Rx)** periodic testing, adjusting, and/or repair to maintain performance achieved during original Cx or RCx process

- ***Retro*Commissioning (RCx) or *Existing Building Commissioning*** performed for existing buildings that were not originally Commissioned – *Almost all buildings*

Basic RCx Definitions

- A systematic process used to discover existing building system ***design*** & ***operating*** deficiencies that adversely impact energy use
- Typically focused on
  - Heating, Ventilating & Air Conditioning Equipment
  - HVAC Control Systems
  - Lighting & Lighting Control systems
  - Domestic Water Systems
  - Building Envelope
- This is **not** an ASHRAE Level 1/2/3 Energy Audit
- This **is** about making what you already have work more efficiently
- This is low cost and sometimes, no cost repairs and adjustments

RCx Financial Facts

- Median annual savings for RCx projects is 16% (LBNL)
  - Much higher in Healthcare and other 24/7 facilities
- Median simple paybacks for RCx are 1.1 years (LBNL)
  - Most EPC retrofits carry paybacks greater than 10 years
- Median cash on cash returns for RCx are 91% (LBNL)
  - Hard to compete when compared to other investments

*LBNL – Lawrence Berkeley National Laboratories, July 2009 RCx Study

Challenges

- Most of the existing building stock in the US was not Commissioned during construction
- Owners inherit buildings with existing deficiencies that are difficult to discover
- This is not the fault of Architect or the MEP - rather it is just our construction paradigm
- “Value Engineering” which is a normal part of the construction process does not contain any value at all
- The norm is having the General, Mechanical, Electrical, Plumbing, or Controls vendor “Commission” their own work
- Control systems are particularly vulnerable to programming & completion abuse

Our Construction Paradigm

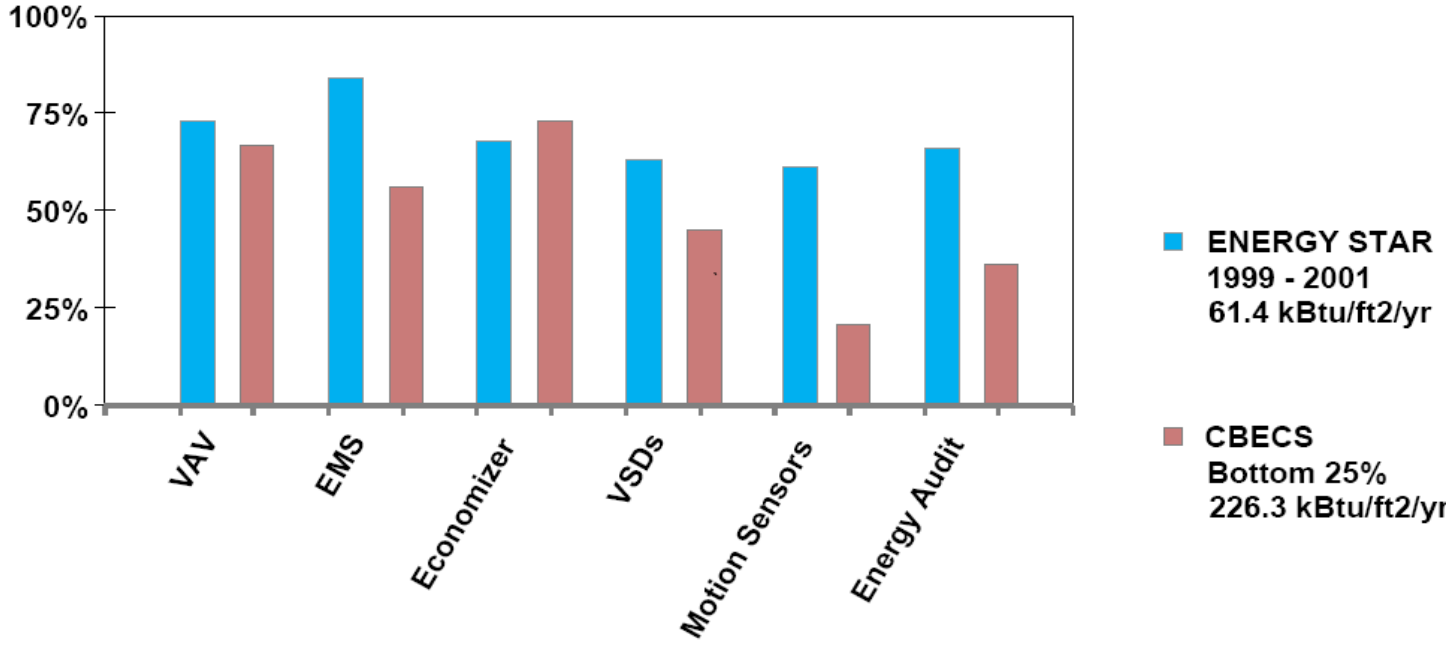
- Design Issues
  - Boiler Plate specs create a high rate of misapplication
  - Risk mitigation by over sizing – up to 15% is common
  - Project cost pressure & urgency – owner driven
- Construction Defects
  - Generally from the absence of Commissioning
  - Nobody is looking out for the owner's interest
  - Low Bid = skinny margins = corners cut

Existing Building Realities

- Equipment & Systems are complex & inter-dependent
  - Poorly controlled "efficient systems" tends to defeat the purpose
- Traditional maintenance activities are devoid of tasks that impact energy performance
  - Maintenance tasks emphasize "uptime" instead of "performance"
  - Grease, oil, visually inspect, tighten, observe, check
  - Little energy value in many of the tasks we take for granted
  - Cleaning a coil does not ensure the economizer works
  - Information at the BAS front end is not necessarily accurate
- Building Operators are expected to do more with less!
  - Today's building systems are complex beyond the basic training provided to facility personnel & building operators
  - And remember, we "Value Engineered" all the training out!

Consequences

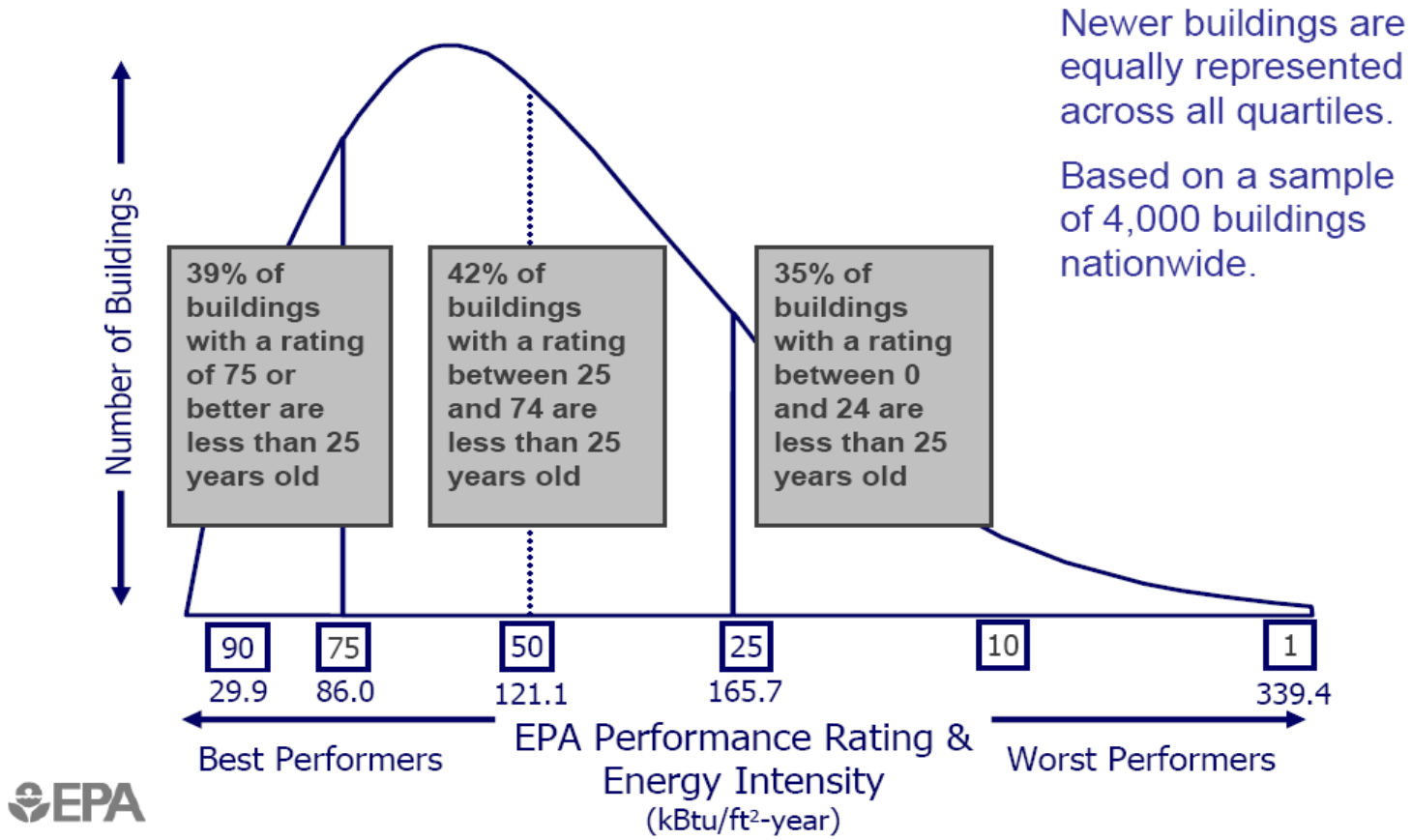
The Case for Commissioning



Note: "CBECS" is the Energy Information Administration's Commercial Building Energy Consumption Survey, http://www.eia.doe.gov/emeu/cbecs/contents.html

EPA

The Case for Commissioning

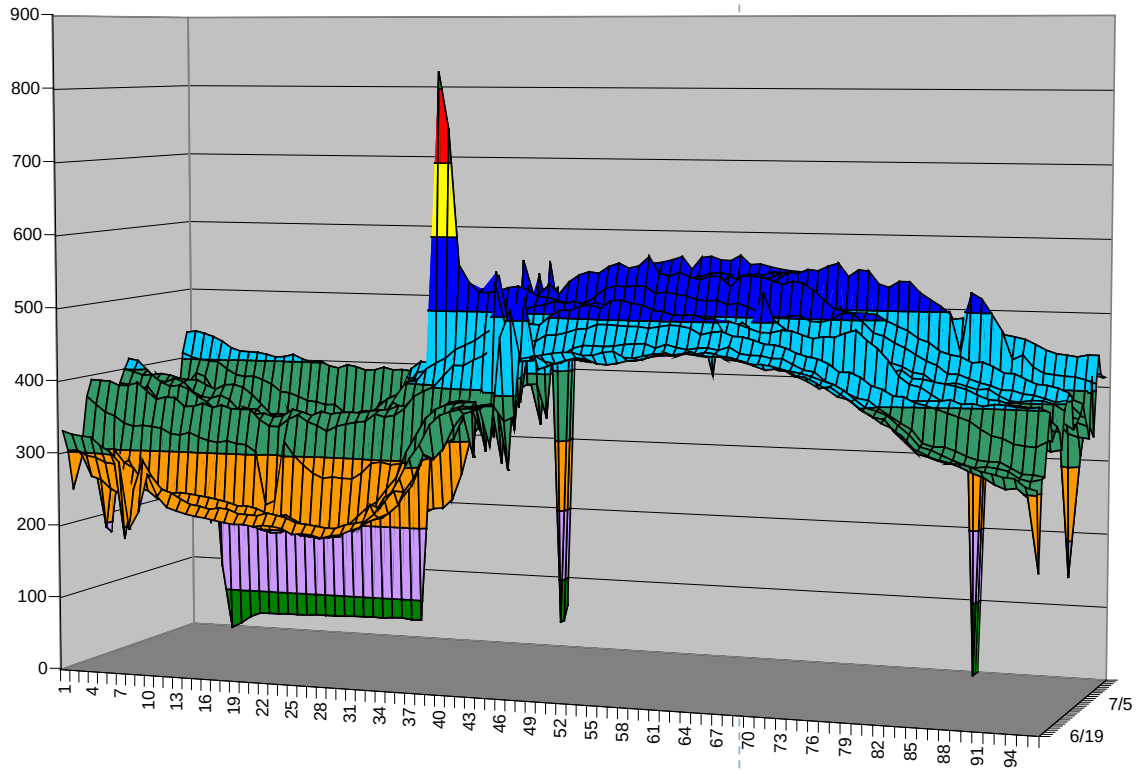


Newer buildings are equally represented across all quartiles.

Based on a sample of 4,000 buildings nationwide.

The Case for Commissioning

Nobody noticed that the Chiller was coming on in the middle of the night



The Case for Commissioning

Out of Sight,

Out of Mind!

The Case for Commissioning

Outdoor Air Damper linkage is in need of attention

The Case for Commissioning

Static Pressure Sensor is too close to the supply fan to deliver appropriate control at the zone level

The Case for Commissioning

Which valve is controlling flow?

The Case for Commissioning

According to the CEC 70% of the Economizers in the State are incorrectly sequenced

The Case for Commissioning

Apparently the Photocell is not functioning

The Case For Commissioning

This chilled water system had a history of failing to meet demand!

The Case for Commissioning

There is no substitute for first hand observation. The inlet vanes on this fan were frozen in position.

The Case for Commissioning

I wonder if these Damper Actuators actually work?

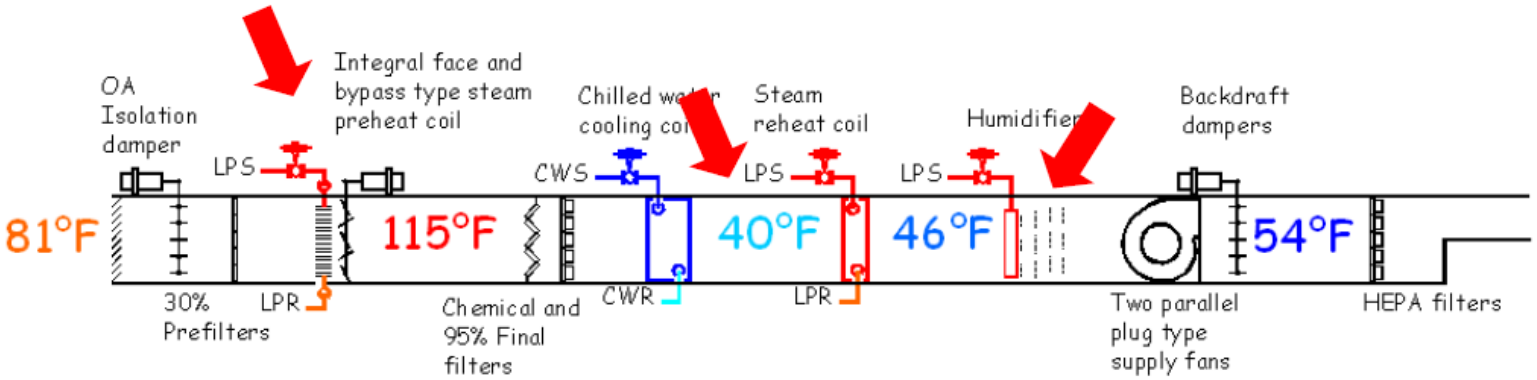
The Case for Commissioning

The filters need to fit the application !

The Case for Commissioning

General Controls Problems

Example from a 300,000 sq ft cleanroom facility



Implementation Cost $7,000

Annual Savings $84,000

Payback: 0.1 year

*Courtesy of Portland Energy Conservation Inc.

Cost Implications

80,000SF Office Building

RCx Rewards

$/kWh: $0.132 $/therm: $0.977

#	Recommended Measures	kWh/yr Savings	therm/yr Savings	$ Maint Savings	Total $ Savings	Estimated $ Cost	In House	Simple Payback	Cumulative Net Cost	Cumulative Savings	Cumulative SPB
1	Overhaul & Reestablish scheduled operation of Roof-Top HVAC Units	169,305	1,728	$0	$24,037	$6,500	No	0.3	$6,500	$24,037	0.27
2	Overhaul and Reestablish scheduled operation of Boilers & HW pumps	27,140	31,426	$0	$34,286	$5,800	No	0.2	$12,300	$58,322	0.21
3	Install Damper on Heat Pump Outdoor Air Intake	10,591	0	$0	$1,398	$2,400	No	1.7	$14,700	$59,720	0.25
4	Provide schedule control for DHW recirculation pumps	2,146	4	$0	$287	$700	No	2.4	$15,400	$60,007	0.26
5	Repair or replace GE Lighting Controller, connect relay panels on Floors 2 - 6 and program	97,742	0	$0	$12,902	$6,400	No	0.5	$21,800	$72,909	0.30
6	Stairwell Lighting Retrofit	19,049	0	$0	$2,514	$6,120	No	2.4	$27,920	$75,423	0.37
7	Retrofit Two Existing Ultrasonic Occupancy Sensors with Two Infrared Occupancy Sensors	5,276	0	$0	$696	$400	No	0.6	$28,320	$76,120	0.37
8	Basement Lighting Retrofit	20,249	0	$0	$2,673	$3,000	No	1.1	$31,320	$78,793	0.40
9	Shut down redundant 3-ton Liebert Unit	10,306	0	$0	$1,360	$0	Yes	0.0	$31,320	$80,153	0.39
10	Increase control differentials on 8-ton Liebert unit	7,200	0	$0	$950	$0	Yes	0.0	$31,320	$81,103	0.39
11	Reset Heating Hot Water Setpoint to minimize total energy usage	0	424	$0	$414	$800	No	1.9	$32,120	$79,207	0.41
12	Reset Condenser Water Setpoint to minimize total energy usage	1,269	0	$0	$168	$400	No	2.4	$32,520	$79,374	0.41
	TOTALS	370,273	33,581	$0	$81,685	$32,520		0.4	$32,520	$79,374	0.41
	Existing consumption	1,511,700	62,338								
	% of existing consumption	24%	54%								

A 31% Decrease in Energy Costs!

Note the Simple Payback

80,000SF Office Building

RCx Rewards

48 Story Office Building

#	Measure	Updated Annual Electric Savings (kWh)	Updated Annual Electric Savings ($)	Updated Annual Gas Savings (therms)	Updated Annual Gas Savings ($)	Updated Annual Total Savings ($)	Updated Peak Demand Savings (kW)	Actual Implementation Cost ($)	Updated Simple Payback (years)	Final Program Incentive ($)	Updated Simple Payback with Incentive (years)
1	Turn off atrium lights when sufficient daylight is available, and late nights/weekends when building	139,606	$11,107	0	$0	$11,107	1	$13,338	1.2	$0	1.2
2	Control chiller #4 with VFD to match load	266,635	$20,660	0	$0	$20,660	0	$48,000	2.3	$21,331	1.3
3	Reset CHW based on ambient between 42 and 44°; Reset CW based on ambient wet bulb temperature plus cooling tower range, between minimum and maximum recommended by chiller manufacturer	126,274	$4,374	0	$0	$4,374	21	$1,640	0.4	$0	0.4
4	Control CW pumps with VFDs, setting speed for rated flow with valves 100% open	161,610	$12,986	0	$0	$12,986	64	$21,840	1.7	$12,929	0.7
5	Open throttled valves, control CHW pumps with VFDs, and control speed based on differential pressure at 48th	114,434	$10,107	0	$0	$10,107	50	$27,440	2.7	$9,155	1.8
6	Open throttled valves, control HW pumps with VFDs, and control speed based on differential pressure at 48th floor	35,864	$3,522	0	$0	$3,522	4	$1,680	0.5	$0	0.5
7	Resheave 18 AHU fans back to near design CFM ratings	174,933	$26,682	0	$0	$26,682	52	$3,689	0.1	$0	0.1
10	Control garage lighting based on time of day schedule to be on 4am - 11pm weekdays and off weekends.	55,263	$4,009	0	$0	$4,009	0	$4,500	1.1	$0	1.1
11	Control restroom lights with occupancy sensors	73,455	$9,762	0	$0	$9,762	0	$13,398	1.4	$0	1.4
	All Findings	**1,148,074**	**$103,208**	**0**	**$0**	**$103,208**	**191**	**$135,525**	**1.3**	**$43,414**	**0.9**

25 Story Office Building

#	Measure	Savings peak kW	kWh	lb steam	$ svgs	Implement'n Cost	Simple Payback	Estimated Incentives	SPB w/ Incentives
1	Reset CW temp based on OA WB temp	21.0	13,555	-	$ 3,742	$ 1,770	0.5	$ 890	0.2
2	Optimize start time of fans, pumps	-	59,295	58,446	$ 9,143	$ 5,220	0.6	$ 2,610	0.3
3	Optimize economizer & CO2 control	13.3	2,334	41,832	$ 2,922	$ 1,980	0.7	$ 990	0.3
4	Reset CHW differential pressure	1.2	4,288	-	$ 650	$ 1,000	1.5	$ 500	0.8
5	Add occupancy sensor lighting controls	-	431,437	-	$ 53,056	$ 126,330	2.4	$ 21,570	2.0
6	Control open CW loop pumps with VFDs	1.9	38,050	-	$ 4,871	$ 12,110	2.5	$ 3,910	1.7
7	Convert interior zones to VAV	15.1	233,869	-	$ 30,248	$ 115,680	3.8	$ 38,240	2.6
8	Control chiller CW pumps with VFDs	7.9	12,513	-	$ 2,323	$ 15,010	6.5	$ 4,000	4.7
		60.5	795,341	100,278	$ 106,955	$ 279,100	2.6	$ 72,710	1.9

150KSF Single Story Office

#	RetroCommissioning Measures	peak kW savings	kWh/yr savings	therm/yr savings	$ maint savings	Total $ savings	Estimated $ cost	Simple Payback	$ rebates	ROI
1	Adjust start and stop times	0.0	137,429	2,954	$0	$14,234	$0	0.0	$0	
2	Implement holiday schedules	0.0	25,768	554	$0	$2,669	$0	0.0	$0	
3	Move janitorial hours earlier	0.0	43,000	0	$0	$3,354	$0	0.0	$0	
4	Repair/adjust economizers; replace controls	0.0	183,711	1,986	$0	$16,693	$16,000	1.0	$0	104%
5	Reset supply air temps; upgrade controls	8.2	49,284	5,844	$0	$11,227	$15,696	1.4	$8,618	159%
6	Reduce heating lockout temp setpoints	0.0	1,808	986	$0	$1,315	$0	0.0	$0	
7	Calibrate zone thermostats	2.4	11,791	273	$0	$1,368	$3,240	2.4	$1,162	66%
8	Adjust VAV box min volume settings	0.0	6,485	150	$0	$685	$4,320	6.3	$639	19%
9	Reset chilled water temperature	0.0	85,324	0	$0	$6,655	$2,400	0.4	$0	277%
10	Reset condenser water temperature	0.0	56,883	0	$0	$4,437	$2,400	0.5	$0	185%
11	Programmable thermostat for AC-101C	0.0	5,568	130	$0	$589	$130	0.2	$0	453%
12	Calibrate and tune AHU controls	0.0	30,223	1,488	$0	$4,128	$800	0.2	$0	516%
13	Relocate static pressure transmitters downstream	3.4	20,289	0	$0	$1,759	$7,600	4.3	$1,623	29%
14	Reduce air leakage from rooftop AC units	2.4	11,712	336	$0	$1,440	$6,000	4.2	$1,206	30%
15	Trim HW pump impellers	0.8	5426	0	$0	$467	$900	1.9	$434	100%
16	Replace inlet vanes with VFDs	28.2	169,078	0	$0	$14,656	$85,425	5.8	$12,250	20%
17	VFD control of CHW pumps	18.5	161,790	0	$0	$13,581	$14,400	1.1	$2,000	110%
18	VFD control of CW pumps	7.0	60,960	0	$0	$5,117	$11,600	2.3	$1,000	48%
19	VFD control of cooling tower fans	6.5	57,348	0	$0	$4,814	$19,100	4.0	$2,500	29%
20	Add boiler cycling optimization controls	0.0	0	6,619	$0	$7,877	$7,200	0.9	$0	109%
21	Replace outdoor PAR head with motion/light head	0.2	1,183	0	$16	$116	$32	0.3	$0	363%
22	Upgrade Bldg 101 electric room lighting	0.1	1,577	0	$0	$127	$300	2.4	$126	73%
23	Install occupancy sensor lighting control	0.0	147,370	0	$0	$11,495	$13,500	1.2	$11,790	672%
24	Convert lobby downlights to CFL; change switches	0.4	3,495	0	$48	$341	$145	0.4	$0	235%
	SUBTOTALS	78.0	1,277,503	21,321	$64	$129,143	$211,188	1.6	$43,348	77%

750KSF Hospital

$/kW:$4.04 $/kwh:$0.116 $/therm$0.924

#	Recommended Measures	peak kW savings	kWh/yr savings	therm/yr savings	$ maint savings	Total $ savings	Estimated $ cost	In-house	Simple Payback	rebates	ROI w/ Rebates
1	Schedule control for AHUs serving intermittently occupied areas	0.0	593,912	55,365	$0	$102,828	$6,960	Yes	0.1	$6,9600	net cost
2	Repair and optimize control of economizers	0.0	462,156	134,489	$0	$177,878	$17,100	Yes	0.1	$17,1000	net cost
3	Optimize variable volume CHW pump control	29.4	514,489	0	$0	$61,104	$9,525	No	0.2	$9,5250	net cost
4	Optimize and tune control loops for CW pump speed controls	13.4	234,987	0	$0	$27,909	$4,400	No	0.2	$4,4000	net cost
5	Reset HHW temperatures	0.0	0	40,347	$0	$37,280	$8,200	No	0.2	$8,2000	net cost
6	Test and adjust ED/CCU air volumes and optimize VFD controls	6.6	291,100	0	$0	$34,090	$8,420	No	0.2	$8,4200	net cost
7	Reset AHU supply air temperature setpoints	0.0	244,733	123,134	$0	$142,165	$35,775	Yes	0.3	$19,579	878%
8	Optimize staging of cooling tower flow and fan speed	0.0	61,366	0	$0	$7,118	$4,480	No	0.6	$4,4800	net cost
9	Replace damaged/missing steam/HW pipe insulation	0.0	0	10,979	$0	$10,145	$6,600	No	0.7	$0	154%
10	Add VFDs where applicable or where existing VFD inoperable	6.4	280,400	0	$0	$32,837	$31,000	No	0.9	$22,432	383%
11	VFDs and Intellihood™ Control for kitchen makeup/exhaust	0.0	105,638	7,294	$0	$18,994	$19,300	No	1.0	$8,451	175%
12	Upgrade all incandescent lighting to more efficient sources	1.5	8,729	0	$0	$1,084	$1,184	Yes	1.1	$436	145%
14	Reset CHW temperatures	0.0	33,214	0	$0	$3,853	$4,300	No	1.1	$2,657	235%
15	Adjust/replace clocks/photo controls for exterior lighting	2.3	10,100	0	$0	$1,283	$1,855	Yes	1.4	$505	95%
16	Provide daylighting controls for lighting in daylit areas	6.6	24,678	0	$196	$3,379	$5,400	No	1.6	$1,234	81%
17	Install vending machine controls	1.3	23,078	0	$0	$2,741	$4,460	No	1.6	$1,846	105%
18	Calibrate zone thermostats	0.0	46,627	20,441	$0	$24,296	$45,250	No	1.9	$0	54%
19	Replace damaged/missing CHW pipe insulation	0.0	2,885	1,536	$0	$1,754	$3,800	No	2.2	$0	46%
20	Repair leaking steam traps	0.0	0	1,251	$0	$1,156	$2,525	Yes	2.2	$1,001	76%
21	Control lighting in support spaces with occupancy sensors	0.0	105,608	0	$0	$12,251	$28,300	No	2.3	$5,280	53%
22	Upgrade all fluorescent lighting to latest generation T8	74.0	546,120	0	$0	$66,937	$162,800	No	2.4	$27,306	49%
23	Repair and re-seal leaking plenums, flex connectors	0.0	514	853	$0	$848	$3,168	Yes	3.7	$0	27%
	TOTALS	141.5	3,590,335	395,689	$196	**$771,929**	**$414,802**		**0.5**	$149,813	291%

Savings, Cost & Payback

750KSF Hospital

Critical Issues for RCx Programs

- Most of the existing buildings in the US are RCx candidates
  - Including many LEED Certified buildings
- Many buildings contain control systems that are beyond the training threshold of existing operations personnel
  - Control contractors are happy to maintain the status quo
- We have not significantly altered the way we train Building Operators or care for building systems in the last 50 years
  - Uptime does not equal Performance – quite the opposite in fact
  - Building systems have changed dramatically but our skill levels have not
  - Traditional tasks do not reflect our new energy & GHG challenges
- RCx should be viewed as an opportunity to train building operators to perform Ongoing Commissioning
  - The most valuable opportunity in RCx is not having to do it again in 4 years – to make the results sustainable!