

Commissioning for LEED Projects:
Realizing the Perils and Potential of "Innovative"
HVAC Systems and Equipment

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Perils and Potential of Innovative
HVAC Systems and Equipment

- Introduction
- LEED, Innovative Systems and Commissioning
- Perils
- Commissioning to Address Perils
- Examples from the Field
- Conclusions
- Q & A

Perils and Potential of Innovative
HVAC Systems and Equipment

- Introduction
- **LEED, Innovative Systems and Commissioning**

LEED and similar rating systems

- Seek to transform the way buildings are built
- Seek to accelerate the adoption of certain types of innovations (energy / environment friendly)
- Result is increased use of innovative equipment and systems

Innovative equipment and systems

- Less familiar to all parties in the design & construction process
- Increases the risk of operational problems
- Poor operation is a threat to wider adoption of the innovations - the goal of LEED
- Consequently a heightened or rigorous level of commissioning is required

Innovative systems and equipment

- Goal under LEED is reduced energy consumption and increased environmental quality
- Often, expected or theoretical gains do not materialize (for various reasons)
- The practice of Commissioning is ideally suited to address these reasons assure that the gains are captured if possible.

To “realize” the potential of innovative systems, we must first realize the perils - and commission accordingly.

What is an “Innovative System?”

- “Normal” innovation mainly driven by short-term economic advantages
- Risk-aversion results in slow “evolution”
- LEED, etc seeks to accelerate certain innovation by providing other advantages
- Result is increased risk, use of systems and equipment that are not “time-tested”

What is an “Innovative System?”

- Anything that is not locally “standard”
- Heat recovery systems
- Evaporative cooling systems
- Thermal energy storage
- Stack-effect cooling / ventilation
- Ground-source heat pumps

What is an “Innovative System?”

- Anything that is not locally “standard”
- Underfloor air distribution
- Low temperature air distribution
- Daylight / dimming
- Local renewable energy (solar thermal, p/v, wind)
- Grey water, composting toilets, etc.

What commissioning do LEED and similar programs require?

- Energy using building equipment and systems must be commissioned
- Intensity / Level of detail is “open ended”
- Therefore care must be taken to tailor the intensity of the commissioning program appropriately to the nature of the equipment and systems being commissioned

Why are we here?

(Why is commissioning needed today?)

- Increasing complexity / capabilities of controls (and other systems)
- Increasing specialization of designers
- Increasing competitiveness / pace of business / priority of “bottom line”

Why are we here?

(Why is commissioning needed today?)

- “Design-build” control system specifications on competitively bid projects carry an inherent conflict of interest
- Turning a stack of paper into a properly functioning building is non-trivial

Innovative equipment and systems

- Less familiar to designers than standard equipment and systems
- Less familiar to installers and inspectors than standard equipment and systems
- Less familiar to manufacturers and vendors than standard equipment and systems
- Less familiar to O&M personnel than standard equipment and systems

We already know that “standard” systems and equipment generally need commissioning

Therefore it follows that “innovative” systems and equipment will generally need more careful commissioning

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- **Perils**

Perils of Innovative Systems

- Design (pre-construction) phase perils
- Construction phase perils
- Operational phase perils

Design Phase Perils

- The peril of irrational exuberance
 - Regarding energy conserving measures
 - Regarding estimate of design work required
- The peril of poorly applied standards
 - Is intent of rating system fulfilled?
 - Is general “standard” applicable to situation?
- The peril of unfamiliar systems and equipment

Construction Phase Perils

- The peril of low-volume equipment manufacturing
 - Custom or semi-custom fabrication, bugs result
 - Documentation not as developed / standardized
- The peril of installing and starting unfamiliar systems and equipment

Operational Phase Perils

- Operators are at an earlier point on the learning curve with innovative systems
- Enhanced training may be required initially and for each newly hired operator
- Maintenance requirements may be greater
- Spare parts may be harder to find
- Equipment may become obsolete sooner

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- **Commissioning to Address Perils**

Commissioning to Address Perils

- Design (pre-construction) phase commissioning
- Construction phase commissioning
- Operational phase commissioning

Design Phase Commissioning

- Skeptical perspective on innovative systems' cost-effectiveness justifications
- Careful review of equipment selection / application
- Appropriate enhancement of QC and other specification requirements

Construction Phase Commissioning

- Consider factory witnessed testing
- Careful examination of equipment upon delivery if no factory witnessed testing
- Training, explanation or "consciousness raising" of installers may be appropriate
- Enhanced awareness of installation issues
- Startup plans may need to be developed from "scratch"

Operational Phase Commissioning

- Design intent and operational theory should be included in training
- Training is more important than it would be for standard systems of types that staff are already familiar with
- Enhanced awareness of equipment failures is appropriate
- Risk of improper operation must be addressed for life of building

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- **Examples from the Field**

Examples from the Field

- Heat recovery classroom unit ventilators in a Northern California coastal climate
- Classroom daylight / dimming system

Project Overview

- Design developed with input from “bright schools initiative” and city “green building” experimental standards.
- “Fit” with CHPS was realized and pursued after design was in progress.
- Rating systems similar to LEED



Commissioning Program

- Sherrill Engineering practices a “hands-on,” expertise dependent style of commissioning.
- Provided Design Intent statement, Commissioning Plan & forms.
- Provided “limited” design review services.

Commissioning Highlights

Mechanical Design review:

- Incomplete and erroneous HVAC equipment schedule data were identified.
- Not addressed in the addendum.

CESAR CHAVEZ EDUCATION CENTER - OUSD										
COMMISSIONING PROBLEM LOG										
ITEM	REPORT	EQUIPMENT	TYPE	TAG	DESCRIPTION	ACTION REQ'D	BY	DATE	CHECKED	REMARKS
1	7/18/03	E	HRUV	ALL	Piping support missing over access on roof	Correct	Tobech			
2	7/18/03	A	AHU	ALL	Equipment not listened to curb. Screwed down	Monarch	AW	11/18/03	X	
3	7/18/03	E	HRUV	ALL	Equipment not listened to curb. Screwed down	Monarch	AW	11/18/03	X	
4	7/18/03	A	AHU	ALL	Backwork tag on connections not sealed. Sealed	Monarch	AW	10/4/03	X	
5	7/18/03	A	AHU	ALL	Oil piping floor hole for control wire needs to be patched. Grout/mortar needed for wire. Added	Monarch	AW	4/1/04	X	
6	7/18/03	A	AHU	ALL	Oil piping floor hole for control wire needs to be patched. Grout/mortar needed for wire. Added	Monarch	AW	11/18/03	X	
7	7/18/03	A	AHU	ALL	Oil piping floor hole for control wire needs to be patched. Grout/mortar needed for wire. Added	Monarch	AW	11/18/03	X	
8	7/18/03	A	AHU	ALL	Piping unions not located to allow coil pull space. Piping can easily be moved to allow for a 1/2" clearance. Corrected	Monarch	AW	11/18/03	X	
9	7/18/03	A	AHU	A1	Socket holes in ductwork need to be plugged. Corrected	Monarch	AW	10/4/03	X	
10	7/18/03	A	AHU	A2	RA ductwork connections on 1st inside air duct. Aligned	Monarch	AW	10/4/03	X	
11	7/18/03	A	AHU	A2.3	HV heating coil installed backwards (probably in factory) per factory arrow	Monarch	AW	1/24/04	X	
12	7/18/03	A	AHU	A3.5	RA ductwork connection to unit needs alignment. Aligned	Monarch	AW	10/4/03	X	
13	7/18/03	A	AHU	A4	Piping supports incomplete. Added adequate additional supports	Monarch	AW	4/1/04	X	
14	7/18/03	A	AHU	A5	HV heating coil installed backwards (probably in factory) per factory arrow	Monarch	AW	4/1/04	X	
15	7/18/03	BT	AHU	B1	Control enclosure needs to be re-fastened. Re-attached	Monarch	AW	1/24/04	X	
16	7/18/03	BT	AHU	B1	Control enclosure needs to be re-fastened. Re-attached	Monarch	AW	2/20/04	X	
17	7/18/03	BT	AHU	B1	Control enclosure door, not enough clearance. Moved enclosure	Monarch	AW	4/1/04	X	
18	9/20/03	ALL	HRUV	ALL	Line provided will not provide scheduled required min 100% outside air CFM per manufacturer. Manufacturer knew of all requirements prior to bid	Monarch				
19	9/20/03	ALL	AHU	ALL	Controls will not provide scheduled required min 100% outside air CFM. Manufacturer knew of all requirements prior to bid per engineer. Controls will be modified to open RA damper to provide min OA during heating. Close RA RA 100% OA during cooling	Monarch	AW	12/15/03	X	
20	10/4/03	ALL	AHU	ALL	Coil piping needs insulated, weatheright box (valve not suitable for outside room) replaced	Monarch	AW	11/18/03	X	
21	10/4/03	ALL	B	ALL	Boilers not bolted down per details 3 & 11MS.02 (1/2" rubber pad needed)	Monarch	AW	2/20/04	X	
22	10/7/03	B,C	HRUV	ALL	Control by motion sensor may require wiring revision coordinated with electrician. Corrected, Latched	JWB	AW	12/15/03	X	
23	10/7/03	B,C	HRUV	ALL	Classroom units not bolted down, sitting directly on floor, may be subject to vibrating up. Manufacturer's mounting requirements needed. Manufacturer agrees to install 4" depth on floor	Monarch	AW	12/15/03	X	
24	10/11/03	ALL	AHU	ALL	HV heating coils not installed with leveling jugs per detail 11MS.01	Tobech	AW	12/15/03	X	
25	10/11/03	ALL	LOFP	ALL	LD tags, labels, arrows needed. Will improve coordination. LD tags ok	Tobech				
26	10/11/03	A,E	AHU	ALL	Pipes at coils needs more support	Tobech				
27	10/11/03	ALL	B	ALL	Pressure relief and other hot water outlet piping not piped to floor drain. Drain proposed	Tobech	AW	12/15/03	X	
28	10/11/03	ALL	B	ALL	Per feeders, air separators, etc. in boiler rooms not secured. Strapping added	Tobech	AW	12/15/03	X	

Commissioning Highlights

Functional Performance Testing:

- Multiple issues identified and integrated with project punchlist(s).
- Heat & Vent units not performing as specified or as advertised.
- Sherrill Engineering has been working with subcontractors to resolve issues.
- See commissioning log.

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COMMISSIONING PROBLEM LOG										
ITEM	REPORT	EQUIPMENT	TYPE	TAG	DESCRIPTION	ACTION REQ'D	BY	DATE	CHECKED	REMARKS
100	3/15/04	ALL	ALL	ALL	Bypass dampers inactive and in their recovery position on no heating call. Active but reversed operation on 1st and 2nd stage heating. Corrected	JWB	AW	3/15/04	X	
101	3/15/04	C	AH	C1	2nd parallel backwards. Do not reverse. Re-logged	Monarch	AW	2/20/04	X	
102	3/15/04	E	HRUV	A1	Control enclosure, replace 3/16" with 1/2" pressure relief if any	Monarch	AW	2/20/04	X	
103	3/15/04	ALL	ERE	ERE	No hand screens on exhaust fan exits in electric room. Installed	Monarch	AW	2/20/04	X	
104	3/15/04	C	AH	C2	Pipes not bolted to curb. Bolts	Monarch	AW	2/20/04	X	
105	3/15/04	C	AH	C2	Pipes supports incomplete	Tech				
106	3/15/04	C	AH	C2	Pipes not bolted to curb. Bolts	B.D.E.				
107	3/15/04	ALL	AH	ALL	Insulation missing on exhaust fan exits and bypass leg of piping. Added except for piping in electric room	Monarch				
108	3/15/04	ALL	B	-	Pressure gauges need calibration / replacement	Tech				
109	3/15/04	C	AH	C1	Connection at base for pipe fitting with 1/2" steel metal stopper	Monarch	AW	2/20/04	X	
110	3/15/04	B	B	1	Connection at base to angle iron done with 1/2" sheet metal stopper	Monarch	AW	2/20/04	X	
111	3/15/04	B	B	1	Connection at base to angle iron done with 1/2" sheet metal stopper	Monarch	AW	2/20/04	X	
112	3/15/04	C	B	B1	CA 10 thermostat appears to have 15 degree deadband	JWB				
113	3/15/04	D	B	1	No response from OA lockout thermostat and not controlling piping or bolts	JWB				
114	3/15/04	B	B	1	Some pressure gauges were mislabeled. ETC	JWB				
115	3/15/04	C	B	C1	Water LEAKING from pressure relief line at floor drain. Leak stopped	JWB	AW	4/1/04	X	
116	3/15/04	ALL	B	ALL	Water gauges from both flow sensors no read	Monarch				
117	3/15/04	ALL	EF	ALL	Exhaust fan timeclock 1 day type. 7 day timeclock required with battery backup in electric room	B.D.E.				
118	3/15/04	ALL	EF	ALL	Exhaust fan timeclock enclosures not sealed as such	B.D.E.				
119	3/15/04	ALL	EF	ALL	Exhaust fan timeclocks have no battery backup. See item 117	Monarch	AW	3/15/04	X	
120	3/15/04	BO	ERE	2	Electric room - adequate ventilation air inlet provided to room	Monarch				
121	3/15/04	C	ERE	3	Electric room - adequate ventilation air inlet provided to room	Monarch				
122	3/15/04	C	CO	CO	Ballroom area to CA 11 motion detector not turning off light	B.D.E.				
123	3/15/04	D	ERE	ERE	Ballroom area to CA 11 motion detector not turning off light	Monarch	AW	2/20/04	X	
124	3/15/04	D	ERE	ERE	Electric room thermostat operating backwards. Fan on when 1 stat turned up	JWB				
125	3/15/04	ALL	EF	ALL	No timeclock on exhaust fan hallway and 1st exhaust fan	B.D.E.				
126	3/15/04	D	ERE	ERE	No hand screen on exhaust fan exits in electric room	Monarch				
127	3/15/04	C	HRUV	26	Room CA 21 bearing with no call for heat. Valve may be stuck open	JWB				
128	3/15/04	E	ERE	ERE	Temporary wiring removed except temporary exposed wiring installed on roof	B.D.E.				
129	3/15/04	B	ERE	ERE	Pipes not shut off by timeclock or stat	B.D.E.				
130	4/3/04	C	AC	CT	No service access to unit. Sides required over ductwork	West Jay				
131	7/22/04	ALL	ERE	ERE	Exhaust fan installation - roof	Monarch				
132	7/22/04	C1	ERE	ERE	Exhaust fan installation - roof	Monarch				
133	7/22/04	C2	ERE	ERE	Exhaust fan installation - roof	B.D.E.				
134	7/22/04	C2	HRUV	218	3rd not secured. Moves easily. Coordination required	West Jay				

REMARKS:
 (1) EXISTING CONDITION DETERMINED TO BE ACCEPTABLE
 (2) DETERMINED NOT TO BE A COMMISSIONING PROBLEM
 (3) OWNER INFORMED, RESOLUTION UNDER CONSIDERATION

Heat Recovery Unit Ventilators

- 28 identical units
- Design (selection / application / document) issues
- Manufacturing issues
- Installation issues
- Operational issues

Design (selection / application / document) Issues

- “Heat pipe” for exhaust air heat recovery
- 3 fans (outside air, recirculated air, exhaust air)
- Mild climate, minimal heating requirement
- Added pressure drop from coils, added fans make savings questionable
- No cost benefit study produced / reviewed

Design (selection / application / document) Issues

- Recommended by manufacturer, vendor and design engineer for this application
- Manufacturer’s marketing and submittal literature claimed performance that could not be achieved and was ultimately not supported by the factory
- Not certified (ARI, etc.)
- Conflicting, unclear, erroneous and incomplete plans & specifications made resolution difficult

Manufacturing Issues

- Noisy at full speed
- High pitched whine from motors / VFD at low speed
- Filtration capacity not as submitted
- Units shipped with multiple functional problems such as screws obstructing dampers, insulation falling off, and (leaky) gaps in seams of plenums
- No provision included for securing unit to structure (other than piping!)
- Hot water piping routed through air stream, uninsulated - not configured properly for the application (RH/LH)

Installation Issues

- Improvisation required to secure units
- Supply and exhaust air connections provided not adequate to traverse wall thickness to louvers, installed anyway
- Short-circuiting of air within wall resulted
- Problem discovered, extension collars retrofitted

Operational Issues

- Design classroom occupancy reduced due to limited ventilation capability
- No provision for user shutting off noisy units
- Custom filters required
- No "ready" solution where enhanced filtration required, teachers complaining
- O&M staff not adequately trained / prepared to repair these unusual units













Daylight / Dimming System

- 3-step dimming in 21 classrooms with skylights
- Design (contract documents) issues
- Installation issues
- Operational issues

Design Issues

- Commissioning review discovered plans did not conform to design intent, details were inadequate, incorrect
- Revised drawings issued
- Revised drawings not made available to field personnel

Installation Issues

- Light sensor not installed per revised detail
- Fixture wiring for zoning installed wrong
- Occupancy sensor interface wired wrong
- Contractor would not adjust per manufacturer's instructions

Operational Issues

- Annoying malfunctions such as short-cycling, lack of independent control
- Many teachers now favor removing system
- O&M staff not adequately trained or prepared to adjust or maintain the system
- O&M staff has no other sites or experience with similar systems





Lessons Learned

- Begin Commissioning early in the design phase for greatest value.
- Don't skimp on the design (peer) review aspect of commissioning.
- Track design issues aggressively.
- Make sure documents such as addenda get commissioning review as well.

Lessons Learned

- "Innovative" systems will probably require special attention including extra commissioning during both design and testing periods.
- Commissioning will generally provide (only) an incremental increase in quality over the underlying design and installation.

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Conclusions

- Adoption of Innovative Systems carries risks and associated expenses for all players from design through operation
- Unsatisfactory performance also poses risk to green building movement
- Commissioning may be applied to mitigate some of these risks

We already know that “standard” systems and equipment generally need commissioning

Therefore it follows that “innovative” systems and equipment will generally need more careful commissioning

To “realize” the potential of innovative systems, we must first realize the perils - and commission accordingly.

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