



California Commissioning Collaborative

NREL's Research Support Facility: Commissioning for Zero-Net Energy

Presented by:

Greg Risko, P.E.

Senior Engineer

Architectural Energy Corporation

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Outline

Commissioning for Zero Net-Energy

- What is the same about commissioning between a 'typical' minimally code compliant building and a zero net-energy building?
- More importantly, what is different?
- Measurement and verification, do we need it?
- Lessons learned?
- Questions?

Cx: What is the same? Best Practice Applies!

Best practice commissioning procedures are the same for a 'typical' building and ZNE building

- Pre-design - OPR, BOD
- Design activities – DD review, CD review
- Construction activities – submittal review, construction observation, PFC, FPT, O&M review, owner training, Cx report, issues log
- Post-Occupancy – warranty review

Cx: What is the same?

Best Practice Resources

- LEED® guidelines
- California Commissioning Guide: New Buildings
- ASHRAE Guideline 0-2005: The Commissioning Process

Cx: What is different?

The Number of Integrated Systems

Zero Net-Energy can have more systems that operate together in an integrated fashion

- NREL RSF Cx - Radiant heating/cooling, air-side economizer, direct evaporative cooling, variable speed drives, transpired solar collector, thermal mass storage, data center waste heat recovery, exhaust air energy recovery, motorized windows, under-floor air distribution, demand control ventilation, duct static pressure reset, supply air temperature reset, lighting control, occupancy sensors, day-lighting control, photovoltaic....

Cx: What is different? Requires a Cx Team

Cx Agent vs. Cx Team

- It's unlikely that one person will have enough time and skill for a ZNE project due to the complexity and numbers of systems involved.
- Perhaps it may require multiple Cx firms
- Typical project – one Cx agent manages the entire project, maybe gets some support from junior staff and some supervision from senior staff, involves the other design and construction members.

Cx: What is different?

NREL RSF/AEC Cx Team

- 1) Senior mechanical engineer – overall project manager
- 1) Senior mechanical engineer – FPT execution and field support
- 1) Junior mechanical engineer – FPT execution and field support, 20 hour/week on-site
- 2) Senior mechanical engineers – FPT development and document review, off-site
- 1) Lighting engineer – FPT development and execution for lighting and day-lighting
- 1) PV specialist – FPT development and execution for photovoltaic

Cx: What is different? Energy Focused

- Energy Use Goals as the major focus
- Traditional commissioning process may be much more focused on assuring the owner is getting what they think they are buying, i.e – does the delivered product meet the intent of the contract documents
- ZNE projects likely more focused on delivering a specific energy goal like energy use intensity (EUI), perhaps with contractual ramifications

Measurement and Verification Essential or After-thought

- Typical projects usually don't have any form of M&V, most simply rely on in-frequent retro-commissioning efforts to improve energy performance over the life of the building
- Some projects may only consider the LEED® Measurement and Verification credit when they realize they need one more point to reach a certain certification level
- For ZNE a strong M&V program is a must
- 'You can not manage what you do not measure'

Measurement and Verification Infrastructure

- Disaggregated Electrical Distribution System
- Campus Central Plant
- Accountability for Energy End-Use using power and BTU meters
- 21 meters installed including: Chilled water, Heating water, Utility meter, and End-Use power meters
- Trends and archiving of BAS points
- Integration of metered data for both M&V process and occupant information kiosk

Lessons Learned

Requires Strong Team

- Designers – Pushing the envelope with advanced integrated low energy designs, yet controlling complexity
- Contractors – GC & MEP installing new technologies and non-standard designs
- Controls and Commissioning – High number of integrated strategies and technologies
- Facility Staff – Needs to be able to maintain the performance, proper training, can't be too complicated

Lessons Learned

Repeatability?

- RSF Occupants and Facility Staff are sophisticated, i.e. – building engineers and scientists
- Construction professionals are a mix of highly reputable local and national firms
- This will not be the case when trying to achieve goals like 50% of all new construction ZNE
- Where will all the qualified players come from?
- Evolution in the skills and training of people in all aspects of design, construction, and maintenance, i.e. – can't do business as usual

Lessons Learned

Commissioning Costs?

- For LEED Credits: Fundamental Commissioning, Enhanced Commissioning, and Measurement and Verification
- ~\$1.25-1.50/sqft which be a little higher for what the industry is used to for simpler buildings
- ~0.5% of overall construction costs, which seems like a very wise investment

Lessons Learned

Air vs. Water

- Likely more low energy designs will see an increased focus on hydronic/radiant strategies instead of more traditional air-side deliver
- This can make balancing and TAB review a little more complicated



Lessons Learned

Radiant Takes Time

- Radiant systems can be functional tested
- Loop-tuning, meeting set-points may take time and trending to verify
- One backwards zone valve overheated a space to 90°F and took 4 days to return to set-point after correction



Lessons Learned Keep Lighting Clean

- Protective coverings for lighting fixtures during construction
- Rated lighting performance was only achieved after two rounds of post-construction cleaning



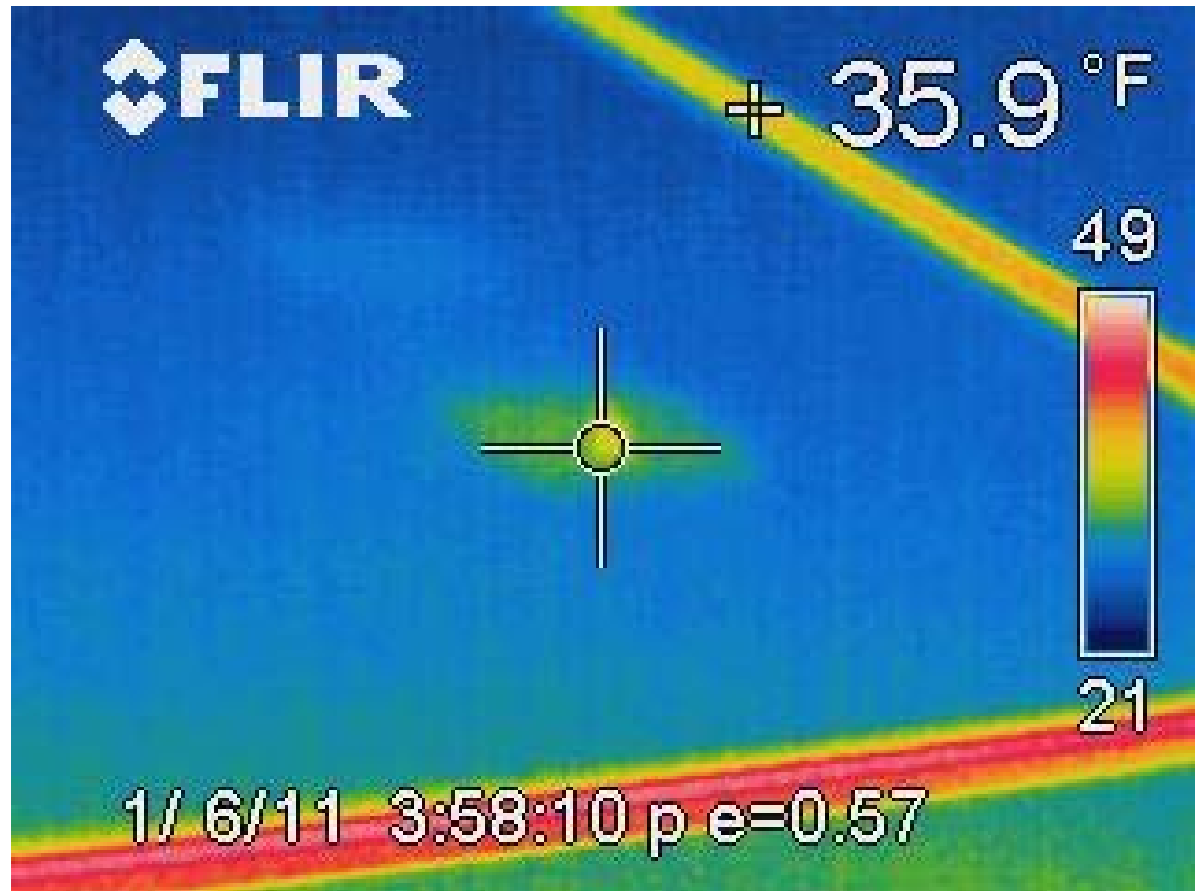
Lessons Learned Photovoltaic

- All ZNE projects are going to have a large PV component
- Be prepared for PV Cx
- Area for industry development standards and best practice



Lessons Learned Photovoltaic

- Example of thermal imagery used for Cx
- PV/PPA risk mitigation for energy targets
- Cx over-sight vs full scope



Lessons Learned

Controls Testing

- Due to the complexity of the design, number of strategies and systems, the control sequence was quite involved
- The FPT required to prove those sequences were also quite involved
- A 'dry run' through the controls at the vendors office can catch a lot of programming bugs before being installed and tested in the field

Lessons Learned

Energy Model + Cx + M&V

- A winning combination for ZNE
- Model informs the design
- Cx ensures performance
- M&V tracks persistence
- The model and the M&V program can be repeated for subsequent M&V periods beyond the first year of occupancy

Lessons Learned

Strong Process for Issues Resolution

- Due to complexity more issues may be detected through the commissioning process than on a typical project
- Diligence in documentation, and a strong forum for issues resolution are required

Lessons Learned

Owner Training

- Since the building maybe more complex than owners, occupants, and facility staff are used to, extra effort should be put into owner training, and the quality of O&M materials, as-builts, etc.
- In the end the owner, occupants, and facility staff are the people most responsible for the on-going energy performance of the building long after the design and construction team are gone



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Thank You! Questions??

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