



LEED BD&C Version 3.0 (2009) Certification & Accreditation

Session 4: Energy & Atmosphere

May 18, 2009

California Department of General Services

Today's Agenda

- Fundamental & enhanced building commissioning
- Energy performance
- Refrigerant management
- On-site renewable energy
- Measurement & verification
- On-site renewable energy
- Green power

Energy & Atmosphere		NC	Schools	CS
		35 Pts.	33 Pts.	37 Pts.
Prereq 1	Fundamental Commissioning of the Bldg. Energy Systems	Req'd	Req'd	Req'd
Prereq 2	Min. Energy Performance: 10% New or 5% Exist. Bldg. Ren.	Req'd	Req'd	Req'd
Prereq 3	Fundamental Refrigerant Management	Req'd	Req'd	Req'd
Credit 1	Optimize Energy Perf. 12-48% New Or 8-44% Exist. Renov.	1 to 19	1 to 19	3 to 21
Credit 2	On-Site Renewable Energy 1-13% Renewable Energy	1 to 7	1 to 7	4
Credit 3	Enhanced Commissioning	2	2	2
Credit 4	Enhanced Refrigerant Management	2	1	2
Credit 5	Measurement & Verification	3	2	NA
Credit 5.1	Measurement & Verification, Base Building	NA	NA	3
Credit 5.2	Measurement & Verification, Tenant Submetering	NA	NA	3
Credit 6	Green Power	2	2	2



Class 1: May 4, 2009

Accreditation

Building Commissioning Defined

Coordinated Process to Optimize Building Performance
Quality Assurance Process



- Articulate/verify owners project requirements
- Construction observation / warranty enforcement
- Controlling first costs
 - Reduced change orders, right sizing of equipment
- Training building operators
- Optimizing performance (comfort, reliability, safety, energy)
- Creating more cohesion among team members
- Enhancing safety and risk management

LBLN Commissioning Study

“The Cost Effectiveness of Commercial Building Commissioning”

<http://eetd.lbl.gov/emills/PUBS/PDF/Cx-Costs-Benefits.pdf>

224 Buildings Studied (150 Exist., 74 New)

Commissioning Costs/Benefits

- Exist. Bldgs - 15% energy savings
 - Cost: \$0.27/s.f. - Energy payback 8.5 months
 - Non-Energy Benefits (NEBs) \$0.18/s.f.
- New Bldgs –
 - Cost: \$1.00/s.f. – Energy payback 4.8 years
 - NEBs \$1.24/s.f.

EA Prereq. 1: Fundamental Commissioning of the Building Energy Systems

1. Prerequisite for NC, Schools & CS
2. Construction Phase Submittal
3. Intent



- Verify that the building's energy related systems are installed, calibrated, and perform according to the owner's project requirements, basis of design, and construction documents



EA Prereq. 1: Fundamental Commissioning (Cx) of the Building Energy Systems

4. Requirements

- a) Designate **Commissioning Authority (CxA)**
 - Experienced as CxA on 2 projects
 - Reports directly to owner
 - Independent of project's design & CM team, although may be employee of those firms, owner or consultant
 - Exception: On projects <50,000 s.f. CxA may be qualified member of design or CM team
- b) Owner to document **Owner's Project Requirements (OPR)**
 - Owner & user requirements
 - Environmental and sustainability goals
 - Energy efficiency goals
 - Indoor environmental quality requirements
 - Equipment and systems expectations
 - Building occupant and O&M personnel requirements

EA Prereq. 1: Fundamental Commissioning (Cx) of the Building Energy Systems

4. Requirements

- c) Design team to develop **Basis of Design (BOD)**
 - Include primary design assumptions
 - Applicable codes & standards
 - Describe performance criteria for commissioned systems
- d) CxA to review OPR & BOD for clarity & completeness
- e) Develop & implement **Commissioning (Cx) Plan**
 - Cx program overview (goals, project info, systems Cx'd)
 - Cx Team members, roles & responsibilities
 - Cx process activities & schedule
- f) Develop & incorporate **Cx reqmts. into Construction Documents (CD's)**
 - Plans & specifications clarifying contractor responsibilities

EA Prereq. 1: Fundamental Commissioning (Cx) of the Building Energy Systems

4. Requirements

g) Verify installation & performance of commissioned systems:

1. HVAC&R and related controls
 2. Lighting & daylighting controls
 3. Domestic hot water systems
 4. Renewables (e.g. solar, wind, etc.)
- Prefunctional checklists & inspections
 - Functional performance testing



h) Complete **Summary Cx Report**

- Summary of process & results
- History of deficiencies & outstanding items
- Performance test results & evaluation
- Confirmation by CxA that reqm'ts are met

EA Prereq. 1: Fundamental Commissioning of the Building Energy Systems

5. Strategies & Implementation

- Owner to seek out qualified CxA to lead Cx process
 - Documented CxA experience on 2 or more bldg. projects
 - Independent of project design & CM, but can be employees of those firms
 - CxA to report directly to Owner
 - Can be qualified member of design team if <50,000 SF
- Consider including other systems:
 - Water using systems
 - Building envelope
 - Acoustics



EA Prereq. 1: Fundamental Commissioning of the Building Energy Systems

6. Documentation

- Include name & company of CxA
- Check off requirements met (all five required)
 - OPR & BOD
 - Cx in Const. Documents
 - Cx Plan
 - Verify installation & performance of systems
 - Completed Cx Report
- Required narrative describing systems commissioned and results
- Additional narrative if alternative approach used

EA Prereq. 1: Fundamental Commissioning of the Building Energy Systems

6. Documentation

Credit Requirements (check all that apply)

- Completed Owner's Project Requirements (OPR) and Basis of Design (BOD) documentation.
- Incorporated Commissioning requirements into construction documents.
- Developed and utilized a commissioning plan.
- Verified installation and performance of commissioned systems.
- Completed Commissioning Report.

Cx Resources

California Commissioning Collaborative (CCC)

- Non-Profit Promoting Cx and RCx
- Funded by Utilities & State Agencies
- Developing State Cx Guidelines
- Online Cx Database and Library
- Cx Training & Tools
- See: www.cacx.org

Building Commissioning Association (BCA)

- See: www.bcxa.org

Cx Toolkit for In-House Cx of Small Projects

- See: www.green.ca.gov/CxToolkit

Cx Toolkit for In-House Commissioning of Small Projects

Focused on Fundamental Cx

Building Criteria for:

- Sustainable Sites
- Water Efficiency
- Energy & Atmosphere
- Materials & Resources
- Indoor Environmental Quality
- Innovation in Design

EA Prerequisite 1: Fundamental Building Commissioning

EA Credit 3: Enhanced Commissioning



State Small Building Types

Forest Fire Stations

- 228 CDF fire stations in 36 counties protecting 31 million acres
- 575 local gov't stations operated by CDF
- 39 conservation camps
- Storage facilities for fire trucks, bulldozers, air tankers & air tactical planes, helicopters
- Barracks, shops, warehouses, admin facilities, misc. structures



Department of Motor Vehicles

- 170 field offices throughout CA
- Also driver safety offices, commercial drive test centers, telephone service centers



California Highway Patrol

- Over 180 offices throughout CA



State Project Teams

Project Directors/Managers

Architects

Mechanical & Electrical Design Engineers

Building Inspectors

Building Inspection Specialists (Mech. & Elect.)

General Contractor & Sub-contractors

Design & Construction Management Consultants

In-House Commissioning (Cx) Toolkit

Executive Summary www.green.ca.gov/CxToolkit

Roadmap/Instructions

Tools:

- Owner's Project Requirements
- LEED Cx Requirements
- Basis of Design
- Cx Plan
- Contract Requirements
- Functional Performance Test Forms
- Cx Summary Report



Other Resources

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Cx Toolkit – Executive Summary

One-page Summary of Cx Toolkit

- Definition of Cx
- Executive Order S-20-04
- LEED Cx Requirements
- Purpose & Content of Toolkit
- Benefits of Cx Integration



Cx Toolkit – Roadmap/Instructions

Instructions on Use of Toolkit

Integrate Cx as Early as Possible

- Portions can be integrated in budget pkg.

Identify Cx Provider

- Design Phase – Design engineer
- Construction Phase – M/E Inspection Specialists

Develop Cx Plan

Implement Activities in Cx Plan



DGS Cx Toolkit: Tools

Owner's Project Requirements

Basis of Design

Commissioning Plan

Commissioning Specifications

A&E Commissioning Scope of Work

Functional Performance Test Forms

Commissioning Summary Report



Owner's Project Requirements (OPR)

- Owner and User Requirements
- Environmental and Sustainability Goals
- Energy Efficiency Goals
- Indoor Environmental Quality Requirements
- Equipment and Systems Expectations
- Building Occupant and O&M Personnel Expectations

DGS Owner's Project Requirements for Small Buildings¹ DRAFT TEMPLATE – April 22, 2008²

[Note to Project Director: Documentation of Owner's Project Requirements (OPR) is a step required for compliance with LEED-NC 2.2 EA Prerequisite 1 for Fundamental Commissioning of the Building Energy Systems. This template is a guide to collecting the information recommended in the LEED-NC Version 2.2 Reference Guide. The information should be developed by the project team in collaboration with the client agency (Owner).]

1. Owner and User Requirements

- A. *[Typically already covered in Project Scope as described in Budget Package. Includes primary purpose, program and use of project. May also describe future expansion needs, flexibility, quality of materials, construction and operation costs.]*

2. Environmental and Sustainability Goals

- A. Project shall meet LEED-NC 2.2 requirements at the Silver performance level.
B. Other Owner requirements: *[e.g. Owner priorities among possible LEED points]*

3. Energy Efficiency Goals

- A. Project shall comply with Title 24 building energy efficiency standards.
B. Lighting systems offer cost effective energy savings potential, and lighting fixtures and/or controls shall be selected to exceed Title 24 minimum efficiency requirements by 14% or greater.
C. High efficiency HVAC equipment offers cost effective energy savings, and HVAC equipment shall be selected that exceeds Title 24 minimum efficiency requirements by 14% or greater.

Commissioning Plan

General Project Information

Commissioning Goals

Systems to be Commissioned

Commissioning Team Information

Commissioning Process – Activities,
Schedule and Responsibilities

Commissioning Plan Activities

Commissioning Activity	Timing (Project Phase)	Responsibility
Owner's project requirements (OPR)	Concept / Budget	Project team, led by Project Director, with CxA review
Cx Plan	Concept / Budget or PP	CxA
Basis of Design (BOD)	PP or WD	Design Team, with CxA review
Cx Specifications	WD	Design Team, with CxA review
Cx Kick-off Meeting	Const.	Lead by CxA, attended by Contractor
Develop pre-functional checklists	WD or Const.	CxA (or Design Team)

Commissioning Plan Activities (cont.)

Commissioning Activity	Timing (Project Phase)	Responsibility
Develop functional test procedures	WD or Const.	CxA (or Design Team)
Complete prefunctional checklists	Const.	Contractor, with CxA (or Inspector) review
Perform functional performance testing	Const.	Contractor, with CxA (or Inspector) guidance, witness and approval
Commissioning acceptance	Const.	CxA
Cx Summary Report	Const.	CxA

Commissioning Specifications

Describes contractor participation requirements
Division 1 Section

- 01810 General Commissioning Requirements

References in relevant mechanical and electrical sections



SECTION 01810 COMMISSIONING (For Small Projects)

PART 1 - GENERAL

1.01 SECTION INCLUDES

- Procedures for Pre-Functional Testing.
- Procedures for Functional Testing.

1.02 RELATED SECTIONS

- Section 01330: Submittal Procedures.
- Document 00700: General Conditions of the Contract for Construction
- Document 00800: Supplementary Conditions
- Section 01750: Starting and Adjusting

E. (Note to PD – Select other Div 1 Sections as applicable such as 01812, 0820, etc.)

- Division 15
- Division 16

Functional Performance Test (FPT) Forms

HVAC

- Packaged rooftop AC units
- Split system AC units



Lighting

- Occupancy sensor controls



Water Heating

- Storage water heater
- Point-of-use water heater



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FPT – Packaged AC Unit

Page One

- General project info
- Prefunctional checklist

Project Name:								
Participant:								
Date:								
Participants:		State	Organization					
Comments:								
Opening Schedule - Record time-of-day and adjust as needed and note any deviation from DESIGN								
	DAY OF THE WEEK							
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Override?
Design:	7AM-6PM	7AM-6PM	7AM-6PM	7AM-6PM	7AM-6PM	override	override	Yes
Actual:								
Comments:								
Prefunctional Checklist								
Record values for current setpoints, control parameters, limits, delays, lockouts, etc and note any deviation from design.								
	Parameter	Per Design	Observed					
	Power to unit							
	Power disconnects installed and labeled.							
	Thermostat is wired to the HVAC system correctly							
	Thermostat meets deadband control requirements							
	Space temperature sensor calibrated							
	Occupied, unoccupied, and holiday schedules programmed							
	Pre-occupancy purge has been programmed							
	Set up and set back setpoints programmed as required							
	Thermostat located within the zone that the HVAC unit serves							
	Unoccupied avg. zone set points (e.g. 85°F setup/60°F setback)							
	Schedule override							
	Condensate drain connected							
	CO2 sensor location							
	CO2 sensor calibrated							
	Return air damper moves through full range							
	Outdoor air damper moves through full range							
	No excessive damper linkage slop.							
	Permanent label attached.							
	Unit secure and level.							
	Maintenance access ok.							
	Test, adjust and balance complete with deficiencies corrected.							
	Outdoor air economizer switchover type and setting							
	Casing condition ok.							

Operating Schedule - Record time-of-day and setpoints and note any deviation from DESIGN

	DAY OF THE WEEK							Override available?
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	
Design:	7AM-6PM	7AM-6PM	7AM-6PM	7AM-6PM	7AM-6PM	override	override	Yes
Actual:								
Comments:								
Prefunctional Checklist								
Record values for current setpoints, control parameters, limits, delays, lockouts, etc and note any deviation from design.								
	Parameter	Per Design	Observed					
	Power to unit							
	Power disconnects installed and labeled.							
	Thermostat is wired to the HVAC system correctly							
	Thermostat meets deadband control requirements							
	Space temperature sensor calibrated							
	Occupied, unoccupied, and holiday schedules programmed							
	Pre-occupancy purge has been programmed							
	Set up and set back setpoints programmed as required							
	Thermostat located within the zone that the HVAC unit serves							
	Unoccupied avg. zone set points (e.g. 85°F setup/60°F setback)							
	Schedule override							
	Condensate drain connected							
	CO2 sensor location							
	CO2 sensor calibrated							
	Return air damper moves through full range							
	Outdoor air damper moves through full range							
	No excessive damper linkage slop.							
	Permanent label attached.							
	Unit secure and level.							
	Maintenance access ok.							
	Test, adjust and balance complete with deficiencies corrected.							
	Outdoor air economizer switchover type and setting							
	Casing condition ok.							

FPT – Packaged AC Unit (cont.)

Simulation Mode/Test	Desired System Response (check box if observed) <input checked="" type="checkbox"/>
1. Heating during occupied condition	
Set control system or programmable thermostat to occupied mode (e.g. adjust clock time to normal working hours). Adjust thermostat to 5 deg higher than current room temperature.	<input type="checkbox"/> Supply fan operates continually. <input type="checkbox"/> Gas-fired furnace, heat pump, or electric heater stages on. <input type="checkbox"/> No cooling is provided by the unit. <input type="checkbox"/> Outside air damper is open to minimum position.
2. No load during occupied condition	
Leave system in occupied mode. Adjust thermostat setpoint to equal current room temperature.	<input type="checkbox"/> Supply fan operates continually. <input type="checkbox"/> Neither heating or cooling is provided by the unit. <input type="checkbox"/> Outside air damper is open to minimum position.

Commissioning Summary Report

General Project Information

Commissioning Team Information

Executive Summary

- Commissioning Process Summary
- Outstanding Issues
- Observations and Conclusions

History of Deficiencies

EA Credit 3: Enhanced Commissioning (Cx) of the Building Energy Systems

1. Credit worth 2 points for NC, Schools & CS
2. Construction Phase Credit
3. Intent

- Begin the commissioning process early in the design process and execute additional activities after systems performance verification is completed.



EA Credit 3: Enhanced Commissioning (Cx) of the Building Energy Systems

4. Additional Requirements

1. Designate independent CxA before start of CD's
2. CxA to conduct Cx design review of OPR, BOD and design documents (Cx'd systems) prior to 50% CD's
 - Verify that OPR's are addressed adequately in BOD & CD's
 - Backcheck in subsequent design submittal
3. CxA to review contractor submittals for Cx'd systems
 - Check for conformance with OPR & BOD
 - Make sure submittals facilitate performance testing
 - Concurrent w/ A&E submittal review, but does not alter design team's role in submittal review

EA Credit 3: Enhanced Commissioning (Cx) of the Building Energy Systems

4. Additional Requirements

4. Develop Systems Manual operation info for future op staff
 - Final versions of OPR & BOD
 - System single-line diagrams
 - As-built sequence of operations, control drawings & orig. setpoints
 - Operating instructions for integrated building systems
 - Recomm. Schedules for maint. & retesting of Cx'd systems & for calibrating sensors & actuators
 - Blank test forms for future retesting from original Cx Plan
5. Verify training requirements are completed for op staff
 - See Table 5, page 227
6. CxA to review building operation within 10 mo. of substantial completion (have contract in place)
 - Include plan for resolving outstanding Cx related issues

LEED BD&C Cx Primary Responsibilities

Tasks	Primary Responsibilities	
	EA Prerequisite 1	EAp1 and EAc 3
*Designate Commissioning Authority (CxA)	Owner or Proj. Team	Owner or Proj. Team
*Document Owner's Project Reqmts (OPR)	Owner	Owner
*Develop Basis of Design (BOD)	Design Team	Design Team
*Incorporate commissioning requirements into the construction documents	Project Team or CxA	Project Team or CxA
Conduct commissioning design review prior to mid-construction documents	NA	CxA
*Develop and implement a Cx plan	Project Team or CxA	Project Team or CxA
Review contractor submittals applicable to systems being commissioned	NA	CxA
*Verify the installation and performance of commissioned systems	CxA	CxA
Develop a systems manual for Cx'd systems	NA	Project Team & CxA
Verify that training reqmnts. are completed	NA	Project Team & CxA
*Complete a summary commissioning report	CxA	CxA
Review building operation within 10 months after substantial completion	NA	CxA

*Red items are included in fundamental commissioning (prerequisite)

EA Credit 3: Enhanced Commissioning (Cx) of the Building Energy Systems

5. Documentation

- Include name & company of independent CxA
- Check off additional requirements met (all 6 required)
 1. Independent CxA designated before CD's
 2. CxA review of OPR, BOD & CD's prior to 50% CD's
 3. CxA review of submittals for commissioned systems
 4. Systems Manual prepared
 5. Verify training of building occupants of O&M of Cx'd systems
 6. CxA review of building operations within 10 months of occup.
- Narrative describing enhanced Cx processes employed by project

EA Credit 3: Enhanced Commissioning Letter Template

Enhanced Commissioning Tasks (check all that apply)

Completed Tasks Completed by

- The CxA has conducted at least one Commissioning Design Review of the Owner's Project Requirements (OPR), Basis of Design (BOD), and design documents prior to mid-construction documents phase and back-check the review comments following design submission.
- The CxA has reviewed contractor submittals applicable to systems being commissioned for compliance with the OPR and BOD.
- A systems manual that provides future operating staff the information needed to understand and optimally operate the commissioned systems has been prepared for the project.
- The operating personnel and building occupants have been trained in the operation and maintenance of the commissioned systems.
- The CxA will review building operation within 10 months after substantial completion, and a plan for resolution of outstanding issues has been completed.

<input checked="" type="checkbox"/>	

Green Building Action Plan

"The CEC shall develop guidelines and standards for commissioning activities to achieve operational and maintenance efficiency savings in commercial and public buildings."

- **California Commissioning Guide: New Buildings**

www.documents.dgs.ca.gov/green/commissioninguidenew.pdf

- **California Commissioning Guide: Existing Buildings**

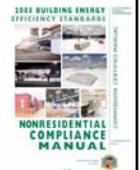
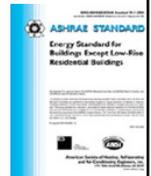
www.documents.dgs.ca.gov/green/commissioninguideexisting.pdf



EA Prereq. 2: Minimum Energy Performance

1. Required for NC, Schools & CS
2. Design Phase Credit
3. Intent

- Establish the minimum level of energy efficiency for the proposed building and systems to reduce environmental & economic impacts associated with excessive energy use.



EA Prereq. 2: Min. Energy Performance

4. Requirements

- **Option 1: Whole Building Energy Simulation**
- 10% better for new buildings; 5% for existing bldg. renov's
 - Calculate baseline building performance rating from **ANSI/ASHRAE/IESNA Standard 90.1-2007 Appendix G**
 - Comply w/ mandatory provisions (5.4, 6.4, 7.4, 8.4, 9.4, 10.4)
 - Include all energy costs assoc. w/ building project
 - Default process energy cost is 25% of total energy cost
 - Process energy is from computers, elevators, equip., kitchen cooking & refrigeration, laundry, exempt lighting (medical)
 - Regulated (non-process) energy includes HVAC, all lighting (int./ext., parking lot & garage, grounds), water heating
 - Process loads must be identical for baseline & design loads
 - **In California, use Title 24-2005, Part 6**
- Schools must establish energy goal using EPA's Target Finder rating tool

EA Prereq. 2: Min. Energy Performance

4. Requirements

- **Option 2: Prescriptive Compliance Path:** (ASHRAE Advanced Energy Design Guide)
 - **PATH 1 - ASHRAE Advanced Energy Design Guide for Small Office Buildings 2004**
 - Office occupancies less than 20,000 sq. ft.
 - **PATH 2 - ASHRAE Advanced Energy Design Guide for Small Retail Buildings 2006**
 - Retail occupancies less than 20,000 sq. ft.
 - **PATH 3 - ASHRAE Advanced Energy Design Guide for Small Warehouses and Self Storage Buildings 2008**
 - Warehouse or self-storage occupancies less than 50,000 s.f.
 - **Schools: Advanced Energy Design Guide for K-12 School Bldgs.**
 - Comply w/criteria for climate zone
 - For projects less than 200,000 sq. ft.

EA Prereq. 2: Min. Energy Performance

4. Requirements

- **Option 3: Prescriptive Compliance Path:**
Advanced Buildings Core Performance Guide
 - Only for buildings less than 100,000 sq. ft.
 - Comply w/ Section 1: Design Process Strategies, & Section 2: Core Performance Requirements
 - Office, school, public assembly and retail projects <100,000 sq. ft. must comply w/ Sections 1 & 2 of Core Performance Guide
 - Other project types <100,000 sq. ft. implement basic reqm'ts of the Core Performance Guide
 - Health care, warehouse and laboratory projects are ineligible

EA Prereq. 2: Minimum Energy Performance

5. Strategies & Implementation

- Design building envelope, HVAC, lighting & other systems to maximize performance
- Utilize California T-24 2005 or 2008, Part 6,
- OR -
- ASHRAE/IESNA 90.1-2007, App. G if outside California
- Energy simulation software packages include
 - DOE-2
 - EnergyPlus

EA Prereq. 2: Minimum Energy Performance

6. Documentation

- Determine Option used
- Determine climate zone for project location
- Calculate energy use by type
- Maintain list of energy uses for project bldg. (baseline & design cases)
- If using computer energy simulation, retain final report
- If using prescriptive paths, assemble documentation
- Narrative(s) for any special circumstances

EA Credit 1: Optimize Energy Performance

1. Credits for

- **NC – 1-19 Points**
- **Schools – 1-19 Points**
- **CS – 3-21 Points**

2. Design Phase Credit

- Aligns with LEED-EB credit

3. Intent

- Achieve increasing levels of energy performance beyond prerequisite standard to reduce environmental & economic impacts associated with excessive energy use.



EA Credit 1: Optimize Energy Performance

4. Requirements

- **Option 1: Whole Building Energy Simulation**
- Demonstrate % improvement over baseline building performance rating from
 - **ANSI/ASHRAE/IESNA Standard 90.1-2007 Appendix G**
 - Comply w/ mandatory provisions (5.4, 6.4, 7.4, 8.4, 9.4, 10.4)
 - Include all energy costs assoc. w/ building project
 - Default process energy cost is 25% of total energy cost
 - Process energy is from computers, elevators, equip., kitchen cooking & refrigeration, laundry, exempt lighting (medical)
 - Regulated (non-process) energy includes HVAC, all lighting (int./ext., parking lot & garage, grounds), water heating
 - Process loads must be identical for baseline & design loads
 - **In California, use Title 24-2005, Part 6**
- Schools must establish energy goal using EPA's Target Finder rating tool

New Bldgs	Exist. Bldg. Renov's	Pts. (NC & Schools)	Pts. (CS)
12%	8%	1	3
14%	10%	2	4
16%	12%	3	5
18%	14%	4	6
20%	16%	5	7
22%	18%	6	8
24%	20%	7	9
26%	22%	8	10
28%	24%	9	11
30%	26%	10	12
32%	28%	11	13
34%	30%	12	14
36%	32%	13	15
38%	34%	14	16
40%	36%	15	17
42%	38%	16	18
44%	40%	17	19
46%	42%	18	20
48%	44%	19	21
50%	46%	*Innovation Credit Available	

EA Credit 1: Optimize Energy Performance

4. Requirements

- **Option 2: Prescriptive Compliance Path (1 Point):**
(ASHRAE Advanced Energy Design Guide)
 - **PATH 1 - ASHRAE Advanced Energy Design Guide for Small Office Buildings 2004**
 - Office occupancies less than 20,000 sq. ft.
 - **PATH 2 - ASHRAE Advanced Energy Design Guide for Small Retail Buildings 2006**
 - Retail occupancies less than 20,000 sq. ft.
 - **PATH 3 - ASHRAE Advanced Energy Design Guide for Small Warehouses and Self Storage Buildings 2008**
 - Warehouse or self-storage occupancies less than 50,000 s.f.
 - **Schools: Advanced Energy Design Guide for K-12 School Bldgs.**
 - Comply w/criteria for climate zone
 - For projects less than 200,000 sq. ft.

EA Credit 1: Optimize Energy Performance

4. Requirements

- **Option 3: Prescriptive Compliance Path (1-3 Points):**
Advanced Buildings Core Performance Guide
 - Only for buildings less than 100,000 sq. ft.
 - Comply w/ Section 1: Design Process Strategies, & Section 2: Core Performance Requirements
- **1 Point** - Office, school, public assembly and retail projects <100,000 sq. ft. must comply w/ Sections 1 & 2 of Core Performance Guide
- Other project types <100,000 sq. ft. implement basic reqm'ts of the Core Performance Guide
- Health care, warehouse and laboratory projects are ineligible
- **Up to 2 additional Points** available implementing Section 3 strategies:
 - Enhanced Performance (1 point available for every 3 strategies)
 - Cannot include strategies addressed in other LEED credits:
 - 3.1 – Cool Roofs
 - 3.8 – Night Venting
 - 3.13 – Additional Commissioning

EA Cr. 1: Optimize Energy Performance

5. Documentation

- Check off compliance method used
- **Option 1 – Whole Bldg. Energy Simulation**
 - Confirm that energy simulation software meets designated sections of CA T-24 2005 or ASHRAE 90.1-2007
 - Modeling requirements on pp 270-273

$$\% \text{ Improvement} = 100 \times \frac{1 - \text{Proposed Bldg. Performance}}{\text{Baseline Bldg. Performance}}$$

EA Prereq. 3: Fundamental Refrigerant Management

1. Required for NC, Schools & CS

2. Design Phase Credit

3. Intent

- Reduce stratospheric ozone depletion

4. Requirements

- Zero use of chlorofluorocarbons (CFC)-based refrigerants in new base building HVAC&R systems.
- When reusing existing base building HVAC equipment, complete a comprehensive CFC phase-out conversion prior to project completion.
 - Phase-out plans extending beyond the project completion date will be considered on their merits.



EA Prereq. 3: Fund. Refrigerant Mgmt.

5. Strategies & Implementation

- For new buildings:
 - Standard practice does not use CFC refrigerants for new HVAC&R equipment & fire suppressant systems in the base buildings
- When reusing existing HVAC systems, or served by existing central plant:
 - Replace or retrofit any CFC-based refrigerants in HVAC&R equipment & fire suppressant systems in the base buildings
 - If bldg. is connected to existing chilled water system, it must be CFC-free or have planned phase out within 5 years.
 - Alt. compliance for bldgs connected to chilled water system, if economic analysis shows replacement or conversion not feasible
 - Not feasible if simple payback > 10 years (3-party)
 - Reduce annual leakage of CFC-based refrigerants to 5% or less (**EPA Clean Air Act, Title VI, Rule 608**)
 - Choose refrigerants w/ short env. Lifetimes, small ozone-depleting potential & small global warming potential values
 - Details pp 253-254

EA Prereq. 3: Fund. Refrigerant Mgmt.

6. Documentation

- Check off compliance path taken
- Narrative describing CFC phase-out plan, if applicable
 - Include dates & refrigerant quantities as % of overall equipment
- Collect manuf. documentation showing type of refrigerant used by base building's HVAC&R systems

EA Credit 4: Enhanced Refrigerant Management

1. Credits for

- NC – 2 Points
- Schools – 1 Point
- CS – 2 Points

2. Design Phase Credit

3. Intent

- Reduce ozone depletion and support early compliance with the Montreal Protocol while minimizing direct contributions to climate change.



EA Credit 4: Enhanced Refrigerant Management

4. Requirements

- **Option 1**
 - Do not use refrigerants
- or -
- **Option 2**
 - Select refrigerants and HVAC&R that minimize or eliminate the emission of compounds that contribute to ozone depletion and global warming.
 - The base building HVAC&R equipment shall comply with the following formula, which sets a maximum threshold for the combined contributions to ozone depletion and global warming potential: **LCGWP + LCODP x 10⁵ ≤ 100**

EA Cr 4: Enhanced Refrigerant Mgmt.

4. Option 2 Reqmts: **LCGWP + LCODP x 10⁵ ≤ 100**

- LCODP = [ODPr x (Lr x Life + Mr) x Rc]/Life
- LCGWP = [GWPr x (Lr x Life + Mr) x Rc]/Life
- LCODP: Lifecycle Ozone Depletion Potential (lbCFC11/Ton-Year)
- LCGWP: Lifecycle Direct Global Warming Potential (lbCO2/Ton-Year)
- GWPr: Global Warming Potential of Refrigerant (0 to 12,000 lbCO2/lbr)
- ODPr: Ozone Depletion Potential of Refrigerant (0 to 0.2 lbCFC11/lbr)
- Lr: Refrigerant Leakage Rate (0.5% to 2.0%; default of 2% unless otherwise demonstrated)
- Mr: End-of-life Refrigerant Loss (2% to 10%; default of 10% unless otherwise demonstrated)
- Rc: Refrigerant Charge (0.5 to 5.0 lbs of refrigerant per ton of cooling capacity)
- Life: Equipment Life (10 years; default based on equipment type, unless otherwise demonstrated)

EA Cr 4: Enhanced Refrigerant Mgmt.

4. Option 2 Reqmts:

- For multiple types of equipment, a weighted average of all base building level HVAC&R equipment shall be applied using the following formula: **[Σ (LCGWP + LCODP x 10⁵) x Qunit] / Qtotal ≤ 100**
- Where:
 - Qunit = Cooling capacity of an individual HVAC or refig. unit (Tons)
 - Qtotal = Total cooling capacity of all HVAC or refrigeration
 - Small HVAC units (containing < 0.5 lbs of refrigerant), and other equipment such as standard refrigerators, small water coolers, and any other cooling equipment that contains < 0.5 lbs of refrigerant, are not considered part of the "base building" system and are not subject to the requirements of this credit.

AND

- Do not install fire suppression systems that contain ozone-depleting substances
 - CFCs, HCFCs or Halons

EA Credit 4: Enhanced Refrig. Mgmt.

5. Strategies & Implementation

- Design and operate the facility without mechanical cooling and refrigeration equipment. **-OR-**
- Where mechanical cooling is used, utilize base building HVAC and refrigeration systems w/ zero or minimal ozone depletion and global warming potential
 - See table 1, page 309
- Select HVAC&R equipment with efficient refrigerant charge and increased equipment life.
 - See table 2, page 310
- Maintain equipment to prevent leakage of refrigerant to the atmosphere
 - Typically lower pressure
- Utilize fire suppression systems that do not contain HCFCs or Halons.
- Use natural refrigerants (water, CO2, ammonia)

EA Credit 4: Enhanced Refrig. Mgmt.

6. Documentation

- Complete refrigerant impact calculation table
- Calculations & letter for bldgs w/ exist. chilled water syst.
- Narrative explaining calculations and any special circumstances, (see example below)
- Retain manuf. Documentation w/ type & quantity of refig.,
- Manuf. confirmation of no halons, CFC's or HCFC's in fire suppression system
- See examples page 312

HVAC&R Equipment Type	N	Q (tons)	Refrigerant	GWPr	ODPr	Rc (lb/ton)	Life (yrs)	Lr (%)	Mr (%)	LCGWP	LCODP x10 ⁵	Refrigerant Impact per ton	Refrigerant Impact Total
Split A/C or Heat Pump	1	.8	R-410a	1,890	0.0	2.35	15	2	10	118.4	0	118.4	89

EA Credit 4: Enhanced Refrigerant Management – Narrative Examples

1. NARRATIVE (Required)

Provide specific information regarding the light trespass analysis conducted to determine compliance. Please provide any additional comments or notes regarding special circumstances or considerations regarding the project's credit approach.

The office space uses a 3/4-ton unit with a 1.76 lb charge of R-410a.

2. NARRATIVE (Optional)

Please provide any additional comments or notes regarding special circumstances or considerations regarding the project's credit approach.

The campus central plant uses a Trane Centrifugal chiller with R123 refrigerant. The leakage rate for this type of chiller is less than the standard used in the above form. For this reason, a different form, and Trane's credit interpretation request and it's subsequent ruling have been uploaded.

The project is seeking point(s) for this credit using an alternate compliance approach. The compliance approach, including references to any applicable Credit Interpretation Rulings is fully documented in the narrative above. (Indicate the number of points documented in the field below).

EA Cr 2: On-Site Renewable Energy 3 Points Possible

1. Credits for

- NC – 1-7 Points
- Schools – 1-7 Points
- CS – 4 Points

2. Design Phase Credit

3. Intent

- Encourage and recognize increasing levels of on-site renewable energy self-supply to reduce environmental and economic impacts associated with fossil fuel energy use.



EA Cr 2: On-Site Renewable Energy

4. Requirements

- Use on-site renewable energy systems to offset building energy cost.
- Calculate % of annual energy produced by renewable systems compared with building annual energy cost
- Determine estimated energy use
 - Use the building annual energy cost (from EA Credit 1)
 - or -
 - Use the Department of Energy (DOE) Commercial Buildings Energy Consumption Survey (CBECS) database (See ref. guide)

EA Cr 2: On-Site Renewable Energy Points Available

% Renewable Energy	Pts (NC & Schools)	Pts (CS)
1%	1	4
3%	2	NA
5%	3	Exemp. Perf.
7%	4	NA
9%	5	NA
11%	6	NA
13%	7	NA
15%	Exemp. Perf.	NA

EA Cr 2: On-Site Renewable Energy

5. Strategies & Implementation

- Assess the project for on-site renewable energy potential and consider:
 - Photovoltaic or Solar thermal
 - Geothermal heating or electric
 - Wind energy
 - Biofuel-based electric
 - Untreated wood waste, incl. mill residues
 - Agricultural crops or waste
 - Animal waste or other organic waste
 - Landfill gas
 - Low-impact hydroelectric power system
 - Wave & tidal power
- Take advantage of net metering with the local utility

EA Cr 2: On-Site Renewable Energy 5. Strategies & Implementation

- Does not include
 - Passive solar
 - Daylighting
 - Geo-exchange (ground-source heat pumps)
- Energy from bio-fuels are not eligible if:
 - Combustion of municipal solid waste
 - Forestry biomass waste other than mill residue
 - Wood coated w/ paints, plastics or formica
 - Treated woods containing halogens, chlorine or halide compounds, chromated copper arsenate or arsenic (1% max.)

EA Cr 2: On-Site Renewable Energy

6. Documentation

- Check off method for determining annual energy
 - Option 1 – Model results from EA c1
 - Option 2 – Use CBECS database
- Document on-site renewable source types, total annual energy generated & backup energy sources
- Calculated energy generated from each on-site renewable energy source
- Maintain documentation regarding incentives provided
- Narrative describing renewable system, calculation method & factors influencing performance

EA Cr 5: Measurement & Verification

1. Credits for

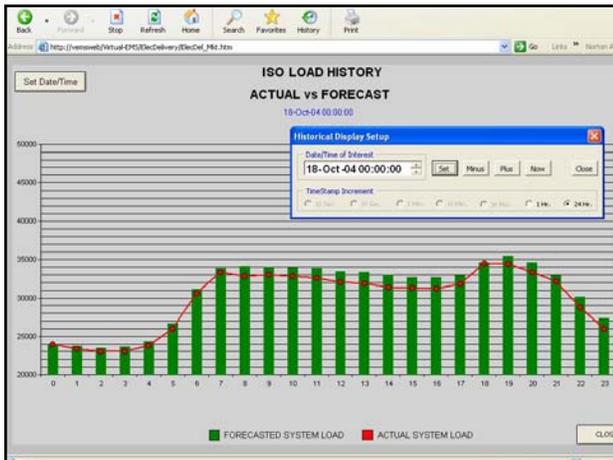
- NC – 3 Points
- Schools – 2 Point
- CS – 1 Point EA c5.1 +
3 Points EA c5.2



2. Construction Phase Credit

3. Intent

- Provide for the ongoing accountability of building energy consumption over time.



EA Cr 5: Measurement & Verification

4. Requirements

- **Option 1** - Develop and implement a Measurement & Verification (M&V) Plan consistent with:
 - Option D: Calibrated Simulation (Savings Estimation Method 2) as specified in the *International Performance Measurement & Verification Protocol (IPMVP) Volume III: Concepts and Options for Determining Energy Savings in New Construction, April, 2003*
 - See Table 2, page 320 for description - OR -
- **Option 2**
 - Option B, IPMVP: Energy Conservation Measure Isolation
 - (see <http://skrzypczak.pl/vol3book.pdf>)
- **M&V period ≥ 1 year** of post-construction occupancy
- Provide process for corrective action if results of M&V plan indicate energy savings are not being achieved

EA Cr 5.1: Measurement & Verification – Base Building (Core & Shell only)

4. Requirements

- For EA c5.1 **Option 1 & Option 2** CS projects, also include:
 - Description of infrastructure design
 - Existing meter locations
 - Existing meter specifications
 - 1-line electrical schematics identifying end-use circuits
 - Guidelines for carrying out tenant sub-metering

EA Cr 5.2: Measurement & Verification – Tenant Submetering (CS only)

4. Requirements

- Include centrally monitored electronic metering network in base building design
 - Capable expanding to accommodate future tenant submetering as required by LEED ID&C EA c3: Measurement & Verification
- Develop tenant measurement & verification (M&V) plan documenting and advising future tenants
- Provide process for corrective action if results of M&V plan indicate energy savings not being achieved

EA Cr 5: Measurement & Verification

5. Strategies & Implementation

- Develop an M&V Plan to evaluate building and/or system performance.
- Characterize the building and/or energy systems through energy simulation or engineering analysis.
- Install metering equipment to measure energy use.
- Track performance comparing predicted performance to actual performance, by component or system.
- Evaluate energy efficiency by comparing actual performance to baseline performance.
- M&V not confined to energy systems
- Refer to IPMVP for guidance on M&V strategies.
- Energy Management System (EMS) can help attain M&V

EA Cr 5: Measurement & Verification

6. Documentation

- Check compliance path for determining annual energy
 - IPMVP Option D – Calibrated simulation savings estimate
 - IPMVP Option B – Energy conservation measure isolation
- Develop IPMVP-compliant M&V plan
- Diagram locations of any meters needed for measurement & update as necessary
- For CS buildings, decide how tenants will be accountable for their energy use (incl. use & cost)
- Narrative describing M&V method & process

EA Cr 5: Measurement & Verification

6. Sample Documentation

IPMVP Option B - Energy Conservation Measure Isolation

The project has developed and implemented a Measurement and Verification (M&V) plan consistent with the referenced option.

A copy of the project's M&V Plan has been uploaded to support achievement of this credit.



NARRATIVE (Required)

The campus EMS controls will record the energy usage of the variable speed supply and return fans for each airhandler. To determine the percentage of the central plant's energy that each building uses, the temperature difference (delta T) and the flow (gpm) of the chilled water will be measured for each building. To determine the boiler efficiency, gas usage, heating hot water flow (gpm) and heating hot water delta T will be recorded.

The building water usage will also be measured and recorded on a daily basis.

EA Credit 6 – Green Power

1. Credit worth two points for NC, Schools & CS

2. Construction Phase Credit

- Aligns with LEED O&M credit

3. Intent

- Encourage the development and use of grid-source, renewable energy technologies on a net zero pollution basis.



EA Credit 6 – Green Power

4. Requirements

- $\geq 35\%$ of the building's electricity from renewable sources
 - Min. 2-year renewable energy contract
 - As defined by the Center for Resource Solutions (CRS) Green-e or equivalent source
- School districts can purchase green power on centralized basis & allocate to a specific project
- CS building's elect. defined as use of CS sq. ft. defined by BOMA standards (min. 15%)
- Determine baseline electricity use
 - **Option 1: annual electricity use from EA Credit 1**
 - **Option 2: Green power, based on default elect. consumption** – see DOE Commercial Buildings Energy Consumption Survey (CBECS) database

* Exemplary performance avail. For 100% of elect.



EA Credit 6 – Green Power

5. Strategies & Implementation

- Determine the energy needs of the building
- Investigate opportunities to engage in a green power contract (2 yrs. min.)
 - solar, wind, geothermal, biomass or low-impact hydro sources
 - See www.green-e.org
- Green-e certified, or other sources satisfying Green-e program's technical requirements
 - From open market or accredited utility program
 - Renewable energy certificates (RECs) if unavail. through utility
 - Tradable renewable certificates (TRCs)
 - Green tags and other forms of green power
 - SMUD's Greenergy - <http://www.smud.com/green/greenergy/index.html>

Green Power – Wind Power



Green Power – Low Impact Hydroelectric



EA Credit 6 – Green Power

6. Documentation

- Select option & enter data for energy cost/consumption
 - Option 1: Annual electricity use from EA Credit 1
 - Option 2: Green power, based on default elect. consumption
- Complete Green Power Provider Summary
- Narrative describing Green Power or Green Tags purchased and any special circumstances

Study References for Today's & Next Classes

LEED BD&C Reference Guide

- 5/18: Energy and Atmosphere (pp. 213-333)
- 6/2: Materials & Resources (pp. 335-400)

LEED Certified Building Tours

- May 26-29th: Schedule will be emailed out
- RSVP with desired tour(s)
- If interested in tour in LA, Bay area, or San Diego area, email daniel.burgoyne@dgs.ca.gov