LEED Building Design and Construction
Activity #6 – Energy and Atmosphere (EA)
Before completing this Activity Read: Reference Guide for Building Design and Construction v4 – Pages 318-465

Note the following abbreviations are used in this activity:
NC LEED BD+C: New Construction and Major Renovation
CS LEED BD+C: Core and Shell Development
S LEED BD+C: Schools
R LEED BD+C: Retail
DC LEED BD+C: Data Centers
WDC LEED BD+C: Warehouses and Distribution Centers
HOS LEED BD+C: Hospitality
HC LEED BD+C: Healthcare

Although the LEED BD+C reference guide does not number the LEED prerequisites and credits, for this exercise they have been numbered in the order presented in the credit category.

Fill-In, Multiple Choice, Matching

1. Test your knowledge of how well you know the names of the credits for the Energy and Atmosphere (EA) credit category:

LEED BD+C: NC, CS, S, R, DC, WDC, HOS, HC	
Credit	Name
P1	
P2	
P3	
P4	
C1	
C2	
C3	
C4	
C5	
C6	
C7	

2. Match the intent shown below to the prerequisite or credit:

LEED BD+C: NC, CS, S, R, DC, WDC, HOS, HC

Credit	ANS	Credit	ANS
EA– P1		EA – C3	
EA – P2		EA – C4	
EA – P3		EA – C5	
EA – P4		EA – C6	
EA – C1		EA – C7	
EA – C2			

	INTENT
A	To reduce stratospheric ozone depletion.
B	To achieve increasing levels of energy performance beyond the prerequisite standard to reduce environmental and economic harms associated with excessive energy use.
C	To increase participation in demand response technologies and programs that make energy generation and distribution systems more efficient, increase grid reliability, and reduce greenhouse gas emissions.
D	To encourage the reduction of greenhouse gas emissions through the use of grid-source, renewable energy technologies and carbon mitigation projects.
E	To support the design, construction, and eventual operation of a project that meets the owner's project requirements for energy, water, indoor environmental quality, and durability.
F	To reduce ozone depletion and support early compliance with the Montreal Protocol while minimizing direct contributions to climate change.
G	To reduce the environmental and economic harms of excessive energy use by achieving a minimum level of energy efficiency for the building and its systems.
H	To support energy management and identify opportunities for additional energy savings by tracking building-level energy use.
I	To reduce the environmental and economic harms associated with fossil fuel energy by increasing self-supply of renewable energy.
J	To further support the design, construction, and eventual operation of a project that meets the owner's project requirements for energy, water, indoor environmental quality, and durability.

3. List the areas that are addressed by the Energy and Atmosphere (EA) category:

   1.

   2.

   3.

4. Accounting for approximately _____ of the total energy used today, buildings are significant contributors to these problems.

5. Energy efficiency in a green building starts with a focus on design that reduces overall energy needs, such as building _____ and _____ selection, and the choice of climate-appropriate building _____.

6. List strategies that could help to reduce a building's energy use:

   1.

   2.

   3.

7. The _____ process is critical to ensuring high-performing buildings.

8. Projects can contribute to increasing the electricity grid's efficiency by enrolling in a _____ response program.

9. EA Prerequisite Fundamental Commissioning and Verification requirements:
   Commissioning Process Scope
   Complete the following commissioning (Cx) process activities for _____, _____, _____, and _____ energy systems and assemblies, in accordance with ASHRAE

Guideline _____ and ASHRAE Guideline _____ for HVAC&R Systems, as they relate to energy, water, indoor environmental quality, and durability.

Requirements for _____ enclosures are limited to inclusion in the _____ (OPR) and _____ (BOD), as well as the review of the OPR, BOD and project design. NIBS Guideline 3-2012 for Exterior Enclosures provides additional guidance.

Develop the _____.
Develop a _____.

The _____ (CxA) must do the following:
Review the _____, _____, and project _____.
Develop and implement a _____.
Confirm _____ of Cx requirements into the _____ documents.
Develop construction _____.
Develop a system _____ procedure.
_____ system test execution.
Maintain an _____ and _____ _____ throughout the Cx process.
Prepare a final Cx process _____.
Document all findings and recommendations and _____ directly to the _____ throughout the process.

The review of the exterior enclosure design _____ be performed by a qualified member of the _____ or _____ team (or an employee of that firm) who is _____ directly responsible for _____ of the _____ envelope.

Commissioning Authority
By the _____ of the _____ development phase, engage a commissioning authority with the following qualifications.
The CxA must have documented commissioning process experience on at least _____ building projects with a similar scope of work. The experience must extend from _____ design phase through at least _____ of occupancy;
The CxA _____ be a qualified _____ of the _____, an _____consultant, or an _____ of the design or construction firm who is _____ part of the project's _____ or _____ team, or a _____ subcontractor of the design or construction team.

For projects smaller than _____ (1 860 square meters), the _____ may be a qualified member of the design or construction team In all cases, the CxA must _____ his or her findings _____ to the _____.

Project teams that intend to pursue EA Credit Enhanced Commissioning should note a difference in the CxA qualifications: for the credit, the CxA may _____ be an _____ of the design or construction firm nor a _____ to the construction firm.

Current Facilities Requirements and Operations and Maintenance Plan
Prepare and maintain a current facilities requirements and operations and maintenance plan that contains the information necessary to operate the building efficiently. The plan must include the following:
a _____ of operations for the building;
the building _____ schedule;

_____ run-time schedules;
_____ for all _____ equipment;
set _____ levels _____ the building;
_____ outside air requirements;
any _____ in schedules or setpoints for different _____, days of the week, and _____of day;
a systems _____ describing the mechanical and electrical systems and equipment;
a _____ maintenance plan for building equipment described in the systems narrative; and
a _____ program that includes periodic commissioning requirements, _____ commissioning tasks, and continuous tasks for _____ facilities.

Data Centers only
For small projects with computer room peak cooling loads less than _____ Btu/h (600 kW) or a total computer room peak cooling load less than _____ Btu/h (175 kW), the CxA _____ be a qualified _____ of the design or construction team.

10. List the benefits of a properly executed Cx process that clearly expresses the owner's project requirements:

    1.

    2.

    3.

    4.

    5.

11. Another potential benefit of Cx is occupants' _____ and comfort because of better _____ and _____ control.

12. The qualified commissioning authority (CxA) chosen to represent the owner's needs should be brought in _____ in the _____ process.

13. The OPR must include all systems to be commissioned plus the _____, even if full envelope commissioning is not pursued.

14. The review should be conducted on _____ documents so that the project team has time to make any necessary changes.

15. List examples of what might warrant an update to the OPR:

    1.

    2.

    3.

    4.

16. In general, _____ are responsible for filling out the _____ and returning them to the CxA.

17. The CxA should _____ any noncompliance to the _____ and _____ team for them to help resolve.

18. The CxA generally _____ the testing; the contractors _____ the testing.

19. List what the CxA should provide information on the process and requirements for:

    1.

    2.

    3.

    4.

    5.

    5.

20. An acceptable sampling rate is "_____ or _____," meaning that for multiple units of the same type with the same components and sequences (e.g., fan coil units or variable air volume systems), the commissioning team may test only _____ units or _____ of the units, whichever is greater.

21. List what the CxA should include in the Cx report:

    1.

    2.

    3.

    4.

    5.

    6.

    7.

    8.

    9.

    10.

    12.

    13.

22. Efficient operations can be defined as the controlling of equipment such that it uses the _____ amount of _____ or _____ to maintain _____ and _____levels.

23. List the systems that must be commissioned:

    1.

    2.

    3.

    4.

24. The _____ must be covered in the _____ and _____, but full envelope commissioning is _____ required unless the project team pursues _____ Option 2.

25. List the Systems that are not required to be commissioned under this prerequisite but may be added to the Cx scope at the request of the owner:

    1.

    2.

    3.

    4.

    5.

26. Complete Table 1. Who can be the CxA?

Table 1. Who can be the CxA?

Can …	**Who is …**	**Be CxA for …**	
		fundamental Cx?	**Enhanced Cx?**
an _____ of the architecture or design firm	A member of the design team (e.g., a project architect, engineer, or energy modeler who is also the _____ designer)	_____, unless project is under _____ ft^2	
	_____ a member of the design team (e.g., a LEED administrator or energy modeler who is not participating in the design)		
a _____ to the architecture or engineering firm	a _____ of the design team (e.g., a project engineer subcontracted to the architect)	_____, unless project is under _____ ft^2	
	_____ a member of the design team (e.g., a LEED administrator, Cx specialist, energy modeler)		
an _____ or subcontractor of the general contractor or construction manager	a member of the construction team	_____, unless project is under _____ ft^2	
	_____ a member of the construction team		
an _____ of the owner or an independent consultant contracted to the owner			

27. The OPR details the functional _____ as well as the _____ of the building's use and operation.

28. List what the OPR might include:
    1.
    2.
    3.
    4.
    5.
    6.

29. The design team must document the basis of design _____ any contractor _____ for commissioned equipment or systems are _____.

30. List what the BOD might include:
    1.
    2.
    3.
    4.
    5.
    6.
    7.

31. List what is included in the Cx plan program overview:
    1.
    2.
    3.

32. List what the Cx plan describes about the Cx team:
    1.
    2.

33. List what the Cx plan summarizes about the process activities:
    1.
    2.
    3.
    4.
    5.
    6.

34. List what is useful for including in the design review log:
    1.
    2.

3.

4.

5.

6.

35. List the sections the functional performance test typically reports on:

    1.

    2.

    3.

    4.

    5.

    6.

    7.

36. EA Prerequisite Minimum Energy Performance requirements:
    Option 1. Whole-Building Energy Simulation
    Demonstrate an improvement of _____ for new construction, _____ for major renovations, or _____ for core and shell projects in the proposed building performance rating compared with the baseline building performance rating.

    Calculate the baseline building performance according to ANSI/ASHRAE/IESNA Standard _____, Appendix _____, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.), using a simulation model.

    Projects must meet the minimum percentage savings before taking credit for renewable energy systems. The proposed design must meet the following criteria:
    - compliance with the mandatory provisions of ANSI/ASHRAE/IESNA Standard _____, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.);
    - inclusion of all energy _____and _____within and associated with the building project; and
    - comparison against a baseline building that complies with Standard _____, _____, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.).

    Document the energy modeling input assumptions for _____loads. Unregulated loads should be modeled accurately to reflect the actual expected energy consumption of the building.

    If unregulated loads are not identical for both the _____and the _____ building performance rating, and the simulation program cannot accurately model the savings, follow the _____ calculation method (ANSI/ASHRAE/IESNA Standard 90.1–2010, G2.5). Alternatively, use the _____ Modeling Guidelines and Procedures to document measures that reduce unregulated loads.

    Retail only
    For Option 1, _____, process loads for retail may include _____equipment, _____ and _____ preparation, clothes washing, and other major support appliances. Many of the industry standard baseline conditions for commercial kitchen equipment and refrigeration are defined in Appendix 3, Tables 1–4. No additional documentation is necessary to substantiate these predefined baseline systems as industry standard.

OR
Option 2. Prescriptive Compliance: ASHRAE 50% Advanced Energy Design Guide
Comply with the mandatory and prescriptive provisions of ANSI/ASHRAE/IESNA _____, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.).

Comply with the _____ and service _____ heating requirements, including equipment _____, _____, _____, and _____and _____, in Chapter 4, Design Strategies and Recommendations by _____ Zone, for the appropriate ASHRAE 50% Advanced Energy Design Guide and climate zone:

- ASHRAE 50% Advanced Energy Design Guide for Small to Medium Office Buildings, for _____ buildings smaller than _____ square feet (9290 square meters);
- ASHRAE 50% Advanced Energy Design Guide for Medium to Large Box Retail Buildings, for _____ buildings with _____ to _____square feet (1860 to 9290 square meters);
- ASHRAE 50% Advanced Energy Design Guide for _____ School Buildings; or
- ASHRAE 50% Advanced Energy Design Guide for Large _____. Over _____ square feet (9290 square meters)

For projects outside the U.S., consult ASHRAE/ASHRAE/IESNA Standard _____, Appendixes B and D, to determine the appropriate _____ zone.

Option 3. Prescriptive Compliance: Advanced Buildings™ _____ Performance™ Guide
Comply with the mandatory and prescriptive provisions of ANSI/ASHRAE/IESNA Standard _____, with errata (or USGBC approved equivalent standard for projects outside the U.S.).

Comply with Section 1: Design _____ Strategies, Section 2: _____ Performance Requirements, and the following three strategies from Section 3: _____ Performance Strategies, as applicable. Where standards conflict, follow the more _____ of the two. For projects outside the U.S., consult ASHRAE/ASHRAE/IESNA Standard 90.1-2010, Appendixes B and D, to determine the appropriate climate zone.

3.5 Supply Air _____ Reset (VAV)
3.9 Premium _____ Performance
3.10 Variable _____ Control

To be eligible for Option 3, the project must be less than _____square feet (9290 square meters).

Note: _____, _____or _____ projects are _____ for Option 3.

Data Centers
Whole-Building Energy Simulation
Demonstrate a _____ improvement in the proposed performance rating over the baseline performance rating. To determine total energy _____ savings, create two models, one for _____ energy cost and the other for _____ equipment energy cost. Calculate the baseline building performance according to ANSI/ASHRAE/IESNA Standard _____, Appendix ____, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.), using a simulation model for the whole building and data center modeling guidelines.

Determine the _____ utilization effectiveness (PUE) value of the proposed design.

For this prerequisite, a minimum of _____ of the _____ energy savings must come from building _____ and _____ infrastructure.

Projects must meet the _____ percentage savings _____ taking credit for _____ energy systems.

The proposed design must meet the following criteria:

- compliance with the _____ provisions of ANSI/ASHRAE/IESNA Standard _____, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.);
- _____ of all energy consumption and costs within and associated with the building project; and
- _____ against a baseline building that complies with ANSI/ASHRAE/IESNA Standard _____, Appendix _____, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.), and data center modeling guidelines.

For data centers, _____ energy includes _____ units for computer and data processing rooms, critical _____ conditioning equipment, critical _____ equipment, heat _____ plants, and mechanical and electrical _____ rooms.

Include in _____ loads both the _____ load and the _____ equipment load. The IT load comprises critical systems and electrical power transformation, which may include servers, storage and networking power use, and operations affecting monthly server CPU utilization percentages.

Develop _____ sets of IT load models using _____ scenarios, one at the _____ estimated IT load rating and the second at the _____ IT rating expected at the time of commissioning.

_____ the energy modeling input assumptions for unregulated loads. Unregulated loads should be modeled accurately to reflect the _____ expected energy consumption of the building.

If unregulated loads are not _____ for both the _____ and the _____ building performance rating, and the simulation model cannot accurately model the savings, follow the _____ calculation method (ANSI/ASHRAE/ IESNA Standard _____, G2.5) to document measures that reduce unregulated loads.

37. List the benefits of identifying an energy goal for the project early in the design process:

    1.

    2.

    3.

    4.

38. List the two approaches projects can take to comply with EA Prerequisite Minimum Energy Performance:

    1.

    2.

39. For EA Prerequisite Minimum Energy Performance, Option 3, the energy performance target must be established using ENERGY STAR's Target Finder and must be greater than a score of _____.

40. Energy costs offset by on-site _____ energy systems do _____ count toward energy savings for compliance with the _____. Renewable energy _____ be included in the model for achievement of _____ under the related credit.

41. Determining the right _____ zone for the project is essential, since the requirements are specific to each climate zone. ASHRAE _____ defines _____ climate zones (Miami is in climate zone ___; Anchorage is in climate zone ___) and three climate types: A (_____), B (_____), and C (_____).

42. To find the project's climate zone and type, consult ASHRAE _____, Appendix ___, for the appropriate _____ and _____. If the project's _____ is not listed, use the climate zone listed for the _____ as a whole.

43. List the name of each of the options for EA Prerequisite Minimum Energy Performance:

    Option 1. _____

    Option 2. _____

    Option 3. _____

44. EA Prerequisite Building-Level Energy Metering requirements:
    NC, S, R, DC, WDC, HOS, HC
    Install new or use existing building-level energy meters, or submeters that can be aggregated to provide building level data representing _____ building energy consumption (electricity, natural gas, chilled water, steam, fuel oil, propane, biomass, etc). Utility-owned meters capable of aggregating building-level resource use are acceptable.

    Commit to sharing with USGBC the resulting energy consumption data and electrical demand data (if metered) for a _____ period beginning on the date the project accepts _____. At a minimum, energy consumption must be tracked at _____ intervals.

    This commitment must carry forward for _____ years or until the building changes ownership or lessee.

    CS
    Install new or use existing base building-level energy meters, or submeters that can be aggregated to provide _____ building-level data representing total building energy consumption (electricity, natural gas, chilled water, steam, fuel oil, propane, etc.). Utility-owned meters capable of aggregating base building-level resource use are acceptable.

    Commit to sharing with USGBC the resulting energy consumption data and electrical demand data (if metered) for a _____ period beginning on the date the project accepts LEED certification or typical occupancy, whichever comes first. At a minimum, energy consumption must be tracked at one-month intervals.

    This commitment must carry forward for _____ years or until the building changes ownership or lessee.

45. List the sources of energy supplied by a utility company or campus plant that must be metered:

    1.

    2.

    3.

    4.

46. If all energy provided to the building is supplied by one or more utility companies and the utility meters provide _____ consumption data, those meters meet the prerequisite requirements.

47. Begin tracking energy use when the project achieves _____ certification or at _____, whichever occurs first.

48. Utility-provided meters are typically regulated by code or law to establish their accuracy. Utility meters are often called "_____" because their measurement results directly in a charge to the customer.

49. EA Prerequisite Fundamental Refrigerant Management requirements:
    Do not use chlorofluorocarbon (_____)-based refrigerants in _____ heating, ventilating, air-conditioning, and refrigeration (HVAC&R) systems. When reusing existing HVAC&R equipment, complete a comprehensive CFC phase-out conversion _____ project completion. Phase-out plans extending beyond the project completion date will be considered on their merits.

    Existing small HVAC&R units (defined as containing less than _____ pound [225 grams] of refrigerant) and other equipment, such as standard refrigerators, small water coolers, and any other equipment that contains less than _____ pound (225 grams) of refrigerant, are _____.

50. Production of CFCs was phased out in industrialized nations that signed the Montreal Protocol before December 1995 and in most other countries by _____.

51. Though both hydrochlorofluorocarbons (_____) and _____ contribute to ozone depletion, only CFCs must be addressed to meet this prerequisite.

52. EA Credit Enhanced Commissioning requirements:
    Implement, or have in place a contract to implement, the following commissioning process activities in addition to those required under EA Prerequisite Fundamental Commissioning and Verification.

    Commissioning Authority
    The CxA must have documented commissioning process experience on at least _____ building projects with a similar scope of work. The experience must extend from early design phase through at least _____ of occupancy;
    The CxA may be a qualified _____ of the owner, an independent _____ , or a disinterested subcontractor of the design team.

    Option 1. Enhanced Systems Commissioning (3-4 points)
    Path 1: Enhanced Commissioning (3 points)
    Complete the following commissioning process (CxP) activities for mechanical, electrical, plumbing, and renewable energy systems and assemblies in accordance with ASHRAE Guideline _____ and ASHRAE Guideline _____ for HVAC&R systems, as they relate to energy, water, indoor environmental quality, and durability.

    The commissioning authority must do the following:
    Review contractor _____.
    Verify inclusion of systems _____ requirements in construction documents.
    Verify inclusion of operator and occupant _____ requirements in construction documents.
    Verify systems _____ updates and delivery.
    Verify operator and occupant _____ delivery and effectiveness.
    Verify _____ testing.
    Review building operations _____ after substantial completion.
    Develop an _____ commissioning plan.

    Include all enhanced commissioning tasks in the _____ and _____.

OR
Path 2: Enhanced and Monitoring-Based Commissioning (4 points)
Achieve Path 1.

AND
Develop monitoring-based procedures and identify points to be measured and evaluated to assess performance of _____- and _____ -consuming systems.

Include the procedures and measurement points in the commissioning plan. Address the following:
roles and _____;
_____ requirements (meters, points, metering systems, data access);
the points to be tracked, with frequency and duration for _____ monitoring;
the _____ of acceptable values for tracked points and metered values (where appropriate, predictive algorithms may be used to compare ideal values with actual values);
the _____ used to evaluate performance, including conflict between systems, out-of-sequence operation of systems components, and energy and water usage profiles;
an _____ plan for identifying and correcting operational errors and deficiencies;
_____ to prevent errors;
planning for repairs needed to _____ performance; and
the frequency of analyses in the _____ of occupancy (at least quarterly).

Update the systems _____ with any modifications or new settings, and give the reason for any modifications from the original design.

AND/OR
Option 2. Envelope Commissioning (2 Points)

Fulfill the requirements in EA Prerequisite Fundamental Commissioning and Verification as they apply to the building's thermal _____ in addition to mechanical and electrical systems and assemblies.

Complete the following commissioning process (CxP) activities for the building's thermal envelope in accordance with ASHRAE Guideline _____ and the National Institute of Building Sciences (NIBS) Guideline _____, Exterior Enclosure Technical Requirements for the Commissioning Process, as they relate to energy, water, indoor environmental quality, and durability.

Commissioning authority must complete the following:
Review contractor _____.
Verify inclusion of systems _____ requirements in construction documents.
Verify inclusion of operator and occupant _____ requirements in construction documents.
Verify systems manual _____ and _____.
Verify operator and occupant training delivery and _____.
Verify _____ testing.
Review building operations _____ after substantial completion.
Develop an _____ commissioning plan.

Data Centers only
Projects that select Option 1 must complete the following commissioning process.

For small projects with peak cooling loads less than _____ Btu/h (600 kW), or a total computer room peak cooling load less than _____ Btu/h (175 kW), the CxA must perform the following activities:

conduct at least _____ commissioning verification review of the owner's project requirements, basis of design, and design documents before _____ documents development;
back-check the review comments in all subsequent _____ submissions; and
conduct an additional full verification review at _____ completion of the design documents and basis of design.

For projects with peak cooling loads _____ Btu/h (600 kW) or more, or a total computer room peak cooling load _____ Btu/h (175 kW) or more, the CxA must conduct at least _____ verification reviews of the basis of design:
one verification review of design documents before the _____ of design development;
one verification review of design documents before _____ documents; and
one final verification review of _____ complete design documents, verifying achievement of the owner's project requirements and adjudication of previous review comments.

53. Monitoring-based commissioning (MBCx) gives the building owner, operators, and the CxA a continual stream of information that helps them identify operational _____ as they occur, thereby saving time, money, and _____ consumption over the lifetime of the building.

54. Complete Table 1. Commissioning activities

Table 1. Commissioning activities

Phase	Cx task	Responsible party	Cx	Enhanced Cx	MBCx	BECx
Predesign	Develop OPR					
Schematic design	Develop BOD, including envelope requirements	Design Team				
	Include general monitoring, metering, and trending requirements	Design Team				
Design	Engage CxA					
Documents	Develop initial commissioning plan					
	Include monitoring requirements, equipment					
	Include envelope requirements					
	Conduct OPR, BOD, and design document review	CxA, owner, design team				
	Prepare systems manual outline	CxA, owner				
	Include monitoring requirements, equipment	CxA, owner				
	Include envelope requirements	CxA, owner				
	Document training requirements	CxA, owner				
	Update OPR and BOD as necessary	CxA, owner, design team				

Phase	Cx task	Responsible party	Cx	Enhanced Cx	MBCx	BECx
Construction Documents	Issue Cx specifications for inclusion in bid/permit documents					
	Include enhanced Cx requirements					
	Include monitoring-based Cx requirements					
	Include envelope based Cx requiremetns					
	Update OPR and BOD as necessary	CxA, owner, design team				
	Conduct design review (recommended)	CxA, design team				
Construction	Update OPR and BOD as necessary	CxA, owner, design team				
	Perform prefunctional inspections					
	Complete submittal reviews concurrently with or before acceptance by design team					
	Update OPR, BOD, Cx plan and systems manual as necessary					
	Issue owner's training requirements	CxA, contractor				
	Issue construction checklists					
	Issue functional performance test scripts for contractor review	CxA, contractor				
	Issue/review verified TAB reprot	Contractor, CxA				
	Issue/review completed construction checklists	Contractor, CxA				
	Execute functional performance tests	CxA, contractor				
	Document issues in issues log					
	Compile final systems manual					
	Complete final commissioning report					
	Verify training plan has been implemented	CxA, contractor, building operators				

Phase	Cx task	Responsible party	Cx	Enhanced Cx	MBCx	BECx
Occupancy and operations	Complete Cx report					
	Compile operations and maintenance plan					
	Compile final systems manual					
	Perform seasonal testing	CxA, contractor, building operators				
	Perform 10-month review	CxA, contractor, building operators				
	Develop ongoing Cx plan	CxA, building operators				

BECx = building envelope commissioning plan
BOD = basis of design
Cx = commissioning process
CxA = commissioning authority
MBCx = monitoring-based commissioning process
OPR = owner's project requirements

55. List the three components of monitoring-based commissioning:

    1.

    2.

    3.

56. List the activities that MBCx allows the user to do:

    1.

    2.

    3.

57. MBCx is most cost-effective when the metering and energy analysis software are integrated into the _____ design of a building.

58. EA Credit Optimize Energy Performance requirements:
    NC, CS, S, R, WDC, HOS, HC

    Establish an energy performance target no later than the _____ design phase. The target must be established as _____ per square foot-year (kW per square meter-year) of source energy use.

    Choose one of the options below.

    Option 1. Whole-Building Energy Simulation (1–18 points except Schools and Healthcare, 1–16 points Schools, 1–20 points Healthcare)

    Analyze efficiency measures during the _____ process and account for the results in design decision making. Use energy simulation of efficiency opportunities, past energy simulation analyses for similar buildings, or published data (e.g., Advanced Energy Design Guides) from analyses for similar buildings.

Analyze efficiency measures, focusing on load _____ and HVAC-related strategies (passive measures are acceptable) appropriate for the facility. Project _____ energy savings and holistic project cost implications related to all affected systems.

Project teams pursuing the Integrative Process credit must complete the basic energy _____ for that credit before conducting the energy _____.
Follow the criteria in EA Prerequisite Minimum Energy Performance to demonstrate a percentage improvement in the proposed building performance rating compared with the baseline. Points are awarded according to Table 1.

Complete Table 1. Points for percentage improvement in energy performance

Table 1. Points for percentage improvement in energy performance

New Construction	Major Renovation	Core and Shell	Points (except S, HC)	Points (Healthcare)	Points (Schools)
	4%	3%		3	1
8%	6%	5%		4	2
10%	8%	7%		5	3
12%	10%	9%		6	4
14%	12%	11%		7	5
16%	14%	13%		8	6
18%	16%	15%		9	7
20%	18%	17%		10	8
22%	20%	19%		11	9
24%	22%	21%		12	10
26%	24%	23%		13	11
29%	27%	26%		14	12
32%	30%	29%		15	13
35%	33%	32%		16	14
38%	36%	35%		17	15
42%	40%	39%		18	16
46%	44%	43%		19	--
	48%	47%		20	--

Retail only
For all _____ loads, define a clear baseline for comparison with the proposed improvements. The baselines in Appendix 3, Tables 1–4, represent industry standards and may be used without additional documentation. Calculate the baseline and design as follows:

Appliances and equipment. For appliances and equipment not covered in Tables 1–4, indicate hourly energy use for proposed and budget equipment, along with estimated daily use hours. Use the total estimated

appliance/equipment energy use in the energy simulation model as a plug load. Reduced use time (schedule change) is not a category of energy improvement in this credit. _____ ratings and evaluations are a valid basis for performing this calculation.

Display lighting. For display lighting, use the _____ method of determining allowed lighting power under ANSI/ASHRAE/IESNA Standard 90.1–2010, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.), to determine the appropriate baseline for both the general building space and the display lighting.

Refrigeration. For _____ refrigeration loads, model the effect of energy performance improvements with a simulation program designed to account for refrigeration equipment.

Option 2. Prescriptive Compliance: ASHRAE Advanced Energy Design Guide (1–6 points)
To be eligible for Option 2, projects must use Option 2 in EA Prerequisite Minimum Energy Performance.

Implement and document compliance with the applicable recommendations and standards in Chapter 4, Design Strategies and Recommendations by Climate Zone, for the appropriate ASHRAE 50% Advanced Energy Design Guide and _____ zone. For projects outside the U.S., consult ASHRAE/ASHRAE/IESNA Standard 90.1–2010, Appendixes B and D, to determine the appropriate climate zone.

ASHRAE 50% Advanced Energy Design Guide for Small to Medium _____ Buildings
Building envelope, opaque: roofs, walls, _____, slabs, doors, and continuous air barriers (1 point)
Building envelope, glazing: vertical _____ (1 point)
Interior lighting, including _____ and interior finishes (1 point)
Exterior _____ (1 point)
Plug loads, including _____ and controls (1 point)

ASHRAE 50% Advanced Energy Design Guide for Medium to Large Box _____ Buildings
Building envelope, opaque: roofs, walls, floors, slabs, doors, and _____ (1 point)
Building envelope, glazing: fenestration - all _____ (1 point)
Interior lighting, _____ lighting power density for sales floor (1 point)
Additional _____ lighting for sales floor (1 point)
Exterior _____ (1 point)
Plug loads, including _____ choices and controls (1 point)

ASHRAE 50% Advanced Energy Design Guide for _____ School Buildings
Building envelope, _____: roofs, walls, floors, slabs, and doors (1 point)
Building envelope, _____: vertical fenestration (1 point)
Interior lighting, including _____ and interior finishes (1 point)
Exterior _____ (1 point)
Plug loads, including equipment choices, controls, and _____ equipment (1 point)

ASHRAE 50% Advanced Energy Design Guide for Large _____
Building envelope, opaque: roofs, walls, floors, slabs, doors, vestibules, and continuous air barriers (1 point)
Building envelope, glazing: vertical fenestration (1 point)
Interior lighting, including daylighting (form or nonform driven) and interior _____ (1 point)
_____ lighting (1 point)
Plug loads, including equipment choices, controls, and _____ equipment (1 point)

Retail only
Meet the requirements of Option 2 and comply with the prescriptive measures in Appendix 3, Tables 1–4, for _____ of total energy consumption for all process equipment.

DATA CENTERS
Whole-Building Energy Simulation
Analyze efficiency measures focused on _____ load reduction and HVAC-related strategies (air-side economizers, hot aisle–cold aisle, etc.). Project the potential energy savings and cost implications for all affected systems.

Follow the criteria in EA Prerequisite Minimum Energy Performance to demonstrate a percentage improvement in the _____ performance rating compared with the _____.

Use energy _____ savings from both the building and IT to determine the total percentage reduction.

59. The option pursued in the prerequisite must also be pursued in the _____.

60. Exemplary Performance
Option 1. New construction, major renovation, and core and shell projects: Achieve at least _____ energy savings.

61. EA Credit Advanced Energy Metering requirements:
NC, S, R, DC, WDC, HOS, HC

Install advanced energy metering for the following:
_____ whole-building energy sources used by the building; and
any individual energy end uses that represent _____ or more of the total _____ consumption of the building.

The advanced energy metering must have the following characteristics.
Meters must be _____ installed, record at intervals of _____ hour or less, and transmit data to a remote location.
Electricity meters must record both consumption and _____. Whole-building electricity meters should record the power factor, if appropriate.
The data collection system must use a local area network, building automation system, wireless network, or comparable _____ infrastructure.
The system must be capable of storing all meter data for at least _____ months.
The data must be _____ accessible.
All meters in the system must be capable of reporting hourly, daily, monthly, and _____ energy use.

CORE AND SHELL
Install meters for future tenant spaces so that tenants will be capable of _____ metering energy consumption (electricity, chilled water, etc.) for all systems dedicated to their space.
Provide a sufficient number of meters to capture _____ tenant energy use with a minimum of _____ meter per energy source per floor.

Install _____ energy metering for all base building energy sources used by the building.

The advanced energy metering must have the following characteristics.
Meters must be _____ installed, record at intervals of _____ hour or less, and transmit data to a remote location.

Electricity meters must record both consumption and _____. Whole-building electricity meters should record the power factor, if appropriate.
The data collection system must use a local area network, building automation system, wireless network, or comparable _____ infrastructure.
The system must be capable of storing all meter data for at least _____ months.
The data must be _____ accessible.
All meters in the system must be capable of reporting hourly, daily, monthly, and _____ energy use.

62. List examples of renewable energy sources that could serve a project:

    1.

    2.

    3.

    4.

63. Identifying major energy _____ uses is the first step in choosing what to meter.

64. List examples of typical end uses for a commercial office building that may require advanced metering:

    1.

    2.

    3.

    4.

    5.

    6.

    7.

    8.

    9.

65. The _____ is responsible for maintaining and calibrating meters according to the manufacturers' recommendations.

66. EA Credit Demand Response requirements:
    Design building and equipment for participation in demand response programs through load _____ or shifting.
    On-site electricity generation does _____ meet the intent of this credit.

    Case 1. Demand Response Program Available (2 points)
    Participate in an existing demand response (DR) program and complete the following activities. Design a system with the _____ for real-time, fully-automated DR based on external initiation by a DR Program Provider. Semi-automated DR may be utilized in practice.

    Enroll in a minimum _____ DR participation amount contractual commitment with a qualified DR program provider, with the intention of multiyear renewal, for at least _____ of the estimated peak electricity demand. _____ demand is determined under EA Prerequisite Minimum Energy Performance.

    Develop a comprehensive _____ for meeting the contractual commitment during a Demand Response event.

Include the DR processes in the scope of work for the _____ authority, including participation in at least _____ full test of the DR plan.

Case 2. Demand Response Program Not Available (1 point)
Provide infrastructure to take advantage of _____ demand response programs or dynamic, real-time pricing programs and complete the following activities.

Install interval recording _____ with communications and ability for the building automation system to accept an external price or control signal.

Develop a comprehensive plan for shedding at least _____ of building estimated peak electricity demand. Peak demand is determined under EA Prerequisite Minimum Energy Performance.

Include the DR processes in the scope of work for the commissioning _____, including participation in at least one full test of the DR plan.

Contact _____ utility representatives to discuss participation in future DR programs.

67. EA Credit Renewable Energy Production requirements:
Use renewable energy systems to offset building energy costs. Calculate the percentage of renewable energy with the following equation:

$$\% \text{ renewable energy} = \frac{\text{Equivalent cost of usable energy produced by the renewable energy system}}{\text{Total building annual energy cost}}$$

Use the building's _____ energy cost, calculated in EA Prerequisite Minimum Energy Performance, if Option 1 was pursued; otherwise use the U.S. Department of Energy's Commercial Buildings Energy Consumption Survey (_____) database to estimate energy use and cost.

The use of solar gardens or community renewable energy systems is allowed if both of the following requirements are met.
The project _____ the system or has signed a lease agreement for a period of at least _____ years.
The system is located with the _____ utility service area as the facility claiming the use.

Credit is based on the percentage of ownership or percentage of use assigned in the lease agreement. Points are awarded according to Table 1.

Complete Table 1. Points for renewable energy

Table 1. Points for renewable energy		
Percentage renewable energy	Points (All, except Core and Shell)	Points (Core and Shell)

68. Excess energy, beyond the building's energy demand at a given point, can be sold to the utility company (_____ metering).

69. List the allowable sources for renewable energy:
    1.
    2.
    3.
    4.
    5.
    6.
    7.

70. Some renewable energy systems do not meet the intent of the credit and are not eligible. List strategies that reduce energy consumption but are not eligible renewable energy systems:
    1.
    2.
    3.

71. List the biofuels that are ineligible:
    1.
    2.
    3.
    4.

72. List the ways that the equivalent cost of the usable energy system can be calculated:
    1.
    2.

73. EA Credit Enhanced Refrigerant Management requirements:
    NC, CS, S, DC, WDC, HOS, HC

    Option 1. No Refrigerants or Low-Impact Refrigerants (1 point)

    Do not use refrigerants, or use only refrigerants (naturally occurring or synthetic) that have an ozone depletion potential (_____) of _____ and a global warming potential (_____) of less than _____.

    OR

    Option 2. Calculation of Refrigerant Impact (1 point)
    Select refrigerants that are used in heating, ventilating, air-conditioning, and refrigeration (HVAC&R) equipment to minimize or eliminate the emission of compounds that contribute to _____ depletion and _____ change. The combination of all new and existing base building and tenant HVAC&R equipment that serve the project must comply with the following formula:

    $LCGWP + LCODP \times 10^5 \leq$ _____

RETAIL
Meet Option 1 or 2 for all HVAC systems.
Stores with _____ refrigeration systems must comply with the following.
Use only _____-depleting refrigerants.
Select equipment with an average HFC refrigerant charge of no more than _____ pounds of refrigerant per 1,000 Btu/h (2.72 kg of refrigerant per kW) total evaporator cooling load.
Demonstrate a predicted store-wide annual refrigerant emissions rate of no more than _____. Conduct leak testing using the procedures in _____ best practices guideline for leak tightness at installation.

Alternatively, stores with commercial refrigeration systems may provide proof of attainment of EPA _____ _____-level store certification for newly constructed stores.

74. List the main threats to the environment posed by refrigerants:

    1.

    2.

75. For any HVAC &R equipment not listed, assume an equipment life of _____ years.

76. Assume that refrigerant leakage rate (Lr) is _____ per year and end-of-life refrigerant loss (Mr) is _____, for all equipment types. No alternative values may be _____ for these percentages.

77. If a packaged air-conditioning unit uses 7 pounds of refrigerant and its cooling capacity is 5 tons, what is the refrigerant charge (Rc)?

78. List examples of natural refrigerants:

    1.

    2.

    3.

79. An office project is installing new HVAC-R equipment. The main cooling system will be (2) 200-ton centrifugal Chillers with HCFC-123 and Rc = 1.63 lb/ton. The computer room air conditioning unit will be (1) 10-ton packaged air conditioning unit with HCFC-22 and Rc = 2.3 lb/ton. The manufacturer has also provided a guarantee that the unit has less than 1% per year leakage.

    Calculate the Average Refrigerate Atmospheric Impact. Does this office project comply with EA Credit Enhanced Refrigerant Management?

Inputs									Calculations				
N (Number of Units)	**Qunit** (Tons)	**Refrigerant**	**GWPr**	**ODPr**	**Rc** (lb/ ton)	**Life** (yrs)	**Lr** (%)	**Mr** (%)	**Tr** Total Leakage (Lr x Life + Mr)	**LCGWP** (GWPr x Tr x Rc)/ Life	**LCODP x 10^5** 100,000 x (ODPr x Tr x Rc)/ Life	**Refrigerant Atmospheric Impact = LCGWP + LCODP x 10^5**	**(LCGWP + LCODP x 10^5) x N x Qunit**
Qtotal:												**Subtotal:**	
Average Refrigerant Atmospheric Impact = [∑ (LCGWP + LCODP x 105) x Qunit] / Qtotal :													

80. EA Credit Green Power and Carbon Offsets requirements:
Engage in a contract for qualified resources that have come online since January 1, 2005, for a minimum of _____ years, to be delivered at least _____. The contract must specify the provision of at least _____ or _____ of the project's energy from _____ power, _____ offsets, or renewable energy _____ (RECs).

Green power and RECs must be _____ certified or the equivalent. RECs can only be used to mitigate the effects of Scope 2, _____ use.

Carbon offsets may be used to mitigate Scope 1 or Scope 2 emissions on a metric ton of carbon dioxide–equivalent basis and must be _____ certified, or the equivalent.

For U.S. projects, the offsets must be from greenhouse gas emissions reduction projects _____ the U.S.

Determine the percentage of green power or offsets based on the _____ of energy consumed, not the cost.

Points are awarded according to Table 1.

Complete Table 1. Points for energy from green power or carbon offsets

Table 1. Points for energy from green power or carbon offsets	
Percentage of total energy addressed by green power, RECs and/or offset	**Points**

Use the project's annual energy consumption, calculated in EA Prerequisite Minimum Energy Performance, if Option 1 was pursued; otherwise use the U.S. Department of Energy's _____ (CBECS) database to estimate energy use.

Core and Shell Only
A core and shell building's energy is defined as the energy usage of the core and shell floor area as defined by the _____ (BOMA) standards, but not less than _____ of the project's floor area.

Green power and RECs must be _____ certified or the equivalent.

Carbon offsets must be _____ certified or the equivalent. Unlike RECs and purchased green power, carbon offsets can be used toward _____ electric and nonelectric energy use.

Net-zero buildings—those anticipated to consume _____ net energy on an _____ basis—are eligible to achieve _____ points under this credit without purchasing any additional renewable energy, RECs, or carbon offsets, provided the project does not _____ any RECs associated with the on-site renewable energy production.