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Green Building Certification System Review

N Wang
KM Fowler
RS Sullivan

March 2012

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The following certification system owners responded to the request for additional information regarding their systems:

- Sarah Alexander, US Green Building Council
- Eden Brukman, Living Building Challenge
- Melissa Gallagher-Rogers, US Green Building Council
- Kevin Stover, The Green Building Initiative
- Vicki Worden, The Green Building Initiative

Certification system users were interviewed to gain additional insights into the use of various systems. Those interviewed include:

- Colonel Barton Barnhart (Air Force)
- Danielle Bogni (GSA)
- Jessica Higgins (GSA)
- Beth Kempton (State)
- Keith Molina (Army)
- Brad Nies (GSA)
- Joseph Parisi (GSA)
- Paula Shaw (Air Force)
- Julie Sobelman (State)

Executive Summary

Background

The General Services Administration's Office of Federal High-Performance Green Buildings (the Office) commissioned this study of green building certification systems in accordance with the Energy Independence and Security Act of 2007 (EISA).[1] Sections 433(a) and 436(h) of EISA require the Director of the Office to identify a green building certification system that the Director "*deems to be most likely to encourage a comprehensive and environmentally sound approach to certification of green buildings*." Federal agencies have been using green building certification systems since such systems were pilot tested in the late 1990s. Now that the Federal government has developed minimum sustainability requirements for its own buildings, it is important to evaluate how different systems perform in helping the government meet its green building objectives. This review of certification systems is designed to provide clarity on how current certification systems align with Federal sustainable design principles and high-performance operational requirements. The framework for analysis is a set of criteria drawn from EISA and Federal building performance requirements. EISA-cited criteria to be used in reviewing certification systems include:

- Robustness of the technical components of the certification system to address Federal high-performance design and operational requirements for Federal facilities
- Independence of auditors or assessors
- Availability of technically qualified auditors or assessors
- Documented verification method
- Transparency of certification systems' approach to collecting and addressing public comments
- Consensus-based standard for documenting a development and revision process
- System maturity
- Usability of the system
- National recognition within the building industry[2]

Most EISA criteria highlight similarities and differences among certification systems and the context of how they are used by the market. The "robustness" criterion as applied here includes a set of measures intended to assess how each system aligns with Federal performance requirements. Building performance is an important, current focus in the Federal sector, and this multi-part criterion compares the legal requirements applicable to Federal real estate portfolios against each certification system's technical components (such as energy, water, siting, etc.).

To meet Federal sustainable design and high-performance operations requirements, agencies need to focus on the existing Federal building stock. Quality, integrated design may make it easier for buildings to meet the Federal requirements, but in the end, there is a need for quality building operations professionals to achieve long term, high-performing buildings. The building occupants also need to be committed to contributing in a positive manner to optimize building operations.

[1] Public Law 110–140—DEC. 19, 2007. Energy Independence and Security Act of 2007. (EISA)
[2] Detailed information about the review criteria used in this evaluation is found in Appendix D.

Green building certification systems can be used to provide design and operations guidance, document progress toward a design or operational performance target, compare buildings using the certification systems structure, and document what design and operations outcomes and/or strategies are being used in the building. None of the systems discussed in this report ensures that a building will meet Federal sustainable design requirements (once certified), or that the building will perform optimally. Federal sector high-performance, sustainable design and operations requirements can be met without the use of a green building certification system. At the same time, certification systems have been identified as useful tools by users when they are documenting, tracking, and reporting a building's progress toward the Federal requirements.

The determination of which, if any, certification system to use depends on the user's goals. This report does not recommend a certification system or compare measured building performance to design intent, but rather is intended to organize certification system information based on the EISA Section 436(h) review criteria to enable a comparable evaluation of the systems. The review focuses on identifying measurable components of each criterion as well as qualitative information that further explains how each certification system relates to the criteria.

Methodology

The information compiled for this review was collected from November 15, 2010 to November 10, 2011 through literature reviews, requests for information from certification system owners, and interviews with certification system users.

Screening criteria were used to identify which systems met the minimum expectations of a green building certification system with respect to EISA criteria. The screening criteria are:

- Systems must employ whole building evaluation, addressing key sustainable design and operations metrics,
- Systems must be available in the U.S. market, and
- Systems must have third party certification.

Three certification systems passed the screening criteria: Green Building Initiative's Green Globes® (2010), U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED®) (2009), and the International Living Building Institute's Living Building Challenge™ (2011) (Table ES.1). Both the new construction and existing building systems for Green Globes and LEED, and the Living Building Challenge Building and Renovation typologies are reviewed.

Table ES.1 Summary of Green Building Certification Systems

Certification System	Owner	Whole-building sustainability	Building Types	Third-party Certification
Green Globes®	Green Building Initiative (GBI)	Green Globes is comprised of seven key areas: energy, indoor environment, site, water, resources, emissions, and project/ environmental management.	Green Globes certifies new buildings and significant renovation, existing buildings, building emergency management, building intelligence, and fit-up.	Green Globes Assessors provide third-party certification services.
LEED®	U.S. Green Building Council (USGBC)	LEED is comprised of five key areas: sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality.	LEED certifies new construction and major renovations, existing buildings, commercial building interiors, core and shell construction, schools, retail, healthcare, and homes.	The Green Building Certification Institute (GBCI) provides third-party certification services.
Living Building Challenge™	International Living Building Institute (ILBI)	Living Building Challenge is comprised of seven performance areas: site, water, energy, health, materials, equity and beauty.	Living Building Challenge certifies development at four scales: building, neighborhood, village/campus, and city.	A third-party auditor is responsible for performing document review and onsite verification.

Green Globes and LEED have separate certification systems focused on new construction and existing buildings.

- Green Globes NC (New Construction) and CIEB (Continual Improvement of Existing Buildings)
- LEED-NC (New Construction and Major Renovation) and EBO&M (Existing Buildings Operations and Maintenance)

Each of these systems is reviewed in this report. The Living Building Challenge has four typologies:

- Building
- Renovation
- Landscape or Infrastructure
- Neighborhood.

For this review, the Building typology is being used for the new construction comparison and the Renovation typology is being used for the existing building comparison.

Tables ES 2-5 illustrate how the certification systems align with the current set of Federal high-performance building requirements using the robustness criterion. There are 27 Federal requirements drawn from the Energy Policy Act, EISA, the High-Performance Sustainable Building Guiding Principles and Executive Order 13514. For each Federal requirement, the technical information available for each certification system was reviewed to determine if the Federal requirement would be fully or partially met.

- Full circles (green) mean that the Federal requirement would automatically be met if the building was certified because the system and Federal requirements fully align, and the system component is mandatory to achieve certification.
- Three-quarter circles (green) mean that the certification system has an option (e.g., point, credit, etc.) that meets the Federal requirement; if that option is included in the certification package, the Federal requirement would be met.

- A half circle (yellow) means the certification system includes an option related to but not directly aligned with the Federal requirement. If the user meets this option within the certification system, it is likely additional effort may be needed to meet the Federal requirement. The certification systems may have a lower standard, different baselines, different calculation methods, or different ways to document compliance with the Federal requirement.
- An empty circle means the Federal requirement is not an identified component within the certification system.

The difference between the three-quarter circle and full circle can be communicated by a waste and materials management example. The Federal requirement is for at least 50% of construction and demolition materials to be recycled. In Green Globes, if the building receives 4 of the 6 possible points, the Federal requirement will be met. In LEED, if at least 1 of the 2 possible credits is achieved, the Federal requirement will be met. The half circle symbol can be illustrated by using a daylighting example. The Federal requirement is to achieve a minimum daylight factor of 2 percent in 75 percent of all space occupied for critical visual tasks.[3] All three systems address daylighting, but in different ways, which is why they received a half circle. In Green Globes points are available for designing primary spaces to receive indirect minimum daylight illumination levels of 25 footcandles. In LEED a point is available for designing regularly occupied spaces achieve daylight illuminance levels of a minimum of 25 footcandles and a maximum of 500 footcandles. The Living Building Challenge requires that every occupiable space provides access to daylight.

The robustness criterion includes a set of measures intended to assess how each system aligns with Federal performance requirements. The robustness criterion for new construction includes 27 Federal requirements (source requirement documents in parentheses):

1. Integrated Design (Guiding Principles)
2. Commissioning (Guiding Principles, EISA)
3. Indoor Water (Guiding Principles, EPAct, EO 13423, EISA, EO 13514)
4. Process Water (Guiding Principles, EPAct)
5. Outdoor Water (Guiding Principles, EO 13423, EISA, EO 13514)
6. Storm Water (Guiding Principles, EISA, EO 13514)
7. Water-Efficient Products (Guiding Principles, EO 13514)
8. Energy Efficiency (Guiding Principles, EPAct, EO 13423, EISA)
9. On-Site Renewable Energy (Guiding Principles, Executive Order 13423, EISA)
10. Measurement and Verification (Guiding Principles, EPAct, EISA)
11. Benchmarking (Guiding Principles)
12. Recycled Content (Guiding Principles, Resource Conservation and Recovery Act, EO 13514)
13. Biobased Content (Guiding Principles, Farm Security and Rural Investment Act, EO 13514)
14. Environmentally Preferable Products (Guiding Principles, EO 13514)
15. Waste and Materials Management (Guiding Principles, EO 13514)
16. Ozone Depleting Compounds (Guiding Principles, Montreal Protocol and Title VI of the Clean Air Act Amendments of 1990)
17. Low-Emitting Materials (Guiding Principles, EO 13514)

[3] Office of Management and Budget. December 2008. High-performance Sustainable Design Guidance. Initially developed by the Interagency Sustainability Working Group. URL: http://www.wbdg.org/pdfs/hpsb_guidance.pdf

18. Ventilation (Guiding Principles)
19. Thermal Comfort (Guiding Principles)
20. Daylighting (Guiding Principles)
21. Environmental Tobacco Smoke Control (Guiding Principles)
22. Protect Indoor Air Quality during Construction (Guiding Principles)
23. Moisture Control (Guiding Principles)
24. Acoustic (EISA)
25. Building System Controls (EISA)
26. Siting (EISA)
27. Greenhouse Gas (EISA)

Each certification system was mapped to the robustness criteria for new construction. Tables ES.2 and ES.3 reflect Federal requirements for new construction and major renovations. The following is a summary of that mapping.

Green Globes aligns at some level with more of the Federal requirements (25) than any other new construction system in this review:

- Green Globes has no points that are specifically required; thus, an examination of the points achieved on each individual project is required in order to determine which Federal requirements would be met by certification.

- Ten of the Federal requirements would be fully met through the Green Globes system if these points are selected by the user and achieved.

- Fifteen requirements may be met if points are achieved and additional efforts are made to conform to the Federal requirement.

- The Green Globes system does not include two of the Federal requirements (benchmarking and building system controls).

LEED aligns at some level with 20 Federal requirements:

- Four Federal requirements would be automatically met if certification is achieved because LEED has minimum requirements that must be met before any level of certification can be attained (called prerequisites). The prerequisites do not add to the total number of points needed to achieve certification.

- Seven of the Federal requirements would be fully met through the LEED system if these credits are selected by the user and achieved.

- Nine of the Federal requirements may be met if the credits are achieved and additional efforts are made to conform to the Federal requirements.

- The LEED system does not include seven of the Federal requirements (integrated design, process water, benchmarking, moisture control, acoustics, building system controls and greenhouse gas emissions).

The Living Building Challenge aligns at some level with 14 Federal requirements:

- The Living Building Challenge requires that buildings meet 100% of the system's design and operations strategies (many of which exceed Federal targets), so these twelve Federal requirements would be met automatically if certification is achieved.

- Three of the Federal requirements could be met if additional efforts are made to conform to Federal requirements.

- The Living Building Challenge system does not include thirteen of the Federal requirements (integrated design, commissioning, water efficient products, measurement and verification, benchmarking, recycled content, biobased content, thermal comfort, moisture control, indoor air quality protection during construction, acoustics, building system controls, and greenhouse gas).

In practice, the Green Globes and LEED certification systems are "tiered," meaning that they require a minimum number of points or credits to be achieved for a base level of certification, with higher levels of certification available based on accumulation of additional points or credits. Table ES.2 reflects how each system aligns with each of the 27 Federal requirements for new construction; it does not reflect how these points or credits may be accumulated to achieve different levels of certification.

Table ES.2: Robustness Criteria for New Building Construction

	GG NC	LEED NC	LBC NC
Robustness - Others			
Integrated Design	◑	○	○
Commissioning	◕	●	○
Robustness - Water			
Indoor Water	◕	●	●
Process Water	◑	○	●
Outdoor Water	◑	◕	●
Storm Water	◕	◕	●
Water-Efficient Products	◑	◑	○
Robustness - Energy			
Energy Efficiency	◑	◕	◑
On-Site Renewable Energy	◑	◑	◑
Measurement and Verification	◕	◕	○
Benchmarking	○	○	○
Robustness - Materials			
Recycled Content	◑	◑	○
Biobased Content	◑	◑	○
Environmentally Preferable Products	◑	◑	●
Waste and Materials Management	◕	◕	●
Ozone Depleting Compounds	◑	◑	●
Low-Emitting Material	◕	◕	●
Robustness - Indoor Environment			
Ventilation	◑	●	●
Thermal Comfort	◑	◑	○
Daylighting	◑	◑	◑
Environmental Tobacco Smoke Control	◑	●	●
Moisture Control	◕	○	○
Protect Indoor Air Quality during Construction	◑	◑	○
Robustness - Not in GP			
Acoustic (Not in GP)	◕	○	○
Building System Controls (Not in GP)	○	○	○
Siting (Not in GP)	◕	◕	●
Greenhouse Gas (Not in GP)	◕	○	○

Table ES.3 summarizes how each system aligns with Federal requirements, based on the total number of points or credits available.

Table ES.3: Summary of Robustness Criteria for New Building Construction

Certification System	Federal Requirement Met	Federal Requirement Met if Point Achieved	Federal Requirement Could be Met	Not Specifically Mentioned
Green Globes	0	10	15	2
LEED	4	7	9	7
Living Building Challenge	12	0	3	12

The robustness criterion for existing buildings includes 28 Federal requirements (source requirement documents in parentheses):

1. Integrated Assessment, Operation, and Management (Guiding Principles)
2. Commissioning (Guiding Principles, EISA)
3. Indoor Water (Guiding Principles, EPAct, EO 13423, EISA, EO 13514)
4. Outdoor Water (Guiding Principles, EO 13423, EISA, EO 13514)
5. Storm Water (Guiding Principles, EISA, EO 13514)
6. Process Water (Guiding Principles, EPAct)
7. Water-Efficient Products (Guiding Principles, EO 13514)
8. Energy Efficiency (Guiding Principles, EPAct, EO 13423, EISA)
9. On-Site Renewable Energy (Guiding Principles, Executive Order 13423, EISA)
10. Measurement and Verification (Guiding Principles, EPAct, EISA)
11. Benchmarking. (Guiding Principles)
12. Ventilation (Guiding Principles)
13. Thermal Comfort (Guiding Principles)
14. Moisture Control (Guiding Principles)
15. Integrated Pest Management (Guiding Principles)
16. Daylighting (Guiding Principles)
17. Low-Emitting Materials (Guiding Principles, EO 13514)
18. Protect Indoor Air Quality during Construction (Guiding Principles)
19. Environmental Tobacco Smoke Control (Guiding Principles)
20. Recycled Content (Guiding Principles, Resource Conservation and Recovery Act, EO 13514)
21. Biobased Content (Guiding Principles, Farm Security and Rural Investment Act, EO 13514)
22. Environmentally Preferable Products (Guiding Principles, EO 13514)
23. Waste and Materials Management (Guiding Principles, EO 13514)
24. Ozone Depleting Compounds (Guiding Principles, Montreal Protocol and Title VI of the Clean Air Act Amendments of 1990)
25. Acoustic (EISA)
26. Building System Controls (EISA)
27. Siting (EISA)
28. Greenhouse Gas (EISA)

Each certification system was mapped to the robustness criteria for existing buildings. Tables ES.4 and ES.5 reflect Federal requirements for existing buildings. The following is a summary of that mapping.

Green Globes CIEB aligns at some level with 22 Federal requirements:

- Green Globes CIEB has no points that are specifically required, thus, an examination of the points achieved on each individual project is required in order to determine which Federal requirements would be met by certification.

- Eight of the requirements would be fully met through the Green Globes CIEB system if these points are selected by the user and achieved.

- Fourteen requirements may be met if points are achieved and additional efforts are made to conform to the Federal requirement.

- The Green Globes CIEB system does not include six of the Federal requirements (commissioning, recycled content, biobased content, low emitting materials, siting, and building system controls).

LEED EBO&M aligns at some level with more of the Federal requirements (27) than any other existing building system in this review:

- One of the Federal requirements would be automatically met if certification is achieved because LEED EBO&M has minimum requirements that must be met before any level of certification can be attained (called prerequisites).

- Sixteen of the requirements would be fully met through the LEED EBO&M system if these credits are selected by the user and achieved.

- Ten requirements may be met if points are achieved and additional efforts are made to conform to the Federal requirement.

- The LEED EBO&M system does not include one of the Federal requirements (greenhouse gas emissions).

The Living Building Challenge aligns at some level with seventeen Federal requirements:

- The Living Building Challenge requires that buildings meet 100% of the system's design and operations strategies (many of which exceed Federal targets), so these twelve Federal requirements would be met automatically if certification is achieved.

- Five of the Federal requirements may be met if additional efforts are made to conform to the Federal requirement.

- The Living Building Challenge system does not include eleven of the Federal requirements (commissioning, water use, stormwater, water efficient products, measurement and

verification, recycled content, biobased content, thermal comfort, integrated pest management, moisture control, acoustics and building system controls.)

Table ES.4 reflects how each system aligns with each of the 28 Federal requirements for existing buildings; it does not reflect how these points or credits may be accumulated to achieve different levels of certification. As noted above, in practice the Green Globes and LEED certification systems are "tiered," meaning that they require a minimum number of points or credits to be achieved for a base level of certification, with higher levels of certification available based on accumulation of additional points or credits.

Table ES.4: Robustness Criteria for Existing Buildings

	GG CIEB	LEED EB	LBC Ren
Robustness - Others			
Integrated Assessment, Operation and Management	◑	◑	◑
Commissioning	○	◑	○
Robustness - Water			
Indoor Water	◑	◕	●
Process Water	◑	◑	●
Outdoor Water	◑	◕	●
Measurement of Water Use	◑	◑	○
Stormwater	◕	◕	○
Water-Efficient Products	◑	◑	○
Robustness - Energy			
Energy Efficiency	◕	◕	◑
On-Site Renewable Energy	◕	◕	◑
Measurement and Verification	◑	◑	○
Benchmarking	◕	◕	●
Robustness - Materials			
Recycled Content	○	◕	○
Biobased Content	○	◕	○
Environmentally Preferable Products	◕	◕	●
Waste and Materials Management	◕	◕	●
Ozone Depleting Compounds	◑	◕	●
Robustness - Indoor Environment			
Ventilation	◑	●	●
Thermal Comfort	◕	◕	◑
Integrated Pest Management	◑	◑	○
Daylighting	◑	◑	◑
Environmental Tobacco Smoke Control	◑	◕	●
Moisture Control	◑	◕	○
Low-Emitting Material	○	◑	●
Robustness - Not in Guiding Principles			
Acoustic (Not in GP)	◕	◑	○
Building System Controls (Not in GP)	○	◕	○
Siting (Not in GP)	○	◕	●
Greenhouse Gas (Not in GP)	◑	○	●

Table ES.5 reflects the total number of points or credits available in each system; it does not reflect how these points or credits may be accumulated to achieve different levels of certification.

Table ES.5: Summary of Robustness Criteria for Existing Buildings

Certification System	Federal Requirement Met	Federal Requirement Met if Point Achieved	Federal Requirement Could be Met	Not Specifically Mentioned
Green Globes	0	8	14	6
LEED	1	16	10	1
Living Building Challenge	12	0	3	13

"Measured performance" is important to the Federal sector because outside of the sustainable design requirements many Federal reporting requirements are based on actual performance, such as the EISA requirement for federal agencies to reduce energy intensity by 3 percent per year, or 30 percent by FY 2015. Federal agencies have begun to measure the performance of sustainably designed buildings using an established protocol for building cost and performance.[4] For example, GSA's study of 22 buildings shows that on average "green" buildings use less energy, less water, cost less to operate, and have occupants that express general satisfaction scores higher than typical buildings, with additional studies underway using the same measurement protocol.

To document progress toward sustainable design and operations, measuring, calculating, or demonstrating evidence of intent are all legitimate mechanisms. Metered energy and water performance data are the most commonly sought forms of measured building performance data, however, quantities of recycled materials, waste generation, and indoor air quality measurements are also examples of measured performance. Calculated performance typically serves as a proxy for measured, using industry standards and assumptions to estimate or project how a building will perform. When measured data is limited, calculated performance provides useful, comparative values that can be used to support design and operational decisions. Evidence of intent documents frameworks that have the potential to facilitate impactful actions.

The Guiding Principles were reviewed for whether they required measured performance data (e.g., energy consumed), calculated values (e.g., energy models), or evidence of intent (e.g., energy policy). Tables ES.6 and ES.7 illustrate that the documentation required to meet the Guiding Principles is primarily evidence of intent for both new construction and existing buildings. The majority of the Guiding Principles can be documented using evidence of intent. The certification systems tend to require more measurement and calculation than is required by the Guiding Principles.

[4] Fowler KM, EM Rauch, AR Kora, JE Hathaway, AE Solana, and KL Spees. 2009. Whole Building Cost and Performance Measurement: Data Collection Protocol, Revision 2. PNNL-18325, Pacific Northwest National Laboratory, Richland, WA. http://www1.eere.energy.gov/femp/pdfs/datacollectionprotocol.pdf

Table ES.6: Measured, Calculation, and Evidence of Intent Assessment of Guiding Principles for New Construction

Guiding Principles				
New Construction and Major Renovations		GG	LEED	LBC
Site				
I	Reduce stormwater runoff	I	I	I
Water				
C	Indoor water use reduction	C	C	M
I	Installation of water meters is encouraged for indoor water use			
I	Consider use of harvested rainwater	C	C	M
C	Outdoor water use reduction	I	C	M
I	Installation of water meters is encouraged for outdoor water use			
I	Reduce process water when life cycle cost effective	C		
I	Specify WaterSense products	I	I	
I	Use certified irrigation system installers when available			
Energy				
C	Energy use reduction	C	C	M
I	Use EnergyStar or FEMP products when available			
C	Solar hot water system, when cost effective	C	C	M
I	Renewable energy	C	C	M
I	Install meters	I	I	M
M	Benchmark energy performance			
I	Commissioning	I	I	
Indoor Environment				
I	Meet ASHRAE 55	C	C	I
I	Meet ASHRAE 62.1	C	C	I
I	Moisture Control	I	I	I
C	Daylighting	C	C	
C	Lighting controls	C	C	
I	Specify low emitting materials		I	I
M	Indoor air quality and construction	M	M	
I	No smoking policy		I	I
Resources/Materials				
I	Specify recycled content materials	M	M	C
I	Specify biobased content materials	M	M	M
I	Specify environmentally preferable materials	M	M	I
I	Design-in recycling container space	I	I	M
C	Construction waste management	M	M	M
M	Eliminate use of ozone depleting substances	M	M	M

Table ES.7: Measured, Calculation, and Evidence of Intent Assessment of Guiding Principles for Existing Buildings

Guiding Principles Existing Buildings		GG	LEED	LBC
Site				
I	Reduce stormwater runoff	I	C	
Water				
M	Indoor water use reduction	M	M	M
I	Installation of water meters is encouraged	M	M	
C	Outdoor water use reduction (measured option exists)	I	C	M
I	Reduce process water when life cycle cost effective	I	C	
I	Specify WaterSense products	C	C	
I	Use certified irrigation system installers when available			
Energy				
M	Energy use reduction (options exist for a calculation method)	M	M	M
I	Use EnergyStar or FEMP products when available			
I	Renewable energy	M	C	M
I	Install meters	M	C	M
M	Benchmark energy performance	I	M	M
I	Commissioning/Re-Commissioning	M	I	
Indoor Environment				
I	Meet ASHRAE 55	I	C	I
I	Meet ASHRAE 62.1	I	C	I
I	Moisture Control	I	I	I
C	Daylighting	C	C	
M	Lighting controls	M	I	
I	Use/Specify low emitting materials		M	M
I	Integrated Pest Management	I	I	
I	Moisture Control	I	I	I
I	Prohibit smoking	I	I	I
Resources/Materials				
I	Specify recycled content materials		M	
I	Specify biobased content materials		M	I
I	Specify environmentally preferable materials	I	M	M
I	Provide recycling services	I	I	M
M	Eliminate use of ozone depleting substances	M	M	M

The EISA evaluation criteria included eight criteria in addition to the category of "robustness" of the technical elements of the certification systems. For many of these criteria the certification systems

perform similarly. Table ES.8 illustrates those criteria where differences were found among the certification systems. In this table:

- Full circles mean that the certification system meets the criterion developed for this report (i.e., essential elements of the criterion are required by the certification system).
- A half circle means the certification system may meet the criterion (metrics cannot be directly compared) or partially meets the criterion.
- An empty circle means that information was not found or is the criterion is not addressed within the certification system.

Information used to review the certification systems against these criteria was provided by the certification system owners and obtained through literature reviews. Detailed information of the mapping of each system against the review criteria can be found in Appendices E-G. Owners of each certification system were provided the opportunity to review and comment on the detailed mapping of review criteria. The system owners' responses are included in Appendices H-J.

Each of the certification systems has different approaches to guide design and operations teams toward high-performance green buildings. These variations in approach and philosophy drive many of the differences found among systems in the review criteria highlighted below. The Living Building Challenge is the system with the largest number of differences as it does not align with eight of the eleven criteria highlighted in Table ES.8. Philosophically, the International Living Building Institute does not employ a consensus-based process in the development of the Living Building Challenge system. The result is that several of the independence, transparency, and consensus related review criteria are not addressed within the certification system.

Other differences found among the systems include:

- Green Globes and Living Building Challenge use on-site auditors to augment the certification information received electronically, while LEED bases its certification solely on the information submitted electronically.

- LEED has an established piloting process that is implemented prior to a revision to the certification system being released.

- LEED requires that new construction projects submit measured energy and water performance to the USGBC for five years following certification.

- The Living Building Challenge is designed to incorporate the results of at least the first year of a building's operations prior to certification, which means this system has the greatest emphasis on measured performance.

Table ES.8 Review questions with different certification system responses

Review Question	Green Globes	LEED	Living Building Challenge
Independence: Is there a documented appeal process?	●	●	○
Verification: Do the assessors/auditors verify the information onsite?	●	○	●
Transparency: Are there methods to collect and address public comments?	●	●	○
Transparency: Are the changes documented and accessible by the public?	●	●	◐
Consensus: Was the certification system developed using a consensus-based approach?	●	●	○
Consensus: Are credits pilot tested before publication	◐	●	○
Consensus: Are there third-party reviewers/moderators of the process?	●	●	○
Maturity: Is there a requirement for post occupancy data collection once a building has been certified?	◐	●	●
Maturity: Is there a mechanism to transfer the certification of a new building to an existing building over time?	○	○	●
Maturity: What is the frequency of changes?	●	●	○
Usability: Does the certification system have performance-based criteria?	◐	◐	●

See Table 2-3 for a more complete description of these criteria

Each of the certification systems in this review has the stated goal of improving the design and operations of buildings so that they operate in a more sustainable manner although each system approaches this challenge differently. Each system addresses what the buildings industry has identified as the major aspects of green buildings (i.e., siting, energy, water, materials, and indoor environment). All of the systems have a set of on-line tools to assist users.

With the exception of the differences outlined above, the three systems align well with the EISA-defined review criteria. Green Globes for new construction and LEED for existing buildings align the most closely with 25 and 27 respectively out of 27 and 28. Green Globes and LEED have a points system offering multiple certification levels, where the Living Building Challenge is an "all-or-nothing" system. LEED and Living Building Challenge have specific minimum requirements that must be met for certification to be achieved; Green Globes has a minimum number of points within each area with flexibility as to how those points would be met. LEED is the dominant tool in the market, with thousands more users than the other two systems. However, all three systems are all generally recognized by building professionals.

Selecting a certification system requires the user to first understand their purpose for using a system. Innovation, market recognition, ease of use, assistance with meeting requirements, and a performance emphasis are some of the reasons a system might be selected. The Federal sustainable design and high-performance operations requirements steer agencies toward the use of green building certification tools to help buildings professionals meet their energy, water, materials, and indoor environmental quality requirements. As commercially-available tools, they have been useful in connecting the Federal sector with the current private sector standards.

Acronyms and Abbreviations

ANSI	American National Standards Institute
ASHRAE	American Society of Heating Refrigerating and Air Conditioning Engineers
CEO	Chief Executive Officer
CIEB	Continual Improvement of Existing Buildings
DOE	U.S. Department of Energy
EB	existing buildings
EBO&M	Existing Buildings Operations and Maintenance
EISA	Energy Independence and Security Act
EO	Executive Order
GBCI	Green Building Certification Institute
GBI	Green Building Initiative
GG	Green Globes
GSA	General Services Administration
ILBI	International Living Building Institute
LBC	Living Building Challenge
LEED	Leadership in Energy and Environmental Design
LEED-NC	LEED for New Construction and Major Renovation
LSC	LEED Steering Committee
NC	new construction
PNNL	Pacific Northwest National Laboratory
USGBC	U.S. Green Building Council

Contents

Tables

1.0 Introduction

The General Services Administration's Office of Federal High-performance Green Buildings (the Office) commissioned this study of green building certification systems in accordance with the Energy Independence and Security Act (EISA) of 2007. Sections 433(a) and 436(h) of EISA require the Director of the Office to identify a green building certification system that the Director "deems to be most likely to encourage a comprehensive and environmentally sound approach to certification of green buildings." This review of existing certification systems is designed to provide clarity on how current certification systems align with Federal sustainable design principles and high-performance operational requirements. Federal agencies are required to employ sustainable design principles and high-performance operational requirements within their facilities. Green building certification systems are one mechanism for documenting success in implementing these requirements.

The purpose of this report is to offer an objective summary of selected green building certification systems based on specific criteria. The review criteria were derived from EISA, the Guiding Principles for Federal Leadership in High-Performance Sustainable Buildings, other legal drivers of Federal green building, and the experience of Federal personnel who have used the certification systems. Publicly available information, both free and for purchase, was examined to document certification system information and to map each system to the review criteria. The certification system owners were offered an opportunity to provide additional information in response to the review criteria. Federal personnel who have had experience using green building certification systems were interviewed to offer anecdotal information about their use of the systems.

1.1 Defining Green Building Certification Systems

Over the past decade, there has been an enormous growth in building evaluation tools, programs, systems and standards focused on sustainable building and product development. Distinguishing and categorizing these numerous types of tools and systems has become more difficult as they have evolved into a myriad of forms. This study is focused strictly on green building certification systems, as distinct from to building evaluation tools and programs such as life cycle assessment, energy simulation, performance evaluation, indoor environmental quality assessments, and operation and maintenance optimization, which are frequently used within certification systems.

The Federal green building requirements and drivers that guided this review include:

- *Energy Independence and Security Act of 2007 (42 USC Part 152) (EISA)*
- *Energy Policy Act of 2005 (Public Law 109-58) (EPAct)*
- *Strengthening Federal Environmental, Energy, and Transportation Management* (Executive Order 13423, 2007, codified by 111th Congress, HR1105 §748)
- *Federal Leadership in Environmental, Energy, and Economic Performance* (Executive Order 13514, 2009)
- *Federal Leadership in High Performance and Sustainable Buildings Memorandum of Understanding* (signed by 21 Federal agencies in January 2006) and *Guidance* (approved by Office of Management and Budget December 2008)

1.1.1 Energy Independence and Security Act

The Energy Independence and Security Act of 2007 (EISA) was signed into law on December 19, 2007. EISA aims "*to reduce our Nation's dependency on foreign oil by investing in clean, renewable, and alternative energy resources, promoting new emerging energy technologies, developing greater efficiency…*"

EISA directs that sustainable design principles be applied to Federal design and construction projects for new buildings and buildings undergoing major renovations (see Appendix A for relevant EISA text). EISA also establishes the General Services Administration's role in evaluating green building certification systems and making recommendations for other Federal agencies. EISA sections 433(a) and 436(h) require the Director of the Office of Federal High-performance Green Buildings to identify a green building certification system that the Director *"deems to be most likely to encourage a comprehensive and environmentally sound approach to ratification of green buildings."* In accordance with EISA section 433, this recommendation is provided to the Secretary of Energy who, in consultation with GSA and the Department of Defense, identifies a certification system and certification level for the Federal sector. EISA requires that GSA re-evaluate certification systems every five years.

This report was developed to provide an objective, independent review of certification systems to inform the Director's recommendation as part of the first five-year evaluation. The first review was performed in 2006, focused around certification systems for new construction and major renovation.[1] Tracking the evolution of green building certification systems in the market, this report reviews certification systems for existing buildings in addition to those for new construction and major renovations.

EISA sections 433 and 436 establish the minimum basis for the Director's recommendation and the Secretary's determination of a green building certification system deemed to be most likely to encourage a comprehensive and environmentally-sound approach as follows:

> *"(B) the ability and availability of assessors and auditors to independently verify the criteria and measurement of metrics at the scale necessary to implement this subtitle;*
>
> *(C) the ability of the applicable standard-setting organization to collect and reflect public comment;*
>
> *(D) the ability of the standard to be developed and revised through a consensus-based process;*
>
> *(E) an evaluation of the robustness of the criteria for a high-performance green building, which shall give credit for promoting—*
>
> > *(i) efficient and sustainable use of water, energy, and other natural resources;*
> >
> > *(ii) use of renewable energy sources;*

[1] Fowler, KM and EM Rauch. 2006. Sustainable Building Rating Systems Summary. PNNL-15858. Pacific Northwest National Laboratory, Richland, Washington.

(iii) improved indoor environmental quality through enhanced indoor air quality, thermal comfort, acoustics, day lighting, pollutant source control, and use of low-emission materials and building system controls;

(iv) reduced impacts from transportation through building location and site design that promote access by public transportation; and

(v) such other criteria as the Federal Director determines to be appropriate; and

(V) national recognition within the building industry."[2]

These EISA requirements were used to develop the review criteria and frame the comparison of certification systems in this report. Before and after passage of EISA, Executive Orders (EOs) 13423 and 13514 were issued to establish high-performance requirements for new and existing Federal facilities. These requirements include performance standards relating to energy use, greenhouse gas emissions, water use, waste reduction, materials use and employee commuting. Requirements in these EOs, as well as the Guiding Principles for High-Performance Sustainable Buildings, informed the development of additional criteria for this review.

1.1.2 Executive Orders 13423, 13514 and the Guiding Principles for Federal Leadership in High-Performance Sustainable Buildings

In 2006, 21 Federal agencies signed a Memorandum of Understanding which included the Guiding Principles for High-Performance and Sustainable Buildings. These Guiding Principles require minimum levels of performance for Federal facilities in five areas:

- Integrated design and operations,
- Energy performance,
- Water performance,
- Indoor environmental quality, and
- Materials impact.

Two Executive Orders, 13423 and 13514, have affirmed that the Guiding Principles are required for all new Federal facilities and 15% of the existing Federal buildings inventory. EO 13423 and 13514 also establish specific targets for agencies in building design, construction and operations in the areas of energy use, water use, greenhouse gas emissions, waste reduction, storm water management, and facility siting.

In 2008, guidance on how to implement the Guiding Principles for High Performance and Sustainable Buildings for new construction and existing buildings (see Appendix B for relevant Guiding Principles text) was approved by the Office of Management and Budget.[3] The Implementing Instruction for the Guiding Principles was updated to incorporate existing Federal requirements from the Executive Orders, EISA, and EPAct.

[2] Public Law 110–140—DEC. 19, 2007. EISA 2007 Section 433(h)(2)
[3] Office of Management and Budget. December 2008. High-performance Sustainable Design Guidance. Initially developed by the Interagency Sustainability Working Group. URL: http://www.wbdg.org/pdfs/hpsb_guidance.pdf

1.2 Federal Green Building Experience

The Federal government has been an early adopter of green building certification.[4] Since the previous study in 2006, numerous agencies have gained substantial experience in applying green building certification systems to Federal facilities. The 2009 American Recovery and Reinvestment Act provided an opportunity for Federal agencies to invest in their real estate portfolios, applying the sustainable design and high-performance operating principles to an even greater number of buildings. As of August 25, 2011, the certification system owners reported that 40 Federal buildings have been certified under the Green Building Initiative's Green Globes' system and 519 Federal buildings have been certified under the U.S. Green Building Council's Leadership in Energy and Environmental Design Rating System. As of August 15, 2011, there were no certified Federal buildings for the Living Building Challenge. However, two Federal projects have been registered by the National Park Service.

[4] Office of the Federal Environmental Executive. 2003. The Federal Commitment to Green Building: Experiences and Expectations. Washington, DC. URL: http://www.epa.gov/greenbuilding/pdf/2010_fed_gb_report.pdf

2.0 Study Approach

This review involved several stages: developing screening and review criteria; using the screening criteria to identify systems for detailed review; mapping selected certification systems to the review criteria using publicly available information; and gathering and mapping additional information from certification system owners and users to the review criteria.

2.1 Screening Approach

Literature reviews, internet searches, and the previous Pacific Northwest National Laboratory (PNNL) report on sustainable building rating systems[1] were used to identify currently marketed green building systems. Certification system documentation that was identified and publicly available during the time period of November 15, 2010 to November 10, 2011 was used for this review.

The screening criteria were selected to ensure that the certification systems reviewed in detail would address the EISA requirements. The screening criteria used are:

- **Relevance:** The certification system addresses buildings (rather than individual products) and multiple sustainable attributes identified in EISA, including energy, water, indoor environmental quality, etc.

- **Availability:** The certification system has been used or is currently available for use in the US commercial building market. The certification system is not limited to one climate zone or geographic region.

- **Third-party certification:** Validation of how the building addresses sustainability is performed by an independent auditor, per EISA's requirement for *"the ability and availability of assessors and auditors to independently verify the criteria and measurement of metrics."*

Table 2-1 provides a summary of the screening analysis. The full set of systems or tools screened can be found in Appendix C.

[1] Fowler, KM and EM Rauch. 2006. Sustainable Building Rating Systems Summary. PNNL-15858. Pacific Northwest National Laboratory, Richland, Washington.

Table 2-1 - Screening of Green Building Certification System

Legend	**√ (Meets the criterion)**	(Does NOT meet the criterion for the listed reason)	(No further evaluation because previous criterion not met.)

Certification System Name	**Relevance**	**Availability**	**Third-Party Certification**
BREEAM (Building Research Establishment's Environmental Assessment Method)	√	For the UK market	
CASBEE (Comprehensive Assessment System for Building Environmental Efficiency)	√	For the Japan market	
CEPAS (Comprehensive Environmental Performance Assessment Scheme)	√	For the Hong Kong market	
Energy Star Portfolio Manager	Building energy only		
EPLabel	Building energy only		
Estidama Pearl Rating System	√	For the Abu Dhabi market	
Green Globes™ US	√	√	√
HQE (High Environmental Quality)	√	For the France market	
LEED® (Leadership in Energy and Environmental Design)	√	√	√
Living Building Challenge	√	√	√
NABERS (National Australian Built Environment Rating System)	√	For the Australia market	
SB Tool	√	For the international market, but not adopted in the U.S. yet	
SPiRiT (Sustainable Project Rating Tool)	√	√	Self Compliance
Three Star System	√	For the China Market	

Table 2-2 summarizes the characteristics of the three green building certification systems that were determined to meet all of the screening criteria.

Table 2-2 - Summary of Green Globes, LEED, and Living Building Challenge

Certification System	Owner	Whole-building sustainability	Building Types	Third-party Certification
Green Globes®	Green Building Initiative (GBI)	Green Globes is comprised of seven key areas: energy, indoor environment, site, water, resources, emissions, and project/ environmental management.	Green Globes certifies new buildings and significant renovation, existing buildings, building emergency management, building intelligence, and fit-up.	Green Globes Assessors provide third-party certification services.
LEED®	U.S. Green Building Council (USGBC)	LEED is comprised of five key areas: sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality.	LEED certifies new construction and major renovations, existing buildings, commercial building interiors, core and shell construction, schools, retail, healthcare, and homes.	The Green Building Certification Institute (GBCI) provides third-party certification services.
Living Building Challenge™	International Living Building Institute (ILBI)	Living Building Challenge is comprised of seven performance areas: site, water, energy, health, materials, equity and beauty.	Living Building Challenge certifies development at four scales: building, neighborhood, village/campus, and city.	A third-party auditor is responsible for performing document review and onsite verification.

Green Globes and LEED have separate certification systems focused on new construction and existing buildings.

- Green Globes NC (New Construction) and CIEB (Continual Improvement of Existing Buildings)
- LEED-NC (New Construction and Major Renovation) and EBO&M (Existing Buildings Operations and Maintenance)

Each of these systems is reviewed in this report. The Living Building Challenge has four typologies:

- Building
- Renovation
- Landscape or Infrastructure
- Neighborhood.

For this review, the Building typology is being used for the new construction comparison and the Renovation typology is being used for the existing building comparison.

2.2 Review Approach

EISA section 436(h) and the Guiding Principles for High-Performance and Sustainable Buildings were used to develop the review criteria and frame the comparison of certification systems in this report (see Appendix A for relevant EISA text). Table 2-3 shows how the EISA and Guiding Principle requirements were translated into the review criteria.

Table 2-3 - Definitions of Review Criteria

Source (PUBLIC LAW 110–140—DEC. 19, 2007 121 STAT. 1613)	Criteria	Criteria Definition
(B) the ability and availability of assessors and auditors to independently verify the criteria and measurement of metrics at the scale necessary to implement this subtitle;	**Independence**	Assessors/auditors have no stake in whether a building receives certification.
	Availability	Assessors/auditors are available to evaluate a building.
	Verification	A documented standard verification method and process must be followed by assessors and auditors.
(C) the ability of the applicable standard-setting organization to collect and reflect public comment	**Transparency**	There is a documented approach for the review and consideration of public comments.
		Public comments are collected on a regular basis.
		Public comments are reflected in the certification systems.
		Development and updating process of the certification system is documented and publicly available.
(D) the ability of the standard to be developed and revised through a consensus-based process;	**Consensus-based**	The certification system contains the attributes of a voluntary consensus standards body defined in OMB Circular A-119: openness, balance of interest, due process, an appeal process, and consensus
(E) an evaluation of the robustness of the criteria for a high-performance green building, which shall give credit for promoting— (i) efficient and sustainable use of water, energy, and other natural resources;	**Robustness**	Certification system ensures the qualification of the certified building.
		Water criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.
		Energy criteria meet Federal requirements including commissioning, at the minimum, and are a relevant part of the certification system.
		Material selection criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.
		Siting criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.
		Renewable energy criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.
(ii) use of renewable energy sources;	**Robustness**	Indoor air quality criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.
(iii) improved indoor environmental quality through enhanced indoor air quality, thermal comfort, acoustics, day lighting, pollutant source control, and use of low-emission materials and building system controls;	**Robustness**	Thermal comfort criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.
		Acoustics criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.
		Daylighting criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.

Source (PUBLIC LAW 110–140—DEC. 19, 2007 121 STAT. 1613)	Criteria	Criteria Definition
(iii) improved indoor environmental quality through enhanced indoor air quality, thermal comfort, acoustics, day lighting, pollutant source control, and use of low-emission materials and building system controls;	**Robustness**	Pollutant source control criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.
		Low-emission material criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.
		Building system controls criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.
		Integrated design criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.
(iv) reduced impacts from transportation through building location and site design that promote access by public transportation; and	**Robustness**	Siting criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.
(v) such other criteria as the Federal Director determines to be appropriate; and	**System Maturity**	Certification system is effectively linked to latest tools and standards.
		Certification system has components to track building performance post-occupancy.
		The certification system is used as basis for development of other systems.
		The certification system has been consistently updated overtime.
	Usability	Cost of use is affordable.
		Technical knowledge needed to use the certification system is generally available in the design and construction industry.
		The certification system requires professional rigor and judgment rather than leading user to prescriptive solutions.
		The certification system organization provides product support.
		The certification system is well-defined, easily communicated, and clearly understood among multiple parties.
(F) national recognition within the building industry	**National Recognition**	The certification system is recognized academically.
		The certification system is recognized within the buildings' industry (including real estate and construction industry).
		The certification system is recognized within the Federal sector.

The certification systems were mapped to these review criteria. Detailed documentation on how each system mapped to the criteria can be found in the Appendices E-G.

3.0 Certification System Overview

Three certification systems were reviewed in detail: Green Globes for new construction and existing buildings (2010),[1,2] LEED for new construction and existing buildings (2009),[3,4] and the Living Building Challenge including the building and renovations typologies (2011).[5,6]

Green Globes is a voluntary certification system intended for commercial buildings. Available since 2004, Green Globes covers project management, site, water use, energy use, indoor environmental quality and resource, building materials and solid waste. (http://www.thegbi.org)

LEED is a voluntary certification system intended for commercial buildings. Available since 1998, LEED covers siting, water use, energy and atmosphere, materials and resources, indoor environment, and innovation. (http://www.usgbc.org)

Living Building Challenge is a voluntary system intended for commercial buildings. Initiated in 2008, it is comprised of seven performance areas: Site, Water, Energy, Health, Materials, Equity and Beauty. These are subdivided into a total of twenty Imperatives. (https://ilbi.org/lbc)

The following summary of the certification systems includes information on the applicable building types, the development and certification processes, online support, governance, financial aspects, research, and outreach.

Green Globes®

Green Globes® US was adapted from Green Globes Canada in 2004 when the Green Building Initiative purchased the rights to the system in the Unites States. The Green Building Initiative received accreditation as a standards developer by ANSI in 2005 and the Green Building Assessment Protocol for

[1] Green Building Initiative. 2010. Green Building Assessment Protocol for Commercial Buildings. ANSI/GBI 01-2010. Green Building Initiative, Portland, Oregon.
[2] Green Building Initiative. 2011. Green Globes CIEB Criteria. Green Building Initiative, Portland, Oregon.
[3] U.S. Green Building Council. 2009. LEED Reference Guide for Green Building Design and Construction. ISBN: 978-1-932444-14-8. U.S. Green Building Council, Washington, DC.
[4] U.S. Green Building Council. 2009. LEED Reference Guide for Green Building Operations and Maintenance. ISBN: 978-1-932444-16-2. U.S. Green Building Council, Washington, DC.
[5] International Living Building Institute. 2010. Living Building Challenge 2.0. International Living Building Institute, Seattle, Washington.
[6] International Living Building Institute. 2010. Documentation Requirements Living Building Challenge 2.0. International Living Building Institute, Seattle, Washington.

Commercial Buildings (new construction and major renovations) derived from Green Globes® became an official ANSI standard in 2010.[7]

Projects that are third-party verified and have achieved over 35% of the points can earn a rating of 1 to 4 Green Globes. Green Globes' major categories include:

- Project Management (integrated design, environmental purchasing, commissioning, emergency response plan)
- Site (site development area, reduce ecological impacts, enhancement of watershed features, site ecology improvement)
- Energy (energy consumption, energy demand minimization, "right sized" energy-efficient systems, renewable sources of energy, energy-efficient transportation)
- Water (flow and flush fixtures, water-conserving features, reduce off-site treatment of water)
- Indoor Environment (effective ventilation systems, source control of indoor pollutants, lighting design and integration of lighting systems, thermal comfort, acoustic comfort)
- Resource, Building Materials and Solid Waste (materials with low environmental impact, minimized consumption and depletion of material resources, re-use of existing structures, building durability, adaptability and disassembly, and reduction, re-use and recycling of waste)

Building types: Currently, Green Globes applies to the design and construction of new buildings, existing buildings, and existing health care facilities.[8]

Technical development and update process: Technical development is based on the ANSI process which includes a committee of users, producers, interested parties and non-government organizations. ANSI requires that the committee be balanced and conduct a technical review that is both open and transparent.[9]

Certification/Verification Process: Green Globes describes the process as follows: "Building projects that have completed the Green Globes assessments and scored a minimum threshold of 35% of the 1,000 available points are then eligible to schedule a thorough third-party review of documentation and an on-site walk through that will then lead to a formal Green Globes rating/certification. Buildings that successfully complete a third-party assessment are assigned a Green Globes rating of one to four Green Globes."[10] Green Globes has prescriptive and performance based paths for achieving some points.

Green Globes uses an online questionnaire, which, once completed, generates a report that provides a rating, a list of achievements, and list of recommendations. Third-party verification is provided by a

[7] Green Building Initiative. "Green Building Initiative Establishes American National Standard for Commercial Green Building." Accessed: May 25, 2011. URL: http://www.thegbi.org/news/news/2010/news_201001_Green_Building_Initiative_ANSI_Commercial_Building.asp
[8] Green Building Initiative. "Green Globes Overview." Accessed: April 29, 2012. URL: http://www.thegbi.org/green-globes/
[9] Green Building Initiative "History of the Green Globes System." Accessed: April 29, 2012. URL: http://www.thegbi.org/products/green-globes/history.shtml
[10] Green Building Initiative. "Green Globes® Rating/Certification." Accessed: May 25, 2011. URL: http://www.thegbi.org/green-globes/ratings-and-certifications.asp

Green Building Initiative-approved and Green Globes trained regional verifier. There are over 170 certified Green Globes Professionals[11] and over 175 certified projects.[12]

Governance: GBI is a 501(c)(3) non-profit organization. GBI has 53 Members and Supporters and 9 Industry Affiliates.[13] In addition, GBI has over 10,000 "Friends of GBI," formerly known as Associate Members who receive the quarterly newsletter and other information from GBI.[14] There is a Board of Directors, Executive Director, executive staff, and Industry Advisory Board. Decisions of the Industry Advisory Board are non-binding.[15]

Financial support: Income sources include membership dues and in-kind contributions, revenue from educational materials and workshops, verification fees and professional certification fees. In addition, GBI also receives grants from various organizations to fund specific projects and efforts.

Research: GBI has an online resource library with several white papers, links to organizations/resources, and links to sustainability organizations.[16]

Outreach: GBI has over 170 Green Globes Professionals. Education and training is provided through web seminars, best practice videos and online customer training.[17]

LEED®

LEED® (Leadership in Energy and Environmental Design) was developed and piloted in the U.S. in 1998 as a consensus-based building rating system based on the use of existing building technology. USGBC received accreditation as a standards developer by ANSI in 2006.

The LEED Reference Guide presents information on how to achieve credits within the following major categories:

- Sustainable Sites (construction related pollution prevention, site development impacts, transportation alternatives, stormwater management, heat island effect, and light pollution)
- Water Efficiency (landscaping water use reduction, indoor water use reduction, and wastewater strategies)
- Energy and Atmosphere (commissioning, whole building energy performance optimization, refrigerant management, renewable energy use, and measurement and verification)
- Materials and Resources (recycling collection locations, building reuse, construction waste management, and the purchase of regionally manufactured materials, materials with recycled

[11] Green Building Initiative. "Green Globes Personnel Certifications Search." Accessed: May 25, 2011. URL: http://www.thegbi.org/green-globes/personnel-certifications/certified-personnel-listing/index.pl
[12] Green Building Initiative. Green Globes Certified Buildings. Accessed: August 25, 2011. URL: http://www.thegbi.org/assets/case_study/Green-Globes-NC-Certified-Buildings.pdf
[13] Green Building Initiative. "Join the GBI Today." Accessed: May 25, 2011. URL: http://www.thegbi.org/join/
[14] Green Building Initiative "Friends of the GBI." Accessed: May 25, 2011. URL: http://www.thegbi.org/about-gbi/who-we-are/friends-and-associates-of-gbi.asp
[15] Green Building Initiative. "About the Green Building Initiative." Accessed: May 25, 2011. URL: http://www.thegbi.org/about-gbi/, GBI Bylaws, 2006
[16] Green Building Initiative. "Green Resource Library." Accessed: May 25, 2011. URL: http://www.thegbi.org/green-resource-library/
[17] Green Building Initiative. "Training." Accessed: May 25, 2011. URL: http://www.thegbi.org/training/

content, rapidly renewable materials, salvaged materials, and sustainably forested wood products)

- Indoor Environmental Quality (environmental tobacco smoke control, outdoor air delivery monitoring, increased ventilation, construction indoor air quality, low emitting materials use, source control, and controllability of thermal and lighting systems)
- Innovation and Design Process (LEED® accredited professional, and innovative strategies for sustainable design)

Building types: Within LEED, there are multiple rating systems based on building type or the building life cycle. In the United States, these include New Construction and Major Renovations (NC), Existing Buildings: Operations & Maintenance (EBO&M), Commercial Interiors, Core & Shell, Schools, Retail, Healthcare (pilot), Homes, and Neighborhood Development.

Technical development and update process: The steps followed for the development of USGBC rating system products include technical development by committee, pilot testing, public comment period, approval by council membership, and then release for public use. For the existing LEED rating systems, minor updates can occur no more than once a year, while major updates occur on a three year cycle to match building code cycle development, and will follow a defined process including two public comment periods. In addition, LEED interpretations provide official, precedent-setting rulings from USGBC based on formal project team inquiries.[18]

Certification process: The rating systems consist of individual credits with assigned point values within general categories. Within each category, credits known as "prerequisites" are mandatory. Most of the rating systems also have geographically based Regional Priority credits which allow region-specific technical and environmental issues to be addressed rather than using a "one size fits all" approach. LEED points are awarded on a 100-point scale with an additional 10 bonus credits available.[19] Project credit interpretation rulings provide technical guidance on issues not covered by the rating systems.[20] LEED has prescriptive and performance based paths for achieving some credits.

With the exception of LEED for Homes, LEED certification is supported by LEED Online which allows building specific information to be uploaded by credit in a series of automated templates. A project is first registered in the LEED Online system. Once documentation of the quantifiable sustainable design measures is provided to the Green Building Certification Institute through LEED Online for third-party verification, the project proceeds through the certification process. Third-party certification is mandatory in order to be termed a LEED building.

There are currently over 10,000 LEED certified projects. There are over 30,000 registered projects.

Other tools include a searchable database for LEED Interpretation rulings, an interactive map showing the Regional Priority credits, a searchable database of LEED Certified and Registered projects, and credit checklists by rating system.

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[18] US Green Building Council. "TSAC: HCFC Task Group." Accessed: May 24, 2011. URL: http://www.usgbc.org/DisplayPage.aspx?CategoryID+19

[19] US Green Building Council. "How to achieve certification." Accessed: May 24, 2011. URL: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1991

[20] US Green Building Council. "Certification Tools." Accessed: May 24, 2011. URL: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=75 Accessed: May 24, 2011

Governance: USGBC is a 501c3 non-profit organization. Over 16,000 companies and organizations comprise the membership of USGBC. Individuals cannot be members. There is a Board of Directors, CEO, and executive staff.[21] There are three strategic committees and various Board committees. Individuals from member companies and organizations are appointed to committees and short term, task-focused working groups.[22]

Financial support: Income sources include membership dues, revenue from educational materials and workshops, and registration fees associated with various conferences and seminars including the annual conference, Greenbuild. USGBC also receives a portion of the revenues from certification fees and professional accreditation programs administered by Green Building Certification Institute (GBCI). In addition, USGBC receives grant funds from various agencies to fund specific projects and efforts.

Research: USGBC has a research program and resources available online including: research publications, a Green Building Information Gateway, a Knowledge Exchange, and a Green Building Research Fund to provide grants for external research projects. In addition, there is an internal research program.[23]

Outreach: USGBC has 79 local affiliates known as Chapters and more than 160,000 LEED® Professional Credential holders.[24] Education and training is provided through various types of educational materials, courses including a full LEED curriculum, and conferences and seminars.[25]

Living Building Challenge™

The Living Building Challenge™ is a certification program for buildings that have been occupied for a minimum of one year. It generally has stricter technical requirements than other green building certification systems. Living Building Challenge was developed and piloted in the U.S. in 2006 by the Cascadia Green Building Council, a Chapter/Affiliate of USGBC. The International Living Building Institute (ILBI) was formed in 2009 to administer the Living Building Challenge.[26] With this standard, ILBI aims to encourage dialogue on the evolution of the building industry and engender support for the first pilot projects, until more Living Buildings emerge. Two rules govern the standard:

- All elements of the Living Building Challenge are required for a building to be certified. Some of the requirements have temporary exceptions to acknowledge current market limitations. These are listed in the footnotes of each section. Exceptions will be modified or removed as the market changes.

[21] US Green Building Council "About USGBC." Accessed: May 24, 2011. URL: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=124
[22] US Green Building Council "About Committees." Accessed: May 24, 2011. URL: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1742
[23] US Green Building Council "About Research Program." Accessed: May 24, 2011. URL: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1718
[24] US Green Building Council "About USGBC." Accessed: May 24, 2011. URL: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=124
[25] US Green Building Council "Education." Accessed: May 24, 2011. URL: http://www.usgbc.org/DisplayPage.aspx?CategoryID=127
[26] International Living Building Institute "FAQ." Accessed: May 25, 2011. URL: https://ilbi.org/about/faq

- Living Building designation is based on measured, rather than modeled or anticipated, performance. Therefore, buildings must be operational for at least twelve consecutive months prior to evaluation.

To earn full program certification (Living status), projects must meet all assigned Imperatives and have proven performance through at least twelve consecutive months of operation. The seven performance areas are referred to as "Petals" and are subdivided into a total of twenty Imperatives as shown in the table below.

A project may also earn partial program certification (Petal Recognition) by satisfying the requirements of a minimum of three categories, of which at least one must be Water, Energy or Materials.

Table 3-1 - Living Building Challenge Imperatives

Petals	Imperatives
Site	Limits to growth
	Urban Agriculture
	Habitat exchange
	Car free living
Water	Net zero water
	Ecological water flow
Energy	Net zero energy
Health	Civilized environment
	Healthy air
	Biophilia
Materials	Red list
	Embodied carbon footprint
	Responsible industry
	Appropriate sourcing
	Conservation + reuse
Equity	Human scale + humane places
	Democracy + social justice
	Rights to nature
Beauty	Beauty + spirit
	Inspiration + education

Building types: The Living Building Challenge is for any building that has been occupied for a minimum of one year.

Technical development and update process: New releases are provided periodically. ILBI sponsors multiple options for feedback on the system: The "Dialogue" supports requests for clarification and feedback, the "Pow Wow" is an informal supplement to the Dialogue, and the "Brain Trust" is an opportunity to share design strategies, tools, etc.[27]

Certification process: The Living Building Challenge has twenty Imperatives organized into seven Petals. The system can be applied to four "Typologies" including renovation, landscape or infrastructure, building, and neighborhood. The building typology is for new or existing roofed and walled structures

[27] International Living Building Institute. 2010. Living Building Challenge 2.0. Seattle, Washington.

created for permanent use. The renovation typology is for projects that do not include a substantial portion of a complete building reconstruction.

As described by the Living Building Challenge, "Renovation projects have 13 Imperatives, Landscape + Infrastructure projects have 16 Imperatives, and Building and Neighborhood projects have 20 Imperatives. For a project to be certified as "Living", all Imperatives assigned to a Typology must be met. The International Living Building Institute also offers partial program certification – 'Petal Recognition' – to projects that satisfy the requirements in three categories of the Living Building Challenge, when at least one is Water, Energy or Materials."[28]

The first step toward Living Building Challenge certification is registration. To register a project you must be a community member. Only registered projects are eligible for direct feedback from the ILBI. Certification is supported on-line and involves review of documentation regarding compliance with the Imperatives and verification of claims during an onsite audit by ILBI certified auditors.[29, 30] There are currently five certified projects. There are over 70 registered projects.[31]

Governance: ILBI is a 501c3 non-profit organization with over 150 funding sponsors.[32] There is a Board of Directors, CEO, and executive staff.[33]

Financial support: Income sources include membership dues, sponsors, and the annual conference. ILBI also receives revenues from registration and certification fees.

Research: ILBI provides online reports and a Building Materials Questionnaire that provides an online questionnaire connecting users with manufacturers and product representatives to learn about a product's attributes.[34]

Outreach: ILBI offers workshops, consultations in terms of charrette facilitation and design development guidance, and educational materials. There is an annual conference and quarterly magazine.[35] ILBI has a training network of volunteers in two categories: Advocates and Ambassadors.[36] Membership is achieved by joining the Living Building Community.[37]

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[28] International Living Building Institute. 2009. Living Building Challenge 2.0 Introduction. (Presentation). Seattle, Washington.
[29] International Living Building Institute. 2010. Living Building Challenge 2.0. Seattle, Washington.
[30] International Living Building Institute. "Join the Living Building Community." Accessed: May 25, 2011. URL: https://secure.ilbi.org/community/registrationpage/
[31] International Living Building Institute. "FAQ." Accessed: May 25, 2011. URL: https://ilbi.org/about/faq
[32] International Living Building Institute. "We are grateful for the generosity of our major contributors. Thank you!." Accessed: May 25, 2011. URL: https://ilbi.org/about/sponsor
[33] International Living Building Institute. "Staff." Accessed: May 25, 2011. URL: https://ilbi.org/about/staff
[34] International Living Building Institute. "Reports." Accessed: May 25, 2011. URL: https://ilbi.org/education/reports
[35] International Living Building Institute. "Education + Resources." Accessed: May 25, 2011. URL: https://ilbi.org/education
[36] International Living Building Institute. "Ambassador Network." Accessed: May 25, 2011 (Community members only). URL: https://ilbi.org/education/ambassador-program
[37] International Living Building Institute. "Join the Living Building Community." Accessed: May 25, 2011. URL: https://secure.ilbi.org/community/registrationpage/

4.0 Certification System Review

Table 4-1 represents a summary list of the EISA review criteria that were used to compare the certification systems, with a detailed list of questions related to the criteria located in Appendix D. Information publicly available and available for purchase was reviewed for each certification system and mapped to each of the review criteria. This information was shared with the certification system owners and they had the opportunity to provide additional information regarding their systems. Appendices E, F, and G contain the compiled information from the publicly available sources and the certification system owners. The information in these tables is color coded and referenced to identify what was independently verifiable or "Owner" provided. The summary tables in this section were built from the information in the appendices, but to know the source of information the appendices must be referenced. Appendices H, I, and J capture the full responses received from each of the certification system owners.

Table 4-1 - Review Criteria

Criteria	Criteria Definition
Independence	Assessors/auditors have no stake in whether a building receives certification.
Availability	Assessors/auditors are available to evaluate a building.
Verification	A documented standard verification method and process must be followed by assessors and auditors.
Transparency	There is documented approach for the review and consideration of public comments.
	Public comments are collected on a regular basis.
	Public comments are reflected in the certification systems.
	Development and updating process of the certification system is documented and publicly available.
Consensus-based	The certification system contains the attributes of a voluntary consensus standards body defined in OMB Circular A-119: openness, balance of interest, due process, an appeal process, and consensus
System Maturity	Certification system is effectively linked to latest tools and standards.
	Certification system has components to track building performance post-occupancy.
	The certification system is used as basis for development of other systems.
	The certification system has been consistently updated overtime.
Usability	Cost of use is affordable.
	Technical knowledge needed to use the certification system is generally available in the design and construction industry.
	The certification system requires professional rigor and judgment rather than leading user to prescriptive solutions.
	The certification system organization provides product support.
	The certification system is well-defined, easily communicated, and clearly understood among multiple parties.
National Recognition	The certification system is recognized academically.
	The certification system is recognized within the buildings' industry (including real estate and construction industry).
	The certification system is recognized within the Federal sector.
Robustness	Certification system ensures the qualification of the certified building.
	Water criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.
	Energy criteria meet Federal requirements including commissioning, at the minimum, and are a relevant part of the certification system.
	Material selection criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.
	Siting criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.
	Renewable energy criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.

Criteria	Criteria Definition
	Indoor air quality criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.
	Thermal comfort criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.
	Acoustics criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.
	Daylighting criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.
	Pollutant source control criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.
	Low-emission material criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.
	Building system controls criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.
	Integrated design criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.
	Siting criteria meet Federal requirements, at the minimum, and are a relevant part of the certification system.

An “apples-to-apples” comparison of the certification systems is challenging because the development basis is different for each system. Green Globes uses a questionnaire-driven approach to guide the users through the design. LEED uses building codes and standards, and a minimum program requirements approach as its base. The Living Building Challenge uses a philosophy-based approach pushing for advanced building design and operations.

In the following sections a summary of the mapping of the certification systems to the review criteria is provided for each criterion. As mentioned above, Appendices E through J offer additional details for how each system mapped to each criterion.

Following is a key to symbols in Tables 4-2 through 4-9.

●	Solid circle	Meets the criterion
◑	Half circle	Partially meets the criterion, or may meet the criterion but the metrics cannot be compared directly
○	Open circle	Does not meet the criterion or information was not found

4.1 Independence

Although each of the certification systems has a different approach for the independent assessment, all have a documented system in place. Green Globes and Living Building Challenge include a site visit with a review of documentation, where LEED involves only a review of submitted documentation.

Table 4-2 - Independence Criteria

Review Question	Green Globes	LEED	Living Building Challenge
Is an assessor/auditor independently assigned/selected?	● (Yes)	● (Yes)	● (Yes)
How is an assessor or auditor assigned/selected to evaluate a project?	Assessors are selected based on their experience in different assessment areas.	Projects are assigned from a pool of qualified assessors based on their availability and expertise.	Auditors are selected first by expertise, then by location.
Is there a documented appeal process?	● (Yes)	● (Yes)	○ (No)[1]
What is the documented appeal process?	The project team can file a written complaint within 30 days after the date of notification of any action.	The project team can file an appeal within 25 business days of the applicable action.	After initiation there are three written instances for providing supplemental/clarifying data.
Is there an independent review and verification process?	● (Yes)	● (Yes)	● (Yes)
What is the method for evaluation?	The evaluation process includes document review and on-site walk through.	The review process is conducted with LEED Online and occurs in two phases.	The evaluation process includes document review, site visit, and a quality control review.

4.2 Availability

Each of the certification systems evaluates buildings for certification in a different way, but they all address the criteria.

Table 4-3 - Availability Criteria

Review Question	Green Globes	LEED	Living Building Challenge
What is the average length of time for a building evaluation from submission to certification?	● (3 months)	● (3-4 months)	● (1-3 months)
Is there a documented feedback/comment resolution process?	● (Yes)	● (Yes)	● (Yes)
What is the documented feedback and/or comment resolution process?	The reviewer provides a preliminary report, score, and rating to the project team which becomes final if accepted by project team.	The reviewer provides detailed feedback to the project team. Project teams are able to contact GBCI technical staff with additional questions.	There are three written instances for supplemental/clarifying data and one verbal opportunity during the site visit.
Is there a projected evaluation schedule provided online?	● (Yes)	● (Yes)	● (Yes)
How long does it take for a project to receive evaluation feedback at various stages of assessment?	5 weeks of lead time Stage 1 assessment (document review): 3 weeks Stage 2 assessment (site visit): 4-5 weeks	Preliminary review: 25 business days/15 business days for expedited reviews Opportunity for project to respond to request for clarifications: 25 business days	Feedback is provided during the evaluation. The evaluation includes: Institute 'completion check': up to 2 weeks Auditor content review: up

[1] According to the certification system owner the appeal process was published on-line, but it could not be located on the system's website.

Review Question	Green Globes	LEED	Living Building Challenge
		Final review: 15 business days/7 business days for expedited reviews	to 4 weeks Auditor single-day site visit: up to 2 weeks Auditor completes written report: up to 2 weeks Institute quality control review of the report: up to 2 weeks
Does the user get feedback in time?	●	●	●
What is the average time an auditor/assessor spends on each project?	8-32 hours of work	40 hours (range 30-120+ hours)	40-80 hours
How many assessors/auditors are typically involved with a project evaluation? Do larger buildings have more than one assessor? Expertise?	One assessor is assigned to each project unless the project has specific needs.	Typically 3 assessors are assigned per project.	One assessor is assigned for each project.

4.3 Verification

As a measure of quality control, a certifier can be ANSI-accredited, which is intended to provide some additional assurance of objectivity on the part of the certifier. Both GBI and USGBC are ANSI-accredited organizations; ILBI is not. The most obvious operational difference among all the systems is in the area of verification (which is focused on validation of the information provided during the certification process): Green Globes and Living Building Challenge use on-site auditors to augment the certification information received electronically, while LEED bases its certification solely on the information submitted electronically.

Table 4-4 - Verification Criteria

Review Question	Green Globes	LEED	Living Building Challenge
What is the process assessors/auditors use to evaluate a project?	Review process for Green Globes includes document review and on-site walk through.	Review process for LEED can involve a one or two phase review of on-line documentation.	Review process for Living Building Challenge includes review of written documentation, site visit and quality control review.
Do the assessors/auditors verify the information onsite?	●	○	●
	(Yes)	(No)	(Yes)
Are the criteria used by assessors/auditors documented?	●	●	●
	(Yes)	(Yes)	(Yes)
What are the evaluation criteria assessors/auditors use when evaluating a project?	For new construction, the Green Building Assessment Protocol specifies evaluation criteria.	Project documentation for compliance with the published system requirements (credits & prerequisites), published Addenda & LEED Interpretations and other USGBC guidance documents.	The documentation requirements provide a verification method and guidelines.
What tools are used to evaluate the technical information provided by a project?	The Pre-Assessment and Assessment Checklist.	LEED Online assessment tool. LEED online tool.	The auditor is provided guidelines/checklists and a report template with prompts for each Imperative.

Review Question	Green Globes	LEED	Living Building Challenge
Are evaluation needs outside the expertise of the auditor/assessor addressed?	● (Yes)	● (Yes)	● (Yes)
What is the process when evaluation needs are outside an auditor/assessor's expertise?	A senior assessor or member of the technical committee may help address special evaluation needs.	USGBC and its technical committee structure may be used to address unique or complex evaluation needs.	Programmatic assistance may be provided by Institute staff to clarify the intent of an Imperative. Content assistance may be provided by the associated Petal Committee to clarify the project's applied solution.

4.4 Transparency

The only noticeable difference among the systems relative to the transparency criteria was with the Living Building Challenge, which only allows its community members access to some feedback information.

Table 4-5 - Transparency Criteria

Review Question	Green Globes	LEED	Living Building Challenge
Are there methods to collect and address public comments?	● (Yes)	● (Yes)	○ (Living Building Challenge subscribers community only)
What methods are used to collect and address public comments?	Comments are collected through periodic public comment forums.	Revised certification systems are open for public comment for at least 45 days.	Comments are collected online through the Dialogue Forum and the Feedback Form.
How frequently are public comments collected?	During the development of the ANSI/GBI Standard[2]	Annually for minor updates and every three years for major revisions	Comments are incorporated whenever they are reviewed and approved
Are public comments incorporated into the revision process?	● (Yes)	● (Yes)	● (Yes)
How are public comments incorporated into the certification system revision process?	Public comments and committee responses are posted at GBI's website.	Comments are evaluated through a formal process and posted, with responses, on USGBC's website.	The Living Building Challenge, the Dialogue activity and completed Feedback Forms are reviewed and comments integrated as appropriate.
Are the changes documented and accessible by the public?	● (Yes)	● (Yes)	○ (Living Building Challenge subscribers community only)
Where are certification system changes documented?	Meeting minutes of the Consensus Body are posted on GBI's website.	Summary of changes and committee meeting minutes are posted on USGBC's website.	Changes can be viewed online by members through the Dialogue Forum.

[2] No information provided from certification system owner regarding update schedule.

4.5 Consensus

The primary differences noted between the systems among the consensus criteria are:

- Green Globes is an ANSI standard
- LEED pilots revisions before releasing new versions, while Green Globes releases a new version and relies on the first buildings to use the new version as pilots. Living Building Challenge does not have a published pilot process
- Living Building Challenge does not align with the criterion's definition of a consensus-based development process. Owner feedback from the Living Building Challenge expressed that transparency is the goal of its certification system and that a consensus-based approach can be "disingenuous."

Table 4-6 - Consensus Criteria

Review Question	Green Globes	LEED	Living Building Challenge
Who has been involved in the development, funding, and management of the certification system - Government, Private Industry, Non-Governmental Organizations, and others?	GBI is governed by a group of stakeholders representing construction companies, industry, architectural firms, and academic institutions.	USGBC is organized around volunteer committees. The committee members come from various types of organizations.	Living Building Challenge was developed and is managed by the International Living Building Institute.
What has been the role and commitment in the development, funding, and management of the certification system by Government, Private Industry, Non-Governmental Organizations, and others?	GBI is responsible for development, management, and funding. GBI was accredited as a Standards Developing Organization (SDO) by the American National Standards Institute (ANSI) in September of 2005. Green Globes is an ANSI standard as of 2010.	Multiple LEED committees play different roles in development and management. USGBC was accredited as ANSI Standards Developer in 2006.	The Institute is responsible for management, development, and funding. Government Agencies and Private Organizations have participated in certification system development.
Was the certification system developed using a consensus-based approach?	●	●	○
	Yes	Yes	No, expert opinion
How are points allocated?	No information was found on how points were weighted.	The allocation of points is split between direct human benefit and direct environmental benefit. The types of impacts are quantified and the resulting allocation of points among credits is called credit weighting.	Living Building Challenge does not use a point-based system.
Are credits or points pilot tested before publication	◑	●	○
	(Pilot projects launched after certification system published.)	(Yes)	No
How are credits or points tested?	GBI is undertaking a limited pilot assessment and certification program.	LEED Pilot Credit Library is used to test proposed or revised LEED credits.	Living Building Challenge does not use a point-based system.
How are different opinions managed?	Differing opinions are managed by the technical committee and in accordance with the GBI Procedures for the	Any party may appeal to the USGBC Executive Committee of the Board and within 30 calendar days of the action.	Use the online Dialogue activity and completed Feedback Forms to manage and document opinion discussion.

Review Question	Green Globes	LEED	Living Building Challenge
	Development and Maintenance of Green Building Standards (GBI-PRO 2005-5)		
Is there a written procedure for managing different opinions?	●	●	●
	(Yes)	(Yes)	(Yes)
Are there third-party reviewers/moderators of the process?	●	●	○
	(Yes)	((Yes)	(No)

4.6 Usability

The publicly available information and certification system owner's responses to questions regarding the cost of certification and availability of services are summarized in Table 4-7. Generally speaking the cost of certification is similar for each of the systems and each system describes a set of technical assistance tools for users.

Table 4-7 - Usability Criteria

Review Question	Green Globes	LEED	Living Building Challenge
What are the direct costs of using the certification system, including materials, registration, and certification fees?	Certification fee: $2,500-22,000 Assessor Travel Expenses: $1,500 Additional analysis fees: $1,000-3,500 Software subscription: $500-2,000	Registration fee: $1200-1500 Certification fee: $1,500-27,500 Reference Guide: $195	Registration fee: $250-1,000 Certification fee: $1,500-25,000 Subscription fee: $125-3,500
What is the availability and responsiveness of direct requests for assistance, availability of training, and usability of information available on the website, through case studies, documented inquiries, and frequently asked questions.	GBI offers several resources for customers including: an online system, which allows customers to keep up-to-date entries, as well as provides instant feedback. There is an FAQ page, case studies, a virtual tour of the software, and a "contact us" page on the website. GBI provides live web seminar events on specific topics and personnel certification.	USGBC develops tools to support the LEED rating system, including reference guides, LEED Online, and workshops and educational courses. These supporting tools are regularly updated to reflect the changes made during LEED development cycles. The various market sectors that use LEED have individual resource pages.	Living Building Challenge offers case studies on the website, educational programs and resources, including public and in-house workshops, technical assistance, and the ability to request a speaker. Users can access the Contact webpage for assistance with specific questions. The Dialogue is a primary way for project teams to receive direct programmatic guidance from Institute staff.

To gain a certification system user perspective, nine Federal green building professionals were interviewed, representing five Federal agencies. Other Federal green building professionals were contacted but were not available for an interview during the interview timeframe. Collectively, these professionals had experience with all of the certification systems included in this review, with most of their experience being with LEED products. The user experience level ranged from six months to 14 years using green building design and certification systems. User comments were highly variable from

person to person and should not be assumed to represent the full experiences of the green building certification system market. User perceptions and anecdotal comments are interesting, but not based on the certification systems records, and are treated as experiential commentary in this report.

The more experience users had, the more the certification systems were described as tools that can be used to support the development of high performing buildings, rather than the mechanism that is directly responsible for green building design and operations. The systems were referred to as 'checklists of things to do to gain recognition,' which in itself has value, but is not necessary to meet the Federal requirements.

Overall, the users stated that the use of certification systems helped the agencies meet the Federal green building requirements, while recognizing that none of the certification systems are directly aligned with all of the current requirements. More than one person expressed an interest in having a certified building being automatically recognized as meeting the Guiding Principles to minimize the additional tracking and documentation needed to complete both. Users also noted that design and construction contractors have a better understanding of certification systems than of the current Federal requirements.

A general benefit identified by the users was how certification systems help "push" users toward integrated design because of the need to collaborate with others to meet the system requirements. A general barrier was the documentation that is required for certification systems. Related to the documentation barrier was the user comment that certification was not necessary because key design elements are already required for federal agencies. In contrast, other users stated that they believed full certification was needed to confirm that green building design features and operations actions were actually incorporated into the building. Users also noted that a certification system label was not a guarantee of building performance. Several users expressed that familiarity with a certification system makes it easier to use.

Users with Green Globes experience stated that the documentation was not time intensive, and the format was not rigid. Users commented that it was "user-friendly" because of the lower level of detail needed for certification. Multiple users commented that they preferred the Green Globes customer service model, as it provided direct interaction with GBI staff who were responsive to questions. The on-site review of the building was mentioned as an effective certification mechanism. One user commented that the cost to certify used to be less expensive, which seemed more commensurate with the rigor. For this user, the change in certification cost structure from individual building to the cost per square foot model increased the cost for certification and decreased their interest in the system. Another user commented they thought the link to the Guiding Principles "was not close enough."

Users with LEED experience stated that the guidance documents, on-line tools, on-line collaboration pages, USGBC webpage, GBCI webpage, credit interpretations, and the case studies were helpful design tools and useful for facilitating certification. One user commented they had experienced poor, non-responsive customer service, where others stated that they had received quick, highly-responsive customer service. Several users commented that customer service had significantly improved over the last two years with GBCI in charge. The volume program and the requirement to document certified buildings' performance were highlighted by users as potentially useful tools in the future. The detail and inflexibility of the certification documentation was identified as a barrier because it can result in an agency duplicating effort to report on Federal requirements. One user stated that the documentation can take time away from improving the quality of the building design and operations and that the expertise

needed to use the certification system is greater than the benefit of certification. One user commented that they thought LEED was more stringent than the Federal requirements.

Users with Living Building Challenge experience identified its strengths as having fewer documentation requirements and an emphasis on performance that was lacking in the other certification systems. Additionally, the case studies provided on the website were useful for providing design ideas for other buildings trying to accomplish sustainable design. However, users also stated that the minimum requirements for meeting the Living Building Challenge are 'not easy' and that the system is not yet recognized as mainstream.

Although it was recognized by the certification system users that the systems alone do not meet the Federal requirements, they stated that the psychology of certification systems provide motivation to design and operate high-performance, sustainably designed buildings.

4.7 National Recognition

LEED has been in the market longer that the other systems (LEED was launched in 1999, Green Globes in 2006, and Living Building Challenge in 2006). LEED features the most certified buildings and the greatest number of locales requiring its use. However, each of these systems are known and in use in the green building market.

Table 4-8 - National Recognition Criteria

Review Question	Green Globes	LEED	Living Building Challenge
Is the certification system included in the curriculum of the top 20 architectural schools?[3]	● (Yes) GBI allowed professors to develop green building curriculum using Green Globes in architecture classes and encouraged student collaboration projects previously with Clemson, Cal Poly, Poloma, Stanford, Cooper Union, Arizona State University, University of Arkansas and University of Florida.	● (Yes) LEED is included in the sustainable courses in Cornell, Syracuse, University of Texas, and University of Oregon.	● (Yes) Living Building Challenge is being used in the curriculum at K-12 institutions as well as in college courses at the undergraduate and graduate levels.
How many students are involved? (Attending conferences or training, becoming assessors or green building professionals, etc.)	GBI participates in an annual EPA higher education building competition.	Approximately 1250 students attend the annual USGBC Greenbuild conference. USGBC has a network of 70 student groups representing 1600 students. From May 2009-August 2011, over 1400 students became LEED professionals	60 student subscribers. 11 student groups entered the Living City Design Competition. 80 students participated in 2010 conference.

[3] American Institute of Architects. 2011. "AIA's top undergraduate and graduate architecture schools." Accessed: July 6, 2011. URL: http://archrecord.construction.com/features/0911BestArchSchools/0911BestArchSchools-2.asp

Review Question	Green Globes	LEED	Living Building Challenge
Is the certification system recognized within the building industry?	●	●	●
What is the adoption rate at the State level?	23 states	35 states	0 state
What is the adoption rate at the County level?	15 counties	58 counties	1 county
What is the adoption rate at the City level?	3 cities	384 cities	0 city (referred by cities, but no adoption)
How many buildings have signed up to participate in the certification system?	2,671	31,696	87
How many buildings have been awarded certification?	176	10,000	4
How many professionals are involved?	173	162,456	Thousands of building industry professionals are involved.
How many institutional/group members?	9 affiliates, 13 associate members	More than 5,000	More than 150 sponsors and recognized by 2 professional associations
Is the certification system recognized within the Federal sector?	●	●	●
How many Federal agencies have identified the system as guidance or a requirement?	9	14	3
How many Federal buildings have been certified?	40	519	0
Does the system address the building types which account for a majority of Federal space?	Yes	Yes	Yes

4.8 System Maturity

There are three differences among the certification systems with regard to the system maturity criteria.

- All three certification systems have at least an option, if not a requirement, for submitting energy performance criteria, but Green Globes does not require it for the prescriptive path option.
- Neither Green Globes nor LEED have a requirement for transferring new construction certifications into existing building certifications.
- Neither Green Globes nor Living Building Challenge identified an established development cycle.

Table 4-9 - System Maturity Criteria

Review Question	Green Globes	LEED	Living Building Challenge
How do the tools and standards within the certification system compare to current versions of standards and latest industry tools?	Efforts were made throughout the process to ensure that the standards were compatible wherever possible.	As LEED evolves it adopts the latest versions of codes and standards. Due to several standards being included in the	Living Building Challenge requirements are more advanced than the current standards.

Review Question	Green Globes	LEED	Living Building Challenge
		LEED guides, a change to one of the standards will not spur an immediate revision to LEED.	
How frequently are the certification systems and referenced standards and tools updated?	Every 5 years.	Update occurred in 2000, 2002, 2005, and 2009.	Updates occurred in 2006, 2008, and 2009.
Does the certification system allow for the evaluation of an existing building?	●	●	●
	(Yes) Green Globes CIEB evaluates existing buildings.	(Yes) LEED EB evaluates existing buildings.	(Yes) Living Building Challenge can be used for both new construction and existing buildings.
Is there a requirement for post occupancy data collection once a building has been certified?[4]	◑	●	●
	Green Globes NC Energy performance path requires post occupancy data through Energy Star. The prescriptive path does not require post occupancy data.	LEED 2009 requires projects to commit to supplying all available whole-project energy and water usage data for a period of at least 5 years post-certification.	Living Building Challenge certification is based on measured post occupancy performance.
Is there a mechanism to transfer the certification of a new building to an existing building over time?	○	○	●
	(No)	(No)	There is no separate certificate for new construction and existing building; no transfers required.
How many other systems refer to the certification system or the certification organization as its basis for development or comparison?	None	10	6
When was the certification system developed, first used, first available for public use, and when was most recent revision completed?	The first US version was developed in 2006 and launched in 2010. It is the most current version.	The first version was developed and launched in 1998. The most current version was completed in 2009.	The first version was developed in 2005 and launched in 2006. The most current version was completed in 2009.
What is the frequency of changes?	○	●	○
	(No development cycle was identified.)	(Every 3 years)	(No development cycle was identified.)

4.9 Robustness

The "robustness" criterion contains a set of measures intended to assess how each system aligns with Federal performance requirements.[5, 6, 7, 8] Building performance is an important current focus in the Federal sector, and this multi-part criterion compares the legal requirements applicable to the Federal real

[4] Post occupancy data collection expectations in the Federal sector involve metrics beyond energy.
[5] Office of Management and Budget. December 2008. High-performance Sustainable Design Guidance. Developed by the Interagency Sustainability Working Group. URL: http://www.wbdg.org/pdfs/hpsb_guidance.pdf
[6] Public Law 110–140—DEC. 19, 2007. Energy Independence and Security Act of 2007. (EISA)
[7] Executive Order 13423—Strengthening Federal Environmental, Energy, and Transportation Management, January 26, 2007, Federal Register Vol. 72, No. 17, pages 3919-3923.
[8] Executive Order 13514—Federal Leadership in Environmental, Energy, and Economic Performance, October 8, 2009, Federal Register Vol. 74, No. 194, pages 52117-52127.

estate portfolio against each certification system's technical components (such as energy, water, siting, etc.). Table 4-11 and 4-12 (new construction) and Tables 4-14 and 4-15 (existing buildings) illustrate how the systems align to the robustness measures. Following is a key to symbols used in the robustness criterion.

- Full circles (green) mean that the Federal requirement would automatically be met if the building was certified because the system and Federal requirements fully align, and the system component is mandatory to achieve certification.
- Three-quarter circles (green) mean that the certification system has an option (e.g., point, credit, etc.) that meets the Federal requirement; if that option is included in the certification package, the Federal requirement would be met.
- A half circle (yellow) means the certification system includes an option related to but not directly aligned with the Federal requirement. The certification systems may have a lower standard, different baselines, different calculation methods, or different ways to document compliance with the Federal requirement.
- An empty circle means the Federal requirement is not an identified component within the certification system.

The difference between the three-quarter circle and full circle can be communicated by a waste and materials management example. The Federal requirement is for at least 50% of construction and demolition materials to be recycled. In Green Globes, if the building receives 4 of the 6 possible points, the Federal requirement will be met. In LEED, if at least 1 of the 2 possible credits is achieved, the Federal requirement will be met. The half circle symbol can be illustrated by using a daylighting example. The Federal requirement is to achieve a minimum daylight factor of 2 percent in 75 percent of all space occupied for critical visual tasks. All three systems address daylighting, but in different ways, which is why they received a half circle. In Green Globes points are available for designing primary spaces to receive indirect minimum daylight illumination levels of 25 footcandles. In LEED a point is available for designing regularly occupied spaces achieve daylight illuminance levels of a minimum of 25 footcandles and a maximum of 500 footcandles. In Living Building Challenge it requires that every occupiable space provides access to daylight.

In addition to the certification systems having a different basis of development, they also have different strategies for achieving similar goals. In some cases within a certification there will be multiple paths or approaches for achieving a goal. To manage the quantity of options in this review, generally speaking the first option was selected. An example of the different options is energy use for new construction. Green Globes and LEED have performance and prescriptive path options, where Living Building Challenge requires measured energy use data for 12 months. Summaries of the performance and prescriptive paths for Green Globes and LEED illustrate the complexity involved in a side-by-side comparison of the systems (Table 4-10). The first path or option for both compares the projected energy use to a baseline, where the prescriptive approaches require specific actions to be taken.

Table 4-10 – Summary of Green Globes and LEED Energy Point Paths/Options

Point Comparison			
Green Globes	8.1 Performance Path A (300/1000 points) 50% reduction in carbon dioxide equivalent emissions compared to the baseline. Baseline energy use is calculated using Energy Star Target Finder score of 50.	8.2 Prescriptive Path B (250/1000 points) User chooses from list of specific design options to achieve points.	
LEED	Option 1 Whole Building Energy Simulation (19/110 points) Percent reduction in modeled energy use compared to the baseline. Baseline energy use is simulated according to Appendix G of ASHRAE 90.1-2007.	Option 2 Prescriptive Compliance Path: ASHRAE Advanced Energy Design Guide (1/110 points) Compliance with all applicable criteria in Guide is required.	Option 3 Prescriptive Compliance Path: Advanced Buildings Core Performance Guide (3/110 points) Compliance with all applicable criteria in Guide is required.

Although none of the certification systems are identical to the Federal requirements, users have expressed that systems offer a useful framework for tracking and/or documenting progress toward meeting the requirements. If an agency identifies a certification system as an alternative to meeting the Guiding Principles and Office of Management and Budget approves that alternative, the certification system documentation is/becomes sufficient evidence for meeting the Guiding Principles (as is the case with the Department of Energy).[9] If that equivalent does not exist for an agency, then specific documentation to demonstrate the building met the Guiding Principles may need to be prepared in addition to certification system documentation.

The certification systems include elements that are not identified in the Guiding Principles. For example, Green Globes has points that address clean diesel practices, bird collisions, and asbestos management. LEED has credits that address light pollution, priorities that vary by geographic region, and purchasing of sustainable food. Living Building Challenge has a materials "red list" (prohibiting use of specific materials) and requires the building address beauty and inspiration.

New Construction and Major Renovation

The robustness criterion includes a set of measures intended to assess how each system aligns with Federal performance requirements. The robustness criterion for new construction includes 27 Federal requirements (source requirement documents in parentheses):

1. Integrated Design (Guiding Principles)
2. Commissioning (Guiding Principles, EISA)
3. Indoor Water (Guiding Principles, EPAct, EO 13423, EISA, EO 13514)
4. Process Water (Guiding Principles, EPAct)
5. Outdoor Water (Guiding Principles, EO 13423, EISA, EO 13514)

[9] U.S. Department of Energy. 2010. Strategic Sustainability Performance Plan: Discovering Sustainable Solutions to Power and Secure America's Future. U.S. Department of Energy, Washington, DC. URL: http://energy.gov/downloads/2010-doe-strategic-sustainability-performance-plan-report-white-house-council

6. Storm Water (Guiding Principles, EISA, EO 13514)
7. Water-Efficient Products (Guiding Principles, EO 13514)
8. Energy Efficiency (Guiding Principles, EPAct, EO 13423, EISA)
9. On-Site Renewable Energy (Guiding Principles, Executive Order 13423, EISA)
10. Measurement and Verification (Guiding Principles, EPAct, EISA)
11. Benchmarking (Guiding Principles)
12. Recycled Content (Guiding Principles, Resource Conservation and Recovery Act, EO 13514)
13. Biobased Content (Guiding Principles, Farm Security and Rural Investment Act, EO 13514)
14. Environmentally Preferable Products (Guiding Principles, EO 13514)
15. Waste and Materials Management (Guiding Principles, EO 13514)
16. Ozone Depleting Compounds (Guiding Principles, Montreal Protocol and Title VI of the Clean Air Act Amendments of 1990)
17. Low-Emitting Materials (Guiding Principles, EO 13514)
18. Ventilation (Guiding Principles)
19. Thermal Comfort (Guiding Principles)
20. Daylighting (Guiding Principles)
21. Environmental Tobacco Smoke Control (Guiding Principles)
22. Protect Indoor Air Quality during Construction (Guiding Principles)
23. Moisture Control (Guiding Principles)
24. Acoustic (EISA)
25. Building System Controls (EISA)
26. Siting (EISA)
27. Greenhouse Gas (EISA)

Each certification system was mapped to the robustness criteria for new construction. Table 4-11 and Table 4-12 reflect Federal requirements for new construction and major renovations. The following is a summary of that mapping.

Green Globes aligns at some level with more of the Federal requirements (25) than any other new construction system in this review:

- Green Globes has no points that are specifically required; thus, an examination of the points achieved on each individual project is required in order to determine which Federal requirements would be met by certification.

- Ten of the Federal requirements would be fully met through the Green Globes system if these points are selected by the user and achieved.

- Fifteen requirements may be met if points are achieved and documentation is adapted to conform to the Federal requirement.

- The Green Globes system does not include two of the Federal requirements (benchmarking and building system controls).

LEED aligns at some level with 20 Federal requirements:

- Four Federal requirements would be automatically met if certification is achieved because LEED has minimum requirements that must be met before any level of certification can be attained, called prerequisites. The prerequisites do not add to the total number of points needed to achieve certification.

- Seven of the Federal requirements would be fully met through the LEED system if these credits are selected by the user and achieved.

- Nine of the Federal requirements may be met if the credits are achieved and documentation is conformed to match the Federal requirements.

- The LEED system does not include seven of the Federal requirements (integrated design, process water, benchmarking, moisture control, acoustics, building system controls and greenhouse gas emissions).

The Living Building Challenge aligns at some level with 14 Federal requirements:

- The Living Building Challenge requires that buildings meet 100% of the system's design and operations strategies (many of which exceed Federal targets), so these twelve Federal requirements would be met automatically if certification is achieved.

- Three of the Federal requirements could be met if documentation or tracking is changed to conform to Federal requirements.

- The Living Building Challenge system does not include thirteen of the Federal requirements (integrated design, commissioning, water efficient products, measurement and verification, benchmarking, recycled content, biobased content, thermal comfort, moisture control, indoor air quality protection during construction, acoustics, building system controls, and greenhouse gas).

Table 4-11 summarizes how each system aligns with Federal requirements, based on the total number of points or credits available; it does not reflect how these points or credits may be accumulated to achieve different levels of certification. The Green Globes and LEED certification systems are "tiered," meaning that they require a minimum number of points or credits to be achieved for a base level of certification, with higher levels of certification available based on accumulation of additional points or credits. Table 4-12 reflects how each system aligns with each of the 27 Federal requirements.

Table 4-11 - Summary of Robustness Criteria for New Building Construction

Certification System	Federal Requirement Met	Federal Requirement Met if Point Achieved	Federal Requirement Could be Met	Not Specifically Mentioned
Green Globes	0	10	15	2
LEED	4	7	9	7
Living Building Challenge	12	0	3	12

Table 4-12 reflects how each system aligns with each of the 27 Federal requirements for new construction.

Table 4-12 - Robustness Criteria for New Building Construction

	GG NC	LEED NC	LBC NC
Robustness - Others			
Integrated Design	◑	○	○
Commissioning	◕	●	○
Robustness - Water			
Indoor Water	◕	●	●
Process Water	◑	○	●
Outdoor Water	◑	◕	●
Storm Water	◕	◕	●
Water-Efficient Products	◑	◑	○
Robustness - Energy			
Energy Efficiency	◑	◕	◑
On-Site Renewable Energy	◑	◑	◑
Measurement and Verification	◕	◕	○
Benchmarking	○	○	○
Robustness - Materials			
Recycled Content	◑	◑	○
Biobased Content	◑	◑	○
Environmentally Preferable Products	◑	◑	●
Waste and Materials Management	◕	◕	●
Ozone Depleting Compounds	◑	◑	●
Low-Emitting Material	◕	◕	●
Robustness - Indoor Environment			
Ventilation	◑	●	●
Thermal Comfort	◑	◑	○
Daylighting	◑	◑	◑
Environmental Tobacco Smoke Control	◑	●	●
Moisture Control	◕	○	○
Protect Indoor Air Quality during Construction	◑	◑	○
Robustness - Not in GP			
Acoustic (Not in GP)	◕	○	○
Building System Controls (Not in GP)	○	○	○
Siting (Not in GP)	◕	◕	●
Greenhouse Gas (Not in GP)	◕	○	○

Table 4-13 is in response to the review question: *What percentage of the certification system is represented by this metric?* Note that the Living Building Challenge is not included in this table because it is not a point-based system.

Table 4-13 - Percentage Represented for NC

Certification System Components	Green Globes		LEED New Construction	
	Minimum Percentage	Maximum Percentage	Prerequisites	Maximum Percentage
Siting	6%	12%	2	24%
Energy	7%	30%	3	41%
Water	4%	13%	1	9%
Materials	4%	15%	1	13%
Indoor Environment	5%	16%	3	14%
Emissions	0.4%	5%	n/a	0%
Management	3%	10%	n/a	0%
Other	n/a	n/a	n/a	9%

Existing Building

The robustness criterion for existing buildings includes 28 Federal requirements (source requirement documents in parentheses):

1. Integrated Assessment, Operation, and Management (Guiding Principles)
2. Commissioning (Guiding Principles, EISA)
3. Indoor Water (Guiding Principles, EPAct, EO 13423, EISA, EO 13514)
4. Outdoor Water (Guiding Principles, EO 13423, EISA, EO 13514)
5. Storm Water (Guiding Principles, EISA, EO 13514)
6. Process Water (Guiding Principles, EPAct)
7. Water-Efficient Products (Guiding Principles, EO 13514)
8. Energy Efficiency (Guiding Principles, EPAct, EO 13423, EISA)
9. On-Site Renewable Energy (Guiding Principles, Executive Order 13423, EISA)
10. Measurement and Verification (Guiding Principles, EPAct, EISA)
11. Benchmarking. (Guiding Principles)
12. Ventilation (Guiding Principles)
13. Thermal Comfort (Guiding Principles)
14. Moisture Control (Guiding Principles)
15. Integrated Pest Management (Guiding Principles)
16. Daylighting (Guiding Principles)
17. Low-Emitting Materials (Guiding Principles, EO 13514)
18. Protect Indoor Air Quality during Construction (Guiding Principles)
19. Environmental Tobacco Smoke Control (Guiding Principles)
20. Recycled Content (Guiding Principles, Resource Conservation and Recovery Act, EO 13514)
21. Biobased Content (Guiding Principles, Farm Security and Rural Investment Act, EO 13514)
22. Environmentally Preferable Products (Guiding Principles, EO 13514)
23. Waste and Materials Management (Guiding Principles, EO 13514)
24. Ozone Depleting Compounds (Guiding Principles, Montreal Protocol and Title VI of the Clean Air Act Amendments of 1990)
25. Acoustic (EISA)
26. Building System Controls (EISA)

27. Siting (EISA)
28. Greenhouse Gas (EISA)

Each certification system was mapped to the robustness criteria for existing buildings. Table 4-14 and Table 4-15 reflect Federal requirements for existing buildings. The following is a summary of that mapping.

Green Globes CIEB aligns at some level with 22 Federal requirements:

- Green Globes CIEB has not points that are specifically required, thus, an examination of the points achieved on each individual project is required in order to determine which Federal requirements would be met by certification.
- Eight of the requirements would be fully met through the Green Globes CIEB system if these points are selected by the user and achieved.
- Fourteen requirements may be met if points are achieved and documentation is adapted to conform to the Federal requirement.
- The Green Globes CIEB system does not include six of the Federal requirements (commissioning, recycled content, biobased content, low emitting materials, siting, and building system controls).

LEED EBO&M aligns at some level with more of the Federal requirements (27) than any other existing building system in this review:

- One of the Federal requirements would be automatically met if certification is achieved because LEED EBO&M has minimum requirements that must be met before any level of certification can be attained, called prerequisites.
- Sixteen of the requirements would be fully met through the LEED EBO&M system if these credits are selected by the user and achieved.
- Ten requirements may be met if points are achieved and documentation is adapted to conform to the Federal requirement.
- The LEED EBO&M system does not include one of the Federal requirements (greenhouse gas emissions).

The Living Building Challenge aligns at some level with seventeen Federal requirements:

- The Living Building Challenge requires that buildings meet 100% of the system's design and operations strategies (many of which exceed Federal targets), so these twelve Federal requirements would be met automatically if certification is achieved.
- Five of the Federal requirements may be met if documentation or tracking is adapted to conform to the Federal requirement.

- The Living Building Challenge system does not include eleven of the Federal requirements (commissioning, water use, stormwater, water efficient products, measurement and verification, recycled content, biobased content, thermal comfort, integrated pest management, moisture control, acoustics and building system controls.)

Table 4-14 summarizes how each system aligns with Federal requirements, based on the total number of points or credits available; it does not reflect how these points or credits may be accumulated to achieve different levels of certification. As noted above, in practice the Green Globes and LEED certification systems are "tiered," meaning that they require a minimum number of points or credits to be achieved for a base level of certification, with higher levels of certification available based on accumulation of additional points or credits.

Table 4-14 - Summary of Robustness Criteria for Existing Buildings

Certification System	Federal Requirement Met	Federal Requirement Met if Point Achieved	Federal Requirement Could be Met	Not Specifically Mentioned
Green Globes	0	8	14	6
LEED	1	16	10	1
Living Building Challenge	12	0	3	13

Table 4-15 reflects how each system aligns with each of the 28 Federal requirements for existing buildings.

Table 4-15 - Robustness Criteria for Existing Buildings

	GG CIEB	LEED EB	LBC Ren
Robustness - Others			
Integrated Assessment, Operation and Management	◑	◑	◑
Commissioning	○	◑	○
Robustness - Water			
Indoor Water	◑	◕	●
Process Water	◑	◑	●
Outdoor Water	◑	◕	●
Measurement of Water Use	◑	◑	○
Stormwater	◕	◕	○
Water-Efficient Products	◑	◑	○
Robustness - Energy			
Energy Efficiency	◕	◕	◑
On-Site Renewable Energy	◕	◕	◑
Measurement and Verification	◑	◑	○
Benchmarking	◕	◕	●
Robustness - Materials			
Recycled Content	○	◕	○
Biobased Content	○	◕	○
Environmentally Preferable Products	◕	◕	●
Waste and Materials Management	◕	◕	●
Ozone Depleting Compounds	◑	◕	●
Robustness - Indoor Environment			
Ventilation	◑	●	●
Thermal Comfort	◕	◕	◑
Integrated Pest Management	◑	◑	○
Daylighting	◑	◑	◑
Environmental Tobacco Smoke Control	◑	◕	●
Moisture Control	◑	◕	○
Low-Emitting Material	○	◑	●
Robustness - Not in Guiding Principles			
Acoustic (Not in GP)	◕	◑	○
Building System Controls (Not in GP)	○	◕	○
Siting (Not in GP)	○	◕	●
Greenhouse Gas (Not in GP)	◑	○	●

Table 4-16 is in response to the review question: *What percentage of the certification system is represented by this metric?* Note that the Living Building Challenge is not included in this table because it is not a point-based system.

Table 4-16 - Percentage Represented for Existing Buildings

Certification System Components	Green Globes CIEB	LEED EBO&M	
	Maximum Percentage	Pre-requisites	Maximum Percentage
Siting	n/a	n/a	24%
Energy	35%	3	32%
Water	8%	1	13%
Materials	11%	2	9%
Indoor Environment	19%	3	14%
Emissions	18%	n/a	n/a
Management	10%	n/a	n/a
Other	n/a	n/a	9%

"Measured performance" is important to the Federal sector because outside of the sustainable design requirements many Federal reporting requirements are based on actual performance, such as the EISA requirement for federal agencies to reduce energy intensity by 3 percent per year, or 30 percent by FY 2015. Federal agencies have begun to measure the performance of sustainably designed buildings using an established protocol for building cost and performance.[10] For example, GSA's study of 22 buildings shows that on average "green" buildings use less energy, less water, cost less to operate, and have occupants that express general satisfaction scores higher than typical buildings, with additional studies underway using the same measurement protocol.[11] Performance measurement averages are useful as a portfolio metric but when investigating the performance of individual buildings it is important to note that there is high variability in performance.[12]

To document progress toward sustainable design and operations, measuring, calculating, or demonstrating evidence of intent are all legitimate mechanisms, however it is generally perceived that measured performance is preferred and something the Federal sector is already doing.[13] Metered energy and water performance data are the most commonly sought forms of measured building performance data, however, quantities of recycled materials, waste generation, and indoor air quality measurements are also examples of measured performance. Calculated performance typically serves as a proxy for measured, using industry standards and assumptions to estimate or project how a building will perform. When measured data is limited, calculated performance provides useful, comparative values that can be used to support design and operational decisions. Evidence of intent is a useful proxy for documenting frameworks that facilitate potentially impactful actions. For example, having an Environmental Management System is a positive indicator that building operations will address commonly identified operational impacts of the building and its occupants.

The Guiding Principles were reviewed for whether they required measured performance data (e.g., energy consumed), calculated values (e.g., energy models), or evidence of intent (e.g., energy policy). Table 4-17 and Table 4-18 illustrate that the documentation required to meet the Guiding Principles is

[10] Fowler KM, EM Rauch, AR Kora, JE Hathaway, AE Solana, and KL Spees. 2009. Whole Building Cost and Performance Measurement: Data Collection Protocol, Revision 2. PNNL-18325, Pacific Northwest National Laboratory, Richland, WA. http://www1.eere.energy.gov/femp/pdfs/datacollectionprotocol.pdf

[11] Fowler KM, EM Rauch, JW Henderson, and AR Kora. 2010. Re-Assessing Green Building Performance: A Post Occupancy Evaluation of 22 GSA Buildings. PNNL-19369, Pacific Northwest National Laboratory, Richland, WA.

[12] Turner, C, and M Frankel. 2008. Energy Performance of LEED for New Construction Buildings. New Buildings Institute, White Swan, WA.

[13] U.S. Government Accountability Office. 2011. Green Building: Federal Initiatives for the Nonfederal Sector Could Benefit from More Interagency Collaboration. GAO-12-79. Government Accountability Office, Washington, DC.

primarily evidence of intent for both new construction and existing buildings. The majority of the Guiding Principles can be documented using evidence of intent. The certification systems tend to require more measurement and calculation than is required by the Guiding Principles. Appendix K contains a preliminary mapping of whether each certification system element uses measurement, calculation or evidence of intent to document compliance.[14]

[14] This mapping has not been reviewed by certification system owners.

Table 4-17 - Measured, Calculation, and Evidence of Intent Assessment of Guiding Principles for New Construction

Guiding Principles New Construction and Major Renovations		GG	LEED	LBC
Site				
I	Reduce stormwater runoff	I	I	I
Water				
C	Indoor water use reduction	C	C	M
I	Installation of water meters is encouraged for indoor water use			
I	Consider use of harvested rainwater	C	C	M
C	Outdoor water use reduction	I	C	M
I	Installation of water meters is encouraged for outdoor water use			
I	Reduce process water when life cycle cost effective	C		
I	Specify WaterSense products	I	I	
I	Use certified irrigation system installers when available			
Energy				
C	Energy use reduction	C	C	M
I	Use EnergyStar or FEMP products when available			
C	Solar hot water system, when cost effective	C	C	M
I	Renewable energy	C	C	M
I	Install meters	I	I	M
M	Benchmark energy performance			
I	Commissioning	I	I	
Indoor Environment				
I	Meet ASHRAE 55	C	C	I
I	Meet ASHRAE 62.1	C	C	I
I	Moisture Control	I	I	I
C	Daylighting	C	C	
C	Lighting controls	C	C	
I	Specify low emitting materials		I	I
M	Indoor air quality and construction	M	M	
I	No smoking policy		I	I
Resources/Materials				
I	Specify recycled content materials	M	M	C
I	Specify biobased content materials	M	M	M
I	Specify environmentally preferable materials	M	M	I
I	Design-in recycling container space	I	I	M
C	Construction waste management	M	M	M
M	Eliminate use of ozone depleting substances	M	M	M

Table 4-18 - Measured, Calculation, and Evidence of Intent Assessment of Guiding Principles for Existing Buildings

Guiding Principles Existing Buildings		GG	LEED	LBC
Site				
I	Reduce stormwater runoff	I	C	
Water				
M	Indoor water use reduction	M	M	M
I	Installation of water meters is encouraged	M	M	
C	Outdoor water use reduction (measured option exists)	I	C	M
I	Reduce process water when life cycle cost effective	I	C	
I	Specify WaterSense products	C	C	
I	Use certified irrigation system installers when available			
Energy				
M	Energy use reduction (options exist for a calculation method)	M	M	M
I	Use EnergyStar or FEMP products when available			
I	Renewable energy	M	C	M
I	Install meters	M	C	M
M	Benchmark energy performance	I	M	M
I	Commissioning/Re-Commissioning	M	I	
Indoor Environment				
I	Meet ASHRAE 55	I	C	I
I	Meet ASHRAE 62.1	I	C	I
I	Moisture Control	I	I	I
C	Daylighting	C	C	
M	Lighting controls	M	I	
I	Use/Specify low emitting materials		M	M
I	Integrated Pest Management	I	I	
I	Moisture Control	I	I	I
I	Prohibit smoking	I	I	I
Resources/Materials				
I	Specify recycled content materials		M	
I	Specify biobased content materials		M	I
I	Specify environmentally preferable materials	I	M	M
I	Provide recycling services	I	I	M
M	Eliminate use of ozone depleting substances	M	M	M

5.0 Summary

The goal of the Federal requirements for sustainable design and construction and high-performance operations is to decrease resource use, reduce operating costs and increase organization's effectiveness. Studies have demonstrated that, on average, sustainably designed and operated buildings use less energy and water, have lower maintenance costs, and have higher levels of occupant satisfaction than comparable buildings.[1,2] Green building certification systems offer a framework for teams to identify high-performance opportunities and to document and track design and operational performance. Certification by any third-party system does not guarantee that a building will achieve continued optimum performance. Every building is unique and there is high variability in performance when examining individual buildings. The experience of the design, construction, and operations teams play a significant role in the ability of a building to meet its performance goals.

Each of the certification systems in this review has the stated goal of improving the design and operations of buildings so that they operate in a more sustainable manner. Each system approaches this challenge differently. Each addresses what the buildings industry has identified as the major aspects of green buildings (i.e., siting, energy, water, materials, indoor environment). All of the systems offer a set of on-line tools to assist the users.

Although none of the certification systems are identical to the Federal requirements, users have expressed that systems offer a useful framework for tracking and/or documenting progress toward meeting the requirements. If an agency chooses to use a certification system, then specific documentation to demonstrate the building met the Guiding Principles may need to be prepared in addition to certification system documentation.

The systems align well with the EISA-defined review criteria, with Green Globes for new construction and LEED for existing buildings aligning most closely (25 and 27 respectively out of 27 and 28). Green Globes and LEED have a points system offering multiple certification levels, whereas the Living Building Challenge is an "all-or-nothing" system. The Living Building Challenge certification system is designed to incorporate the results of at least the first year of a building's operations into the certification, which means this system has the greatest emphasis on measured performance. Green Globes and Living Building Challenge feature on-site verification of the user submitted documentation, whereas LEED uses on-line documentation alone. LEED and Living Building Challenge have specific minimum requirements that must be met for certification to be achieved, whereas Green Globes defines a minimum number of points within each area with flexibility as to how those points would be met. LEED is the dominant tool in the market, with thousands more users than the other two systems, however, they are all generally recognized by building professionals.

An "apples-to-apples" comparison of the certification systems is challenging because the development basis is different for each system. Green Globes uses a questionnaire-driven approach to guide the users through the design. LEED uses building codes and standards, and a minimum program requirements approach as its base. The Living Building Challenge uses a philosophy-based approach

[1] Fowler KM, EM Rauch, JW Henderson, and AR Kora. 2010. Re-Assessing Green Building Performance: A Post Occupancy Evaluation of 22 GSA Buildings. PNNL-19369, Pacific Northwest National Laboratory, Richland, WA.
[2] Fowler KM. 2011. "Assessing Federal Green Building Performance." Interagency Sustainability Working Group, Washington DC on January 11, 2011. PNNL-SA-77169.

pushing for advanced building design and operations. Additionally, the certification systems have different strategies for achieving similar goals. In some cases there are multiple paths or approaches for achieving a goal within a certification. An example of the different options is energy use for new construction. Green Globes and LEED have performance and prescriptive path options, where Living Building Challenge requires 12 months of measured energy use data.

Selecting a certification system requires users to clearly understand their purpose for using a system. Innovation, market recognition, ease of use, assistance with meeting requirements, and a performance emphasis are some of the reasons a system might be selected. The Federal sustainable design and high-performance operations requirements steer agencies toward the use of green building certification tools to help buildings professionals meet these energy, water, materials, waste, recycling and indoor environmental quality requirements. As commercially available tools they have been useful in connecting the Federal sector with the current private sector standards.

The certification systems also include elements that fall outside those identified by EISA or the Guiding Principles. For example, Green Globes has points that address clean diesel practices, bird collisions, and asbestos management. LEED has credits that address light pollution, priorities that vary by geographic region, and purchasing of sustainable food. Living Building Challenge has a materials "red list" (prohibiting use of some materials) and requires the building address beauty and inspiration.

To meet Federal sustainable design and high-performance operations requirements, agencies need to focus on the existing Federal building stock. Quality, integrated design may make it easier for buildings to meet the Federal requirements, but in the end, there is a need for quality building operations professionals to achieve long term, high-performing buildings. The building occupants also need to be committed to contributing in a positive manner to optimize building operations.[3]

[3] National Academy of Sciences. 2011. Achieving High-Performance Federal Facilities: Strategies and Approaches for Transformational Change: A Workshop Report. ISBN-13: 978-0-309-21168-0 and ISBN-10: 0-309-21168-9. The National Academy Press, Washington, DC.