

Implementation of LEED NC (v.2009 and v.4) and Its Effect on Costs in the U.S. Construction Industry

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Green buildings are becoming conventional in the modern built environment. A common measure of green certification is the United States Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) credit-based program. As new green building components, technologies and processes emerge and progress, the LEED rating system also evolves, becoming increasingly rigorous. Because of project constraints and cost of implementing green technologies into buildings, architects, engineers and contractors (AECs) oftentimes need help in effectively selecting credits. This study uses a credit frequency indicator (CFI) to determine the common credits employed by AECs to attain certification under LEED NC v.2009 for 159 publicly owned civic facilities. A cursory review was performed and the v.2009 credits were then compared to the requirements of related credits in the newest LEED v.4 that is considered to have a greater emphasis on documentation and verification after installation, which places a greater burden on contractors. The increased requirements necessary to achieve these credits is analyzed and discussed. This study will aid practitioners, as well as construction management instructors and students, in understanding and preparing for the increasing demands in achieving LEED certification.

Key Words: project planning, green building, LEED v.2009, LEED v.4

Introduction

As the United States Green Building Council (USGBC) continues to publish updated versions of the Leadership in Energy and Environmental Design (LEED), Contractors, as well as owners and designers, must understand the obligations of the new requirements. There have been many discussions about the cost of LEED based on Return on Investment or Life Cycle Cost & Analysis. For contractors and public owners, the initial cost of construction is paramount. To determine the incremental cost increase for projects being certified under LEED v.2009, methods previously proposed for other versions of LEED were imposed on the current version. These methods include; a Cost Impact Factor established by a General Services Administration (GSA) LEED v.2.1 Cost Study (Steven Winters Associates, 2004), a Credit Frequency Indicator (CFI) initially identified using Canadian projects (Da Silva and Ruwanpura, 2009), a framework to reconcile LEED credits (v2.1) with municipal government cost (Mosier and Gransberg 2013), and credit frequencies compared to cost impact factors (Reginato 2016). Using these methods as a basis, contractors and owners will be able to more accurately estimate v.2009 projects.

Public buildings were chosen for this and previous studies due to the transparent nature of government projects in the U.S. Typically bids are exposed to all bidders and even published via the Internet for public inspection purposes. The specific public building types; Fire Stations, Libraries and Criminal Justice Facilities, is predicated by their visibility in the public sector. All three building types are iconic in a community, establishing a sense of place. Each has its' own specific code requirements having to do with occupancies, parking and public versus private interior spaces. Based on existing data available from the USGBC, a determination may be made of which LEED credits are typically chosen for each building type. For Libraries, a large amount of glass may be preferable aesthetically. However for Fire Stations and Criminal Justice Facilities, this is not the case. There are many places in a Criminal Justice Facility that should have little to no glass for security purposes.

The LEED credits have evolved and the onus of the work continues to shift. Referring to v.2.1, the low hanging fruit was pursued. Sustainable Sites and Environmental Quality have a similar number of credits to Materials and Resources. Sustainable Sites is very owner and designer focused with choices on project location and design providing many of the credits. Materials and Resources v.2.1 required more from the contractor like reusing building materials and construction waste recycling. For LEED v.4, Contractors will be required to collect product data from their suppliers through the Materials and Resources (MR) category. In review of the USGBC data, MR credits have not been used as heavily in the "Certified" level buildings based on the inclusion of contractors in the process. However, LEED v.4 identifies additional requirements to the existing MR credits, which place additional requirements on the contractor and suppliers. LEED v.4 has requirements that vary by building type. The building types include New Construction, Core & Shell, Schools, Retail, Data Centers, Warehouses & Distribution, Hospitality, and Healthcare (USGBC 2016). This research focuses on v.2009 New Construction for fire Stations, libraries, and criminal justice facilities. This research seeks to identify credits causing additional contractor requirements and creates a framework for use in determining which credits can be expected on a LEED v.4 project.

Review of Contractor Impacts

In previous LEED NC versions, like v2.2, there were fifty-five different types of credits including prerequisites. This is not the same as the number of points available. Of the different credits, MR accounted for nine or about 20% (USGBC 2005). For the update known as v.2009, there are 59 different types of credits with nine MR credits or about 15% (USGBC 2014). In LEED v.4, there are fifty-four different types of credits with seven in the MR category or about 13% (USGBC 2016). This might indicate that the MR category has been reduced in scope. However to the contrary, the Building Life-Cycle Impact Reduction credit replaced two credits from the previous version while having the same impact. Likewise the v.4 MR credit Building Product Disclosure and Optimization - Sourcing of Raw Materials replaces the former Certified Wood and Recycled Content credits. The reorganized credits contain all the rigor of the previous versions plus more. Most important to contractors are the changes within the MR credits and others which have unknown costs.

Very little has been written on the association of actual cost for credits. Mosier and Gransberg (2013) developed a framework to reconcile LEED credits (v2.1) with cost. Further to compare the credits

achieved with cost, the frequencies are compared to cost impact factors using Reginato's methodology (2016), which was adapted by using a Cost Impact Factor established by a General Services Administration (GSA) LEED Cost Study (Steven Winters Associates, 2004) based on LEED v.2.1. The Cost Impact Factors (CIF) are:

1. GSA Mandated (no cost)
2. No Cost/Potential Cost Decrease
3. Low Cost (\$<\$50,000)
4. Moderate Cost (\$50,000 to \$150,000)
5. High Cost (>\$150,000)

Building upon the Credit Frequency Indicator (CFI) initially identified using Canadian projects (Da Silva and Ruwanpura, 2009); a determination of the most frequently chosen credits for commercial buildings was conducted. Reginato (2016) illustrates how different building types will have different frequencies based on a review of courthouses. A discussion of a variety of building types follows, specifically fire stations, libraries, and criminal justice facilities.

It is important to notice that in updating from the GSA study from LEED v.2.1 to v.2009 and looking forward to v.4, several of the credits have changed. In the MR category, Materials Reuse and Recycled Content have gone from each having two distinct credits to being singular credits worth up to two points. These changes have made both CIF and CFI application less direct, but still worth reviewing. Thus, revising the methodology presented by Reginato (2016), credit frequencies for fire stations, libraries, and criminal justice facilities were determined. The methodology includes comparing project type based on credit frequencies versus the CFI (Da Silva and Ruwanpura, 2009) and CIF (Steven Winters Associates, 2004).

Case studies were performed on three distinct types of civic buildings; fire stations, libraries and criminal justice facilities. As publicly owned facilities, these building types are similar to the GSA study on government buildings. Government buildings are publicly funding which frequently causes budget limitations. Similarly public buildings frequently have code requirements, which limit what can be considered a fire station or criminal justice facility, creating a more homogenous group for research.

Case Study - U.S. LEED NC v.2009 Fire Stations

As of May 2016, a total of 76 U.S. fire stations receiving LEED v.2009 certifications were analyzed to determine which credits were most common to fire stations. By providing the most frequently used credits, the design team and contractors can better estimate a LEED project. The projects represent a wide range of locations across the U.S. Table 1 shows the 76 fire station projects used for this analysis and the breakdown of the certification level. Also, Figure 1 illustrates the locations of these fire stations.

Table 1

Distribution of U.S. Fire Stations by Certification Level (LEED v.2009, as of May 2016)

Certification Level	No. of Projects	Percentage
Certified (40-49 points)	14	18%
Silver (50-59 points)	38	50%
Gold (60-79 points)	19	25%
Platinum (>80 points)	5	7%
Total	76	100%

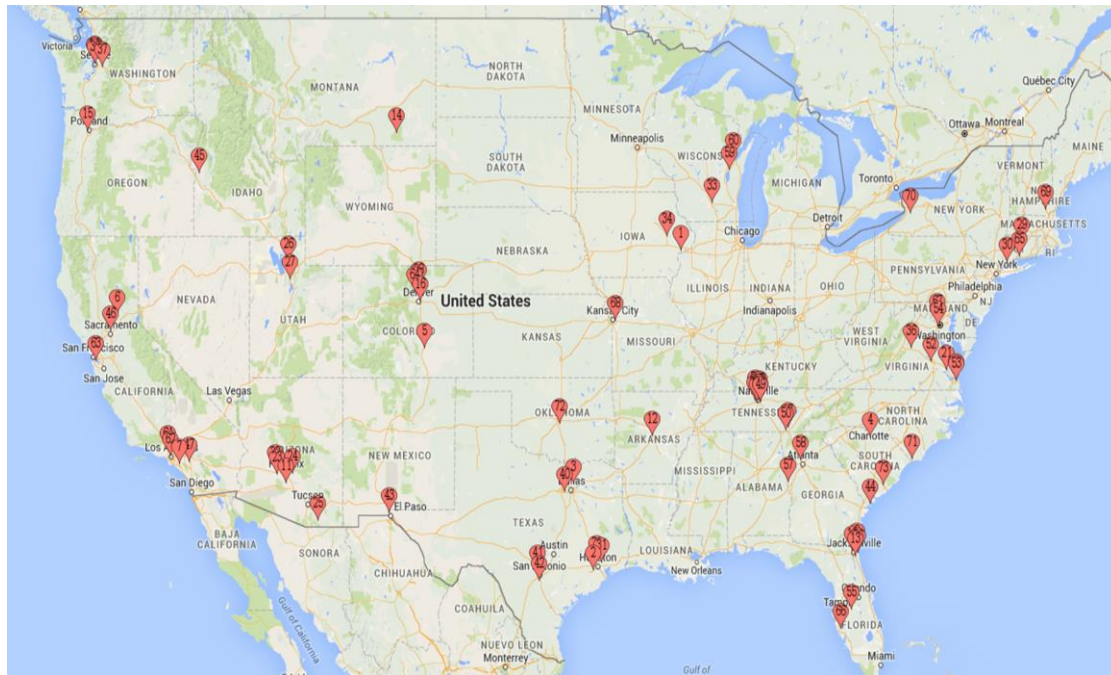


Figure 1: U.S. Fire Station Projects that has Achieved LEED NC v.2009 certifications.

When reviewing all of the fire stations as a group, the Material Resources (MR) credits were achieved at the smallest rate or on average 37% of the MR credits were achieved. One reason for this result might be that most of the projects included in this analysis are new construction; thus, the four building reuse credits are not applicable to the majority of this building type. If those four credits are not considered part of the analysis, then Energy and Atmosphere (EA) will be the category with the lowest achievement of 41%. On the other hand, Indoor Environmental Quality (IEQ) and Water Efficiency (WE) credits were obtained at the highest rate or on average about 65% in both cases. However, when we look at each specific credit, there are several credits from various categories that are at the top and bottom of achievement levels as shown in Table 2.

Table 2

Fire Stations Credit Frequency versus CFI and CIF

Top Ten	Credit Name	% Achieved	CFI	Diff.	CIF
IDc2	LEED Accredited Professional	100.0%	100.0%	0.0%	2
EQ c4.2 (1)	Low-Emitting Materials – Paints	97.4%	97.4%	0.0%	2
SS c4.3 (3)	Alternative Transportation – Alternative Fuel Vehicles	96.1%	96.1%	0.0%	3
EQ c4.1 (1)	Low-Emitting Materials – Adhesives and Sealants	94.7%	94.7%	0.0%	2
SS c4.2 (1)	Alternative Transportation – Bicycle Storage and Changing Rooms	93.4%	93.4%	0.0%	5
EQ c3.1 (1)	Construction IAQ Management Plan – During Construction	93.4%	93.4%	0.0%	3
EQ c4.3 (1)	Low-Emitting Materials – flooring systems	92.1%	92.1%	0.0%	1?
MR c2 (1-2)	Construction Waste Management	93.4%	88.8%	-4.6%	2, 3 or 4
EQ c6.1 (1)	Controllability of Systems – Perimeter Spaces	88.2%	88.2%	0.0%	4 or 5
SS c7.2 (1)	Heat Island Reduction – Roof	84.2%	84.2%	0.0%	2 or 5
Bottom Ten		% Achieved	CFI	Diff.	CIF
SS c5.1 (1)	Reduced Site Disturbance – Protect or Restore Open Space	23.7%	23.7%	0.0%	2
EA c2 (1-7)	Renewable Energy	43.4%	23.1%	-20.3%	5
EQ c5 (1)	Indoor Chemical & Pollutant Source Control	21.1%	21.1%	0.0%	2 or 3
EQ c8.1 (1)	Daylight & Views – Daylight	19.7%	19.7%	0.0%	No Data
WE c2 (2)	Innovative Wastewater Technologies	15.8%	15.8%	0.0%	No Data
SS c3 (1)	Brownfield Redevelopment	9.2%	9.2%	0.0%	2
MR c1.1 (1-3)	Building Reuse – maintain existing walls, floors and roof	5.3%	3.9%	-1.3%	2
MR c6 (1)	Rapidly Renewable Materials	2.6%	2.6%	0.0%	No Data
MR c3 (1-2)	Materials Reuse	2.6%	1.3%	-1.3%	No Data
MR c1.2 (1)	Building Reuse – maintain interior nonstructural elements	0.0%	0.0%	0.0%	2

Overall, for fire station project, the top ten credits have a wide range of CIFs, the expectation was to see CIF below 3. In the case of the credits at the bottom of the list, the tendency is that the data is not available. It appears that further cost analysis will be required to better compare and contrast frequency to

cost impact factors (CIF). Thus, further studies could include currently cost data to conduct a more rigorous analysis instead of Steven Winter Associates report created in 2004.

Case Study - U.S. LEED v.2009 Libraries

As of May 2016, a group of 55 U.S. libraries receiving a variety of certification levels under LEED v.2009 were analyzed to determine which credits were most common to libraries. By providing the most frequently used credits, a LEED project estimate can be more precise by the design team and contractor. The projects represent a wide range of U.S. locations as shown in Figure 2. The breakdown of certification levels for the libraries is shown in Table 3.



Figure 2: U.S. Library Projects that have Achieved LEED NC v.2009.

Table 3

Library Certification Levels

Certification Level	No. of Projects	Percentage
Certified (40-49 points)	5	9%
Silver (50-59 points)	20	36%
Gold (60-79 points)	22	40%
Platinum (>80 points)	8	15%
Total	55	100%

When reviewing all of the projects as a group, the MR credits were achieved at the smallest rate or on average 36% of the MR credits were achieved. Indoor Environmental Quality (IEQ) credits were achieved at the highest rate or on average about 66%. It appears that owners and designers are aware that the MR credits are those requiring the most input and action from the contractor and may be avoiding them. All of the credits were reviewed, but only the top ten and bottom ten CFI are presented in Table 4.

Table 4

Library Credit Frequency versus CFI and CIF

Top Ten	Credit Name	% Achieved	CFI	Diff.	CIF
SSc1	Site selection	89.1%	100.0%	10.9%	2
EQ c 4.3	Low-emitting materials - flooring systems	89.1%	100.0%	10.9%	1
IDc2	LEED Accredited Professional	100.0%	100.0%	0.0%	2
EQ c 7.1	Thermal comfort - design	87.3%	97.0%	9.7%	1 or 5
EQ c 3.1	Construction IAQ Mgmt plan - during construction	92.7%	93.9%	1.2%	3
EQ c 4.2	Low-emitting materials - paints and coatings	96.4%	93.9%	2.5%	2
EQ c 4.1	Low-emitting materials - adhesives and sealants	92.7%	90.9%	1.8%	2
SSc4.1	Alternative transportation - public transportation access	61.8%	84.9%	23.1%	2
SSc2	Development density and community connectivity	81.8%	83.7%	1.9%	2
SSc5.2	Site development - maximize open space	76.4%	81.8%	5.4%	2
Bottom Ten		% Achieved	CFI	Diff.	CIF
EQ c 6.2	Controllability of systems - thermal comfort	45.5%	24.2%	21.3%	1
EQc2	Increased ventilation	36.4%	18.2%	18.2%	1 or 2
SSc5.1	Site development - protect or restore habitat	18.2%	15.2%	3.0%	2
EAc2	On-site renewable energy	20.3%	9.7%	10.6%	5
EQ c 8.2	Daylight and views - views	50.9%	6.1%	44.8%	5
MRc6	Rapidly renewable materials	0.0%	3.0%	3.0%	N/A
WEc2	Innovative wastewater technologies	7.3%	2.7%	4.6%	N/A
EAc3	Enhanced commissioning	65.5%	0.0%	65.5%	1
EAc4	Enhanced refrigerant Mgmt	58.2%	0.0%	58.2%	N/A
EQ c 8.1	Daylight and views - daylight	32.7%	0.0%	32.7%	N/A

As might be expected, seven of the top ten credits identified have a CIF of 2. A CIF of 2 would indicate no additional cost or possible decrease in cost. This information is important for all members of the project team to know and understand. In Table 2, all of the CIF indicating N/A did not have associated costs in the original study. The difference between the library group frequency and commercial building frequency is shown to indicate that as building types change, so does the frequency of credits.

If the same top ten list is based solely on the library group, six of the ten credits are still CIF of two or no additional cost. However, there is an additional CIF of 3, so this might indicate that the libraries were based on a more flexible budget or had different goals. The additional credit was Construction Waste Management. The last question to answer is if the actual credits could be predicted using a frequency indicator. Using this method would prove to be predictive in nature for estimating purposes and for identifying potential credits for a standard building type.

Case Study - U.S. LEED v.2009 Criminal Justice Facilities

As of September 2016, a total of 28 buildings serving in the administration of criminal justice receiving LEED v.2009 certifications were analyzed to determine which credits were most common in them. Criminal justice facilities include structures where people suspected in criminal or civil activity are held or prosecuted during the investigation or prosecution of alleged crimes. Criminal justice facilities include courthouses, police and sheriff stations, and other related justice facilities. The geographic distribution of the projects analyzed is displayed in Figure 3. Of these 28 projects, none achieved Platinum certification. The breakdown is shown in Table 5.

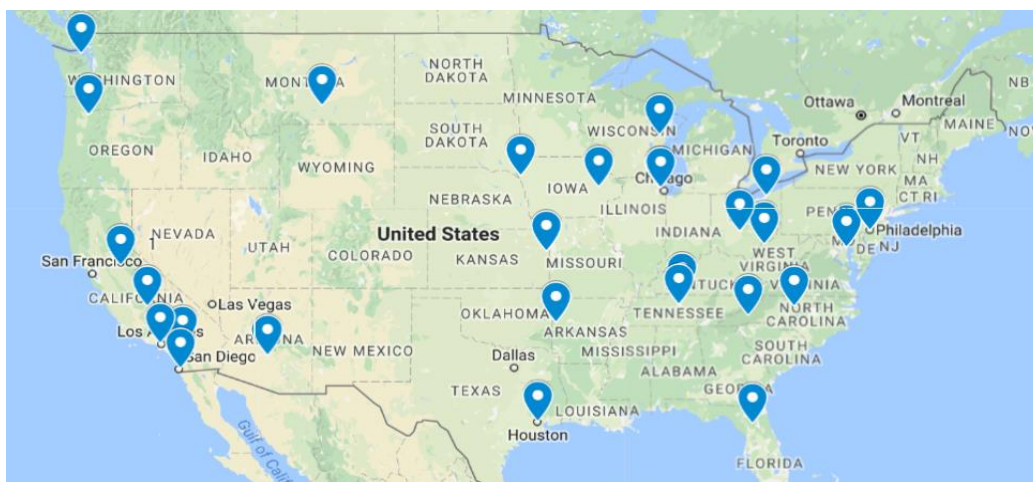


Figure 3: U.S. Criminal Justice Projects that has Achieved LEED v.2009 certifications.

Table 5

Distribution of U.S. Fire Stations by Certification Level (LEED v.2009, as of May 2016)

Certification Level	No. of Projects	Percentage
Certified (40-49 points)	5	18%
Silver (50-59 points)	13	46%
Gold (60-79 points)	10	36%
Platinum (>80 points)	0	0%
Total	28	100%

The rate of credit attainment by group are as follows: Sustainable Sites (SS) at 61%, Indoor Environmental Quality (IEQ) at 58%, Innovation and Design Process (IDP) at 55%, Water Efficiency (WE) at 53%, Material and Resources (MR) at 41%, and Energy and Atmosphere (EA) at 38%. It should be noted that Regional Priority credits, awarded on the basis of implementing credits above and beyond what is necessary for the credit(s) offered, were achieved at a rate of 63%. As done previously for fire stations and libraries, all of the credits were reviewed; the top ten and bottom ten CFI are presented in Table 6.

Table 6

Criminal Justice Credit Frequency versus CFI and CIF

Top Ten	Credit Name	% Achieved	CFI	Diff.	CIF
IDc2	LEED Accredited Professional	100.0%	100.0%	0.0%	2
EQ c 3.1	Construction IAQ Mgmt plan - during construction	96.4%	96.4%	0.0%	3
EQ c 4.2	Low-emitting materials - paints and coatings	96.4%	96.4%	0.0%	2
EQ c 4.3	Low-emitting materials - flooring systems	96.4%	96.4%	0.0%	1
SSc1	Site selection	92.9%	92.9%	0.0%	2
EQ c 4.1	Low-emitting materials - adhesives and sealants	92.9%	92.9%	0.0%	2
SSc4.3	Alternative transportation – low-emitting and fuel-efficient vehicles	89.3%	89.3%	0.0%	3
SSc7.2	Heat island effect - roof	89.3%	89.3%	0.0%	2 or 5
MRc2	Construction waste management	92.9%	89.3%	3.6%	2, 3, 4
EQ c 7.1	Thermal comfort - design	89.3%	89.3%	0.0%	1 or 5
Bottom Ten		% Achieved	CFI	Diff.	CIF
EAc5	Measurement and verification	35.7%	16.7%	19.0%	4
SSc8	Light pollution reduction	14.3%	14.3%	0.0%	2
EAc2	On-site renewable energy	17.9%	12.8%	5.1%	5
SSc5.1	Site development – protect or restore habitat	7.1%	7.1%	0.0%	2
MRc1.2	Building reuse – maintain 50% of interior non-structural elements	7.1%	7.1%	0.0%	2
WEc2	Innovative wastewater technologies	3.6%	3.6%	0.0%	N/A
EQ c 8.1	Daylight and views - daylight	3.6%	3.6%	0.0%	N/A
EQ c 8.2	Daylight and views - views	3.6%	3.6%	0.0%	5
MRc3	Material reuse	0.0%	0.0%	0.0%	N/A
MRc6	Rapidly renewable materials	0.0%	0.0%	0.0%	N/A

These results are not entirely surprising. In some respects, the findings from criminal justice facilities mirror those of courthouses as reported by Reginato (2016). Energy and Atmosphere and Material and Resources are relatively more difficult to attain because they are greatly impacted by the codes and regulations that dictate building designs that place a high priority on the safe detention of defendants and the protection of law enforcement and judicial personnel. For example, materials are chosen on their ability to not be compromised, not on minimizing environmental degradation and energy sources are chosen based on robustness, not renewability. On the other hand, for categories like Sustainable Sites and Water Efficiency the restrictive codes have much less bearing.

LEED NC v.4

Looking forward, all new projects will be certified under LEED v.4 as of October, 2016. It is important to determine if the cost data still valid and can it be applied to the new version. There is a new category in LEED v.4, Location and Transportation, which contains credits that typically do not include a high level of contractor involvement. LEED v.4 credits like Sensitive Land Protection, Green Vehicles and Integrative Process are more design and owner focused than construction related. Using the methodology proposed by Syal et al. (2007), the construction related credits were identified for v.2.1. Mosier et al. expanded on Syal et al. by using the same methodology for v.2009 and v.4. A comparison was then made to the top ten credits for each of the building types.

Based on the top ten from fire stations, libraries and courthouses, the most frequently used credits for all three types of buildings were identified and compared to construction related credits. Although v.2009 Heat Island Effect – roof (v.4 Heat Island Reduction) was used in two building types, it is not identified as having a major impact on construction. However, v.2009 Construction Waste Management (v.4 Construction and Demolition Waste Management) are identified as having a major impact on construction and should be of specific interest to construction estimating. Continuing in this vein, the three v.2009 Low-emitting Materials credits (combined into one credit v.4 Low-emitting Materials) were top ten for all three building types and all have a major impact on construction. It is these credits, which need to be reviewed in depth to determine cost to construction for these types of credits and why they are chosen as credits to achieve.

Conclusion

Although very little research has been performed on the actual cost of LEED to contractors, the Cost Impact Factor, has been used to represent the cost of LEED to construction. Three building types, fire stations, libraries, and criminal justice facilities have been reviewed with both factors to determine if cost was a factor in choosing which credits were sought for certification. As expected the majority of the top five credits were low cost credits. In applying this research to multiple versions, the basic tenet did not change. Certain credits are less expensive and will be chosen more readily than those with higher costs. Based on this finding, additional research in the area of LEED v.4 is necessary once more buildings are certified in the U.S. Further, certain credits in LEED v.4 have now changed their focus from contractor to supplier. To date only four U.S. buildings have been certified under LEED v.4. It is of great interest to

determine if this change in focus will also cause a change in cost to the contractor or if these credits continue to be top ten.

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