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Labs21 Environmental Performance Criteria: Toward "LEED™ for Labs" [1]

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ABSTRACT
Laboratory facilities present a unique challenge for energy efficient and sustainable design, with their inherent complexity of systems, health and safety requirements, long-term flexibility and adaptability needs, energy use intensity, and environmental impacts. The typical laboratory is about three to five times as energy intensive as a typical office building and costs about three times as much per unit area.

In order to help laboratory stakeholders assess the environmental performance of their laboratories, the Labs21 program, sponsored by the US Environmental Protection Agency and the US Department of Energy, is developing the Environmental Performance Criteria (EPC), a point-based rating system that builds on the LEED™ rating system. Currently, LEED™ is the primary tool used to rate the sustainability of commercial buildings. However, it lacks some attributes essential to encouraging the application of sustainable design principles to laboratory buildings. Accordingly, the EPC has additions and modifications to the prerequisites and credits in each of the six sections of LEED™. It is being developed in a consensus-based approach by a diverse group of architects, engineers, consulting experts, health & safety personnel and facilities personnel.

This report describes the EPC version 2.0, highlighting the underlying technical issues, and describes implications for the development of a LEED version for Laboratories.

Keywords: LEED, Laboratory, Labs21, EPC, Environmental Performance Criteria

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1. INTRODUCTION

Laboratory facilities present a unique challenge for energy efficient and sustainable design, with their inherent complexity of systems, health and safety requirements, long-term flexibility and adaptability needs, energy use intensity, and environmental impacts. The typical laboratory is about three to five times as energy intensive as a typical office building [1,2] and costs about three times as much per unit area. Any efforts to reduce energy use and environmental impact are heavily impacted by special functional and health and safety requirements, which need to be considered in rating and benchmarking the overall environmental performance of a laboratory.

The Labs21 Environmental Performance Criteria (EPC) is a rating system for use by laboratory building project stakeholders to assess the environmental performance of laboratory facilities. Currently, the U.S. Green Building Council's LEED™ Rating System [3] is the primary tool used. However, LEED™ was designed for U.S. commercial office buildings and as such, lacks some attributes essential to encouraging the application of sustainable design principles to laboratory buildings (e.g. managing laboratory effluents).

The Labs21 EPC is a project of the Laboratories for the 21st Century (Labs21) Program (http://www.epa.gov/labs21century). This is a program aimed at improving the environmental performance of public and private laboratory buildings. The U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE) are the lead sponsors of this effort. Labs21 recognized the need for a tool to guide and evaluate laboratory environmental performance, and that building upon an already popular "green" rating tool like LEED™ would avoid "re-inventing the wheel", as well as support a unified green building effort. A workshop was held to develop an initial version, which was released in December 2001. Subsequently, volunteers were solicited to develop version 2.0, which was released in October 2002.

This report describes the content of the EPC, highlighting the underlying technical issues, and describes implications for the development of a LEED version for Laboratories.

2. DEVELOPMENT PROCESS

Eight working groups have been established to develop the EPC, reflecting the LEED™ sections:

WG1 Sustainable Sites
WG2 Water Efficiency
WG3a Energy & Atmosphere (Energy Supply)
WG3b Energy & Atmosphere (Energy Efficiency)
WG3c Energy & Atmosphere (Laboratory Equipment)
WG4 Materials and Resources
WG5 Indoor Environmental Quality
WG6 Innovation & Design Process

Participation in working groups is open to all interested stakeholders. Collectively, the working groups currently have over 40 participants, including architects, engineers, consulting experts, health & safety personnel, and facilities personnel. The EPC is being developed in a consensus-based approach. In the few cases where a consensus cannot be reached within a reasonable timeframe, a voting mechanism is used.

3. LABS21 EPC CREDITS

3.1 Overview

The Labs21 EPC 2.0 follows the format of LEED™ Version 2.0. The EPC has additional credits and prerequisites and in a few cases has modifications to the existing LEED™ credits (see figures 1,2). The EPC is more heavily weighted towards energy & atmosphere credits than LEED 2.0, since energy use has a more significant environmental impact in laboratories when compared to other commercial buildings.

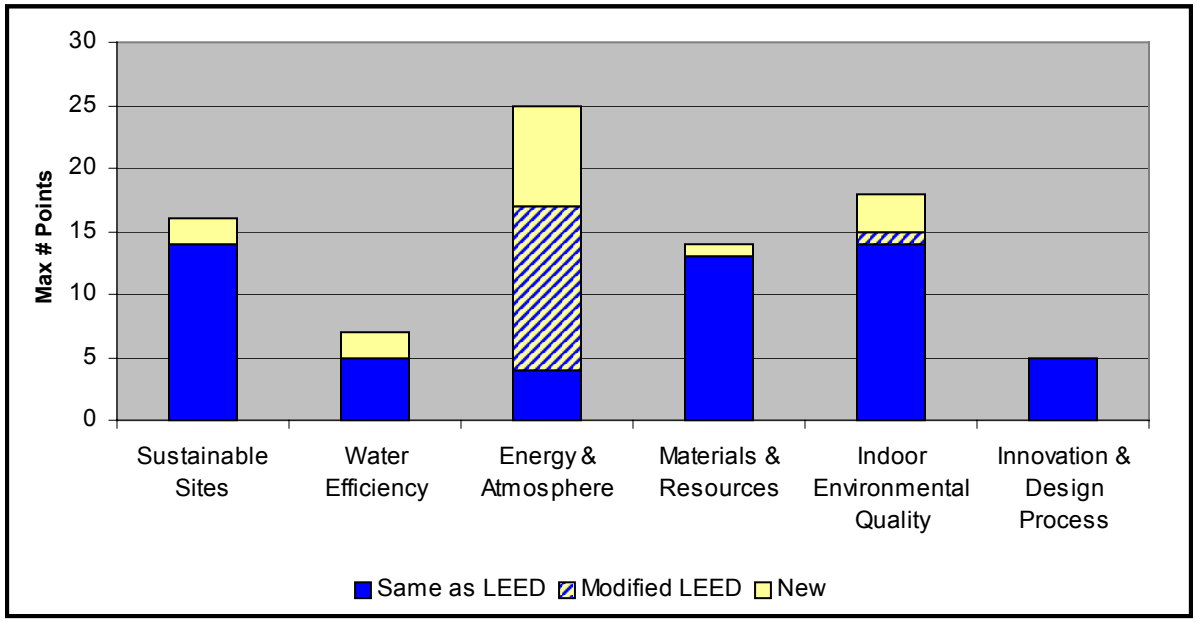

Figure 1 *Total number of EPC points in each section. (Note that the number of points is more than the total number of credits since some credits have multiple points.)*

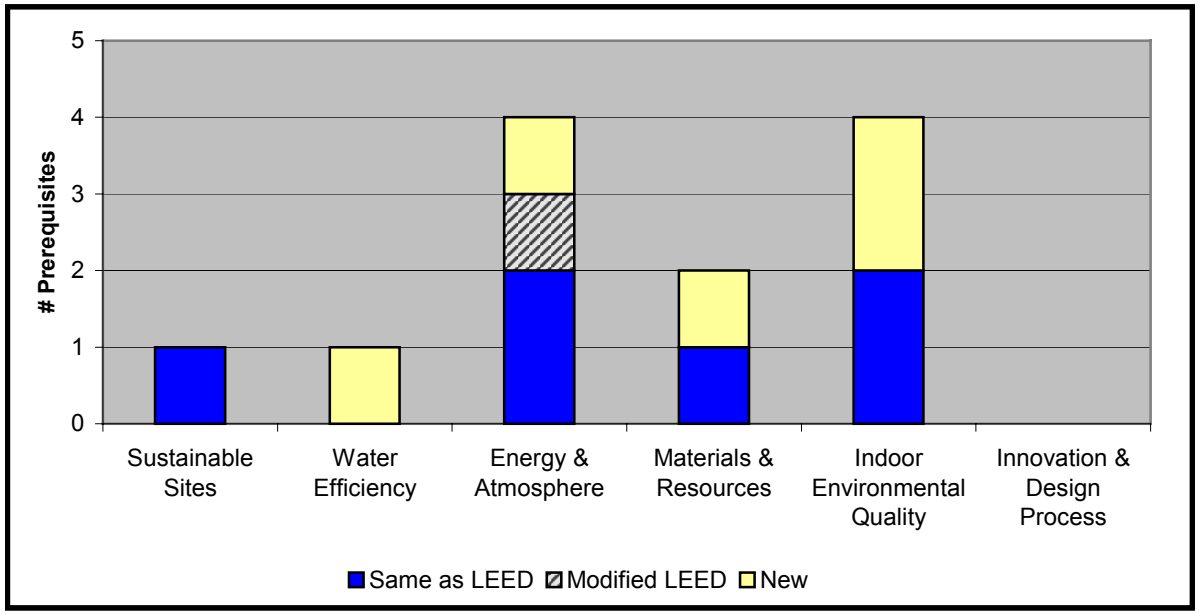

Figure 2 *Total number of EPC prerequisites in each section*

In the following sections, we only discuss credits and prerequisites that are additions and modifications to LEED™2.0. All other LEED™ credits are assumed to remain the same. For example, in the Sustainable Sites (SS) category the LEED™ prerequisite and credits SS-1 through SS-8 remain unchanged. Labs21 EPC proposes an additional credit (SS-9), Safety and Risk Management with a potential two-point credit. In the interest of brevity, the technologies and strategies are not included in the credit descriptions below. The latest version of the EPC may be downloaded from http://labs21.lbl.gov/epc.html.

3.2 Sustainable Sites

All the LEED™ 2.0 credits for sustainable sites are valid for laboratory facilities. However, unlike other types of commercial buildings, laboratories typically have air and water effluents that could present risks to people and the environment. Accordingly, the EPC adds credits for design efforts to manage these risks.

Credit 9	**Safety and Risk Management**
Intent	
Minimize building effluents and environmental, safety and health impacts to site and neighbors.	
Requirements	
Credit 9.1 (1 point)	Meet all standards and generally accepted guidelines for outdoor protection of workers and general public from airborne chemical, radioactive and biological hazards. Use mathematical modeling, physical modeling and/or post-construction testing and certification to prove compliance. Use effluent controls that minimize generation of waste subject to special regulations.
Credit 9.2 (1 Point)	Prevent releases of hazardous chemicals and other pollutants to sanitary sewer, using containment and engineering controls.

In developing credit 9.1, there was significant discussion on whether the requirement should specify a standard. Unfortunately, existing standards are not necessarily consistent or even comprehensive in the scope of effluents that they address, and it was deemed to be beyond the scope of the EPC to address limitations in standards and codes. Therefore, the requirement for this credit focuses on design process – in essence giving a credit for "conscientious effort" to study and address air effluents via CFD modeling and/or wind tunnel modeling. The premise is that a conscientious design effort will increase the probability of a better design.

3.3 Water Efficiency

All the LEED™ 2.0 credits for water efficiency are valid for laboratory facilities. The EPC adds a prerequisite to ensure that no domestic water is used "once-through" for any laboratory equipment, since this is often a major cause for excess water use.

The EPC also adds a credit specifically addressing process water use, since this is significant in laboratories. Unfortunately, there are no standards for water use efficiency that can be used as a benchmark (analogous to ASHRAE 90.1 for energy efficiency). Therefore, this 2-point credit provides 1 point for baselining and meter installation and 1 point for reducing process water use.

Prerequisite 1	**Laboratory Equipment Water Use**
Intent	
Reduce water use for laboratory equipment	
Requirements	
Prerequisite 1.0	No domestic water shall be used "once-through" for any laboratory equipment, unless it is needed as direct contact process water.

Credit 4	**Process Water Efficiency**
Intent	
Reduce process water use and process wastewater generation	
Requirements	
Credit 4.1 (1 point):	Calculate and document baseline of annual process water use and process wastewater generation. Install water meters to measure process water use.
Credit 4.2 (1 point):	Adopt technologies and strategies to reduce process water use and process wastewater generation by 20%. Document the reductions from baseline.

3.4 Energy & Atmosphere

Given the significance of energy use in laboratory buildings, this section dominated the development of the EPC, and contains several additions and modifications to LEED™.

3.4.1 Energy Efficiency

Generally, there are two approaches to address energy efficiency requirements, each with associated advantages and disadvantages.

- Prescriptive Approach: This approach would essentially give points for implementing certain energy efficiency measures (e.g. VAV fumehoods), or for doing certain design process steps (e.g. CFD modeling). This approach is easier to specify, but also has less flexibility to the design team to meet the intent of the credit – a building design may have energy efficiency measures that the credit did not anticipate.
- Performance approach: This approach would define a baseline energy performance and give points for percentage reductions from the baseline. This approach is conceptually preferable, but more difficult to specify and verify.

Addressing laboratory energy efficiency is an especially challenging task, since laboratories can have very different functional requirements. LEED™ credit 1 adopts a performance-based approach and uses ASHRAE 90.1 energy cost budget method (ECB) [4] as the benchmark, with points awarded for reductions below the benchmark. However, ASHRAE 90.1 ECB does not suitably address baseline assumptions for laboratory systems.

After consideraing alternate methods, the EPC development team chose to tentatively maintain the performance-based approach for credit 1, using ASHRAE 90.1 ECB, but modifying it to include specifications for laboratory systems. Furthermore, recognizing that ventilation is typically 50% of laboratory energy use [5], the EPC adds a preprequisite to ensure that ventilation requirements are optimized. Since ventilation requirements cannot be universally

prescribed, the prerequisite outlines a process by which ventilation rates must be determined. The prerequisite and the credit are given below.

Prerequisite 4 Assess Minimum Ventilation Requirements

Intent

To determine minimum ventilation requirements in laboratories based on user needs, health/safety protection and energy consumption.

Requirements:

The ventilation requirements shall be determined and documented by a team including each of the following professionals: A/E Team, Laboratory Consultants*, User Representative, Owner Facilities Group, Facilities Maintenance, Owner Environmental Health & Safety, Commissioning Agent*, Construction Manager*

(*If these have not been appointed, an individual who independently and conscientiously represents these interests.)

The team shall, at a minimum, do the following:

- Determine the necessary fresh air ventilation rate and number of fume hoods and other exhaust devices based on applicable codes and the planned use of the laboratory over the next 5 years.
- Consider exhaust alternatives such as instrument exhausts and ventilated storage cabinets with very low flow ventilation and good ergonomic accessibility.
- Develop a workable fume hood sash management plan including: a) Informational placards for hoods; b) Awareness and Use Training. The Sash Management Plan should be incorporated in the Chemical Hygiene Plan for the laboratory.

The process and findings should be documented.

Credit 1 Optimize Energy Performance *(Replaces LEED Credit 1)*

Intent

To achieve increasing levels of energy performance to reduce environmental impacts associated with excessive energy use.

Requirements

Reduce design energy cost compared to the energy cost budget for regulated energy components described in the requirements of ASHRAE/IESNA Standard 90.1-2001, as demonstrated by a whole building simulation using the Energy Cost budget Method described in section 11, with the following modifications to the specifications for the budget building design and proposed design:

Laboratory Space	*Budget Building Design*	*Proposed Design*
Fumehood/exhaust device density	Same as proposed design	Based on prerequisite 4
Plug loads	Same as proposed design	Based on laboratory requirements and operation
Lighting power density in lab spaces	1.8 W/ sf (net)	As designed
Fumehood configuration	100 fpm face velocity w/ vertical rising sash 18" open	As designed
Ventilation system control	100% outside air, constant volume, no heat recovery	As designed, using same occupied hours schedule as budget design

All other characteristics of the budget building design and proposed design (e.g. envelope, etc.) shall remain the same as in the standard. Plug loads should be included in the simulation, but should be excluded in calculating the percentage difference between budget building and proposed design.

Credit 1.1 (1 point)	Reduce design energy cost by 5%
Credit 1.2 (2 points)	Reduce design energy cost by 10%
……	
Credit 1.10 (10 points)	Reduce design energy cost by 50%

Note that there is legitimate concern that a performance based approach can be ”gamed”, especially in laboratory facilities, with all their inherent assumptions on functional requirements. The EPC team will be testing the viability of this approach with case studies.

3.4.2 Energy Supply

LEED^{TM} credit 2 provides points for on-site renewable energy generation, expressed as a percentage of the building's total energy use. Since laboratories typically have 3-5 times the energy intensity (energy use per unit area) of an average commercial office buidling, the percentage values in LEED^{TM} are consequently 3-5 times as hard to achieve for laboratories. In order to compensate for this, the EPC reduces the percentage thresholds for each point.

Credit 2 **Renewable Energy** *(Replaces LEED Credit 2)*

Intent

Encourage use of renewable energy technologies to reduce fossil fuel energy use

Requirements

Supply a net fraction of the building's total energy use (as expressed as a fraction of annual energy cost) with on-site renewable energy systems.

Credit 2.1 (1 point)	Renewable energy, 2% contribution
Credit 2.2 (2 point)	Renewable energy, 5% contribution
Credit 2.3 (3 point)	Renewable energy, 10% contribution

Due to a their high energy loads and need for back up generation, laboratories are usually good candidiates for cogeneration systems. Credit 1 does not reward source energy reductions through the use of co-generation systems, since its scope is limited to demand side systems. The EPC adds a credit for energy efficient on-site generation, as measured in terms of total source energy use. By using source energy as the metric, the credit provides flexibility as regards system type, system efficiency, waste heat utilization, etc.

Credit 7 Energy Supply Efficiency

Intent

Reduce the total non-renewable source energy required for the facility through increased energy supply efficiency

Requirements

Calculate the total annual non-renewable source energy requirements for the facility as designed, using the calculated site energy requirements and the source conversion values provided in the table below. Calculate the percentage reduction in the total annual non-renewable source energy, achieved through the use of combined heat and power systems, or other methods of cascading energy recovery of primary fuel supplies.

Fuel Type	*Site (kBTU)*	*Source (kBTU)*
Electricity	1	3.013
Natural gas	1	1.024
Fuel oil	1	1
Steam	1	1.38
Hot Water	1	1

Local air emissions regulations must be met. This credit cannot be applied for fuel switching without the use of energy generation equipment.

Credit 7.1 (1 point) Reduce source energy use by at least 10%

Credit 7.2 (2 points) Reduce source energy use by at least 20%

…..

Credit 7.5 (5 points) Reduce source energy use by at least 50%

One issue pertinent to on-site generation is emissions. Ideally, this credit should establish a baseline for emissions. The California standards (CARB) was considered to be too stringent as a national baseline. Therefore, the credit currently requires just meeting local standards. As national standards emerge, they can be incorporated.

3.4.3 Laboratory Equipment Efficiency

Equipment loads in laboratories are typically much higher than commercial buildings and can vary widely, from 2 W/sf to 15 W/sf. In addition to direct consumption, equipment loads also affect cooling energy use. Equipment loads are often overlooked as an area for increased efficiency. Credit 1 does not reward reductions in equipment load. The EPC adds two credits to encourage reducing equipment loads.

Credit 8 encourages the selection of energy efficient laboratory equipment. The credit reflects the EnergyStar™ approach by requiring the selection of equipment that is above the 75th percentile in terms of efficiency. (There is little if any laboratory equipment that has an EnergyStar™ rating.) Obviously, this will only apply when there is a choice of functionally equivalent equipment.

Credit 8 Improve Laboratory Equipment Efficiency

Intent

Save energy with efficient laboratory equipment.

Requirement

Credit 8.0 (1 Point)	Use Energy Star™ compliant equipment or equipment in the top 25th percentile for at least 75 percent of new Class 1 and Class 2 equipment and at least 30 percent of all Class 1 and Class 2 equipment. Acceptance of equipment in the 25th percentile requires a minimum of 4 different models that meet the functional needs of the research. If only 2 or 3 functionally equivalent models are available, acceptance requires selection of the most energy efficient model.

Another issue pertaining to equipment loads is that HVAC designers often overestimate the equipment loads and consequently oversize HVAC systems (chillers, fans, etc.). This can be avoided by getting a more accurate estimate of equipment loads by metering similar laboratory spaces, as required in credit 9.1. An additional credit is given for providing for metering.

Credit 9 Right-size Laboratory Equipment Load

Intent

"Right-size" mechanical equipment by improving estimates of heat-gain from laboratory and process equipment.

Requirements

Credit 9.1 (1 point)	Measure base usage of equipment electrical loads in a comparable laboratory space for each functional type of laboratory space and design electrical and cooling systems based on these measurements.
Credit 9.2 (1 point)	Design electrical distribution system to provide for portable or permanent check metering of laboratory equipment electric consumption. Design for safe access to electrical feeder enclosures and provide sufficient space to attach clamp-on or split core current transformers.

3.5 Materials & Resources

All the LEED™ 2.0 credits for materials and resources are valid for laboratory facilities. There was some initial concern about the appropriateness of credit 1, which encourages building resuse - the concern is that adapting existing buildings for laboratory spaces inhibits energy efficient design. However, it was concluded that energy efficiency issues are adequately covered in other credits and that this credit should be retained, to encourage building reuse where possible.

The EPC adds a prerequisite and a credit pertaining to the handling of hazardous materials. The purpose of the prerequisite is to ensure that an information system for tracking hazardous materials is installed, and the credit encourages the effective management of hazardous material streams.

Prerequisite 2	**Hazardous Material Handling**
Intent	
Develop information system to manage hazardous materials stream.	
Requirement	
Prerequisite 2.0	Develop a system to maintain current information about hazardous material types, quantity, location, and disposal/use histories, and deliver information to a central location.

Credit 8	**Chemical Resource Management**
Intent	
Reduce potential harm to the environment and people through improved management of chemicals.	
Requirements	
Credit 8.0 (1 point)	Develop an action plan to eliminate, minimize, substitute, recycle, and dispose of harmful chemicals safely. Plan should improve distribution, and limit quantities, storage and waste.

3.6 Indoor Environmental Quality

All the LEED™ 2.0 credits for indoor environmental quality are valid for laboratory facilities. The EPC adds preprequistes pertaining to minimum health and safety requirements, and credits to encourage measures that improve worker health and saftey.

Prerequisite 3	**Laboratory Ventilation**
Intent	
Ensure that minimum requirements for IAQ and safety are met	
Requirement	
Prerequisite 3.0	Meet the minimum requirements of ANSI Z9.5 (latest version).

Prerequisite 4	**Exterior Door Notification System**
Intent	
Ensure that use of exterior doors does not compromise laboratory safety.	
Requirement	
Prerequisite 4.0	Provide an explicit notification system for all doors leading directly from pressure-controlled laboratory spaces to the outside.

Credit 9 Indoor Environmental Safety

Intent

Ensure health and safety of employees. Design laboratories to ensure contaminants are contained and workers are protected.

Requirements

Credit 9.1 (1 point)	Optimize indoor airflow based on results of computational fluid dynamics (CFD) or physical modeling.
Credit 9.2 (1 point)	Conduct fume hood commissioning that includes ASHRAE-110 Method of Testing Performance of Laboratory Fume Hoods (latest version) *As Installed.* Scope of testing to include 6.1 Flow Visualization, 6.2 Face Velocity Measurements and 7.0 Tracer Gas Test Procedures. The hood performance rating for the Tracer Gas Test procedure shall be at least 4.0 AI 0.1 as specified in ASHRAE-110.
Credit 9.3 (1 point)	Design all alarm systems in the laboratory to be inherently self-identifying and failsafe.

The EPC also modifies LEED credit 6, exempting pressure-controlled laboratory spaces from requiring operable windows, since this compromises safety.

Credit 6 Controllability of Systems *(Replaces LEED Credit 6)*

Intent

Provide a high level of individual occupant control of thermal ventilation and lighting systems to support optimum health, productivity and comfort conditions.

Requirements

Credit 6.1 (1 point)	Provide a minimum of one operable window and one lighting control zone per 200 SF for all occupied areas within 15 feet of the perimeter wall. Pressure-controlled laboratory spaces are exempted from the operable window requirement.
Credit 6.2 (1 point)	Provide controls for each individual for airflow, temperature, and lighting for 50% of the non-perimeter, regularly occupied areas.

3.7 Innovation & Design Process

All the LEED™ 2.0 credits for innovation and design process are valid for laboratory facilities. The EPC provides a list of suggestions for innovation credits e.g. mini-environments, displacement ventilation, design for flexibility, etc.

4. TOWARD LEED™ FOR LABS

As noted earlier, the EPC leverages the existing LEED™ Rating System 2.0, and is a public domain document. Labs21 does not provide a project certification process. The USGBC is considering developing and publishing a LEED™ Application Guide for Laboratories and/or a Laboratory Supplement to LEED™, and has expressed a strong interest in using the EPC as a basis for this effort.

The development of a LEED for Labs raises several issues that have not yet been fully addressed:

- Building type definition: Thus far, LEED™ has been applied uniformly to all building types i.e. building type is not an issue. However, with the development of LEED™ for different building types, it is necessary to define each building type to determine applicability of the appropriate versions. This is especially relevant in mixed-use buildings (e.g. 40% office, 60% laboratory).
- Wieghting of credits: This issue is inherent to any rating system that has criteria in multiple domains, e.g. "Is a 5% reduction in energy as beneficial as a 20% reduction in water use?" In the case of EPC, this issue is relevant even within the energy domain, since there are separate credits for demand side efficiency measures (credits 1, 8, 9) and supply side measures (credits 2, 7). It is, in principle, possible to address the energy domain with a single credit that uses source energy as the metric.
- Number of points: This version of the Labs21 EPC increases the number of possible points from 69 to 85. This will dictate a commensurate increase in the threshold values for certification and the ratings of silver, gold and platinum. As of this writing, threshold values have not yet been proposed, and will be determined based on pilot-testing of selected laboratory facilities.

Finally, the development of a LEED for laboratories should be viewed in the broader context of LEED for other complex buildings, such as hospitals. From the standpoint of rating systems, complex buildings may be defined as those that have special functional requirements (e.g. health, safety) that directly and significantly impact sustainability criteria. Such buildings challenge the applicability of a general rating system for all commercial buildings, and may well justify the development of a LEED™ version for these building types. Obviously, there are advantages to limiting the number of versions of a rating system, and the special versions should as far as possible maintain all the existing LEED™ credits (the EPC modifies only 3 LEED™ credits). With appropriate guidelines and standards for creating special versions for complex buildings, LEED™ can broaden its scope while maintaining overall consistency.

6. REFERENCES

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7. ACKNOWLEDGEMENT

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