



Developing a LEED Credit Roadmap Analysis for the United States Green Building Council

For Client Use Only

Sam Meleika, Paul Torcellini, Robin Tuttle,
and Allison Moe

National Renewable Energy Laboratory

Technical Report
NREL/TP-5500-81183
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Executive Summary

Leadership in Energy and Environmental Design (LEED) is a certification program managed by the United States Green Buildings Council (USGBC), and used worldwide for the design, construction, operation, and maintenance of residential and commercial buildings. Certification comprises meeting criteria for a variety of LEED credits, and professional knowledge and skills are needed to effectively achieve these credits. The USGBC is interested in developing a “roadmap” that can be used to draw direct connections between its LEED credits and the skills required to achieve these credits. This will help the USGBC modify, align, and supplement current online courses to better address skill development for its learners.

The National Renewable Energy Laboratory (NREL) was tasked by the USGBC to develop a LEED Credit Roadmap (LCR) for one specific LEED credit offering to establish a process for identifying the technical skills required to earn this LEED credit. NREL chose the Indoor Air Quality (IAQ) Assessment, which is used as the example credit for the LCR. This report summarizes the methods taken to construct this LCR. It also offers a visual depiction (flowchart) of the process used to develop the LCR, and a rubric for evaluating gaps between skills needed and existing courses offered. The flowchart and rubric can be adapted for use by USGBC in evaluating other LEED credits in the future.

It is important to note that a specific LCR may identify more skills than the minimum required to achieve a specific LEED credit. For example, the “IAQ Assessment” LEED credit includes several different methods for performing particulate matter (PM) assessment. Although the LCR may list all these skills, they are not all necessarily required to achieve the IAQ Assessment LEED credit (i.e., only one of the various PM methods is required). The LCR tool is therefore not intended as a strict guide for what learners need to achieve to earn a LEED credit. Rather, it serves as a general guide for someone looking to understand the skills required for, or relating to, a specific LEED credit—in this case the USGBC and its goals discussed previously. Furthermore, although an LCR may be developed for one specific LEED credit, and a USGBC learner may successfully complete all the courses listed on the LCR, achieving the necessary skills, this does not always guarantee successful achievement of the LEED credit.

It is recommended to run this LCR analysis for another LEED credit to ensure these methods apply and investigate how well LCRs align. Furthermore, it may also be beneficial to apply this LCR analysis to another IAQ LEED credit to see how well the skills align with the skills required.

List of Acronyms

ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASTM	American Society of Testing and Materials
EPA	United States Environmental Protection Agency
IAQ	indoor air quality
HVAC	heating, ventilating, and air conditioning
LCL	LEED Credit Library
LCR	LEED Credit Roadmap
LEL	LEED Education Listing
LEED	Leadership in Energy and Environmental Design
LSAPC	light scattering airborne particle counter
NREL	National Renewable Energy Laboratory
PM	particulate matter
USGBC	United States Green Building Council
VOC	volatile organic compound
ZE	zero energy/net zero energy

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Introduction

Leadership in Energy and Environmental Design (LEED) is a certification program used worldwide for the design, construction, operation, and maintenance of residential and commercial buildings. LEED was developed by the United States Green Buildings Council (USGBC), and it includes a set of rating systems for buildings to help building owners and operators be environmentally responsible and use resources efficiently. There are a various LEED credits that can be earned for a specific building depending on the design, location, and specific energy efficiency measure desired. Attainment of these LEED credits requires specific skills and knowledge to be implemented in a successful and efficient manner.

Given the wide range of LEED credits and associated skills, the USGBC is interested in developing a “roadmap” that can be used to draw direct connections between existing LEED credits and the skills required to implement these credits. This will help the USGBC modify, align, and supplement current online courses to better address skill development for its learners. It may also help them better communicate with prospective learners, professionals, green building employers, and education or training institutions regarding the skills needed for particular elements of green building.

The National Renewable Energy Laboratory (NREL) was tasked by the USGBC, through its participation in the Better Buildings Workforce Accelerator, to develop a LEED Credit Roadmap (LCR) for one specific LEED credit; NREL chose the Indoor Air Quality Assessment (IAQ). The purpose of this effort was to develop a process and framework for identifying the technical skills required to earn this LEED credit, the existing LEED courses offered by the USGBC that can be used to attain these skills, and any gaps that may exist. The USGBC hopes to use the LCR developed in this project as a template that can be applied to other LEED credits.

This report describes the primary methods used by NREL to develop the LCR for Indoor Air Quality Assessment, and provides additional recommendations to ensure successful application and modification of this LCR to other LEED credits.

1 Methods

The following subsections describe in detail the steps taken by NREL staff scientists to develop an LCR for the “IAQ Assessment” LEED credit.

1. Select a LEED credit.
2. Identify skills required for LEED credit.
3. Investigate LEED courses offered.
4. Identify gaps between courses offered and skills required.
5. Recommend additional LEED courses and resources.
6. Generate tools for future application.

This detailed process may or may not be fully necessary for USGBC staff in reviewing other LEED credits in the future but is included as background. The flowchart graphic provided in the appendix of this document offers a more general outline that could be applied to other credits.

1.1 Select a LEED Credit

The first step in developing a successful LCR was to identify a LEED credit that strongly aligns with the expertise of the NREL staff scientists involved in this task. NREL recruited two researchers from the Building Technologies and Science Center with backgrounds that relate to the development and integration of new and existing energy efficiency standards—specifically energy standards related to Zero Energy (ZE), indoor air quality (IAQ), and heating ventilating, and air conditioning (HVAC) systems.

The two NREL staff scientists who developed the LCR are Dr. Paul Torcellini and Dr. Sam Meleika. Dr. Paul Torcellini is the principal engineer for the Commercial Buildings Research Group and spent three years as a technical advisor to the U.S. Department of Energy in Washington, D.C. He has received two American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Technology Awards for his energy-efficient buildings work, has been instrumental in the development of the ASHRAE Advanced Energy Design Guide series, and has chaired two of the guides for K–12 schools and grocery stores. Dr. Sam Meleika is a researcher in the Residential Buildings Research Group at NREL. His research focuses on the energy efficiency of residential and commercial HVAC appliances. He is currently working on moisture and mold mitigation techniques in hot and humid climates and development of new Energy Star standards for HVAC appliances. His previous work included development of a new American Society of Testing and Materials (ASTM) test standard and Home Ventilating Institute certification program for the “capture efficiency” of kitchen range hoods.

Given that both NREL researchers involved in this task have significant experience in both commercial and residential HVAC systems, new energy efficiency standards, and overall building/environmental health, a determination was made to focus on a LEED credit in building HVAC systems or IAQ. After a meeting with USGBC representatives that discussed NREL staff expertise, previous experiences, and current knowledge of LEED credits, several LEED credits were proposed and subsequently narrowed down to three IAQ credits: Minimum Indoor Air Quality Performance, Enhanced Indoor Strategies, and Indoor Air Quality Assessment. NREL chose the Indoor Air Quality Assessment based on the staff’s extensive experimental experience. In addition, as it was the most complex of the three IAQ credits, NREL expected to encapsulate a wider range of LCR roadmap elements¹ and develop a more useful tool for USGBC.

While the process described in this step is specific to the Technical Assistance format of this project, it will be important that anyone who may undertake this process for other LEED credits have a similar level of knowledge and skills pertinent to the credit being reviewed.

1.2 Identify Skills Required for LEED Credit

The main tool used to identify skills required for a LEED credit was the “Requirements” section of the USGBC LEED Credit Library (LCL).² Upon selection of the IAQ credit, it was observed

¹ A wider range of possible LCR elements includes more LEED points attainable, more options and paths for achieving LEED points depending on building operator preference, more industry standards incorporated, and more knowledge and skills required.

² The LCL also has an “Intent” section. This is a useful tool for learners to evaluate whether the selected credit will meet their needs, but it was not used in this evaluation process.

that the “Requirements” section listed different “Options” and “Paths,” i.e., different options to earn different levels of LEED credits depending on personal preference, expertise, and capabilities.³ A careful review of the standards listed in the “Requirements” section was conducted for all paths and options, and the team put together the following list of required skills:

- Performing a “building flush out” by bringing in fresh outside air and exhausting air with leftover construction pollutants and volatile organic compounds (VOCs)
- Ability to read and interpret design drawings for building
- Ability to read and interpret design drawings for building HVAC systems and power distribution systems
- Knowledge of one or more of the following techniques for determining building envelope leakage:
 - Combined building depressurization (or pressurization) and infrared scanning
 - Building depressurization (or pressurization) and smoke tracers or theatrical fog
 - Building depressurization (or pressurization) and airflow measuring devices
 - Generated sound and sound detection
 - Tracer gas detection
- Ability to implement the techniques involved in one or more of the following methods for determining particulate matter (PM) concentration
 - Light scattering airborne particle counter
 - Discrete microparticle counter
 - Time of flight particle sizing apparatus
- Ability to set up IAQ measurement systems that incorporate high precision sensors, calibrated gas systems, flow meters, pumps, air filters, and reaction chambers to gather and interpret IAQ data (e.g., ozone, CO, PM_{2.5}, PM₁₀, VOCs)
- Knowledge of the techniques involved in one or more of the following non-dispersive IAQ assessment techniques:
 - Infrared spectrometry
 - X-ray spectrometry
 - Ultraviolet photometry.

The list of skills above was compiled based on review of the scope, definitions, and experimental apparatus/methodology presented in each Industry Standard that pertains to the set “Path” selected. It is important to note that depending on the IAQ Assessment path or option chosen, different combinations of the skills listed above may be used. Moreover, not all the skills listed above are required in order to achieve the IAQ Assessment LEED credit; for some paths/options there are skills listed above that do not apply. For instance, knowledge of a light scattering airborne particle counter is a skill primarily used for performing IAQ analyses of larger particles (e.g., PM_{2.5}, PM₁₀), and thus more suited for the “Particulate Matter and Inorganic” path rather than the VOC path. Therefore, the list above is meant to serve as a thorough review of the skills

³ The “Requirements” section for this LEED Credit also listed different industry test standards (e.g., ASTM/EPA/International Organization for Standardization) and acceptable concentration levels of PM and inorganic gases used to determine acceptable IAQ levels associated with a specific option or path. Therefore, it is important that whoever conducts the future review of other LEED credits be familiar with such standards.

required to accomplish one of the various options/paths for this LEED credit, as opposed to a cumulative list of all the skills required to earn any IAQ Assessment LEED credit.

1.3 Investigate LEED Courses Offered

After compiling the “Skills Required” list, the group investigated USGBC resources currently available that can help teach and train these skills. The primary resource that USGBC offers is the [LEED Education Listing](#) (LEL), which lists various courses and seminars that one can attend to gain familiarity with the LEED accreditation system.

A search of the LEL was performed by entering keywords from the skills required list shown in Section 2.2 and ensuring that each of the skills required has been addressed through existing coursework. Some of the keywords used in the search include, but are not limited to, the following: “air quality,” “leakage,” “particulate matter,” “ASHRAE,” “VOC,” “sensors,” “spectrometry,” and “photometry.” The LEL can also be filtered by course level, format (online or printed), and LEED credit category/certification type. Some of the LEED credit categories explored include “Indoor Environmental Quality,” “Energy Efficiency and Environment,” and “Energy & Atmosphere.”

After a detailed look through the LEL categories and a thorough search of keywords, the following “List of Courses Offered” was finalized:

1. [IAQ Testing for LEED: The Why and The How](#)
2. [A Detailed Look into WELL Indoor Air Quality Features](#)
3. [Construction IAQ Management in LEED](#)
4. [Arc Performance Pro - A Data-Driven IAQ Framework](#)
5. [Intro to HVAC: Designing for Comfort](#)
6. [The Envelope, Please! How Everyone Wins with Building Envelope Commissioning](#)
7. [Introduction to Ventilation & the latest ASHRAE 62.2 standard\(s\)](#)

It is important to reiterate that there is an element of redundancy and overlap in the courses list above, meaning not all of them are required to achieve a certain LEED credit. This list is meant to capture all the courses that apply to, and facilitate understanding of, the IAQ Assessment LEED credit. For instance, the course on “Arc Performance Pro” discusses how this software can be used to monitor and analyze IAQ and other indoor environmental quality factors. However, knowledge of this software is not essential to earning IAQ Assessment credits.

1.4 Identify Gaps Between Courses Offered and Skills Required

In reviewing the “List of Courses Offered” in Section 1.3, we found that the topics covered related to the IAQ Assessment credit were lacking in depth. Specifically, the courses that discussed ASHRAE 62.2 primarily focused on outdoor ventilation rates and did not go into the details required to perform a successful IAQ assessment (e.g., infiltration, leakage testing). In

addition, we found that it can be difficult to return successful results in the LEL search bar using keywords relating to International Standards (i.e., ASHRAE, ASTM, Home Ventilating Institute). When a course did contain a reference to a specific standard, the coverage was often limited and did not guarantee that the content covered would be sufficient for successful earning of a LEED credit.

The following section incorporates details on the shortcomings identified in the current course offerings and recommends additional LEED courses that can better prepare a technician/certifying body to earn IAQ Assessment credits.

1.5 Recommend Additional LEED Courses and Resources

After reviewing the shortcomings in current course offerings on the LEL, the following list of recommendations was compiled to better prepare learners to earn credits through the LCL. Below each recommended course is additional discussion about why the current LEL courses are not sufficient:

- 1. An advanced look at using ASHRAE Standard 62.1/62.2 to assess and design for acceptable indoor air quality (IAQ)**
 - a. Course #2 (A Detailed Look into WELL Indoor Air Quality Features) touches on these standards briefly, but it would be beneficial to also include a separate course that goes into more detail and can be easily referenced. That is, it may not be very intuitive to look for ASHRAE 62.2 information in Course #2.
 - b. Course #5 (Intro to HVAC: Designing for Comfort) includes a slightly more detailed discussion of ASHRAE Standard 62, but only limited coverage as this course also covers two other ASHRAE Standards as well (ASHRAE Standard 55 and ASHRAE Standard 90.1).
 - c. Course #7 (Introduction to Ventilation & the latest ASHRAE 62.2 standard(s)) generally focuses on outdoor ventilation rates based on floor area and number of bedrooms. It is perhaps worthwhile to put more emphasis on infiltration (i.e., building/duct leakiness and air tightness) so that a technician/certifying body is better equipped to perform and understand different IAQ Assessment techniques.
- 2. Discussing different types of VOCs and inorganic particulate matter**
 - a. Course #1 (IAQ Testing for LEED: The Why and The How) gives a brief overview/introduction of VOCs and some methods for testing, but it would be beneficial to have a separate course, or multiple courses, that are more PM/VOC specific. That way a trained technician or certifying body can more clearly identify the best LEED credit path for a specific application
- 3. Choosing the best air quality metric/sensor and proper sensor usage techniques**
 - a. Course #1 (IAQ Testing for LEED: The Why and The How) does not discuss tips for selecting a proper IAQ sensor/method. However, Course #1 references a

supplemental United States Environmental Protection Agency (EPA) [air sensor performance evaluations guidebook](#). Although, this document is a helpful reference, it is quite lengthy, and it is not guaranteed that the student enrolled will review this guidebook when completing the course.

- b. Some of the IAQ assessment skills shown in the “List of Skills Required” require an advanced knowledge of IAQ techniques. It is recommended that a course, or multiple courses, be designed to educate technicians on the proper methods for these IAQ assessment techniques.
4. **Advantages and disadvantages of different IAQ analysis methods (i.e., tracer gas, non-dispersive, pressurization versus depressurization)**
 - a. Neither Course #1 (IAQ Testing for LEED: The Why and The How) nor the EPA guidebook provide explicit guidance on the advantages/disadvantages of different IAQ assessment techniques, but only different PM/VOC sensors (i.e., different accuracies, costs). In fact, the EPA guidebook makes no reference to non-dispersive or tracer gas methods for performing IAQ assessments.
 5. **Proper techniques for performing a leakage test**
 - a. Course #6 (The Envelope, Please! How Everyone Wins with Building Envelope Commissioning) discusses the importance of a properly sealed/ventilated building envelope, but leakage testing and sealing of a building is a necessary skill for some IAQ assessment techniques. However, we did not see any courses that discuss proper leakage testing techniques (i.e., sealing, pressurizing/depressurizing, measuring in accordance with industry standards).
 6. **Reading and interpreting engineering drawings (i.e., building construction, HVAC systems, power/lighting systems)**
 - a. We did not see a course that explicitly covers this topic. Perhaps it is implied that this is an inherent skill of any technician seeking LEED certification, but we feel this is an important skill to have for planning or performing a successful IAQ assessment.

1.6 Generate Tools for Future Application

The flowchart shown in Appendix A was developed to outline the LCR process followed for this effort. The path highlighted in the flowchart is specific to the LEED credit investigated in this project. However, the skills listed in Section 2.2 of the flowchart are meant to encapsulate all skills required for the IAQ Assessment LEED credit. That is, the flowchart shown in Appendix A is meant to convey how a flowchart or LCR may look, and how it can be expanded to the entire list of skills required for all types of IAQ assessment.

The rubric shown in Appendix B offers a different tool for making the connection between the skills required to earn a LEED credit from the LCL and the courses offered on the LEL. It has been completed for the IAQ Assessment credit described in this report.

This step, i.e., creating the flowchart and rubric, is likely not necessary for future evaluation of other LEED credits by USGBC. Instead, it is our hope that these tools can be adapted and used to guide this process for others.

2 General Discussion

The process developed and followed for this project helped shed light on the usefulness of existing functions within the LEL system. One LCL and LEL feature that was particularly useful was the auto-populate feature on the search bar that begins recommending credits and courses as soon as the user begins typing. This feature allowed for quick browsing of available resources while also exposing the user to other potential LEED credits. It was also particularly helpful to be able to sort the LCL/LEL by category, certification path, and format.

It is important to note that development of a thorough LCR that can address all aspects of a LEED credit takes a lot of time and specialized expertise. Our team spent approximately 10 hours distilling skills from a LEED credit, and another 10 hours analyzing the courses. If one is not thoroughly familiar with the industry standards and terminology associated with a specific LEED credit, it can be very difficult to begin developing, or even navigating, an LCR. Therefore, it can be concluded that the ability of an LCR to successfully map a LEED skill to a credit depends on the user's familiarity (and current skill level) associated with that industry.

It should also be acknowledged that successful completion of a course from the LEL, as well as the quiz at the end, does not guarantee that the individual has all the necessary skills to successfully earn a LEED credit from the LCL. Courses vary in terms of content, format, and presenters, and although there are ample resources for a learner to explore given adequate time, courses may be completed in a rush or as a technicality. It is therefore not clear that the individual taking a given course will fully explore, or more importantly understand, the topics presented. And although there is a quiz that tests understanding prior to earning credit for that course, this is not the same as saying that successful completion of this course, or even a certification/badge program, ensures successful implementation of a LEED credit from the LCL.

3 Future Recommendations

Although a successful LCR was developed for one specific LEED credit, and there is some overlap between LCRs, this does not mean that all other LCRs will follow the same path or not require additional steps. It is recommended to run this LCR analysis for another LEED credit to see how these methods apply and how LCRs compare. Furthermore, it may also be beneficial to apply this LCR to another IAQ LEED credit to see how well the courses and skills align and how heavily the LCRs overlap. Based on the results of this analysis (e.g., overlap between credits, drawing connections between LEL/LCL), it may be helpful to present future LCRs graphically and interactively (i.e., a large, interactive flowchart, table, or graphic that users can click to expand and collapse).

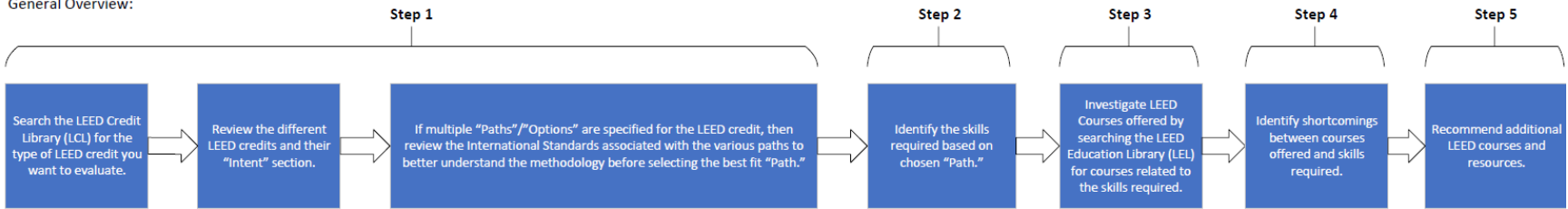
Some recommendations to the LEL/LCL are to add a link next to some of the entry fields to describe what the field being filtered represents. For instance, the options for "Select a Rating System" on the LCL are not clear, and it would be helpful to have a link that quickly sends a user to an external reference describing these different "rating systems." Furthermore, it was not clear whether the "V4.1 Sample Forms" are for IAQ Assessment, if there are any, or how these forms

are to be filled out, submitted, or used in the LEED accreditation process. A clear section outlining these forms on the LEED website would be helpful.

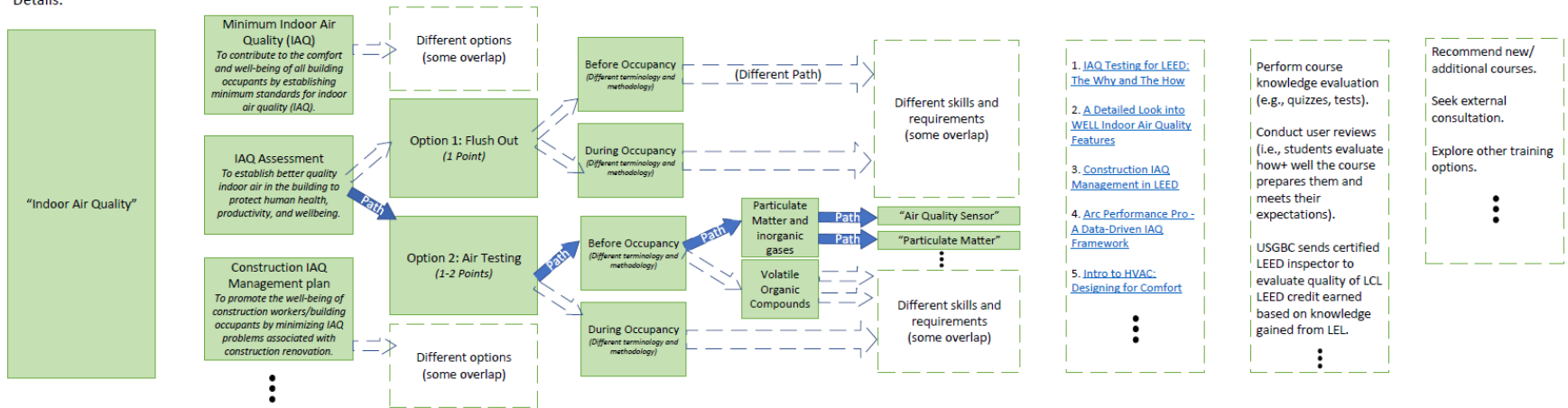
As LEED accreditations are closely interwoven with International Standards (e.g., ASHRAE, ASTM, EPA, International Organization for Standardization), it would be helpful to incorporate more International Standards into the search bar and possibly include an option to filter by these standards. The current auto-populating fields work well for auto-populating titles of current LEED credits and courses, but it would be helpful if this feature could populate common standards and keywords as well (e.g., “air quality,” “depressurization,” “ASHRAE 62.2”). Additionally, it may be beneficial to update the search bar such that a user can ensure the keywords searched are specific to a certain field (e.g., a keyword search for “ASHRAE” returning results from the “Contains Text,” “Relevant Code/Standard,” or “LEED program” search bar).

Appendix A: LCR Process Flowchart

General Overview:



Details:



Appendix B: LCR Evaluation Rubric

LEED Credit: Indoor Air Quality Assessment		
Required Skill	Relevant Existing Coursework	Recommended Coursework
Perform a “Building flush out”	<ul style="list-style-type: none"> The Envelope, Please! How Everyone Wins with Building Envelope Commissioning 	<ul style="list-style-type: none"> Proper techniques for performing a leakage test
Read and interpret design drawings for buildings	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> Reading and interpreting engineering drawings (i.e., building construction, HVAC systems, power/lighting systems)
Read and interpret design drawings for building HVAC systems and power distribution systems	<ul style="list-style-type: none"> Intro to HVAC: Designing for Comfort Introduction to Ventilation & the latest ASHRAE 62.2 standard(s) 	<ul style="list-style-type: none"> Reading and interpreting engineering drawings (i.e., building construction, HVAC systems, power/lighting systems)
Knowledge of techniques for determining building envelope leakage	<ul style="list-style-type: none"> The Envelope, Please! How Everyone Wins with Building Envelope Commissioning 	<ul style="list-style-type: none"> Proper techniques for performing a leakage test
Knowledge of the techniques involved in determining particulate matter (PM) concentration	<ul style="list-style-type: none"> IAQ Testing for LEED: The Why and The How A Detailed Look into WELL Indoor Air Quality Features 	<ul style="list-style-type: none"> Discussing different types of VOCs and inorganic particulate matter
Ability to set up indoor air quality (IAQ) measurement systems	<ul style="list-style-type: none"> IAQ Testing for LEED: The Why and The How 	<ul style="list-style-type: none"> An advanced look at using ASHRAE Standard 62.1/62.2 to assess and design for acceptable indoor air quality (IAQ)
Knowledge of the techniques involved in non-dispersive IAQ assessment techniques	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> Choosing the best air quality metric/sensor and proper sensor usage techniques Advantages and disadvantages of different IAQ analysis methods (i.e., tracer gas, non-dispersive, pressurization versus depressurization)
Additional reference courses	<ul style="list-style-type: none"> Construction IAQ Management in LEED Arc Performance Pro - A Data-Driven IAQ Framework 	