Unintentional Sustainability in Schools—A Case Study of a Newly Built School's Accordance with the LEED Rating System

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This research was funded by the U.S. Environmental Protection Agency (EPA), Science to Achieve Results (STAR) Initiative, Grant# 83563401-0.

Abstract

The effects of the built environment on its occupants are important when considering schools and the impact of the physical learning space on students' ability to learn. Therefore, in order to provide students and teachers a healthy and comfortable place in which to effectively work and learn, it is important that school buildings are constructed using guidelines that recognize the unique nature of K-12 school design, and national environmental and health goals. A guideline that not only emphasizes the efficient use of essential resources like energy, water, materials, and land than buildings that are simply built to code, but also helps to create healthier work, learning, and living environments, with more natural light and cleaner air, and contribute to improved employee and student health, comfort, and productivity (Kats, Alevantis, Berman, Mills, & Perlman, 2003).

Many school administrators understand the importance of sustainability and want to implore sustainable practices in building and maintaining schools, but tight budget constraints prevent them from pursuing options such as Leadership in Energy & Environmental Design (LEED). The aim of this study is to determine how close a new state of the art school building is to the minimum LEED standard unintentionally. If it can be shown that meeting LEED standards is within reach, school decision makers might be more apt to consider sustainability standards such as LEED.

The aim of this study is to determine the compliance of a newly renovated high school in a larger city school district with the green building criteria established by the U.S Green Building Council (USGBC) standard LEED checklist for schools. Specifically, the authors determined the extent to which a recently renovated inner-city school building is in compliance with the LEED criteria for schools without being built to this standard.

Keywords: LEED, K-12 Schools, occupant's health & performance, healthy space

Introduction

People spend almost all their life inside different buildings, and they interact with the building and its furniture in different ways, because of that it is important to construct our buildings in a way that not only afford our mental health's relaxation, but also promotes the health of us and its surrounding environment. The effects of the built environment on its occupants become even more important when concerned with schools and the impact of physical

learning space on students' ability to learn. Therefore, in order to provide the children and teachers a healthy and comfortable place, in which to effectively work and learn for eight hours a day, it is important that school buildings are constructed using special guidelines that recognizes the unique nature of K-12 school design, national environmental and health goals. A guideline that not only emphasizes the efficient use of essential resources like energy, water, materials, and land than buildings that are simply built to code, but also helps in creating healthier work, learning, and living environments, with more natural light and cleaner air, and contribute to improved employee and student health, comfort, and productivity (Kats, Alevantis, Berman, Mills, & Perlman, 2003). This guideline should also address issues such as classroom acoustics, master planning, mold prevention and environmental site assessment.

The immethodical use of fossil fuel has led to numerous deleterious effects on people's health and the environment. The residential buildings share of U.S. primary energy consumption in 2015 was 21.5% and the commercial buildings share was 18.5%, which gives us a total 40 % in the energy usage of buildings of a total 28 trillion Kwh (U.S Department of Energy, 2012). Because of this considerable amount of energy usage by the buildings, the United States Green Building Council (USGBC) has created a scorecard rating system called LEED, a scoreboard rating system, which if it is done properly, can enhance the humans' health and wellbeing, protect and restore water resources, protect biodiversity and ecosystem services, promote sustainable and regenerative resource cycles, build a greener economy, enhance community, social equality and reverse contribution to climate change (Owens, Macken, Rohloff, & Rosenberg, 2011).

In the year 2012, USGBC conducted research in order to prove its efficiency in buildings. In this research, they analyzed 275 commercial building in the District of Columbia in an effort to better understand the energy performance characteristics of LEED certified commercial office buildings. After doing different studies, analyses and comparison between buildings, they found that the buildings which are LEED certified have a 13% lower average site energy use in year per building's floor area (64.0 kBtu/SF vs. 73.3 kBtu/SF), 11% lower average electricity usage (18.0 kWh/SF vs. 20.2 kWh/SF) and 16% lower average water usage (17.9 Gal/SF vs. 21.4 Gal/SF) when compared to non-LEED certified office buildings (Kuziemko, 2014). LEED has also shown to be frugal, where according to the California's Sustainable Building Task Force a minimum increase in upfront costs of 0-2% to support green design will result in life cycle savings of 20% of total construction costs, more than ten times the initial investment buildings (Kats, Alevantis, Berman, Mills, & Perlman, 2003). The benefits of a green building is not limited to tangible factors such as energy, health and water saving; it also covers topics such as productivity of the occupants and their health benefits.

LEED Basics

The agenda of LEED is simple, the more energy efficient the building is, the more points it will earn. LEED has 6 main categories which are:

- Sustainable sites (SS)
- Water Efficiency (WE)
- Energy and Atmosphere (EA)
- Material and Resources (MR)
- Indoor Environmental Quality (IEQ)
- Innovation in Design (ID)

The six categories form 110 points, where the first five have 100 base points with innovation in design accounts regional priority accounting for six and four points respectively (United States Green Building Council, 2013). Each category is further divided into subcategories with each subcategory having differing point values and weights depending on the type of building and its needs. For example, in the LEED rating system for schools, energy performance improvement is worth up to 16 points, a subject which is important especially in schools, while the use of green vehicles is only one point. Projects achieve different levels of certification based on the combined total of points earned. The different levels of certification are as follows (Samarasekera, 2015):

- Certified: 40–49 points
- Silver: 50–59 points
- Gold: 60–79 points
- Platinum: 80+ points

This rating system is designed for all types of buildings, which includes new constructions, core and shell, residential, educational, retail, warehouse and distribution centers, healthcare, and data centers. There are four primary LEED rating systems that are listed below:

- LEED Building Design and Construction (BD+C)
- LEED for Interior Design and Construction (ID+C)
- LEED for Building Operations and Maintenance (O+M)
- LEED for Neighborhood Development (LEED ND)
  (United States Green Building Council, 2013)

Methodology

This case study was conducted through building drawings and construction specifications which were provided from the LWPD Architects & Planners P.C, the 2016 enrollment numbers, which were driven from the Planning, Research, and Evaluation Department, and surveys completed by visual building inspection, trying to calculate the accordance of this school with the LEED guideline.

The information obtained from the school was evaluated by LEED V4 for Building Design and Construction, updated July 1st, 2015. This kind of LEED is used for buildings that are being newly constructed or going through a major renovation. The LEED V4, which is the latest version of the rating system, has been used to see the how compatible the school is towards the LEED.

The New Douglass High School (NDHS) is a 204,806 SF, two story building, located at 900 N Martin Luther King Ave, Oklahoma City, OK 73117. The school plan consists of three main parts (Fig 1):

Fig 1: New Douglass High School Site

1- The classes and offices, which consist of three wings. The first wing faces the south east side of the building, and runs through a 620 feet east-west wing. The height of the windows and glazing system systems is one of the salient features of this wing. As shown in Fig 2, the south side of the building uses curtain wall systems and windows which rises two stories, making the interior corridors of the building dependent from ambient lights through the day by bringing the natural lighting inside the building. The other two wings are adverse of each other: one facing west, and running from south west to north east, which is mainly the offices and the other one facing east, runs from south east to North West, which mainly consists of classes. These two wings get connected to each other by the central lobby located at the center of the building.

The courtyard in the center of the building, (Fig 2) can regulate daylight, air movement and thermal interaction with the outdoor environment. While the windows of this building are not operable and therefore natural ventilation can't be used in this building as an air system strategy, the numerous installed windows around the courtyard not only allows the daylight to enter the building, but also provides an outside view of nature for the occupants.

2- The auditorium, a large mass located on the north side, with a higher ceiling height compared to the other parts, without any openings and windows, unlike the office and class wings.
3- The gym, on the north east side, which connects to the east wing, and the auditorium by a central lobby.

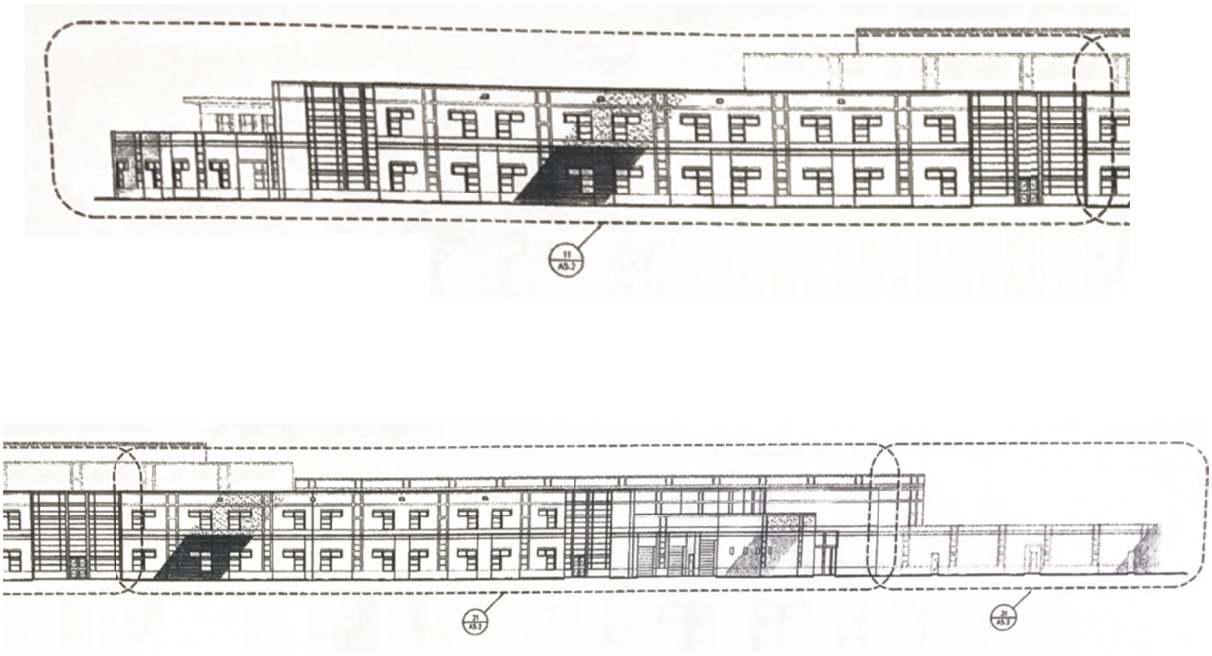


Fig 2: Overall South Elevation

When scoring a building for LEED certification, all the general requirements must be observed. All the prerequisites defined by the LEED guideline, which define the minimum standard for a building in order to be eligible for LEED (Samarasekera, 2015), must be met by the building; otherwise the project would not be qualified even if each of the green building criterion were achieved individually. The prerequisites that the school buildings must met in order to be eligible for LEED certification are as follows:

1- Construction Activity Pollution Prevention
2- Environmental Site Assessment
3- Outdoor Water Use Reduction
4- Indoor Water Use Reduction
5- Fundamental Commissioning and Verification
6- Minimum Energy Performance
7- Building-Level Energy Metering
8- Fundamental Refrigerant Management
9- Storage and Collection of Recyclables
10- Construction and Demolition Waste Management Planning
11- Minimum Indoor Air Quality Performance
12- Environmental Tobacco Smoke Control
13- Minimum Acoustic Performance

Based on a review of the architectural drawings, construction drawings specifications and a visual building inspection of NDHS, the building met some but not all the specified prerequisites. The prerequisites that were ***met*** by the building are as follows:

Construction Activity Pollution Prevention; a subset of criterion intended to reduce pollution form construction activities by controlling soil erosion, waterway sedimentation, and airborne dust. This credit is achieved according to drawing C4.8; Phase 2 Overall Erosion Control Plan, which shows the building had a unified plan for this matter before starting the renovation.

Outdoor Water Use Reduction; a prerequisite credit for water efficiency which focuses on reducing the water consumption used for landscaping and irrigation, by using non vegetated surface areas or reducing irrigation by at least 30% from the calculated baseline for the site's peak watering month. The Environmental Protection Agency (EPA) WaterSense Water Budget Tool was used to calculate the amount of water use reduction (further discussion of this tool is provided on page 17).

Indoor Water Use Reduction; another prerequisite credit that falls under the water efficiency category, defines the maximum allowable water consumption for plumbing fixtures in order to reduce the water consumption. Based on the information provided in the plumbing fixture schedule, sheet P3.1, it is determined that NDHS meets this prerequisite.

The "Indoor Water Use Reduction" and "Outdoor Water Use Reduction" are the two subjects that are considered both as a perquisite credit and also credits with earnable points. Each of these credits will be discussed later in the respective section.

Construction and Demolition Waste Management; with the purpose of reducing the construction waste and preventing of landfills becoming a waste disposal place, a waste management program is needed to identify at least five materials (both structural and nonstructural) targeted for diversion, describing the strategies needed for diversion. According to information provided in construction drawing specifications, Volume 1, the building demolition, section 02070, a waste management program had been intended for the NDHS.

Storage and Collection of Recyclables; some areas specifically for collecting waste and storing recyclable materials for the entire building must be considered. According to information provided in construction drawing specifications, Volume 1, the building demolition, section 02070, this kind of area is provided at the NDHS.

Other prerequisites were either not met or documentation was unavailable to researchers at the time of the study to make a determination. Although the prerequisites were not met, the researchers determined to complete the LEED assessment process with the NDHS to determine how far the school district buildings may be from LEED compliance and to identify possible cost effective measures of improving buildings. In the following section, a detailed breakdown of the LEED score card is provided along with the points earned by the NDHS. Through this more detailed analysis, recommendations for cost effective improvements can be made.

The summary of the school points are shown in the following table:

Category	Available Credits	Earned Credits
SENSITIVE LAND PROTECTION	**1**	**1**
HIGH-PRIORITY SITE	**2**	**0**
SURROUNDING DENSITY AND DIVERSE USES	**5**	**0**
BICYCLE FACILITIES	**1**	**0**
REDUCED PARKING FOOTPRINT	**1**	**0**
SITE ASSESMENT	**1**	**0**
GREEN VEHICLES	**1**	**0**
OPEN SPACE	**1**	**0**
HEAT ISLAND REDUCTION	**2**	**1**
LIGHT POLLUUTION REDUCTION	**1**	**1**
SITE MASTER PLAN	**1**	**0**
JOINT USE OF FACILITIES	**1**	**1**

Category **OUTDOOR WATERUSE REDUCTION**	Available Credits	Earned Credits
50% Percentage Reduction From Baseline	1	-
100% Percentage Reduction From Baseline	2	-
Total credit	2	1

Category	Available Credits	Earned Credits
INDOOR WATER USE REDUCTION	**7**	**0**

Category **COOLING TOWER WATER USAGE**	Available Credits	Earned Credits
Maximum number of cycles achieved without exceeding any filtration levels or affecting operation of condenser water system (up to maximum of 10 cycles)	1	-
Achieve a minimum 10 cycles by increasing the level of treatment in condenser or make-up water OR Meet the minimum number of cycles to earn 1 point and use a minimum 20% recycled no potable water	2	-
Total Credits	2	1

Category	Available Credits	Earned Credits
RENEWABLE ENERGY PRODUCTION	**3**	**0**
ENHANCED REFRIGERANT MANAGEMENT	**1**	**1**

Category	Available Credits	Earned Credits
BUILDING LIFE-CYCLE IMPACT REDUCTION		
25% **of** completed project surface area reused	2	-
50% of completed project surface area reused	3	-
75% of completed project surface area reused	4	-
Total Credits	5	2

Category	Available Credits	Earned Credits
BUILDING PRODUCT DISCLOSURE AND OPTIMIZATION— ENVIRONMENTAL PRODUCT DECLARATIONS:	**2**	**0**
BUILDING PRODUCT DISCLOSURE AND OPTIMIZATION– SOURCING OF RAW MATERIALS	**2**	**1**
BUILDING PRODUCT DISCLOSURE AND OPTIMIZATION – MATERIAL INGREDIENTS	**2**	**1**

Category	Available Credits	Earned Credits
CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT	2	2
diversion of 50% of the total construction and demolition materials from at least three materials stream	1	-
diversion of 75% of the total construction and demolition materials from at least four materials stream	2	-
Total Credits	2	2

Category	Available Credits	Earned Credits
ENHANCED INDOOR AIR QUALITY STRATEGIES	**2**	**2**
LOW- EMITTING MATERIALS	**3**	**2**
CONSTRUCTION INDOOR AIR QUALITY MANAGEMENT PLAN	**1**	**1**
INDOOR AIR QUALITY ASSESMENT	**2**	**1**
THERMAL COMFORT	**1**	**1**
INTERIOR LIGHTING	**2**	**1**
DAYLIGHT	**3**	**0**
QUALITY VIEWS	**1**	**0**
INNOVATION	**5**	**0**
LEED ACCREDITED PROFESSIONAL	**1**	**1**
REGIONAL PRIORITY	**4**	**3**

As noted many of the LEED criteria could not be directly measured due to a lack documentation which effects the validity of this case study. Researchers assumed NDHS did not meet a given criterion when documentation was absent to provide a more conservative assessment. The criteria which could not be evaluated as a result of absent of information are stated as following:

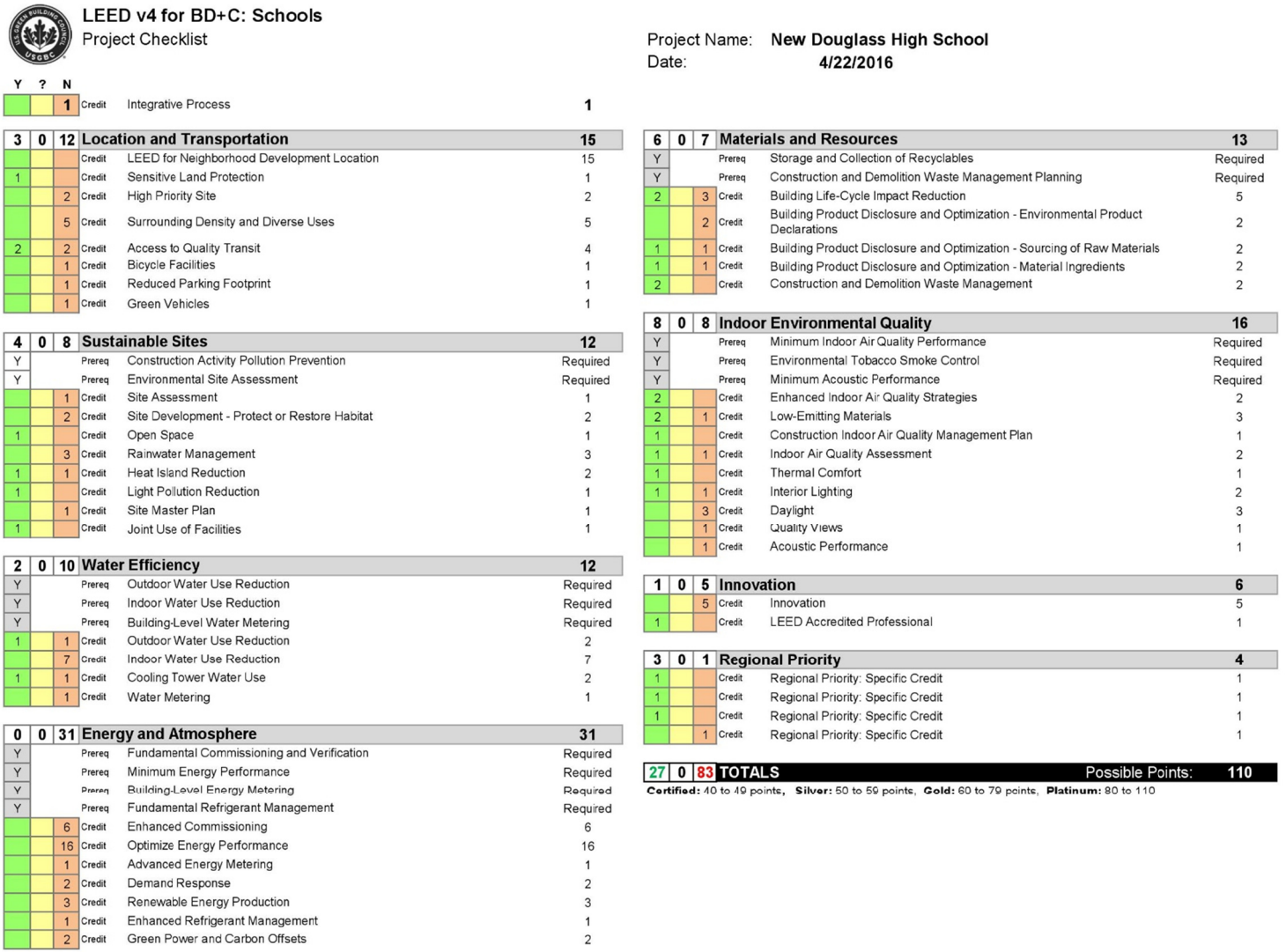
- **INTEGRATIVE PROCESS**
- **SITE DEVELOPMENT- PROTECT OR RESTORE HABITAT**
- **RAINWATER MANAGEMENT**
- **WATER METERING**
- **ENHANCED COMMISIONING**
- **OPTIMIZE ENERGY PERFORMANCE**
- **ADVANCED ENERGY METERING**
- **DEMAND RESPONSE**
- **GREEN POWER AND CARBON OFFSETS**
- **ACOUSTIC PERFORMANCE**

Conclusion

NDHS was built in 2006, two years before legislation made it mandatory to follow LEED (American Council for an Energy-Efficient Economy, 2015). As mentioned earlier, a project cannot be certified for LEED if all the prerequisite requirements are not met, even if all other criteria conform to the LEED guideline. Therefore, NDHS cannot be LEED certified until all the perquisites become applicable. While the minimum score for being certified in LEED is 40 points, the project, with a total score of 27, is not considered as a certified project. Although most of the LEED criteria need to be incorporated during the early stages of design, there are some fairly inexpensive modifications or additions that could be made that to create a healthier school environment.

1- By installing bike racks for the building and providing a shower room, more students and staffs would be encouraged in using bicycles, which promotes a healthy environment, and helps the project to gain one additional point in the LEED scoreboard.
2- By providing shade or putting cover under a minimum 75% of the parking spaces, not only the heat island would be reduced, but also the shade areas which face the sun can be used for other means, e.g. installing PV panels and harnessing the sun's energy. This feature can be used in both the "Heat Island Reduction" and "Renewable Energy Production" and can gain up to four points.
3- Use low flow fixtures to help reduce water consumption. Observing this small task can bring the project up to seven points in the LEED scoreboard.
4- Participate in Enhanced Commissioning and demand response programs to minimize energy and water consumption.

Different buildings have different priorities due to their functions; for example, daylighting and quality views in a warehouse are not as important as they are in a healthcare or a school project. As shown in the LEED summary of the NDHS (Fig 3), the "Indoor Environmental Quality" and "Material and Resources" are the two categories that have earned the highest points compared to other categories. Both of these subjects contain value, especially in a school building due to the interaction with the students.



LEED v4 for BD+C: Schools
Project Checklist

Project Name: **New Douglass High School**
Date: **4/22/2016**

Y	?	N			
		1	Credit	Integrative Process	1

3	0	12	**Location and Transportation**		**15**
			Credit	LEED for Neighborhood Development Location	15
1			Credit	Sensitive Land Protection	1
		2	Credit	High Priority Site	2
		5	Credit	Surrounding Density and Diverse Uses	5
2		2	Credit	Access to Quality Transit	4
		1	Credit	Bicycle Facilities	1
		1	Credit	Reduced Parking Footprint	1
		1	Credit	Green Vehicles	1

4	0	8	**Sustainable Sites**		**12**
Y			Prereq	Construction Activity Pollution Prevention	Required
Y			Prereq	Environmental Site Assessment	Required
		1	Credit	Site Assessment	1
		2	Credit	Site Development - Protect or Restore Habitat	2
1			Credit	Open Space	1
		3	Credit	Rainwater Management	3
1		1	Credit	Heat Island Reduction	2
1			Credit	Light Pollution Reduction	1
		1	Credit	Site Master Plan	1
1			Credit	Joint Use of Facilities	1

2	0	10	**Water Efficiency**		**12**
Y			Prereq	Outdoor Water Use Reduction	Required
Y			Prereq	Indoor Water Use Reduction	Required
Y			Prereq	Building-Level Water Metering	Required
1		1	Credit	Outdoor Water Use Reduction	2
		7	Credit	Indoor Water Use Reduction	7
1		1	Credit	Cooling Tower Water Use	2
		1	Credit	Water Metering	1

0	0	31	**Energy and Atmosphere**		**31**
Y			Prereq	Fundamental Commissioning and Verification	Required
Y			Prereq	Minimum Energy Performance	Required
Y			Prereq	Building-Level Energy Metering	Required
Y			Prereq	Fundamental Refrigerant Management	Required
		6	Credit	Enhanced Commissioning	6
		16	Credit	Optimize Energy Performance	16
		1	Credit	Advanced Energy Metering	1
		2	Credit	Demand Response	2
		3	Credit	Renewable Energy Production	3
		1	Credit	Enhanced Refrigerant Management	1
		2	Credit	Green Power and Carbon Offsets	2

6	0	7	**Materials and Resources**		**13**
Y			Prereq	Storage and Collection of Recyclables	Required
Y			Prereq	Construction and Demolition Waste Management Planning	Required
2		3	Credit	Building Life-Cycle Impact Reduction	5
		2	Credit	Building Product Disclosure and Optimization - Environmental Product Declarations	2
1		1	Credit	Building Product Disclosure and Optimization - Sourcing of Raw Materials	2
1		1	Credit	Building Product Disclosure and Optimization - Material Ingredients	2
2			Credit	Construction and Demolition Waste Management	2

8	0	8	**Indoor Environmental Quality**		**16**
Y			Prereq	Minimum Indoor Air Quality Performance	Required
Y			Prereq	Environmental Tobacco Smoke Control	Required
Y			Prereq	Minimum Acoustic Performance	Required
2			Credit	Enhanced Indoor Air Quality Strategies	2
2		1	Credit	Low-Emitting Materials	3
1			Credit	Construction Indoor Air Quality Management Plan	1
1		1	Credit	Indoor Air Quality Assessment	2
1			Credit	Thermal Comfort	1
1		1	Credit	Interior Lighting	2
		3	Credit	Daylight	3
		1	Credit	Quality Views	1
		1	Credit	Acoustic Performance	1

1	0	5	**Innovation**		**6**
		5	Credit	Innovation	5
1			Credit	LEED Accredited Professional	1

3	0	1	**Regional Priority**		**4**
1			Credit	Regional Priority: Specific Credit	1
1			Credit	Regional Priority: Specific Credit	1
1			Credit	Regional Priority: Specific Credit	1
		1	Credit	Regional Priority: Specific Credit	1

27	0	83	**TOTALS**	Possible Points:	**110**

Certified: 40 to 49 points, **Silver:** 50 to 59 points, **Gold:** 60 to 79 points, **Platinum:** 80 to 110

Fig 3: LEED Summary scoreboard for the NDHS

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