The Sustainable Substation

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1.0 INTRODUCTION

Safety, reliability, affordability, new regulations, or new technology…regardless of the topic, customers and investors expect their businesses to lead by example and be the best in class. Sustainability, the environmentally sensitive approach to long-term stewardship of limited resources, and the ability to be "green" in business practices, has been added to that list. Northeast Utilities Service Company (NUSCO) has partnered with Burns & McDonnell (BMcD) to explore the possibilities of integrating common sustainable design strategies into their standard substation plans as part of the response to the ever-increasing customer demand for sustainable environmental practices. The Connecticut Light & Power Company's (CL&P's) 115/13.8 -kV Sherwood Substation in Westport, Connecticut will be used as a pilot site. NUSCO and BMcD will evaluate various environmentally friendly or sustainable design strategies, and the viability of incorporating these designs into the design, for future substation projects.

This study focuses on five different sustainability components:

1. Stormwater Management
2. Material Strategies
3. Control Building Optimization
4. Plug-in Hybrid Electric Vehicle (PHEV) and Electric Vehicle (EV) Charging Station Implementation, and
5. Public Education and Awareness.

To optimize and evaluate the cost/benefit comparison, BMcD identified unique opportunities that are unique to the Sherwood Substation site within the framework of the five identified sustainability components:

- **Stormwater Management -** A typical substation has many requirements for stormwater management. Using a new innovative strategy, the Sherwood site's stormwater runoff impacts will be minimized.
- **Material Strategies -** There are many opportunities for responsible use of building materials at the site. Beyond optimizing the efficiency of the new construction materials, using salvageable materials from the demolition of the house currently existing on the proposed building footprint creates a recycling opportunity.
- **Control Enclosure Optimization -** There is a significant opportunity for energy savings by simple modifications to standard control enclosure specifications by using common sustainable building principals.

- **PHEV/EV Charging Station -** The proximity of the site to the commuter rail parking lot is very attractive. Strategically, the proximity to this lot allows for the convenient installation of future high-voltage, plug-in hybrid electric vehicle (PHEV) and electrical vehicle (EV) charging stations.
- **Public Education and Awareness -** The volume of people that will be exposed to the innovative strategies provides NUSCO with a great opportunity to educate and increase awareness among its customers about its environmental initiatives.

One of the leaders in the movement to promote sustainable building practices, the U.S. Green Building Council (USGBC), promotes sustainable building practices among the nation's owners, architects, engineers, and contractors. USGBC is best known for the development of the Leadership in Energy and Environmental Design (LEED) green building rating systems. The LEED manual is one of the most comprehensive guides to sustainable design, providing many ideas, strategies, and implementation techniques for the design of commercial and residential buildings. Several of these same concepts can be applied to substation design and easily integrated into the design process. One of the advantages BMcD has in identifying these types of opportunities is its experience within the sustainable design market. The strategies used in the Sustainable Substation Concept have been used successfully in other industries, but never implemented in this arena. Currently, LEED certification does not apply to unoccupied, industrial facilities like electric substations. NUSCO, in its effort to lead by example and meet the ever-changing expectations of customers, regulators, and investors, will evaluate the application of sustainable, LEED-like design parameters in future substations in their system.

2.0 STORMWATER MANAGEMENT

One key way to reduce the impact of any new development is to mitigate the impacts on the surrounding areas from stormwater released from the site. Stormwater regulations vary from state to state, but most require at least limiting stormwater volume and flow rates from the site to pre-existing conditions, in addition to requiring the removal of pollutants carried from the site with the runoff. The stormwater design requirements for the state of Connecticut in the 2004 Stormwater Quality Manual were used to develop the stormwater plans for the purpose of this study. The three main goals of the state requirements are:

1. reducing pollutants,
2. maintaining groundwater recharge, and
3. controlling peak runoff flow from a potential site.

Stormwater mitigation at a site can be achieved through a variety of both structural and low impact design (LID) and best management practices (BMPs) explained in detail in the 2004 Stormwater Quality Manual. The type of BMP to be used at each site is dependent on the site location, the land area available for development, the existing drainage patterns, and the soil type at the site, among other determining factors.

The existing site for the proposed development of the Sherwood Substation was occupied by a residential house, has a wetland on the lot's west side, and is covered with trees in the remaining areas. The site is constrained to the north by a commuter rail line and to the south and east by local roadways. In general, the natural drainage of the property runs from east to west, toward the existing wetlands.

2.1 TRADITIONAL DESIGN

Stormwater management is an integral part of the design and development of new substations due to increasing governing regulations. The transition of a site from a wooded area or meadow into an impervious or partially impervious development decreases the amount of water naturally absorbed by the ground. This causes increased runoff generated from the site and decreases the amount of water that naturally recharges the groundwater table. To mitigate these impacts, the typical design approach collects the stormwater in underdrains, inlets, or ditches, and is conveyed to a stormwater pond or basin where it is infiltrated or released through a regulated outlet structure.

The traditional design layout for the Sherwood Substation is shown in SK-001 in **Error! Reference source not found.**. The entire site within the substation fence, and a three-foot extension outside of the fence, is surfaced with crushed stone approximately 4 to 6 inches thick. The total area within the substation fence to be covered with stone is 0.56 acre. The site slopes to the west where the stormwater is collected in an infiltration basin west of the site. Placed outside of the substation fence line, the infiltration basin area encompasses approximately 2,500 square feet and is approximately 4 feet deep. A portion of the stormwater is infiltrated per the State of Connecticut Department of Environmental Protection (DEP) Stormwater Manual requirements. The remainder of the stormwater is then discharged to the wetland west of the developed substation and to the existing stormwater system east of the site.

2.2 SUSTAINABLE DESIGN

In the Sherwood Substation sustainable design, infiltration within the yard is utilized to facilitate runoff rate reduction, volume reduction, groundwater recharge, and pollutant removal, while minimizing construction disturbance area. To mitigate the effects of the development while also minimizing the area of disturbance, the sustainable substation design proposes using a new method of surfacing within the substation fence. A plastic grid system will be placed between 12 inches of #2 stone below and 6 inches of topsoil above utilizing UrbanGreen™ Grass, Gravel Pavers Grass, and Gravel Pavers. The installed cost for the pavers and installation of the pavers on site is approximately $2.50 per square foot.

Figure 2-1 Grass and Gravel Pavers Installation

Native low-growing warm-season and drought-tolerant grasses are proposed to be planted in the topsoil above the pavers for low-maintenance purposes. The vegetated drive space will require minimal maintenance; no watering will be required. Care will have to be taken during snow removal to ensure the plow does not hit the pavers which might result in pulling the pavers from the ground.

The use of the vegetated system will decrease the amount of graveled surface within the substation fence by 52 percent to 0.27 acre. The grid system is proposed to be utilized from five feet outside of the equipment to the fence line. To maintain standard surfacing and grounding procedures in areas where an operator has a potential to come in contact with equipment, the areas around the equipment will be surfaced with crushed rock. Crushed rock will also be placed around the exterior perimeter of the fence per standard design requirements to maintain standard touch potential protection levels. To account for high rains and potential for slow infiltration, perforated underdrains connected to agridrains at the low end of the substation will allow water to flow out. This prevents saturating the soil layer or the substation pad that would otherwise lead to potential rutting within the substation fence.

In addition to capturing runoff and infiltration, Grass and Gravel Pavers provide the following benefits beyond traditional stormwater design:

- Maximize green space while providing a stable working platform and driving surface;
- Minimize disturbance area compared to traditional design; and
- Lower heat island effect.

2.3 DESIGN RESULTS

The site was analyzed for the 2, 10, 25, and 100-year 24-hour storms. The results of both the traditional and sustainable models are shown in Table 2-1 below.

Table 2-1 Stormwater Flow Summary

Storm Event (recurrence years)	Pre-Construction (cfs)	Post Construction		Sustainable Design % Change from Existing Conditions
		Traditional Design (cfs)	Sustainable Design (cfs)	
2	1.68	0.62	0.62	36.90%
10	3.65	1.39	1.36	37.26%
25	4.52	2.61	1.74	38.94%
100	6.45	6.27	4.06	62.95%

The sustainable design meets or exceeds the performance of the traditional detention basin design while minimizing the area of disturbance. This benefit allows more of the purchased land to be developed as less area is needed to manage stormwater. It also presents the possibility of purchasing smaller plots of land for substations. Both of these scenarios offer cost savings. In addition to potential cost savings, the sustainable substation provides a design meeting or exceeding all permitting requirements, while providing a positive impact to the environment and surrounding landowners.

3.0 MATERIAL STRATEGIES

According to the LEED Manual, the total waste stream in the United States is comprised of almost 40% construction and demolition wastes. Even a relatively small construction project presents ample opportunities to utilize sustainable materials and practice waste reduction. The waste stream for the Sherwood Substation construction can be greatly reduced via the implementation of a construction waste management plan. To optimize efficiency and effectiveness, it is imperative to develop this plan in conjunction with the recycler/waste hauler for the project. Additionally, the use of recycled, salvaged, or sustainable products further decreases the overall waste stream associated with the project. Contractors, vendors, and suppliers should not only be selected solely upon cost and product, but also by the sustainable practices employed throughout their business. With green and sustainable building practices beginning to transition from small market niches to industry-wide standards, like-minded suppliers are also evolving their business practices. This is creating a market where more competitively priced products are readily found. To successfully execute a change in the way materials are used, all parties involved must be jointly aware and involved in the scope, schedule, and overall project process. Failing to capitalize on this opportunity for coordination and synergy decreases the potential level of sustainability of the end product.

3.1 CONSTRUCTION WASTE MANAGEMENT PLAN

The goal of a construction waste management plan is to divert construction and demolition debris from disposal in landfills and incineration facilities, thereby creating opportunities to recycle and salvage materials for future use. The two main focuses of this plan are reduction of source materials and demolition waste.

3.1.1 Source Reduction

Source reduction of waste is the largest factor in reducing the total waste stream. One simple way of addressing this issue is working with vendors and suppliers to reduce the amount of packaging and to practice shop fabrication where possible. In many cases it is possible to reuse packaging material on larger substation equipment. The use of modular construction is also a means of source reduction, a strategy exemplified by the control house. See Section 4.0 for more details on the control house.

3.1.2 Demolition Waste Plan

At the Sherwood Substation site, several opportunities exist to minimize the impact of demolition waste, including the materials from the existing residential structure, pavement, trees, and shrubs. A thorough assessment of the existing house on the site reveals which materials can be recycled or reused after the demolition process. Easily recycled/reusable materials can include metal, concrete, wood, gypsum wallboard, crushed asphalt, masonry, and cardboard among others. Local demolition contractors with experience in recycling and salvaging materials are able to outline a plan for this methodical process to maximize the amount of waste diverted. The contractor is then able to present the owner with a tonnage and percentage of recycled material and waste diverted. Not only are benefits seen by diverting waste from landfills and incinerators, but also certain recyclables, such as metals, can provide an economic payback to the project. With a site filled with trees and shrubs, there is a fair amount of land clearing debris that can be chipped and utilized in erosion control, specifically in construction staging areas and entrances to the site. Taking advantage of these opportunities will make the best use of the necessary demolition at the Sherwood site.

3.2 SUSTAINABLE MATERIALS AND VENDORS

Certain materials used on this project are already established as products with high recycled content, including steel. Others materials, including concrete, are not as common, with relatively high amounts of recycled content, but still available. By finding products containing recycled content (and the vendors supplying them), the amount of virgin materials used on the project is reduced and the recycled material market is additionally promoted.

3.2.1 Recycled Content

Identified below are products and the associated opportunities by using them within the site (excluding the modular control house in Section 4.0).

3.2.1.1 Retaining Walls

More manufacturers are ensuring their wall blocks are made from a considerable amount of recycled concrete, and utilize recycled fly ash in the new blocks. Retaining walls help with erosion and runoff into the nearby waterway leading directly into the ocean.

3.2.1.2 Concrete

Many concrete suppliers have successfully utilized recycled concrete and fly ash and maintained a high level of quality. Per NUSCO standard SUB 12, fly ash is not allowed in structural concrete, but it may be acceptable to use it in non-structural concrete (i.e. duct banks) in limited percentages while complying with ASTM C311 and ACI 318-08 Building Code. The quantity and application would have to be evaluated on a case-by-case basis. Fly ash will reduce the carbon footprint of the project by replacing portions of the Portland Cement, and thus eliminating some of the greenhouse gases produced via its manufacturing process. The use of higher quantities of fly ash will also be an economical benefit; fly ash is generally cheaper than the Portland cement it replaces.

3.2.1.3 Steel

Steel is typically made from high recycled content. Due to its readiness, any steel product used on this project should contain a high recycled-content percentage. Nucor Corporation, the nation's largest recycler, provided recycled percentages of bar and beam products at 99.9% and 82.9% as seen in Figure 1 in **Error! Reference source not found.**.

3.2.1.4 Wood

It is unlikely that any wood will be permanently installed on this project, but there may be opportunities to reuse wood for concrete forms. Alternatively, contractors may utilize reusable metal forms.

3.2.1.5 Rock Aggregate

Several opportunities exist to use reclaimed crushed concrete on this project:

- as a sub base for foundation and roads,
- for temporary erosion control,
- for slope stabilization, and
- for the substation pad itself.

The percentage of recycled content within each opportunity varies depending on Connecticut Department of Transportation (CDOT) specifications and NUSCO standards. Further research of each opportunity may be necessary to determine which opportunities will be beneficial to the project.

3.2.2 Regional Materials and Local Suppliers

According to the LEED Manual, vendors and suppliers should be located within a 500-mile radius of the project, where possible. The benefits of this requirement are twofold:

- Cutting down on transportation costs reduces the carbon footprint of the project.
- Using local suppliers supports the local economy.

The concept is taken a step further by identifying vendors and suppliers who extract and manufacture their raw materials within that 500-mile radius as well. A 100-mile radius is preferred for heavier materials such as steel and aggregate. If executed properly, then the potential tangible and intangible benefits of using regional materials and local suppliers are realized in Sherwood Substation.

4.0 CONTROL & SWITCHGEAR ENCLOSURES OPTIMIZATION

Sustainable Design is commonly implemented in commercial and residential buildings. Although the Control of the Sherwood Substation is not for commercial or residential use, it does allow for common sustainable building strategies to be used to optimize its efficiency. The Control Enclosure, HVAC, lighting, and auxiliary power were analyzed for efficiency improvements. These improvements were compared to the minimum allowed in the ASHRAE Standard 90.1-2007 Energy Standards. This standard was selected because it is the energy compliance benchmark for LEED 3.0.

The State of Connecticut has a separate, less restrictive Energy Code than Standard 90.1-2007 Energy Standards. International Code Council (ICC)-2006 International Energy Conservation Code (IECC) is based on ASHRAE Standard 90.1-2004. The enclosure envelope is in voluntary compliance with the minimum requirement of the State of Connecticut Energy Code. Because the purpose of this evaluation is to discuss sustainable solutions, it will not refer to the State's Energy Code. References to the Energy Code shall imply compliance with ASHRAE Standard 90.1-2007.

The comparison of optimized envelope and equipment to Energy Code minimum was limited to annual energy consumption. The auxiliary power of the control enclosure would offset the annual energy consumption of the enclosure. The analysis assumes solar power will be converted to AC; however, it may be possible to use solar panels to maintain the bank of battery chargers.

4.1 BUILDING ENVELOPE

The building envelope in the current specification does not comply with envelope performance requirements of the Energy Code. The current specification has been revised to comply with the minimum roof, wall, and floor insulation requirements and is located in **Error! Reference source not found.**.

By providing more insulation in the roof, walls, and floor, and providing thermal breaks, the envelope performance is improved beyond the minimum levels outlined in the Energy Code. Increasing the insulation does not have a significant impact on equipment capacity and annual energy consumption. The peak cooling load due to the enclosure is only 6,900 BTUH, slightly more than a half of a ton cooling. The peak heating load due to the enclosure is only 15,000 BTUH.

If the envelope performance were improved to reduce the envelope heating and cooling load by half, it will reduce the heating and cooling equipment capacity only to the next smaller size. This will result in a small capital savings due to the smaller capacity equipment. Table 4-1 compares the minimum code requirements to the values required to reduce peak heating and cooling loads by 50%.

Table 4-1 Insulation Requirements

Building Envelope Element	Minimum Envelope Requirements		Reduce Envelope Loads to Half	
ROOF	U=0.065	R-19 [1]	U=0.031	+ R-16.8 c.i. [4]
WALL	U=0.113	R-13 [2]	U=0.500	+ R11.2 c.i. [5]
FLOOR	U=0.064	R-30 [3]	No change	No change

[1] 6 inches of fiberglass batt insulation
[2] 3-1/2 inches of fiberglass batt insulation
[3] 8 inches of expanded polystyrene molded beads
[4] 6 inches of fiberglass batt insulation plus 5 inches of expanded polystyrene molded beads
[5] 3-1/2 inches of fiberglass batt insulation plus 3 inches of expanded polystyrene molded beads

Control Enclosure suppliers, PowerCon Corporation and Trachte, were contacted regarding this opportunity, but the revisions to the enclosure that would reduce the envelope load by 50% are currently not an available. However, they are considering increased insulation as a future option. BMcD's recommendation to the suppliers is to comply with the required allowed enclosure insulation. NUSCO will realize little benefit to improving the enclosure performance beyond that required by the Energy Code.

4.2 HEATING, VENTILATION, AND AIR CONDITIONING (HVAC) SYSTEMS

In the control enclosure, the peak heating and cooling loads are small. Heating loads are 15,000 BTUH and cooling loads are 29,100 BTUH. The minimum required efficiency rating for the standard wall-pack units is 3.0 Coefficient of Performance (COP) for heating, and 9.0 Energy Efficiency Ratio (EER) for cooling. Bard Manufacturing Company's equipment has been specified and their equipment exceeds the minimum requirements as follows: 3.2 COP heating and 10.5 EER.

The improved efficiency reduces the annual energy consumption for heating and cooling by 2,400 kWh or 20.7%. Assuming $0.1105 per kWh at the time of the study, an annual savings of $265 is realized compared to the Energy Code minimum. A comparison was also done between the energy consumption of the Bard equipment and a geothermal water source heat pump system. The geothermal system reduced the annual energy consumption by 4,700 kWh or 40.9%. A price of $0.1105 per kWh, would realize an annual savings of $519 compared to the Energy Code minimum.

When comparing the overall energy consumption of the building using the minimum allowed HVAC equipment efficiency to a highly efficient geothermal system, the overall savings are not as large (only a

5.2% reduction) due to energy consumption by the control equipment. The process loads are the dominant energy consumer, making the relatively large envelope heating and cooling savings small in comparison.

Bard does have newer, more efficient equipment in development. The updated equipment will utilize variable speed compressors that will match the capacity to the load by varying compressor speeds. Any reduction of compressor speed will reduce energy consumption. The energy consumed by a pump is related to the power required over time. A variable speed compressor can reduce the energy consumed by operating at lower speeds. If the compressor can operate at 50% speed instead of 100% speed, then the power required would be around one-eighth of the power required at 100%. The Bard equipment efficiency was compared to other manufacturers' efficiencies and Bard's equipment proved significantly better than the competition.

BMcD's recommendation is to continue specifying the Bard equipment and upgrade to the higher efficiency Bard equipment as it becomes available and is adequately tested.

4.3 LIGHTING SYSTEM

The lighting system in the Control Enclosure is very basic. A light simulation was performed for the enclosure. It determined that eight fixtures in a 3×2×3 arrangement comply with the 50-footcandle requirement at 30 inches above finished floor. Energy Code allows for 1.5 watts per square foot in this type of enclosure. Using the lighting simulation program, a 33% reduction, or 1.0 watt/square foot, in energy use was achieved by use of high-efficiency 28 watt T8 or 49 watt T5HO lamps. The possibility of utilizing LED lamps was investigated, but an LED option in a 4-foot industrial strip was unavailable.

4.4 AUXILIARY POWER – PHOTOVOLTAIC PANELS

Electric power from photovoltaic (PV) panels can be utilized by converting energy from the sun to alternating current, and power the enclosure equipment and the station service auxiliary load. The PV panel was assumed to be installed on one side of the sloped roof. This limited the available area of PV panels to approximately 290 square feet. Using an automated solar electric estimate tool (solar-estimate.org), approximately 25% of the annual energy consumption could be offset. The payback on the PV panels is estimated to be approximately 17 years, based on lifecycle cost.

5.0 PLUG-IN HYBRID ELECTRIC VEHICLE INTEGRATION

Electric Vehicles are looked upon by some as of the future car market. In addition to meeting increasingly stringent fuel efficiency mandates, auto manufacturers are evolving their businesses to meet consumer demands for more environmentally friendly products. Many major car manufacturers have some variation of an Electric Vehicle (EV) or Plug-In Hybrid Electric Vehicle (PHEV) model in their line for 2011 with even more coming in 2012/13. The typical EV or PHEV owner charges their vehicle at home in their garage at night. One of the problems with that model is not all customers have the opportunity to charge at home and will require public charging stations around their local community. By integrating charging stations into their public infrastructure, NUSCO can gain the benefit of positive environmental branding and the opportunity to directly communicate with customers about its commitment to sustainability in the community.

When located near population centers like residential buildings or office complexes, substations can be positioned in strategic locations to support large numbers of public charging stations without the added cost of improvements to existing power infrastructure. Sherwood Substation is located adjacent to a commuter parking lot for the local rail line. This convenient location, paired with the fact that Connecticut is a pilot community for EVs such as the all-electric Nissan Leaf, makes the timing perfect for NUSCO to integrate public charging infrastructure into the Sherwood Substation. As the technology and development process progresses, many convenient situations such as this could create opportunities for integration between substations and public EV charging systems.

5.1 CHARGING EQUIPMENT

There are several manufacturers that provide EV and PHEV charging equipment from proven manufacturers on the market today. While several different levels exist within the entirety of charging station models, two main levels are used for public charging application. The two levels of charging stations currently in use are:

- AC Level 2 Charging Stations – This unit is ideal when the user has the time to leave the car connected to the charger unattended. Ideally, this would be for commuters to charge their vehicles while they are at work during the day.

- DC Fast Charging Stations – This unit is more comparable to a standard gasoline pump. The unit can support faster charging, giving the user a substantial charge in a matter of minutes, depending on conditions. The target user of this unit would be one who can take a few minutes in the evening to receive sufficient charge to complete their commute home.

5.2 REQUIRED SUBSTATION MODIFICATIONS

For charging stations on the market today, little modification is needed. Ten charging stations are typically placed in commuter lots similar to the size of the one adjacent to Sherwood. As the use of electric vehicles increase, the number of stations per commuter lot can increase. The station load for 10 Level II charging stations is 72 kW. The small amount of load does not affect the overall design and capacity of the substation.

Multiple ways exist to connect the charging stations in the commuter lot back to the substation. One option is to connect the load to a service off one of the distribution circuits. This is treated as any other customer load and service. Another option is to connect the charging stations directly to the substation through the station service. For this site, this option is not feasible due to the parking lot located on the other side of the existing rail. Connecting the chargers to the substation station service would require a crossing under the railroad.

6.0 PUBLIC EDUCATION AND AWARENESS

One aspect in the concept of sustainable building is educating the public about the technology and progress made in the area. Being the Sherwood Substation is near a school and directly across from public commuter parking lots, this could offer great opportunities to display the features of the Sherwood Substation. Substations are often viewed as eyesores in communities, often overshadowing their necessity. Providing information about the Sherwood Substation can make the public more aware about the sustainable building practices employed within the substation.

6.1 DISPLAY BOARDS

There are three commuter parking lots adjacent to the substation that will provide opportunity for great visibility for the project. Large boards with simple messages and web links to the project's website will draw attention to the project and direct the commuters to find more information. In an age where one has to look no further than their smart phone for information, a waiting commuter will provide a perfect audience.

6.2 LOCAL SCHOOL PARTNERSHIP

In the nationwide public education debate, there is a push to reemphasize mathematics and sciences involving young adults at an earlier age, and encourage them to dig deeper and grow an interest in technical subjects. The current generations of young people genuinely take an interest in sustainable building and green power. With neighboring Green Farms Academy less than a quarter mile away, a great opportunity exists to further that interest. Projects such as the Sherwood Sustainable Substation are the types of engineering projects kids can get exposed to at a young age to motivate their exploration of the sciences. Showcasing this substation allows NUSCO to provide an example of innovative sustainable building applications on an inconspicuous site within walking distance of the school. Topics to cover include, but not limited to:

- The purpose of substations
- General substation concepts
- The layout and equipment in the substation
- Sustainable building practices utilized on site, and
- Renewable energy projects.

Showcasing the Sherwood Substation will allow NUSCO to provide firsthand examples of sustainable building applications within a very short distance of the school.

7.0 CONCLUSION

This study focused on five different opportunities to improve the sustainability of substation design:

7.1 STORMWATER MANAGEMENT

A new stormwater design allows for 100% of the stormwater to be collected on site. The benefits of the performance of this new design concept, while maintaining the safety and functionality of the traditional site, are both tangible and intangible. This design concept creates a direct savings by eliminating the need for excessive land acquisition traditionally used to retain the stormwater runoff from the substation site. Additionally, the new site acts as a working advertisement with respect to its improved aesthetic appearance.

7.2 MATERIAL STRATEGIES

The material strategy substantially reduces the carbon footprint of the substation site. It responsibly takes care of pre-existing conditions on the site. For example, an existing house that would otherwise be sent straight to a landfill is recycled and reused. Optimizing the recycled content of the necessary materials on the site reduces the need for additional raw building materials to be manufactured, as does cutting down on the construction packaging material. Finally, utilizing local suppliers within a defined distance decreases carbon emissions required by transportation operations.

7.3 CONTROL ENCLOSURE OPTIMIZATION

A closer look at the design of the control enclosure identifies savings in several areas. A better designed building envelope decreases energy output by excessive HVAC units. The increased envelope insulation creates a cost savings by allowing for purchase of smaller HVAC units. Energy typically wasted in lighting the enclosure is saved with an optimized lighting design and use of LED lamps. Exploring the possibility of supplementing energy usage with the use of roof-top photovoltaic panels creates decreased levels of energy usage while providing an additional working advertisement to complement the stormwater design.

7.4 ELECTRIC VEHICLE CHARGING STATIONS

By integrating public electric vehicle charging stations, NUSCO will enable growth of the emerging EV industry by integrating public EV infrastructure into its substation planning and design. This new integration can potentially reduce the carbon footprint of the entire transportation sector.

7.5 PUBLIC EDUCATION AND AWARENESS

One of the many benefits that the Sherwood Substation offers is the opportunity for public education and awareness. In addition to the working advertisements the new systems create, providing promotional material and interacting with the surrounding community helps NUSCO develop their brand as a forward-thinking company taking initiative in environmental responsibility.

Customers and shareholders alike are demanding environmental responsibility from the corporate world in which they live. As the owner of New England's largest energy delivery system, NUSCO knows that it has a great responsibility in managing the thousands of acres of property which it owns. In addition to the environmentally conscious practices that NUSCO already follows, The Sustainable Substation concept is another way to meet the demand of its customers and investors to integrate sustainability into everyday business practices.

APPENDIX A GLOSSARY

2006 International Energy Conservation Code (IECC) – Sets forth compliance methods for energy-efficient construction for both residential and nonresidential construction.

ASHRAE Standard 90.1-2007 – American Society of Heating, Refrigeration, and Air-Conditioning Engineers' design standard to establish minimum energy efficiency requirements of buildings, other than low rise residential buildings, for design, construction, and operations.

Building Envelope – The separation between the interior and the exterior environments of a building. It serves as the outer shell to protect the indoor environment as well as to facilitate its climate control.

Btuh – British Thermal Unit (BTU)/Hour

Carbon Footprint – The total amount of greenhouse gases produced to directly and indirectly support human activities, usually expressed in equivalent tons of carbon dioxide (CO2e).

Construction Waste Management Plan – A plan that diverts construction debris from landfills through planning to recycle, salvage, and beneficial reuse.

Coefficient of Performance (COP) – Ratio of work or useful output to the amount of work or energy input, used generally as a measure of the energy-efficiency of air conditioners, space heaters and other cooling and heating devices.

Energy Efficiency Rating (EER) – A rating system for appliances such as air conditioners that indicates how much heat is removed per hour for each watt of energy used. Heat is measured in British thermal units (Btu) and the rating is expressed in Btu per hour per watt.

Electric Vehicle (EV) – A vehicle that uses one or more electric motors for propulsion

Foot-candle – A measure of illuminance (or light intensity) on a surface equal to one lumen per square foot.

Green Farms Academy – Independent co-educational college preparatory day school for grades K-12 located in Green Farms, CT near the Sherwood Substation location.

Heat Island Effect – A phenomenon that occurs in developed areas where the replacement of natural land cover with paving, buildings, roads, parking lots, and other structures result in an increase in outdoor temperatures.

HVAC – (Heating, Ventilating, and Air Conditioning) refers to technology of indoor or automotive environmental comfort.

Leadership in Energy and Environmental Design (LEED) – Established by the US Green Building Council, a set of building standards aimed to improve energy efficiency, and environmental aspects and sustainability of the built environment. This process establishes building credits and leads to a certification for the project.

LEED Certification – The LEED process has been followed and achieved in the building process.

LEED Manual – Identifies the program requirements and policies put in place by GBCI for the purposes of administering the LEED certification program.

Level I Charging Station – A charging station for electric vehicles using 120-volt, single phase outlet charging a vehicle in 8-14 hours. Level I is the slowest charger available.

Level II Charging Station – A charging station for electric vehicles charging a vehicle in 4-8 hours. Level II is a mid-level charger.

Level III Charging Station – A charging station for electric vehicles requiring higher levels of voltage and current, potentially charging a vehicle in as little as 15 minutes.

Low Impact Design (LID) – A development that has less impact on the environment than a traditional development.

Pilot Community – An experimental program designed to test administrative and operational procedures within a certain area to collect information on service demands and costs that will serve as a basis for operating programs efficiently.

Public Charging Stations – Supplies electricity for the recharging of electric vehicles that is open to the general public.

Sustainable Design – Design which reduces the possible negative effects on the environment as far as possible and makes the most of social and economic benefits.

U.S. Green Building Council (USGBC) – A non-profit trade organization that promotes sustainability in how buildings are designed, built, and operated.

T5HO Lamps – A high output four-foot fluorescent lamp that gives off roughly twice the light output as T8 lamps reducing the amount of lights to be used and the amount of mercury used in the production of the lamps.

T8 Lamps – Fluorescent lamps with a tube diameter of 26 mm.

Waste Stream – The total flow of solid waste from homes, businesses, institutions, and manufacturing plants that are recycled, burned, or disposed of in landfills.