A New Norris House:
An Analysis of Achieving LEED For Homes Platinum and Beyond

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ABSTRACT: A New Norris House is an award-winning, university-led Design|Build|Evaluate project located in Norris, Tennessee. A LEED for Homes Platinum project, the New Norris House pursues high performance building through both traditional and innovative means. This paper focuses on the completed project as a case study for sustainable building certification. Using records from the design|build process, an analysis of the LEED for Homes Platinum certification is presented to quantify the resources (time and costs) necessary to achieve this result over baseline standards of the typical US home. Currently, the project is in a demonstration and evaluation phase. Quantitative assessments are collected through digital sensors installed in the home and landscape, and reflect the occupancy patterns and qualitative experiences of two live-in subjects. Finally, the paper presents analysis of the preliminary performance and occupancy data in order to speculate on the additional resources that full Living Status as part of the Living Building Challenge would have required.
Keywords: Certifications; Residential; LEED; Living Building Challenge; Post-occupancy Evaluation; Case Study

INTRODUCTION

In 1933, by the passing of the TVA Act, the United States Congress created the Tennessee Valley Authority—the nation's first federally operated utility. Tasked with the goal of bringing the impoverished region out of the depression, the agency would address "a wide range of environmental, economic, and technological issues, including the delivery of low-cost electricity and the management of natural resources". [1] Shortly after its formation, the TVA began the Norris Waterworks Project. As part of the dam construction effort, the TVA also created a small model community to serve as worker housing. Built entirely anew, the town of Norris was designed around the principles of the Garden City movement and was envisioned as a self-sustaining utopian community.

A key feature of this New Deal Village was the Norris House, a series of homes built for modern, efficient, and sustainable living. Employing a large team of designers, engineers, and both skilled and unskilled laborers, the TVA experimented with new types of materials and delivery methods. [2] New technologies and prefabricated elements were quietly integrated into aesthetically pleasing, vernacularly-inspired homes, allowing residents to immediately identify with the new structures. However, despite their familiar aesthetic, the introduction of electricity and indoor plumbing revolutionized the way residents of the Tennessee Valley would dwell. The TVA's interest in exploring new building technologies, including prefabricated housing, would continue for many years, though the town of Norris and its iconic Norris Houses would stand as their most complete effort. [3]

In 2008, a University of Tennessee team, led by the School of Architecture and Department of Planning set out to reinterpret the Norris paradigm and to reconsider the shape of landscapes, communities and homes today. The design consists of an infill lot and a single-family dwelling that is modular, prototypical, and resource efficient. A LEED for Homes Platinum project, the New Norris House (NNH) pursues high performance building through both traditional and innovative means. Inspired by the TVA's organization, the project was delivered by a multidisciplinary team integrated across professional, academic, and industry lines. The home conforms to the local, vernacular form yet sharpens it with crisp, contemporary details. Complimentary performance and design intentions also inform the site and landscape, and a monitoring, residency and demonstration program is extending lessons learned from the old and the new Norris houses. This paper focuses on the completed project as a case study for sustainable building certification. By using detailed records from the design|build process, an analysis of the LEED for Homes Platinum certification is presented to quantify the resources (time and costs) necessary to achieve this result over baseline standards of the typical US home. Using performance results of the design and environmental strategies employed, similar analysis to predict additional resources necessary to achieve full Living Status as part of the Living Building Challenge is presented.

LEED FOR HOMES

The New Norris House earned LEED for Homes (LEED-H) Platinum certification from the United States Green Building Council (USGBC), the highest level of certification awarded by the USGBC for this project type. These efforts were undertaken by an integrated academic and professional team that sought high environmental standards from the project's inception.. Measures to achieve this end were aggressively pursued throughout all stages of project design and delivery and the team went to great lengths to explore each credit in the academic and research setting (often beyond the requirements of the certification program). To this end, the NNH earned a total of 106 points—exceeding the adjusted threshold for Platinum certification (80 points) by 33% (Table 1).

Table 1: LEED for Homes credits achieved at the NNH.

Category (LEED-H)	Points
Innovation and Design	09 / 11
Location and Linkages	10 / 10
Sustainable Sites	16 / 22
Water Efficiency	13 / 15
Energy and Atmosphere	27 / 38
Materials and Resources	14 / 16
Indoor Environmental Quality	15 / 21
Awareness and Education	02 / 03

Comparison Home

A typical US home with no explicit consideration for environmental sustainability serves as a basis for comparison, and is henceforth referred to as the "comparison home". For purposes of this study, the comparison home is treated as a custom home located at the NNH site. The comparison home is derived through revisions to the NNH energy model (using REM/Design) in order to create an alternate version of the home with a home energy rating score (HERS) of 100—the standard recognized by the Residential Energy Service Network (RESNET) as representative of a typical new home in the US. Other factors (such as materials choices, landscape efforts, and those not directly related to energy performance) were also altered based on reasonable assumptions. Considerations of the analysis include differences in design cost, speciality labor costs, and general labor costs (calculated using rates of $75/hour, $75/hour, and $25/hour, respectively). Differences in material costs directly related to achieving LEED-H Platinum between the two homes are also reflected, using exact pricing from the completed NNH project and gathered cost estimates from local suppliers to form a comparison. Credits not pursed by the NNH project were not investigated in this study.

Analysis and Initial Conclusions

Analysis of the comparison between the baseline comparison home and the NNH indicates that an additional $45,216 was necessary to achieve the environmental goals of the NNH. (See figure 4 - full spreadsheet at conclusion.) Analysis to date attributes most of the additional input required during design and construction to meet the LEED-H Platinum threshold to increased material costs.. Comparison of the NNH project costs (including labor, materials, overhead, etc.) and that of the comparison home confirmed this, requiring 52% (or $23,678) of the total additional investment for increased material costs alone. Speciality labor for the installation of advanced systems (rainwater, solar, HVAC, etc) required 17% ($7,575), and additional design fees (including product research) required a 26% portion ($11,850). General labor accounted for the lowest allocation, necessitating only 5% of the additional costs ($2,113). (Figure 1)

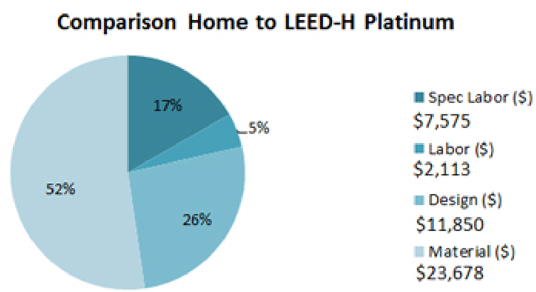

Figure 1: Allocation of cost to achieve LEED-H Platinum.

A two-year post occupancy evaluation program began in August of 2011. Over this period, the house consumed an average of 6,606 kWh (22.6 MMBTU) per year. The 2009 EIA Residential Energy Consumption Survey has calculated the average annual consumption for Tennessee homes at 22,059 kWh (78.7 MMBTU)—a reduction of energy consumption at the NNH project of 16,421 kWh (56,051 MMBTU) [4]. This is a cost savings of $1,533 per year (at $0.093/kWh), which generates a 29.049 year payback period on a $45,216 investment to reach LEED for Homes Platinum. This figure does not reflect benefits resulting from other "green" efforts that do not contribute directly to the reduction of energy consumption. For example, "green" strategies employed at the NNH to improve indoor air quality, lower embodied energy, conserve water, and enhance habitat, flora and fauna.

Assumptions and Methodologies

In the process of designing and building the New Norris House, the project team not only attempted to reach LEED-H Platinum criteria, but to do so while fully integrating systems and sustainability efforts into the larger total design effort. This thoroughness of design, in addition to the academic nature of the project yields several assumptions pertinent to this analysis:

First, because much of the work (design and on-site labor) was completed by students, tasks often took longer to complete than could be reasonably assumed if completed by experienced trade or design professionals. For this analysis, effort was made to “normalize” design time and labor hours (to a degree). These figures are reasoned estimates generated from the direct experience of working within these capacities while the project was underway.

Secondly, while cost was a major concern (as a research parameter and consequence of limited funding), the project team was often directed to investigate systems, techniques, and components that did not necessarily carry the lowest financial costs. In the design and specification process, these decisions were always weighed against the larger design intent (the creation of a responsive, contemporary home in the historic context of Norris, Tennessee), but sometimes yielded solutions that could have been achieved easier when viewed only through the controlled lens of LEED-H requirements. Solutions incorporated in the NNH are thus presented, but it can be reasonably assumed that many measures could be completed more cost effectively.

Finally, the modular nature of a large portion of the project’s delivery was difficult to quantify. It is assumed in this study that based on the one-off and research nature of the partnership with the modular builder that the cost comparison is nullified. Modular construction increased efficiencies of materials and labor, but added high extra costs related to delivery and alternate critical path flows to on-site labor.

LIVING BUILDING CHALLENGE

Though the project began in the fall of 2008 and has always set an aggressive environmental agenda, it was not until garnering support from the US Environmental Protect Agency’s (EPA) P3 Award program in the spring of 2009 that the project team began to specifically pursue and layout a track to LEED for Homes Platinum certification. Funding of the project was an ongoing effort and to a degree the thoroughness of the project (sustainability efforts included) was bolstered along the way as additional support was secured (primarily in the landscape). That said and as described in the previous section, given the resources available to the project team, the NNH easily achieved LEED for Homes Platinum certification upon completion. Post occupancy evaluation has shown energy and water reduction in the home and landscape on par with projected models. Energy use intensity observed at 22.5kBTU/sf is a 50.5% reduction from the national average. (Based on 1971SF average home size and 89.6 MMBTU/year per household.) [5] The home reuses 73% of all waste water on-site, and has reduced potable water use by 61.6%. (Based on 12.6 gallons/capita/day use of toilet (8.2gal) and kitchen faucet (5.4gal); Typical US home uses 69.3 gallons/capita/day for indoor use.) [6] While these numbers are impressive, they represent a gap that is often hard for designers and clients alike to bridge between resource reduction and complete independence (design challenges for architects and the justification of additional costs, lifecycles, and future ownership for potential clients). Furthermore, the Living Building Challenge considers significantly deeper connections between the built, biological, and ecological realms than quantifiable reductions in resource use. Nonetheless, this paper presents a method for quantitative assessment of the LBC program in comparison to the LEED program as a framework for evaluating the sustainability of the NNH project.

Analysis and Initial Conclusions

Analysis of modifications to the NNH necessary to achieve the Full Living Building Challenge Certification reveal that an additional investment of $29,056 is required. (See figure 5 - full spreadsheet at conclusion.) Of this investment, the overwhelming majority is generated by the addition of a 6kW photovoltaic installation and other costs related to materials (58% of total). Similar to the previous comparison (modifications to the baseline comparison home to reach LEED-H Platinum), design related fees (including materials research) and speciality labor require similar investment increases - requiring 20% ($5,700) and 21% ($6,113), respectively. General labor required little to no extra investment ($275), due in part to cost savings related to devoting substantially more site area to agriculture (rather than costly and labor intensive native landscapes).

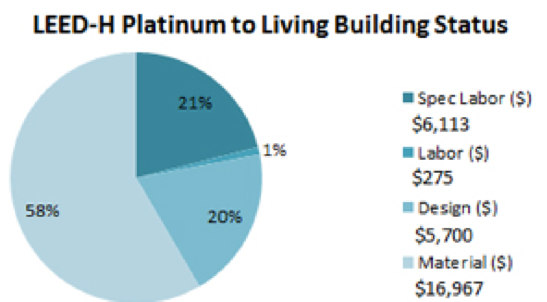

Figure 2: Allocation of cost to achieve Living Building Status.

Of particular note, however, are several significant design changes the NNH would be subject to, without which LBC certification would be impossible. First, the Floor Area Ratio (FAR) of the home to site does not currently fit into the appropriate transect zone (T-3, Village). The density of the site would need to be increased, and this would require adding 120 sf of floor area to the NNH. This could add considerable cost. However, a carefully considered design that enlarges area outside of the conditioned envelope and adds valuable storage and mechanical space to expand the rainwater system would be an improvement to the current design.

Second, the town of Norris includes an overabundance of residentially zoned properties (<70%) and low-density of commercial/light industrial properties by LBC criteria, making the existing site ineligible for the "04 - Car Free Living" imperative. Conformance to this LBC criteria would necessitate a complete change in site, and likely community. This is particularly interesting in light of the town of Norris' historical role as a model (even utopian), self-sustaining community as imagined in the 1930's. [7] Assessment through the lens of the LBC criteria, however, confirms indications that Norris has become largely a bedroom community for nearby Oak Ridge and Knoxville, Tennessee. According to the American Community Survey, commute times to work for residents of Norris (27.1 minutes) average 42% higher than those of Knoxville residents. This largely aligns with commuting patterns of NNH residents participating in the post occupancy evaluation program) [8, 9]. This criteria indicates a significant contradiction between LBC and NNH criteria. The NNH received "Outstanding Community Resources" credit (LL 5.3— 3 points) from the LEED-H program—earning full credit in the "Locations and Linkages" category. (See previously noted Table 1.)

A third potential conflict relates to water treatment on-site. There is currently a temporary exemption within the LBC "05 – Net Zero Water" imperative that allows municipal water supply where rain water is not permitted for consumption. No such exemption exists for LBC "06 – Ecological Water Flows" however. Current regulations in the project's municipality, Norris, do not permit the use of composting toilets or on-site anaerobic digestion—disqualifying the project from potential LBC certification. The NNH team acquired a temporary, experimental permit and permission to install a grey water infiltration system. This process required over 14 months and without the academic/research context this would not likely be an option for most homeowners or developers. Further, the treatment of blackwater (as opposed to lightly soiled grey water) would raise considerably more concerns with the same regulatory bodies that granted the NNH team temporary permits.

In order to provide the necessary allotment of Urban Agricultural space (LBC Imperative 02), 4279sf (or 35% of the site area) must be dedicated to given to this programmatic use. Approximately 30% of the NNH site is unusable for this purpose due to steep slopes. A major redesign of the landscape in order to handle the imperatives requirements entirely on-site would be required. The LBC allows the use of "scale jumping" which would allow off-site portions of the required agricultural area to serve the neighbourhood. For the purposes of this study, the agricultural area would be accommodated on-site.

Finally, the NNH site and home orientation (aligned longitudinally N-S) are less than optimal for the efficient placement of a 6kW photovoltaic system. The town of Norris is on the National Register of Historic Places, and though not required by town ordinances, the design team decided that general conformance with the existing street pattern and house form was critical. The ridge of the gable roof is thus oriented E-W. A major redesign of the home's orientation would be required to accommodate a roof-mounted PV system. Alternately, and with additional funds, a 500sf stand-alone mounting system would be necessary. Limited site frontage at the southern end of the site would make a 500sf PV array a considerable design challenge, as would sensitivity to the historic context.

Assumptions and Methodologies

Each Imperative within the LBC was considered against similar efforts at the NNH project. (See figure 5 - full spreadsheet at conclusion.) As with analysis quantifying attainment of a LEED-H Platinum certification, exact pricing from construction of the NNH was compared with cost estimates obtained from local suppliers, unless noted otherwise. The availability and cost of environmentally preferable materials fluctuates widely. These figures would thus likely change when estimating the potential redesigns described above. Major changes to the design of the NNH home suggested above were largely ignored in this analysis; necessary modifications would presumably have been addressed during the design process had the team pursued the LBC designation from the outset. A similar argument can be made for "Biophilia", "Beauty and Spirit", and "Inspiration and Education" imperatives. Also, like the previous analysis, estimated general labor and design hours are generated from the direct experience of working within these capacities while the project was underway, and speciality labor has been estimated by trade professionals. Where exact values could not be obtained, reasoned estimates have been input.

CONCLUSIONS

A quantified analysis of the LEED for Homes and Living Building Challenge green rating systems revealed an interesting breakdown of costs associated with achieving these ends. As expected, the largest share of the additional resources necessary to reach certification is projected to result from higher materials costs. Specialized labor to install advanced building systems and design fees for extra research, development, and integration of green strategies necessitated approximately equal investments to one another. As these two divisions of labor become more familiar with projects pursing aggressive sustainable design, the amount of additional investment will only become lower. Though the LBC is built on much more stringent criteria than LEED, the LBC “all or nothing approach” leaves little room for interpretation and the frustrating acrobatics commonly associated with LEED Platinum certifications (across all LEED rating systems - New Construction, Retail, Homes, etc).

The additional cost to achieve LEED-H Platinum ($45,216) compares interestingly to the total NNH project costs ($174,000) and RSMeans estimating data for “luxury” (designed by an architect with high level of craft) 1000sf, 1-story wood homes in Tennessee ($126,750). [10] The similarity in differences (within 5%) suggests a level of accuracy to the analysis. Also of note are payback periods associated with each certification. At 29.49 years, the payback period of constructing a LEED-H Platinum NNH parallels the timeline of a traditional 30-year mortgage period. As energy and building modelling technologies become increasingly accurate, projected energy use data could begin to inform progressive mortgage structures that respond to and reflect a home’s incorporation of sustainable design and performance features. A limited but useful assessment of the two analyses pursued in this paper - a) analysis of the cost of going from a baseline standard home to a LEED-H Platinum home, and b) analysis of the cost of going from a LEED-H Platinum Home to a LBC certified home – projects that a combined total of $74,272 could move a baseline standard home to an LBC home (with a payback period of 34.5 years, assuming zero energy use). Though the additional $74,272 is a significant investment, it is reasonable to assume the payback period could be made to reach the same 30-year threshold with additional design refinements and the consideration of the rising cost of energy in both the short and long terms. [11, 12]

The figures above present a way to consider the measurable costs to achieve one of two types of environmental certification, LEED-H Platinum and LBC, in the NNH. Dissection of the respective certification programs in this manner could be understood as undermining the spirit of the individual programs. Yet, those not motivated to pursue these types of efforts by ethical or philosophical concerns stand to benefit the most from this type of analysis. The NNH project as analyzed in this paper serves as an ideal vehicle for creating an overview and identifying potential issues. More detailed analysis of similar projects such as the NNH will be necessary to continue to educate contractors, owners, and designers. These analyses must be presented in an easily accessible manner in order to disseminate effectively and demonstrate through comparative investigation that green building strategies require a significant investment, but are feasible and within reach of project teams.

Figure 3: A New Norris House as seen from the street.

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	106	Comparison Home	NNH	Spec Labor ($)	Labor ($)	Design ($)	Material ($)	Notes
Innovation and Design (min 0 points)	**9**							
1.1 Preliminary Rating (prerequisite)	n/a	Not applicable	Development of preliminary rating	$0	$0	$113	$0	Develop preliminary rating to project LEED-H goals
1.2 Integrated Project team	1	Not applicable	Minimum 3 extra meetings	$0	$0	$1,500	$0	Must conduct monthly meeting with 3 portions of integrated team.
1.4 Design Charrette	1	Not applicable	One day design charette	$0	$0	$1,800	$0	Must conduct 8-hour charette with integrated team.
2.1 Durability Planning (prerequisite)	n/a	Not applicable	Durability plan in place and integrated into CDs	$0	$0	$450	$0	Larger effort for NNH, based on size/scope of set.
2.2 Durability Management (prerequisite)	n/a	Not applicable	Green Rater services	$2,750	$0	$0	$0	Can be completed by project team, but conducted by Green Rater
2.3 3rd Party Management Verification	3	Not applicable	Green Rater services	$0	$0	$0	$0	Covered by Green Rater
3.1 Innovation 1	1	Not conducted	Materials and Resources - Extra Credits	$0	$0	$150	$0	Easily accomplished in Southeast US with a little research
3.2 Innovation 2	1	Not conducted	Materials and Resources - Extra Credits	$0	$0	$150	$0	Easily accomplished in Southeast US with a little research
3.3 Innovation 3	1	Not conducted	Exemplary Performance: Basic Landscape SS2.2	$0	$0	$0	$0	Basic landscape Design in addition to water reduction . (Absorbed into SS 2.2)
3.4 Innovation 4	1	Not conducted	Exemplary Performance: Advanced Framing MR1.5	$0	$0	$0	$0	Advanced framing and modular production. (Absorbed into MR 1.5)
Location and Linkages (min 0 points)	**10**							
2 Site Selection	2	Not a unique, critical, or threatened site	Not a unique, critical, or threatened site	$0	$0	$0	$0	Requirement Met
3.1 (Absorbed Below)	n/a							(Absorbed Below)
3.2 Infill	2	Infill Site	Infill Site	$0	$0	$0	$0	Requirement Met
3.3 Previously developed	1	Previously developed	Previously developed	$0	$0	$0	$0	Requirement Met
4.0 Infrastructure	1	Exisiting Infrastructure	Exisiting Infrastructure	$0	$0	$0	$0	Requirement Met
5.1 (Absorbed Below)	n/a							(Absorbed Below)
5.2 (Absorbed Below)	n/a							(Absorbed Below)
5.3 outstanding community resources	3	15 Community Resources	15 Community Resources	$0	$0	$0	$0	Requirement Met
6 Access to open space	1	Access to parks and nature preserve	Access to parks and nature preserve	$0	$0	$0	$0	Requirement Met
Sustainable Sites (min 5 points)	**16**							
1.1 Erosion control (preq)	n/a	Little or no erosion control measures	Extensive erosion control measures	$0	$200	$113	$300	Standard for larger projects, but not typically done for small residential projects
1.2 Minimize disturbed site (rehabilitate site)	1	Little rehab; typical landscape (turf)	Total landscape design and native plants	$0	$0	$0	$0	Absorbed into total landscape design (SS 2.2) and invasive removal (SS 2.0)
2.0 No invasive plants (perquisite)	n/a	No removal	All removed via on-site labor and identification	$0	$500	$0	$0	Must identify and remove all non-native species
2.2 Base landscape design (ID)	n/a	Typical landscape (mostly turf)	Total landscape design and native plants	$0	$1,000	$3,000	$5,000	Total landscape design (SS 2.2)
2.5 Reduce overall irigation demand	6	Typical landscape (mostly turf)	Total landscape design and native plants	$0	$0	$0	$0	Absorbed into total landscape design (SS 2.2)
3.0 Reduce heat island	1	Concrete drive/walks	Gravel Drive and walks	$0	($700)	$0	($1,795)	Absorbed by permeable driveway, which are low-albedo materials (SS4.1)
4.1 Permeable lot	3	Concrete drive/walks	Gravel Drive and walks	$0	$0	$0	$0	Must install permeable driveway
4.2 permenant erosion control	1	Little or no erosion control measures	Total landscape design and native plants	$0	$0	$0	$0	Absorbed into total landscape design (SS 2.2)
4.3 Management of runoff	2	Little or no runoff management	Professional designed Rainwater system	$0	$0	$0	$0	Professional designed and installed rainwater system (swallowed into WE 1.1)
5.0 Non-toxis pest control	2	Some measures taken, but likely accidental	Sealed envelope, landscape away from building, con	$0	$150	$225	$0	Extra labor and some design consideration required related to envelope
Water Efficiency (min 3 points)	**13**							
1.1 rainwater harvesting	4	No rainwater system	Professional designed Rainwater system	$1,875	$0	$1,875	$4,853	Must install rainwater system could be done for less without heavy treatment
2.3 reduce irrigation demand	4	Typical landscape (mostly turf)	Extensive landscape and native plants effort	$0	$0	$0	$0	Absorbed into total landscape design (SS 2.2)
3.1 high efficiency Fixtures	1	Standard toilet ($250)	Dual flush toilet ($350)	$0	$0	$0	$100	Must specify dual-flush or low-flow toilet
3.2 very high efficiency fixtures	4	Standard faucet & shower	Low-flow faucet and shower	$0	$0	$0	$0	Must specify low-flow faucet and shower-- easy acquired at a comparable price
Energy and Atmosphere (min 0 points)	**27**							
1.1 ENERGY STAR (preq)	n/a	80 HERS Rating	49 HERS Rating	$0	$300	$0	$3,860	Low-E Windows; More insulation; Better air seal; better water heater; CFLs
1.2 Exceptional energy performance	23	100 HERS Rating	49 HERS Rating	$1,000	$400	$750	$6,500	Advanced framing; More insulation; SHW; pin based lighting; ERV; Ductless HVAC
7.1 efficient water distribution	2	Small footprint	Efficient layout driven by very small footprint	$0	$0	$0	$0	Requirement Met
7.2 pipe insulation	1	Insulated HW piping	Insulated HW piping	$0	$0	$0	$0	Requirement Met
11.1 refrigerant charge test (preq)	n/a	Refrigerant Charge test	Refrigerant Charge test	$0	$0	$0	$0	Requirement Met
11.2 appropriate refrigerants	1	Appropriate refrigerants	Appropriate refrigerants	$0	$0	$0	$0	Requirement Met
Materials and Resources (min 2 points)	**14**							
1.1 waste factor (preq)	n/a	Waste factor Generally observed	Waste factor observed (modular)	$0	$0	$38	$0	Requirement is generally met by comparable contractors, but must be calculated
1.5 off-site fab	4	On-site construction	Pre-fabricated shell	$0	$0	$0	$0	Trade off, but difficult to quantify given one-off nature and research element
2.1 fsc tropical wood (preq)	n/a	No notice provided or preference for origin	No tropical wood installed	$0	$0	$38	$0	Notice to suppliers for no tropical wood.
2.2 environmental preferable products (EPP)	8	No preference for origins, content, etc	Preference for E.P.P.	$0	$0	$1,050	$0	Easily accomplished in Southeast US with a little research
3.1 waste management plan (preq)	n/a	No plan or diversion	Management plan and diversion rates monitored	$0	$0	$0	$500	Contract of waste diversion management - 5 pulls @ $100 extra each for diversion
3.2 waste reduction	2	No diversion of waste	70% Diversion of waste	$0	$0	$0	$0	Diversion services absorbed into MR 3.1
Indoor Environmental Air Quality (min 6 points)	**15**							
2.1 Basic combustion venting (preq)	n/a	Co2 sensors; vented combustion; no fireplace	Co2 sensors; No combustion; no fireplace	$0	$0	$0	$0	Requirement Met
2.2 Enhanced combustion venting	2	Matter of specification	No fireplace; non-combustion stove	$0	$0	$0	$0	Achieved with comparable subsitutes and no fireplace
3.0 Moisture load controls	1	Typical HVAC with no dehumidification option	Minisplit system with dehumidification mode	$1,500	$0	$0	$3,500	Minisplit systems have this capability built in
4.1 Basic outdoor air ventilation (preq)	n/a	Meets ASHRAE 62.2	Meets ASHRAE 62.2	$0	$0	$0	$0	Requirement Met
4.2 Enhanced outdoor air ventilation	2	No ERV Installed	ERV Installed	$450	$0	$0	$600	Must install energy recovery device.
4.3 3rd party testing	1	Not Applicable	Green Rater conducted test	$0	$0	$0	$0	Absorbed by Green Rater Costs
5.1 Basic local exhaust (preq)	n/a	Meets ventilation requirements	Meets ventilation requirements	$0	$0	$0	$0	Requirement Met
5.2 Enhanced local exhaust	1	No enhanced measures installed	Continous exhaust provided by ERV	$0	$0	$0	$0	Must install energy recovery device. Cost absorbed by IQ 4.2
5.3 3rd party testing	1	Not Applicable	Green Rater conducted test	$0	$0	$0	$0	Absorbed by Green Rater Costs (See ID 2.2)
6.1 Room-by-room calcs (preq)	n/a	Manual J completed	Manual J completed	$0	$0	$0	$0	Requirement Met
6.3 Air Flow testing / Multiple Zones	2	No test of forced air system	Multiple zones (different track of credit)	$0	$0	$0	$0	Absorbed into HVAC costs (See IQ 3.0)
7.1 Good filters (preq)	n/a	"Good" Filters installed	Project Exempt based on ductless system	$0	$0	$0	$0	Requirement Met
8.1 Indoor construction contaminent control	1	Not generally controlled	Contaminent Control in place	$0	$13	$0	$10	Must seal ductwork during construction.
8.2 (Not Pursued)	n/a			$0	$0	$0	$0	(Not Pursued)
8.3 Pre-occupancy flush	1	No flush conducted	Pre-occupancy flush conducted	$0	$75	$0	$0	Conduct a cumulative 48-hour flush of home.
9.1 Radon resisent in risk areas (preq)	n/a	Sealed crawlspace a code requirement	Non-mechanically vented sealed radon barrier	$0	$75	$0	$100	Must vented sealed crawlspace (sealed crawlspace a code requirement in Norris)
10.1 No HVAC in garage (preq)	n/a	No HVAC in garage/ no garage	No Garage	$0	$0	$0	$0	Requirement Met
10.2 (Absorbed Below)	n/a							(Absorbed Below)
10.3 (Absorbed Below)	n/a							(Absorbed Below)
10.4 Detached or no garage	3	No garage	No garage	$0	$0	$0	$0	Requirement Met
Awareness and Education (min 0 points)	**2**							
1.1 Basic operations training (preq)	n/a	No operations training	Operations training with occupants	$0	$0	$150	$0	1-hour operations training and review with ooccupants
1.2 Enhanced training	1	No enhanced training	Tour of another comparable home	$0	$0	$150	$0	Tour of Another comparable home
1.3 Public awareness	1	Not conducted	Tours, website, signs, etc	$0	$100	$300	$150	Website information about home and LEED; LEED on jobsite; Newspaper article
TOTALS and Conclusions				**$7,575**	**$2,113**	**$11,850**	**$23,678**	
			Grand TOTAL	**$45,216**				

Figure 3: Summarized Table of Selected Analysis to reach LEED-H Platinum

	Baseline (NNH LEED-H Platinum)	Living Building	Spec Labor ($)	Labor ($)	Design ($)	Material ($)	Notes
01 Limits of Growth	Previously developed site	Previously developed site	$0	$0	$0	$0	Requirements Met
	Native landscape system	Native landscape system	$0	$0	$0	$0	Requirements Met
02 Urban Agriculture	133sf of garden	4279sf of Garden required (35%)	$0	($300)	$0	($400)	Probable savings allocating sf away from native landscape
03 Habitat Exchange	No habitat offsets made	0.4 Hectare acre offset required	$0	$0	$150	$500	Financial and research investment
04 Car Free Living	76% Residential	<70% of any single occupancy	$0	$0	$150	$0	Basically no way around-- can't certify
05 Net Zero Water	78% of permissable needs met	100% of permissable needs met	$0	$0	$150	$400	Need bigger cistern + bigger floor area to fit it. Extra design time and reseach
06 Ecological Water Flow	Kohler K-3654 ($350) dual flush	Composting toilet ($1800)	$750	$0	$300	$1,450	Not legal in our municipality
07 Net Zero Energy	No Generation installed	6Kw System needed	$4,500	$0	$1,800	$10,500	Extra hours to integrate, interface with contractor, etc
08 Civilized Environment	Operable windows in every room	Operable windows in every room	$0	$0	$0	$0	Requirements Met
09 Healthy Air	No walk off mats	Needed indoors and outdoors	$0	$50	$75	$300	Need to integrate design, purchase, and install
	Temp and humidity sensors	Temp, humidity, and co2 sensors	$150	$0	$75	$200	Not possible with current system. Sensor itself is ~$200 + install / integratation
	Air quality tests completed	Air quality tests completed	$0	$0	$0	$0	Requirements Met
10 Biophilia	Some Biophila design elements	Biophila design elements	$0	$0	$225	$0	We likely could make a case as-is... but some extra design time
11 Red List	PVC; caulks and sealants	HDPE drain piping; approved caulks	$713	$200	$225	$136	20% higher material cost; 35% higher labor (specialty and general - landscape & hon
12 Embodied Carbon Footprint	No Carbon offset	Need to offset 21 metr. Tons of CO2	$0	$0	$75	$10	At current market price of $0.50 / ton
13 Responsible Industry	Not FSC Decking, siding, or lumber	All FSC @ 20% increase in cost	$0	$0	$0	$1,371	Assuming 20% increase in cost to get FSC
	No letters written	Advocacy letters written	$0	$0	$150	$0	Must write advocacy letters to trade associations
14 Appropriate Sourcing	Most divisions sourced appropriately	All divisions sourced appropriately	$0	$0	$1,200	$1,500	Primarily met already or could have met. Extra hours and materials costs estimated
15 Conservation and Reuse	Some material management planning	Material management @ all phases	$0	$0	$300	$0	Need to create plans for conservation and reuse during End of Life Phases
	70% diversion rate	~90% diversion (varies by material)	$0	$300	$0	$0	Need to increase diversion (though our rate SHOULD be higher)
16 Human Scale and Humane Places	Meet min/max scaler criteria	Meet min/max scaler criteria	$0	$0	$0	$0	Requirements Met
17 Democracy and Social Justice	Near ADA	Must Meet ADA	$0	$0	$750	$600	Design tweaks/specifications to meet ADA - (kitchen, bathroom, entry)
	No seating on public walkway	Seating on public walkway	$0	$25	$75	$400	
18 Rights to Nature	No blocking air, sunlight, or water	No blocking air, sunlight, or water	$0	$0	$0	$0	Requirements Met
19 Beauty and Spirit	Genuine effort to "enrich"	Genuine effort to "enrich"	$0	$0	$0	$0	Requirements Met
20 Inspiration and Education	Design features for human delight	Design features for human delight	$0	$0	$0	$0	Requirements Met
TOTALS and Conclusions			**$6,113**	**$275**	**$5,700**	**$16,967**	
		Grand TOTAL	**$29,056**				

Figure 4: Summarized Table of Selected Analysis to reach full Living Building Status.