1101 19th Avenue South Renovation Project Case Study

In Partial Fulfillment of LEED Green Building Education Credit

VANDERBILT UNIVERSITY®

FutureVU SUSTAINABILITY

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Executive summary

In 2015, Vanderbilt University purchased the building located at 1101 19th Ave. S. Nashville, TN. The three-story building was constructed in 1956 and housed offices and archives for the Disciples of Christ organization. Once completed, the newly renovated space will be a multi-use facility for faculty development, cross-campus collaborations, offices, library archives, meeting rooms, conference spaces, and a video studio. Due to both the building's historic nature and campus sustainability goals, renovating the building instead of tearing it down to build a new structure was more appealing.

This case study will highlight the immersive, student-driven process that was used to calculate embodied carbon analysis and measure the environmental benefits of preserving much of the historic structure during renovation. The embodied carbon calculation and case study was substantially completed by student interns from the Vanderbilt University Sustainability and Environmental Management Office over the course of three semesters. Through this work, the students gained valuable experience that can be used in their future sustainability careers.

The embodied carbon calculation showed the relative benefits in terms of carbon mitigation of renovating and reusing a building versus building a new structure. Overall, 81% of the original building shell and structural components were retained, which saved 921.6 Metric Tons of Carbon Dioxide Equivalent (MTCO2E) compared to replacing those materials with new construction. This equaled a reduction of 93% of the total embodied carbon used in a comparative new building. These carbon savings are equivalent to taking almost 200 cars off the road for one year.[1] This embodied carbon calculation provided both a valuable educational experience for our students, and data to help building teams make informed decisions about embodied carbon in renovations.

FAST FACTS

81%	of the original building shell and structural components were preserved in the renovation.
921.6 MT CO2E	was conserved by reusing existing building materials instead of building new.
93%	total embodied carbon reduced by keeping structure instead of building new.

[1] Greenhouse Gas Equivalencies Calculator. (2018, October 15). Retrieved from https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

Brief historical background, including aesthetic and historic value

The former Thomas W. Phillips Memorial is a Tudor-Gothic historic building, constructed in 1956 and listed on the National Register of Historic Places since November 9, 2006. The building was home to the Disciples of Christ Historic Society (DCHS) until 2015, when Vanderbilt purchased it. The building is constructed of poured concrete, steel beam, and clay block with Indiana limestone exterior walls and a slate roof.[2] The aesthetic and historic value of the building is hard to quantify, but because the building is on the National Register of Historic Places, preservation of its character, including the outer envelope, stone exterior, slate roof, stained glass windows, and grounds, was a key goal in this project. In addition to historic preservation, the team determined that an equally important goal for the renovation was to retain as much of the existing materials as possible for environmental purposes.

Once completed, the newly renovated space will be a multi-use facility for faculty development, cross-campus collaborations, offices, library archives, meeting rooms, conference spaces, and a video studio. There is to be no change to the footprint of the building, no expansion of the envelope, and minimal changes to the grounds. Exterior renovations include drainage modifications, addition of wheelchair access, and renovations to the patio and planting areas. The main building will include 15,000 square feet (sf) of usable space including 7,548sf of "stack" space at the center of the building which currently houses the DCHS library archives.[3]

Sustainable strategies

This large-scale renovation was guided by an integrated design process which allowed a multi-disciplinary team to communicate effectively about desired building performance early in the design process. By looking at the entire life cycle of the building and project, the team was able to improve energy efficiency and assess renewable energy options for the site to support Vanderbilt's sustainability and carbon neutrality goals.

The key project goals included: 1) historic preservation; 2) retention of as much of the original structure as possible to retain embodied energy of the existing structure; 3) emphasis and maintenance of existing urban density, walkability and access to mass transport; 4) energy conservation, energy efficiency, and avoidance of on-site combustion by using electricity only for HVAC and water heating; 5) preservation of existing vegetation and soils, which are long-since adapted to the natural water cycle, thereby preserving the existing biodiversity and avoiding additional demands on the city's potable water system, and; 6) increased student involvement to maximize learning opportunities.

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[2] Vanderbilt Communications. (2015, July 20). Vanderbilt acquires DCHS building on 19th Avenue South. Retrieved from https://news.vanderbilt.edu/2015/07/20/vu-acquires-dchs-building/

Historical preservation

Historic preservation was a key goal of this renovation and it was integral to maintain the building's aesthetic and historic value. The building is on the National Register of Historic Places, meaning preservation of its character, including the outer envelope, stone exterior, slate roof, and grounds, was a key goal in this project. By renovating instead of building new, Vanderbilt was able to preserve this unique neo-Gothic building and retain much of the original structure.

Material retention

To better understand the environmental benefits of the decision to renovate, a team comprised of student interns, the project architect, a LEED consultant, and Vanderbilt staff worked together to calculate how much of the original building would be reused and how much of the original building would be demolished. More specifically, the team worked to identify how much of each building element, including structural elements, interior finishes, doors, cladding, and the foundation, would be saved. Through this research, the team was able to discern that 81% of the building was reused in the renovation. In the future, this research can serve as a foundation for a more in-depth embodied carbon analysis and it can help the university understand the environmental and historical benefits of preserving elements of existing buildings.

Embodied carbon calculation

The embodied carbon hotspot analysis represented a unique approach to analyzing the difference in carbon impacts from a renovation versus a demolition and new build. Embodied carbon is increasingly recognized as a key metric to understand the life cycle impacts of a building.[4] Operational carbon, the carbon used once a building is occupied, has been a key focus of practitioners for some time. Now, there is a growing realization that it is just as important, if not more important, to address the carbon contribution of materials selected to construct new buildings. A recent study showed that "achievable reductions in embodied carbon could provide more than four times the overall Greenhouse Gas (GHG) reductions than energy efficiency improvements to reduce operational carbon between 2020 and 2050."[5] When this type of life cycle approach is used, it becomes clear that building reuse is a key way to reduce the total, life-cycle Greenhouse Gas impacts of the building sector. In cases where new buildings are necessary, it is crucial to pay attention to material selections at the front end, choosing carbon storing materials and low-carbon impact materials where possible.[6]

The team concluded that wherever possible, renovations should be considered before demolition and rebuild, as over the life of these projects and 30 years of operations, the carbon footprint for the

[4] Melton, P. (2018, September 10). The Urgency of Embodied Carbon and What You Can Do about It. Retrieved from https://www.buildinggreen.com/feature/urgency-embodied-carbon-and-what-you-can-do-about-it

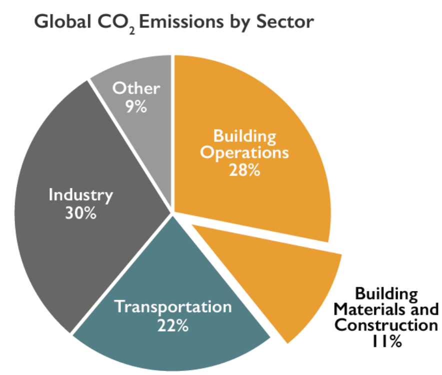
[5] Magwood, C. (2019). Opportunities for CO2 Capture and Storage in Building Materials. 10.13140/RG.2.2.32171.39208.

[6] Magwood, C. (2019). Opportunities for CO2 Capture and Storage in Building Materials. 10.13140/RG.2.2.32171.39208.

renovation is lower than the carbon footprint of a new, highly-efficient building. Use of carbon storing materials is another strategy that can lower embodied carbon to mitigate carbon emissions.

Lastly, student assistance was invaluable in looking at embodied carbon, which is a new area of research for Vanderbilt University. The team looked at the possible avenues for analysis and settled on a hotspot analysis of three major material streams used in the renovation and in new builds. The hotspot analysis focused on the most carbon intensive materials used in the building: concrete, brick, and metal. Proxy data was obtained from a building with similar materials and uses for comparison of embodied carbon in the amounts of the three materials used in a newly constructed building versus this renovation. Through the team's hotspot analysis of embodied carbon of three high-impact materials, they found that the renovation produced only 6.6% of the embodied carbon, 921.6 Metric Tons of Carbon Dioxide Equivalent (MTCO2E) less than what would have been produced in a newly built structure. This aligns with Vanderbilt's FutureVU goals and its stated goal of achieving carbon neutrality by 2050. Methodology of the embodied carbon calculation can be found in Appendix A. Appendix B and C show the specific calculations that were used to determine the embodied carbon of the renovation in comparison to the comparative building.

In the future, this research can serve as a foundation for a more in-depth embodied carbon analysis and can help the university understand the environmental and historical benefits of preserving elements of existing buildings. Looking at ways to reduce the embodied carbon in building materials through selection of carbon-storing construction materials can be a powerful new tool in reducing the overall carbon footprint of buildings. Currently, the bulk of attention is focused on operational carbon used for lighting, heating, cooling, and ventilation, but addressing life cycle embodied carbon is an important way to reduce the impact the building sector is having on climate change.



Source: © 2018 2030, Inc. / Architecture 2030. All Rights Reserved. Data Sources: UN Environment Global Status Report 2017; EIA International Energy Outlook 2017

LOCATION AND TRANSPORTATION: MAINTAINING EXISTING URBAN DENSITY, WALKABILITY AND ACCESS TO MASS TRANSPORT

Vanderbilt University's FutureVU initiative emphasizes walkability and connectivity. This historic building is co-located with mass transit, providing access to low-carbon transportation. Bike racks have been intentionally installed inside the building to communicate that bikes would be secure and out of the weather, promoting alternative transport and reducing use of personal cars.

ENERGY & ATMOSPHERE: ENERGY CONSERVATION AND ENERGY EFFICIENCY

In order to continue progress towards Vanderbilt's 2050 carbon neutrality goal and to meet Vanderbilt's long-term energy use intensity (EUI) goals for building retrofits, this renovation introduced energy conservation and energy efficiency measures. EUI measures a building's annual energy consumption relative to its gross square footage. This project's energy modeling estimates an EUI of 31.8, which exceeds EUI targets laid out by the BlueSky Vision to be met by 2045. The assumption at the beginning of the project was that the site and exterior of the building would not be changed and the focus would be on interior renovation of the building and energy efficiency. The existing building, both walls and roof, were uninsulated. Existing windows were stained glass (some pictorial, most plain colored) with lead came separating single-thickness panes. Existing lighting was primarily incandescent fixtures with some later retrofitted fluorescent fixtures. To improve the efficiency of the building, spray foam insulation was added to the attic area only, given that adding insulation to the exterior walls would have required extensive demolition and replacement of wood paneling and plaster finishes. In addition, internal window panes were installed to create double-paned windows for the stained glass windows that remained in the building, which act to reduce leakage, insulate the building envelope, and reduce energy use while still preserving the building’s original windows and historic character. Any of the pictorial stained glass windows that were removed were sent to the Disciples of Christ organization, who previously owned the building.

SUSTAINABLE SITES: PROTECTING AND RESTORING HABITATS

When the Disciples of Christ building was constructed in 1956, preservation of soil and landscape was not a priority, and the top layer of good soil was likely stripped, disrupting the microbiome. Since that time, however, nature has regenerated this site's soil and plants. With this current renovation, great care was taken to protect the fully adapted landscape, preserving the existing healthy biodiversity which has been developing over 70 years. To achieve this, construction activity was restricted in order to avoid disturbing the larger part of the landscape. Maintaining the existing landscaping also allowed the project to reduce the building’s potable water use by 55%, a majority of which was a result of avoided irrigation.

INNOVATION: STUDENT INVOLVEMENT AND GREEN BUILDING EDUCATIONAL CREDIT

One key element in this renovation was a high level of student involvement. Student interns from the Sustainability and Environmental Management Office conducted research on embodied carbon calculations. The students were involved in every step of the process, including:

- performing on-site documentation of materials and volumes during construction
- calculating volumes of existing materials using building CAD drawings
- researching embodied carbon databases for different materials and finding Environmental Product Declarations (EPD) for specific materials used in the building
- researching case studies on embodied carbon calculations on new buildings
- calculating embodied carbon used in 1101 19th Ave. renovation
- developing this case study
- developing LEED educational signage

This experience brought learning out of the classroom, bridging the gap between classroom theoretical knowledge and real-world application. Students were directly involved with the design team, LEED professionals, and architects as the building was actively under construction, gaining access to the practical work those professions.

Earning LEED Green Building Education Credit

Vanderbilt recognized that this building is a beautiful neo-Gothic building that contributes to the Nashville landscape and retains historic and aesthetic value. With this idea and the environment in mind, it was decided to renovate the building to retain the major features of the structure while upgrading systems to increase its energy efficiency. As part of the renovation and work to attain LEED certification, the project team is looking to achieve a LEED Green Building Education credit. The pieces of this education credit include the following:

1) Student driven embodied carbon calculations
2) This case study, describing major sustainability measures and embodied carbon calculations.
3) Comprehensive signage that will educate the visitor on the various sustainability measures incorporated into the building as it was being renovated.

Conclusions

The embodied carbon calculation demonstrates that it was far preferable (in terms of embodied carbon added to the building) to renovate this historic structure, preserving 81% of the original building materials, than it would be to tear down the structure and build it with new materials. The renovation was found to produce only 6.6% of the embodied carbon than what would have been produced for a new building construction. The renovation process also reduced the building's potable water use by 55% by preserving the mature landscape at the site.

This project has revealed the value in using embodied carbon emissions alongside operational carbon emissions in order to better comprehensively explain total carbon emissions for a building and the value in choosing to renovate instead of building new. This embodied carbon calculation methodology was a new practice at Vanderbilt and may provide a further dimension to evaluate future building projects. The project also provided valuable experiential learning opportunities for Vanderbilt students, bringing their learning out of the classroom and into the field and providing them with access to various sustainability professions in practice.

FAST FACTS

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921.6 MT CO2E	was conserved by reusing existing building materials instead of building new.
93%	total embodied carbon reduced by keeping structure instead of building new.

Special Recognition

We wish to recognize the student interns who were instrumental in this project:

- Nicole Gillis: Class of 2019, Public Policy Major and Environmental and Sustainability Studies Minor
- Daniel Shin: Class of 2021, Civil Engineering Major
- Zahra Biabani: Class of 2021, Environmental Sociology Major and Earth and Environmental Science and Human and Organizational Development Minors

Appendix A – Methodology for embodied carbon calculation

METHODOLOGY:

This hotspot analysis compares the embodied carbon contained in three major construction materials, metal, concrete, and brick, added to the renovated space at 1101 19th Ave S and used in a newly built structure. The embodied carbon hotspot analysis looks only at the cradle-to-gate impacts from materials, in other words the material production phase, which includes resource extraction, transport and manufacture of materials. These three major materials for each of these types of projects (this renovation and a newly constructed building) are analyzed side by side. Data for the renovation includes all additions of the three materials being studied. The proxy data for a new build is excerpted from a study done in Sri Lanka, looking at a newly constructed concrete frame, steel and brick office building. These three materials are the focus of this analysis because they represent just over 70% of total embodied carbon in the Sri Lankan case study.[7] Since the building analyzed in the case study is for a smaller building, the data from that study is scaled up to match the area of 1101 19th Ave. For the renovation, the data needed to calculate impacts from the added steel, concrete and brick are obtained from environmental product declarations (EPDs) provided by the contractor, EPDs from major companies, and some data provided in the EC3 open source database, which uses thousands of EPDs from companies across the United States. The latter are used to produce average, conservative values on GHG impacts of each material used in the renovation. There are some mismatches in building conditions between the two building locations, including weather and seismic activity, that can drive variations in quantities of material used: less/more foundation, different building codes, different structural and seismic considerations. For a hotspot analysis, these approximations and caveats are fine, as the purpose is to give a first-blush idea of the difference in magnitude between embodied carbon from the use of these materials in a renovation versus in a newly built structure.

[7] Kumanayake, R., Luo, H., & Paulusz, N. (2018). Assessment of material related embodied carbon of an office building in Sri Lanka. *Energy and Buildings, 166*, 250-257. doi:10.1016/j.enbuild.2018.01.065

Appendix B – Weight and embodied carbon of materials added to project

Material	Quantity	Unit	Weight per Unit (pounds)	Weight Installed (Metric Tons)	GHGs (MTCO2E) per metric ton	GHG contribution from this building material (MTCO2e)	Source
Building Concrete	10	Cubic Yards	4050	18.38	0.13	2.45	EC3 Database
Site Concrete	30	Cubic Yards	4050	55.13	0.13	7.35	EC3 Database
Grout	6.7	Cubic Yards	4050	12.31	0.13	1.64	EC3 Database
Concrete Block (CMU)	945	Blocks	40	18.90	0.02	0.29	British Precase Block EPD database
Brick	200	Bricks	8	0.80	0.42	0.34	ASTM Brick EPD
Rebar	0.75	Tons	2000	0.75	1.05	0.79	ASTM EPD Rebar
Structural Steel and Rail	3	Tons	2000	3.00	2.39	7.17	Cold formed Steel Clark Dietrick EPD
Door Frames (steel)	45	Each	40	0.90	0.04	1.85	Clark Dietrich Steel Craft Industry EPD
Metal duct	9824	Pounds	1	4.91	2.39	11.74	Cold formed Steel Clark Dietrick EPD
Refrigerant piping	5260	Pounds	1	2.63	3.37	8.86	Copper Development Association, Inc. Life Cycle Assessment
Plumbing piping				3.00	3.06	9.17	Copper Development Association, Inc. Life Cycle Assessment
Metal studs				5.00	2.76	13.80	Pro Stud Diamond Plus Clark Dietrick EPD
TOTAL						65.44	

Appendix C – Embodied carbon of 1101 19th Ave to comparative building

Materials of concern	Mass (kg)	Embodied carbon (MTCO2E)
*Ready-mixed concrete	1,383,696	170.19
*Reinforcement steel	114,760	213.45
*Clay bricks	855,439	205.31
*Structural steel	3636	7.38
*Galvanized iron	569.4	1.16
*Cement mortar	492,377	73.86
TOTAL		671.35

*Source: Kumanayake, R., Luo, H., & Paulusz, N. (2018). Assessment of material related embodied carbon of an office building in Sri Lanka. *Energy and Buildings, 166*, 250-257. doi:10.1016/j.enbuild.2018.01.065

Building	Square Feet
*Comparative Building	14,284
1101 19th Ave	21,000

*Source: Kumanayake, R., Luo, H., & Paulusz, N. (2018). Assessment of material related embodied carbon of an office building in Sri Lanka. *Energy and Buildings, 166*, 250-257. doi:10.1016/j.enbuild.2018.01.065

Scaling Multiplier	
Multiplier to scale comparative building to size of 1101 19th Ave	1.47

Embodied carbon comparison between 1101 19th Ave and comparative building	
MTCO2E of comparative building scaled to 1101 19th Ave	987.01 MTCO2E
MTCO2E of 1101 19th Ave Renovation	65.44 MTCO2E
Difference in embodied carbon in study and 1101 19th Ave	921.57 MTCO2E
% embodied carbon of 1101 19th Ave vs. comparative building	6.6%
% reduction of embodied carbon in 1101 19th Ave to comparative building	93.4%