Whole Building Re-Use—It Adds Up

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ABSTRACT: Notwithstanding efforts today to reduce the waste of paper, plastic, and other routinely disposed of products, we continue to undervalue a measurably greater means of resource conservation—the recycling and reuse of existing, durable building stock. According to Author and Preservationist Donovan Rypkema, Principal of PlaceEconomics in Washington D.C., tearing down even a small building—approximately 25 feet wide by 140 feet deep—nullifies "the entire environmental benefit of recycling an estimated 1.3 million aluminium cans". [1] The prevailing system for assigning value to sustainable building design, the U. S. Green Building Council's Leadership in Energy and Environmental Design (LEED) Program, awards up to 4 "points" out of a total possible 110 "points" for partial or total building re-use. [2] However, current research on material life-cycle impact, including data collected from case studies conducted as part of this research, reveals that the conservation of existing, durable building stock, whether as a whole or in part, can be a significant means of resource conservation.

This paper will present three of a series of original case studies conducted by the Green Scale Research Project at Notre Dame (GSRP) which specifically examine the value of material conservation through whole building recycling alongside equally meaningful qualitative aspects and complexities of building preservation.

- The Avon Theater
  South Bend, Indiana (1926-2012)
  Evaluating the cultural and ecological impact of demolishing an historic structure

- The Robert L. Miller, Sr. Center for Homeless Veterans
  South Bend, Indiana
  Demonstrating the value of whole building conservation and the restoration of urban fabric

- St. Gerard's Roman Catholic Church
  Buffalo, New York
  Evaluating the sustainability of "long haul" building re-use

Each Case Study involves the comparative quantitative analysis of primary building components and whole building design for each Subject Case building, including material embodied energy and embodied water, building site impact, footprint, actual and operating, and recurring costs related to baseline life expectancy (100 years). Quantifying the ecological impact of whole building conservation versus demolition (and subsequent new construction, potentially) considers the resources already consumed by and captured in standing buildings, and the potential value of maintaining those resources by *in situ* recycling.

Conference theme: METRICS
Keywords: durability, conservation, quantification

INTRODUCTION

Despite increasing efforts—and expense, in programs, marketing, and infrastructure—to reduce the waste of routinely disposed of products and their attendant land-fill and ecological impacts, comparatively little attention is directed at the recycling and reuse of existing, durable building stock—a measurably significant means of resource conservation. Debris generated as a result of the construction, use, renovation, and demolition of buildings in our country amounts to nearly 26 percent of all non-industrial waste produced annually, [3] a staggering statistic when coupled with the following: as of 1995, an average of 170, 000 new commercial buildings were constructed annually in addition to an estimated 44,000 commercial buildings that were demolished in the same period. [4] Current studies suggest that it takes approximately 40 years for a new, energy efficient commercial building to begin realizing energy savings when the embodied energy involved in its construction is considered in conjunction with its operating energy consumption. [5] The U. S. Green Building Council's Leadership in Energy and Environmental Design Program (LEED), the leading voluntary rating system for evaluating sustainable building design awards up to 4 "points" for the whole or partial adaptive re-use of a structure, and 4 for recycled or salvaged materials, out of a total 110 possible "points" and 40 necessary for minimum certification. However, up to 19 "points" can be earned by a single project for incorporating high-performance heating and cooling systems (regardless of the building design). According to statistics from a 2009 U.S. Energy Information Administration survey, a single family home uses an average of 11,319 kilowatt-hours or 38.6 million British thermal units (Btu) per year of electricity. [6] However, data generated from GSRP case studies indicate that the embodied energy of buildings can amount to millions -- or billions -- of Btu, suggesting that the initial design choices that influence the energy investment of a building and its materials can be as important to achieving sustainable design as the decisions tied to optimizing building energy use (in operation).

Methodology

In each of the three case studies, the Subject building is dichotomized into primary building assemblies (roof, wall, openings, floor spans, and foundation systems) and components followed by the empirical evaluation of these assemblies in order to quantify the energy embedded in the structure, along with other construction impacts, like embodied water, carbon, and thermal performance. With the exception of the Avon Theatre Case, the studies also explore – and quantify – potential alternative construction methods and materials for the Subject case. The energy expended in demolition is omitted in two of the three cases, but the benefits of preservation are amplified in these cases, as the net energy calculation including subsequent new construction would rise even higher. Our analyses seek to determine both the benefits of whole building re-use and adaptive design, and the potential boundaries for its application.

THE HISTORIC AVON THEATER: QUANTIFYING BUILDING (MATERIAL) VALUE

Background information

The first case is focused on calculating the amount of energy and materials that were wasted in the demolition of a small (7200 SF) historic movie theatre. The Avon Theatre in downtown South Bend, Indiana was built in the early 1920s and operated as a movie theatre, initially showing silent movies followed by first-run commercial films, and later, artistic and foreign films, to audiences of 800-900 patrons. The theatre ran its last film in the mid-1970's and remained vacant until its recent demolition in the fall of 2012. In 2007, the adjacent landowner, the St. Joseph County Public Library, purchased the property from a development company and subsequently sought the rights to raze the building to pave the way for a future parking garage. The Library's master plan for their campus, which will eventually cover a full-city block, includes the construction of an expanded library building, including two smaller theaters, and parking facilities. The vacated Theatre, which had not been maintained by its previous Owner nor its current Owner (the Public Library) had fallen into disrepair, leading the Library to hire a consultant to declare that debris from the building put pedestrian passers-by in eminent danger (a claim that went uncorroborated before the building was destroyed). The character of the building, however, is iconic of the city's past downtown streetscape and the Historic Preservation Commission of South Bend and St. Joseph County, along with some community support, sought to have the Avon Theatre protected from demolition and retroactively designated as a local landmark.

Public support for the protection of the Avon Theatre; close-up view of façade; full façade prior to demolition.
Images: Elicia Feasel and Author

Prior to the Theatre's demolition, the City of South Bend/ St. Joseph County Historic Preservation Commission asked the Green Scale research team to conduct a case study to help quantify what would be lost in the demolition, including the energy embedded in the existing building. To accomplish this, a REVIT™ model of the Avon Theatre was constructed using old photographs and historic documents provided by the Commission. When dissected into its primary assemblies and component parts, the original structure consisted of triple-wythe load-bearing brick exterior walls (3 sides), poured, reinforced concrete slab floors, and open web steel truss roof structure. A significant feature of the Theatre – and of the time of its construction – was its glazed terra cotta tile façade, which was ultimately saved from the land-fill by the SB/SJ HPC and committed to a warehouse for a future, undetermined purpose. Inside the Theatre, extant figural plaster suspended on lathe ceilings were also documented and accounted for in the study – and ultimately demolished. Although the interior finishes were damaged by over thirty years of neglect, the envelope of the building remained structurally viable, as confirmed by the engineering report submitted to the SB/SJ HPC, and the two-room plan flexible for adapted re-use.

Preliminary Findings

By amassing the energy cost of each individual material, the Green Scale team calculated the total embodied energy and water of the existing Avon Theatre to be approximately 9,250 million Btu and 1.88 million gallons, respectively. To put this number in perspective, it takes 521.29 Btu to manufacture a single disposable coffee cup (insert citation). Therefore, the energy saved by *in situ* repurposing of the Avon Theatre could be used to produce more than 17 million coffee cups; enough to supply all (US) Starbucks stores for 2 days. [7] In another perspective, the energy used to produce the Avon Theatre – and wasted in its demolition – could power the average single-family home for 3 months. [6]

When considered in the broader context of similar fragmented – or the self-imposed fragmenting of – small City urban fabric, these preliminary results reveal additional critical baseline criteria that should be considered alongside other motivating factors for whole building demolition. In the context of the Public Library's full master plan, the embodied energy and water wasted in the demolition of the Avon represents a small fraction of the future demolition and construction impacts planned for the site. According to the Library, the current library building (the main branch of thirteen in St. Joseph County) will be demolished and replaced with a new building in 2018. This existing library building was constructed in 1960 and underwent major renovations in 1999. The future-planned library building will replace a building that has been in use for only 60 years; more than a decade less than the average life expectancy for a building in the United States (74 years); and less than half of the 132 year life expectancy of buildings in the United Kingdom. [8] Designing for durability and adaptability – or buildings made to last 100 years (or more) is possible, and from what these preliminary results reveal, is measurably more sustainable than *planning* to rebuild every half-century.

ROBERT L. MILLER VETERAN'S CENTER: SUCCESSFUL BUILDING RE-USE

Background information

This second case demonstrates that an alternative solution to a similar challenge is not only feasible, but can also be highly successful. In 2009, a former typesetting shop located at 747 S. Michigan St. was adapted to a new purpose by the South Bend Center for the Homeless (CFH). The CFH's main building is located down the block and the 747 property is included in the CHF's long-range master plan to create a 'campus' of buildings just south of downtown to serve the City's homeless community. The project was funded by the Honorable Robert L. Miller, Senior, a former St. Joseph County Superior Judge, lieutenant commander in the U. S. Navy, and founder of the community's Miller's Vets Honor Guard and Drill Team, and a Capital grant from the U. S. Department of Veterans Affairs. The decision to preserve the existing structure was made in an effort to demonstrate an economically, environmentally, and socially sustainable choice by maintaining the urban fabric of South Bend; using fewer new materials; requiring less capital; and serving a social good with its new occupation.

The focus of this study is a comparison of the Subject building as-renovated to an all-too-common alternative, the demolition of the original structure and its replacement with an entirely new and nearly identical building on the same site. For the Subject Case, the preliminary data collected reflects actual construction processes and materials used, assuming new (and recurring) embodied energy and water costs for virgin (non-original) materials only.

Original typesetting building at 747 S. Michigan Street and façade of new Veterans' Center completed in 2011 (Buccellato Design, LLC). Images: Author

In the renovation of the Subject Case building (Buccellato Design, LLC), all primary building assemblies were preserved: foundations, multi-wythe load-bearing exterior brick walls, concrete slab and structural tile floor systems, and low-slope wood roof trusses. New partition walls were constructed out of framing materials salvaged on-site along with limited new material in order to achieve the building's new function as a community gathering space and temporary emergency housing for 25 homeless U. S. military veterans. To increase efficiency, the structural walls were padded with additional insulation, a hydronic radiant heat system was added, and the floor was levelled and finished with an additional few inches of poured concrete. Finally, the original windowless faux-stone façade was removed and replaced with large double-glazed windows and brick veneer detailing to recall traditional storefronts of the early 20th century and aspects of the neighboring Center for the Homeless main building.

Preliminary Findings

Electing to preserve the structural envelope of the building with only slight adaptations meant that 80% less new materials were used to complete the building than if a structure of equivalent size and materiality were constructed anew. The Subject Case was completed using only 12% of the energy cost of new materials of an identical new construction, even when the analysis excluded the cost of demolition had the current building been razed and constructed anew. While some energy-intensive materials, such as high efficiency double-glazed windows had to be new other energy-intensive materials, such as concrete foundations and masonry structural walls, were preserved. Re-using such a substantial amount of material also saved an estimated $418,000 in material costs, not including labor or the cost of demolition (if new construction were to take its place).

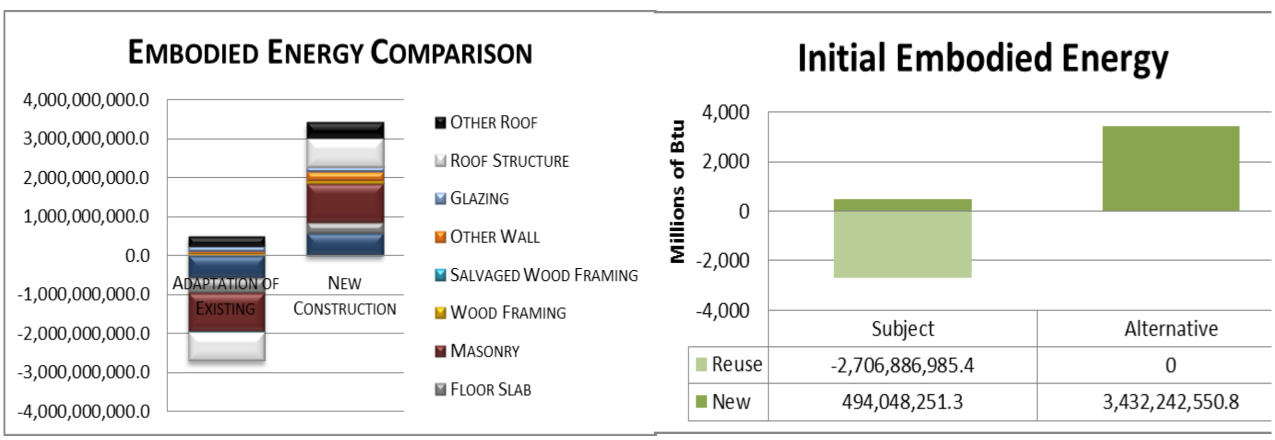

Chart displaying embodied energy costs of Subject and Design Alternative Cases for Veterans' Center. Image: Author.

ST. GERARD'S CHURCH: BUILDING A CASE FOR LONG-HAUL PRESERVATION?

Background Information

The preservation of building structures *in situ* can be a sustainable alternative to new construction, but what about another type of building reuse—preservation by relocation? The salvage and re-use of building materials and even the transport of entire buildings is not a novel concept or practice. And while the value of conserving and preserving existing durable building stock has been studied, what has yet to be quantified are the broader impacts of “long haul preservation”, particularly the energy involved; and what, if anything, is to be saved—or gained—by relocation and reconstruction.

While many churches in the northeastern United States have been forced to permanently close their doors due to a decline in membership, parishes in the American southeast simultaneously struggle to physically accommodate their growing congregations. Facing just this challenge, in 2008, The Reverend Father David M. Dye, Pastor of Mary Our Queen in Norcross, Georgia, went in search of a church and found one—in Buffalo, New York. The Green Scale study of St. Gerard’s Church involves the empirical analysis of dismantling, moving, and reconstructing an early 20th century stone church 900 miles from its original site. Limestone blocks (the primary exterior material of the unreinforced masonry walls), interior granite columns, and decorative millwork will be salvaged and re-used in the new church design; the limestone, for example, will be cut into a 4” veneer and hung from insulated concrete forms. A significant focus of our study of the proposed plans concerns the energy involved in the deconstruction, modification, and transportation of the structure. The number and type of machinery involved in the deconstruction process, as well as the duration of use, are included in the Subject Case, along with the transportation cost over land and the potential benefits of recycling materials, particularly metals, not needed at the new church in Georgia. The Alternate Construction Cases represent building the same church out of new materials; in one case, using traditional load-bearing masonry, and in the other, using a contemporary construction system of insulated concrete forms clad with a limestone veneer.

St. Gerard’s Church in Buffalo, New York. Photgraph and REVIT™ model: Author

Preliminary Findings
The Subject Case initial embodied energy total, accounting for only new materials, was calculated to be 8.05 billion Btu, in comparison with the 5.24 billion Btu for new construction *in situ* using traditional materials and methods. This is due to the insulated concrete forms used as a structural wall for the Subject Case, which have an inherently higher manufacturing cost than the masonry used in the Alternate Design Case. The embodied energy saved by recycling materials from the original St. Gerard’s, from brick and clay tile crushed into rubble to the limestone and granite re-used in the new building, is an estimated 3.01 billion Btu. That number outweighs the GSRP’s calculated 2.41 billion Btu of transportation energy expended to move supplies. It does not, however, compensate for the overall energy cost of the Subject Case in comparison with the new, traditional design. The initial embodied energy total less the recycled material cost is still over 2 billion Btu more costly than the new construction case using traditional materials and methods, the lowest energy option.

What the data and analysis generated in this case study show is that, though there is a gain from recycling scrap and re-using major components from the existing building, those gains do not offset the energy spent in the deconstruction and subsequent transportation of the building to Georgia. This leads us to a question: is there an *empirical* threshold for whole or partial building preservation where the “costs” involved in the salvage, transportation, and reconstruction of such structures outweigh the quantifiable benefits? Is there, for example, a maximum radius from the original building site beyond which preservation by relocation is no longer a truly sustainable option?

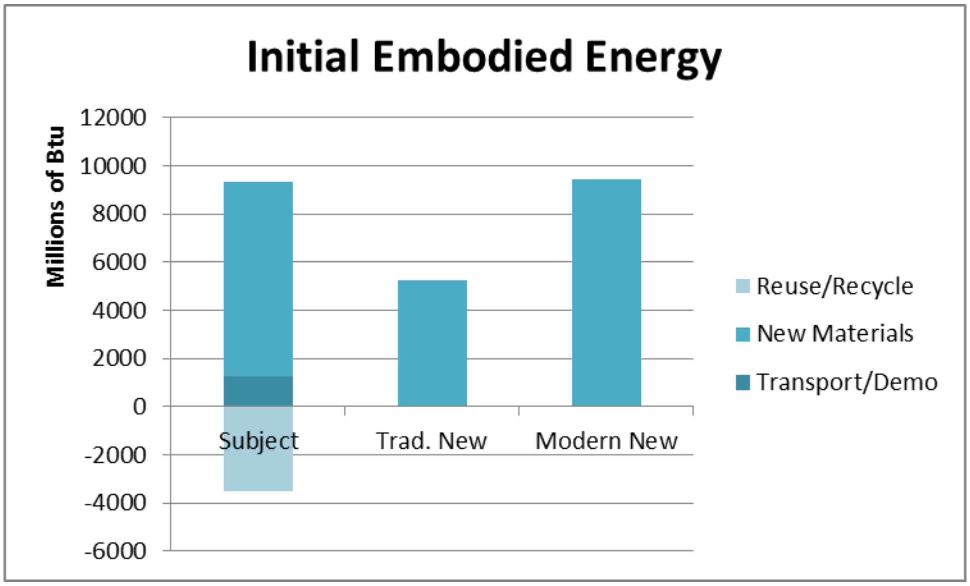

Chart displaying embodied energy costs of Subject and Alternative Construction Cases for St. Gerard's Catholic Church. Image: Author.

CONCLUSION

In our world of diminishing resources and increasing energy costs, the value of whole (or even partial) building re-use is measurable and potentially significant. The responsibility to reduce the ecological impact of the building sector is shared between architects, engineers, planners, and building owners and available data and metrics should be used to motivate the consideration of existing durable building stock when confronting the design of a new structure. Moreover, these preliminary results, and similar studies, emphasize the broader impacts of designing single-use, rapidly obsolete buildings, particularly when the energy and attendant construction-site impacts of existing, durable structures with flexible and adaptable floor plans can be feasibly extended and further amortized.

In situ re-use is often the simplest and most sustainable option, both quantitatively and qualitatively, when tradition, place, and culture are considered alongside empirical data related to energy and construction cost. The ability to quantify the ecological impact of recycling entire buildings can be a powerful tool enabling architects and engineers to make more informed decisions when considering when to demolish or save an existing structure. As these select case studies reveal, the environmental benefit of reusing buildings and, in some cases, select components is clear when we compare conservation approaches with modern construction methods. In order to ensure a more sustainable future, the paradigm for building-scale resource consumption must shift, as the cases reveal, from a mode of single-use distinctness to one of large-scale conservation and durability.

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