Life Cycle Assessments: Lighting, HVAC, Loans, and Treatments

By Sarah Nunberg, Pamela Hatchfield, Dr. Matthew Eckelman, and the AIC Sustainability Committee

How do I know which option is "greener?"

As conservators, we collaborate with other museum professionals and related fields to choose proper light sources, HVAC systems, treatment methods, and exhibition materials for collection care. Our selections are based on cost, resources, and safety of the artwork. Since the 1990's, industries have used the life cycle assessment tool to address the environmental, social and economic impact of their actions, enabling them to make educated choices in their production, manufacture and disposal methods. In this study, the American Institute for Conservation of Historic and Artistic Works (AIC) and the Museum of Fine Arts, Boston (MFA) have commissioned Northeastern University (NEU) environmental engineering students under the direction of Dr. Mathew Eckelman to address issues concerning choices we make in art and heritage conservation.

What Is Sustainability?

"…Development that meets the needs of today without compromising the needs of future generations." (1987 World Commission on Environment and Development on Our Common Future)

What is a Life Cycle Assessment (LCA)?

A quantitative tool used to evaluate the environmental and human health impact of an action or product from cradle to grave. It is a holistic approach that takes into account the extraction and treatment of raw materials, product use and disposal.

Methodology

Data gathered at the MFA, Boston was evaluated using SimaPro 7.3- professional software with the inventory databases Ecoinvent, TRACI, and BEES (Building for Environmental and Economic Sustainability).

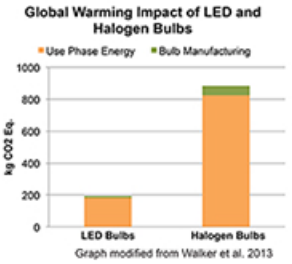
LCA Pros and Cons

The LCA focus depends on client interests and the LCA practitioner's approach, both of which are subjective. For example, in the loan LCA of this study, the number of views was used to normalize the study. Using this approach, we found that an exhibit traveling from Boston to Nagoya, Japan resulted in a much lower impact than an exhibit traveling to Tampa, Florida because the exhibit in Japan received over ten times more visitors. If the number of views was not given a weight, the study results would have been very different.

What is the environmental impact difference between LEDs and halogen lamps?

Introduction: In one gallery the MFA put light-emitting diode (LED) lamps in housings intended for halogen bulbs, but found that the LED lifespan was significantly shortened. An LCA comparing MR16 halogen lamps to MR16 LED lamps placed in halogen housing was conducted to determine if the MFA should continue using LEDs in the original housings, or return to using the halogen bulbs. The MFA has about 25,000 lights with maintenance and energy use comprising about 35% of the Museum's total utilities costs. The efficiency and impact of material use from cradle to grave was examined for both lamps.

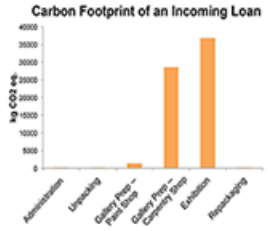
Results and Discussion: The graph on the left compares the cradle to grave impact of halogen bulbs with LEDs, illustrating that **LEDs are over four times more efficient than MR 16 halogens** even considering the shortened lifespan when the LEDs are used in a housing intended for halogen bulbs. Specifically, use of LED lamps results in ¼ the environmental impact from cradle to grave compared to halogen lamps when considering global warming impact, human health impact and eco-toxicity.

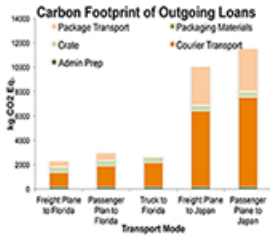


Graph modified from Walker et al. 2013

What aspects of a loan have the biggest environmental impact?

Introduction: Exhibition preparation calls for case and gallery construction made from high environmental impact materials, often produced from virgin natural resources. Loaning objects requires specialized packing materials, transport of objects, and courier transport. In this LCA we studied the environmental impact of an incoming loan and transport of art and couriers from the MFA to the Nagoya/Boston Museum of Fine Arts in Japan, and another from the MFA to the Tampa Museum of Art, Florida. The LCA considered the carbon foot print resulting from gallery preparation, art packing, crate construction, and exhibition space preparation, with one round trip for the artwork and two round trips for couriers. The assessment assumed one three-foot by three-foot crate for a ceramic vessel.





Graphs modified from Sanchez et al., 2013

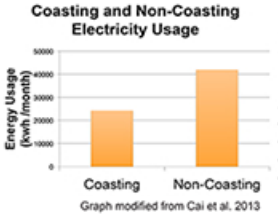
Results and Discussion: The graphs (left) depict the carbon footprints of incoming and outgoing loans. For exhibition and preparation phases, the **biggest contributors to carbon emissions are Plexiglas® vitrines, lighting and climate controls. Crate and Plexiglas® reuse would significantly lower the loan carbon impact.**

Out of all the loan activity analyzed, couriers contributed more than twice as much as the packing materials and crate construction, traveling two round trips for every single art object trip. The development of a national courier network is encouraged as one way to reduce courier impact, allowing for designated couriers to meet the artwork at its destination.

How much energy does regularly shutting down, or "coasting," the HVAC system save?

Introduction: The MFA wanted to determine energy (and cost) savings from the temporary shutdown of air handling equipment for a group of galleries in a newly constructed wing. The galleries (in blue at right) are composed of 16 zones over four floors with a total volume of 650,000 cubic feet. Data was collected from March 6 to April 4, 2013 when the HVAC system was shut down each night for 12 hours (10 PM - 10 AM). During shutdown, 50% of supply and return fans were shut off. If the relative humidity dropped below 40% or above 60%, or the temperature dropped below 18 °C or above 24 °C, the system came back online.

Central American Wing Gallery shown in blue



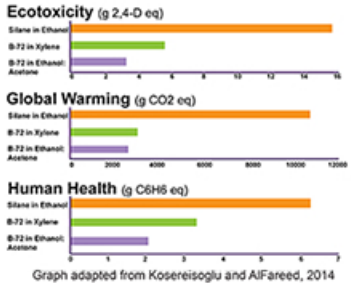
Graph modified from Cai et al. 2013

Results and Discussion: **The energy use during periods of system shutdown resulted in 40% savings of kwh/month.** The application of this study to other institutions must always consider the unique nature of the specific building structures, climates, and galleries in question.We encourage institutions to consider the potential energy and cost savings from controlled, periodic air handler shut downs. The wear of the system resulting from repeated turning on and off should be examined further.

Which Has a Higher Human and Environmental Impact: Tetra-ethyl siliate (silane) or Paraloid™ B-72 in Acetone:Ethanol or Paraloid™ B-72 in Xylene?

Introduction: This study examined the environmental and human health impact from solvents and consolidants used to treat a Romanesque sandstone church façade exhibited inside the MFA. Three systems were examined: B-72 in acetone:ethanol, B-72 in xylene, and silane in ethanol. Aspects of environmental impact included: global warming in grams of CO2 eq, acidification, human health - cancer and non cancer, air pollutants, eutrophication, ecotoxicity, smog, natural resource depletion, habitat alteration, water intake, and ozone depletion.

Church Portal from San Miguel Uncastillo, Spain
Accession Number: 28.32
Museum of Fine Arts, Boston ©



Graph adapted from Kosereisoglu and AlFareed, 2014

Results and Discussion: The study found that **silane use accounted for over three times the impact of B-72** in all areas due to the high energy output required for production. Interestingly, for B-72 the resin production itself had lower impacts (except for water intake) than the ethanol:acetone or xylene.

Conclusions

The LCA studies were successful in their analysis of lighting options from cradle to grave, global warming impact of a loan and exhibition, energy and cost savings from controlled shutdown of air handling units, and examining aspects of consolidants and their environmental impact. Although the lighting study unequivocally demonstrated the benefits of LED use in galleries, the HVAC systems analysis clearly demonstrates the need for caution in applying LCA results too broadly. Although LCA work is subjective and the focus depends on the client requests and the skill of the practitioner, the relevance of the study requires full participation by someone fluent in the field of focus. For art and heritage conservators to take advantage of LCA, it will be necessary to collaborate with environmental engineers and LCA practitioners . Conservators should also venture to use the LCA programs themselves as familiarity with the software tool can add to a deeper understanding of the materials we use, the environmental, social and economic impact of the methods we depend on, and our ability to "go green."

Further Research

Future work will include a systematic evaluation of potential LCA projects to determine the most beneficial topics for study. Adaptation of LCA software programs that museums could use for site-specific work is another goal.

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