

King School Carbon Accounting Study
September 11, 2012

RE: Carbon Accounting for the Martin Luther King School Renovation and Construction Design Options

Dear Mr. Healy,

The documentation for the Martin Luther King School project includes a study of "Carbon Accounting for Martin Luther King Jr. Design Options", by Linnean Solutions. This study examines the carbon impact of the several new construction and renovation options for the school, including both the carbon embodied in the construction or renovation, and the carbon footprint due to annual operational energy use. By graphing the cumulative total carbon footprints of the schemes over time, the study estimates when the break-even point between various schemes will occur: the year in which the lower annual carbon footprint of new construction schemes will compensate for the higher initial embodied carbon of their construction, when compared to the lower initial carbon footprint and higher annual carbon footprint of the renovation scheme.

The calculations indicate that the break-even point between the most efficient of the new construction scheme (the "Pi scheme") and the pure renovation option ("Current Modified") will be in 2025, only 13 years from now, and that of the other two new construction schemes are in 2024 and 2026, a result strongly in favor of accepting the greater initial carbon impact of new construction in return for its higher operating efficiency.

We appreciate the City of Cambridge's, Perkins Eastman's, and Linnean Solutions' efforts to understand the carbon impacts of the various options. We believe that analyses such as Linnean Solution's will be very helpful in guiding long term decisions regarding municipal construction in Cambridge. They should be undertaken as a matter of course as the City of Cambridge takes a leadership role in minimizing the emission of anthropogenic greenhouse gasses.

We recognize that our understanding of the issues and of the scope of Linnean Solution's work is incomplete, and that there are reasons for preferring the new construction schemes that have to do with issues other than carbon footprint. However, the Carbon Accounting Study itself does not make a convincing case for new construction. Our comments and questions regarding the Study fall into four broad categories:

1. Defining the parameters of comparison so as to fairly evaluate alternatives (so as to create "apples-to-apples" comparisons),
2. Energy use and carbon footprint in general, and the overall climate within which this energy is used (which by affecting the annual carbon footprint of operating the building in all of the schemes will affect how long it will take to arrive at the break-even point between them).
3. Questions about apparent discrepancies in the calculated quantities of carbon.
4. The issue of net-zero energy.

1. Apples to Apples issues:

In several important respects, the comparison of the carbon footprint of the pure renovation scheme ("Current Updated") to the several new construction options isn't "apples-to-apples": The three new construction schemes incorporate Photovoltaic arrays to generate electricity on site, while the renovation scheme doesn't. The three new construction schemes include geothermal heat pump systems, and heat exchangers, while the renovation scheme seems not to. In addition, it is not clear how the carbon accounting addressed the issues of window replacement and the carbon footprint of demolition.

Photovoltaics:

Based on the study (p 8), about half of the difference in operational carbon footprint between the three new construction schemes (about 500 tons of CO2 equivalent / year) and the renovation scheme (about 800 tons of CO2 Equivalent / year) derives from the energy contribution of photovoltaics on the roofs of all three new construction schemes. One of the three new construction options retains the roof shape of the southern wing of the existing building; evidently the irregularities of that roof and skylights don't preclude a PV installation. If one assumes that photovoltaics could be also added to the renovation option ("Current Updated"), and accordingly credits the building with half the difference between the carbon footprint of the renovation vs. the new option (i.e.: if one assumes that the Current Updated scheme's annual CO2 footprint is 650 tons / year, rather than 800), the breakeven point in total CO2 footprint would change from 2025 to roughly 2035.

Thus it appears that the addition of photovoltaics on the roof of the existing building would eliminate about half the difference between the energy performance of the renovation scheme and the new construction. Unless the renovation option is completely out of consideration for reasons besides carbon footprint, it seems that it would be well worth asking Linnean Solutions to calculate the potential benefits of a Photovoltaic system.

Geothermal:

Was a Geothermal Heat Pump System modeled for the Current Modified option? The estimate includes it for the three new construction schemes, but the Linnean Study doesn't mention it. If Geothermal wasn't included in the Current Modified option, then adding it would push the break-even point farther into the future.

Heat exchangers:

Were heat exchangers for the recapture of both the energy of heated and cooled air modeled for the Current Modified option? The estimate includes it for the three new construction schemes, but the Linnean Study doesn't mention it. If heat exchangers

weren't included in the Current modified option, then adding them would push the break-even point even farther into the future.

Windows:

The renovation option ("Current Updated") seems to not have included the replacement of its windows, which may have a considerable energy benefit, and if so would push the break-even point of new construction schemes vs. renovation even further into the future.

Demolition:

It seems fair to include the carbon footprint of demolition and the transportation of construction waste from the site. Was it included in the carbon assessment of the new construction options? Note that not only would there be less demolition waste from the Current Updated option, there would also be less demolition waste in the Existing Modified option than in the other two new construction schemes.

2. General issues of energy use, carbon footprint, and climate:

Carbon Intensity of Electricity:

We hope and expect that the carbon intensity of electricity – the amount of carbon produced per kwh - will decline over the next 50 years, as additional sources of renewable electricity (wind, solar, tidal, etc.) come on-line and produce an increasing portion of our electricity. A reduction in the carbon intensity of electricity would push the break-even point between schemes farther into the future.

- What were the assumptions about the carbon intensity of electricity over the time frame of the study?

Climate Predictions:

What assumptions were used about the future climate?

- What were the assumed degree days of heating and cooling in the context of global warming?

Constraints of the site:

The study points out that the site is not large enough for photovoltaics to contribute enough electricity to operate the building. The building cannot achieve net-zero energy on the site.

- Were off-site options for generating electricity considered?

Efficiency and Alternative Energy Sources:

Various other energy efficiency possibilities and possibilities for on-site energy capture could be applied to all schemes. Doing so would reduce their annual operating energy and therefore would push the break-even point between the total carbon footprints of the schemes farther into the future.

- HVAC Systems:
 - What assumptions were made about Heating, Ventilating, and Air Conditioning systems?

- Was Displacement Cooling considered (for the new construction schemes)?
- What were the assumptions about operating set points? Are the City and School System willing to utilize higher than typical summer settings and lower than typical winter settings?
- Is the HVAC control system capable of utilizing open windows on nice days? How many days per year would this enable the heating and cooling to be shut off?
- Was Solar Hot Water considered?
- Water:
 - As the treatment of water uses a considerable amount of energy, efforts to reduce the amount of fresh potable water used by the building (such as the use of greywater for toilet flushing) will have energy implications. Would these be worth modeling?
- Construction:
 - How great would be the benefit of using Low Carbon Intensity and High Carbon Absorbing Concrete.
 - What window systems were assumed? (triple glazed?)
 - What were the assumptions about the long term durability of materials – minimizing the carbon impact of replacing finishes and equipment over time?

3. Apparent inconsistencies:

There are several apparent inconsistencies in the relative representations of the quantities of carbon for the schemes. It is quite possible that these are not significant – that they do not affect the overall outcome, but it would increase confidence in the study if they were explained or corrected if appropriate. They include:

- The relative amounts of carbon for the schemes as shown on the two diagrams on page 7.
- The embodied energy of the various schemes as shown on the diagram on page 9 vs. the embodied carbon of the schemes as shown on page 7.
- The operational energy of the various schemes as shown on page 9 vs. the attendant CO₂ emissions as shown on page 8. (One would think that the Pi scheme would be able to use more BTU's of operational energy relative to its operational carbon footprint than the Current Upgraded scheme, since the Pi scheme is getting some of its electricity from photovoltaics and the Current Upgraded scheme relies solely on the power grid.)

4. Net Zero in Cambridge:

Note that according to the analysis, none of the schemes achieves net-zero energy. The graphs of cumulative energy use by the various schemes increase every year, rather than run horizontally. We understand that given the high operating energy demands of a school building—with its high occupancy, high plug loads, kitchen equipment, etc.—net-zero might not be feasible on this site.

- Is the energy use of the MLK School being considered in the context of a broader strategy of energy use by the School District and by Cambridge's Municipal buildings?

Our primary intent in the above is not to focus on the details of this particular project, but rather to make clear our support for Cambridge's efforts to reduce our Greenhouse Gas footprint, to better understand the process by which the City of Cambridge makes major decisions affecting energy and climate, and to encourage the City to fully evaluate alternatives. Nevertheless, we would be interested in reviewing the Carbon Accounting Study with Linnean Solutions should that be possible – for our own background knowledge if nothing else.

Sincerely,
Erik Thorkildsen,
on behalf of Green Cambridge

cc. City Council