EcoCalculator Assembly Definitions, Assumptions & Impact Measures

The ATHENA® EcoCalculator results reflect the assumptions inherent within the ATHENA® Impact estimator for buildings. However, the Impact Estimator offers additional options for many of the assemblies and the basic approach to developing EcoCalculator results was to select assumptions that would be fair in terms of assembly comparisons. These essential underlying assumptions are described below. Users wishing to explore other supported options can do so using the Impact Estimator.
http://www.athenasmi.org/tools/impactEstimator/index.html

Global Assumptions

- In the development of specific LCA results using the Impact Estimator, one must define quantities of assemblies, such as the length of an exterior wall. The results are presented on a per unit area (such as per square foot) basis, but the base Estimator runs used large quantities, such as 1000 linear feet of wall. This was performed to reduce the effect of end conditions, such as the additional stud at the end of a wall or the perimeter columns in a beam and column assembly.
- The Impact Estimator does not yet include all the required information for all materials or assemblies within the defined list. For materials within assemblies that are not currently supported by the Estimator, assumptions were made to approximate their environmental impact from first principles. For this version, estimated embodied effects were developed for EIFS cladding, precast concrete cladding, welded wide flange (WWF) steel columns, structural Insulated panel walls (SIPs), and Glulam and LVL columns.
- We assumed that all assemblies would be installed in either low- or high-rise office buildings, using components and loadings typical for central areas of the United States (i.e., no unique seismic loadings were considered), but with a differentiation between northern and southern climates for the purposes of properly defining assemblies in terms of thermal performance.
- The Impact Estimator requires a definition of building type, ownership and expected life. This affects the maintenance schedule and repair / replacement of certain building assemblies. For the purposes of the EcoCalculator, we assumed an “owner occupied office” building type with a 60-year life for both high and low-rise buildings.
- The life cycle stages included in the LCA results include resource extraction, resource transportation, building product manufacturing and component manufacturing (components incorporate two or more building products), transportation from manufacturing plant to building site by various modes, on-site construction, maintenance and replacement of components over a sixty year period and end-of-life (demolition) effects.

- The building exterior walls were assumed to have 40% windows by area, with all windows having low E glass..
- All concrete (except floor topping) was assumed to be 4000 psi (30 MPa).
- All cast-in-place concrete was assumed to contain 25% flyash in place of Portland cement; although this is not necessarily typical, it was considered more appropriate to use an environmentally beneficial formulation.
- All concrete masonry was assumed to contain 0% flyash, while precast concrete was assumed to contain 10% silica fume in place of Portland cement.
- All gypsum board was assumed to be 5/8" thick regular gypsum board with latex paint.
- The live load for all intermediate floors, columns and beams was set at 75 psf (3.6 kPa). The live load for roofs was set at 45 psf (2.4 kPa).
- All wood structural panels (WSP) used data for oriented strand board (OSB).
- All structural composite lumber (SCL) used data for LVL beams.
- All vapor barriers were assumed to be 6 mil PET.

Column and Beam Assumptions

- Bay sizes were set at 30 feet by 30 feet for the purpose of assessing columns and beams.
- Column heights were set at 10 feet.

Exterior Wall Assumptions

- Concrete masonry exterior walls were assumed to be 8" thick and ICF exterior walls were assumed to be 8" in total thickness.
- Cast-in-place concrete and concrete tilt-up walls were assumed to be 6" thick.
- Wood studs were assumed to be kiln dried, 2x4 or 2x6 depending on the climate zone.
- Steel studs were assumed to be 20 gauge, 1 5/8" x 3 5/8".
- Precast cladding was 4" thick, with 5,000 psi concrete
- Stucco was assumed to be Portland cement based traditional stucco with steel mesh reinforcement.
- All rigid insulation was assumed to be extruded polystyrene, 4" thick in the northern climate zone and 2" in the southern region.
- All batt insulation in exterior walls was assumed to be fiberglass, 8" thick in the northern climate zone and 4" thick in the southern region.

Interior Wall Assumptions

- Interior concrete masonry walls were assumed to be 6" thick.
- Wood studs were assumed to be 2x4, kiln dried.
- Steel studs were assumed to be 25 gauge, 1 5/8" x 3 5/8"

Floor and Roof Assumptions

- Floor and roof decking was assumed to be 5/8" OSB.
- Wood-I joists incorporated ½" thick OSB webs, and 2.5" x 1.5" LVL flanges.
- Steel joists were assumed to be 1 5/8" x 10", 16 Gauge, and 16" on center.
- All rigid insulation in roof assemblies was assumed to extruded polystyrene, 8" thick in the northern climate zone and 4" in the southern region.
- All batt insulation in roof assemblies was assumed to be fiberglass, 9.5" thick in the northern climate zone and 5.5" in the southern region.

Impact Measure Definitions

Embodied primary energy is reported in Mega-Joules (MJ). Embodied energy includes all non-renewable energy, direct and indirect, used to transform or transport raw materials into products and buildings, including inherent energy contained in raw or feedstock materials that are also used as common energy sources. (For example, natural gas used as a raw material in the production of various plastic (polymer) resins.) In addition, the measure captures the pre-combustion (indirect) energy use associated with processing, transporting, converting and delivering fuel and energy.

Global Warming Potential (GWP) is a reference measure. Carbon dioxide is the common reference standard for global warming or greenhouse gas effects. All other greenhouse gases are referred to as having a "CO_2 equivalence effect" which is simply a multiple of the greenhouse potential (heat trapping capability) of carbon dioxide. This effect has a time horizon due to the atmospheric reactivity or stability of the various contributing gases over time. The International Panel on Climate Change (2001) 100-year time horizon figures have been used here as a basis for the equivalence index:

$$CO_2 \text{ Equivalent kg} = CO_2 \text{ kg} + (CH_4 \text{ kg} \times 23) + (N_2O \text{ kg} \times 300)$$

The **air and water pollution** measures are similarly intended to capture the pollution or human health effects of groups of substances emitted at various life cycle stages. In this case we used the commonly recognized and accepted critical volume method to estimate the volume of ambient air or water that would be required to dilute contaminants to acceptable levels, where acceptability is defined by the most stringent standards (e.g., drinking water standards). The ATHENA® Impact Estimator software calculates and reports these critical volume measures based on the worst offender—that is, the substance requiring the largest volume of air and water to achieve dilution to acceptable levels. The hypothesis is that the same volume of air or water can contain a number of pollutants.

The final measure is an **ecologically weighted measure of resource use**, using weights developed in the mid 1990s through a survey of Canadian resource extraction and environmental experts, none of whom were at the time working for an industry involved in the production of any of the six

resources studied. The expert panel was asked to weigh the relative effects of extraction in terms of four dimensions: the extensiveness of the area typically impacted; the intensiveness of the typical extraction activity; the significance of the areas typically impacted; and the duration of impacts in terms of the time that it typically takes for an impacted area to return to a level of reasonable ecological balance and productivity. The resulting weights range from 1 for aggregates extraction (used to normalize the results) to 3.25 for timber harvesting in coastal British Columbia rain forests. All other resources used in products have since been given a weighting of 1 until a more comprehensive survey can be undertaken.

With regard to the air and water pollution measures, it is worth noting that critical volume approaches were well recognized in the LCA literature at least through the 1990s.[1] Those measures still stand today as an indicator of toxic flows that can have human and ecosystem health effects. Given the uncertainties associated with other measures, and the lack of international agreement on many of the otherwise accepted measures, we still feel that these two measures have value and should be retained until more robust measures can be supported. Like the other measures used in the Impact Estimator, a 'less is better' governs their relevance and interpretation.

The weighted resource use measure was not included in the original assembly analysis because, as noted in the first briefing paper, we were concerned about its Canadian focus and age. However, in view of the concerns expressed by some subcommittee members over the lack of a land use measure, we have included this measure. It comes as close as any other measure to getting at the relevant endpoints given that we are dealing with generic, or representative, LCI data.