U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON

SOLAR TEXAS

Texas A&M University

Solar Texas

Embodied Environmental Impact Narrative

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Embodied Environmental Impact Narrative
Solar Texas | Texas A&M University (TAMU)

Life Cycle Assessment

Embodied energy is the cost of energy used to produce a building. Often this energy consumption needs to be noticed. Engineers and environmentalists would reduce the operational energy consumed because this is the first concern that architectural and civil engineers think of as being more prominent. However, depending on the hours of operation, the building's embodied energy can be more costly than the operational energy. Therefore, engineers must reduce embodied and operational energy consumption to preserve the environment.

Simulation models by Solar Texas indicate that it is possible to improve housing livability while reducing embodied energy. One of our most critical steps was to increase energy efficiency using modern appliances. Our house is built from prefabricated panels and will be mass-produced. Sustainable housing will significantly outweigh the energy needed to produce a panel mold. Solar Texas has also decided to source our materials locally to reduce truck carbon emissions. The construction team we have decided to partner with is also based in College Station, Texas, meaning the carbon footprint of construction will also be reduced.

What is Being Measured

In LCA, information is gathered at every phase of a product’s life, and viewed through the lens of defined environmental impact measures such as global warming potential, primary energy consumption, air and water pollution, and use of natural resources. Typically, LCA reports on these environmental effects due to a product, building or service:

* Fossil fuel depletion
* Other non-renewable resource use
* Water use
* Global warming potential
* Stratospheric ozone depletion
* Ground level ozone (smog) creation
* Neutrification/eutrophication of water bodies
* Acidification and acid deposition (dry and wet)
* Toxic releases to air, water and land

In LCA terminology, the effects associated with making, transporting, using and disposing of products are referred to as ‘embodied effects’, where the word “embodied” refers to attribution or allocation in an accounting sense as opposed to true physical embodiment. All of the extractions from and releases to nature are embodied effects, and there are also embodied effects associated with the production and transportation of energy itself (known as pre-combustion effects). Note that all phases, but the “use” phase in particular, include environmental accounting of associated activities and their products such as periodic cleaning and repainting. For example, a life cycle assessment for a deck needs to include the energy, water use and detergents involved with cleaning, the various impacts associated with coating products like stain, and the possible replacement of some boards over the life of the deck.

Ref:http://www.athenasmi.org/resources/about-lca/technical-details/

Design Decision & Conclusion

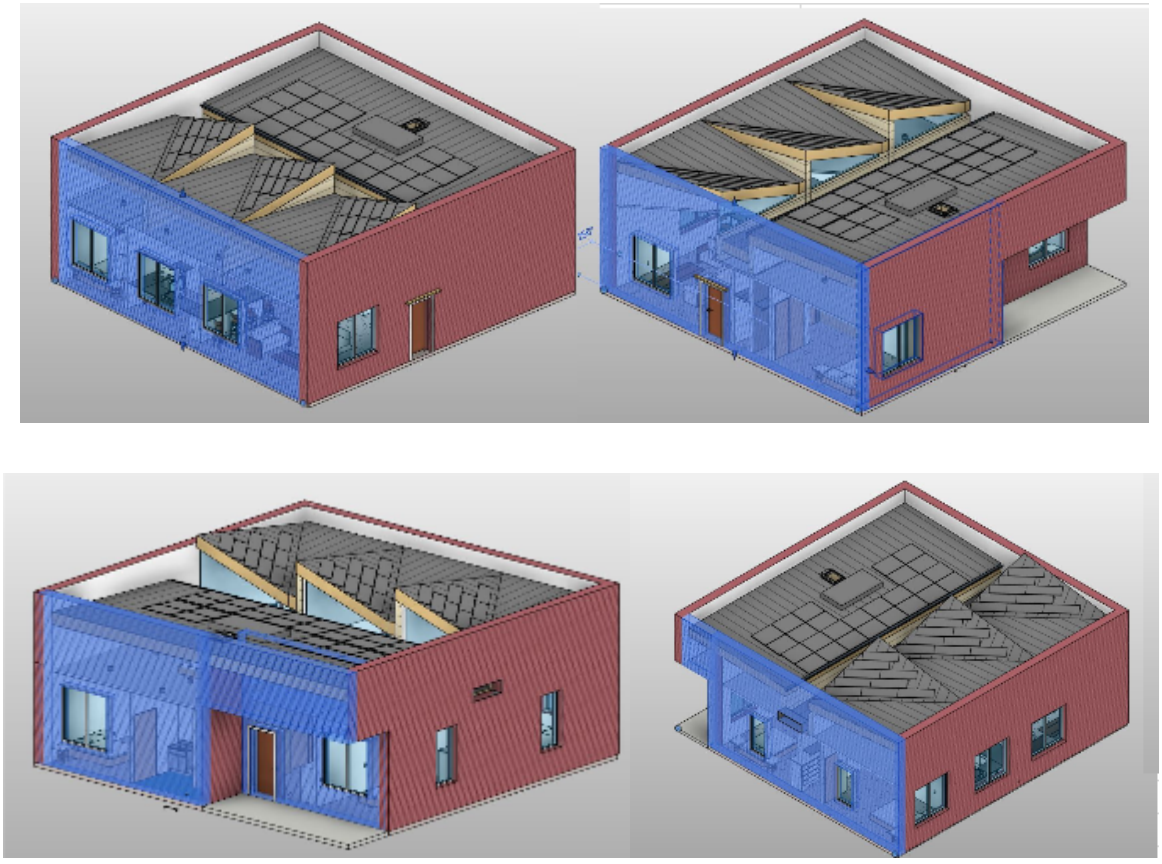

Figure 1: To quantify environmental impacts, Solar Texas team members first created Autodesk Revit models to calculate material quantities.

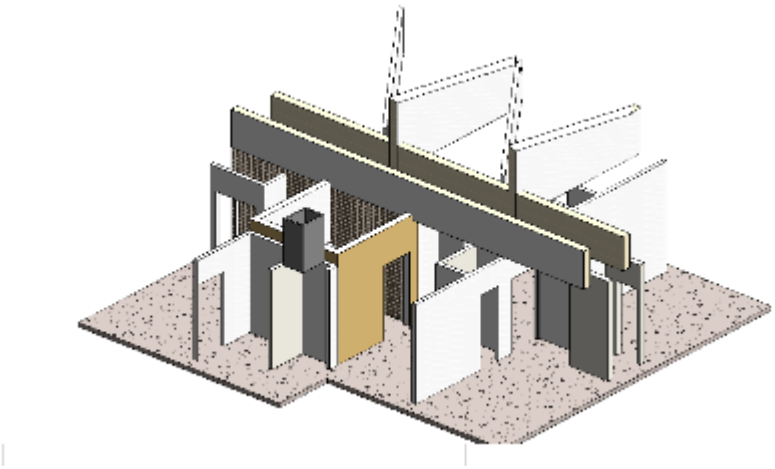

Figure 1 (cont.): To quantify environmental impacts, Solar Texas team members first created Autodesk Revit models to calculate material quantities. (Cont.)

Impact Evaluation

The Solar Texas team spent time and effort to research the various environmental impacts of the new build project. The items researched and analyzed, along with the data produced by the student team are summarized below.

Acidification:
Acidification is when air pollution from ammonia, sulfur, dioxide, and nitrogen oxides, mainly released into the atmosphere by burning fossil fuels, is converted into acids. The resulting rain is well known for its damage to forests and lakes.

Eutrophication:
Eutrophication is the increase in chemical nutrients in an ecosystem, such as nitrogen and phosphorus often found in fertilizers. The added nutrients stimulate excessive plant growth, promoting algal blooms or weeds. The enhanced plant growth reduces oxygen in the land and water, reducing water quality and fish to other animal populations.

Global Warming Potential (GWP)
Global warming potential (GWP) is an index that describes the radiative characteristics of well-mixed greenhouse gases and that represents the combined effect of the differing times these gases remain in the atmosphere and their relative effectiveness in absorbing outgoing infrared radiation. This index approximates the time-integrated warming effect of a unit of mass of a given greenhouse gas in today's atmosphere relative the that of carbon dioxide, which has a GWP of 1.

Ozone depletion potential (ODP)

Ozone depletion potential (ODP) is a number that refers to the amount of ozone depletion caused by a substance. The ODP is the ratio of the impact on ozone of a chemical compared to the impact of a similar mass of CFC-11. Thus, the ODP of CFC-11 is defined to be 1.0. Other chlorofluorocarbons and hydrochlorofluorocarbons have ODPs that range from 0.01 to 1.0. The halons have ODPs ranging up to 10. Carbon tetrachloride has an ODP of 1.2, and methyl chloroform's ODP is 0.11. Hydrofluorocarbons have zero ODP because they do not contain chlorine.

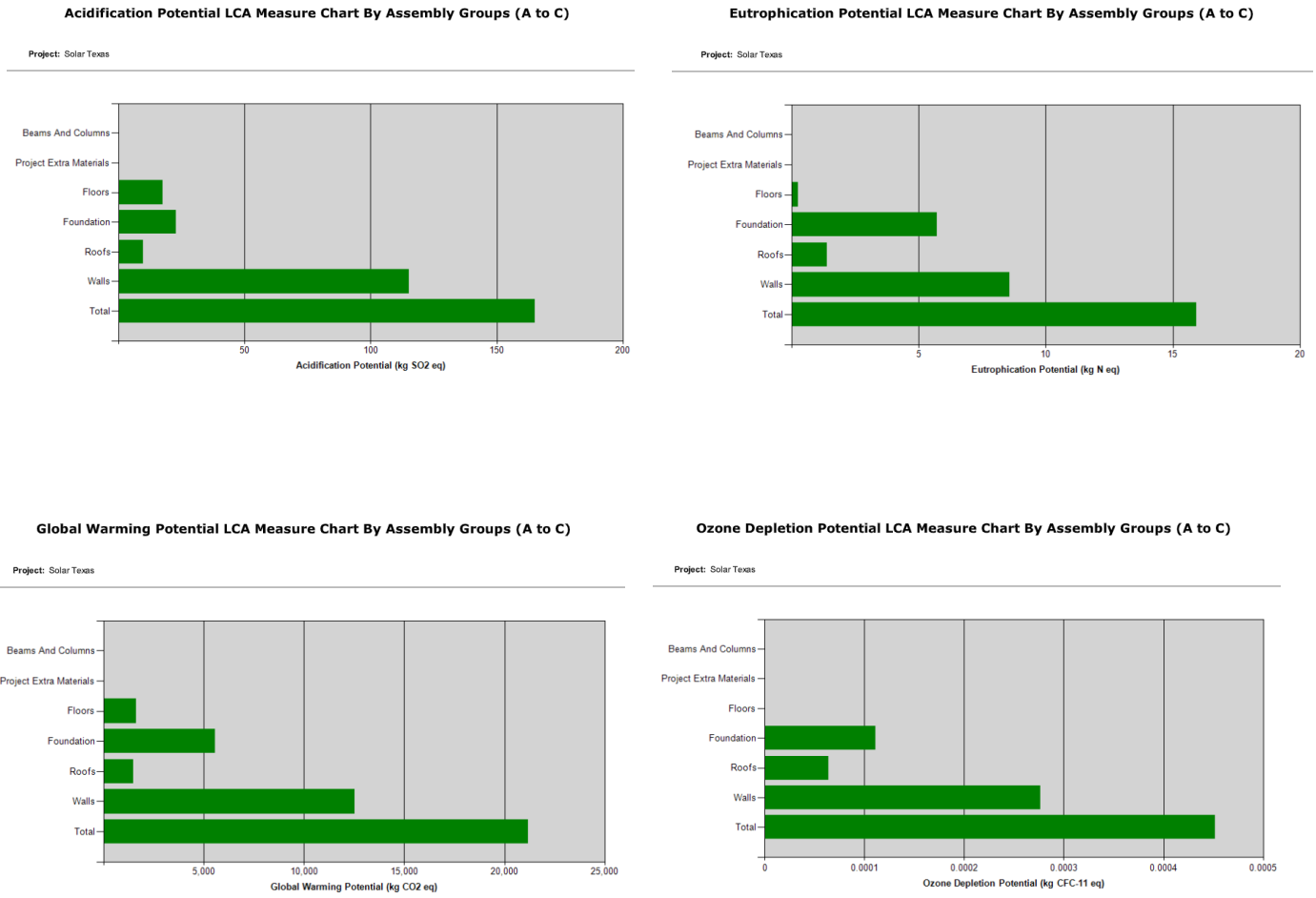

Figure 2: LCAs conducted on the home's design are encouraging, but also reveal opportunities for continuous improvement.

Table 1. Tabulation of LCA of Solar Texas home.

LCA Measure Table By Assembly Groups (A to C)

Project: Solar Texas

LCA Measures	Unit	Foundations	Walls	Columns and Beams	Roofs	Floors	Project Extra Materials	Total
Global Warming Potential	kg CO2 eq	5.55E+03	1.25E+04	0.00E+00	1.49E+03	1.61E+03	0.00E+00	**2.12E+04**
Acidification Potential	kg SO2 eq	2.27E+01	1.15E+02	0.00E+00	9.81E+00	1.75E+01	0.00E+00	**1.65E+02**
HH Particulate	kg PM2.5 eq	4.02E+00	1.88E+01	0.00E+00	3.90E+00	5.96E+00	0.00E+00	**3.27E+01**
Eutrophication Potential	kg N eq	5.72E+00	8.58E+00	0.00E+00	1.38E+00	2.49E-01	0.00E+00	**1.59E+01**
Ozone Depletion Potential	kg CFC-11 eq	1.11E-04	2.76E-04	0.00E+00	6.41E-05	7.96E-09	0.00E+00	**4.52E-04**
Smog Potential	kg O3 eq	5.51E+02	1.53E+03	0.00E+00	2.83E+02	9.45E+01	0.00E+00	**2.46E+03**
Total Primary Energy	MJ	4.36E+04	2.17E+05	0.00E+00	4.45E+04	2.76E+04	0.00E+00	**3.32E+05**
Non-Renewable Energy	MJ	4.24E+04	1.89E+05	0.00E+00	3.14E+04	2.76E+04	0.00E+00	**2.90E+05**
Fossil Fuel Consumption	MJ	3.94E+04	1.85E+05	0.00E+00	3.07E+04	2.75E+04	0.00E+00	**2.82E+05**

Innovation Achieving LEED Standards

Architectural engineers learn that the best building is the building that already exists, and embodied energy proves this to us. The most crucial step in reducing embodied energy costs is constructing buildings with longevity in mind. The fewer buildings built means there will be less embodied energy costs. Building renovations also contribute to embodied energy, and engineers should use proper judgment to decide if renovating a building or constructing a new structure in its place is more energy efficient and better for the environment overall. Solar Texas has decided that building a new structure in our chosen neighborhood is the best action. This is due to the cheap and poorly manufactured housing surrounding the construction site. Our new structure will be built to harness solar energy and follow stringent energy standards provided by ASHRAE and the United States Department of Energy. ASHRAE Standards 90.2, 189.1, 62.1, and 55 were met with this project in addition to IECC.

Embodied Environmental Impact Jury
Design Decision & Conclusion

Solar Texas exceeds its net-zero energy status with a HERS score of -37 in accordance with reducing the home's environmental impact. Through several design strategies, Solar Texas has reduced energy consumption and implemented ways to self-produce enough energy to function on its own. This "net zero" target promotes the depletion of greenhouse gas emissions by balancing the amount of these harmful gasses in the atmosphere. This, in turn, will reduce the home's carbon footprint, which is the ultimate goal in responding to climate change.

Energy Performance:

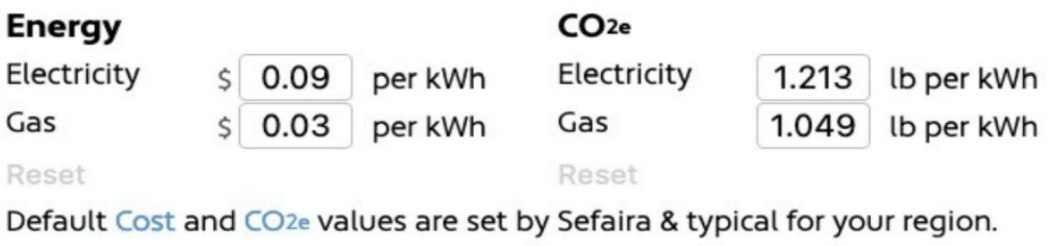

Figure 2: Cost and CO_{2e} values for Typical Home

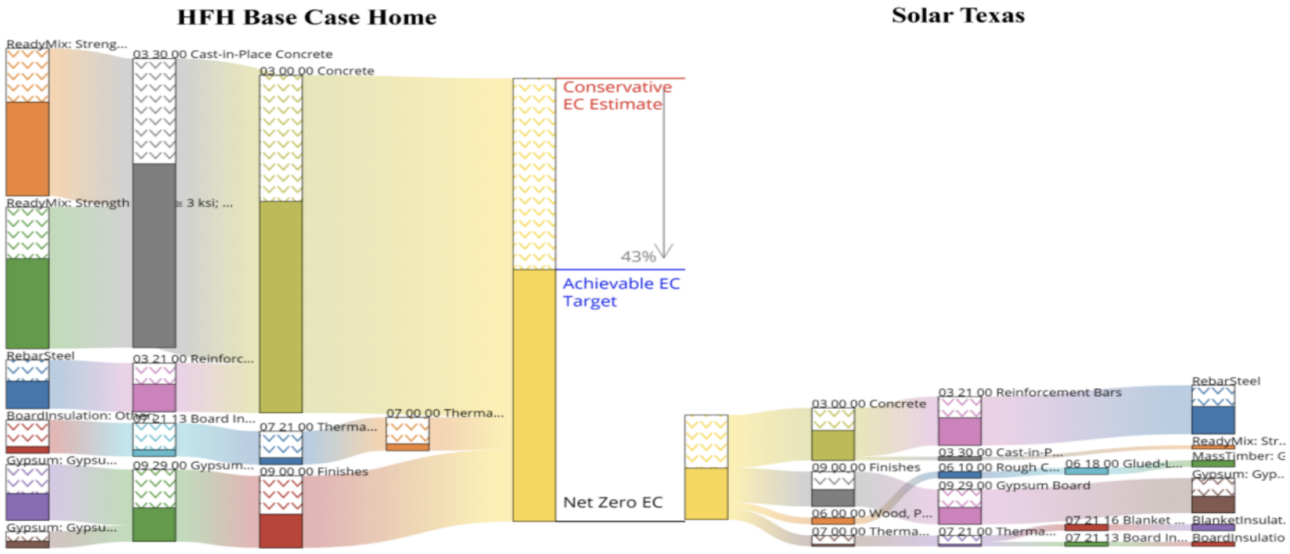

Figure 4: Life Cycle Assessment Analysis comparing a Base Case Home for Habitat for Humanity vs. the Solar Texas home

Impact Evaluation:

By implementing environmentally sustainable features, this proposed home is able to have an annual energy impact of"net zero". Through reducing energy consumption Solar Texas was able to decrease the electrical load on the home significantly. Some of the design features that allowed this home to decrease the load so significantly include: building orientation, window type, window-to-wall ratio, roof and wall insulation, reducing HVAC loads, use of energy-efficient utilities, and infiltration rate. In order to reduce the energy consumption of the buildings, the home is also proposed to provide significant amounts of clean energy that allow this dwelling to be deemed net zero energy. Solar Texas's home is able to produce a significant amount of solar energy using PV and BIPV solar photovoltaic panels. The average home in the United States typically consumes around 10,000 kWh per year from the grid. Per Figure 1, the Sefaira default CO_{2e} values per kWh is 1.213 pounds for the region our proposed home is located in. Thus, a typical home emits around 12,130 CO_{2e} per year. However, Solar Texas's proposed home is achieving net zero energy consumption. Thus, through this net zero milestone, this home is saving about 12 thousand pounds of CO_{2e} per year compared to the average home.