

Life Cycle Energy Analysis of Single Family Residential Buildings Over Decades: Atlanta Case Study

Arezoo Shirazi and Baabak Ashuri, Ph.D.
Georgia Institute of Technology
Atlanta, Georgia

According to the United Nations Environment Program (UNEP), by the increasing number of population in the urban area, there is an urgent need of city-level action on reducing environmental emissions. Based on the 2015 US energy flow chart, residential and commercial buildings are responsible for around 20% of US energy consumption and consequential environmental emissions. Therefore, there is a great need of a systematic national and regional observation and management plan for monitoring buildings' energy consumption and their environmental impacts. Several studies have been conducted previously on observing and analyzing total energy usage of a particular building (residential, commercial such as office buildings and universities, etc.) over its life time and different environmental emissions associated with it. The goal usually was to identify the main contributors to energy usage and environmental emissions within the scope of buildings, with the idea of moving toward more efficient and environmental friendly buildings in the future. Furthermore, researchers went beyond building scenarios, and included transportation and other infrastructures such as pavements, water and waste water to expand the study to the urban scale. However, very few studies focused into buildings of a region which have been built over decades.

The objective of this research is to study the energy consumption rates for residential buildings built in each decade separately, and observe the trend of embodied and operational energy usage and the total environmental emissions in the City of Atlanta. In this research, embodied energy is the energy consumed by all of the processes associated with the production of a building, from the mining and processing of natural resources to manufacturing, transport and product delivery. The goal is to analyze the building's life cycle energy portfolio considering their year of built and compare the results. Finally, the main question of this research is whether to keep the older buildings or construct new ones from the sustainability perspective. For this purpose, we have quantified the operational and embodied energy consumption of residential buildings and assessing the life time environmental emissions of them in the City of Atlanta. Life-Cycle Assessment (LCA) is one of the most powerful quantitative sustainable technology management tools to assess the environmental impacts of a system. Therefore, process-based LCA method has been used to calculate the embodied energy of buildings considering their construction methods and materials. To this end, several qualified estimations were made and validated by regional building construction experts. For building operations, nationally averaged public datasets such as Department of Energy (DOE) and Residential Energy Consumption Survey (RECS) from US Energy Information Administration (EIA) were utilized. In addition, simple building energy simulation scenarios were conducted using EPC building energy simulator tool developed at Georgia Tech to increase the accuracy of the results.

The preliminary results indicate that there is a decreasing trend in the total operational energy consumption over the life cycle of residential buildings, as the building's year of built get newer. The embodied energy however, was almost constant for different categories of buildings. The result of this research can be used by policy makers and city planners to improve the sustainability and energy-efficiency of this metropolitan areas.

Keywords: Life Cycle Energy Analysis, Life Cycle Assessment, Residential Buildings