Due to increasing concerns for global climate change, onshore and offshore wind energy technologies have stimulated a tremendous interest worldwide, and are considered as a viable solution to mitigate the environmental impacts related to electricity generation. Although wind energy technologies have been considered as one of the cleanest energy sources, they have a wide range of direct and indirect environmental impacts when the whole supply chain is considered. This study aims to quantify the direct and indirect environmental impacts of onshore and offshore wind power technologies by tracing all of the economy-wide supply chain requirements. To accomplish this goal, we developed a comprehensive hybrid life cycle assessment (LCA) model in which process-based LCA model is combined with the economic input-output (EIO) analysis. The analysis results show that on average, concrete and steel and their supply chains are responsible for 37% and 24% of carbon footprint, consequently. On average, offshore wind turbines produce 48% less greenhouse gas emissions per kWh produced electricity than onshore wind turbines. For the onshore wind turbines, concrete, aggregates, and crushed stone approximately consume 95% of total water in this construction phase. On the other hand, concrete, lead, copper, and aggregate are responsible for around 90% of total water for the offshore wind turbines. It is also found that the more capacity the wind turbine has, the less environmental impact the wind turbine generates per kWh electricity.

Moreover, based on the economic and environmental impacts of studied wind turbines and also three more nonrenewable energy sources, this study develops a decision making framework to understand the best energy source mix for a building in the state of Florida. This framework accounts for the uncertainty in the input material by deploying a Monte Carlo simulation approach. The results of decision making framework show that natural gas is a better option among nonrenewable sources. On the other hand, V90-3.0 MW offshore wind turbine is the best source of energy among renewable energy sources for a building.

The findings of this research are critical for policy makers to understand the direct and indirect environmental impacts of different onshore and offshore wind energy systems. Also this study furnishes the decision maker with a range of possible energy mixes based on different economic and environmental weights.

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Approved for distribution by Dr. Mehmet Tatari, Committee Chair, on September 15, 2013.

The public is welcome to attend.