Sustainable Innovations for Electricity Generation in Ontario

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The electricity generation sector is far from sustainable; in Ontario, 77% of electricity consumed is generated from non-renewable sources such as coal, natural gas and nuclear. As a result, this sector contributes significantly to many environmental challenges including global warming, smog formation, and acid deposition. It is critical to improve the sustainability of electricity generation through the incorporation of sustainable design concepts. Sustainable design takes into account the environmental performance of a product or process over its entire life cycle (including design and development, raw material acquisition, production, use, and end-of-life). Innovative design has resulted in new technologies for electricity generation. Generating electricity from biomass is one of the alternative technologies which could have the potential to improve the sustainability of the electricity generation sector. In this research we examine various scenarios for displacing coal-based generation. Coal gasification is a mature technology and to replace some or all of the feedstock with biomass, a re-design of some portions of the electricity generation technology are required. The technical changes in the process depend on several issues including the physical and chemical characteristics of biomass. We evaluate the environmental performance of electricity generation from agricultural residues through conducting a life cycle inventory for three biomass-to-electricity scenarios for the Province of Ontario; 1) a 5% co-firing of agricultural residues with coal in existing coal plants, 2) a 15% co-firing of agricultural residues with coal in existing coal plants, and 3) a hypothetical power plant which produces electricity from 100% agricultural residues using biomass gasification technology. For comparison purposes, we analyze a current coal only option using plant specific data. We quantify life cycle energy use, greenhouse gas and air pollutant emissions for electricity. Our results suggest that on a life cycle basis electricity generated from biomass can achieve a reduction in greenhouse gas emissions of 4% (for the 5% biomass co-firing) to 96% (for the 100% biomass gasification) compared to the coal-only option. Similarly, reductions in air pollutant emissions (sulfur oxides, nitrogen oxides, and particulate matter) range from 4% to 98%. Our study indicates that life cycle analysis is a useful tool for assisting decision makers in the selection of more sustainable design options for future electricity generation.

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