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ARTICLE

Toward sustainable electricity generation mix: an econometric analysis of the substitutability of nuclear energy and hydropower for fossil fuels in Canada

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ABSTRACT

The dominance of fossil fuels in electricity generation fuel mix continues to undermine the importance of electricity as a critical factor for sustainable economic development. As with most economies of the world, the Canadian fuel mix for electricity generation is dominated by fossil fuels. This scenario creates both environmental and resource sustainability challenges. There are questions marks over the potentials of nonfossil energy sources to address these challenges and ensure a more sustainable electricity generation. This study aims to examine the potentials of nuclear energy and hydropower to substitute the fossil fuels of coal and natural gas in electricity generation for Canada. A trans-log production function was estimated with the ridge regression method to obtain the parameter estimates. The empirical findings show that, with the exception of coal input, all energy inputs have positive output elasticities, which indicate that an increase in the energy inputs will increase output in Canada. The results further provide evidence of positive elasticity of substitution between the non-fossil energy sources and the fossil fuels which give credence to the hypothesis that clean energy sources such as nuclear energy and hydropower have the potential to substitute for the fossil fuels of coal and natural gas the electricity generation process for Canada. The estimates show that the smallest substitution occurs between coal and gas, which is an additional evidence that clean energy has higher chances of substituting fossil fuels. Policies that promote the adoption of more renewable and clean energy sources are recommended in the body of the paper.

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Interfuel substitution; electricity; nuclear energy; hydropower; ridge regression; Canada

1. Introduction

The rising greenhouse gas emissions in several parts of the world are chiefly due to the energy mix being dominated by fossil fuels (including coal, oil, and natural gas). The same scenario of fossil fuel domination is being witnessed in the electricity generation mix (Al-Ghussain, 2019). About 16947 terawatt-hours or 63% of the total electricity was generated through fossil fuels sources, while only 2796 terawatt-hours or 10% of the total electricity was generated through nuclear energy in 2019 (British Petroleum 2020). Hence, there is a need to find substitutes for the use of fossil fuels and two of the available frontline alternative electricity generation sources are nuclear power and hydropower. On one hand, nuclear power, in addition to adding to the list of available electricity sources that can lead to the reduction of greenhouse gas emissions (Joo, Kim, and Yoo 2015; Wang and Yan 2005; Xiao et al. 2015), is not as expensive as most of the other sources of electricity generation. One of the exceptions to this advantage is when a power plant has easy accessibility to cheap fossil fuels. Moreover, nuclear energy is safe energy to use as it has the lowest mortality rate among the major sources of energy (even after accounting for a nuclear disaster such as Chernobyl and Fukushima).

While nuclear power is responsible for 90 deaths per thousand-terawatt hour, other electricity sources such as coal, oil, natural gas, hydropower, rooftop solar, and wind energy are responsible for 100,000, 36,000, 4000, 1400, 440, and 150 deaths per thousand-terawatt hour, respectively, in 2012 (Tiseo 2020). Nuclear power plants generate a huge quantity of waste heat, which are particularly useful in the agricultural sector. For instance, pre-production applications could include soil-free substrates or heat sterilization of soils that are employed in greenhouse and nursery production. Moreover, several horticultural outputs can be generated with waste heat supplied production mechanisms, especially through the utilization of controlled environment production mechanisms including greenhouses that allow numerous harvest cycles. Post-harvest processing of agricultural products that can profit from waste heat produced by nuclear power plants such as drying and preservation of grain stocks (Miernicki et al. 2020). Nuclear power plants provide the opportunity to reuse fuels. Uranium-235 and thorium are common fuels used in nuclear energy project and they can be reused. The importance of reusing fuels is that it reduces waste associated with nuclear energy.

Hydropower also offers several advantages apart from being primarily used to generate electricity. It can be deployed for flood control, irrigation, recreation activities, and even water supply. A micro or small hydroelectric power plant can generate adequate electric power for a farm, house, or

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