Optimization Model for Energy Planning with CO_2 Emission Considerations

Haslenda Hashim, Peter Douglas, Ali Elkamel,* and Eric Croiset

Department of Chemical Engineering, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada

This paper considers the problem of reducing CO_2 emissions from a power grid consisting of a variety of power-generating plants: coal, natural gas, nuclear, hydroelectric, and alternative energy. The problem is formulated as a mixed integer linear program (MILP) and implemented in GAMS (General Algebraic Modeling System). Preprocessing and variable elimination strategies are used to reduce the size of the model. The model is applied to an existing Ontario Power Generation (OPG) fleet analyzed under three different operating modes: (1) economic mode, (2) environmental mode, and (3) integrated mode. The integrated mode combines the objectives of both the economic and environmental modes through the use of an external pollution index as a conversion factor from pollution to cost. Two carbon dioxide mitigation options are considered in this study: fuel balancing and fuel switching. In addition, four planning scenarios are studied: (1) a base-load demand, (2) a 0.1% growth rate in demand, (3) a 0.5% growth rate in demand, and (4) a 1.0% growth rate in demand. A sensitivity analysis study is carried out to investigate the effect of parameter uncertainties such as uncertainties in natural gas price, coal price, and retrofit costs on the optimal solution. The optimization results show that fuel balancing can contribute to the reduction of the amount of CO_2 emissions by up to 3%. Beyond 3% reductions, more stringent measures that include fuel switching and plant retrofitting have to be employed. The sensitivity analysis results indicate that fluctuations in gas price and retrofit costs can lead to similar fuel-switching considerations. The optimal carbon dioxide mitigation decisions are found, however, to be highly sensitive to coal price.

* To whom correspondence should be addressed. Tel.: (519) 888-4567 ext 7157. Fax: (519) 746-4979. E-mail: aelkamel@cape.uwaterloo.ca.

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