Comparison of Incentive Policies for Renewable Energy in an Oligopolistic Market with Price-Responsive Demand

Miguel Pérez de Arce, Enzo Sauma

Executive Summary

Due to the great concern worldwide about reducing carbon dioxide (CO_2) emissions, different policies have been implemented to incentivize the development of renewable energy (RE) sources, such as wind, solar and geothermal, among others. This article compares the different incentive policies to encourage the development of RE. These incentive policies (carbon tax, feed-in tariff, premium payment and quota system) are modeled in a simplified radial power network, using price-responsive demand. Most results are derived assuming an oligopolistic Cournot competitive framework and that the costs of subsidies are covered by the government (i.e., customers do not directly pay back for the subsidies). We compare the different RE incentive schemes at different congestion levels in terms of energy prices, RE generation, CO_2 emissions, and social welfare.

The main result of the article is that the cost effectiveness of the different incentive schemes varies significantly depending on the market structure assumed, the costs of RE, and the subsidy recovery method considered. Subsidy policies (FIT and premium payments) are more cost effective in reducing CO_2 emissions than those policies that apply penalties or taxes, when assuming oligopoly competition and that customers do not directly pay back for the subsidies. However, quota system and carbon tax policies are more cost effective when assuming that either a perfectly competitive electricity market takes place or customers directly pay back for the subsidies through the

electricity tariff. Nonetheless, this latter result may be reversed in the case that the costs of RE dramatically drop.

We also showed that network congestion affects nodal prices, and thus social welfare, in each of the studied policies. For example, under the quota obligation system, it was observed that power transmission congestion decreases the maximum demand to be reached for a given obligation and the penalty cost, which in turn affects renewable and conventional generation. In addition, after varying the quota obligation while keeping the penalty constant, it is observed that congestion affects the quota obligation percentage that we must demand in order to attain a certain level of RE generation. This is in agreement with the findings in Munoz et al. (2013), suggesting that there should be a higher obligation demanded when there is line congestion to attain the same amount of RE generation than when there is no congestion.

Additionally, we show that in the feed-in tariff system, there is an interaction among incentive levels for renewable energy technologies. Given a certain feed-in tariff price to be set for a particular renewable technology, this price influences the optimal feed-in tariff price to be set for another technology. When applying the proposed formulations to more complex networks, we should expect that these interrelationships among RE technologies encourage even lower required FIT prices. This is due to the multi-nodal and multi-technology relationships that may occur.

Our results indicate that the best-performing RE policy varies depending on the market structure, the costs of RE, and the subsidy recovery method considered. Accordingly, in order to compare our results with those appearing in the literature, we should first answer the following questions: (1) What is the market structure considered? (2) What is levelized cost of the RE considered? and (3) Who bears the cost of the subsidy?