A CGE Study of Green Electricity Policy in Taiwan

Yunchang Jeffrey Bor*

Abstract

In order to speed up the development of renewable energy industries, the Taiwan government passed the "Renewable Energy Development Bill" in 2009. Based on the statute, a feed-in tariff subsidy policy for renewable electricity production has been framed. The fund for the feed-in tariff comes from an additional fee that the electric power providers who are using non-renewable energies are obliged to pay. The present paper adopts a CGE (Computable General Equilibrium) model to analyze the cost-effectiveness of the feed-in tariff subsidy policy. In order to find a suitable subsidy rate and a proper way of levying an additional fee for using electricity, this paper compares two different ways of levying additional fees and two different subsidy rates. The empirical evidence shows that a fixed rate in the form of an additional fee and a fixed rate in the form of a subsidy will achieve the policy goal and minimize the impacts on both the economy and the electric power industry.

Keywords: Renewable energy, electricity, Feed-in tariff, subsidy policy, CGE model.

Introduction

In 2009, the Taiwan government passed the "Renewable Energy Development Bill". The motive underlying and purpose of the statute was to increase the production and consumption of renewable electricity and to speed up the development of the renewable electric power industry. A renewable electricity production policy goal has also been set to double the generation of renewable electricity by 2020 compared to the generation of renewable power in the base year (2010) (Executive Yuan, 2010). A feed-in tariff subsidy has been included in the statute to support the policy target.

The feed-in tariff subsidy policy is one of the most commonly seen renewable energy policies in the world and is perhaps one of the most effective policies in supporting the development of renewable energies. Over 50 countries in the world

* Professor & Head, Department of Economics, Chinese Culture University, Email: byc2@faculty.pccu.edu.tw; Corresponding Author.

have a feed-in tariff subsidy policy included in their energy policies. (REN 21, 2011)

For instance, when one compares the feed-in tariff subsidy policy (Erneuerbare Energien Gesetz, EEG[1]) in Germany with the portfolio standard policy (Renewables Obligation, RO) in the United Kingdom, it is observed that the EEG policy has a higher cost in the starting period. However, when consideration is given to the overall policy effectiveness and other side effects, the total cost of EEG is actually lower than that of RO (Butler and Neuhoff, 2008).

In practice, there are three basic types of feed-in tariff subsidy policy. The first one involves providing producers with a fixed amount of subsidy for each kilowatt; the second is concerned with adjusting the amount of the subsidy every year according to the inflation rate; and the third has to do with providing a higher rate of subsidy at the beginning stage, but lowering the subsidy rate in a stepwise fashion after the industry is able to stand on its own feet (because of technology improvements and cost down). Although combining the first two policies will usually require a higher fiscal burden on the part of the treasury, such a combination will provide renewable electric power producers with more revenue and compensate for the loss due to inflation as reflected in the increased costs.

Moreover, the fixed-amount-subsidy scheme provides an expectable cash flow in the future, which in turn reduces the investment risk and creates stronger incentives to provide greater capacity for renewable electricity production. If the feed-in tariff subsidy policy could be combined with the portfolio's standard policy, then the resulting two-in-one policy will result in lower risk as well as create favorable conditions for investment by electric power companies. This may be one of the reasons why the fixed amount feed-in tariff model is adopted by most countries (Couture and Gagnon 2010).

In the new Renewable Energy Development Bill, the basic norm is that the Bill provides a feed-in tariff for renewable electricity. In order to meet the policy demand, the fund is collected from all electricity sources other than renewable sources. This pattern is similar to the Energy Tax Regime in the Netherlands (van de Lindt and Emmert, 2008). The main electric power company, the Taiwan Power Company (Taipower), is a state-owned monopoly electricity provider. Therefore, the electricity price is under state-control. In this way, the additional charge on non-renewable electricity can easily be collected by the government according to the Bill. After that

[1] Amendment to the Renewable Source Act, in English.

the fund can be used to support renewable electricity development.

There are many studies that use CGE models in the economic analysis of energy policies. Dannenberg, Mennel, and Moslener (2008) collected information on quite a few energy policy analyses that focused on EU countries. Most of the studies concluded that imposing a tax on the traditional fossil fuel energies would have a slightly negative effect on economic growth. Moreover, the economic impacts were mainly focused on energy-intensive industries because of higher energy prices. However, a tax on fossil fuel energies or a subsidy on renewable energies did effectively suppress carbon emissions and increase the consumption of renewable energies. Based on the above references, CGE models have proved capable of simulating the effects of an energy policy on the economy and industry levels. This research also builds a CGE model as an analytical tool. The purpose of this research is to simulate and compare the impacts of several methods of levying funds and remunerating feed-in tariffs. Through model simulation, this paper can find the scheme which has the lowest cost to the economy and the minimum impact on electric power providers.

Enfore-Green Model

The Enfore-Green Model was originally based on the ORANIG-RD model developed by MONASH university in Australia (Pearson, Parmenter, Powell, Wilcoxen and Dixon, 1992). Based on the ORANIG-RD model, the Enfore-Green model extends the ORANIG-RD model to a multi-dimensional and comprehensive energy policy assessment model. It integrates the energy industry/commodity module, the R&D investment module, the energy tax/subsidy module and the public finance module (Bor and Huang 2010). The Enfore-Green production sector is, basically, the combination of a hierarchical nest structure of constant elasticity of substitution (CES) system equations. Each CES production equation controls the combination and substitution of each type of commodity input, sources of the commodity (domestic economy, imports), and primary factors according to the market conditions. For example, Equation (1) describes the top level in the hierarchy of system equations. The model uses the elasticity of substitution relationships to compute a combination of the minimum cost for the output Y. Parameter α, which is computed from input data, in Equation (1) is the share of the commodity input cost. Parameter h_k, which ranges between [-1,0), in Equation (2), is set to express the CES function's curvature. The parameter h_k must be calculated from input data. In this research, part of the substitution elasticity parameter σ_k is adopted from the GTAP database for the Taiwan region and the other part σ_k is estimated by using the industrial data in Taiwan. In

Equation (1), Y is the rate of change in the output level; *x* is the rate of change in the commodity input, and *P* is the rate of change in the commodity price. Subscript k stands for commodities at the same hierarchical level, and subscript i stands for commodities at the upper hierarchical level. The output of industry is affected by the combined cost of the commodities bought, raw materials used, and primary factors serving as inputs.

$$x_k = Y - \sigma_k(P_k - \sum_i \alpha_i P_i) \quad (1)$$

$$\sigma_k = \frac{1}{1-h_k} \quad (2)$$

In the Enfore-Green model, the funds required for the renewable energy subsidy are assumed to be collected as additional fees based on an electricity charge (similar to an energy tax) imposed on all the electricity users. The additional fee is collected through the Taipower company (the sole owner of the grid) and transferred into the renewable electricity fund. The subsidy from the renewable electricity fund is given to the renewable electric power producers according to the renewable energy types and power generated. The policy can reduce the costs of the renewable electric power producers directly, with a view to reducing the price gap between renewable and nonrenewable electricity. A lower price for renewable electricity will provide an incentive for consumption.

In the model, the method used to collect an additional electricity fee involves adding a user-controlled parameter P_i' to the traditional electricity commodity bought by industry and households as in Equation (3). The user-controlled subsidy parameter is added to the renewable electricity production equation in a similar manner. By raising the price of traditional nonrenewable electricity and lowering the price of renewable electricity, the demand for renewable electricity will be stimulated.

$$x_k = Y - \sigma_k[P_k - \sum_i \alpha_i (P_i + P_i')_i] \quad (3)$$

The variables in the Enfore-Green model have been assigned according to two types: exogenous variables and endogenous variables. The values of the exogenous variables can be controlled by the user; however, the values of the endogenous variables must be generated by the model itself. Some variables can be switched according to their type, and the purpose in switching variables between endogenous and exogenous variables depends on the simulation goals of the research and the requirements of policy. The present paper uses two approaches to determine the subsidy and fee collected. The first one sets a renewable power generation growth rate as the exogenous variable, and then the model generates the subsidy amount required. The second one sets up a subsidy fund as an exogenous variable, and then the model generates the growth of renewable electricity generation by itself. As mentioned above, the government's goal in terms of renewable electricity growth is to double the renewable electricity generation by 2020. Thus, this research sets 100% growth of renewable electricity as the policy target (from 2012 to 2020), and compares the economic and industry impacts between those two simulation approaches. The input data are obtained from the 2006 input-output table for Taiwan. The baseline prediction duration is from 2011 to 2020 according to the real GDP forecast for Taiwan by the IMF (International Monetary Fund). Before policy simulation, the model calibrates all necessary parameters by performing a historical simulation from 2006 to 2010 so as to create a robust and credible representation of economic reality in Taiwan for the Enfore-Green model. By comparing the results between the policy simulation and baseline simulation, the impact of a renewable energy subsidy policy can be predicted.

Simulation Results

There are, basically, three scenarios in this paper, and all can achieve the policy goal. The first two scenarios focus on a comparison of the cost-effectiveness of the quantitative control measures and price control measures. Scenario 2 and scenario 3 compare the patterns of fee collection and subsidy payments.

In the first scheme of this research, scenario 1, the average growth rate of renewable electricity power generation is set to be uniformly fixed. Under the assumption of neutrality of tax, the model will calculate the changes in the rates of additional fees and subsidies endogenously. On the contrary, scenario 2 sets the subsidy rate and additional fee rate as being uniformly fixed, and the renewable electricity growth rate is open to endogeneity. However, due to the policy goal of 100% growth of renewable electricity, the model designs a repeat process to stop the simulation when the policy goal has been reached. The simulation results are as shown in Figure 1 and Figure 2. From 2012 to 2020, scenario 1 achieves the policy target based on a geometrical average growth rate of 7.7%. In scenario 2, the average fixed additional fee rate is 2.5% and the average fixed subsidy rate is 60% for meeting the policy goal.

Figure 1 shows the growth rates between scenario 1 and scenario 2. Scenario 1's growth rate is a positive-slope line as shown in the present paper. However, scenario

2’s growth rate is expressed as an upward curvature curve. The comparison between the subsidy fund required to reach the policy goal in scenario 1 and scenario 2 is depicted in Figure 2.

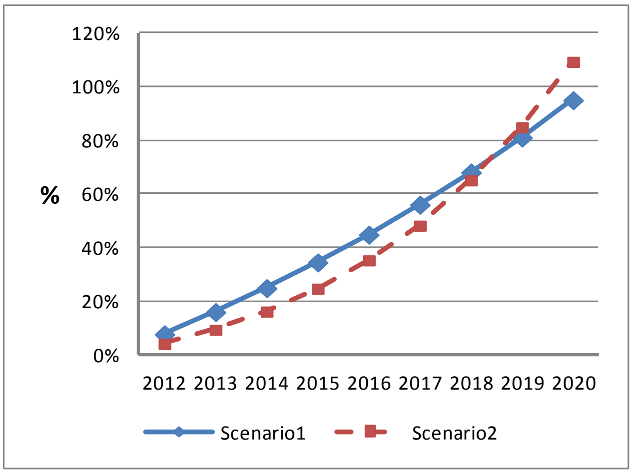

Figure 1. Renewable Electricity Growth Rate

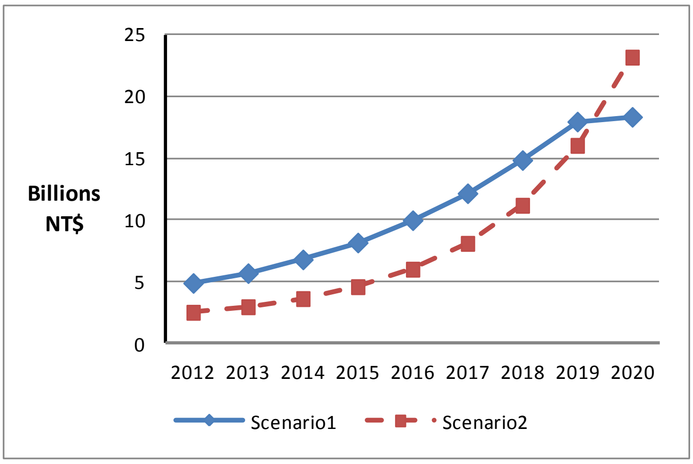

Figure 2. Renewable Electricity Subsidy

In scenario 1, the subsidy amount demanded is increased roughly evenly each year, but the subsidy rate declines gradually at a slow pace. Once the policy goal is achieved, the slope of the subsidy curve gradually becames flat. In scenario 2, the amount of the subsidy is less than the amount of the subsidy in scenario 1 at the beginning of the period, but the subsidy demand then grows exponentially. It is expected to pass the amount of the subsidy in scenario 1 when approaching the final stage of the simulation. However, during the whole of the simulation period, the total funds required based on scenario 2 amount to NT$ 78,094 million which is less than the NT$ 98,677 million based on scenario 1. Two comments can be made by observing the simulations in Figure 1 and Figure 2. First, a fixed subsidy rate policy costs less than the fixed electricity growth rate policy under the assumption of achieving the same policy goal. The basic reason for this is that the price control policy allows for more economic flexibility in electricity production and consumption. Secondly, a reduction in the subsidy rate does not necessarily have a negative impact when the scale of the renewable electricity industry grows larger and larger. This may result from the improvement in the technology and cost down.

According to the simulation underlying the Enfore-Green model, collecting an additional fee from the traditional nonrenewable electric power producers will raise the production cost, and then result in the traditional nonrenewable electricity market becoming depressed. In this paper, two ways of collecting an additional fee are compared. The first method, as in scenario 2 above, sets a fixed uniform additional fee rate of 2.5%. The second method uses a variable additional fee rate schedule, starting with a low rate, but the rate is increased each year due to the higher demands placed on the subsidy fund. The second method is as in scenario 3 in this paper. The impacts on the traditional nonrenewable electric power industry are illustrated in Figure 3.

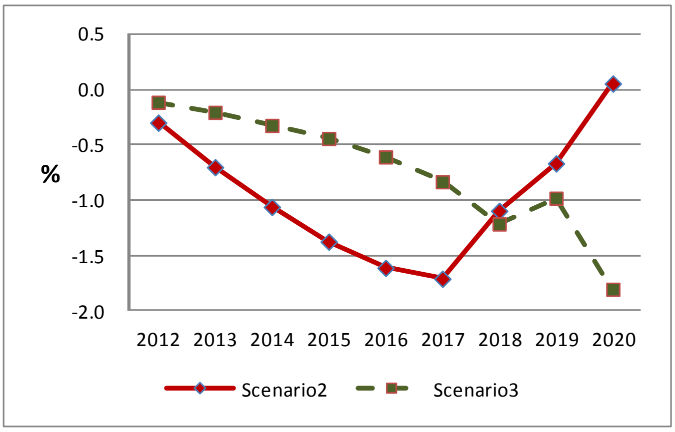

Figure 3. Production Change Rate of Nonrenewable Electric Power Industry

As in scenario 2, the additional fee rate is uniformly fixed. The traditional nonrenewable electric power industry suffers from the negative impact and their scale of operations will shrink fast. However, after a period of time, the industry is going to get back on track and grow again. The simulation shows that, under the no other change assumption for the economic environment in Taiwan, the traditional nonrenewable electric power industry will take about 5 years to adopt the policy disturbances. In the last year of the simulation period, the scale of the traditional nonrenewable electric power producers' operations will exceed the original scale in the beginning year of the simulation. On the contrary, in scenario 3, under the condition of increasing the fee rate by an additional amount each year, although at first the rate of scale shrinkage is not as rapid as the scale of the decline in scenario 2, the impact will continue to become stronger. The increasingly strong impact will cause the shrinkage to continue in the case of the traditional nonrenewable electric power industry. By the end of the simulation in scenario 3, the scale of the traditional nonrenewable electric power industry will have been reduced by about 1.8% compared to the scale at the beginning. The simulation results show that an increasing additional fee rate gives rise to a larger impact on the traditional electric power producers, as compared with the fixed additional fee rate policy. Therefore, a fixed additional fee rate plus a fixed subsidy rate may be the best policy from an economic viewpoint when developing a renewable energy policy.

Conclusion

The present paper focuses on the recently passed renewable energy policy in Taiwan. This policy includes collecting renewable electricity funds from traditional nonrenewable electric power producers, and using the funds to support the subsidizing of renewable electricity generation. The policy will have an impact on the current and long-time low electricity price policy. The goal of this paper is to find a proper way of implementing the renewable energy policy and minimizing the impact on the economy and the traditional electric power industry. The empirical evidence from the Enfore-Green model shows that the policy in Scenario 2, which is to collect an additional fixed-rate electricity fee to supplement the renewable electricity fund and provide a fixed-rate subsidy for producers of renewable electricity, is the policy that is the most cost-effective and that has the smallest impact on the economy and the traditional electric power industry. Because the electricity market is not a free market in Taiwan, renewable electricity is not yet a commodity in the electricity market. If renewable electricity and nonrenewable electricity could be combined and mixed as new electricity products, the renewable electricity industry will surely benefit. At the current stage, this research has provided a primitive assessment of the renewable electricity subsidy policy and the direction of policy to be implemented in the near future. The results of this paper are valuable for policy-makers as the future renewable electricity market requires more study and observation in Taiwan.

References

Bor, Yungchang Jeffery and Yophy Huang. 2010. “Energy taxation and the double dividend effect in Taiwan’s energy conservation policy—An empirical study using a computable general equilibrium model”. *Energy Policy* 38(5): 2086-2100.

Butler, Lucy, and Karsten Neuhoff. 2008. “Comparison of feed-in tariff, quota and auction mechanisms to support wind power development". *Renewable Energy* 33 (8) (August): 1854-1867.

Couture, Toby, and Yves Gagnon. 2010. "An analysis of feed-in tariff remuneration models: Implications for renewable energy investment". *Energy Policy* 38 (2) (February): 955-965.

Dannenberg, Astrid, Tim Mennel and Ulf Moslener. 2008. "What does Europe pay for clean energy?—Review of macroeconomic simulation studies". *Energy Policy* 36 (4) (April): 1318-1330.

van de Lindt, M.C., and S.B. Emmert. 2008. National report on the Dutch Energy Regime. TNO Built Environment and Geosciences.

REN 21. 2011. *Renewables 2011, Global Status Report*.

New Energy Development Enhancing Commission., Executive Yuan. 2010. *New Energy Developing Target, Revised Version*.

Pearson, K.R., B.R. Parmenter, A.A. Powell, P.J. Wilcoxen and P.B. Dixon. 1992. *Notes and Problems in Applied General Equilibrium Economics*. Advanced Textbooks in Economics 32. NORTH-HOLLAND.

Acknowledgement

I would like to thank my research assistant, Mr. Yen-Ting Lin, for his handling the GEMPACK program for me. In addition, I also like to thank National Science Council, Taiwan for her financial support to this study.