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Short communication

Economic, welfare and environmental impact of feed-in tariff policy: A case study in Iran

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ABSTRACT

Following a particular attention given to environmental issues over the last few decades, establishing proper developmental policies to increase electricity production from renewable energy (RE) has not only been an important issue but also a challenge for many countries. Feed-in Tariff (FIT) Policy is one of the tools that is being used to facilitate the development of RE. This research evaluated the economic, welfare and environmental impact of this policy on Iran's economy. Therefore, after developing an Economic-Energy-Environmental (E3) type of Hybrid General Equilibrium model, the effect of FIT policy was examined under different scenarios in order to find an optimal condition in which 10% of electrical energy could be produced from renewable resources. The comparison between the results showed that the application of subsidies to RE and the way the government finances these subsidies can affect the results of FIT policy. Meanwhile, regardless of the role considered for the impact of environmental factors, our policies under the scenario of technology neutral is the most efficient, as it has less impact on the decline of GDP of different sectors and also has less financial cost for government.

1. Introduction

The energy demand growth is increasing rapidly in developing countries and causes a rise in fossil fuels use (REN21, 2016). Since the conventional energy sources have negative environmental impacts, accessing a reliable, secure, affordable, climate-friendly and sustainable energy is one of the challenges these countries face. RE is considered as one of the best alternatives for substitution of fossil fuels, although high capital costs and spurring changes in the level and composition of investment make it an expensive energy source (Word Bank, 2015).

The lack of interest in external benefits of clean energy (Sovacool, 2009) higher risks of these projects (Zhou et al., 2011) have caused low investment in RE projects. Confronting these risks and the factors which are against the development of RE needs careful and deliberate Policymaking (Kancs and Wohlgemuth, 2008). The RE development policies seek to create economic justifications for the use of this type of energy (Kissel and Krauter, 2006). Similar to any other policies, it is needed to define goals and introduce possible strategies to achieve them. In addition, these policies require an implement as a means to apply their strategies (World Bank, 2012).

A number of policies have been used historically in order to stimulate the growth of the renewable electricity sector. There exist different types of policy tools to support RE development including Price Based Incentives such as Feed-in Policies, Quantity Based Incentives or Quota Obligations including Renewable Portfolio Standards (RPS) in combination with RE Certificate or Credit (REC) markets, Fiscal and Financial Incentives such as Tax Credits and Voluntary Measures such as Green Tariffs (World Bank, 2011).

One of the most common strategies used in the development of RE is the FIT policy (Hoppmann et al., 2014). FIT policy is an important policy tool supporting global deployment of RE technologies (Couture et al., 2015). As of year-end 2015, 110 jurisdictions at the national or state/provincial level had enacted FIT policies, making this the most widely adopted regulatory mechanism to promote renewable power (REN21, 2016). Developing countries that have introduced FIT policy are almost four times more likely to attract private investment in RE—resulting in about seven times more total investment—than countries where such support mechanisms have not been introduced (World Bank, 2015). FIT policy can provide a low risk of investment and high security for capital-intensive projects with a high proportion of fixed costs in total costs (Guillet and Midden, 2009).

There are a number of advantages and benefits for this policy among which we can mention: The creation of a sustainable safe market for investors (Ragwitz et al., 2007; Lipp, 2007; Lesser and Su, 2008), Significant induction of local industries and jobs creation (Lipp, 2007; Fell, 2009), low transaction cost in this policy (Fell, 2009), the

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increase in the consumers' satisfaction by creating a barrier against price fluctuations (Lesser and Su, 2008), the increase in the access to the market for investors by eliminating uncertainty around the access to electricity network (Couture and Gagnon, 2010) and finally the possibility of policy adjustments in accordance with a variety of power generation markets, including competitive and regulated markets, in addition to encouraging technology at different levels of its progress (Lesser and Su, 2008).

In contrast to all these advantages, the FIT policy has some disadvantages and difficulties such as access to a suitable location for the project (Butler and Neuhoff, 2008), and the misfit of price in the equilibrium of free market pricing. However, according to Porter Hypothesis, strict environmental rules will increase the competitiveness of enterprises, sectors and economy through developing new technology as a way to lower production costs or create other relative advantages (Dannenber et al., 2008).

Although the FIT policy is aimed to develop RE through changes in relative prices, it can also have various economic and welfare effects. Mechanisms that can cause reactions from producers and consumers have many different effects such as the cost and price effects, the structural demand effects, the multiplier and accelerator effects, and the invention and productivity effects (Ragwitz et al., 2007).

Recently, there have been a number of studies that focused on the effects of FIT policy, for example Hoppmann et al. (2014), Lin et al. (2014), Casisi et al. (2015), Peng and Pu_Yon (2015), Nordensward and Urban (2015), Couture et al. (2015), Wang et al. (2016). Due to the lack of such studies on the economy of Iran and recent decision of Iran's government to support RE by establishing guaranteed purchase policy (RE-Organization of Iran, 2016), this research is going to study the economic, welfare and environmental effects of FIT policy on the economy of Iran in an imaginary case of achieving a 10% share of RE in total electricity production. In other parts of this study, we will look at the status of RE in Iran. We will also give a brief description of the structure of the model, the simulation results, and discussion.

2. The status of renewable energy in Iran

RE holds a very small share of energy production in Iran. Besides the casual factors, this low share is because of the subsidies on energy consumption, especially the electricity production from fossil fuels. Based on the statistical reports between 2005 and 2012, the share of fossil fuels in the total primary energy supply was 99.3 present and these numbers for RE and nuclear energy were 0.63 and 0.08 respectively. Iran's energy economy indices also show a high rate of energy consumption per capita. Also, these findings indicate an increasing amount of pollutants that impose high environmental and economic costs (Energy Balance of Iran, 2013). The total welfare losses of pollutants from the energy sector in Iran's economy, in 2013, was 30,599 million 2011 U.S. dollars (World Bank, 2016).

Producing electricity from water is considered among the oldest RE in Iran. Therefore, regarding the subject of development, the focus is more on other sources such as wind, sun, geothermal and biomass. Considering the widespread windy areas in Iran, this field has a lot of potentials for development. According to the Iran's wind potentiometric project, exploitable wind potential in the country has been estimated at 100 thousand MW. On the other hand, since Iran is located in the Sun Belt, solar energy is an important Renewable source. Moreover, the national studies have estimated the maximum of 800 MW power generation from the use of Biomass (Islamic Parliament Research Center, 2011). Although Iran has not participated in international agreements that pledged to reduce emissions and greenhouse gasses, Iran's government has recently planned to support RE by establishing guaranteed purchase policy (RE-Organization of Iran, 2016).

3. The model structure

In order to study the economy, energy and environmental Interactions of FIT policy, we have used a static hybrid computable general equilibrium (CGE) model in which it is possible to consider the characteristics of power generation technology in mid-level. Using advanced mathematical techniques, Böhringer and Rutherford (2006) demonstrated an approach of linking a CGE model with bottom-up activity analysis for electricity generation while other sectors are represented by conventional functional forms used in Top-down analysis. This model is used in this study to evaluate the economic, welfare and environmental effects of FIT policy. For calibrating the model and calculating the levels of emissions, researchers use Social Accounting Matrix (SAM) table, energy balance table (2011) and specific engineering based on cost information for each electric generating technology. In order to obtain separate price and quantity observations, the common procedure chooses units for goods and factors so that they have a price of unity (net of potential taxes or subsidies) in the benchmark equilibrium.

With a given technology, the industrial sectors combine the primary factors of production with intermediate material and energy inputs to produce final consumption goods. These goods fulfill private and public consumption through the representative consumer and government respectively and meet the demand for intermediate inputs through the production sectors. When the quantity of goods supplied equals the quantity demanded, the model has achieved market clearance.

In this model, particular attention is paid to energy production. 14 economic sectors in five main groups of energy production, energy transformation, energy intensive industry, transportation and everything else have been considered. Each industrial sector produces a single output that is consumed by the representative consumer and the government and used by the production sectors as intermediate inputs. All production sectors outside of electricity generation operate with a single technology, but the electricity sector includes 5 individual technology: fossil energy (gas, steam, combined cycle, diesel), electricity wind power, solar and biogas. In the technology-based approach, each electric generating technology is represented by an individual fixed-coefficient production function, which could be active or inactive in equilibrium depending on its profitability. These production functions are combined in a logit nest. The FIT policy can decrease the levelized cost of RE technology per kWh, therefore, the new technology will receive a larger share of new investment after applying the FIT policy. In this approach, the unit cost function for a fixed-coefficient technology j and the cost function for electricity production can be written respectively as (Schumacher and Sands, 2006):

$$C_j = \frac{1}{\alpha_{0j}} \sum_{i=1}^{N} \frac{P_i}{\alpha_{ij}} \tag{1}$$

$$g(P) = \sum_j S_j C_j \tag{2}$$

Where C_j is the unit cost for technology j, P_i is the price of input i, α_{0j} is the technical coefficient for technology j, α_i is the share coefficient for input i, g (P) is the total unit cost of power production and s_j is the share of technology j in power production.

Except for electricity sector, other sectors use a nested CES production function to show technology. With a given technology, producers combine domestic and imported intermediate inputs and primary factors (land, natural resources, capital, and labor) at the lowest cost to produce outputs which are then sold as intermediate inputs to other producing sectors, traded as export goods, and sold to fulfill final demand given by the public and private sectors. Similar to Phoenix model (Wing et al., 2011), the primary factors of production are commonly grouped into one nest separate from the intermediate inputs. We further differentiate intermediate inputs and place the energy commodities into a nest separate from the remaining inputs.

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