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Economic Cost of the Feed - in - Tariff (FiT) in Thailand

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ABSTRACT

This study aims to determine how much of an economic loss results from the FiT policy and to provide such information to the government, which in turn sets policy for future decisions. Findings from a SUR estimation show that the supply of each energy source does not respond to the purchase price, except in the case of natural gas. Increases in the purchase price of natural gas increases the quantity used to produce electricity by natural gas at a significance level 1%. The FiT policy is found to create an economic loss that comes from violating the law of one price and from ignoring an externality cost, amounting to 46.67 and 356.44 billion per year, respectively. Therefore, this study suggests that the Thai government should adjust the electricity purchase price by setting the purchase price by following the law of one price and thus reflecting the full cost pricing in power generation.

Keywords: Economic Loss, SUR Estimation, FiT Policy, Law of One Price, Full Cost Pricing
JEL Classifications: Q41, Q48, Q51

1. INTRODUCTION

The electricity market in Thailand is a monopsony in which the electricity generating authority of Thailand (EGAT) monopolizes electricity distribution activities. This is called the "enhanced single buyer model." Most of the fuel used in Thailand's power generation comes from fossil fuels, which are a major cause of climate change, which affects human, plants, and animals. So, in 2007 the Thai government adopted the "adder" policy to generate incentives for producing electricity through renewable sources of energy. The adder structure can be represented as"

$$\text{Electricity purchase rate} = \text{Electricity cost (peak/off-peak)} + \text{Fuel adjustment charge } (F_t) + \text{adder} \quad (1)$$

Later, in 2010, the Thai government changed the policy from using adder to feed-in-tariff (FiT) to promote using renewable energy to produce electricity. This changed the electricity purchase rate to

$$\text{Electricity purchase rate} = FiT_f + FiT_{v,t-1}(1\text{-core inflation}) + \text{FiT premium} \quad (2)$$

Although these two policies both subsidize producers that use renewable energy in power generation, the main fuel for electricity generation is still natural gas (Energy Policy and Planning Office, 2017). Because the Adder and FiT policies are cost-plus approaches, the government provides financial support only according to the production costs of each firm. Thus, both the Adder and FiT policies violate "the law of one price," which in turn leads to economic losses. These two policies do not provide the correct price signal for the economy to produce electricity at minimal cost.

Moreover, the Adder and FiT policies as implemented in Thailand ignore the full-cost pricing principle. This generates even more economic loss in the electricity sector in Thailand. Therefore, the objective of this study is to determine how much of an economic loss is caused by the FiT policy and then to inform the government so that a new cost-saving policy can be drafted.

2. LITERATURE REVIEW

This literature review includes various studies of the levelized cost of energy (LCOE), the externality cost in power generation, and full-cost price. The LCOE method examines the cost of lifetime-generated energy that is used to assess the cost-effectiveness of different energy generation technologies. Using data from 17 power plants, Ouyang and Lin (2014) adopted an energy generating cost (EGC) spreadsheet model to estimate the LCOE of renewable energy in China. They suggest that the Chinese government uses the FiT system to subsidize in the short term because of the higher cost of renewable energy. Since the cost of renewable energy generation is higher than it is for fossil fuels, but that on the other hand renewable energy has a lower environmental impact, they recommended that to make renewable energy more competitive in the mid- and long-term the FiT should reflect the environmental impacts of various types of energy production. Similarly, Streimikiene and Alisauskaite-Seskiene (2014) found that the most efficient technologies for electricity generation that had the lowest external cost were renewable energy sources such as hydropower and wind while all fossil fuel technologies had the highest external cost in all categories. Moreover, they suggested that Lithuania had to increase pollution taxes and increase the FiT for renewable energy because the pollution taxes in place were lower than the external cost.

In a related study, Georgakellos (2012) argues that the carbon footprint of the electricity sector in Greece can be an indicator of global warming potential (GWP) that represents the greenhouse gas (GHG). He used carbon footprints to calculate the external cost of CO_2 creation from electricity generation from seven different sources—lignite, oil, natural gas, hydropower, wind, solar (photovoltaic), and biomass—by applying the EcoSenseLE tool and using the life cycle assessment (LCA) approach. Results show that the average external cost of CO_2 emission equals €18.38 per MWh. In addition, he also found that hydropower and wind power plants have very low external costs while oil and lignite have very high external costs. Rentizelas and Georgakellos (2014) used a linear programming model to discover which electricity generation source should be used to minimize the cost of electricity generation and used life-cycle assessment to calculate the external cost in order to determine the best mix for future electricity generation in Greece. They found that most of the new generating capacity until the year 2020 should be renewable energy, especially wind and biomass. This study corresponds with that of Turconi et al. (2014), who studied the environmental impact of future low-carbon electricity systems in Denmark by comparing the situation in 2010 with the alternative situation in 2030. The result shows that Denmark could reduce global warming impacts by reducing coal electricity generation and by substituting residual biomass and wind generation instead.

In addition, full-cost pricing can be used to address increasingly rigorous environmental standards and to reflect the external cost of power generation, which could in turn be used to set policy in the electricity market. Keske et al. (2012) did this for Colorado, using secondary data to proxy the external costs of electricity generation. They found that a full-cost pricing mechanism could create incentives to continually improve the environmental and performance characteristics of electricity generation, integration, and even conservation technologies. Furthermore, Roth and Ambs (2004) developed a model of electricity generation pricing that reflects long-term economic feasibility and sustainability and that encourages optimal resource selection. The model is used to compare the efficiency of power generation from different technologies. The authors investigated the cost of emissions and other social impacts of power generation at all stages of the fuel cycle, including calculating the LCOE for 14 different generation technologies: Conventional coal boilers, advanced fluidized bed combustion (AFBC), integrated gasification combined cycle (IGCC), conventional oil boilers, simple cycle gas turbines, advanced gas turbines, advanced combined cycle, mass-burn municipal solid waste (MSW), landfill gas (LFG) recovery, solid oxide fuel cells (SOFCs), utility scale wind turbines, utility scale flat plate photovoltaics (PV), hybrid solar thermal parabolic troughs, and biomass combustion. They found that clean and efficient power generation technologies are the best option.

3. DATA AND METHODOLOGY

3.1. Data

At present, Thailand produces electricity using the following 11 technologies: natural gas, coal/lignite, oil, solar photovoltaic, concentrated solar power, onshore wind, hydropower, geothermal, biomass, biogas, and municipal solid waste. Due to limitations in the available data, this study will focus on only seven technologies, namely, natural gas, coal/lignite, oil, solar (both solar photovoltaic and concentrated solar power), onshore wind, hydropower, and bioenergy (combinations of biomass and biogas). The data used for analysis in this study were collected from the International Renewable Energy Agency (IRENA), the International Energy Agency (IEA), the Intergovernmental Panel on Climate Change (IPCC), the Energy Information Administration (EIA), the Meteorological Department, the Electricity Generating Authority of Thailand (EGAT), the Energy Policy and Planning Office (EPPO), the Energy Regulatory Commission (ERC), the Bureau of Trade and Economic Indices, the World Bank, and the CEIC from the first quarter of 1993 through the first quarter of 2019. And the data comprise the quantity of electricity generation from each energy source, purchase price, levelized cost of each fuel (LCOE), electricity peak demand, gross domestic product (GDP), temperature, export volume, and leading rate.

To determine the economic loss from the FiT policy in Thailand, this study will, first, create a demand curve for electricity, which is the EGAT demand, and a supply curve for each energy source by using a seemingly unrelated regressions model (SUR) with quarterly data. Second, the marginal external cost (MEC), which is the damage cost, will be calculated by investigating the external cost coming from power generation. When the demand, supply, and MEC are known, this study will be able to determine the economic loss, both the expenditure loss and damage cost, from the FiT policy.

3.2. Demand and Supply of Electricity Model

There are several ways to estimate demand and supply. For example, Lin (2011) estimates supply and demand in the world oil market by using separate equations and ordinary least square

(OLS). Other ways include estimating supply and demand jointly using a seemingly unrelated regression model (SUR) and a simultaneous equation model (SEM)—by using two-stage least square (2SLS) and three-stage least square (3SLS). Since the demand and supply equations are structural equations, estimating them separately equation by OLS is neither efficient nor consistent. So, a joint estimation of equation would be preferred. The difference between SEM and SUR is that SEM contains both endogenous and exogenous regressors, but SUR contains only exogenous regressors. However, the SUR model can be further generalized into the simultaneous equations model, where the right-hand side regressors can be the endogenous variables as well. Thus, this study will use a SUR model to estimate demand and supply of electricity in Thailand. The SUR is a linear system of equations that includes multiple equations instead of just one equation. The equations are correlated through error term across equations (Katchova, 2013). In general, the SUR model can be written as:

$$Y_i = x_i\beta_i + u_i \quad (3)$$

Where i is number of equations in the system. For example, if the model includes an m equation, then the SUR model is

$$\begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_m \end{bmatrix} = \begin{bmatrix} x_1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & x_m \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \\ \vdots \\ \beta_m \end{bmatrix} + \begin{bmatrix} u_1 \\ u_2 \\ \vdots \\ u_m \end{bmatrix} \quad (4)$$

In applying SUR to estimate demand and supply of electricity in Thailand in this study, the markets are assumed to clear. This means that the price acts to equate demand and supply. And both demand and supply functions are in linear form. The supplier of power generation will produce electricity by using different fuels, namely, natural gas, coal/lignite, oil, solar (both solar photovoltaic and concentrated solar power), onshore wind, hydropower, and bioenergy (combinations of biomass and biogas).

Market clearing

$$q^d(p_t, x) = q^s_{gas}(p_t, x) + q^s_{coal}(p_t, x) + q^s_{oil}(p_t, x) + q^s_{solar}(p_t, x) + q^s_{wind}(p_t, x) + q^s_{hydropower}(p_t, x) + q^s_{bioenergy}(p_t, x) = Q \quad (5)$$

Where q^d is the quantity of electricity that EGAT purchases from supplier, q^s is the quantity of electricity that each supplier generates, p^t is the price of electricity that EGAT pays to supplier, x is exogenous variables, and Q is total quantity.

The demand and supply functions are in linear form

$$\text{Demand}: q^d(p_t, x) = \beta^d_p p_t + \beta^d_x x + u^d \quad (6)$$

$$\text{Supply}: q^s(p_t, x) = \beta^s_p p_t + \beta^s_x x + u^s \quad (7)$$

Substituting x into the demand and supply equation:

$$\text{Demand}: q^d = \beta^d_p p_t + \beta^d_x x^d + \beta^d_x x^n + \beta^d_x x^c + u^d \quad (8)$$

$$\text{Supply}: q^s = \beta^s_p p_t + \beta^s_x x^s + \beta^s_x x^n + \beta^s_x x^c + u^s \quad (9)$$

Where x^d is a demand shifter, which is an exogenous variable that shifts the demand curve but not the supply curve. x^n represents endogenous variables that affect both demand and supply, and x^c is exogenous variables that may affect both demand and supply, which can be varied from equation to equation depending on the model. x^s is a supply shifter, which is an exogenous variables that shift the supply curve but not the demand curve. Furthermore, the purchase price of electricity in Thailand from each energy source is not the same because the government, in accord with its subsidy policy (FiT), purchases electricity coming from renewable energy at a higher rate than from fossil fuels. Therefore, the demand and supply of electricity in the Thailand model is

Demand:

$$q^d = \beta^d_p P + \beta^d_{EDP} EPD + \beta^d_{TEM} TEM + \beta^d_{GDP} GDP + \beta^d_{CPI} CPI + u^d \quad (10)$$

Supply:

$$\begin{aligned} q^s_i =^s_p P_i &+ \beta^s_{coal} LCOE_{coal} + \beta^s_{gas} LCOE_{gas} + \beta^s_{oil} LCOE_{oil} \\ &+ \beta^s_{LCOEh} LCOE_h + \beta^s_{LCOEw} LCOE_w + \beta^s_{bio} LCOE_{bio} \\ &+ \beta^s_{solar} LCOE_{solar} + \beta^s_{EXPORT} EXPORT \\ &+ \beta^s_{LENDING} LENDINGRATE + \beta^s_{GDP} GDP + \beta^s_{CPI} CPI + u^s \end{aligned} \quad (11)$$

Where q^d is the total quantity of electricity generation (GWh). q^s_i is the quantity of electricity generation by i fuels when i is natural gas, coal/lignite, oil, hydropower, solar, wind, and bioenergy (GWh). P is the purchase price, which is an endogenous variable that affects both demand and supply (THB per KWh). EDP is electricity peak demand, which is a demand shifter (MW). TEM is temperature, which is a demand shifter (°C). GDP is gross domestic product, which is an exogenous variable that may affect both demand and supply (million THB). CPI is consumer price index, which is an exogenous variable that may affect both demand and supply (2015=100). $LCOE_{coal}$ is the cost of coal, which is a supply shifter (THB per KWh). $LCOE_{gas}$ is the cost of natural gas, which is a supply shifter (THB per KWh). $LCOE_{oil}$ is cost of oil, which is a supply shifter (THB per KWh). $LCOE_h$ is the levelized cost of hydropower power, which is a supply shifter (THB per KWh). $LCOE_w$ is the levelized cost of wind, which is supply shifter (THB per KWh). $LCOE_{bio}$ is wood and waste price in the electric power sector, used to proxy the cost of bioenergy, which is a supply shifter (THB per KWh). $LCOE_{solar}$ is solar price, used to proxy the cost of solar, which is a supply shifter (THB per KWh). EXPORT is export volume of electricity, which comprises exogenous variables that may affect both demand and supply (million THB). LEANDRATE is the lending rate, which is an exogenous variable that may affect both demand and supply (percent).

3.3. The Calculation of Economic Loss

An economics loss is calculated from two factors. First is the financial loss from setting a price according to the production cost. Second is the externality cost from setting a price that does not consider the externality cost of producing electricity since each energy source releases a different externality.

This study will consider the externalities of each supply energy source in terms of GHG emission cost, health impact, and crop yield losses affecting society based on Samadi (2017), as shown in Table 1.

4. RESULTS

4.1. Demand and Supply of Electricity in Thailand Model

Results show that the purchase price is strongly significant (at a significance level of 1%) in the demand and the supply of natural gas model. This means that an increase in the purchase price of natural gas decreases the quantity consumed and increases the quantity of electricity produced by natural gas. Thus, when the purchase price increases by 1 THB per KWh, the quantity consumed decreases by 2,749.61 GWh, and the quantity of electricity produced by natural gas increases by 1,372.34 GWh.

On the other hand, the purchase price is insignificant for coal/lignite, oil, and each renewable energy (hydropower, solar, wind, and bioenergy). This means that an increase in the purchase price does not affect the quantity of electricity produced by these sources. The reason for the insignificance of the purchase price of renewable energy is that in practice the government determines the quantity of electricity produced from each type of renewable energy. And for coal/lignite and oil, the purchase price is insignificant because most is imported from foreign countries. So it is no wonder that the purchase price does not affect the quantity of electricity produced in this case.

In addition to the purchase price of electricity, the estimation also shows the effect of another demand and supply shifter, which consists of an exogenous variable that may affect both demand and supply, an exogenous variable that shifts the demand curve but not the supply curve, a demand shifter and an exogenous variable that shifts the supply curve but not the demand curve, and a supply shifter. First is an exogenous variable that may affect both demand and supply. Results show that GDP is positively significant at 1% for the hydropower, wind, and bioenergy models. This means that an increase in GDP will increase the quantity of electricity produced by hydropower, wind, and bioenergy. With regard to the CPI, it is negatively significant at 5% in the demand model and the supply of hydropower. That is, an increase in the CPI decreases both the quantity of electricity consumed and produced by hydropower. But the CPI is positively significant at 5% for both the supply of natural gas and solar. And it also strongly positively significant at 1% for the supply of coal/lignite. Thus, an increase in the CPI will increase the quantity of electricity produced by natural gas, solar, and coal/lignite. Second is the demand shifter, comprising temperature and peak electricity demand. Results show that temperature is strongly positively significant at 1% and peak electricity demand is positively significant at 5%. Thus, it can be said that an increase in temperature and peak electricity demand will increase the quantity of electricity consumed.

The last factor is a supply shifter, which includes nine variables. The first seven variables are the costs of each type of energy, which implies which type can be used as a substitute to produce electricity. Results show that electricity generated from natural gas can be used to substitute for electricity generated for coal/lignite. And, likewise, solar energy can substitute for oil. But coal/lignite cannot be used to substitute for any other source at all. It was also found that for electricity generation by renewable energy, hydropower can substitute for natural gas, solar, wind, and bioenergy whereas solar can substitute for natural gas and hydropower, and wind and bioenergy can substitute only for hydropower. The last two variables are (1) export volume—when export volume increases, electricity generation by natural gas also increases, but electricity produced by coal/lignite, hydropower, and solar decreases; and (2) lending rate—increasing the lending rate will decrease the quantity of electricity produced by natural gas, solar, and wind, but it will increase electricity produced by oil and hydropower (Table 2).

From the SUR estimation of demand and supply of the electricity model in Thailand, the demand curve and the supply curve can be created. For the supply of each energy source for which the purchase price is insignificant, this study will assume the supply of each energy source is perfectly elastic at the current purchase price.

Table 3 presents the average purchase price under the FiT policy in 2014. Actually, the purchase price under the FiT policy did not

Table 1: The externality of each supply technology (THB per KWh)

Supply technologies	GHG emission cost	Health impact	Crop yield losses	Material damage	Total[1]
Lignite	3.65	0.32	0.01	0.00	3.98
Coal	3.22	0.47	0.01	0.01	3.71
Natural Gas	1.61	0.14	0.00	0.00	1.75
Coal CCS (post combustion)	1.07	0.51	0.01	0.01	1.61
Coal CCS (oxy-fuel)	0.72	0.37	0.01	0.01	1.10
Natural gas CCS	0.54	0.12	0.00	0.00	0.66
Biomass	0.14	0.68	0.03	0.01	0.86
Hydropower	0.04	0.00	0.00	0.00	0.04
Solar PV	0.11	0.21	0.00	0.00	0.32
Wind (onshore)	0.04	0.00	0.00	0.00	0.04
Wind (offshore)	0.04	0.03	0.00	0.00	0.06
CSP	0.07	0.05	0.00	0.00	0.13
Geothermal	0.18	0.00	0.00	0.00	0.18
Ocean	0.04	0.05	0.00	0.00	0.09
Nuclear (LWR)	0.04	0.03	0.00	0.00	0.06

Source: Samadi (2017). [1]1 EUR=35.775 THB exchange rate on April 09, 2019

Table 2: The dem and supply model estimated by sur model (cont.)

Variable	Total demand and the supply of each energy without government subsidies							
	Electricity generation: Total demand	Electricity generation: Natural gas	Electricity generation: Coal/lignite	Electricity generation: Oil	Electricity generation: Hydropower	Electricity generation: Solar	Electricity generation: Wind	Electricity generation: Bioenergy
Purchase price	−2749.9060 (590.4332)***	1372.3350 (358.0496)***	62.1592 (198.3632)	−137.3040 (183.6465)				
Gross domestic product	0.0209 (0.0016)	−0.0010 (0.0016)	0.00006 (0.0008)	−0.0007 (0.0007)	0.0019 (0.0004)***	0.00009 (0.0001)	0.0002 (0.00008)***	0.01068 (0.02181)***
Temperature	1028.9720 (263.6038)***							
Electricity peak demand	0.2833 (0.1214)**							
Consumer price index	−205.2985 (105.4504)**	219.2289 (100.2740)**	140.0231 (51.8841)***	−54.3740 (47.6504)	−73.8731 (31.0024)**	14.5083 (6.6751)**	7.2034 (514.1748)	−18.9514 (13738.3500)
Cost of natural gas		−158.8451 (132.0881)	20.3254 (68.5563)	−247.0648 (62.8985)***	85.1844 (43.71445)**	47.3376 (8.9396)***	8.2836 (6.9030)	104.8873 (192.2751)
Cost of coal/ lignite		6378.8530 (2035.4090)***	1072.1000 (1055.5300)	2191.5890 (968.0578)**	−1345.5940 (621.3699)**	−279.9982 (133.1642)**	−246.3062 (101.0718)**	2668.3010 (2711.1540)
Cost of oil		−85.6107 (100.8362)	−11.8630 (52.4697)	72.1400 (48.1220)	−19.4139 (30.1901)	−7.9830 (6.4677)	−7.4810 (4.9073)	−19.4179 (130.6891)
Levelized cost of hydropower power		−121.7538 (208.1943)	23.7773 (107.8766)	119.1149 (99.0826)	−284.3756 (63.7643)***	674.4297 (13.6527)***	87.6556 (10.2901)***	1309.8510 (285.6270)***
Cost of solar		45.3009 (14.0238)***	8.8688 (7.2671)	31.7130 (6.6669)***	18.4263 (9.0946)**	7.2586 (0.9268)***	0.1257 (0.6950)	4.0338 (18.8513)
Levelized cost of wind		−2834.7730 (2583.2460)	−260.8171 (1338.3670)	−3160.7500 (1227.6580)***	2752.4170 (794.5425)***	−5978.9830 (170.0072)***	−649.5090 (128.4007)***	−10276.910 (3471.8620)***
Cost of bioenergy		−52.6729 (31.5968)*	4.7532 (16.5555)	−30.9793 (15.2013)**	18.4263 (9.0946)**	−14.1365 (1.9166)***	−4.7848 (1.4641)***	−156.4535 (40.1430)***
Export volume		1.3508 (0.82521)*	−0.7969 (0.4283)*	−0.4587 (0.3927)	−0.8242 (0.2504)***	−0.0896 (0.0537)*	−0.0560 (0.0406)	−1.2929 (1.0839)
Lending rate		−1512.0080 (284.1504)***	200.3156 (147.5589)	487.4742 (135.2549)***	487.0021 (86.1629)***	−154.7278 (18.4972)***	−32.8960 (14.0008)**	−364.6380 (370.2609)
Purchase price with adder/FiT: Hydropower					−7.5174 (39.8890)			
Purchase price with adder/FiT: Solar						1.7742		

*** P<0.01, **P<0.05, *P<0.1, Standard errors in parentheses

Table 3: The electricity purchase price under the FiT policy

Supply technologies	The purchase price (THB per KWh)
Hydropower	4.90
Solar	6.23
Wind	6.06
Bioenergy	4.70

Source: EPPO (2015)

Table 4: The LCOE of each renewable energy source

Supply technologies	The LCOE (THB per KWh)
Hydropower	1.53
Solar	4.32
Wind	1.75
Bioenergy	1.94

Source: IRENA (2018)

depend on only the cost of technologies that are used to produce electricity. The government added more to subsidies and more for three border provinces.

Figure 1 indicates an intersection of demand and supply of natural gas at 4.56 THB per KWh and quantity produced equal to 32,008.13 GWh. At a price for coal/lignite and oil of 3.46 THB per KWh, the quantity of electricity produced will equal 34,534.35 GWh. Under the FiT policy, the quantity produced at the equilibrium of hydropower, solar, wind, and bioenergy will be 31,069.46, 27,412.08, 27,879.57, and 31,619.44 GWh respectively.

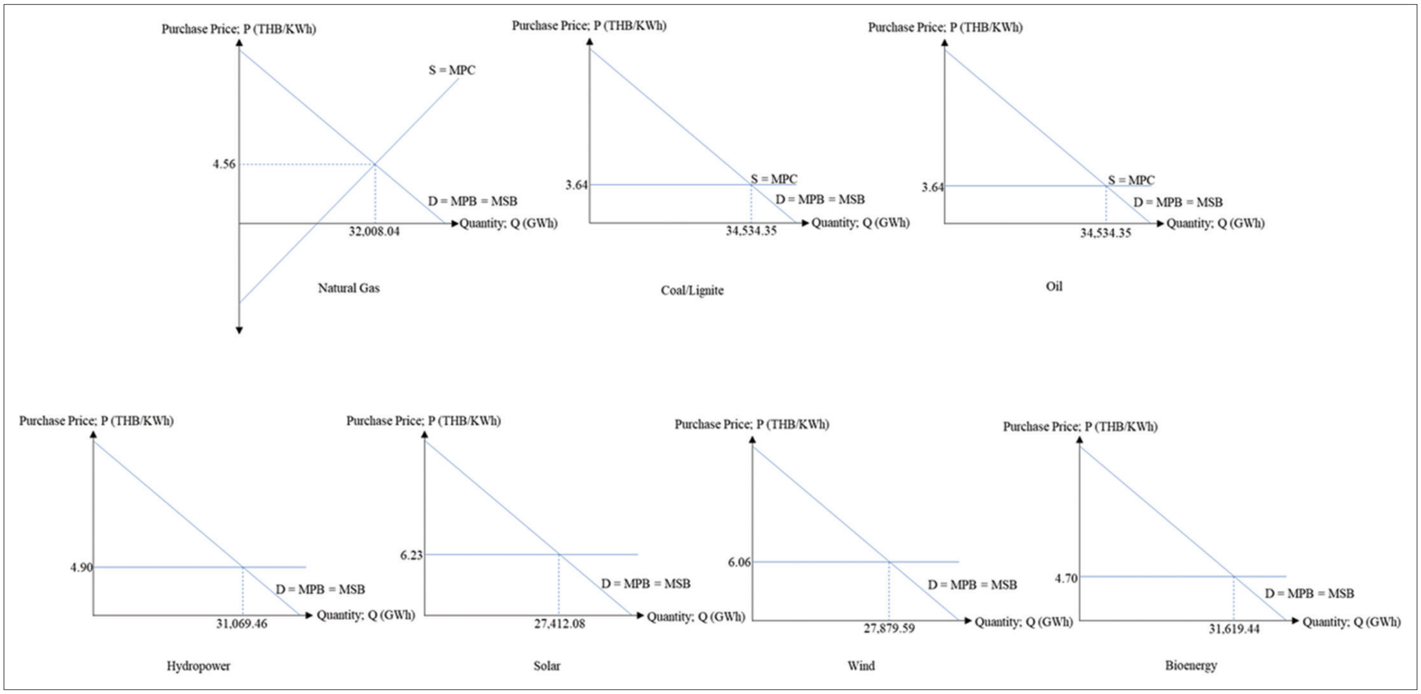
4.2. Economic Losses of Electricity in Thailand

For the economic loss calculation, this study will measure the economic loss in two parts, as expenditure loss and social loss.

1. Expenditure loss

According the FiT policy, the government sets the purchase price according to production cost and sets subsidies at different rates for each energy source. This violates the law of one price and creates an economic loss, which is the expenditure loss. Furthermore, it also ignores the external costs in power generation. This, in turn, creates more economic loss in terms of social or environmental loss.

Figure 1: The equilibrium price and quantity of each energy source



Source: Author

Table 5: The expenditure loss from setting purchase price at different rates

Supply technologies	Purchase price (THB per KWh)	Quantity purchase (million KWh)	Economics loss (billion THB per quarter)
Bioenergy	4.70	33,810.48	0
Hydro	4.90	1,954.62	0.39
Wind	6.06	1,139.13	1.55
Solar	6.23	6,357.25	9.73
Total (billion THB per quarter)			11.67
Total (billion THB per year)			46.67
		million KWh	Average price
Total electricity consumption		15,308.52	3.64
Total expenditure (million THB per quarter)			55.72
Electricity price increase (%)			20.94

Source: Author

Table 6: The external cost of each supply technology

Supply technologies	Total externality cost (THB per KWh)
Natural gas	1.21
Coal/lignite	2.60
Hydropower	0.04
Solar	0.23
Wind	0.04
Bioenergy	0.86

Source: Samadi (2017)

Table 4 shows the LCOE of each renewable energy source in 2018, which is lower than the purchase price, as shown in Table 3. This means that the government pays more than it should. However, this is an intended loss, an accounting loss. Actually, an expenditure loss is calculated using the purchase prices of electricity, which are different. For example, the government purchased electricity generated from bioenergy at 4.70 THB per KWh but paid 6.23 THB per KWh for solar energy. This means that for 1 KWh of electricity, if the government were to switch from solar to bioenergy, it could save 1.53 THB per KWh (6.23-4.70=1.53).

Table 5 indicates that if the government purchases electricity produced by bioenergy, which is the cheapest renewable energy source, it can save as much as 11.67 billion THB per quarter or 46.67 billion THB per year. These expenditure losses resulting from government overpayments create an economic loss to society and will result in people paying 20.94% more for electricity than they should.

2. The social loss

In power generation, each producer releases an externality to society, but they do not take responsibility for doing so. This creates a social loss, which becomes a burden on people, who end up paying for the damage costs.

However, this study recalculates the externality cost which accrues in Thai power generation. (Table 6). The SUR estimation shows a price and quantity equilibrium that does not incorporate externality into account. As a result, this equilibrium creates social loss because producers will decide by looking at how much cost they must bear to produce (marginal private cost – MPC) against

Table 7: Social losses at current quantities

Supply technologies	Total externality cost (THB per KWh)	The current quantity (million KWh)	The social loss (billion THB per quarter)
Natural gas	1.21	29,508.19	35.70
Coal/lignite	2.60	8,746.98	22.74
Hydropower	0.04	1,954.62	0.08
Solar	0.23	6,357.25	1.46
Wind	0.04	1,139.13	0.05
Bioenergy	0.86	33,810.48	29.08
Total social loss (billion THB per quarter)			89.11
Total social loss (billion THB per year)			356.44

Source: Author

how much they stand to gain from production (marginal private benefit – MPB), without concern for what is best for society.

At the equilibrium price and quantity of each energy source in the SUR estimation, electricity generation by coal/lignite created the highest social loss, equal to 9.29 billion THB per quarter. The next highest social loss (equal to 2.02 billion THB per quarter) was created by natural gas. In contrast, electricity generated by hydropower and wind created the lowest social loss, equal to 0.002 billion THB per quarter. And solar and bioenergy created a social loss equal to 0.07 and 1.02 billion THB per quarter, respectively.

Actually, in practice each energy source does not produce electricity equal to the quantity at equilibrium. Data from the first quarter of 2019 indicates that all energy sources produce electricity lower than the quantity at equilibrium, except for bioenergy, which produces more than the quantity at the equilibrium. Therefore, this study calculates the social loss of each energy source by multiplying the current quantity of each energy source by their externality cost per KWh. Table 7 shows that the social loss from electricity production is 89.11 billion THB per quarter. In another words, ignoring the externality costs under the FiT policy creates social costs up to 356.44 billion THB per year.

5. CONCLUSION

The Thai government adopted the Adder and FiT policy to promote renewable energy, but these two polices are cost-plus approaches—the government merely provides financial support according to the production cost. This means that these two policies violate the law of one price, which in turn creates an economic loss because they do not provide the correct price signal for power generation. The setting purchase price under the FiT policy does not take the cost of externalities into account. This generates a greater economic loss in power generation. So, this study has aimed to illustrate just how much of an economics loss is created by the current policy in order to encourage the government to draft more efficient electricity-generating policies.

The result from the SUR estimation shows that the supply of each type of energy does not respond in purchase price except in the case of natural gas, for which increasing purchase price increases the quantity produced at a significance level of 1%. As the supply of each energy source does not respond to price, this study will assume that the supply of each is perfectly elastic at the current electricity purchase price, which is determined by the government under the FiT policy, which sets a different purchase price for each supplier depending on the cost of technologies that are used to produce electricity. After that, a balance between demand and supply of electricity in Thailand can be created. In addition to the electricity purchase price, the estimation also shows an effect of another demand and supply shifter, which is an exogenous variable that may affect both demand and supply or may affect just demand or supply.

It was found that under the FiT policy, setting the purchase price according to production cost and setting subsidies at different rates for each energy source created an expenditure loss equal to 46.67 billion THB per year. Moreover, the method does not take externality cost into account, and this creates a social loss equal to 356.44 billion THB per year. Therefore, this study suggests that the government adjust the electricity purchase price by

1. Providing the correct price signal for the economy to produce electricity at a minimum cost and to allocate resources effectively. The electricity purchase price should follow the law of one price, under which all energy sources that produce electricity are bought and sold at the same price
2. Setting electricity purchase prices that reflect the full-cost pricing of power generation by taking externalities into account.

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