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The Challenge of Feed-In-Tariff (FIT) Policies Applied to the Development of Electricity from Sustainable Resources – Lessons for Vietnam

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Abstract – *Feed-in-tariff (FIT) policies are valuable tools for enhancing the growth of sustainable energy, which have been applied successfully in many countries. The Ministry of Industry and Trade of Vietnam enacted an FIT policy for wind power in 2011. However, according to the Vietnam Electricity annual report (2016), electricity from renewable resources contributes only 0.4% of the total of 38,553 MW electricity generated and the potential for sustainable energy resources are not being fully exploited. In this paper, the authors give an overview of the current situation of the resources used to generate electricity in Vietnam and the proportions accounted for by sustainable resources, as well as reviewing the existing FIT policies and some limitations of those policies. In addition, the paper investigates seven FIT models according to their theoretical background and considers FIT policies in three successful countries, namely, Thailand, Germany, and Australia. Some lessons are proposed for Vietnam to encourage renewable energy resource development in the future.*

Keywords – *electricity generation, feed-in-tariff, renewable energy, sustainable energy, Vietnam.*

1. INTRODUCTION

Feed-In-tariff (FIT) policies are effective tactics to promote sustainable energy production and consumption [1], [2]. Most countries in the world are aware of the necessity of developing sustainable energy resources in order to protect the environment and human health, and in view of the potential exhaustion of fossil fuels. The number of countries, provinces or states that have applied FIT policies increased from 34 to 113 in the period, 2004-2017 [3], [4]. Further, there are 20 member countries of the European Union (EU), who use FIT as one of their primary tools for supporting renewable energy growth [5] and many of those countries, including Germany and Denmark have successfully implemented FIT [2]. Many countries in Asia and other areas have also implemented FIT schemes and have been successful in using them to aid sustainable development, for instance, India [6], Australia [7] and the USA [8]. Since 2011, Vietnam has also applied an FIT policy to enhance its sustainable energy sector from wind energy. However, the electricity generated from renewable energy still makes up only a small percentage of the total electricity generated in Vietnam.

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According to the Vietnam Electricity annual report, 2016, electricity generation in Vietnam is mainly from hydropower, natural gas, and coal, which account for 38%, 20.7%, and 33.5%, respectively. In contrast, generation from renewable energy resources accounted for only 0.4% of the total electricity generation. The amount of electricity from oil-fired power stations and diesel and small hydropower also accounts for a very small proportion of the total electricity produced (2.3% and 5.1%) and Vietnam does not produce any electricity from nuclear power [9]. Moreover, by generating electricity using hydropower, the large dams built for hydropower plants can be used in flood control although serious flooding can reduce the amount of electricity generated in the flood period. Generally, however, water accumulates during periods of flooding at as much as 1 m^3/s and this can be used for electricity production by storing the water behind dams to produce power later [10]. However, hydropower development in Vietnam has negative effects on households that have to be resettled [11]. Large dams also have some bad effects on the environment and human health [12]. In addition, hydropower development has caused deforestation and Vietnam has lost about 133,930 hectares of forest land as a result of the construction of hydropower plants, with around 44,557 homes and 200.000 people having to be relocated [13]. The capacity to generate electricity from hydropower energy inevitably entails a loss of forests [14]. Deforestation can also reduce river discharge and decrease generating power capacity [15]. Power generation will fluctuate due to the level of water discharge and shortages of electricity can regularly occur during the hot season and excessive demand for power during busy periods has led to safety challenges for the electricity sector in Vietnam [16].

Vietnam is the 20th largest worldwide user of coal-fired power plants, which has led to the country producing the highest level of greenhouse gas (GHG) emissions in Asia [17]. Most of the coal-fired plants in Vietnam use anthracite coal to generate electricity, which results in an ash content by weight of as much as 33%. Therefore, electricity generation from coal in Vietnam causes a significant problem with emissions [18]. Under Vietnam's Power Development Master Plan VII [19] for the energy industry between 2011 and 2020 with a longer-term view until 2030, electricity generated from coal will increase from 14 GW in 2010 to 55 GW by the year 2030 with coal-fired electricity in Vietnam accounting for 53.2% of the total electricity production capacity. Under the revised Power Development Master Plan VII [20], Vietnam will continue to develop coal-fired generating plants while also importing electricity from Lao and China. EUROCHAM has warned that the increase in coal-generated electricity, which will rely mainly on imported coal at a high cost, will represent a hazard to the Vietnamese government's budget. Vietnam will have to buy almost 10 million tons of coal per annum from 2017 onwards, which represents a significant fiscal and transport challenge that was not fully reflected in the assumed cost of coal. Vietnam's Power Development Master Plan VII and the revised plan showed that coal for coal-fired power plants would increase by up to 15 times by 2030 and that Vietnam would become the eighth highest coal-consuming country in the world [17]. Further, the number of coal-fired power plants in Vietnam will increase from 38 to 133 plants between 2011 and 2030 [21]. A joint study by Greenpeace and Harvard University estimated that the GHG discharges from coal-fired electric power plants in Vietnam are currently responsible for the deaths of around 4,300 people in Vietnam each year and that the number would increase to 25,000 each year if the plants planned for the Mekong Delta go ahead [22].

Currently, electricity is provided by the state-owned Electricity Corporation of Vietnam (EVN), which is the monopoly wholesaler of electricity in Vietnam. To encourage the private sector to invest in renewable energy, Vietnam needs to devise a clear policy for investors. According to Solangi *et al.*, [23], renewable energy development is mainly supported by energy policy, which might include international treaties, legislation, and incentives for investment. Feed-in tariffs (FITs) are important support mechanisms for enhancing renewable energy development which assure sufficient compensation for renewable energy investors through either a long-term fixed price or the electricity market price plus a special bonus, thus encouraging the development of renewable energy and decreasing uncertainty for potential investors [24]–[26]. Feed-in tariffs (FITs) are also known as renewable energy payments, feed laws, standard offer contacts, minimum price payments, and advanced renewable tariffs [27], and they have been demonstrated to be a more effective policy for stimulating the development of renewable energy resources compared to other policies [28].

Vietnam does not yet have a Ministry of Energy. Therefore, every policy associated with energy is enacted by the Ministry of Industry and Trade (MOIT) and the Government. In Vietnam, according to the government's Decision No. 37/2011/ QD-TTg, EVN will buy wind power from investors at a price equal to 7.8 US cents/kWh from wind-power projects on land and 9.8 US cents/kWh for wind power investments in the sea [29]. However, the price of wind power does not guarantee an economic return to investors [30]. EVN's biomass electricity purchase price for investors is equivalent to 5.8 US cents/kWh [31]. For solar power, EVN will buy from partners at 9.35 US cents/kWh, but this decision only applies to solar photovoltaic technology (solar cells), not to other types of solar power generation, such as solar concentrators. In addition, none of the decisions mention the lifetime of applying the various technologies nor any adjustment of the electricity tariffs based on the consumer price index (CPI) [32].

Therefore, as set out above, Vietnam has already adopted FIT for wind energy, biomass (including refuse) and solar-generated electricity in 2011, 2014 and 2017 respectively. However, the Vietnamese FIT policy seems to be unsustainable because of the unreasonable price for which electricity will be purchased from the private sector. Therefore, Vietnam's FIT policy is still not attracting investors into the renewable energy sector. Hence, this paper will review the seven FIT models of Couture and Gagnon [27], [33] and review some countries that have successfully applied FIT policies to act as guidelines based on which Vietnam can reconsider and suitably adjust its FIT model to attract investors into the renewable energy sector.

2. STATUS OF GENERAL ELECTRICITY AND ELECTRICITY FROM RENEWABLE ENERGY RESOURCES IN VIETNAM

2.1 Electricity Generation in Vietnam

According to the annual report of EVN, between 2015 and 2016 the total electricity generated increase from 38,553 MW to 42,135 MW. As can be seen in Figures 1 and 2, around 90% of electricity in Vietnam is generated from hydropower plants, coal-fired and natural-gas-fired power stations, of which, hydropower and coal-fired power make up over 70% of the total electricity produced [9], [34]. Vietnam's MOIT has cooperated with the World Bank to stimulate the growth of renewable energy resources. and in December 2017, the Minister of Industry and Trade, Tran Tuan Anh and the World Bank Country Director for Vietnam Mr. Ousmane Dione, held discussions on the improvement of renewable energy resources. It was also suggested that Vietnam needs to improve its regulatory framework for renewable energy and in particular its FIT pricing mechanism [35].

2.2 Electricity from Renewable Resources in Vietnam

Currently, Vietnam has four major wind power plants with a total capacity of 159 MW, which will account for only 2.7% of the wind energy target up to 2030. The amount of electricity and heat generated from biomass in 2010 was only 552 kilotons of oil equivalent (KTOE). That number is very small compared to the 8,915 KTOE utilized as fuel for private activities, 1,168 KTOE for heaters and 2,173 KTOE for incinerators [36]. In addition, the application of rooftop solar electricity is also very low compared to the colossal potential available to the nation. Up to February 2019, there were only 1,800 customers (including public and government offices, enterprises, and households) who had installed rooftop solar generating facilities on their houses or buildings. This number is very small compared to the population of 95 million people [37] or 30 million households in the country [38]. Details of Vietnam's renewable energy development plans between 2015 and 2050 are shown in Table 1.

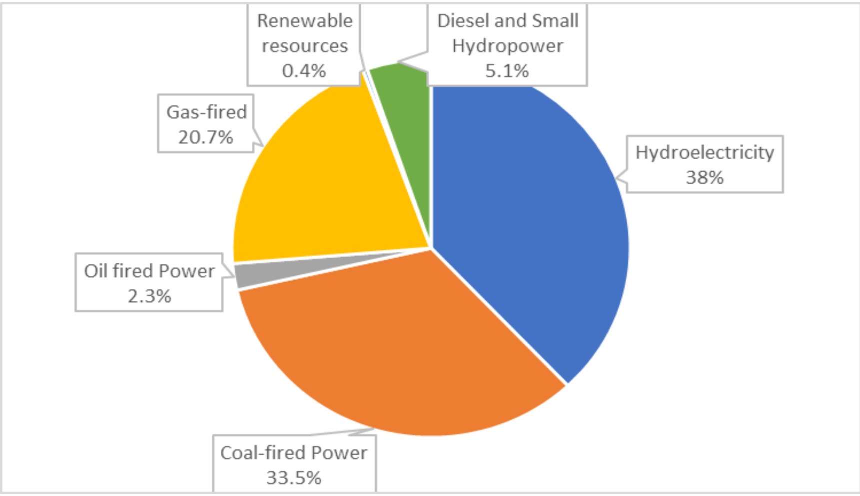

Fig. 1. Electricity generated by resources in Vietnam on 31st December 2015. ***Source: [9].***

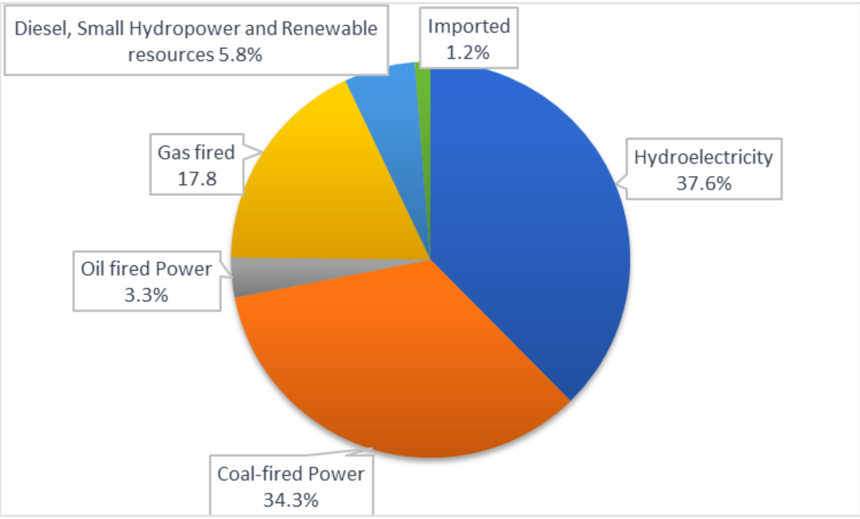

Fig. 2. Electricity generated by resources in Vietnam on 31st December 2016. ***Source: [34].***

Table 1. Vietnam's electricity generation from renewable energy resources: actual and targets for the development.

	2015		2020		2030		2050	
	Quantity (TWh, MW, TOE)	% of the total electricity generated	Quantity (TWh, MW, TOE)	% of the total electricity generated	Quantity (TWh, MW, TOE)	% of the total electricity generated	Quantity (TWh, MW, TOE)	% of the total electricity generated
Electricity generated from sustainable energy resources (TWh)	58	35%	101	38%	186	32%	452	43%
Hydropower (TWh)	56	-	90	-	96	-	-	-
Pump storage (MW)	-	-	-	-	2400		8000	-
Biomass energy (TOE)	0.3	1%	1.8	3%	9	6.3%	20	8.1%
Wind energy (TWh)	-	-	2.5	1%	16	2.7%	53	5%
Solar energy (TWh)	-	-	1.4	0.50%	35.4	6%	210	20%

Source: [36].

Based on the targets for the development of sources of electricity up to 2050, Vietnam will continue to rely heavily on electricity generated from hydropower (96TWh) until 2030. In particular, during the period, 2015-2020 hydropower-generated electricity will almost double from 56TWh to 90TWh. However, no electricity is planned to be generated from hydropower in 2050 although electricity from pump storage hydropower will be generated in both 2030 and 2050 with the amounts generated being 2400MW and 8000MW, respectively. Solar power is forecasted to increase sharply from 0.5% in 2020 to 6% in 2030 rising to 20% of the total electricity generated in 2050. Wind power and biomass will continue to increase slightly, accounting for 5% and 8.1% of total electricity generated, respectively, in 2050.

2.3 Current Support for Electricity from Sustainable Resources in Vietnam

In order to stimulate the growth of power from sustainable resources, Vietnam's MOIT has offered several incentives for electricity development in Vietnam as set out below in Table 2.

Table 2. Current support for electricity from renewable energy sources in Vietnam.

Renewable resources	Technology	FIT	Power purchase price
Small hydroelectricity	Power generation	Avoiding paying tariff yearly	2,158 VND/kWh (capacity price)
Wind energy	Power generation	Assurance 20-year FIT	7.8 US cents/kWh (onshore)
Biomass	Co-production	Assurance 20-year FIT	5.8 US cents/kWh
	Power generation	Assurance 20-year FIT	7.5551 US cents/kWh (Power Plants in the north of Vietnam) 7.3458 US cents/kWh (Power plants in central Vietnam) 7.4846 US cents/kWh (Power plants in the south of Vietnam)
Waste/refuse	Burned directly	Assured 20-year FIT	10.5 US cents/kWh
	Gas generation	Assured 20-year FIT	7.28 US cents/kWh
Solar energy	Electricity connected to the grid	Assured 20-year FIT	9.35 US cents/kWh

Source: [36].

None of the FIT policies above mention the types of technology used to generate electricity from renewable resources nor the size of the plants at which the electricity is generated. For example, solar power does not include large-scale rooftop solar power or solar farms, nor does it mention concentrated PV cell or mono-crystalline solar panels or other types of solar power technologies. Thus, it is difficult to attract investors, who have advanced technologies in the renewable energy sector, who may be prepared to invest in Vietnam.

It can, therefore, be of little surprise that although Vietnam has used FITs to encourage the development of electricity from renewable energy resources, the current FIT model has not attracted investors into the sector. In the next section, the authors will explore two groups of FIT models comprising seven FIT models, which have been applied successfully in other countries around the world. Vietnamese policymakers can thus choose an appropriate model to promote the development of renewable energy commensurate with the country's renewable energy resource potential.

3. MODELS USED IN FEED-IN-TARIFF POLICIES

The FIT policies examined consist of seven models divided into two broad categories: market-dependent FIT models and market-independent FIT models [6], [27]. The different categories of models are based on whether the payoff is related to or fixed based on the price of electricity in the market, or whether it is adjusted based on the customer price index (CPI).

3.1. Market-dependent FIT Policies

Market-dependent FIT policies are crucial for renewable energy suppliers who meet customers' demands by supplying appropriate power to them and who are in competition with other power providers. The market dependent FIT policies considered in this paper comprise three models, namely, the fixed premium price model, the variable premium FIT model and the percentage of the retail price model [27].

The fixed premium price commonly gives a fixed bonus based on the retail cost so that the total price paid exceeds the retail cost, with the premium unchanged for the whole period even if the price of electricity increases. For example, the available premium in Denmark is from 7.5 to 9.6 Euro Cent/kWh for electricity generated from renewable resources. Italy has also applied a constant bonus for solar power generation [39]. Klein *et al.* noted that because the amount of reward is offered above a fluctuating retail price, there will be a greater risk when the price varies significantly upward or downward. Therefore, this model may entail unfavorable results in terms of market development, investment safety, and the community. Moreover, this model does not provide an assured payback; therefore, the investors may be at risk if they enter the market [40]. However, Langnib *et al*. argued that this policy is suitable in a competing market. Consequently, investors will be encouraged to provide electricity from renewable energy at an appropriate price and electricity from renewable energy sources will be easy to integrate into the grid [41].

The variable premium FIT policy design was applied in Spain in 2007 due to rapidly increasing electricity prices between 2005 and 2006 [42]. This model's structure incorporates either a ceiling payment or a floor payment. The reward given to investors would depend on the behavior of the market. In this model, the amount of the reward decreases gradually until the market price comes to a definite level, at which point, the reward decreases to zero, and investors get only the retail price.

The percentage of the retail price model states that the policymaker agrees on a constant price to purchase electricity from the supplier based on a percentage of the retail market price and the proportion may be higher, lower or equal to the retail price. Therefore, the revenue earned by investors from renewable-energy electricity is completely dependent on the market situation and they will get more profit if the market price goes up but their income will decrease if the market price goes down. Basically, this model has proved to be unable to stimulate the broad-based improvement of non-wind renewable energy resources, since the rewards have been insufficient to guarantee the recovery of investments, thus the percentage of the retail price model has some drawbacks and in practice, it is no longer applied today [43].

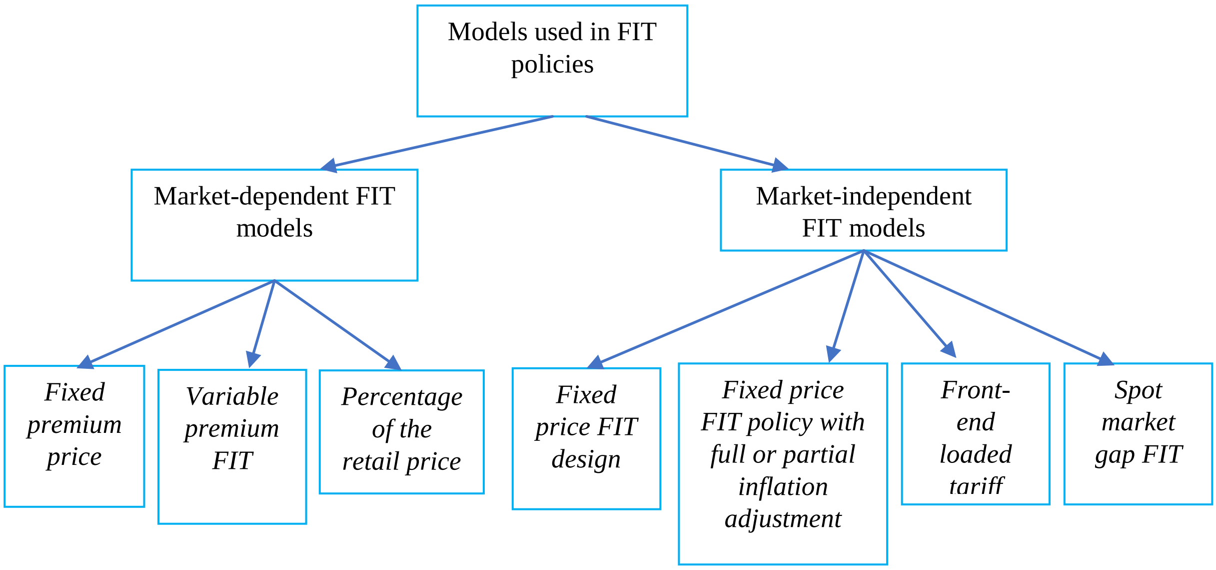

Fig. 3. Models used in FIT policies. ***Sources: [6], [27].***

3.2. Market-independent FIT Models

Market independent FIT models are normally employed where markets are in a more or less stable price situation because they provide an unchanged or minimum price over a long period specified in the contract, such as twenty years, which is not related to the retail price of electricity. There are four market independent FIT models described in this paper, the fixed price FIT model, the fixed price FIT model with full or partial inflation adjustment, the front-end loaded tariff model, and the spot market gap FIT model [27].

The fixed price FIT is a constant price model for buying electricity generated from renewable energy resources during the contract period independent of the market price of electricity. Thus, this model is independent of many variables, such as inflation or the price of fossil fuels. The price within such a model can, however, be calculated based on the costs entailed in generating electricity from renewable energy resources. The model has some disadvantages; because the payment is fixed for a long period without consideration of inflation or changes in the CPI, this may appear to make the real return on the investment decrease gradually over time. However, if the constant price is calculated based on the technology's functional life and the cost of generating electricity from renewable resources, this model tends to generate sufficient financial returns to attract the attention of investors. Therefore, the constant price model can be constructed in such a way as to guarantee that the investors in renewable energy will profit from their investment [44].

The fixed price model with full or partial inflation adjustment can enable investors to avoid their actual profits decreasing by reflecting changes in the background economy. To take account of fluctuations in inflation in the model, the entire FIT price or a portion of it can be adjusted every year or even every three months. For example, Iran offered a full readjustment of the FIT price based on the rate of inflation according to the type of sustainable power used to generate electricity including wind power, solar power or biomass [45].

Further, Spain offered an adjustment based on the full rate of inflation with a fixed subtraction depending on the cost of the technology employed [46].

The front-end loaded FIT model offers greater payments in the early years than in the later years of the contract, which benefits the recovery of project costs in the early years. Although higher payments in the earlier years place pressure on the wholesale cost, this policy has many advantages. The higher initial cash flows will help to support the investors' financing costs such as loans or stakeholders' equity in the early years, while the lower payments in the later stages of the project lessen the effect on the market price of electricity. This model ensures that the investors receive their full revenue reliably through the fixed payment arrangement, while lenders or capital providers will get their money back quickly. Moreover, by setting out a clear payment framework from the beginning of the project, the investors can predict their revenue and profit for the whole period of the project. However, applying this form of the FIT model will cost the government more money during the early years and it might, therefore, be difficult for politicians to accept it [6].

The spot market gap FIT model offers various payments in different periods. The payment will be calculated based on the difference between the spot retail price and the FIT price. Thus, the total FIT payment is fixed but payments are made up of an amount based on the retail price and a varying FIT subsidy. If the movement of the retail price is upward, the FIT subsidy will move downward and vice versa. This model has some benefits for the development of the renewable energy market. Firstly, the policy requires renewable energy investors to participate in the market for electricity, leading to the greater market integration of sustainable power sources as well as enhancing the unity between the current sources of electricity and new ones, and this may help to decrease the retail price of electricity. In addition, this model is not strictly a market-dependent FIT model because it protects the investors in the long term by guaranteeing the purchase of electricity for a fixed amount. Moreover, the reward is determined based on the short-term retail gap, which makes the calculation of the payments easier over the period of the project. However, this policy also has disadvantages because it may put pressure on the government budget when the retail price decreases dramatically.

The strengths and weaknesses of each policy and its practical operability are summarized in Table 3.

Table 3. Discuss the strengths and weaknesses of each policy and its practical operability.

FIT models	Strengths	Weaknesses	Countries in which applied	Year implemented	% of electricity capacity from sustainable resources in total electricity generation
I. Market dependent models					
		– Investors may be at risk if they enter the market because it does not assure payback period – The risk for the Government and community if the price goes up	Spain and Thailand	1998 [47], 2006 [48]	33.7% [49], 17% [48].
2. Variable premium FIT policy	Incorporating either a ceiling payment or a floor payment guarantees the benefit of investors and Governments.	The ceiling payments are sometimes lower than the real market price, so it may not attract the investors.	Switzerland, and Germany	1993 [44], 1991 [52]	7.7% [53], 38.2% [54].
3. Percentage of the retail price model	Depends on the market situation, so it may be fair for every investor	Risky for the investors, unable to stimulate the broad-based improvement of non-wind renewable energy resources	Initially applied in Germany, Denmark, and Spain but found to have some limitations and therefore, no longer used today		

II. Market independent models					
1. Fixed price FIT policy	The real return on the investment decreases gradually over time because the FIT is fixed for a long period and it does not take inflation or changes in the CPI into consideration.	If the constant price is calculated based on the technology's functional life and the cost of generating electricity from renewable resources, this model tends to generate sufficient financial returns to attract the attention of investors.	– The Vietnamese government applied fixed price FIT in 2011 but the electricity from renewable energy accounts for only 0.4% [19]. – Kenya has used fixed prices since 2008 based on estimating the cost of technology, the lifespan of power plants and the amount of electricity to be generated [50]. Electricity generated from renewable energy in Kenya accounted for 45.7% of the total electricity generation [51].		
			Ontario-Canada (20% inflation adjusment) [52].	2009 [52]	43% [52]
2. Fixed price model with full or partial inflation adjustment	Providing better value for investors and reduces the investors' risk from inflation.	It difficult to adjust prices in high inflation areas, and the adjustment may not be commensurate with the market price.	Ireland (100% inflation adjusment) [53].	2006-2010 (wind onshore) 2011 (wind offshore and other sustainable energy resources) [55].	8% [54]
3. Front-end loaded model	Benefits of the recovery of project costs during the early years	Governments who applied this FIT model will pay more money during the early years, and it is, therefore, difficult to get politicians to accept it	Thailand [56]	– Applied in Thailand for PV rooftop solar in 2013 with the price of the first 4 to 10 years at 6.5 Bht/1kWh, and the second period of 11-25 years at 6.16Bht/kWh [49]. Electricity from renewable energy made up 17% of the total electricity generated by technology in Thailand in 2015 [48]	
4. Spot market gap model	Either depends on the retail market price or guarantees the investor a long term contract.	May put pressure on the government budget when the retail price decreases dramatically	Netherlands [57]	1989 [58]	14% [59]

4. FIT POLICIES SUCCESSFULLY APPLIED TO SUSTAINABLE ENERGY POWER IN THAILAND, GERMANY, AND AUSTRALIA

Although many nations have successfully applied FITs to promote the development of power from sustainable resources this paper will describe their implementation in three countries, namely, Thailand, Germany, and Australia where a relatively high percentage of the total electricity generated annually is based on renewable resources, as lessons for Vietnam to study in seeking to apply FIT to its development of renewable energy resources.

4.1. FIT in Thailand

Thailand is one of the countries which has succeeded in encouraging electricity production from renewable power resources by adopting a FIT policy. In 2006, the Thai Government implemented its first FIT program based on a fixed premium tariff or "adder scheme" falling under the definition of a market-dependent FIT in this study. Electricity generated from renewable energy sources received a fixed bonus on the top of retail electricity prices over a seven-year guarantee period. There was no FIT for onshore wind and solar power at the early stage of the scheme because the rewards under the model were insufficient to cover investors' initial costs [60]. Wind and solar power were then included in the scheme at the end of 2007 with a 10-year guarantee period [56], [60], [61]. The first FIT in Thailand was successful in encouraging the generation of power from renewable resources by private power producers. As of December 2011, there was a generating capacity of 8,000 MW power from renewable energy projects in development and 1,000 MW from renewable energy projects already connected to the grid [60], [62]. Because the cost of solar power generating equipment had decreased significantly, the FIT premium program for solar power was not included in 2010 but other forms of renewable energy were offered a FIT premium until 2014. Further, a new Fixed FIT program (excluding solar power) with guarantees for 10 years and 20 years has been introduced for waste-to-energy from landfill gas and other renewable resources, respectively.

For solar power, in 2013, the government offered a fixed price with a 25-year guarantee for ground-mounted, and front-end-loaded rooftop facilities with the price in the first 4 to 10 year being 6.5 Bht/1kWh, and in the second period of 11-25 years it was 6.16 Bht/kWh [56]. A fixed price FIT was applied to both rooftop and ground-mounted panels in 2014.

In Thailand, FIT policies have been applied flexibly to successfully promote renewable energy development in both the short and long term and from every kind of power generating technology.

4.2. FIT in Germany

Germany was the first country in the world to produce electricity from sustainable resources and to date, solar power has been developed with the full support of the government in terms of finance, administration and approval procedures [63].

The objective of renewable energy policy in Germany is cutting GHG emissions by 40% in 2020, 55% in 2030 and 95% in 2050, based on the 1990 level. In addition, the country expects that renewable energy will occupy 60% in its gross final power consumption in 2050. In 2017, renewable energy resources accounted for 33.1% of gross power production in Germany and 36.2% of the electricity consumed in the country was from renewable energy resources [64].

A FIT for electricity generated from renewable energy resources was implemented through an act of the German parliament in 1991 with payment based on a percentage of the retail price for electricity. The FIT payments were to be adjusted every year based on the average specific rates of return for all the power provided on the national power grid in the last year. Electricity from solar and wind power attracted the highest payment (90% average specific returns), followed by biomass, biogas, and hydropower, with inputs lower than 500 kW receiving 75%, rising to 80% in the later years of a project. Electricity from biomass, biogas, and hydropower between 500 kW and 5 MW, received an average specific return of 65%. The 1991 FIT-law did not apply to renewable energy installations producing over 5 MW. The FIT payments declined after 1996 because of the removal of the tax on coal, which led to a decrease in the cost of electricity. Therefore, because of the liberalization of the market for electricity, the FIT law was revised in 1998. Local power providers were obliged to buy 5% of their total power requirements as electricity generated from renewable sources rising to a ceiling purchase rate of 10%. The revised law later became the standard for the deployment of wind power. In 2000, The Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz EEG) changed the FIT law by establishing identical common standards, but with no maximum limit [65]. Germany has continued to revise its FIT rate with adjustments for the cost of renewable energy technology and FIT prices will fall by a certain percentage as the cost of renewable energy technology declines. "If the electricity of the RES-E plant (of capacity also higher than 100 kWp) is sold under the feed-in tariff as an exceptional case, the tariff has to be reduced by 20% (§53 EEG 2017)" [66]. The FITs in Germany are illustrated in Table 4.

4.3. FIT in Australia

Sustainable energy resources in Australia are mainly supported by FITs. However, the FITs are not the same in every state or territory. The government uses a FIT to encourage households and small enterprises to install rooftop solar power to satisfy part of their own consumption [69]. After the end of the FIT period, biogas generation may also be supported by a FIT if it meets specific criteria, while rooftop solar power and small or medium-sized hydropower developments are supported by subsidies. Power from sustainable energy resources is input into the national electricity grid based on the national energy laws incorporating non-discriminatory principles [70].

According to the Australian Department of the Environment and Energy, between 2015 and 2016, electricity from renewable energy accounted for 15% of the total power generated. Although hydropower is still the biggest provider of sustainable energy generation (40% of renewable energy generation compared to 95% in the period of 2000-2001), the forms of sustainable energy resources that have provided electricity to the grid in Australia have diversified remarkably. Wind power was the second largest contributor after hydropower, contributing 32% of the total renewable energy and making up 5% of all power creation. Wind power increased by 6% in 2015–2016 and is popular in South Australia, making up one-third of the total electricity created in that state. Solar power also grew strongly by 24% in 2015–2016 and accounted for 3% of all electricity generated in the country. In New South Wales, in addition, to large-scale solar power developments consisting of the Broken Hill and Moree solar farms, much small-scale solar power, and rooftop solar panel installations have also been connected into the electricity grid, accounting for most of the solar power generation [7]. The electricity generated from renewable energy sources from 1990 to 2016 is illustrated in Figure 4.

5. THE LESSONS FOR VIETNAM FROM THE EXPERIENCE OF OTHER COUNTRIES IN SUCCESSFULLY IMPLEMENTING FIT MODELS

As noted in Section 2 of this paper, Vietnam introduced FITs for wind energy, biomass and refuse and solar power in 2011, 2014 and 2017, respectively. However, the power created from sustainable energy sources accounted for only a tiny amount (0.4%) of the total electricity generated in 2015 which is not commensurate with the tremendous potential for renewable energy in the country. Vietnam's FITs provide a fixed minimum price for the entire 20-year contract period and this is not dependent on the electricity price in the market. Moreover, FIT policies in Vietnam do not take into account renewable energy technologies or the area selected by investors to construct renewable energy plants. By studying the current situation of Vietnam's electricity production and supply and FIT model theory as well as the successful application of FIT to stimulate the growth of sustainable energy resources in Thailand, Germany, and Australia, the authors propose some lessons for Vietnam as set out below.

Table 4. FITs in Germany in 2017.

FIT policies	Period of application	Explain the FIT policies at each period
Percentage of retail price FIT	1991-1999	The SEG would buy electricity from renewable energy at the average retail electricity price in the past year. The FIT payments were to be adjusted every year based on the average specific rates of return for all the power provided on the national power grid in the last year.
Variable premium FIT	2000-2008	The EEG guaranteed that the FIT would be above market price for a 20-year period from the point of installation. The FIT was variable due to the technology of each energy resource. The priority FIT of this scheme was especially for solar PV.
Variable premium FIT	2009-2011	Since 2009, the PV price declined significantly, thus the government reduced the premium for new solar power installations
Variable premium FIT and Frond and load FIT	2012-2013	- Continued to reduce the premium for solar energy and other renewable resources (excluding offshore wind) due to the decrease in the cost of all renewable resources. - Applied front and load FIT for offshore wind at a price of 15 Euro cents for the first 12 years and 3.5 Euro cents thereafter.
Fixed price FIT	2014-2016	Applied fixed price FIT for all power from renewable energy sources. The fixed price FIT was enough to guarantee investors' return on investment.

Sources: [71], [72].

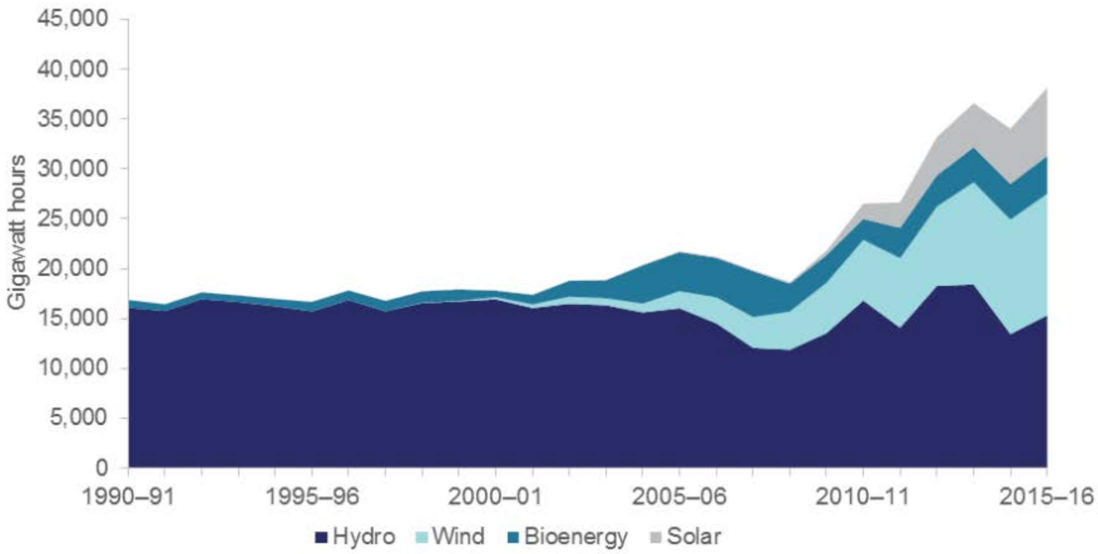

Fig. 4. Electricity generated from renewable sources in Australia. ***Source: [7].***

Firstly, Vietnam has different economic and social conditions from Germany or Australia, but the country has a high potential for renewable energy resources as to the basis for enhancing the development of alternative energy resources. The Vietnamese Government has sought to increase energy generation from renewable energy resources in its revised electricity development plan in order to reduce the dependence on hydropower and coal power [20]. However, Baulch *et al.* (2018), noted that the current FIT has been a constraint on the development of home solar systems in Hochiminh City [15], and the present market-independent fixed-price FIT model is not capable of encouraging renewable energy resources as noted in the Introduction of this paper. The authors propose that if the Vietnamese government maintains the current FIT, it needs to be adjusted for local inflation and to take into consideration different technologies for each renewable resource. For example, the government should apply a different price for FIT for rooftop solar panels from that paid for ground-mounted solar panels.

Secondly, the front-end loaded FIT model as successfully applied in Germany and France for wind power has been shown to encourage sustainable energy development. Thailand also selected a front-end loaded FIT model for rooftop solar in 2013 [56] and renewable energy resources occupied 17% of total power generation based on that technology in 2015 [48]. Vietnam can apply this model in a similar manner to Thailand since the economic conditions are similar in the two Asian countries. According to the electricity development plan as described in Section 2.2 and Table 1, solar power can be increased rapidly in the future. Thus, Vietnam may prefer to initially apply the front-end loaded FIT model for solar farms, particularly during the first stage of a solar farm's development contract. Under this model, policymakers set a higher price for solar energy than that paid for other types of energy. The length of the first stage can be long enough to encompass initial production and the price paid must take into account the technology cost and ensure profitability for the solar farms' investors. In the second stage of the contract, when solar electricity production has stabilized, and fixed costs have been reduced, the price can be adjusted to a lower level than that in stage one. Once the goal of developing its solar energy resources is been achieved, Vietnam can then give priority to other types of energy, such as wind power and repeat the same development process utilized for solar power.

Thirdly, Vietnam could choose a market-dependent FIT model to encourage the development of sustainable energy resources. However, the electricity supply market would need to be liberalized so that the price would be competitive based on customer demand. Currently, the retail price of electricity in Vietnam is fixed through EVN which is a monopoly power supply company.

At present, the majority of power in Vietnam is generated from hydropower and coal-fired plants and the negative effects of the exploitation of those energy resources on the environment and human life are well-known as previously mentioned. Vietnam can reduce the use of traditional forms of energy generation such as from fossil fuels and enhance sustainable fuel development through tax incentives. For instance, a coal consumption tax could be used as a means of achieving a reduction in emission levels because this power resource accounts for a relatively high proportion of Vietnam's GHG emissions [71], [72].

In addition, policies related to Vietnam's electricity development are currently promulgated by the MOIT of Vietnam, which may not be appropriate for the energy sector. Vietnam should create its own Ministry of Energy to better control investment in, and the supply and quality of electrical equipment. A Ministry of Energy could also enact legislation to introduce appropriate policies for future renewable energy development.

Moreover, choosing a suitable FIT policy to encourage the development of electricity from renewable resources will bring many more benefits to Vietnam besides those associated with green energy indicated in the Section 1. When investors build new renewable energy plants, they employ workers and other staff which leads to a reduction in unemployment. Those investors and workers will also pay taxes such as corporate or personal income tax, which will help to increase the government's budget. Investors will also have to buy equipment which will create business opportunities for renewable energy equipment suppliers.

6. CONCLUSIONS

Sustainable energy development helps to combat climate change, environmental pollution and increases the quality of human life. In Vietnam, renewable energy also helps to reduce the deforestation caused by the development of hydropower, decreases shortages of electricity in the hot season and improves safety in the electricity sector. FIT is an important means of enhancing the generation of electricity from renewable energy resources in many countries around the world. Although an FIT has been applied by the MOIT in Vietnam to stimulate the development of renewable energy since 2011, electricity from renewable sources only accounts for a very small proportion of the total electricity generated and the amount is not commensurate with the potential of renewable resource-based generation in Vietnam. The lessons from other countries and recommendations in this paper may help Vietnam to adopt a suitable FIT model to stimulate future renewable energy development, employing one or more of the seven common FIT models falling into either the market-dependent or market-independent FIT categories described. Choosing the right FIT model is a vital factor in the renewable energy development policy of a nation. This study shows the limitations of the current FIT policy which has failed to attract developers willing to invest in renewable energy resources. The authors, therefore, suggest that Vietnam should adjust its current FIT policy by choosing a more suitable FIT model. In addition, the authors suggest that Vietnam should liberalize its electricity market and set up a Ministry of Energy to better manage the development of renewable energy.

ACKNOWLEDGEMENT

The authors would like to thank The Prince of Songkla University (PSU) Graduate School and Interdisciplinary Graduate School of Energy System for grants supporting the conduct of this study.

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