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Analysis of renewable energy feed-in tariffs in selected regions of the globe: Lessons for Saudi Arabia

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ABSTRACT

In this paper, an analysis of renewable energy feed-in tariffs (REFIT) for the selected regions of the globe is done with the aim of drawing lesson for Saudi Arabia. A brief background and status of renewable energy sources (RES) utilization in Saudi Arabia is given at the beginning of this paper, followed by a review of the feed-in tariff (FIT) design models reported in literature. The application of the policy in Europe, the United States, Australia, Asia and Africa is then reviewed. Some observations from the analysis of the FIT application in different countries have been discussed and finally, lessons have been drawn from the study. Some policy recommendations have been given for Saudi Arabia. The analysis of the lessons identified shows that the application of FIT scheme in Saudi Arabia is likely to speed up the development of renewable energy resources within the area.

Contents

1. Introduction

Renewable energy (RE) technologies will have a key role to play in providing future energy supply mix purposely to attain energy sustainability [1]. The fossil fuels are approaching their exhaustion while at the same time exerting a devastating consequence on the environment, a factor that have given RE a green light to achieve more attention all around the world. For instance, in late 2010, the solar thermal collector volume was 195.8 GWth (gigawatts thermal) worldwide, most of which was installed in the United States (7.5%), Europe (18%) and the biggest portion in China (60%) [2]. In 2001, the European Union (EU) embarked on promoting RES as an important action to combat environmental pollution in line with the Kyoto protocol targets [3]. RE systems can improve some aspects of energy security and several researches focused on analysis of energy security aspects of RE systems on the basis of a broad typology on energy and security [4]. Various research works were also being conducted directed towards optimization of

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PV systems in order that a number of PV modules, capacity of inverter, capacity of storage battery as well as wind turbine capacity are optimally selected [5,6]. All these are aimed at bringing the price of RE at lower level to make it more competitive in the energy market.

Although all the efforts are being made through research and technological advancement to bring the cost of RE resources to the lowest levels, many jurisdictions have already included them into their energy systems through various support schemes.

By 2008, at least 48 countries, 14 from developing countries, had some types of policies to promote RE. These policies comprise feed-in tariffs, tax credits for investment/production, research, development and demonstration programs, RE mandates, reduction on import duty and export support, technology-forcing regulations, preferential loans, accelerated depreciation rates, government green purchasing preferences and consumer purchasing incentives, competitive bidding and green certificate trading [7]. Energy policy is the major strategy used to support RE development. The qualities of energy policy might include international treaties, legislation, and incentives to investment [8]. Public support can be categorized not only as direct and indirect supports, but also as supply or demand policies. Supply policies or technology-push policies intend to develop the products portfolio by providing public subsidies; while demand-pull policies or market-pull measures correspond to Keynesian policies that act on demand in order to create employment and increase production [9,10]. Technology-push policies are frequently followed by demand-pull measures purposely to encourage the consumers to embrace and use the established innovations [10]. The support for RES according to the above analysis need to be and has been in both categories for a long time.

In China, wind energy production increased because a series of effective support policies were embraced to support wind power system installation. For example, China introduced support schemes including the Renewable Energy Law, Wind power concession Program and a number of additional laws and regulations [11]. As soon as the RE Law introduced in 2006, penetration of PV has been accelerated. FIT and capital subsidies, which were under trial stage, public bidding and the teamwork within the government agencies played important roles in China [12]. The European Union realized that RE resources could not be developed in the absence of government policy and support on the medium term basis. The schemes for RE support therefore have been directed towards the development of RE including the incentives or the electricity producers and utilities obligation to buy electricity produced from RE at a minimum percentage to support research or financing mechanisms like guarantee funds, parafiscal tax, and interest subsidies on other energy sources [13]. The Tradable Green Certificates (TGC) is a RE support system based on quota obligation where electricity producers or suppliers and consumers are obliged to give a designated minimum contribution from a total energy consumption from RES [3]. In the EU, despite the success at its inception, TGC met much more problems, in consequence of long-term unpredictability faced by investors whereas the FIT policies are continuing to succeed. In January 2009, renewable energy net pricing law was applied in Germany, in which 0.55 euros per kWh was adopted as a net price for generated PV power [14].

The most desirable and common supporting policy to RE is the FIT mechanism that sets the obligation to the utility to purchase the electricity produced from RE from the area of operation. Since 1978, when the US passed the national feed-in law, until 2006 FIT mechanism has been adopted by a minimum of 32 countries and 9 states [7,15,16]. Gao et al. noted that the dominant policy measures applied to RE include FIT that evolved from net-metering and/or investment grants, and renewable portfolio standards or tendering scheme, of which, FIT has become the most successful and prevailing approach to promote PV around the globe [17]. In addition to rebating the amount of generated renewable electricity to investor, FIT is also defined as a CO_2 mitigation policy in electricity generation from renewable sources [18].

With FIT policy, a tariff is paid, which is designed by the public authorities and guaranteed for a definite period. Several research works have been carried out on the feasibility of REFIT to benefit both the RE developers (investors) and the ratepayers, mainly the governments and the public of the jurisdictions in which resulting energy is used. In Australia, an economical model to define FIT for grid-connected PV has been developed by Zahedi [19]. In [20], the cost of PV was determined using a closed form equation and the prices of solar systems were forecasted to establish the optimal FIT for small scale PV systems in China. Chua et al. highlighted the global positive indicators to advocate for implementation of FIT in Malaysia based on the successful utilization of RES on a world scale [21]. The appropriateness of FIT for wind energy resource development in New Zealand was revealed based on stakeholder's perspectives through a survey of 366 respondents [22]. Another research work found out that grid-connected PV systems in Turkey are feasible based on FIT and the time-of-use [23]. Whereas in a similar study in our previous work, it was established that grid-connected PV systems could replace diesel as an alternative to hydro power if FIT are to be implemented in Uganda [24].

On a practical point of view, the application of FIT in the energy system is being reported to have significant positive outcomes in the jurisdictions where it is applied. The introduction of FIT for RE in the year 2000 resulted into an enormous rise in newly erected PV plants reaching an overall installed capacity of 35 GWp by November 30th, 2013 in Germany [25]. The Organization of Economic Cooperation and Development (OECD) states' economies have showed increasing interest in RES to ensure energy security and diversification of the energy mix. It has been noted that the interest is being backed by several government policies, such as FIT in addition to tax rebates, benefits and markets for RE [26]. The significance of motivations and barriers related to micro generation application in UK were investigated and the results indicated that the introduction of FIT has evidently encouraged a new, more financially-motivated group to install [27]. Furthermore, the consequences of REFITs on the economic success of hydropower energy recovery in Europe were assessed in [28]. The study indicated that only 18 of the 28 countries evaluated have FITs for hydropower and the rates are on average the lowest for all RES, with several countries choosing to prioritize wind and solar PV. It is also worth noting that by the end of 2006 about 45,000 MW of wind power was installed through FIT schemes on European continent [29].

Lund has reported that Germany, Italy, and Spain have cut the FIT support to PV whereas in another incident in Greece it has been done in retrospect. This cutting does not stop the application of FIT by the willing parties as it does not affect the new entrants in the RE market since this reduction has been driven by the reduction in the price of new RE technologies as Lund noted [30]. The effects of FIT adjustments on installed PV in Germany were analyzed where it was concluded that the current system temporarily accelerates installments and does not countervail over investment. A cost-related FIT system is said to be the best mechanism to combine the advantages of the actual FIT regime (to promote investment) and of linearly decreasing FITs (to reduce consumers' burden) though it will prevent the FITs from decreasing very fast [31]. The period of economic recession and succeeding cuts of subsidies in European nations influenced the attractiveness of various support policies; yet, FITs remained the key RE policy, considered by venture capitalists and private financiers when the decision to finance RES is deliberated [32]. This support policy is significant to venture capitalists and private equity investors, since it provides steady inducements for investors in the RE sectors.

Although many countries have adopted the use of FIT to support and promote RE, some have not yet realized the full benefits resulting from the implementation of this policy. It is therefore important to elaborate the pros and cons of the FIT for other economies to weigh if they are also to try and take up such measures for the benefit of their population and the whole world at large. At the present time, Saudi Arabia has not yet implemented the FIT policy. Hence, this paper aims to review the FIT models reported in literature followed by the assessment of their applications in different selected countries in Europe, Asia and Africa to evaluate their implications in the jurisdictions where they are applied. Finally, lessons are drawn for Saudi Arabia to justify the need for the implementation of the FIT in the country.

2. A brief background and status of renewable energy resource utilization in Saudi Arabia

Saudi Arabia is one of the largest world's producer and exporter of petroleum products and major users of total primary energy. The Saudi electricity generation is anticipated to be more than double by the year 2025 due to a rising population. Moreover, almost all electricity is generated using diesel except some generated from renewable energy [33]. Hence, CO_2 emissions are more likely to increase if future power needs are met using current fossil fuel with no RE and green energy technologies [34]. The methods suggested to lessen greenhouse gas (GHG) emission include the implementation of a plan, strategy and programs that reduce the GHG as well as the emphasize on RE and green energy sources, rational use of energy, and further energy efficient technologies [35].

Saudi Arabia pioneered the investment in RE research ahead of other GCC countries by taking on major collaborative programs with developed countries, such as United States and Germany [36]. Since the mid-seventies, Saudi Arabia has been conducting research and development for RES production more specifically solar energy. The main pertinent accomplishments included the use of PV system to provide electricity to run highway devices, presenting and ordering the use of water heating system powered by solar for household heating. As a result, about 1100 solar flat plate collectors were fitted on the top of the roof amounting to 380 homes in campus of King Abdulaziz City for Science and Technology (KACST) in Riyadh during the year 1996 [37].

Saudi Arabia projects 54 GW of renewable energy installations which comprised of different types of solar, wind, waste-to-energy and geothermal at the end of 2032. The goal is to achieve 5.1 GW by 2018, and 23.9 GW in the year 2020. As part of the plan, the first solar power project was inaugurated in October 2011 [38]. A solar PV car park system was also constructed by Saudi Aramco at their offices in Dhahran. It consists of 10 MW capacity, spanning spaces of the top of 4500 parking shades [39]. This solar power project was intended to provide the energy demand of Al-Midra Tower at Dhahran owned by Aramco [40]. The 2 MW solar PV plant was setup on the King Abdullah University of Science and Technology (KAUST) campus rooftop by a German photovoltaic company, Conergy [41], leading to a third solar power plan in the region to be completed in 2010. The company built the power plant in collaboration with the kingdom's solar system integrator, Saudi Arabian National Solar Systems (NSS).

Despite the efforts so far taken to generate electricity, it can be noted that the progress in RE exploitation has been too slow for a number of reasons. Many countries faced the complicated process of the project implementation and they have continued to fail to overcome these challenges and barriers. However, these problems are taken into consideration while designing the future projects and policies [42]. In Saudi Arabia, although the plans are put in place, there are multitudes of barriers and challenges to project implementation, rendering most of the plans are very difficult to achieve so as to meet the projected targets. Like in other developing countries, there is high risk of doing business in Saudi Arabia. This may be one of the reasons why RE investors are reluctant to participate in this RE sector. There is also a problem of lack of data related to solar energy development within the Gulf regions as there are very few earlier solar projects completed and documented in these areas [43].

To have sustainable electricity generation from RES, economically competitive privatization is needed in this sector. True understanding based on transparent information is one of the outstanding needs for the private sector to invest in the energy business. In [44], the researchers analyzed the factors considered by the private sector in order to improve their participation in the electricity generation markets from renewable sources in the Middle East. They discovered that the most important factors are governmental policies, consumption markets, and engineering efficiency all of which are categorized based on varying perspectives, such as techno-engineering, business and appropriate policies and the environment. It is no doubt that the environment in Saudi Arabia is not the best for the intended investors in RE due to various risks. Therefore, it is necessary to ensure that the level of return on investment expected on RE investment in Saudi Arabia is moderate enough to attract the investors in this corridor of the world. Investment security is another important factor which needs to be addressed through streamlining the policies related to RE project development.

The major world economies such as Germany and US have applied FIT policies in the last few decades to boost the RE sector. Many other countries in both developed in Europe and developing in Africa and Asia are utilizing the same mechanisms in their jurisdictions and it was the FIT that provoked significant growth of the PV industry in Germany and Italy [45]. However, no single country in the GCC countries that has implemented such policies like FIT policy [46]. Therefore, it is the objective of this paper to study how the most utilized policy (FIT) has been handled by different countries so that lessons can be drawn for the Saudi Arabian government to implement the same policy in the RE sector. Following this analysis and policy recommendations which will be highlighted in the following sections, the Saudi policy makers will be in better position to confidently choose suitable FIT schemes to implement in their jurisdiction.

3. Feed-in tariff design models

FITs are among the features that will be integrated into the smart grid. As technological advancement, the deployment of smart meters will be followed up by other regulatory intervention comprising of variations in tariffs, adaptation of FITs and renewable heat incentives to the future needs of micro generation, etc. [47]. Therefore, research has been underway to streamline the FIT design models. The FIT models have been classified into two broad categories, i.e. market-independent and market-dependent FIT design models [48]. Features that distinguish rate to be paid depend on whether the payoff is fixed or related to the electricity market price, or whether it is inflation adjusted or not. Market-dependent models are those where the payment is dependent on the electricity price while in market-independent models the remuneration remains free from electricity price. To foster various investor choices, some regions adopt the fixed price as well as premium price models together and offer them to RE developers to decide which one is best for them in order to suit their level of risk.

It is therefore important for researchers and RE project developers to have concrete understanding of all the FIT mechanisms in order to make proper decision during selection of the FIT scheme to implement. For countries like Saudi Arabia that have not yet

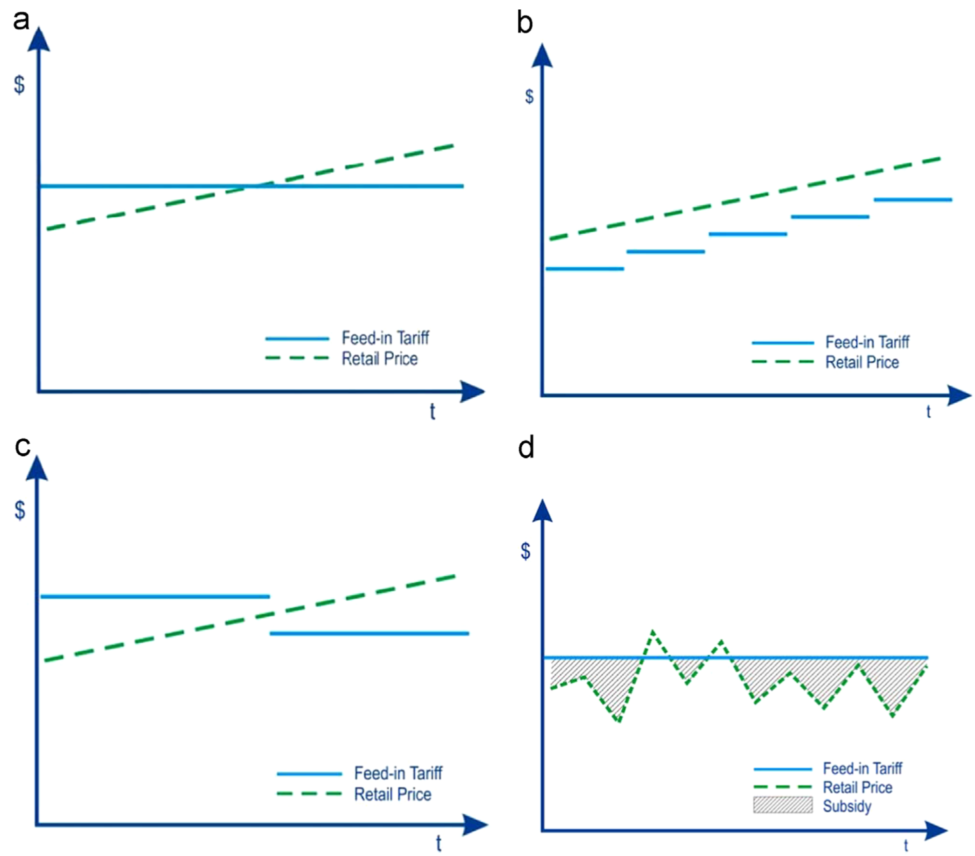

Fig. 1. Market-independent feed-in-tariff design models: (a) fixed price FIT model, (b) fixed price with full or partial inflation adjustment FIT model, (c) front-end loaded tariff model and (d) spot market gap model [48].

embraced the FIT scheme, it is equally necessary to find out how other countries have applied the FIT in their RE sectors. This will ensure proper implementation of the scheme and also achieve better results after implementation. Therefore, in the next section, a detailed discussion of the types of FIT schemes will be given together with the merits, demerits and example of country where the FIT model is applied.

3.1. Market-independent FIT design models

In these FIT models, a fixed and minimum price at which the electricity generated from RES will be bought is established, set for a specific period of time defined in the contract terms e.g. 20 years. The fixed price is left constant for the whole period of the contract, regardless of the retail price of electricity. Fixed-tariff scheme is similar to fixed-premium but both are not the same. Both alternatives allow for technology diversity by adjusting the support level to different maturity levels and costs. However, fixed-premiums involve greater risks, given the unstable electricity price whereas, for fixed-tariffs the total support is guaranteed and known in advance [49]. The main four market independent models include; fixed price FIT design model, fixed price FIT policy with full or partial inflation adjustment, front-end loaded tariff model, and spot market gap FIT model as shown in Fig. 1(a)–(d) and are discussed as follow.

The fixed price FIT policy functions in such a way that a fixed and minimum price at which the electricity generated from RES is bought is set or fixed for a contracted period of time. This model, therefore, ignores variables like inflation and fossil fuel prices. The FIT can be determined based on the cost of RE for which it is set. The electricity retail prices are also estimated to increase as the price of fossil fuels, other commodities, and the carbon legislation expansion increase. The fixed price FIT model offers significant profits to RE project developers by ensuring that the set FIT payments for solar PV, for example, are sufficiently high enough to cover the project costs. This model is illustrated in Fig. 1(a).

The fixed price with full or partial inflation adjustment FIT model functions by tracking changes in the monetary value, that is, the FIT is adjusted when there is a change in inflation level. In so doing, this adjustment aid in protecting the RE investors fall in the value of currency and the value of revenues from RE as well. This model is clarified in Fig. 1(b). To respond to changes in inflation, the whole or part of the FIT rates can be changed on annual basis by employing an established formula, whichever choice is desired. In a case where a portion of the FIT is adjusted, a percentage of the original tariff is added to the adjusted part. While in another method, full inflation adjustment is done and a given number of basis points are subtracted. The inflation adjustment can also be done depending on RE technology, for example 20% of the base price on all other RE technologies saves for solar as in the case of Ontario.

Front-end loaded is the third market-independent FIT design where lower payments are paid in later years whereas in early years, payments are set to be higher in order to transfer the cash flows in the initial period of the project. In Minnesota, the front-end loaded model offers a higher FIT for a period of 10 years following the beginning of the contract but lower FIT rates are paid in the succeeding and remaining years. On the other hand in Slovenia after the first 5 years of the project's life, FIT rates drop by 5% and also by 10% below the initial premium values for 10 years. This practice ensures that the cost of RE is reduced and the burden to the rate payer is reduced. However, the dropping rates are a reflection of the diminishing costs that a RE project developer has to pay for the project period. This model is demonstrated in Fig. 1(c) [48].

Table 1
Market-independent FIT design models, their advantages and disadvantages [48].

FIT models	Benefit to RE operators and rate payers	Disadvantages to RE operator and rate payers	Country of application
Fixed price model	*Operators* • Price fixed irrespective of retail price of electricity • Remains independent of inflation, fossil fuel prices • Offers high revenues in the early years and lower in later years • Modifications can easily be included • Investment security to attract investor in RE *Rate payers* • Positive environmental impact • Reliable project revenues calculations to avoid cheating rate payer • Setting special price premiums for specific technologies is possible e.g. for higher efficiency systems	*Operators* • Price is set at a flat rate, it neglects inflation and variations in the consumer price index (CPI) • Gradual decline in the real value of RE operator revenues	Germany, Kenya, Malawi
Fixed FIT with full or partial inflation adjustment	*Operators* • Tracking inflation in the FIT payments can provide greater value for investors • Encourage risk-averse investors to invest in RES • High degree of security is guaranteed • Protection against changes in the CPI *Rate payers* • Easier to implement politically due to the lower initial tariff price • Long- term purchase price adjustment is consistent with utility Power Purchase Agreements (PPAs).	*Rate payers* • Undue burden on ratepayers in the long term • Inflation adjustment in areas with high inflation rates	Canadian (Ontario), France, Ireland, Spain, Uganda
Front-end loaded model	*Operators* • Reduces the long-run costs of RE supply • Enables project operators to benefit from higher revenues streams when they are needed most • Allows developers to settle up loans and/or equity investors faster • Offers anticipated project revenues until the very end of the project's useful life • Ensures investment security by making the remuneration framework clear to all investors *Rate payers* • Diminished impact on retail electricity prices in the later years of a RE project's life	*Rate payers* • Policy seems more costly in the early years • May work against the principle of comparative advantage, in which most productive sites should be tapped first. • Difficult to be accepted by politicians	Minnesota, Slovenia, France, Germany, Switzerland, Cyprus
Variant of front-end loaded design	*Operators* • Increases the opportunities for different regions to participate in RE development • Promotes greater shifting flexibility *Rate payers* • Avoids overcompensation for the projects at the windiest sites • Reduces the overall costs of the policy over time • Balancing costs are reduced through greater geographic dispersion of projects		Germany, France, Cyprus, and Switzerland
Spot market gap model	*Operators* • Model retains the purchase obligation, which further increases investor security • There is transparency in spot market • transparency enables total policy costs to be calculated over time, as the sum of the premium payments • Transparency could also help facilitate cost sharing between utilities operating in different parts of one country. *Rate payers* • Increases the market integration of RE sources	*Operators* • There is a burden on smaller RE developers if they are to market the power on the market	Ontario (Canada) [52], Netherlands
Variant of Spot market gap model	*Rate payers* • Covering the difference by government subsidy	*Operators* • Further risk that the government budget will be	Netherlands

Table 1 (*continued*)

FIT models	Benefit to RE operators and rate payers	Disadvantages to RE operator and rate payers	Country of application
	means no impact are felt on electricity prices ● The ratepayers are prevented from the adverse effect of economic competitiveness	exhausted ● Projects are riskier to develop since the cost of RE is not integrated into the rate base but depend on subsidies ● Lack of ratepayer backing *Rate payers* ● Increases budgetary commitment on the government ● May hinder RE project development ● Added uncertainties may render investment environment unstable and unreliable for RE project developers	

A variant of front-end loaded design was used to rectify FIT payments in accordance with resource quality. Menegaki observed that technological learning must be reflected in the FIT system by taking into account and correcting any overcompensation produced by uniform tariffs, namely introducing tariff degression based on the technological progress made [50]. For examples, France, Germany, Switzerland and Cyprus applied this variant on wind power where a higher payment was offered for an initial period that ranged from 5 to 10 years beyond which the payment was adjusted downward. In one particular instance in Germany, rates were set according to the installation size and type. The larger, ground-mounted arrays have the lower rates while the small, building-integrated systems have the highest rates [51].

The spot market gap model is the fourth FIT scheme that is somehow similar to the market-dependent FIT models but still regarded as a market independent model on the producer perspective as the remuneration is fixed. In this FIT design the real FIT payment is combination of the gap between the spot market price and the required FIT price. As a result, the total remuneration is a fixed price consisting of the sum of the spot market price and the variable FIT premium, which, when combined, make up the total FIT payment as given in Fig. 1(d). As the market price goes up, the premium goes down and the reverse is true, a reason why it would have been regarded as a market-dependent model. Table 1 summarizes the advantages and disadvantages of market-independent FIT tariff models.

3.2. Market-dependent FIT design models

Market-dependent FIT policies necessitate RE developers to provide their electricity to the market and compete with other suppliers to encounter market demand; they then receive a premium above the spot market price for the electricity sold. Under market-dependent FIT policies, payment levels tend to rise in step with rising retail prices, and vice versa. In order to avoid exorbitant profits if the market prices rise, some areas implement caps and floors on FIT premium amounts to make sure the remuneration is within acceptable limits without overburdening the ratepayers in case the market prices rise. Fig. 2(a)– (c) illustrates the main three market-dependent FIT design models.

Using premium price model, electricity is sold on the spot market, rather than through guaranteed, long-term contracts. It offers a constant premium or bonus over and above the average retail price (Fig. 2(a)). Whereas for fixed FITs the total feed-in price is fixed, for premium schemes the amount to be added to the electricity price is fixed [53]. The premium can be designed either to reflect the environmental and social attributes of RE, or to approximate RE project costs. To date premium price policies generally operate in deregulated electricity markets where the retail price for electricity fluctuates continually according to fuel costs, as well as supply and demand factors. With the premium price remuneration scheme, the price paid to the renewable energy developers fluctuates according to the market price of electricity at the time. In this way, renewable energy producers are remunerated more if market prices go up, and less if market prices go down, all else being equal. Similar to fixed-price policies, the premium amounts can be differentiated according to technology type and project size, allowing a diversity of renewable energy projects and technologies to be profitable.

The second market-dependent FIT model is the variable premium FIT policy design that embraces the caps as well as the floors into the FIT policy system so as to allow the premium to vary according to the market price as shown in Fig. 2(b). The premium reduces slowly until the retail price attains a given level, where the premium is at a zero value and finally the power producer gets the spot market price.

The third market-dependent FIT policy option is the percentage of the retail price FIT design model that creates a fixed percentage of the retail price at which the electricity from RES is bought. This model is illustrated in Fig. 2(c). Under this model, the total remuneration paid to renewable energy producers is entirely dependent on changes in the market price for electricity. This means that if prices increase suddenly, RE producers are likely to benefit from sudden windfall profits, while if they decrease suddenly, they are likely to fall short of the revenues required to ensure profitability. This exposure to market volatilities that have no immediate relationship to RE generation costs makes this policy option significantly more risky from a producer's perspective, as cash flows are no longer primarily contingent on efficient project operation, but instead on factors in conventional energy markets.

This FIT was used in Germany, Denmark and Spain before the year 2006 but was abandoned due to some pitfalls. Table 2 summarizes the advantages and disadvantages of market-dependent FIT tariff models.

4. Detailed description of the FIT applications in selected regions around the world

4.1. Selected regions in Europe

European Union (EU) has introduced a number of planned flexibility mechanisms including the voluntary transfer guarantee of Origin (GoO) between EU member countries which the EU regards as a balanced tool. It was found that the most commonly applicable RE promotion instruments are between feed-in laws on the one hand, and tax incentives, soft loans and investment subsidies on the other [54]. However, several countries have raised concerns about

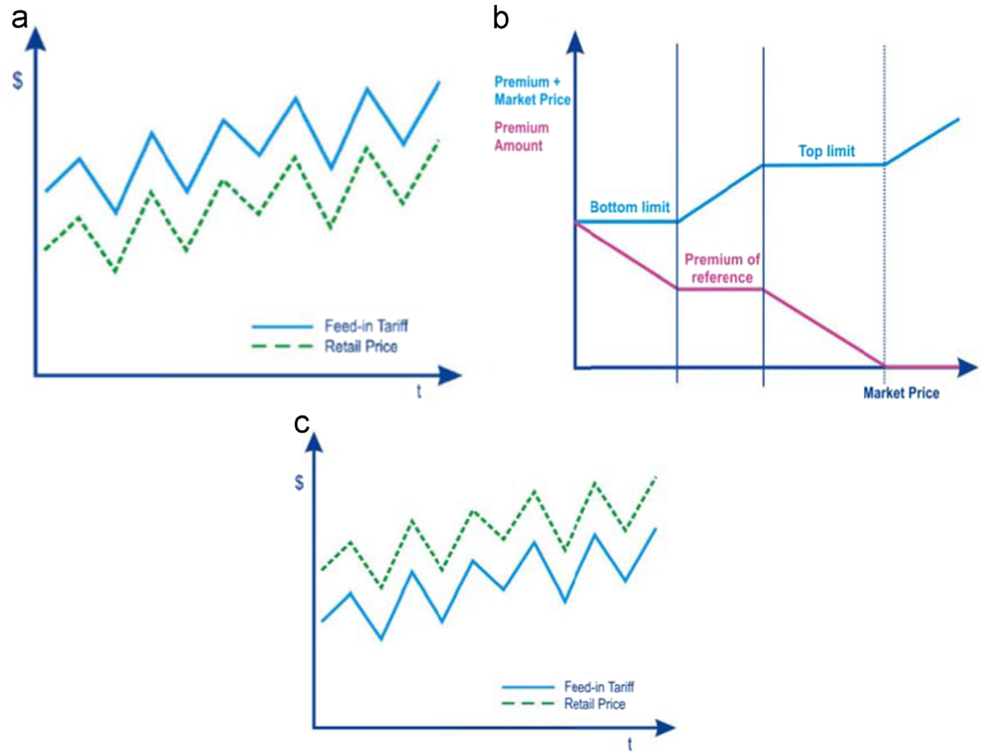

Fig. 2. Market-dependent FIT design models: (a) premium price model, (b) variable premium FIT policy design and (c) percentage of retail price model [48].

the potential negative impacts on existing national support schemes such as FIT already in practice in several EU member countries [55]. FIT are the most commonly employed RES support scheme in Europe and majority of the EU member countries have embraced FIT as main support mechanism [56]. The survey conducted indicates that the most widely accepted support mechanism within the EU-25 and EU-28 member countries is FIT system [57,58]. The FIT schemes of selected EU member states are reviewed as follow.

The UK initiated the implementation of national FIT mechanism on 1 April 2010, which comprised specific payment tariffs for PV installations. The revised FIT rate was again put in place starting from 1 April 2012, applicable to any installations with an eligibility date of on or after 3 March 2012 [59]. The introduction of the FIT schemes has rapidly increased deployment of PV technologies at small scale since its introduction in April 2010. Small scale solar PV systems also qualify for the FITs scheme [60]. In UK jurisdiction, the FITs are considered as in-service or end-of-service in order to assess the profitability of future installations.

Germany introduced the FIT in 1991 so as to create wind energy market by offering sufficient price to the producers to recover the generation costs [61]. In [62], the effect of Germany's FIT policy for small roof-top solar PV systems installed between 2009 and 2030 was examined. The conventional FITs were mainly successful for PV and other renewable energy technologies as measured by market growth. It guaranteed a fixed price for PV electricity for duration of 20 years. On the other hand, the FIT policy was critically criticized by political and scientific elements. They argue that when the policy is implemented, there is a high cost of promoting PV with relatively low solar irradiation and large profits repaid to PV investors.

RES Act (Erneuerbare Energien Gesetz, EEG) is a key support mechanism for RE in Germany. The EEG consists of priority feed-in, a purchase guarantee and a fixed FIT for electricity generated by RES. The electricity from renewables fed into the grid through the EEG is mainly sold by network operators on the day-ahead (spot) market [63]. An alternative modification of the EEG was done in 2008. The fast decline in PV prices since 2009 also called for the government of Germany to modify the level remuneration for new installations to respond to the deployment volumes [64]. Outwardly, the modification seemed to be a flexible tool with market oriented tariff digression rates. However, a thorough examination suggests that the adjustment is more political influenced than solid economic strategy. In actual sense, the failure of Germany's FIT policy is mainly attributed to the government's support mechanisms that have disrupted these incentives [65]. Croatia government introduced FIT system whereby Electricity Market Operator is supposed to off-take electricity from appropriate producers. For renewable energy a fixed price is offered for a period of 12-year contract whereas for cogeneration units fuelled by natural gas the contract period is 10 years [66].

Compared to other RE support mechanisms, FIT implementation has encouraged green electricity production in Ukraine, since FIT rates are high, and grid access is guaranteed by law, a major advantage of the current legislation on renewables in Ukraine [67]. Trypolska assessed the optimal level of FITs in Ukraine in regard to the investment attraction and business operation. It was discovered that the existing FIT is adequate for rooftop solar systems, medium and large wind projects, rehabilitated small hydropower projects and biogas derived power. The FIT were found to be suitable to attract intending investors and compensate for the high risk of investing in the Region. FIT policy was also introduced in Ireland and it was also revised to include the co-firing of biomass with peat in order to facilitate the bioenergy production [68].

Antonelli and Desideri [69] observed that Italy has become one of the leading markets for PV power plants and one of the countries in the world with the largest number of installations and installed peak power in less than 6 years. This has been attributed to a series of FIT schemes that have been operated till 2012. The Italian market has experienced a boom in the PV market after the first mechanism of FITs was promoted in 2005 [70]. The variations of the tariff structure in the following years caused significant changes in the market structure in terms of average size and technical characteristics of installed plants.

Table 2
Market-dependent FIT design modes, their advantages and disadvantages [48].

FIT models	Benefit to RE operators and ratepayers	Disadvantages to RE operator and Ratepayer	Country of application
Premium price model	*Operators* • More compatible with competitive electricity markets than fixed-price FITs • Makes an incentive to generate electricity when it is highly needed. • Enables integration of RE into the electricity system,	*Operators* • Results in higher overall cost of RE deployment • Lower cost-efficiency than fixed price policies based on the cost of generation • There is a greater risk that payment levels will be either too high, or too low • Less investor and society security • Do not offer a purchase guarantee, which can increase the risks for project developers *Ratepayers* • Incurs high costs in compensating for the added risk • Higher per-kWh costs for each unit of RE generated	Slovenia, Czech Republic, Spain, Estonia and Denmark.
Variable Premium model	*Operators* • Minimizes exorbitant profits when retail prices rise suddenly • Higher degree of investment security • Reduces the risks for investors by providing a floor on the minimum payment price • Retains several merits of premium price model but avoids a number of drawbacks *Ratepayers* • Allows payment levels to reflect RE technology costs over time • Reduces the risks for society by introducing a cap on the total premium price.		Spain, Germany
Percentage of retail price model		*Operators* • Limited investor security due to unstable prices • Discourage RE development because it is less attractive to investors • Less market-based than premium models • Leads to highly volatile payments when electricity increases • More costly to the government	Germany, Denmark, Spain

FITs are used in Portugal to boost distributed generation such as wind parks, while Spain chooses between getting a regulated FIT or the market price and a participation prize [71]. Spanish solar PV FIT and its design elements were analyzed in [72], in which some implications for the effective and cost-efficient deployment of solar PV were identified. The important role of design elements within FIT system were highlighted, where it was observed that a greater risk to investors raises the risk premium for solar PV investments and, thus, induces a greater level of support. In countries like Italy, FIT systems for solar PV in the past resulted into an intense increase in the total costs of support and decreased the social acceptability for all renewables [73]. Therefore, Italy is one the countries in EU which have reduced the FIT rates due to financial constraints.

Serbian government introduced the system of FITs for electricity generated from renewable sources. The proposed FIT for PV was set to 0.23 euro/kWh paid for 12 years, with the PV electricity produced after the first 12 years being sold at the grid electricity market price of 0.054 euro/kWh for the rest of the project lifetime. Although such FIT could have been justified by the small, average retail grid electricity price of just 0.054 euro/kWh for Serbian households, the investment appraisal of actual price of 2.82 kWp for PV power plants clearly indicated that the proposed FIT structure could not sufficiently attract investments into PV in Serbia [74]. Therefore, several other FIT schemes were suggested such as a larger FIT payment or the extension of the rate period from 12 years to the whole period of the project which is 35 years.

4.2. The United States and Australia

In US, the Tennessee Valley Authority (TVA) has implemented an incentive program based on the performance for solar, wind, hydro and biomass systems, which offers the retail electricity rate plus $0.12/kWh for solar and $0.03/kWh for all other systems in the first decade and retail electricity rate for all systems in the second decade [75]. The program has been employed in Georgia, Alabama, Mississippi, Kentucky, Virginia, North Carolina and Tennessee. Other FIT systems have also been deployed in Connecticut, California, Florida, Indiana, Hawaii, New York, Minnesota, Washington, Wisconsin and Oregon. For instance, FIT policy in Florida reward a fixed rate of $0.15 kWh–$0.21/kWh for solar RE subject to the size as well as the type of a system. New York State is one amongst several states in United States to have considered FIT legislation and the FIT rates varying from state to state [29]. As reported in [76], despite the efforts made by some states to develop energy policies to support RES development and fuel diversity by passing renewable portfolio standards, California and some others have decided to use FIT because of the benefits it presented to countries such as Germany. However, FITs are provided alongside other support mechanisms, for example, in addition to federal tax credits, the state government of Colorado gave financial incentives for generation and deployment of solar power [77].

Since 2001, Australia is said to have had a national Renewable Portfolio Standard (RPS) support scheme that supports the Renewable Energy Target scheme that applies to electricity retailers but it was criticised for failing to support the lower-priced large-scale wind development leaving the country with a narrow renewable energy generation capacity. The Australian Capital Territory's (ACT's) Large-scale Solar Auction FIT scheme is one of the initiatives that has supported specific types of large-scale solar development [78]. The FIT were introduced and applied in various territories and states for small-scale grid-connected PV systems [79]. There is a big gap between PV system production cost and FIT especially in states where FIT based on net metering is applied. This means that the RE project developers receive enough profits that keeps them in RE business.

4.3. Selected regions in Asia

The authors in [80] carried out a study on RE policy in Asia as a qualitative comparative analysis of factors affecting sustainability transitions. They analzyed FIT as demand support measure to contribute to increased RE generation. The countries reported to have embraced FIT mechamisms in Asia include China, India, Japan, Malaysia, Mongolia, Pakistan, Phillipines, Taiwan, South Korea, Vietn am, Thailand, and Sri Lanka.

The FITs for solar and wind in these jurisdictions range from $0/kWh to $.59/kWh. Analysis of the FIT in the stated countries is as follow.

Thailand is one of the first Asian countries to introduce the FIT program [81]. The assessment of the effectiveness of FIT policies to achieve the strategic targets set in Renewable Portfolio Standards (RPS) was done in [82].

Lin et al. quantified the benefits provided by Chinese FIT policy for solar power generation by using real option pricing approach to estimate the value of solar energy technologies in the face of uncertain fossil fuel prices and learning effects in solar technologies. The optimal solution as calculated renders the government's FIT effort as a sufficient mechanism to make solar an economically competitive alternative in China's energy future [83]. The RE in China is largely subsidized through REFITs. In 2010, RE subsidies accounted for 10.97 billion CNY with a bigger percentage of 97% spent on electricity generation [84].

In Malaysia, in an effort to achieve its target, the National Renewable Energy Policy 2010 was launched with specific ambitions to introduce the FIT and establish RE fund for its support. The Act for a FIT implementing agency and Renewable Energy Act were expected to be unveiled by 2011 [85], [15]. It has been reported in 2014 that under the RE Act with the grant of FIT rates, the applications for a total of about 311 MW of various RE power plants have been approved [86]. The projected capacity of RE by year 2020 and 2030 is 2000 MW and 3000 MW, respectively.

India, regarded as one of the world's energy giants has taken various measures to diversify its energy supply from fossil fuels to RE [87]. The FIT policy alongside with the renewable portfolio obligation (RPO) was specified by the State Electricity Regulatory Commissions (SERCs) in different states under their authority in India [88]. To encounter the challenges in the evolving competitive environment, the Electricity Act 2003 was enacted to promote RE generation and co-generation. One of the provisions of the Act defines the terms and conditions under which RE tariffs could be prescribed by the commission.

The Frankfurt School UNEP Collaborating Centre for Climate and Sustainable Energy Finance has reported that small-scale renewable energy projects attracted $76 billion of investment worldwide in 2011, part of which Japan also made significant investments in small-scale PV panels [89]. Therefore, RE sector expansion has speeded up when the Fukushima nuclear power plant accident took place, which resulted into the adoption of FIT mechanism [90]. Japan implemented the FIT scheme in July 2012 that encompassed specific tariffs for solar PV installations. The review of major RE policies and evaluation of the financial impact for the FIT system on consumers was carried out in [91]. The analysis revealed that the FIT rate generates a good profit, a moderate annual return on investment and a satisfactory payback period which proposes the increasing trend of solar PV.

4.4. Selected regions in Africa

Suberu et al. [92] noted the major challenges affecting RE sector in Africa and among them they reported are: poor financial capital investment, insufficient research and development guide slack of renewable energy promotion strategies. The application of FIT mechanism easies some of the challenges by bring in more funding and skilled manpower from developed to developing countries and it is one the major strategies to promote RE development being applied in the world today. Fortunately, some countries in Africa have seen this reality by applying the FIT policy in their RE sectors as observed by various researchers. Shaaban and Petinrin observed that Mauritius, Algeria, Tanzania, Kenya, Rwanda, Egypt, Uganda, and South Africa have introduced FIT while Ghana, Ethiopia, Botswana, Namibia and Nigeria were preparing their FITs deployment by 2014 [93]. The application of FIT policy by selected countries is discussed in the following paragraphs.

The policy instrument most recently introduced in South Africa in support of RE technologies is the REFIT. At first, low FIT were planned for review annually with a guarantee of 15 years but it was later realized that the period was short when compared to the lifespan of RE equipment assumed to be 25–30 years. Therefore, the national regulator, NERSA, revised the guarantee period to 20 years without degression [94]. RE technologies were assigned different FIT based on their costs in order to allow RE investors to recover what they invested with a reasonable profit. The REFIT rates are revised annually for the first 5 years followed by a 3-year review to avoid the danger of inadequate FIT to investors. These new modifications were welcomed by the RE developers as well as the environmental organizations. It is however noted that monopolistic tendencies of selling electricity from RE to Eskom, the sole buyer in South Africa causes considerable doubt among RE project developers. The electricity price paid by the consumers depends on the FIT as well as on the success it has in stimulating RE investment. The greater the amount of electricity from RE to the grid, the higher the price paid by the end users. But as the price of RE resources get lower day by day, the FIT rates will also keep decreasing while the increasing diesel prices and the continuous exhaustion of other fossil fuels will increase their electricity price until there is an equilibrium price between fossil electricity and RE electricity. It is also reported that in German RE law is estimated to have resulted into about 12% rise in price of electricity between 2002 and 2006 although Germany has one of the highest RE penetration levels on the world scale. Hence, REFIT rate is not the major problem but the varying nature of the energy resources.

Kenya's FIT policy covers electricity generated from small hydro, wind and biomass resource. The objectives of introducing the policy were to attract private investors in RE development, improving the energy security, employment creation in addition to income generation. Power producers are supposed to sell renewable electricity to the distributors while the distributors have the obligation to buy all RE at a defined fixed FIT on a priority basis [95]. Other secondary objectives were to ensure market stability for RES investors, reduce administrative and transaction costs by getting rid of the bureaucratic bidding processes and to encourage private investors to operate the power plant cautiously and efficiently so as to maximize its profits. The current FIT for solar PV is set at $0.10–$0.20/kWh, depending on whether PV system is categorized as firm or non-firm, while that for geothermal was set at $0.085/kWh [96]. These rates are all fixed and market-independent FIT rates that are independent of time. However, such low FITs were criticized for not being able to attract the investors. Therefore, it has been suggested that the FIT is to be increased to the level which is suitable enough to trigger convincing investment in RE and a net metering plant is to be introduced for small scale commercial consumer to be able to participate in FIT system [97].

In Malawi, a FIT policy was introduced for RE to accelerate private sector investment in RE technologies in the year 2012 [98]. The FIT for non-firm and firm solar PV were set at $0.10/kWh and $0.20/kWh respectively, while that of wind at $0.13/kWh. Similarly the FIT for non-firm and firm small hydro was fixed at $0.08– $0.12/kWh and $0.10–$0.13/kWh respectively depending on the size whereas $0.08/kWh and $0.10/kWh set for firm and non-firm electricity from biomass or biogas respectively. The FIT for geothermal was set at $0.105/kWh. It can clearly be observed that Malawi's FIT system also follows the market-independent fixed FIT rates.

Uganda provides a typical example of an under-electrified country, with less than 12% of Ugandans having access but efforts have been underway to boost the energy supply of the country [99]. Uganda adopted the Global Energy Transfer Feed-in Tariff (GET FiT) scheme for RE. The GET FiT program is an arrangement intended to help the advancement of RE in the developing countries through the creation of international public-private partnerships. In this set-up, international AAA-rated donors such as national governments, development banks, and international climate-related funds, contribute premium payments for RE projects in partnership with developing country governments [100]. In Uganda, the FIT for each RES technology are determined by means of a $/kWh levelized cost approach with the consideration of electricity generation costs incurred by RE project developers [101]. The Uganda program offers FIT for all RE technologies comprising hydro in different capacities, solar, geothermal and bagasse in addition to the caps for specified RE technologies [102]. To cope up with the unstable foreign exchange rate of the dollar in the country, the REFITs are accustomed to accommodate the inflationary changes by applying the equation:

$$FIT_y = \left[FIT_{y-1} * (1-w)\right] + \left[FIT_{y-1} * \frac{PPI_y}{PPI_{y-1}} * w\right] \quad (1)$$

It is observed that Uganda adopts both fixed price FIT and fixed FIT with full or partial inflation adjustment market-independent FIT design models. The FIT scheme has attracted some investors in the RES development and in January 2014, the Electricity Regulatory Authority (ERA) announced the construction of eight RE projects with a total capacity of 83.7 MW to commence soon. These projects are part of the GET FiT scheme which is an initiative including a premium in the range of $0.01–$0.02/kWh on REFIT [103].

In Tanzania, there is political recognition that off-grid systems are necessary to complement grid-extension, but the responsible agencies are yet to become fully operational. The introduction of off-grid FIT has presented a chance for the civil society and private sector to play an active role in RE development [104]. Under the new energy policy, energy providers are authorized to generate electricity from diverse sources including wind and solar [105]. An energy-sector reform has taken place during the past decade, leading to the enactment of the Electricity Act in 2008 which is considered as a driver for RE development. The important changes after the reform are that private sector is now encouraged to take an active role and standardized small power purchase agreements, working as off-grid FIT for small power producers. Some RE projects are also driven by local actors, e.g. local politicians and entrepreneurs. The reform process in Tanzania is an important step towards a more dynamic sector with more actors, and the FIT by 2011 had some positive impacts on the number of privately funded off-grid projects. Local Tanzanian actors who engage in off-grid RE projects are church organizations, entrepreneurs and small industry, international and domestic NGOs, and local authorities.

The Middle East and North Africa (MENA) of which Algeria is a member is recognized internationally as an important contributor of RE development. Algeria introduced various national programs for promoting RE and in 2004 the government announced several incentives including FIT for RE [106]. The Algerian Regulatory Commission of Electricity and Gas (CREG) set out a short term strategy to increase the electricity production from PV by at least 5% by the year 2017. The FIT scheme is one of current promotion mechanisms put in place to facilitate in achieving this target [107].

Elsewhere on the African continent, Rwanda has taken tremendous steps in developing the RES and in 2009 plans were in place to construct micro hydropower stations by four newly registered firms each constructing one with a subsidy of about 30–50% from PSP hydro project [108]. However, the developments were faced with a number of regulatory challenges because the FIT was then not in place. Therefore, the FIT received a high level of political support as it was taken as broad development strategy for RE development instead of an additional plan [109].

5. Lessons to be drawn from the FIT applications by Saudi Arabia

As we pointed out in Section 2, the main objective of this paper is to analyze the application of FIT scheme by different locations in the world and finally pick lessons for Saudi Arabia to apply similar policies. After looking at FIT design models and their application in selected parts of the world, let us now draw some more important observations:

- As a demand push strategy for encouraging RE development, FIT mechanism is still one of the most commonly used incentive around the globe to promote RE.
- Although some incidents are reported where the FIT rates are cut such as in Germany, it can be observed that this does not stop the new RE project developers as this is done following the reduction in price of RES on the world scale, but temporarily affects the existing investors if the cutting of the rates is not well managed. For example in Germany, the FIT Act was amended in 2009, when some of the FIT rates were raised (particularly for wind), and degression rates accelerated for several technologies (notably wind and solar power) [110]. Increased degression was as a result of the rapidly declining price of solar panels and wind turbine components.
- A number of FIT design models exist which are applied in different scenarios as analyzed in Section 3. Though one model can be used to encourage the investors by assuring them constant revenue in case of fixed FIT design, another model such as the variant of the front-end loaded can be used to cut the earnings of the RE developers to avoid overburdening the rate payers. In this way, a FIT scheme can be regarded as a self-reliant strategy, which suffers a disease with the means to cure it.
- It is observed that many of the jurisdictions in Africa and Asia mainly apply fixed price FIT design with or without inflation adjustment with the aim of ensuring investment security and access to financial support. This has had a great positive impact on RE development in these areas by bringing in more investors as in the case of Uganda [103] and some have been able to reduce the burden of funding RE project as in the case of Rwanda [109].
- On the other hand, in most of the developed countries the fixed price is rarely used. Instead other market-independent model such as front-end loaded model or its variant are being mostly used depending on the type of RE technology, location, project size, and application [111]. For example France, Germany,

Switzerland and Cyprus applied a variant of front-end loaded FIT model for adjustment of FIT payments based on resource quality for wind energy resource [48].

- As the case with Serbia and other countries discussed, the FIT policy has been subjected to various changes, several of which are due to the fact that the policy makers attempt to address specific project issues and bottlenecks. The German FIT for PV, for example, has evolved in a highly iterative way with policy makers adjusting the policy design overtime. Some of the policy changes were due to politics and policymakers correcting flaws in previously implemented legislations [112].

From these observations we can proceed to draw lessons for Saudi Arabia regarding FIT policy application.

- The application of FIT has had tremendous success in the developing nation from the time of its inception until today. This has attracted governments, NGOs and donor community to replicate these policies in the developing countries to share similar experience success in the RE development effort [113].
- Although Saudi Arabia is known to have a huge amount of oil reserves, putting it in position to be able to produce cheaper electricity using thermal power plants, countries like Algeria are also having huge amount of oil, though they have already embraced the FIT policy to boost the renewable energy sector.
- Saudi Arabia has always been at the forefront of promoting research and development of RES, leading other countries in GCC and more generally in the Middle East. Therefore, the application of FIT is likely to speed up RE development as it will attract more investment due to increased investment security and incentives that come with its implementation.
- As the REFIT scheme requires some premium to protect RE project developers against losses, the funding in least developed countries is mainly obtained through support from donor countries. However, this may not be a serious challenge for Saudi Arabia as government has been continuously funding research and development in the RE sector.
- It has been learnt that, the policy framework is always kept flexible while implementing the FIT scheme to enable the policy makers correct the bottlenecks that come up during the project.

6. Conclusion

A sound policy is necessary for the development and utilization of renewable energy resources. A number of support strategies have been employed in this regard although the FIT scheme is still the most widely applied and proven efficient in promoting RE by providing significant benefits to both RE project developers and rate payers. In this paper, an analysis of the REFIT for the selected regions of the globe has been done with the aim of drawing lesson for Saudi Arabia. The reviews of FIT design models indicate that several of them are interdependent. Whereas one FIT model may have a disadvantage, the benefits of the other can help overcome the disadvantage of the former, leading to a FIT mechanism to be stronger in supporting RE development. The application of the policy in Europe, US, Australia, Asia and Africa has also been reviewed. Although Germany has cut FIT rates, it has been observed that the cutting process is normal as it is done following the decreasing price of RE technology and therefore does not scare away new investors in RE sector. Finally, lessons are drawn to show that Saudi Arabia is bound to benefit if the country is to integrate the FIT policy into the RE development strategies. The analysis of the lessons identified shows that the application of FIT scheme in Saudi Arabia is likely to speed up the development of RES within the area since it has been observed that many countries have benefited from the application of FIT whereby there has been a tremendous increase in the renewable energy resource development as investors are attracted due to improved investment security in the renewable sector. As a policy recommendation, the implementation of FIT scheme can be done in stages first by implementing market-independent FITs such as fixed price while restructuring energy market. Once the competition is introduced in the energy market, then market-dependent FIT models can be implemented to enjoy the complete advantages of the FIT strategy. Based on international evidence, countries with renewable energy resources such as Saudi Arabia should introduce the FIT support strategy as it has been proven efficient incentive method.

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