



FEED-IN-TARIFF AND COMPETITIVE AUCTIONS AS SUPPORT MECHANISM FOR RENEWABLE ENERGY: A REVIEW

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ABSTRACT

Since the last two decades, many countries have passed regulations to encourage renewable energy (RE) electricity generation due to policy driven environmental such as rising concerns over climate change and pollution, national security risks associated with fossil fuels, a desire to promote innovation and increase the competitiveness of new energy sources. The Feed-in-Tariff scheme (FiT) and the competitive auctions are the most common successful support schemes that have been implemented. Numerous investors interested to bring growth of the technology because of the high profitability due to high FiT rate, but it will influence the end-user. However, competitive auction through bidding round may lower the prices and have potential to discover real production cost of RE. This study reviews the scenario and the use of the competitive auction mechanism and FiT scheme for the promotion of power generation from RE technologies, also provides an overview of the policy frameworks and support mechanisms scheme in several countries including the Association of South East Asian Nation (ASEAN). A reform should take into account the merit order effect caused by renewable energy sources even the feed-in of electricity generated by renewable energy sources lowers the wholesale price, since they offer electricity at close to zero marginal costs. Overall, the interaction of policy design, electricity price, and electricity production cost are more important determinant of RE electricity generation development than policy enactment alone.

Keywords: renewable energy, competitive auctions, feed-in-tariff.

INTRODUCTION

Feed-in tariffs have been the most widely used support mechanism to encourage the growth of renewable energy, but many countries starting to implement the competitive tenders or auctions. As a case, in South Africa which initially implement the FiT scheme for RE but then turned to competitive auctions, where the initial outcomes are encouraging and there has been much market interest, subsequently bidding rounds have seen prices fall (Eberhard, 2013). Motivations for regulatory support of RE electricity generation include rising concerns over climate change and pollution, national security risks associated with fossil fuels, and a desire to promote innovation and increase the competitiveness of new energy sources (Schmalensee, 2011). Nowadays, the global energy scenario shows that the fossil fuels play a greater roles to face significant energy and environmental challenges. To overcome these challenges, the worldwide are increasing the contribution made by RE resources to their energy supplies. Therefore, there are a range of policy frameworks and support mechanisms to promote the penetration of RE technologies into the energy mix assembled by the governments and regulatory bodies around the world. The most common support schemes that have been implemented and proven successful in the past including the competitive auctions and the FiT scheme. This study reviews the scenario and the use of the competitive auction mechanism and FiT scheme for the promotion of power generation from RE technologies in several countries such as in Asia and Europe.

Modern biomass, which produced in a sustainable way and wind are the main RE growth areas globally for the time being, while global electricity supply by RE is predicted to surpass those by conventional energy. As

shown in Figure-1 solar energy is expected to increase beyond 2030, which will contribute 25% of the energy supply by 2050, and more than 60% by 2100 (Chua *et al.*, 2011).

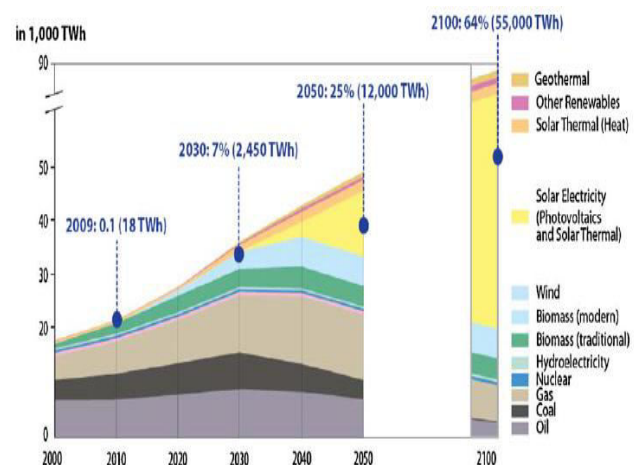


Figure-1. Electricity supply by global renewable resources.

RE TARIFF-BASED MECHANISMS

There are two RE tariff-based mechanism; i) FiT or feed-in premium (FiP), and ii) auction schemes. For the FiT/FiP, the quantity of RE is determined by market actors, and the price of RE is set or partially set by responsible regulatory body. Meanwhile, for the auction schemes, the quantity of RE is determined by regulatory body, and the price of RE is defined by competitive bidding from market actors (Renewable Energy, 2012). There are two types of FiT. For FiT 1, level of RE



tariff is set independently of the electricity market price according to electricity cost and additional support, while FiT 2, it's guaranteed for a long period, from 15 to 20 years, with technology and condition specific such as size, location and load hours (Renewable Energy, 2012). FiT 2 offered several options. In Great Britain, FiT implemented as fixed tariff or it will be indexed to inflation, but in Germany, FiT will cut down after few years. In the meantime, FiP, provides premium payments on top of electricity market price, which is a more market oriented FiT design (Rathmann *et al.*, 2011). FiT/FiP increasing popularity in developing nations with more than sixty countries has adopted FiT/FiP by early 2012. Figure-2 illustrated the number of countries adopting feed-in policies from year 1978 to 2012 (Renewable Energy, 2012).

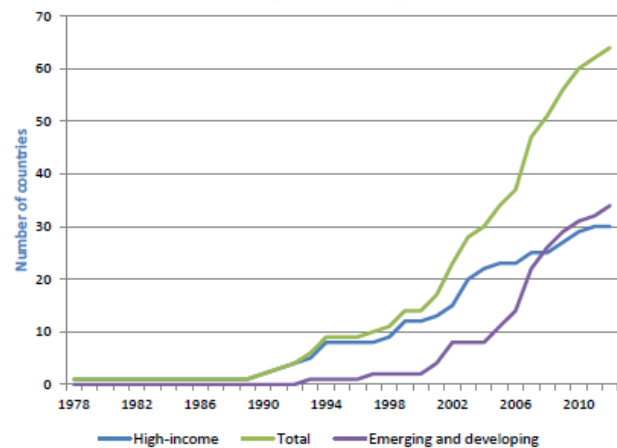


Figure-2. Number of countries adopting feed-in policies from year 1978 to 2012.

Table-1. Feed-in-tariff characteristics.

| Item | Description |
|--|--|
| <ul style="list-style-type: none"> • Fixed-price vs. premium tariff • Cost allocation • Cost containment • Contract duration • Tariff amount • Digression rate | <ul style="list-style-type: none"> • A FiT structured as either a fixed-price tariff, that guarantees the electricity generators can sell their electricity to the grid at a set price, or a premium tariff, which adds a bonus to the wholesale market price received by generators. • The generator signs a contract that entitles it to feed electricity into the grid prior to any other conventional source. The difference between the tariff and the actual market price is re-distributed among end-users or paid from state budgets in most countries. • Some countries cap the total capacity that may be installed or total tariffs that may be awarded under a FiT policy each year. • The duration over which the FiT is paid to the generator varies between policies. There is often a tradeoff between duration and magnitude. Some countries provide a relatively high tariff for a short contract duration of 10 years, while others provides a lower tariff for up to 25 years. • The tariff received by generators may differ in size between countries and energy technologies. Factors that influence the size of the tariff provided by a policy include generation cost, location, system size, receiving party, and the purpose of the host building. • Many FiT policies have a built-in digression rate, a mechanism for gradually reducing the tariff value according to the number of years after policy enactment the contract is signed. The goal is to slowly adjust the incentive provided and to adapt to increasing economic viability of RES-E technologies over time. |

A new indicator for FiT strength that captures variability in tariff size, contract duration, digression rate, and electricity price and production cost to estimate the resulting return of investment (Jenner *et al.*, 2013). However, there is considerable variety in the design of individual FiT policies (Couture, 2010). Each FiT is unique in structure, and in the investment incentive it provides. FiT policies may differ in one or more as shown in Table-1 (Jenner *et al.*, 2013).

FiT and FiP strengths and weaknesses

Globally, the generator of renewable energy sources for electricity (RES-E) have gained much importance in electric power systems and RE technologies are growing steadily to occupy a central role in electricity generation. Under a FiT scheme, the generator of RES-E is guaranteed to receive a fixed price per kWh generated or fed into the electricity grid. The tariff guaranteed covers both the electricity price and the additional support, and



they cannot be distinguished from one another because the level of tariff is set independently of electricity market prices.

FiP schemes are similar to FiT, but FiP provide a premium payments (e.g. €/MWh) on top of market prices for electricity. Under this scheme, RES-E generators have

two sources of income; one from selling power directly on the electricity market and one from the feed-in premium. To explain more details, Table-2 and Table--3 shows the strengths and weaknesses of FiT and FiP respectively (Renewable Energy, 2012).

Table-2. FiT strengths and weaknesses.

| Strengths | Weaknesses |
|---|---|
| <ul style="list-style-type: none"> • Limits the risks investors also in emerging technologies • Facilitates the penetration of new players in the market • Can be flexibly designed to accommodate different policy objectives and adapt to changes • Often funded by consumers and not exposed to public budget cuts • Long term investment security offered in FiT drives industrial development in RES-E technologies | <ul style="list-style-type: none"> • Costly when high deployment rates are achieved • Tariff setting and tariff adjustment process is challenging and complex • Generation is not exposed to electricity market prices |

Table-3. FiP strengths and weaknesses.

| Strengths | Weaknesses |
|--|---|
| <ul style="list-style-type: none"> • Fixed premiums encourage RES-S generators to react to market signals • Sliding premiums or capped fixed premiums minimize the support cost • Limit risk for investors, especially when sliding premium or fixed premium with floor • Flexibility for different designs • Well suited for liberalized electricity markets | <ul style="list-style-type: none"> • Fixed premiums without floor create revenue risk for investors and higher policy costs • Premium setting and adjustment process is challenging and complex |

FiT IN ASEAN COUNTRIES

Malaysia

In early 1970s, Malaysia's framework in energy development began, when petroleum was found. In 17 August 1974, Petroliaim Nasional Berhad (Petronas) was establish (Petronas, 2015). Since then, other consecutive policies were published including the National Petroleum Policy 1975, National Energy Policy 1979, National Depletion Policy 1980, Four Fuel Diversification Policy 1981, Fifth Fuel Policy 2000, National Biofuel Policy 2006, and National Green Technology Policy 2009 (Chua *et al.*, 2011). Under National Renewable Energy Policy and Action Plan (2010), Malaysia's FiT mechanism was established (Wong *et al.*, 2015). According to that, in order to achieve the objectives of FiT mechanism, 5 strategic thrusts (ST) have been set. In the 8th Malaysian Plan (2001-2005), RE was considered as the 5th fuel, which implied 5% of RE in energy mix (Ministry of Energy, Green Technology and Water, 2011). Ministry of Energy, Green Technology and Water (KeTTHA) via the Sustainable Energy Development Authority (SEDA)

Malaysia, Malaysia's FiT mechanism is feasible (Wong *et al.*, 2015).

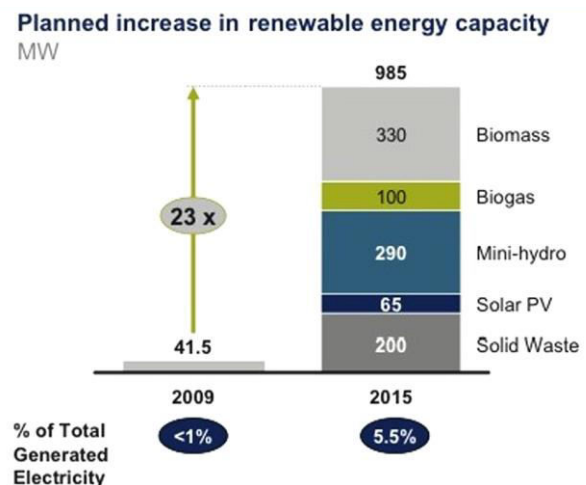


Figure-3. Renewable energy plan for Malaysia.



At present, there are biomass (including solid waste), mini-hydro, solar photovoltaic (PV) and biogas (including landfill and sewage) technology listed under the FiT mechanism, which are proven as energy sources to be practically viable in Malaysia (Wong *et al.*, 2015). Malaysia's FiT was the latest scheme launched in Malaysia, which started in November 2011. In the FiT scheme, RE producers will be paid at a set rate (tariff) for each unit of electricity fed into the grid. Normally, obliges the power companies to purchase all the electricity from eligible producers in their service area over along period of time (15-20 years) (Muhammad-Sukki *et al.*, 2012). Malaysia is different from other countries by introducing the capping source of the FiT with its objective is to ensure that the RE fund, the sole funding source for FiT, is sufficient to pay for the electricity from renewable sources. The FiT fund source is limited to 1% of the revenue from electricity sold to end users imposed on the utility's electricity revenue (Wong *et al.*, 2015). From the tenth Malaysia plan, Figure-3 shows the increasing of renewable energy application from 1% in 2009 to 5.5% of Malaysia's total electricity generated by 2015 (Fadaeenejad *et al.*, 2014, The Economic Planning Unit, 2011). It is expected that in the near future, the overall cost for a particular RE technology will decrease gradually as its technology is becoming easier and cheaper.

Thailand

Thailand was one of the first countries in ASEAN introducing a feed-in tariff policy scheme. The feed-in adder is one of the effective measures used by the government to achieve targets stipulated in its RE policies. This program also known as "Adder" because it adds additional payment to RE generators on top of the normal prices that power producers would receive when selling electricity to the power utilities (Ismail *et al.*, 2015, EIA, 2015). In 2009, Renewable Energy Development Plan (2008-2022) was introduced, when the government aimed to increase the share of RE to 20 percent of the total final energy consumption. The "Adder", a feed-in premium, guarantees higher rates for RE, making the investments profitable. In June 2010, the Thai government approved a plan to switch from a premium-price FiT payment to a fixed-price FiT payment, and studies to determine the rate for each type of RE technologies (Tongsopit, 2013). However, in 2014, according to the Department of Alternative Energy Development and Efficiency, this plan was amended in 2011 by The Alternative Energy Development Plan (AEDP 2012-2021), which targets 25 percent of the total final consumption in 2021 coming from the renewable energies. Figure-4 shows the RE target based on the AEDP 2012-2021, of which 22% is intended to come from solar energy (Ismail *et al.*, 2015).

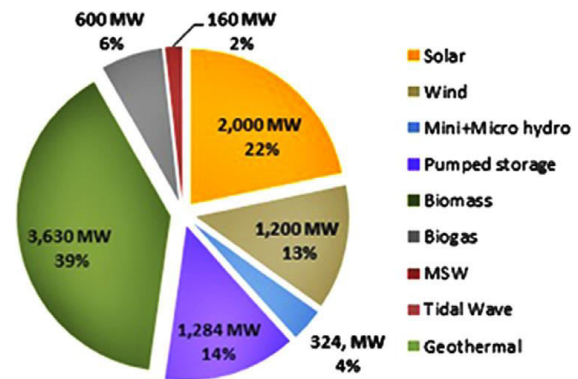


Figure-4. Thailand's RE targets according to the 10-year alternative energy development plan (AEDP 2012-2021).

Philippines

The Philippines has limited indigenous fossil fuel resources and is highly dependent on imported energy, but yet, conventional fossil fuels are still the dominant primary energy sources. Nevertheless, the share of renewable sources is comparably high (41%) due to large contribution from geothermal and biomass energy resources, which is currently the world's second largest producer of geothermal energy (Ismail *et al.*, 2015, Ogena, 2013). However, from Figure-5, solar, wind and biofuel, the contribution is only 1% (ASEAN Centre for Energy, 2013). The legal framework Feed-in Tariff in the Philippines was enacted under the Renewable Energy Act (2008) by the Department of Energy (DOE) (Pacudan, 2014). Following in 2011, Renewable Energy Plans and Programs (2011-2030) was launched (Ismail, 2015). The objectives are to promote development, usage and commercial exploitation of RE resources. Moreover, the government aims to increase the total installed renewable energy power from more than 5 GW in 2010 to more than 15 GW in 2030 (Pacudan, 2014).

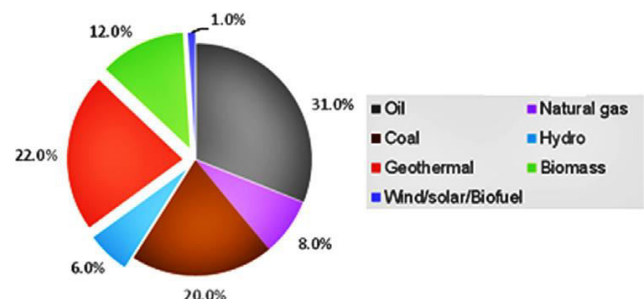


Figure-5. Share of energy sources contributions to Philippines primary energy consumption in 2011.

Singapore

The entire Singaporean population has access to the electricity network; with per capita electricity consumption of Singapore is about 8514 kWh per year (Bakhtyar *et al.*, 2013). The entire energy demand in Singapore is supplied via thermal resources. Meanwhile, hydropower energy plays no role in supplying energy in



this country. Singapore has not shown interest in investing in wind energy, while biomass energy production is limited to 220 MW of wood waste, besides biogas and geothermal energy are not produced in Singapore (Bakhtyar *et al.*, 2013). About 80% of electricity in Singapore is produced through burning gas (Ewe, 2012). Singapore rely on an external energy supply, particularly of natural gas, from neighbourhood, Indonesia and Malaysia, because limitations of land and natural resources.

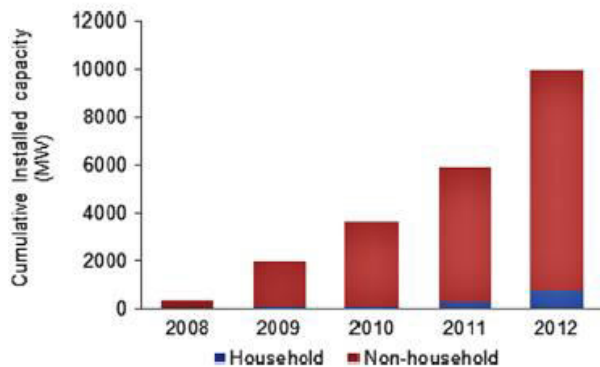


Figure-6. Installed capacity of grid-connected solar PV in Singapore from 2008 to 2012.

However, solar energy remains the most promising RE source for Singapore when it comes to electricity generation, with an average insolation of around 1635 kWh/m² per year (Energy Market Authority [EMA], 2013, Kannan *et al.*, 2007). Thus, due to its high solar insolation and strong semiconductor manufacturing and innovation base, the government is committed to developing its clean energy sector, and in particular its solar energy capabilities (Ismail *et al.*, 2015, EIA, 2015). As shown in Figure-6, the installed capacity of grid-connected solar PV systems has risen continuously since 2008 (Wong *et al.*, 2013). Meanwhile, the total installed capacity of solar PV reached 3.7 MW in 2011. In 2012, referring to the Energy Market Authority of Singapore, there were 120 grid-connected commercial solar PV installations with a capacity of 5.26 MW (EIA, 2015).

FiT SCENARIO IN EUROPE

Feed-in-Tariffs are the most popular renewable energy sources for electricity (RES-E) support scheme in European countries. FiTs refer to the regulatory, minimum guaranteed price per kWh that an electricity utility has to pay to a private, independent producer of renewable power fed into the grid (Qiang *et al.*, 2010). In contrast, a FiT is a form of price regulation under which producers of RES-E sign a contract that increases the payment they receive for each kilowatt-hour (kWh) generated, and it provides a technology-specific subsidy to improve the competitiveness of RES-E generation relative to conventional sources (Jenner *et al.*, 2013). As a pioneer, Germany has developed successful mechanism to promote the renewable energy sources (RES) and often cited as a model case study. In Germany, the

Stromeinspeisungsgesetz (StrEG) was first introduced in 1991, which obligated the public utilities to purchased renewable electricity at calculated rates between 65% and 90% of average electricity prices (Kylili and Fokaides, 2015). The German Renewable Energy Act was introduced in 2000, in order to guarantee the payments for fifteen or twenty years, but then it was amended twice; first in 2004 for an incentive for a more geographically distributed generation and a deggression model for the guaranteed payments, which considered the technological development of the RE technologies, and secondly in 2009, which the amended Act accelerated the rates of the deggression model (Kylili and Fokaides, 2015, Mabee *et al.*, 2012). Due to the success led by Germany, more than 60 countries has adopted the FiT.

TENDERS/AUCTIONS SCHEME

A tender is not a support scheme by itself; it can be combined with all other support scheme, most commonly with FiTs or FiPs. In traditional FiT/ FiP schemes, the support level is determined administratively, usually based on estimated production cost (LCOE). In a tender/auction, the FiT/FiP is determined in a competitive procedure as shown in Figure-7 (Klessmann, 2014).

RE auctions are quantity-driven support instruments, where the government or the regulatory body initially sets the desired capacity to be installed for the specific renewable energy technology (RET) (Haas *et al.*, 2011, Battle *et al.*, 2012, Becker *et al.*, 2013). The interested parties place their bids in the form of cost per electricity unit i.e., €/kWh, and the winning bidder with the best offer or a lower bid is allocated the project for that tariff rate over a certain period of time (Kylili and Fokaides, 2015). Figure-8 illustrates the flowchart for the auction/public tendering, where only selected generators benefit, and level of tariff based on prices indicated by project developers in the bid during the auction process. (Renewable Energy, 2012).

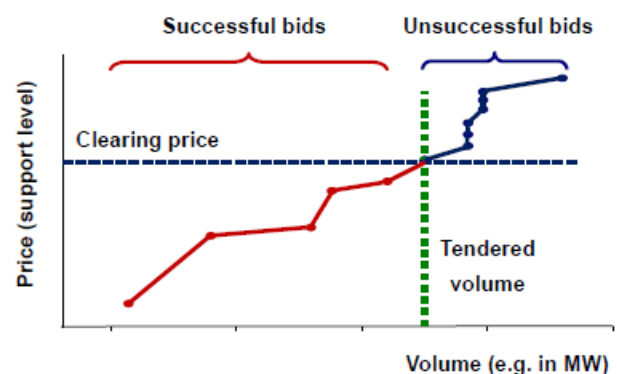


Figure-7. Competitive auctions.



Figure-8. Flowchart for the auction/public tendering.

Countries implementing auctions scheme

A number of countries worldwide have implemented an auction scheme. This include France, US, Taiwan, India and South Africa.

In France, the government decided to phase out the FiT scheme in late 2012, in order to give way to the more market-driven auction mechanism. A series of auctions for PV plant held throughout 2013. For first and second round of auctions achieved an average weighted price of 0.220€/kWh and 0.194€/kWh respectively. For third and fourth rounds of auctions, more than 200 projects of solar PV plants have been selected, totaling to 49.4 MW of installed capacity, where the costs were less than 0.235€/kWh (Kylili and Fokaides, 2015). In March 2013, France announced three more rounds of auctions by taking into consideration the carbon footprint of manufacturing the PV modules and favouring projects planned at degraded sites, and in the same month, France decided to hold another auction for 400 MW of solar PV plants, which aims to double the country's target to 1 GW of annual installations to reach the goal of 5.4 GW of installed capacity by 2020 (Solar Server, 2013).

In China, due to high costs of solar electricity generation, the government focused on solar panel exports. However, the Chinese National Development and Reform Commission (NDRC) has approved the project proposed by local governments with the price of electricity reaching 0.445 €/kWh in 2007, but then the price dropped to 0.128 €/kWh (Kylili and Fokaides, 2015). In 2009 and 2010, the Chinese government have launched competitive auctions that guaranteed plant investment and management license for a period of 25 years, resulting the winning bids ranging from 0.081 to 0.121€/kWh (Kylili and Fokaides, 2015). However, these winning bids were proven economically too low for the project to be feasible, because not only the actual installations much lower compared to the contractual capacities but also found to suffer low quality. In Taiwan, the FiT scheme led to the growth of the number of PV installations, causing the country reached its target for 2015-2020 by 2010. In 2011, due to higher cost rate of PV installation, the government incorporated the auction mechanism into FiT scheme, in order to reduce the tariff rates, the introductions of limitations on the

eligibility for the tariff rates and the control over the PV development rate and installations using caps (Kylili and Fokaides, 2015). The fact that the tariff rates dropped by 38% from 2010 levels by the third round of auctions that occurred within the same year before the introduction of the auction mechanism is a distinctive proof of the high effectiveness of incorporating the auction mechanism into the FiT scheme (Ponnampalam *et al.*, 2012).

The Indian government introduced its first FiT scheme in 2007 to promote the solar PV deployment, in order to keep the electricity at affordable price, thus to expand its access throughout the country. The scheme targeted for 50 MW of new installed capacity, however, it failed because the investors were not interested due to low incentive, with the tariff set at 0.178 €/kWh to be paid over 10 year period (Becker *et al.*, 2013, Government of India, 2008). To overcome the problem, the government introduced a new more attractive FiT scheme in 2010, that offered tariff rates of 0.276 €/kWh for 25-year period that would incorporate the auction mechanism in case the interested investors' submitted a volume of bids exceeded the desired capacities (Becker *et al.*, 2013, Government of India, 2010, Arora *et al.*, 2010).

South Africa has an independent power producer (IPP) programme promoting the development of non-hydro renewables such as solar PV, concentrating solar power (CSP) and wind but does not have large hydropower resources. The South African competitive bidding process called the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP), which was introduced in 2011, has produced costs much lower than the South African Power Pool (SAPP) estimates (Analysis of Infrastructure, 2014). The REIPPPP was introduced by the Department of Energy in place of the Renewable Feed in Tariff (REFiT) scheme that had been planned by the National Energy Regulator of South Africa (NERSA) (Yuen, 2014). The cost from REIPPPP are much lower, especially for solar PV, compared to those proposed under the REFiT. The comparison of the cost is given in Table-4, which also gives the international costs as researched by International Renewable Energy Agency (IRENA) in American Dollar (USD) and South African Rand (USc) (Arora *et al.*, 2010). It is interesting but expected to note that the REIPPPP has produced prices that are generally more favourable than REFiT scheme.

Table-4. Renewable cost comparisons (Regional and International).

| Generation technology | South Africa (SA) | | | IRENA | |
|-----------------------|--------------------------|---------------------------|--------------------------------------|--------------|---------------------|
| | 2012 SA REIPPPP (USD/kW) | 2012 SA REIPPPP (USc/kWh) | 2009 NERSA Feed in tariffs (USc/kWh) | 2012 USD/kW | 2012 LCOE (USc/kWh) |
| Solar PV | 2 889-3 471 | 16.5-27.6 | 23.1 - 39.4 | 3 600-6 000 | 15-31 |
| CSP* | 7 577-8 966 | 25.1-26.7 | 14-31.4 | 4 600-10 500 | 22-25 |
| Wind | 1 935-2 007 | 9.0-11.4 | 9.4 - 12.5 | 1 300-2 200 | 8-12 |
| Bio-energy | | | | | 5-6 |

NOTES: *The higher CSP costs reflect 3 to 15 hour storage; USD costs from 2010.



Auction scheme strengths and weaknesses

Auction schemes are different from FiT or FiP in that only selected RES-E generators benefit from the support tariff or premium, and the level of the tariff or premium is based on the prices indicated by the project

developers in their offers during the auction process. Table-5 shows the strengths and weaknesses of auction schemes (Renewable Energy, 2012). Table-6 summarized the comparison between FiT and auction scheme.

Table-5. The strengths and weaknesses of auction schemes.

| Strengths | Weaknesses |
|--|---|
| <ul style="list-style-type: none"> • High cost efficiency due to price competition • Useful to establish competitive pricing • High investor security if auctions are linked to long-terms PPAs • Useful for volume and budget control • Well scheduled auctions can increase the predictability RES-E supply • Other policy objectives can be achieved through auctions | <ul style="list-style-type: none"> • Discontinuous market development (stop-and go cycles) • Relatively high risks of not winning the project for high investment costs from bidders • High administrative cost • Underbidding and need for penalties |

Table-6. The comparison between FiT and auction scheme.

| FiT scheme | Auction scheme |
|--|--|
| <ul style="list-style-type: none"> • The quantity of RE is determined by market actors, and the price of RE is set or partially set by responsible regulatory body • Remuneration is more effective and efficient for small-scale systems • Costs of equity and cost of debt are generally lower, thus, the weighted average cost of capital is significantly lower | <ul style="list-style-type: none"> • The quantity of RE is determined by regulatory body, and the price of RE is defined by competitive bidding from market actors • Competition between RES-E producers may lower prices • Potential to discover real production cost of RES-E • Remuneration is more effective and efficient for large plants • Higher transaction cost |

CONCLUSIONS

The tariff-based support schemes for RES-E have been used in an increasing number of countries over the last ten years. Although FiT and FiP are still the most popular mechanisms, but the use of auctions is increasing worldwide.

The design of the policies has improved from time to time, to adapt to market conditions, maturity of the technologies, and public budget deficits. The policy learning between countries is an important driver for improving policy design. FiT, FiP and auctions mechanisms have experienced significant changes in the way they are designed to account for these changes and to make them more effective and more efficient. The FiT rates are predetermined by the policy makers. Therefore, considerable 'guesswork' is necessary concerning the situation of future market conditions and the rates of technological developments. Furthermore, many investors interested to bring growth of the technology because of the high profitability due to a high feed-in-tariff rate. Subsequently, it will affect the end-user whose burden due to the added levy, which increases the price of end energy as the overall share of RET increases.

The competitive auction mechanisms face several challenges, especially for immature RETs, where the investors often appear to issue bids of unrealistically low costs that cannot recover their development and running costs and consequently fail to deliver their projects. Thus, countries that have legally binding goals for RES can easily fall back on their plan and targets. Nevertheless, through auctions scheme, a few opportunities can be taken into account such as able to control of maximum volume and support cost, the support level is determined by the market but not the administration, competition between RES-E producers may lower the prices and finally, have potential to discover real production cost of RES-E.

A reform should take into account the merit order effect caused by renewable energy sources. On a liberalized electricity market, the feed-in of electricity generated by renewable energy sources lowers the wholesale price, since they offer electricity at close to zero marginal costs. It is indicate that the renewables come to the market the lower will be overall prices that can be achieved on this market.



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