Renewable Energy in Pakistan: Policy Strengths, Challenges & the Path Forward

Mashael Yazdanie
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Energy Economics & Policy
Dr. Thomas Rutherford
ETH Zurich

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1. Introduction: Renewable Energy in Pakistan

Today, only 55% of Pakistan's population has access to electricity. The nation is currently facing a 3 GW power supply shortage - the most severe energy crisis to ever hit the country (Harijan, Uqaili and Memon 2008). The occurrence of prolonged and frequent power outages has had a negative impact on industry operation, the economy and the livelihood of citizens in general (Harijan, Uqaili and Memon 2008). While the energy shortage continues to grow, abundant indigenous sustainable energy resources such as wind, solar and biomass remain virtually untapped. The government attempted to promote the adoption of renewable energy technologies (RETs) in 2006 by implementing its first renewable energy policy. However, this policy has had limited success and faces a number of challenges. These policy challenges must be clearly identified and addressed in order to pave the way forward for a sustainable energy future in Pakistan.

Currently, approximately 66% of power generation in Pakistan is derived from fossil fuels (primarily oil and gas) followed by hydroelectricity (30%) and nuclear energy (3%) (International Energy Agency 2007). Figure 1 below illustrates the shares of electricity generation by fuel type in 2007.

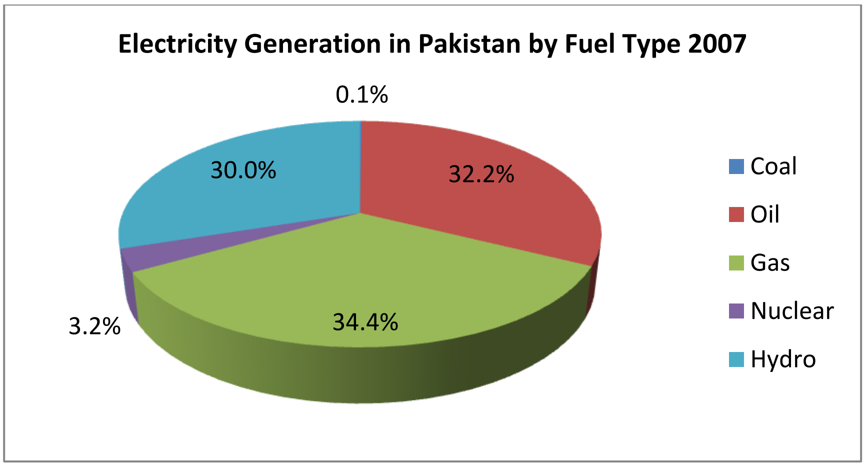

Figure 1: Electricity Generation in Pakistan by Fuel Type 2007 (International Energy Agency 2007)

As it can be observed from the figure above, hydro is the only sustainable energy resource which Pakistan employs for large-scale power generation. The implementation of the 2006 renewable energy policy has stimulated some interest in large-scale renewable power generation, but only one

50 MW wind energy project has been deployed in the Sindh region to date - that, too, with limited success (Daily Times, PM Inaugurates Pakistan's First Wind Power Project 2009).

The potential for renewable energy technologies to bridge the gap between energy supply and demand in Pakistan is significant. Renewable energy projects have the potential to improve energy security, provide socioeconomic benefits, reduce local pollution and mitigate climate change (Masud 2009). Further, due to the decentralized nature of renewable energy projects, they have the potential to provide electricity to remote and rural areas, thereby helping to alleviate poverty and reducing the need to collect and burn biomass fuel (Masud 2009).

Solar, wind, biomass and hydro energy resources are widespread and abundant in Pakistan. The potential for each of these energy resources to help meet energy needs will be discussed below.

Solar Energy

Pakistan lies in a region of high solar irradiance; as such, it is ideally suited for solar energy projects. Pakistan receives about 15.5×10^{14} kWh of solar irradiance each year with most regions receiving approximately 8 to 10 sunlight hours per day. The installed capacity of solar photovoltaic power is estimated to be 1600 GW per year, providing approximately 3.5 PWh of electricity (a figure approximately 41 times that of current power generation in the country) (Harijan, Uqaili and Memon 2008).

Wind Energy

Wind energy has also been shown to have strong technical potential in Pakistan, particularly in the southern regions of Sindh and Balochistan. Pakistan has approximately 1000 km of coastline with steady average wind speeds ranging between 5-7 m/s. The projected installed capacity for wind energy projects is estimated at 122.6 GW per year, providing about 212 TWh of electricity (a figure approximately 2.5 times that of the current power generation level) (Harijan, Uqaili and Memon 2008).

Biomass Energy

The availability of biomass in Pakistan is also widespread. Approximately 50 000 tonnes of solid waste, 225 000 tonnes of crop residue and over 1 million tonnes of animal manure are produced daily. It is estimated that the potential production of biogas from livestock residue is 8.8 to 17.2 billion cubic meters of gas per year (equivalent to 55 to 106 TWh of energy). Additionally, the annual electricity production from bagasse (the fibrous residue remaining after sugarcane or sorghum processing) is estimated at 5700 GWh; this figure is about 6.6% of Pakistan's current power generation level (Harijan, Uqaili and Memon 2008).

Hydro Energy

As mentioned previously, hydro is the only sustainable energy resource which Pakistan has been effectively employed for large-scale power generation. Currently, Pakistan has an installed hydropower capacity of approximately 6.6 GW. This figure is only 16% of the total hydropower potential in Pakistan, estimated to be about 41.5 GW (Harijan, Uqaili and Memon 2008).

Undoubtedly, renewable energy resources in Pakistan are widespread and present significant technical potential to meet energy needs. This begs the question then, if the potential for renewable energy resources in Pakistan is so great, why has there been such little development in this field? The technical potential and availability of renewable energy resources alone provides little indication about the success of renewable energy project development in a country. For instance, Pakistan has a greater technical potential for wind energy projects compared to its neighbour, India, yet India has the fourth largest installed capacity of wind power in the world (Ahmed, et al. 2007) (Asif 2009). Indeed, no matter how much technical potential exists, it is of little use unless an effective policy bolsters development. To this end, Pakistan instituted its first renewable energy policy in 2006. However, this policy has stimulated limited growth since its implementation.

The slow uptake of renewable energy technologies can be attributed to numerous factors, ranging from a lack of infrastructure to poor competition with conventional power generation. In order to pave the way forward for a sustainable energy future in Pakistan, the challenges which energy policies face must be systematically identified and addressed. This paper intends to discuss policy strengths and challenges and to provide insight into how Pakistan can move forward towards a sustainable energy future.

2. Energy Policy in Pakistan

Before an assessment of policy challenges can be made, an understanding of Pakistan's energy policy, in the context of renewable energy, must first be ascertained.

2.1 Energy Policy Development in the Context of Renewable Energy

The push to restructure Pakistan's power sector first began in the mid-1980s when country-wide power shortages crippled the nation (Hagler Bailly Pakistan 2003). In order to address the energy crisis, the government of Pakistan instituted its first private power policy in 1985. This policy was aimed at attracting private investors to the power sector. Prior to its implementation, power generation in Pakistan was a monopoly, exclusively state-owned and operated (Hagler Bailly Pakistan 2003).

During this period, Pakistan made its first move towards exploring renewable energy options. The government invested 14 million rupees towards feasibility studies for solar energy and biogas production between 1983 and 1988 (Khattak, et al. 2006). However, no significant project developments resulted from this investment.

New energy policies were also instituted in 1994, 1998 and 2002. The 2002 Power Policy, currently still in place, encouraged the use of local resources including renewable energy resources (Environmental Protection Department 2007). This policy aimed to develop approximately 500 MW of renewable (non-hydel) power generation by 2015 and about 1000 MW by 2020 (Hagler Bailly Pakistan 2003).

Although various energy policies implemented between 1985 and 2002 stressed the need for employing renewable energy resources, none provided a framework for the implementation of such projects (Khattak, et al. 2006). Renewable energy development was virtually non-existent as these policies failed to attract private sector confidence and investment (Khattak, et al. 2006).

2.2 Government Organizations for the Promotion of Renewable Energy Technologies

Various government institutions have been established over the past 30 years in order to promote the implementation of RETs as well. The National Institute of Silicon Technology (NIST) was founded for research and development (R&D) in the field of solar energy in 1981. The Pakistan

Council for Appropriate Technology (PCAT) was also established four years later. This group aimed to promote hydropower, biogas and small-scale wind energy technologies. The two institutions were merged into one, forming the Pakistan Council of Renewable Energy Technology (PCRET) in 2002 (Khattak, et al. 2006). The goal of PCRET was to organize, coordinate and promote R&D efforts within the field of renewable energy.

The Alternative Energy Development Board (AEDB) was established in 2003. The objective of this institution was to develop renewable energy policies for the promotion of wind, solar and small-scale hydro power projects (Khattak, et al. 2006).

2.3 The 2006 Policy for Development of Renewable Energy for Power Generation

AEDB introduced the Policy for Development of Renewable Energy for Power Generation in 2006. This is Pakistan's first energy policy aimed specifically at the promotion of renewable energy power projects. The goal under this policy is for RETs to provide 10% of Pakistan's energy supply mix by 2015. The policy focuses on solar energy, wind energy and small-scale hydro power projects (Hussain 2007). The policy objectives are to:

- increase the deployment of renewable energy technologies (thereby diversifying the energy supply mix and increasing energy security);
- promote private sector investment in RETs through incentives and by developing renewable energy markets;
- develop measures to mobilize financing;
- facilitate the development of a domestic RET manufacturing industry (thereby lowering costs, improving service, generating employment and improving local technical skills);
- increase per capita energy consumption and social welfare, especially in remote and rural areas where poverty can be alleviated and the burden on women collecting biomass fuel can be reduced; and
- promote environmental protection and awareness (Government of Pakistan 2006)

The policy intends to meet these objectives through several key initiatives. Salient features of the policy (directed at wind, solar and small-scale hydro projects) are briefly outlined below (Government of Pakistan 2006) (Bhutta 2008):

- Private investors are invited to submit proposals in the following categories:
  - for selling power to the grid exclusively (Independent Power Producer or IPP projects)
  - for self-use and sale to the utility, if desired (captive power projects)
  - for small-scale standalone projects (isolated grid power projects)
- For all non-IPP projects, Letters of Intent (LOI), Letters of Support (LOS) and Implementation Agreements (IA) with the government are not required.
- Producers may sell surplus electricity to the grid at a given point in time and draw electricity, as required, at a later point in time (known as net metering and billing).
- Producers are permitted to inject electricity at one point on the grid and receive an equivalent amount at another location upon paying a wheeling charge (accounting for transmission charges).
- There are no customs or sales taxes on equipment.
- There are no income taxes.
- IPP projects may obtain carbon credits.
- IPPs are protected against resource variability (e.g. variable wind speeds or water flows); this risk is borne by the power purchaser.
- It is mandatory for power distribution utilities to purchase all power offered by renewable energy projects.

This policy has stimulated some interest in renewable energy project development for large-scale power generation since its implementation in 2006; however, progress has been slow and only one 50 MW wind energy project has come to fruition (Bhutta 2008). This project, as mentioned previously, was launched in 2009 in the Sindh region. The reasons for the slow uptake of RETs from a policy perspective, as well as the positive aspects of Pakistan's RET policy will now be considered.

3. Policy Strengths & Challenges

3.1 Policy Strengths

The 2006 Policy for Development of Renewable Energy for Power Generation presents several valuable initiatives which support the development of RETs in Pakistan. The policy encourages both large and small-scale project development. It encourages the adoption of small-scale, deregulated and standalone systems which are especially important in the context of remote and rural areas. Power transmission infrastructure in Pakistan is limited and mostly unavailable in rural areas; dependence on the grid and its reliability is eliminated by using standalone systems. Additionally, transmission losses are avoided (Khattak, et al. 2006). By deregulating small-scale power projects, transaction costs are also reduced and any able person may set up a power project (Bhutta 2008). The net metering and billing system for small-scale projects provides advantages as well. This system results in optimized capacity utilization and is economically beneficial for dispersed, decentralized means of power production (Bhutta 2008).

Key policy features also support large-scale renewable energy project development. An important financial incentive is income tax exemption, as well as equipment sales and customs tax exemption. Additionally, carbon credits for IPPs help to increase financial returns and reduce production costs (Bhutta 2008). Protective measures such as resource variability risk aversion for IPPs and the guaranteed purchase of power by utilities have also been designed to encourage project development. Such protective measures are particularly important for new industries where pioneering projects are subject to the greatest risks.

3.2 Policy Challenges

Several positive features of Pakistan's renewable energy policy have been presented. However, the fact remains that these initiatives have not been enough to stimulate significant growth in Pakistan. This is a result of the policy's failure to effectively address several significant issues, some which have been acknowledged in the policy framework and others not. The challenges which the renewable energy policy still faces are discussed below.

Lack of Competition with Conventional Power Generation

Perhaps one of the principal reasons for the slow uptake of RETs is their lack of competition with means of conventional power generation in Pakistan. Despite tax exemptions, RETs remain comparatively more expensive than their fossil fuel counterparts. This can be explained by several factors. Firstly, RETs have high capital investment costs compared with fossil fuel technologies. One study actually found that "if it had not been for [the] larger capital involved in installing a photovoltaic (PV) cell power plant [in Pakistan], it would have been a very clear winner in [terms of] economic comparisons" (COMSATS 2005). The lack of a domestic manufacturing industry means that equipment must be imported as well, which drives the costs of renewable energy projects up even further (Khattak, et al. 2006).

Another significant factor for consideration is that fossil fuels such as oil are heavily subsidized and the power generated by these plants is purchased at high rates by the government (Economic and Industrial Publications 2008) (Khattak, et al. 2006). These factors play an important role in hindering the development of RETs in Pakistan, as will be explained here.

One purpose of subsidizing fossil fuels is to protect domestic prices from volatile global market fluctuations (Economic and Industrial Publications 2008). In doing so, however, the government inhibits the drive for businesses and citizens to adapt to changes by adopting alternative, more efficient technologies in the long-run (Economic and Industrial Publications 2008). For example, people will not search for alternative transportation methods or look to purchase energy efficient appliances should energy prices remain constant over time.

Additionally, subsidies drive the prices of fossil fuel energy down, placing the already capital-intensive RETs at a further disadvantage. This is illustrated conceptually using the classical supply and demand model shown in Figure 2 below.

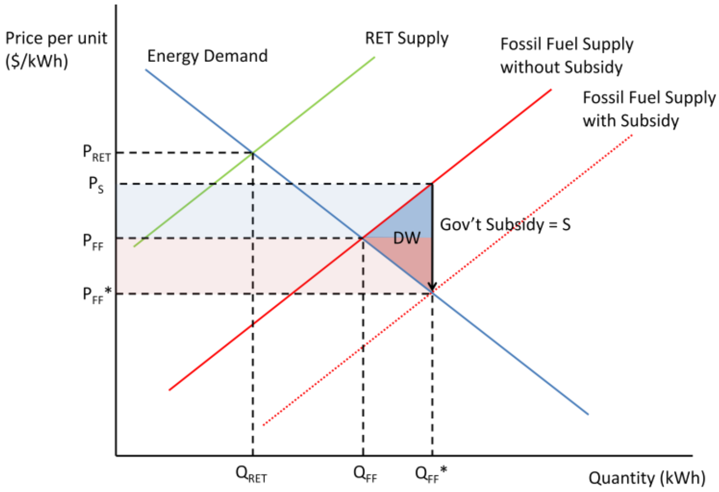

Figure 2: Supply & Demand - Effect of Government Subsidy on Fossil Fuel Prices

This figure illustrates RET and fossil fuel energy supply curves before and after the application of a government subsidy. It can be seen that the equilibrium price and quantity (P_{RET} and Q_{RET}) for RETs is higher than that of fossil fuels. The equilibrium price and quantity (P_{FF} and Q_{FF}) of fossil fuels before and after the subsidy is also shown. The effect of applying a government subsidy on fossil fuels is to shift the fossil fuel supply curve downward (effectively increasing supply). As a result, the equilibrium point shifts to P_{FF}* and Q_{FF}*, a lower price and higher quantity compared to P_{FF} and Q_{FF}. The subsidy has the clear effect of reducing the cost of fossil fuels, thereby increasing the competitive gap between RETs and conventional power generation.

Figure 2 above also illustrates consumer and fossil fuel producer surpluses. The consumer and producer surpluses are illustrated by the transparent pink and blue polygons. The deadweight loss indicates economic inefficiencies and is represented by the opaque pink and blue triangles. The cost to the government for providing the subsidy is given by the pink and blue shaded areas (both opaque and transparent); this cost will always be greater than the net consumer and producer gains.

Another factor to consider is that of negative externalities. External costs such as the health and environmental costs associated with air pollution through fossil fuel combustion are not factored into energy prices (Khattak, et al. 2006). At the same time, positive externalities such as the social and environmental benefits of non-polluting RETs are not accounted for either. This results in further marginalization of RETs. In order to illustrate the concept of socially efficient production levels, the marginal cost model for negative externalities associated with fossil fuels is considered in Figure 3 below.

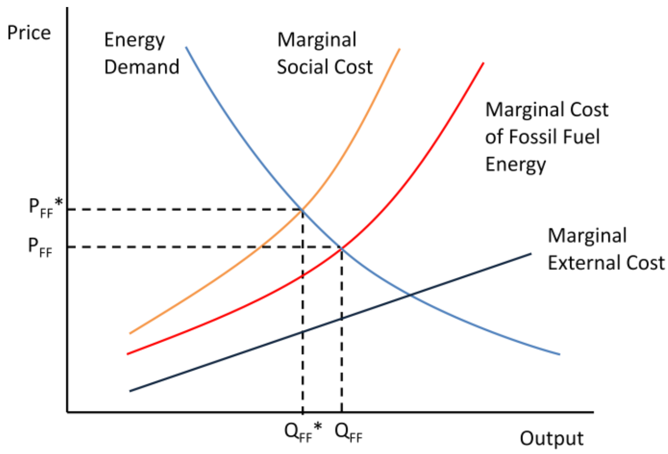

Figure 3: Socially Efficient Fossil Fuel Energy Production

The marginal social cost is higher than the marginal private cost of power production for negative externalities, as illustrated in Figure 3 above. The difference between the marginal social cost and marginal private cost is called the marginal external cost. When negative externalities are not considered, power producers attempt to maximize profits by operating at the equilibrium price P_{FF} and output quantity Q_{FF}. This describes the current situation for the power production industry in Pakistan. When the health and environmental costs caused by fossil fuel combustion are considered however, the socially efficient production level is at the higher price P_{FF}^* and lower output quantity Q_{FF}^*. By accounting for the external costs associated with fossil fuels, these conventional technologies are placed at a disadvantage compared to RETs; however, this is not currently the case.

The abovementioned factors, taken together, result in RETs being unable to compete effectively with conventional means for power generation. Although RETs are tax exempt under the new 2006 policy, these incentives are not sufficient to stimulate significant growth in a field where returns have long gestation or breakeven periods (Haq 2008).

Market Barriers

As a result of the competitive disadvantage of RETs, the dominance of non-renewable power producers, and market prices which do not reflect external costs and benefits of technologies, the market penetration of RETs is small (Mirza, Ahmad and Harijan, et al. 2009) (Khattak, et al. 2006). With respect to biomass fuel specifically, market barriers are a result of unreliable biomass supply and frequent price fluctuations (Mirza, Ahmad and Harijan, et al. 2009). Limited market penetration can also be attributed to limited marketing (for example, through promotional campaigns) and a lack of previously successful business models (Mirza, Ahmad and Harijan, et al. 2009). Market expansion would result in a larger demand and supply of RETs.

Financial Barriers

Another important challenge is that there is a lack of adequate financing for renewable energy projects in Pakistan, particularly for small-scale projects (Mirza, Ahmad and Harijan, et al. 2009) (Mirza, Ahmad and Majeeda, et al. 2007). Part of this difficulty stems from a lack of awareness regarding RETs, a high risk perception of investment and also uncertainty about the reliability of resource assessments (for example, unreliable wind speed projections). Additionally, the relatively higher capital cost of RETs discourages financers (Mirza, Ahmad and Harijan, et al. 2009).

Poor Infrastructure

Another key factor hindering the development of RETs is a lack of supporting infrastructure. There are currently few transmission and distribution lines in rural areas where load demand is low and dispersed (COMSATS 2005). The cost of extending high-voltage transmission lines to these areas is prohibitively high and uneconomical given the low and dispersed load demands. To illustrate, constructing an 11 kV, 132 kV and 220 kV line costs approximately 0.2 million, 3 million and 5 to 7.5 million rupees/km, respectively (COMSATS 2005). The unstable nature of the electricity grid in Pakistan also presents challenges during power off-take from RETs (Mirza, Ahmad and Harijan, et al. 2009). Therefore, standalone RET projects serve as a good solution for remote rural electrification.

Another infrastructure challenge is that RETs are generally decentralized in nature, whereas Pakistan's current electric power system has been designed to support the needs of centralized systems. The infrastructure requirements of decentralized means of energy production differ from those of centralized energy systems and therefore, the existing system must be adapted to support RETs more efficiently and effectively (COMSATS 2005).

Market-support infrastructure is also required. Market-support infrastructure refers to networks of dealers and manufacturers, after-sale services and support technologies (COMSATS 2005). Such infrastructure will result in market growth, increased sustainability and lower renewable energy project costs.

Institutional Barriers

Pakistan has a history of poor coordination and cooperation between governmental agencies. No governmental body was responsible for the planning and development of renewable energy policies in Pakistan prior to the founding of AEDB. Prior to PCRET, there were a number of disparate governmental organizations with uncoordinated and limited objectives (including NIST and PCAT, which were merged to form PCRET as a result of their inability to cooperate) (Khattak, et al. 2006). A lack of coordination and cooperation between government agencies, institutions, ministries and stakeholders continues today (Mirza, Ahmad and Harijan, et al. 2009). A good example is that of PCRET and AEDB, two organizations which work towards the same goal yet do not work jointly (Hassan 2006). Efficiency losses are incurred and progress is delayed as a result. R&D efforts are often duplicated where information sharing would have been far more efficient (Mirza, Ahmad and Harijan, et al. 2009).

Poor Information & Technology Access

Limited access to RET-related information and technology is also prohibitive to renewable energy project development in Pakistan. There is a shortage of technical information with respect to resource assessment such as wind and water flow data (COMSATS 2005). The availability of such data is vital for supporting investor interest and project development. Technical knowledge regarding the potential of mature technologies is also largely unavailable as a result of deficient resource assessment databanks and a lack of understanding about relevant technical and cost considerations (Mirza, Ahmad and Majeeda, et al. 2007). A lack of information regarding energy supply and demand at the dispersed level also hinders development (Khattak, et al. 2006). The commercialization of RETs is additionally affected by a lack of information regarding the durability, reliability and performance of products (Mirza, Ahmad and Harijan, et al. 2009). There is a lack of feedback data in this regard preventing experiential learning.

Technology access is also limited. There is no notable manufacturing industry for RETs in Pakistan today. As a result, technologies must be imported at a higher cost and there is a lack of domestic technical knowledge regarding these products (Khattak, et al. 2006). Furthermore, maintenance facilities for these technologies are inadequate, leading to low operational reliability and customer confidence (Mirza, Ahmad and Harijan, et al. 2009). R&D activities in renewable energy are very limited as well (Khattak, et al. 2006). The lack of an overall technically supportive environment inhibits RET project development.

Lack of Capacity & Training

A skilled workforce is also required for the successful deployment and development of renewable energy projects. At present, there is lack of both trained personnel and training facilities for the installation, operation, and maintenance of RETs (Khattak, et al. 2006). Skilled individuals from a wide range of academic disciplines are also required for R&D activities (COMSATS 2005). Without an adequate indigenous skilled and semi-skilled workforce, a sustainable renewable energy industry in Pakistan is difficult to achieve.

Lack of Social Awareness & Acceptance

Finally, there are a number of social challenges which renewable energy policies must manage. There is a considerable lack of awareness regarding renewable energy technologies and the benefits they can provide to communities. This is largely due to inadequate awareness programs aimed at educating the general public about the advantages of RETs, especially for those in rural and remote areas (Mirza, Ahmad and Harijan, et al. 2009). Practical information regarding the installation, operation and maintenance of renewable energy projects is also limited thereby preventing communities from exploring RET options. Widespread adoption of these technologies is difficult given the lack of social awareness and acceptance of RETs (Mirza, Ahmad and Harijan, et al. 2009).

Land availability is another social barrier of potentially significant consequence. Ideal locations for renewable energy projects, such as wind energy projects, are often located on traditional lands. Gaining community confidence and acceptance can result in extensive negotiations and can require significant compensation payments (Mirza, Ahmad and Harijan, et al. 2009).

Undoubtedly, Pakistan faces a number of challenges in its efforts to promote the adoption of renewable energy technologies. The 2006 renewable energy policy has certainly made important first steps to this end; however, several challenges remain to be addressed.

4. The Path Forward: Addressing Policy Challenges

The previous section detailed key policy challenges facing renewable energy project development in Pakistan. Moving forward, it is necessary to identify possible approaches to address these challenges for future energy policies. Strategies for improvement are discussed below.

Energy Subsidy Transfers

It is a bold but necessary step for the government to consider transferring subsidies from fossil fuels to RETs in order to bridge the competitive gap between them (COMSATS 2005). For example, subsidies on kerosene oil can be applied to solar lanterns instead. A classical supply and demand model will be utilized in order to illustrate this concept, shown in Figure 4 below.

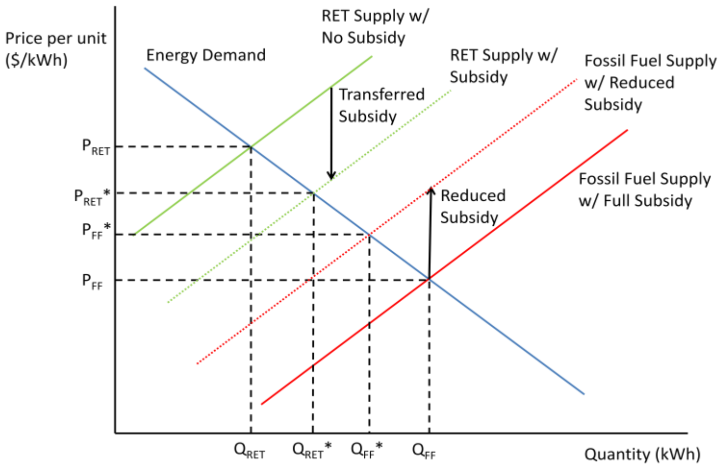

Figure 4: Supply & Demand - Transferring Subsidies from Fossil Fuels to RETs

In this figure, P_{FF} and Q_{FF} represent the equilibrium price and quantity of fossil fuel-based energy (with subsidies applied), while P_{RET} and Q_{RET} represent the equilibrium renewable energy price and quantity (with few or no subsidies applied). The concept of transferring subsidies is illustrated as the upward shift of the fossil fuel supply curve (i.e., reducing the subsidy and effectively decreasing supply) and the downward shift of the RET supply curve (i.e., introducing the subsidy and effectively increasing supply). The net effect is that the fossil fuel price (P_{FF}*) is comparatively higher and the quantity (Q_{FF}*) is lower, while the RET price (P_{RET}*) and quantity (Q_{RET}*) are now comparatively lower and higher, respectively. It can be seen here how a transfer of subsidies has the potential to significantly bridge the competitive gap between RETs and fossil fuels.

It is also important to note that the cost burdens and gains of transferring subsidies are shared by both consumers and producers. The exact share is determined by the elasticity of energy supply and demand. To illustrate, consider the case of reducing fossil fuels subsidies. Figure 5 below depicts the situation in which demand is relatively inelastic and Figure 6 depicts the situation in which supply is relatively inelastic.

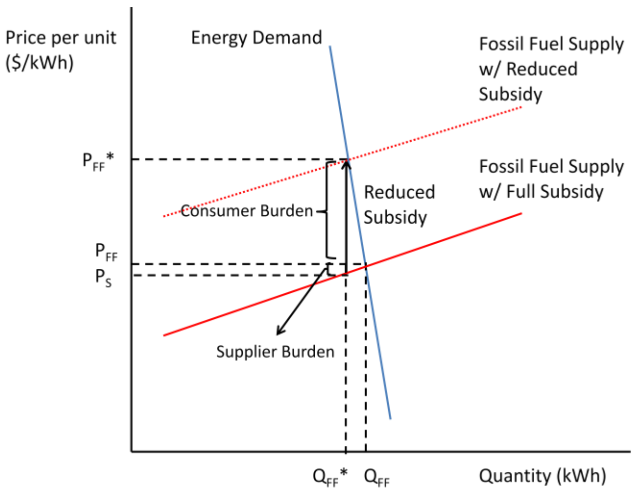

Figure 5: Subsidy Reduction Burden Sharing for Relatively Inelastic Demand

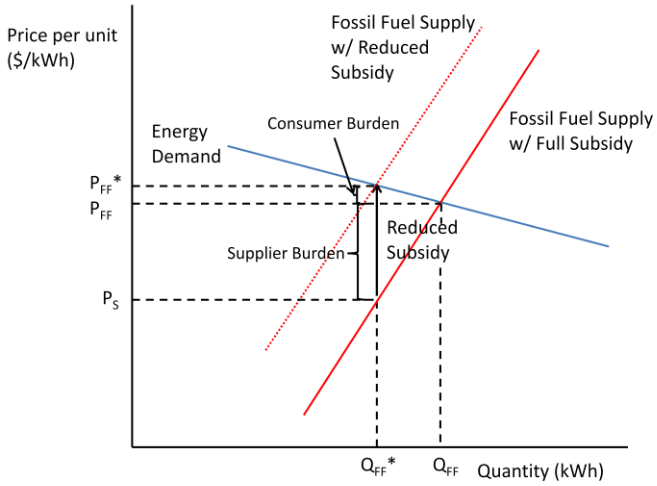

Figure 6: Subsidy Reduction Burden Sharing for Relatively Inelastic Supply

Here, P_S represents the seller price; it is given by the buyer price (P_{FF}*) minus the subsidy. As it can be seen in the figures above, when the demand is relatively inelastic the majority of the burden caused by the subsidy reduction is borne by consumers. The opposite holds true when supply is relatively inelastic; in this case the majority of the burden is borne by producers. In a similar way the advantages gained by the introduction of a subsidy (i.e., for RETs) is also shared between consumers and producers.

Historically the demand for fossil fuels has been relatively inelastic in the short-run, indicating that a subsidy reduction would initially affect consumers more than producers (Economic and Industrial Publications 2008). However, benefits would be gained from the subsidy transfer to RETs at the same time. Additionally, the demand for fossil fuels such as oil has been shown to become elastic in the long-run (Economic and Industrial Publications 2008). Overall, the transfer of subsidies from fossil fuels to RETs could significantly increase RET competitiveness.

Feed-In Tariffs

The implementation of feed-in tariffs (FITs) is another important policy tool that can be used to increase the deployment of RETs and improve competitiveness. A feed-in tariff guarantees payment to renewable energy developers at a set rate for electricity production over a given period of time (usually 15 to 20 years). Grid operators are typically required to provide grid access and to purchase all of the electricity produced within their service area. The FIT rate is also reduced over time in order to promote innovation (DeMartino and Blanc 2010).

Feed-in tariffs have been successfully employed in numerous developed and developing countries. In Germany, for example, FITs have been shown to play an instrumental role in increasing renewable energy power generation from 6.3% in 2000 to more than 15% in 2008 (Mendonça and Jacobs 2009). FIT policies have been empirically proven to promote the most rapid growth of RETs at the least cost. Accelerated deployment and economies of scale also encourage technological development and cost reduction, which improves RET competitiveness at a faster rate. Additionally, FITs have low administration and transaction costs and are transparent in nature (DeMartino and Blanc 2010). FITs also cost governments little in comparison with subsidies or tax credits. Costs are distributed amongst electricity consumers as part of their standard bill (Mendonça and Jacobs 2009).

Feed-in tariffs in Pakistan could be an effective policy tool to increase the deployment of RETs such as solar energy. The tariff rates would be calculated based on power generation costs of specific technologies and would be reduced over time. The end result would be an increase in renewable power generation and improved cost-competition with fossil fuels.

Accounting for Externalities

A third approach to bridge the competitive gap between renewable energy and fossil fuels is to account for the negative and positive externalities associated with each, as discussed in section 3.2. The negative externalities associated with fossil fuel combustion include health and environmental costs and the positive externalities associated with RETs include reduced air pollution and biomass combustion in rural areas. As it was illustrated in Figure 3, accounting for the external costs associated with fossil fuels results in a higher price and reduced output, placing these conventional technologies at a disadvantage compared to RETs. Therefore, it is possible to narrow the competitive gap between renewable and fossil fuel-based energy by considering externalities.

Public Sector Involvement

Market expansion is vital for the growth of the renewable energy industry in Pakistan. The public sector can play a significant role in this respect. One simple measure to increase the market penetration of renewable energy, for example, is to utilize RETs on public buildings. Germany and Australia have successfully utilized such measures (COMSATS 2005). The German government, for instance, installed photovoltaic systems on government buildings, while Australia utilized solar energy technologies extensively during the Sydney Olympics (PV systems were used to light the Olympic stadium and both PV modules and solar water heaters were used in Olympic housing) (COMSATS 2005). Such measures also act to spread public awareness and support for RETs.

Institutional Cooperation

It is vital for groups such as the AEDB and PCRET to cooperate by sharing information and coordinating efforts in order to increase efficiency and progress. PCRET, currently focused on solar thermal, hydro and biogas technologies, should expand its portfolio to include wind and solar PV systems as well (Mirza, Ahmad and Harijan, et al. 2009). AEDB and PCRET can each contribute unique skills and insights by working together, enabling them to effectively achieve common goals. PCRET can provide valuable experiential information from project deployment in the field while AEDB can utilize this information as an input to more effective policy development.

Financing for Renewable Energy Projects

It is also vital that sufficient RET financing is made available to stimulate and encourage project development in Pakistan. Financing arrangements to support investment in RETs must be developed at the local, national, and international level in order to encourage technology adoption. Aside from government subsidies, innovative funding programs should be developed, particularly for small RET project investors (Mirza, Ahmad and Harijan, et al. 2009). One study has suggested that the government can provide banks with funds from donors and international financing institutions for IPP projects. Banks would then lend funds to renewable energy IPPs; however, it is suggested that the banks share the credit risk by lending at least 20% of their own funds in order to avoid irresponsible lending behaviour (Bhutta 2008). Another study has suggested that the government develop a financing scheme for RETs similar to the system successfully implemented for thermal and hydro projects in Pakistan (Mirza, Ahmad and Majeeda, et al. 2007).

Improving Information & Technology Access

Improving access to RET-related information and technology is crucial to the success of renewable energy project development in Pakistan. Foremost, a central information database should be established which is both comprehensive and accessible. This system should document field experience gained through the installation, operation and maintenance of RET systems. Such information serves as an essential learning tool enabling developers to improve and adapt RETs for specific environmental conditions. Additionally, resource-assessment databanks are needed which should include regional wind speed and water flow data, for example. The development of resource-assessment tools, as well as monitoring and evaluation tools are also vital in this process.

In addition to aiding developers and investors, an accessible information system would also serve to increase general awareness, acceptance and interest in RETs. Information should be made available on policies, incentives and technologies including guidance on the deployment of RET systems for small-scale investors.

With respect to technology access improvement, is it vital for the government to invest in RET R&D activities. In order to promote sustainability, a domestic manufacturing industry for RETs must be also established, thereby reducing the dependency on foreign technology imports and knowledge. This would also result in reduced capital costs of renewable energy projects (Khattak, et al. 2006).

Increasing Capacity & Training

It is necessary to recruit and train a semi-skilled and skilled workforce in Pakistan in order to increase domestic capacity to support RET development. Educational facilities should be established to train semi-skilled workers on the installation, operation and maintenance of RETs. Universities should develop programs to educate scientists and engineers in the field of renewable energy.

Generating Social Awareness, Acceptance and Interest

The general public must be educated on the availability and benefits of renewable energy technologies, particularly in remote and rural areas. It was noted earlier that the availability of an accessible information system will help to spread general awareness, acceptance and interest in RETs. The media can play a significant role in this respect as well. Broadcasting media can be effectively utilized in order to spread awareness about the existence of RETs and their associated benefits. In areas lacking access to such media outlets awareness can be spread through demonstration projects which actively involve members of the community.

5. Concluding Remarks

Pakistan has struggled to resolve its energy shortage problems for decades. As the country is now facing an unprecedented energy crisis the drive to find effective long-term energy solutions is stronger now than ever before. Renewable energy resources such as wind and solar energy are abundant in Pakistan and show significant technical potential to meet energy needs; however, the development of renewable energy power projects is hindered by social, economic, technical, institutional and informational barriers. The 2006 renewable energy policy makes important steps towards encouraging RET deployment, but several policy challenges remain to be addressed.

The answer to strengthening the presence of renewable energy technologies in Pakistan does not lie in any one solution to these challenges; rather, a holistic approach must be employed. A number of approaches have been discussed to address the roadblocks which RETs face. The government of Pakistan must take bold steps towards restructuring energy policy in order to increase energy security and move towards a sustainable energy future. Primarily, policies should focus on bridging the competitive gap between RETs and fossil fuels through measures such as subsidy transfers, feed-in tariffs and accounting for negative and positive externalities. Of course, increasing the competitiveness of RETs alone is not sufficient; issues such as poor infrastructure, financing and technology access must also be addressed. However, the biggest challenge lies in initially stimulating growth in renewable energy. Upon addressing the most significant challenges facing RETs, market penetration will naturally develop and the support for addressing further RET challenges will ensue.

The path towards a sustainable energy future in Pakistan is by no means simple, but a solution certainly exists. Although a number of approaches have been presented to encourage the growth of renewable energy in Pakistan, all of these solutions will undoubtedly require significant effort and dedication on behalf of the government. Pakistan must consider the long-term social, economic and environmental benefits of renewable energy power generation for its people. Investing in sustainable energy technologies today will pave the road towards a secure energy future for tomorrow.

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