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Lack of foresight in energy planning of Pakistan

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Abstract

Pakistan's energy sector has gone through an electricity crisis recently and blackouts have occurred several times in history. At the current stage, Pakistan is facing energy surplus primarily because of over-investments into the energy sector to overcome the shortages. Moreover, losses, distribution companies’ poor recovery factors, inefficient generators, and expensive power purchase agreements with power producers by the government lead to uncontrollable circular debt. This study presents a review of Pakistan’s power sector policies and studies conducted by the government and highlights some serious issues related to energy supply and demand, power sector losses, financial threats, and climate change. Furthermore, this paper suggests strategies and recommendations to help the policymakers and energy sector officials to minimize the power sector crisis by taking actions accordingly.
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1 Introduction

In Pakistan, a severe power shortfall caused long-hour blackouts for more than a decade. These blackouts led to the shutdown of various local factories and industries causing less production, and unemployment. In 2007, the electricity shortfall was recorded as of 7,000 MW, in 2018 it was a record high of 9,000 MW and was reported 4,000 MW in 2020. Power cuts in 2010 incurred a loss of 2.5% in the overall GDP, unemployment of half a million industrial workers, and $1.3 billion export loss (Perwez et al. 2015). Presently, Pakistan’s power sector is facing the worst financial crisis with a circular debt of $13.4 billion (Mustafa 2020). Inadequate power plant maintenance leading to de-rated plant capacities, misuse of subsidies in tariffs, and incorrect forecasting are the primary reasons for the electricity shortfall. Apart from electricity shortage, high tariffs, circular debts, and major transmission & distribution losses factor into the power sector crisis whereas the root cause of the problem lies in inept energy policies and poor governance.

Pakistan, after partition in 1947, started with 60 MW of generation capacity. Gradually, the country’s power infrastructure gained momentum. In the 1970s and 80s the generation capacity rose to 1,331 MW and 3,000 MW respectively followed by 7000 in 1990-91. Later, there was a decrease in the progress of power sector leading to decline in generation capacity, and transmission and distribution infrastructure. The electricity supply too could not meet the required demand mainly due to urbanization and rural electrification. The 1994 power policy was designed in a way that it could overcome the electricity crisis, therefore, a 13000 MW capacity was added through Independent Power Producers (IPPs), but this resulted in excess power than the forecasted demand (Mirjat et al. 2017a; Rauf et al. 2015). The growth rate in 1990s rose from 4% to 10% in 2007-2008, but unfortunately the investments required for the capacity addition were not made in order to fulfil the demand (Mirjat et al. 2017b).

In the 1970s, an integrated energy modeling approach was introduced globally so that the national policies and their objectives might be implemented in close coordination. This concept was introduced in Pakistan in the 1980s, however this could not be sustained due to disintegration and fragmentation of policy institutions (Bazmi 2019). In 2010, an Integrated Energy Model (IEM) was developed upon the technical assistance provided by Asian Development Bank (ADB), but no recommendations were taken as an input from this study to develop energy policies.

Various surveys and studies on power planning and power capacity expansion were carried out in different years by the successive governments (Annexure-A). Unfortunately, almost all new governments neglected the previously prepared energy plans and policies, which resulted in energy and economic crises.

Despite the efforts Pakistan has made in using energy modeling tools towards effective energy policy formulation and energy planning, it still faces capacity and reliability issues due to poor planning and flawed implementation. Moreover, effective energy planning should not rely solely on energy modeling, but it should be analyzed with different energy policy options to meet the objectives of effective policy formulation and to achieve sustainability. Therefore, this policy brief aims to identify the government institutions data gaps and discrepancies while highlighting the demand and supply gaps, threatened energy economics, and alarming climate change in the future.
2 Methodology

Indicative Generation Capacity Expansion Plan 2018 (IGCEP-2018) is used as a data source for this study because the data is up to date. Forecasted demand for 5.5% growth rate scenario is selected which proposes the peak demand of 80,000 MW and 458,000 GWh annual generation by the year 2040. On the supply side, 95,000 MW of capacity additions is proposed, as around 9,000 MW of generation is meant to be retired by the end of year 2040 (National Transmission & Dispatch Company [NTDC] 2019).

In this study, a simple excel based model is developed, which calculates the supply in terms of monthly generation in MW for all power plants that are currently installed and proposed in the capacity expansion plan and compares it with the forecasted monthly demand. Monthly capacity factors of electricity generation plants are collected from National Electric Power Regulatory Authority (2019) and tentative dependable capacity, and peak demand factors from National Transmission & Dispatch Company (2019). A generalized formula for monthly demand and generation is given in equation (1) and (2) below.

\[
\text{Monthly Demand}_{(Y)}(\text{MW}) = \text{Annual forecasted demand} \times \text{Monthly demand factor} \quad (1)
\]

\[
\text{Monthly generation}_{(Y)}(\text{MW}) = \sum_{\text{Plant}=1}^{N} \text{Dependable plant capacity} \times \text{Monthly plant factor} \times \text{Monthly demand factor} \quad (2)
\]

where \( Y \) is equal to a year for which demand and supply in terms of MW is calculated, whereas \( N \) is the total number of plants that are operational at year \( Y \). Moreover, a qualitative analysis is carried out based on research papers, news articles and energy reports to evaluate the power sector gaps while highlighting the absence of future impacts of climate change, energy market restructuring, and electric vehicles in the previously presented plans by government and neglection of key factors in mapping demand and supply in future electricity planning.

3 Discussion and Results

3.1 Energy demand and supply

Figure 1 illustrates the demand and generation in terms of MW for five different years in the study period. These results show that the demand and supply gaps will be evident in the middle of the study periods (2018-2040). Owing to the intermittent nature of renewables and varying capacity factors of hydropower over the months, the supply shortage in a few months is evident. However, in a few months the generation was also in surplus: for example, in September, the hydropower generation reached at its maximum capacity, therefore, the power was in surplus. Similarly, all other generation technologies capacity factors vary according to their technical limitations within the energy mix. These results suggest that the capacity additions proposed are enough to meet the peak demand, however the mapping of commissioning dates of the power plants with energy demand should be reconsidered.
3.2 Power sector losses and financial threats
Pakistan is already facing a circular deficit of $13.4 billion in the year 2020 (Mustafa 2020). Transmission and Distribution (T&D) losses due to poor maintenance of outdated grid infrastructure, faulty meters, inefficient generators, expensive power purchase agreements with power producers by the government, and DISCOs poor recoveries are among many reasons in
piling-up the circular debt and pose a serious challenge to Pakistan’s power sector. In FY 2017-18, the distribution companies incurred a loss of Rs 46 billion due to T&D. In addition, a loss of Rs 147 billion was reported in FY 2017-18 due to 87.71% recovery from DISCOs. Table 1 and Table 2 show the recovery position and T&D losses of all DISCOs in FY 2017-18. According to the current proposition of 60,000 MW capacity addition, an annual investment of $8-9 billion would be required, meaning that Pakistan’s energy sector would consume 20 per cent of its overall investment capacity (Ali 2019). Given the current financial crisis, these multi-billion-dollar investments on capacity additions should be reduced by adopting energy conservation strategies, improving existing power plants efficiencies, and replacing high-cost furnace oil operated power plants to low-cost alternate fuel. Moreover, instead of retiring old thermal power plants, extensions should be given to these power plants upon increasing their efficiencies.

3.3. Climate change
Pakistan falls among those 197 countries that ratified the Paris agreement, which aims to cap the global rise in temperature at 2°C above industrial levels by reducing the greenhouse gas emissions (Abubakar 2020). As part of the Paris agreement, Pakistan has submitted an obligatory Nationally Determined Contribution (NDC), which estimates 1,603 Mt.CO$_2$ equivalent GHG emissions in 2030. An investment of $40 billion would be required to reduce 20% of the projected emissions (Government of Pakistan 2016). At present, Pakistan is ranked 5th among the most vulnerable countries to climate change (Pakistan ratifies 2016). If the current target of 30% coal power capacity of the overall mix by the end of 2040 (National Transmission & Dispatch Company [NTDC] 2019) does not change, the climate change targets might not be achieved, and the country may become a significant contributor to the greenhouse effect. Therefore, a complete environmental evaluation of Pakistan’s power generation sector is required to evaluate the impacts of generated emissions on climate change targets. Moreover, an Integrated Energy Plan (IEP) based model and power policy is needed to address environmental concerns from power generation and ensuring energy security.

3.4. Electric vehicles
Pakistan has approved an Electric Vehicle (EV) policy which aims to capture 30% of the passenger vehicles by the year 2030 (Pakistan launches electric vehicle 2020). Electricity demand would increase significantly upon the implementation of the EV policy. In the past, Pakistan's power sector has faced several problems related to power generation and was unable to fulfil the demand of the country. Therefore, a plan is needed to counter the impacts that it would cause to the electricity demand and supply situation in the future upon the implementation of the policy.
### Table 1 - Recovery Position of DISCOs (%)

<table>
<thead>
<tr>
<th>DISCO</th>
<th>Domestic</th>
<th>Commercial</th>
<th>Industrial</th>
<th>Agricultural</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>PESCO</td>
<td>83.86</td>
<td>99.94</td>
<td>96.43</td>
<td>84.17</td>
<td>88.6</td>
</tr>
<tr>
<td>TESCO</td>
<td>66.34</td>
<td>37.74</td>
<td>69.11</td>
<td>58.7</td>
<td>66.61</td>
</tr>
<tr>
<td>IESCO</td>
<td>97.56</td>
<td>99.75</td>
<td>96.27</td>
<td>102.66</td>
<td>89.75</td>
</tr>
<tr>
<td>GEPCO</td>
<td>98.75</td>
<td>100</td>
<td>95.83</td>
<td>99.55</td>
<td>96.07</td>
</tr>
<tr>
<td>LESCO</td>
<td>98.26</td>
<td>98.64</td>
<td>93.88</td>
<td>86.09</td>
<td>95.93</td>
</tr>
<tr>
<td>FESCO</td>
<td>99.05</td>
<td>99.8</td>
<td>95.94</td>
<td>97.36</td>
<td>97.93</td>
</tr>
<tr>
<td>MEPCO</td>
<td>98.43</td>
<td>98.16</td>
<td>91.26</td>
<td>82.41</td>
<td>94.58</td>
</tr>
<tr>
<td>HESCO</td>
<td>58.52</td>
<td>95.28</td>
<td>94.44</td>
<td>86.27</td>
<td>75.41</td>
</tr>
<tr>
<td>SEPCO</td>
<td>35.65</td>
<td>98.2</td>
<td>86.26</td>
<td>68.69</td>
<td>59.72</td>
</tr>
<tr>
<td>QESCO</td>
<td>46.93</td>
<td>94.34</td>
<td>93.3</td>
<td>11.79</td>
<td>25.01</td>
</tr>
</tbody>
</table>

### Table 2 - Transmission and Distribution Losses of DISCOs

<table>
<thead>
<tr>
<th>DISCO</th>
<th>2017-18 (Units in GWh)</th>
<th>Losses (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Purchased</td>
<td>Sold</td>
</tr>
<tr>
<td>PESCO</td>
<td>14213</td>
<td>8796</td>
</tr>
<tr>
<td>TESCO</td>
<td>1693</td>
<td>1482</td>
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<tr>
<td>IESCO</td>
<td>11672</td>
<td>10606</td>
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<tr>
<td>GEPCO</td>
<td>10987</td>
<td>9887</td>
</tr>
<tr>
<td>LESCO</td>
<td>23731</td>
<td>20449</td>
</tr>
<tr>
<td>FESCO</td>
<td>14452</td>
<td>12925</td>
</tr>
<tr>
<td>MEPCO</td>
<td>19006</td>
<td>15853</td>
</tr>
<tr>
<td>HESCO</td>
<td>5743</td>
<td>4027</td>
</tr>
<tr>
<td>SEPCO</td>
<td>4679</td>
<td>2963</td>
</tr>
<tr>
<td>QESCO</td>
<td>6338</td>
<td>4916</td>
</tr>
<tr>
<td>Overall Average</td>
<td>112,514</td>
<td>91,904</td>
</tr>
</tbody>
</table>

**Source:** National Electric Power Regulatory Authority (NEPRA) 2019

### 3.5. Energy Markets

According to Pakistan’s current energy model, a single buyer model is being followed, however, soon this model will shift towards a competitive market. This model opens a wholesale electricity market competition by allowing multiple sellers and buyers, which would not only reduce the electricity prices but also increase the grid and plant efficiencies (Central Power Purchasing Agency [CPPA] n.d.). A multivariable analysis is required to evaluate the effects of shifts in energy markets on electricity prices and energy demand.
3.6. Net Metering
NEPRA has issued net metering regulations and allowed DISCOs to purchase the excess electricity produced by consumers (Alternative Energy Development Board [AEDB] 2015). In Pakistan, local home-based independent renewable power systems are being installed and they are also providing electric power to the grid using the net metering concept. This will significantly change the supply and demand situation in the country if the quantity of these virtual power plants increases, therefore, should be considered in long-term energy planning studies.

4 Conclusion and Recommendations
Effective energy planning cannot be concluded by developing an energy system model. It should rather assess and project different future energy patterns as well as suggest policy options by keeping the model alive for a feasible policy formulation to attain sustainability. Pakistan has been lacking proper application of this planning paradigm and policymaking to-date. As a result of poor energy planning and policies at different levels, the country will continue to face severe energy crisis and debts.

Following are some key recommendations to rectify the energy sector issues:

- Capacity additions proposed in the capacity expansion plan are enough to meet the peak demands and generation needs of the country in the future, however, the mapping and positioning of the power plants installation should be revised given the technical limitations of each technology.
- Efficiencies and capacity factors of installed power plants should be improved to minimize capital investments required for capacity additions.
- There is a need to introduce demand management strategies and improve grid technology to minimize transmission and distribution losses while making sure that close to 100% recovery of DISCOs is achieved.
- The government should present an energy plan based on multivariable analysis while considering the global energy trends to portray long-sightedness of the plan rather than meeting short term goals.
- The government should also incorporate an environmental evaluation of the energy mix in the future energy plan to quantify the emissions generated from the power generation. It is necessary for the country to evaluate and achieve the climate change targets.
- It is needed to develop energy efficiency targets and establish electricity demand and supply early warning mechanisms and monitoring systems.
- The government should involve all stakeholders of the energy sector and evaluate all influential factors to prioritize the goals on a political and economic level and present a long-term policy to eradicate energy sector problems.
- An Integrated Energy Planning policy should be developed, and implementation of integrated energy models is needed to create a future without greenhouse gas emissions and economically viable energy infrastructure. Moreover, different government policies and plans should remain in-line with each other and must be kept alive.
- Strong collaboration between government and academia should be developed to allow them to work in close liaison.
References
Alternative Energy Development Board 2015, Net-metering reference guide for electricity consumer, AEDB, Ministry of Water and Power, Govt of Pakistan
Government of Pakistan 2016, Pakistan’s Intended Nationally Determined Contribution (Pak-INDC).
International Atomic Energy Agency 2005, Comparative assessment of energy options and strategies in Mexico until 2025, October, IAEA.


Quijano, H R, Botero, BS and Domínguez BJ 2012, MODERGIS application: Integrated simulation platform to promote and develop renewable sustainable energy plans, Colombian case study, *Renewable and Sustainable Energy Reviews*.


### Title of Study

<table>
<thead>
<tr>
<th>Title of Study</th>
<th>Year</th>
<th>Conducted by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liefticnk Report</td>
<td>1967</td>
<td>World Bank</td>
</tr>
<tr>
<td>RESPAK Model</td>
<td>1988</td>
<td>Energy Wing, Planning Commission of Pakistan</td>
</tr>
<tr>
<td>Energy and Nuclear Power Planning Study</td>
<td>1994</td>
<td>Pakistan Atomic Energy Commission</td>
</tr>
<tr>
<td>National Power Plan</td>
<td>1994</td>
<td>Water and Power Development Authority</td>
</tr>
<tr>
<td>Electricity Demand Forecast Based on Multiple Regression Analysis</td>
<td>1998</td>
<td>National Transmission and Dispatch Company</td>
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<tr>
<td>Energy Security Action Plan</td>
<td>2005</td>
<td>Planning Commission of Pakistan</td>
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<tr>
<td>Pakistan Integrated Energy Model (Pak-IEM)</td>
<td>2007</td>
<td>by International Resource Group</td>
</tr>
<tr>
<td>Vision 2025</td>
<td>2014</td>
<td>Planning and Development Division, Govt of Pakistan</td>
</tr>
<tr>
<td>Electricity Demand Forecast Based on Power Market Survey</td>
<td>2014</td>
<td>National Transmission and Dispatch Company</td>
</tr>
<tr>
<td>National Power System Expansion Plan</td>
<td>2011</td>
<td>National Transmission and Dispatch Company</td>
</tr>
<tr>
<td>Least Cost Generation and Transmission Expansion Plan</td>
<td>2015</td>
<td>Japan International Cooperation Agency</td>
</tr>
<tr>
<td>Indicative Generation Capacity Expansion Plan</td>
<td>2018</td>
<td>National Transmission and Dispatch Company</td>
</tr>
</tbody>
</table>

**Source:** (National Transmission and Dispatch Company [NTDC] 2019; Rauf et al. 2015)