



## A review of energy and power planning and policies of Pakistan



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### ABSTRACT

Pakistan is facing multiple challenges for harnessing the indigenous energy resources and devise rational energy policies. The country is believed to have abundant energy resources, however, coping substantial electricity supply gap of over 5000 MW. This paper analyses country's energy and power planning studies conducted since its independence in 1947 and policies announced so far. It is found that water resources management attained more emphasis in early decades of post-independence rather than energy concerns. The first energy and power planning study was conducted in late 1960s and since then various studies were undertaken to supplement five yearly medium term development plans of government. However, it is pertinent to mention that formal energy and power policies were only announced from 1994 onwards owing to growing electricity demand and progressing industrialization. Beside this, the focus of these policies is not only varied but were conceived without undertaking integrated energy planning using energy modeling tools e.g. MARKAL/TIMES; LEAP, ENPEP BALANCE, MESSAGE and EnergyPLAN. It is despite the fact that these tools are successfully applied globally for devising the energy policies and address the complexities of energy system by assisting effective policy formulation. This study recommends that integrated energy planning using energy modeling tools will be helpful to develop sustainable energy policies in Pakistan to eradicate electricity crises.

### 1. Introduction

Energy in the form of electricity is essential for economic development of any nation and now largely recognized as an important commodity for the human being. However, Pakistan is facing severe electricity crisis and outages ranging from 8 to 12 h a day in urban areas and up to 18 h in rural areas [1,2]. These crises have led to the shutdown of hundreds of industries and factories, paralysing the production and exacerbating unemployment. The major reason for this increasing gap between demand and supply is enhanced electricity demand on one hand and planning and governance issues on other hand. Pakistan's indigenous oil and natural gas reserves are also limited and fast depletion of these is another challenge. The progress on harnessing the indigenous coal and renewable resources is extremely slow whereas financial constraints and discipline are further widening the electricity demand and supply gap. The root cause of these crises can be traced back to the policy decisions made in the last couple of decades.

Pakistan's energy sector has had predominantly been considered to

be electricity system until industrial and transport sector development. The establishment of an autonomous and statutory body i.e. Water and Power Development Authority (WAPDA) in 1958 was also primarily for the management of water resources to boost the agro-economy of the country. As a result, various small to large dams and reservoir projects were undertaken by WAPDA during early years of its establishment. On other hand majority of primary energy resources, mainly fossil fuel, for many years were generally dedicated for the electricity generation. As such, concept of integrated energy planning could not evolve and attain any importance until rapid growth of other sectors of economy owing to the rapid urbanization in 1980's. WAPDA remained one of the mega organisation of country with its headquarters at Lahore until restructuring of same undertaken in the 1990's. The organisation during its initial years had plenty of support from international agencies both in the technical capacity building as well as in financing the various mega projects. During this period various studies were undertaken on power system planning to supplement the regular five year plans announced by various governments. However, no energy policy was formally announced by any government until 1994. The energy and power

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policies then announced either lacked integrated energy planning approach using energy modeling tools or they faced implementation and consistency issues.

Energy planning in general attained much of the formal attention followed by the oil crisis of 1970s. The planning approaches then only emphasized on identifying the efficient supply options. This followed development of much recognized planning approaches wherein it is a process to explore the minimum cost solution that meets the present and future power and energy demands. Other criteria, such as environmental concerns and the reliability of supply are given monetary values, and included on the cost criteria, thus considered only as constraints [3]. Much of these energy planning approaches are now being well worked away using various computer based energy modeling tools. Market Allocation (MARKAL), ENergy and Power Evaluation Program (ENPEP), Model for Energy Supply Systems And their General Environmental Impact (MESSAGE), Long Range Energy Alternatives Planning System (LEAP) and EnergyPLAN are well recognized energy modeling tools used for energy planning at various levels. These models help to organize large amount of data, reflect complete energy system in understandable form and provide a consistent framework for testing hypothesis. These energy modeling tools are useful for various energy planning applications which are diverse in terms of the regions they analyse, the technologies they consider and objective they fulfil [4,5].

There are various studies on energy planning found in literature that have been undertaken both by governments and academia globally using energy modeling tools to support the energy policy formulation. Studies conducted in several countries, such as China [6], Nigeria [7], South Africa [8], Taiwan [9], UAE [10], Spain [11], France [12,13], USA [14], Crete [15], Portugal [16,17] Greek [18,19] Iran [20], Panama [21], Mongolia [22], Argentina [23], Turkey [24], Greece [25], Mexico [26], India, [27,28] Indonesia [29], Brazil [30], Syria [31], Malaysia [32,33], Tanzania [34] Ireland [35], Latvia [36], UK [37], Macedonia [38], and Germany [39] shows the significance of applications of the energy modeling tools for analysing the energy policy options at different levels.

Further, there are various other studies, such as [40–56], and [57] which greatly emphasis energy modeling as most appropriate way of energy policy analysis and formulation. These studies have also put forward recommendation for effective utilization of energy models and linking modeling results to policy development. It is important to mention that energy modeling is not undertaken alone to develop model of any specific energy system instead they should be developed to analyse the energy policy options and address particular objectives for rational policy formulation to achieve precise socio-economic development.

It is, however, important to note that Pakistan so far lack in appropriate application of energy modeling tools towards integrated energy planning and energy policy formulation. Meanwhile, disintegrated energy planning at various levels has fetched country in a state of electricity crisis. There are only a few studies that also mainly by academia [42,58–63] and [64] wherein energy modeling tools have been used. There is only one integrated energy planning effort at government level which was in fact in the shape of Technical Assistance (TA) from Asian Development Bank (ADB) in 2007 [65]. This study used International Energy Agency's (IEA) TIMES energy model, however, the PAK-IEM model of this study also could not find any connection to the policy formulation. As such, none of energy policies announced by country so far reflect the finding of energy modeling exercise. It is, therefore, high time that Pakistan employ these modeling tools for a planning paradigm and energy policy analysis that should deliver integrated planning agenda not only to help to overcome electricity crisis but at the same time ensure sufficient supplies for the other sectors of the economy.

There are various reviews on Pakistan's energy system in the literature with varying objective and agenda. Bhutto, Bazmi [66],

Bhutto, Bazmi [67], Bhutto, Bazmi [68], Bhutto, Bazmi [69], Abbas, Bazmi [70] in series of five papers have reviewed in detail the various issues and challenges Pakistan is facing towards development of its indigenous and renewable energy resources. In these papers they have identified technological challenges, financial constraints, capacity building, energy planning and governance issues as key barriers which are not allowing harnessing of the indigenous and renewable energy resources of the country. Rafique and Rehman [71] have discussed in detail the energy consumption patterns in Pakistan highlighting the issues of security of electrical energy supply as key to socio-economic uplift. They have suggested renewable energy resources of country as most promising sources to meet the increasing electricity demand. However, indigenous technology development, institutional infrastructure and capacity building in their opinion are the daunting challenges faced in this context. Sheikh [72] in a comprehensive review of energy and renewable energy scenario of Pakistan have concluded that effective planning and exploitation of renewable energy resources and use of modern technologies can only help to the energy sector development in country. Shah, Qureshi [73] have identified the fundamental policy mistakes pertaining renewable energy development as key barrier of sustainable development in Pakistan. They have suggested awareness through educational and S & T policies to support the harnessing of renewable energy resources of Pakistan. Nayyar, Zaigham [74] have undertaken assessment of conventional and non-conventional energy resources of Pakistan for meeting its energy needs. The results of this study indicate that conventional resources in Pakistan are and will not be enough to meet the ever growing energy demand and consequently highlight the importance of the renewable energy sources that are encouraging in the country but have not been developed to any satisfaction. They attribute lack of energy planning over the past 70 years of the country as main cause of on-going energy crisis. Uqaili [75] analysed Pakistan's electricity system and has forecasted commercial energy demand in Pakistan using Modified Econometric Models, considering per capita GDP, energy price, population, technology advancement and environmental concerns as explanatory variables. He has predicted demand for oil, gas, coal, hydropower and nuclear energy at sectoral and aggregate level, up to 2018 under four different scenarios. Rauf, Wang [76] have completed a comprehensive review on energy status and development in Pakistan. This review provides varying roles and responsibilities of different energy sector organisations, status of various energy resources and efforts being undertaken for development of these resources in particular renewables. In their opinion, faulty management information system, failure to correctly forecast and future planning are the main causes of energy shortfall in the country. A detailed review of the diagnosis of an electricity crisis and alternative energy development in Pakistan has been undertaken by Shaikh, Ji [77]. They have focused National Energy Security Action Plan (NESP) of 2005–2030 and suggested that if the short-term measures contained in the NESP had been adequately executed, could have resulted sufficiently in bridging the existing electricity supply-demand gap and the country may have been out of the electricity crises. Amongst other recommendations, it is suggested by the authors that a capacity building program involving stakeholders both at provincial and federal level should be undertaken to improve energy sector performance, ensure efficient planning and operation. Siddique and Wazir [78], Mirza, Ahmad [79], and Harijan, Uqaili [80] have undertaken a review of wind power development in Pakistan and lists various suggestions that can help improve the wind power penetration in the national energy mix including effective planning. Yazdanie, Economics [81] have specifically focused 2006 renewable energy policy of Pakistan and identified the policy strengths, challenges and way forward which in their opinion only lies in serious planning effort. Asif [82] have explored and discussed in detail the indigenous energy resources of county as only sustainable energy options for Pakistan. Qudrat-Ullah [2] has examined the electricity sector reforms undertaken in Pakistan during past two decades and

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