DESIGNING AND MANAGING SUSTAINABLE ENERGY MIX: HOW OPTIMAL ENERGY MIX IMPACTS ON ECONOMY AND POLICY FRAMEWORK

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ABSTRACT

Despite its extremely rich supply of mineral resources, Pakistan has been suffering from the world's worst power supply crisis over the past few years. Facing the severe power supply shortage, people stay on the roads to protest long hours of unscheduled electricity load-shedding. For instance, in the summer of 2013, electricity shortage in Pakistan add up to 6500 (MWh) or roughly 40% of annual demand of 16,500 (MWh). As reported by NEPRA (National Electric Power Regulatory Authority, 2012), some rural areas have been continuously suffering from spontaneous load shedding and lengthy blackout period up to 12-16 hours a day. In some urban area duration of electricity load shedding lasts up to 12 hours a day. Pakistan's power supply uncertainty is affecting its already fragile economy to pose a serious threat to nation's economic security. The power supply uncertainty in the last decade have put many industrial sectors of Pakistan on the verge of collapse. Closing down of hundreds of factories due to energy deficiency leads to significant decreasing in production capacity of key industries by nearly 40%-50%, and it cause sharp increase of unemployment rate (Santana, 2013). In the past few years, it is estimated that the cost related to power supply uncertainty could amount to 2–4% of GDP annually (Institute of Public Policy, 2009). Nevertheless, after decades of power shortages, thanks to President Xi Jinping's Belt and Tad Initiative, the country is now anticipating power supply surplus. With changing of the ambient condition, Pakistan's energy sector is now facing three problems. The first is underdeveloped power transmission grid, the second is the need to supply cheaper electricity stably, and the third is keeping emission is check and provide cleaner electricity (Faseeh Mangi, 2021, Khurram Hsain, 2021). Apparently, Pakistan's current power generation infrastructure is incapable of satisfying its fast- growing demand and the two problems mentioned above. Thus, it is imperative for Pakistan government to restructure its current energy industry and power generating infrastructure to enable its energy sector to gain the ability to supply inexpensive and clean electricity stably. To achieve this goal, one must first identify the problems that cause the Pakistan's current power supply crisis.

We apply supply chain management approach to address the unique features of the coal fired energy industry and present a new class of mathematical models for optimally designing the energy supply chain. Our model aims to achieve target economic growth while minimizing total energy supply chain cost subject to various types of constraints associated with mining, coal transportation, power generation and transmission costs. The model incorporates unique features of power generation and transmission operation and describes interaction between various parts of the coal fired energy supply chain from mining to power generation and distribution.

Applying the mathematical model of the energy supply chain to Pakistan's recent energy crises enables us to test effectiveness of the solution and to gain new insights from the model. We extend the framework in Rafique, Mun, and Zhao (2017) to consider: (1) designing the optimal power plant capacity mix that consists of 300MWh, 500MWh, and 800MWh power plants, (2) planning the power transmission network that consists HVDC and HVAC lines, (3) incorporating economic growth model to the long term planning of the coal-fired power supply industry.