Long Term Integrated (Multi-Agent) Modeling of Power Sector Under Sustainable Development Pathway

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The study involved a detailed analysis of existing energy models and uncertainties attached to the energy systems. To address energy security and climate change challenges, long-term energy plans for least cost electricity generation (OPT) and demand management for household sector (DSM) were devised. This includes sustainable policies that represent Nationally Determined Contributions (NDCs), mix of efficient and conventional technology and appliances, and targets for renewable energy. The power supply scenario (SSM) exhibits different energy supply policies with lowest socio-economic and environmental impacts. On the basis of analysis of current and historical policies and energy consumption patterns, macro-economic modeling was carried out for the period 2011-2050, using the Long-range Energy Alternative Planning modeling tool. Results indicate that electricity generation sector is expected to continue posing more global warming than any other sector if the current scenario prevails such that the environmental emissions will quadruple the current global warming potential in 2050. Therefore, the SSM alternatives were further compared to analyze their potential with and without externality cost of environmental emissions. Results of optimization of SSM show that wind, solar and hydel power plants are the most economic options with respect to their fuel inputs whereas residual oil based plants cost very high due to their consumption of expensive imported furnace oil. Though natural gas and coal are locally available, their mining and extraction charges are costlier than renewable resources. For a holistic decision on the most suitable scenario, a cost benefit analysis of these scenarios was performed in terms of societal perspective. This sustainability evaluation leads to formulation of a least cost electricity generation mix (OPT) for Pakistan which included the supply target of 10% renewable electricity till 2025. Conventional market valuation and benefits transfer approaches were used for economic analysis of demand side

policies. It was found that the “efficient water heating” scenario for demand management in household, offers the maximum energy-saving potential (up to 270 M.TOE) whereas “efficient space cooling” is the lowest-cost scenario. To achieve the best-fit mitigation scenario (MIT), targets for renewable energy supply were also incorporated. Findings were weighed against the reference scenario (REF), which reveals a huge GHG reduction under DSM. Moreover, the cost required to implement MIT is estimated to be US $ 3.4 billion/ton of carbon dioxide-equivalent, less than the REF. The resultant policy set features a best-fit sustainable management plan in terms of its energy saving potential, social cost, and environmental impacts. Hence, the findings of this study are extremely important for developing countries, in order to meet their energy related GHG targets, especially NDCs.