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Dynamic Life-Cycle Analysis of India's Electricity System

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Abstract

Energy production and consumption cause environmental and human health damages. Their exclusion by the market leads to inefficient resource allocations. Because of weak market regimes in developing countries, the conventional development pathways overlook these inefficiencies. A sustainable energy system would need to ameliorate this adverse trend while maintaining the equilibrium path that represents true life-cycle cost of energy resources. This paper considers life cycle analysis (LCA) for full accounting of externalities of energy use with specific focus on electricity sector. The LCA is carried out for major energy resources and technologies. The dynamic equilibrium analysis is carried out, spanning period up to year 2050 using an energy system model, ANSWER-MARKAL. The results show that the shift to an efficient frontier can be made at a very low cost by introduction of technologies that mitigate local air pollutants like SO_2, NOx and SPM. Internalization of these local externalities too results in co-benefits including reduction in carbon intensity of energy. In addition, the inclusion of life carbon price in life cycle equilibrium leads to further reduction in carbon emissions, besides also delivering the local air quality co-benefits. Our results show that renaissance of domestic coal in India could last so far as national policymakers are concerned with local pollutants. However, mitigation of CO2 emissions to achieve low stabilization target would significantly shift the energy system equilibrium, notwithstanding the introduction of CCS technology. Finally, a generic lesson from our analysis is that the inclusion of all external cost of each energy technology and resource still leads to 'no silver bullet', i.e. a single dominant technology, which dominate future energy system. The energy-environment efficient frontier thus would evolve through a mix of choices from a portfolio of energy resources and technology options. The diversity of these options including their cost structures; multiple objectives of energy-environmental policies and the varied inter-linkages of energy and environmental policy dynamics call for a hybrid package of direct regulation and market based economic instruments to sustain energy-environment-economy frontier on the efficient path.