Economic and environmental evaluation of flexible integrated gasification polygeneration facilities equipped with carbon capture and storage

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Among the diverse menu of technologies for reducing greenhouse gas (GHG) emissions, one option involves pairing carbon capture and storage (CCS) with the generation of synthetic fuels and electricity from co-processed coal and biomass. In this scheme, the feedstocks are first converted to syngas, from which a Fischer-Tropsch (FT) process reactor and combined cycle turbine produce liquid fuels and electricity, respectively. With low concentrations of sulfur and other contaminants, the synthetic fuels are expected to be cleaner than conventional crude oil products. And with CO_2 as an inherent byproduct of the FT process, most of the GHG emissions can be eliminated by simply compressing the CO_2 output stream for pipeline transport. In fact, the incorporation of CCS at such facilities can result in very low—or perhaps even negative—net GHG emissions, depending on the fraction of biomass as input and its CO_2 signature.

To examine the potential market penetration and environmental impact of coal and biomass to liquids and electricity (CBtLE), which encompasses various possible combinations of input and output parameters within the overall energy landscape, a system-wide analysis is performed using the MARKet ALlocation (MARKAL) model. With resource supplies, energy conversion technologies, end-use demands, costs, and pollutant emissions as user-defined inputs, MARKAL calculates—using linear programming techniques—the least-cost set of technologies that satisfy the specified demands subject to environmental and policy constraints. In this framework, the U.S. Environmental Protection Agency (EPA) has developed both national and regional databases to characterize assorted technologies in the industrial, commercial, residential, transportation, and generation sectors of the U.S. energy system. Here, the EPA MARKAL database is updated to include the costs and emission characteristics of CBtLE using figures from the literature. Nested sensitivity analysis is then carried out to investigate the impact of various assumptions and scenarios, such as the plant capacity factor, capital costs, CO_2 mitigation targets, oil prices, and CO_2 storage costs.