GCAM USA – A Tool For State-Level Energy and Emissions Projections

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The Global Change Assessment Model (GCAM) is a dynamic-recursive model that projects global energy use, land use, and resulting emissions through the end of the century.[1] GCAM models regional and global supply and demand for energy and agricultural products within a partial economic-equilibrium framework with a relatively technology-rich representation (as compared to other global, long-term models) of energy production, transformation, and consumption across 32 global geopolitical regions. Agricultural production and any associated land-use changes are also modeled endogenously, which allows a dynamic coupling between energy and land-use systems. The emissions of greenhouse gases and pollutants associated with these activities, and the subsequent global changes in temperature and sea-level are also modeled. The model is open source and runs in 5-year time steps out to 2100.

As an integrated model, the prices of energy and agricultural goods, including biomass, are endogenously determined. GCAM has been extensively used to examine climate mitigation policies including carbon prices, carbon trading, and accelerated deployment of energy technologies. Carbon prices are also determined endogenously and are applied in the climate policy scenarios to all sectors of the economy, with a number of options for valuing carbon in terrestrial systems (Wise et al. 2009, Calvin et al. 2013). The model has also been used to examine interactions between air pollutant emissions, climate policy, and climate change (West et al. 2013, Smith and Mizrahi 2013).

The model has recently been extended as GCAM-USA, which is a fully global integrated assessment model with additional detail for the fifty U.S. states and the District of Columbia (Zhou et al. 2013, Patel et al. 2015). The energy system of each state is represented in terms of electricity generation, other transformation, and end-use demands including industrial, residential, and transportation sectors. Electricity is traded freely within regional markets based on NERC (North American Electric Reliability Corporation) regions, with stylized options for inter-regional electricity trade. Residential and commercial building energy demands are separately modeled in each state, with heating, cooling, lighting, hot water, appliances, and other services explicitly represented.

This enhanced tool has the capability of modeling state-level energy supply and demand as coupled with air pollutant and greenhouse gas emissions, all within a consistent global

[1] http://www.globalchange.umd.edu/models/gcam/

modeling framework. This allows future U.S. state-resolved scenarios to be evaluated within the context of global scenarios, including consistent changes in both domestic and international emissions. The relatively high level of detail in the electric, transportation, building and agricultural sectors facilitates the evaluation of the potential impact on emissions of specific technologies, renewable energy technologies, and energy efficiency measures. These evaluations can be conducted at the state, regional, and national levels.

While modeling at this level cannot take the place of more detailed sectoral analysis, this tool has the flexibility necessary to evaluate a large number of scenarios over time, including different socio-economic development, various technology deployment paths (costs, availability, and penetration), and air pollution and greenhouse gas policies. A strength of the integrated assessment approach is the consistent representation of interactions across sectors and spatial scales, which allows representation of feedbacks between sectors, regional electricity markets, and international trade all with endogenous prices. A pilot project has begun that will evaluate the ability of GCAM-USA to project air pollutant emissions at the U.S. state level and to provide useful insights on the regional impact of a range of energy- and emissions-related developments.

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