A Life Cycle Assessment Framework for Evaluating Options, Impacts, and National Energy Choices

Maryam Arbabzadeh[a], Tony (Wenzhao) Wu[b] and Emre Gençer[a]

[a] MIT Energy Initiative, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge MA 02139, US

[B] ExxonMobil Research and Engineering Company, Corporate Strategic Research, 1545 Route 22E, Annandale NJ, 08801 United States

Low-carbon transformation of the energy system requires a combination of technology and policy options to ensure reliable, affordable, and clean energy. An assessment of plausible transition pathways can be guided with a set of tools that cover multi-sector dynamics of transitions and consider economy-wide and sectoral life- cycle analysis of numerous options. While there is considerable related academic work emerging, there is a lack of readily available or generally accepted models or tools that take into account a broad and robust life-cycle-analysis approach for the range of plausible energy futures at regional and national levels. Such a tool is needed to help policy makers, investors and the financial sector to better understand and make decisions on energy choices and energy transitions, and avoid narrowly-framed and advocacy-driven pathways. One of MIT's current generation of modeling tools associated with energy choice evaluation is a comprehensive system-level and pathway-level model that does LCA (life-cycle assessment) and TEA (techno-economic assessment), which is called Sustainable Energy Systems Analysis Modeling Environment (SESAME). SESAME has a modular framework, which constitutes the underlying analytical engine that covers all life stages of major energy conversion pathways. The underlying analytical engine includes the cradle-to-grave life stages of major energy conversion routes and covers more than 1300 individual pathways. Detailed process simulation capabilities have been incorporated for in-depth analysis of GHG emission sources such as power plants and selected chemical conversion pathways. In addition to performing conventional LCA, we have implemented models for vehicle fleet and electric power systems to analyze systems-level interactions.

In the current study, we develop an expanded SESAME platform to quantify footprints of criteria pollutants and water, among others. The expanded SESAME version will be a publicly available technology options and scenario analysis tool that can use input information from any economy-wide system (or use the default settings that represent our base values). The tool will evaluate options, impacts, and national energy choices for exploring the impacts of relevant technological, operational, temporal, and geospatial characteristics of the evolving energy system. The presentation will focus on the overview of the tool, the modeling approach, as well as the results of regional case studies.