Appendix J

System for the Analysis of Global Energy Markets (SAGE)

Projections of world energy consumption and supply in *IEO2007* were generated using EIA's SAGE model. SAGE is used to project energy use in detail at the end-use sector level. It is an integrated set of regional models that provide a technology-rich basis for estimating regional energy consumption. For each region, reference case estimates of 42 end-use energy service demands (e.g., car, commercial truck, and heavy truck road travel; residential lighting; steam heat requirements in the paper industry) are developed on the basis of economic and demographic projections. Projections of energy consumption to meet the energy demands are estimated on the basis of each region's existing energy use patterns, the existing stock of energy-using equipment, and the characteristics of available new technologies, as well as new sources of primary energy supply.

Period-by-period market simulations aim to provide each region's energy services at minimum cost by simultaneously making end-use equipment and primary energy supply decisions. For example, in SAGE, if there is an increase in residential lighting energy service, either existing generation equipment must be used more intensively or new equipment must be installed. The choice of generation equipment (type and fuel) incorporates analysis of both the characteristics of alternative generation technologies and the economics of primary energy supply.

SAGE produces projections for 16 regions or countries of the world, including OECD North America as a whole and the United States, Canada, and Mexico individually; OECD Europe; OECD Asia and the countries of Japan, South Korea, and Australia/New Zealand individually; non-OECD Europe and Eurasia as a whole and Russia individually; non-OECD Asia and China and India individually; and Central and South America as a whole and Brazil individually. Projections of world oil prices over the projection horizon are provided to the *IEO2007* from EIA's *AEO2007*. All U.S. projections are taken from *AEO2007*.

IEO2007 provides projections of total world marketed energy consumption, as well as projections of energy consumption by primary energy type (liquids, natural gas, coal, nuclear, and hydroelectric and other renewable resources) and projections of net electricity consumption. Projections of carbon dioxide emissions resulting from fossil fuel use are also provided.

A new addition to this year's report is the inclusion of world oil price scenarios. The World Energy Projections Plus (WEPS+) model is an enhancement to the SAGE modeling system that was used to generate the high and low world oil price cases that appear in *IEO2007*, as well as the high and low macroeconomic growth cases. WEPS+ is a microeconomic model, used primarily to provide alternative energy projections under different assumptions about GDP growth and fossil fuel prices. It serves as a repository for reference case output generated from complex models that focus on specific supply or demand series. The reference case reflects output from those models and incorporates analysts' judgment on the potential for demand by end-use sector and fuel type on a regional basis. Carbon dioxide emissions, electricity generation, and installed electricity generation capacity also are projected within the WEPS+ system.

After the reference case is established, WEPS+ is used to calculate coefficients for the response surface and save them into a database. The reference case output tables reflect the same information that is embedded in the input tables. Alternative cases reflect changes in assumptions about future economic growth (as measured in GDP) and prices. When an alternative case is run, the model uses the previously calculated coefficients to produce new projections relative to changes in GDP and energy prices and produces output tables that reflect the changes.

The projections for world liquids production in *IEO2007* reflect an expanded assessment of world oil supply, using assumptions about additions to proved reserves, the relationship between proved reserves and production, geopolitical constraints, and prices to generate conventional crude oil production cases. Projections of conventional liquids production for 2009 through 2015 are based on analysis of investment and development trends around the globe. Projections of unconventional liquids production are based on exogenous analysis.

Nine major streams of liquids production are tracked on a volume basis: (1) crude oil and lease condensates, (2) natural gas plant liquids, (3) refinery gains, (4) Canadian oil sands, (5) ultra-heavy oils, (6) coal-to-liquids, (7) gas-to-liquids, (8) shale oils, and (9) biofuels (tracked on both a volume basis and an oil equivalent basis). Biofuels are reported in terms of barrels of oil equivalent, unless otherwise stated.

A full description of the SAGE model is available in a two-volume set. The first volume provides a general understanding of the model's design, theoretical basis, necessary user-defined assumptions, and output. It also

lists the software necessary to develop and analyze the results of SAGE-based policy and energy market scenarios. In addition, Volume I includes a Reference Guide, which explains each equation in detail. The second volume serves as a User's Guide for those actively developing SAGE-based scenario analyses. The documentation is available on EIA's web site in the model documentation section of "Current Publications" (http://www. eia.doe.gov/bookshelf/docs.html). SAGE documentation is also available as part of the documentation for the MARKAL family of models (http://www. etsap.org/ MRKLDOC-III_SAGE.pdf).