American Council for an Energy-Efficient Economy

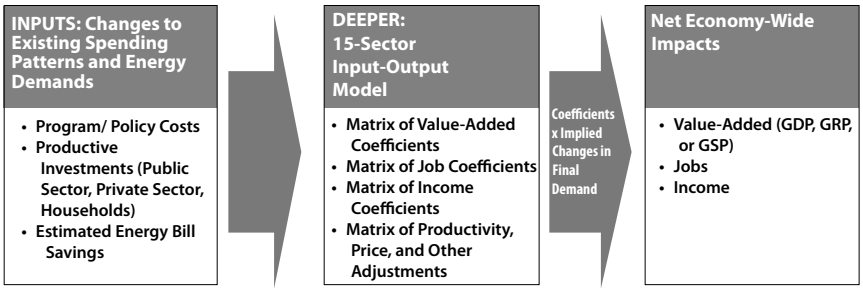
Fact Sheet

A Brief Methodology of the DEEPER Modeling System

To evaluate the macroeconomic impacts of a variety of energy efficiency, renewable energy, and climate policies at the local, state, and national level, ACEEE uses the proprietary **D**ynamic **E**nergy **E**fficiency **P**olicy **E**valuation **R**outine, or DEEPER model. The model has a 20-year history of use and development, though it was more recently renamed "DEEPER."

The DEEPER Modeling System is a 15-sector[1] quasi-dynamic input-output (I/O) model[2] of the U.S. economy that draws upon social accounting matrices[3] from the Minnesota IMPLAN Group,[4] energy use data from the U.S. Energy Information Administration's Annual Energy Outlook (AEO), and employment and labor data from the Bureau of Labor Statistics (BLS). The Excel-based tool is made up of three linked modules [(i) the Energy and Emissions Module; (ii) the Electricity Production Module; and (iii) the Macroeconomic Module][5] and contains approximately two dozen interdependent worksheets. The model functions as laid out in the flow diagram below:

DIAGRAM OF THE DEEPER MODEL



DEEPER results are driven by adjustments to energy service demands and alternative investment patterns resulting from projected changes in policies and prices between baseline and policy scenarios. The model is capable of evaluating policies at the national level through 2050. However, given uncertainty surrounding future economic conditions and the life of the impacts resulting from the policies analyzed, it is often used to evaluate out 10–15 years. Although the DEEPER Model, like most I/O models, is not a general equilibrium model,[6] it does provide accounting detail that balances changes in investments and expenditures within a sector of the economy. With consideration for goods or services that are imported, it balances the variety of changes across all sectors of the economy.[7]

The Macroeconomic Module contains the factors of production — including capital (or investment), labor, and energy resources — that drive the U.S. economy for a given "base year." DEEPER uses a set of economic accounts that specify how different sectors of the economy buy (purchase inputs) from and sell (deliver outputs) to each other. [8]

The DEEPER model is typically used to evaluate impacts of selected policies in 15 different economic sectors that are usually affected by changes in energy use and investment: Agriculture, Oil and Gas Extraction, Coal Mining, Other Mining, Electric Utilities, Natural Gas Distribution, Construction, Manufacturing, Wholesale Trade, Transportation and Other Public Utilities (including water and sewage), Retail Trade, Services, Finance, Government, and Households.[9] The model looks at different labor intensities[10] in different sectors to provide insights about the net employment benefits to the economy.

The Macroeconomic Module translates the selected different policy scenarios, including necessary program spending and research and development (R&D) →

expenditures, into an annual array of physical energy impacts, investment flows, and energy expenditures over the desired period of analysis. DEEPER evaluates the policy-driven investment path for the various financing strategies, as well as the net energy bill savings anticipated over the study period. It also evaluates the impacts of avoided or reduced investments and expenditures otherwise required by the electric and natural gas sectors. These quantities and expenditures feed directly into the final demand worksheet of the module that generates the net changes in sector spending.

The resulting positive and negative changes in spending and investments in each year are converted into sector-specific changes in aggregate demand.[11] These results then drive the I/O matrices utilizing a predictive algebraic expression known as the Leontief Inverse Matrix.[12]

Employment quantities are adjusted annually according to assumptions about the anticipated labor productivity improvements based on forecasts from the Bureau of Labor Statistics. The DEEPER Macroeconomic Module traces how changes in spending will ripple through the U.S. economy in each year of the assessment period. **The end result is a net change between the reference and policy scenarios in jobs, income, and value-added,[13] which is typically measured as Gross Domestic Product (GDP), Gross Regional Product (GRP), or Gross State Product (GSP) for the study region (e.g., national, state, or local).**

Like all economic models, DEEPER has strengths and weaknesses. It is robust by comparison to some I/O models because it can account for price and quantity changes over time and is sensitive to shifts in investment flows. It also reflects sector-specific labor intensities across the U.S economy. However, it is important to remember when interpreting results for the DEEPER model that the results rely heavily on the quality of the information that is provided and the modeler's own assumptions and judgment. The results are unique to the specified policy design. The results reflect differences between scenarios in a future year, and like any prediction of the future, they are subject to uncertainty.

NOTES

[1] The current mix of 15 sectors reflects the analyst's efforts to exhibit key outcomes while maintaining a model of manageable size. It is possible to expand and reduce the number of sectors in the model with relatively easy programming adjustments. If the analyst chooses to reflect a different mix of sectors and stay within the 15 x 15 matrix, that can be easily accomplished through minor changes.

[2] Input-output models use economic data to study the relationships among producers, suppliers, and consumers. They are often used to show how interactions among all three impact the macroeconomy.

[3] A social accounting matrix is a data framework for an economy that represents how different institutions — households, industries, businesses, and governments — all trade goods and services with one another.

[4] See http://implan.com/V4/Index.php. The entire IMPLAN database for the U.S. economy can be expanded to more than 400 sectors as needed.

[5] See Laitner, J., S. Bernow, and J. DeCicco. 1998. "Employment and Other Macroeconomic Benefits of an Innovation-Led Climate Strategy for the United States." *Energy Policy*, 26(5), 425-433 for an example of an earlier set of modeling results. For a more recent review of modeling assessments, see also Laitner, J. and V. McKinney, 2008. *Positive Returns: State Energy Efficiency Analyses Can Inform U.S. Energy Policy Assessments*. ACEEE Report Number E084. Washington, D.C.: American Council for an Energy-Efficient Economy.

[6] General equilibrium models operate on the assumption that a set of prices exists for an economy to ensure that supply and demand are in an overall equilibrium.

[7] When both equilibrium and dynamic input-output models use the same technology assumptions, both models should generate a reasonably comparable set of outcomes. For a diagnostic assessment that reached that conclusion see Hanson, D. and J. Laitner. 2005. "Tripling the Nation's Clean Energy Technologies: A Case Study in Evaluating the Performance of Energy Policy Models." In *Proceedings of the 2005 ACEEE Summer Study on Energy Efficiency in Industry*. Washington, D.C.: American Council for an Energy-Efficient Economy.

[8] Further details on this set of linkages can be found in Hanson, D. and J. Laitner. 2009. "Input-Output Equations Embedded within Climate and Energy Policy Analysis Models," in S. Suh, Editor, *Input-Output Economics for Industrial Ecology*. Dordrecht, Netherlands: Springer, 2009.

[9] Household spending is allocated to each of the sectors using the personal consumption expenditure data provided in the IMPLAN data set.

[10] This is the magnitude of jobs supported by a given level of investment.

[11] This is the total demand for final goods and services in the economy at a given time and price level.

[12] For a more complete discussion of these concepts, see Miller, R. and P. Blair. 1985. *Input-Output Analysis: Foundations and Extensions*, Prentice-Hall, Inc., Englewood, NJ.

[13] This is the market value of all final goods and services produced within a country in a given period.