ENERGY INNOVATION
POLICY & TECHNOLOGY LLC

www.energyinnovation.org
98 Battery Street; San Francisco, CA 94111
policy@energyinnovation.org

METHODOLOGY AND DATA SOURCES FOR THE ENERGY POLICY SIMULATOR

The Energy Policy Simulator (EPS) is a free, non-partisan, open-source computer model that can estimate the impacts of climate and energy policies on emissions, cash flows, technology deployment, health impacts, and job creation. The model and all its data can be accessed online or downloaded to your computer by navigating to the desired regional model at https://energypolicy.solutions.

Full documentation of the model's structure and methodology is available at https://us.energpolicy.solutions/docs. Each regional model includes documentation on the underlying data sources and assumptions used in each policy scenario. This document highlights the key data sources, assumptions, and calculation methodologies used in the EPS.

ENERGY SYSTEM MODELING

The core of EPS modeling is a simplified version of the energy system modeling approach used in "pathways" modeling exercises such as the Deep Decarbonization Pathways Project. This approach divides the energy system into key energy demand sectors and simulates transformation of the energy system over several decades. It follows the Intergovernmental Panel on Climate Change conventions for emissions reporting for states or nations, adding up direct emissions within jurisdiction boundaries, as well as imported electricity emissions where state greenhouse gas accounting includes imported emissions: This is known as "production emissions" accounting. It does not include "consumption emissions" resulting from goods and services, including fuels and energy infrastructure, imported from outside the boundary, with the exception of electricity as noted above.

BUILDINGS AND INDUSTRY PROJECTIONS

The EPS builds a Business-as-Usual (BAU) scenario as a starting point for all analysis. For buildings and industry, the BAU scenario relies on energy or service demand projections from other models as a baseline. For example, the EPS reads input data on projected energy demand in buildings by building type, end use, and fuel type. These projections are used directly in the BAU scenario for building energy use. Industry energy use relies on a similar methodology. Key data sources include the U.S. Energy Information Administration's Annual Energy Outlook and State Energy Data System, as well as the National Renewable Energy Laboratory's Electrification Futures Study.

TRANSPORTATION AND ELECTRICITY PROJECTIONS

The BAU transportation projections begin with input data defining the size of the start year vehicle fleet, distance traveled by different vehicle types, and vehicle loading. Input data defining future service demand growth is also used to define how service demand evolves over time. The model then estimates deployment of different vehicle types based on the corresponding new service demand and vehicle retirements using the estimated total cost of ownership including purchase costs, operating costs, fuel costs, and maintenance costs. While service demand matches input data, vehicle deployment is handled endogenously in the EPS and therefore the vehicle mix may vary from other input data sources.

Like transportation, the EPS electricity sector projections choose what types of plants to build and dispatch based on current and projected costs including capital costs, operating and maintenance costs, and fuel costs, among others. Service demand is the sum of all electricity demand in the model, inclusive of net electricity exports.

It is important to note that the EPS is an annual, low-resolution energy and emissions model. It is not a complex electricity reliability model and should not be treated as such. The EPS does include several mechanisms to approximate grid constraints such as estimated curtailment, grid flexibility implications, and estimates of required peak capacity (and deployment of that capacity). The EPS should be viewed as a starting point for understanding the implications of deep decarbonization of the power sector and should be coupled with further analysis using reliability models.

ESTIMATING POLICY IMPACTS

Policy impacts are estimated by layering on policies and tracking the difference from the BAU scenario. In other words, the EPS is a "difference" model where changes in emissions, cash flows, and technology deployment are tracked relative to a BAU scenario. The EPS is specifically designed to account for policy interactions across and within sectors of the economy. For example, changes in electricity demand from transportation electrification will cause greater electricity capacity to be built. Reduced fossil fuel demand will reduce in-region emissions from the fossil fuel sector, to the extent demand for those fuels is reliant on in-region production, as well as associated process emissions and process emissions abatement potential.

One key EPS feature is its ability to evaluate the relative magnitude of emissions reductions by policy within a scenario. The graph containing this information is called the CO_2e Wedge Diagram. This graph displays information on the size of each policy's emissions reduction in each year within a policy scenario. The data for this graph is calculated by starting with all the policies in a scenario turned on, then turning off a policy and testing emissions changes, then turning it back on and moving to the next policy, and so forth. Additional calculation is required to ensure policy reduction amounts are scaled to sectoral emissions and then re-scaled so that the sum of all individual reductions in every year equals the sum of all reductions together in every year. In sum, this approach provides information on the size of a policy's impact *within* a scenario, contingent on the other policies that are enabled. The CO_2e Abatement Cost Curves follow a similar methodology.

HEALTH IMPACTS AND MONETIZED SOCIAL BENEFITS

Health impacts in the EPS are estimated by converting changes in health-damaging pollutant emissions into estimated avoided health impacts. The EPS first estimates changes in pollutant emissions by multiplying changes in fossil fuel consumption by sector (and sometimes technology-specific) emissions factors, taken from the U.S. Environmental Protection Agency (EPA)[i]. The EPS calculates emissions of 12 different pollutants, including four relevant for public health: PM2.5, SOx, NOx, and VOCs. The EPS then uses a separate set of EPA data, called benefit-per-ton estimates, to convert emissions changes in each sector to estimated avoided morbidity and mortality. This methodology relies on publicly available EPA data to approximate health impacts, but is not as robust as a full air quality modeling assessment.

Avoided premature mortality is also monetized by multiplying the number of avoided deaths by EPA's Value of a Statistical Life. To monetize avoided climate damages, the EPS multiplies avoided CO_2e emissions by the Obama administration's Social Cost of Carbon, assuming a 3 percent discount rate.[ii]

JOBS AND GDP CHANGES

The EPS includes an embedded input-output macroeconomic model used to estimate changes to jobs and Gross Domestic Product (GDP) that result from the policies within a scenario. Input-output models take data on changes in spending by industry and convert this to jobs based on the share of an industry's output that is spent on labor and the wage rates for each industry. The input-output model in the EPS calculates changes in direct, indirect, and induced jobs and GDP, and flows these changes back through the model in the following time-step so that macroeconomic impacts influence future year emissions.

- Direct impacts are those that result directly from a policy, such as increased wind and solar deployment that might result from a clean electricity standard.
- Indirect impacts are those used to provide the change in output for direct impacts, for example increased iron and steel and electrical equipment output to supply solar panel and wind turbine manufacturers.
- Induced impacts are those that are caused by changes in re-spending as a result of direct and indirect impacts, for example increased spending on food and retail that might result from a large increase in employment resulting from a clean electricity standard.

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[i] Emissions factors for non-GHGs are calculated by dividing emissions by sector and source from EPA's National Emissions Inventory by fuel consumption from the EIA by sector and source.

[ii] The Interagency Working Group estimate from 2016, from https://www.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf. The central estimate of $42/ton in 2020 is used. Note that recent studies have suggested much higher possible ranges for social cost of carbon, such as $187-805/ton in https://www.nature.com/articles/s41558-018-0282-y.

The EPS breaks these job and GDP types apart so that each can be studied individually.

Because the EPS is designed as an international model, we rely on significant sectoral aggregation to allow for use of international data. Other state or region-specific models may have significantly greater detail and can complement any analysis from the EPS.

LIMITATIONS

The EPS is an annual, economy-wide model that can provide detailed information on potential impacts - including emissions reductions, technology deployment, employment change, and health outcomes - from implementing climate and energy policies. It also runs extremely fast, at about one run a second. As such, the EPS is an excellent screening tool to help understand broad implications of policies and how those policies fit together. While it provides significant detail in the power sector and energy demand sectors, it is not a replacement for models solely focused on these sectors, such as detailed stock-turnover models or power system reliability models. The EPS is best used in conjunction with these models to understand the full implications of policy scenarios. Similarly, while the model includes land use and agriculture emissions and policies, these areas are not the primary focus of the model. The model does not substitute for regional land use or transportation demand models, and future changes in building and transportation energy demands are modeled simply or assume existing patterns continue. Complementary models and research can supplement the findings in the EPS.