# Read Me for the Energy Policy Simulator

The Energy Policy Simulator (EPS) is a computer model developed by [Energy Innovation, LLC](http://energyinnovation.org/) as part of its [Energy Solutions Project](https://www.energypolicy.solutions/), an effort that aims to provide guidance to policymakers and regulators on how to reduce emissions of greenhouse gases and other harmful pollutants.

This Read Me contains helpful information about running and adapting the model for new regions. The EPS can be adapted to national, subnational, and supernational regions by simply swapping the input data for region-specific data; there is no need to modify the core model.

## Documentation

Complete [model documentation](https://us.energypolicy.solutions/docs/index.html) and [instructional videos](https://us.energypolicy.solutions/docs/video-series.html) are available online. The documentation and videos provide an overview of the model’s functionality, how to install and perform analysis using Vensim Model Reader, a detailed explanation of the model structure, and guidance for using the included python scripts.

## License

The EPS is released under the GNU General Public License Version 3 (GPLv3) or any later version and is free and open-source software. A copy of the license is included in the model distribution (in “License.txt”).

## Model Adaptation

The EPS is open-source and as such can be adapted to any new region by model users, provided the final model adaptation and underlying data is made publicly available. The process for updating the model is outlined in the fourth EPS video and generally consists of these steps:

1. **Finding replacement data suitable for the regional adaptation.**

Users can start by referencing the acronym-key.xlsx file included in the InputData folder, which lists all the input variables used in the model as well as the priority for updating each one. Though not all variables need to be updated, the more that are updated to reflect the specific region being modeled, the more accurate the model will be. Our recommended approach is to start with the highest importance variables and then to work down the list to the variables where updates are least important.

1. **Transforming replacement data into the format required by the EPS and exporting the required .csv files.**

Once data is collected, it needs to be transformed into the format read by the model. This is handled in the Excel files within each variable folder. The Excel files can be customized for a given region Most tabs may include data in any format and using any units, but the dark blue tabs must contain data formatted the same way and using the same units as the US data. By default, the EPS works in grams of pollutant, 2012 US dollars, and BTUs of energy. (These are only the units used for internal calculations. The model’s final output units are customized for each region using variables in the InputData/web-app folder.) The dark blue tabs are exported as .csv files, which are read in by the model. They cannot contain blanks where there is supposed to be data and they cannot contain commas. Once the data transformation is complete, users must export each of the dark blue tabs as a .csv file in the variable folder, using the name of the tab as the exported file’s filename. Detailed documentation of the updated reference data and methodology should also be added to the “About” tab of each file.

1. **Model testing.**

Once all the desired variables have been updated and exported, it is time to see if the model will run. To do this, users can open the EPS.vpm file and click “Simulate.” In most instances, the model will fail to run and produce an error. This happens because small mistakes in input data or errors in exported .csv files will cause the model to crash. Though it is necessary to investigate the error to know what to fix, there are some general rules to follow.

If the model fails because of a floating point overflow, this typically means that there is a zero used for a variable where it should have a value greater than zero. As a result, when the model divides by zero, it gets an infinite value, producing this error.

If the model fails because it cannot get data from an input data file, this likely means that either the .csv file was not exported, or the .csv file is open (Vensim cannot run if any of the input .csv files are currently open).

If the model says data is incorrectly dimensioned or values are missing, this is likely due to an incorrectly exported .csv file.

These examples are meant to help in the debugging process, but they do not represent all cases where the model will fail to run.

1. **Model calibration**

Once the model is up and running, it must be calibrated to ensure the results are reasonable. Users should compare key outputs, such as energy demand in each sector, power sector composition, vehicle deployment, etc… with outputs of other models of the same region. To be clear, the EPS results *need not match* other models. But significantly different results can sometimes indicate an issue with input data or other assumptions. At a minimum, it is useful to understand why the EPS produces results that differ from other modeling. During calibration, issues may be identified that necessitate updates to input data.

1. **Creating the webtool**

Once the model is finalized, the last step is to create the web interface and deploy the model online. This is a very straightforward process. Users must update the WebAppData.xlsx file included in the model folder so that the guidance text and policy descriptions are applicable to the covered region. Additional reference scenarios can be added or removed and policy maximum and minimum settings can also be customized. The set of graphs and graph labels can also be adjusted at this time. Region-specific energy and currency units can be customized, but this is done in input data (see Steps 1 and 2). Once all updates are complete, Energy Innovation can upload and deploy the model online.

## Useful Resources

To assist with model adaptations, Energy Innovation has compiled a list of models and datasets commonly referenced in model adaptations. These models are not the property of Energy Innovation and come with their own limitations and restrictions, but they often serve as data sources for EPS adaptations or as comparisons during calibration (see Step 4).

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| **Resource** | **Description** |
| [Argonne National Lab GREET Model](https://greet.es.anl.gov/greet_1_series) | The GREET model includes detailed information on emissions and efficiencies of many different types of equipment. It is particularly useful for identifying emissions factors and for data related to biofuels. |
| [Asia-Pacific Energy Research Center Energy Demand and Supply Outlook](https://aperc.ieej.or.jp/publications/reports/outlook.php) | The Energy Demand and Supply Outlook contains energy projections for many Asian-Pacific and other large countries through 2050, with detailed information on types of energy consumed and power sector composition. It could serve as input data for regional adaptations and is also a great resource for model calibration. |
| [EIA Annual Energy Outlook database](https://www.eia.gov/outlooks/aeo/) | The Annual Energy Outlook database contains the EIA’s projections through 2050 of US energy demand, prices, and energy infrastructure. It is a key component of the US EPS and contains much data that is used in other international adaptations. |
| [EIA International Energy Outlook database](https://www.eia.gov/outlooks/ieo/) | The International Energy Outlook is EIA’s complement to the Annual Energy Outlook and contains energy and emissions forecasts for a subset of countries and regions. It is a useful data source for model calibration and can also be used to estimate start year data or projected growth rates of energy consumption. |
| [EIEE WITCH model simulator](https://www.witchmodel.org/simulator/) | The WITCH model is an Integrated Assessment Model (IAM) that can be used in calibration or for input data. Limited results are available through an online interface. |
| [EPA Mitigation of Non-CO2 Gases database](https://www.epa.gov/global-mitigation-non-co2-greenhouse-gases) | This report by EPA contains projections of non-CO2 emissions for every country, as well as mitigation potential in the major emitting countries. It is used widely by many different models to estimate the potential and cost of non-CO2 GHG mitigation. It can directly or indirectly be used for much of the data on process emission in the EPS (in indst/BPEiC and indst/PERAC). |
| [European Commission’s EDGAR database](https://edgar.jrc.ec.europa.eu/) | The EDGAR database contains historical emissions estimates for most countries across many different pollutants and sectors. It is a valuable resource for finding historical non-CO2 emissions (such as industrial process emissions, used in indst/BPEiC). |
| [FAO Agriculture Modeling World Projections database](http://www.fao.org/global-perspectives-studies/food-agriculture-projections-to-2050/en/) | The Agriculture Modeling World Projections database includes detailed projections of agricultural outputs for many countries. It is a great resource for estimating future agriculture and livestock emissions in the EPS (in indst/BPEiC). |
| [FAOSTAT](http://www.fao.org/faostat/en/#data) | FAOSTAT contains various agricultural and livestock statistics that can be used for agriculture in the EPS. |
| [IEA Energy Statistics database](https://www.iea.org/statistics/?country=WORLD&year=2016&category=Energy%20supply&indicator=TPESbySource&mode=chart&dataTable=BALANCES) | The Energy Statistics database contains detailed historical information, by country, on energy consumption by fuel type and sector. It can be a valuable resource for model calibration and for determining start year energy consumption in various sectors and sub-industries. |
| [IEA Energy Technology Perspectives visualizer](https://www.iea.org/etp/explore/) | The Energy Technology Perspective visualizer contains useful projections on emissions and technology diffusion for a small set of regions under three different scenarios developed by the IEA. It can help during model calibration and with some of the business as usual forecasts for technology uptake in the EPS (such as CCS). |
| [IIASA GAINS model](http://www.iiasa.ac.at/web/home/research/researchPrograms/air/GAINS.html) | The GAINS model contains useful information on activity drivers, technology composition, and energy and emissions estimates for many regions. Datasets extend through 2030 and include subnational coverage for several countries. The GAINS model is particularly valuable for finding emissions factors (used in fuels/PEI) for new regions. |
| [IIASA RCP Scenario database](http://www.iiasa.ac.at/web-apps/tnt/RcpDb/dsd?Action=htmlpage&page=welcome) | The RCP Scenario database contains all the data produced by models used to project the RCP scenarios in the UNFCCC Assessment Report. The database includes outputs from many different models across many different scenarios, with some regional detail. It can be a useful resource during model calibration. |
| [IIASA SSP Scenario database](https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=10) | The SSP Scenario database contains outputs from many IAMs using a common set of assumptions about major economic drivers, such as population and GDP. The SSP scenearios are helpful in understanding how models produce different outputs using the same set of input assumptions. Data from the SSP Scenario database can be used as input data to the EPS, including GDP, population growth, and energy demand. |
| [Lazard’s LCOE Analysis and LCOS Analysis](https://www.lazard.com/perspective/levelized-cost-of-energy-and-levelized-cost-of-storage-2018/) | The LCOE and LCOS analyses published by Lazard contain detailed information on the costs and efficiencies of various power plant and storage technologies. These estimates are useful for determining capital and operating and maintenance costs for power plants in the EPS. |
| [NREL Annual Technology Baseline database](https://atb.nrel.gov/electricity/data.html) | The ATB database contains projections of power plant capital and operating costs through 2050. NREL updates this database every year and the data serves as a good source for projected power sector equipment costs and cost trends. |
| [OECD.Stat and OECD.Stat Input-Output Tables](https://stats.oecd.org/Index.aspx?DataSetCode=IOTSI4_2018) | OECD.Stat is a database of country-level information ranging from employment, to GDP, to environmental performance. Of particular note are the Input-Output tables for specific regions. These can be used for various industry sector data in the EPS. |
| [PIK PRIMAP-Hist database](https://www.pik-potsdam.de/paris-reality-check/primap-hist/) | The PRIMAP-Hist database contains detailed historical emissions estimates by country, sector, and gas. It is a useful resource for identify start year emissions (for example for indst/BPEiC) and can also be used in model calibration. |
| [PNNL/UMD’s GCAM model](http://www.globalchange.umd.edu/gcam/) | GCAM is an Integrated Assessment Model (IAM) with global coverage and regional detail for 32 different regions. It is publicly available and can be run locally. GCAM can produce many outputs that can serve as inputs to the EPS, including energy consumption, transport service demand, and non-CO2 emissions projections. |
| [UK DECC Global Calculator 2050 models](http://2050-calculator-tool-wiki.decc.gov.uk/pages/1) | The Global Calculator 2050 models are a set of spreadsheet models built for a select group of countries that forecast energy consumption and emissions across a variety of scenarios. Inputs and outputs into these models can be used as input data to the EPS as well as in calibration. |
| [WRI CAIT/ClimateWatch database](https://cait.wri.org/) | The CAIT/ClimateWatch database includes lots of data at the national level for dozens of countries, including historical emissions by sector and future emissions trajectories. |

## Contact Us

Should you have any questions or comments about the EPS, please let us know by emailing us at: [policy@energyinnovation.org](mailto:policy@energyinnovation.org)