EPRI

2025 SOFTWARE MANUAL

Open-Source U.S. Regional Economy, Greenhouse Gas, and Energy (US-REGEN) Model

Version 2025.0.0.1

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SOFTWARE DESCRIPTION

The U.S. Regional Economy, Greenhouse Gas, and Energy (US-REGEN) model is an energy-economy model developed and maintained by EPRI's Energy Systems and Climate Analysis (ESCA) group. The open-source version of US-REGEN (initially published in 2025) currently includes the electric sector capacity planning and fuels supply portions of the model.

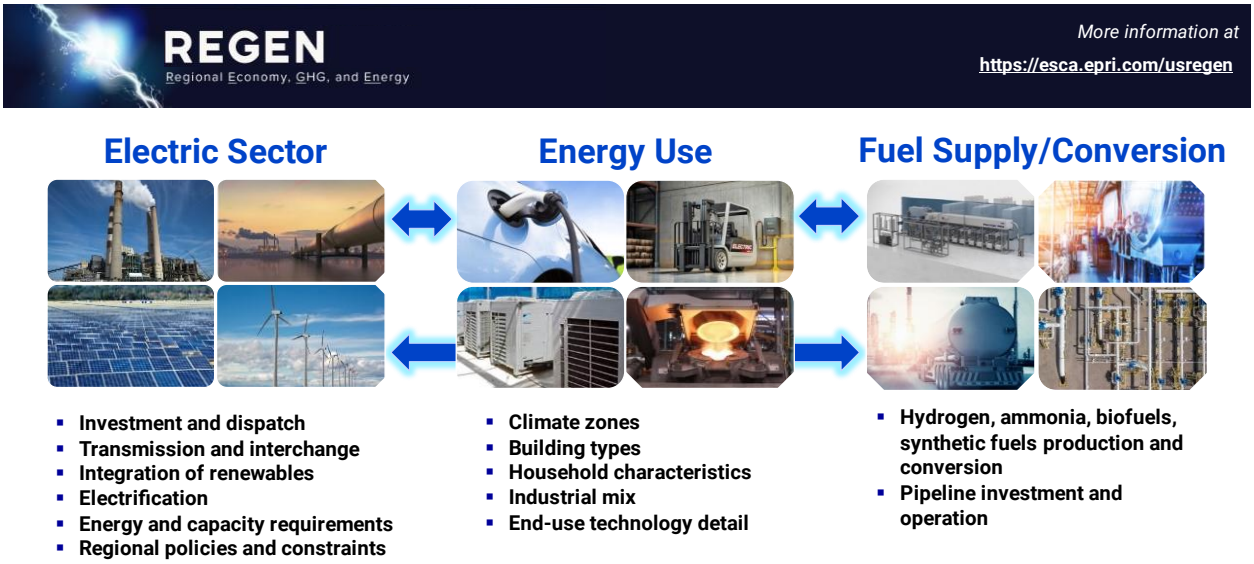

Figure 1. Overview of EPRI's US-REGEN energy systems model.

Description

The US-REGEN model links a detailed electric sector capacity planning and fuels supply model with representations of demand in buildings, transport, and industry. The open-source version of US-REGEN includes the electric+fuels model that jointly optimizes regional investments in electricity generation and energy storage, system dispatch, transmission, and non-electric fuels supply, which includes high temporal resolution and chronology to better characterize the economic incentives of variable renewables, energy storage, and dispatchable generation.[1] The model identifies least-cost investment and operations to meet demand over a multi-decadal period, subject to policy, market, and technology constraints.

Detailed US-REGEN model documentation and recent peer-reviewed articles and white papers can be found at https://esca.epri.com/usregen/.

[1] These methods are summarized in Blanford, et al. (2018). Simulating Annual Variation in Load, Wind, and Solar by Representative Hour Selection (*The Energy Journal*), and Merrick, et al. (2024). On Representation of Energy Storage in Electricity Planning Models (*Energy Economics*).

Benefits and Value

US-REGEN provides a customizable platform for policy analysis, technology assessment, and strategy that is informed by decades of EPRI research on energy modeling and technology analysis. The electric sector model represents detailed dispatch and capacity expansion and includes representations of a range of electric sector resources that can be jointly optimized under technology, policy, and market assumptions. The fuels model describes the supply and conversion of primary energy into delivered fuels supplied to the electric and end-use models and characterizes technologies for conversion, blending, and synthesis of fuels, including petroleum refining, biomass to liquids or gas, blending fuel supply, ammonia production, and fuel synthesis (Figure 2). The model can quantify the implications of scenario differences on system costs, emissions, capacity investments, and other outputs of interest.

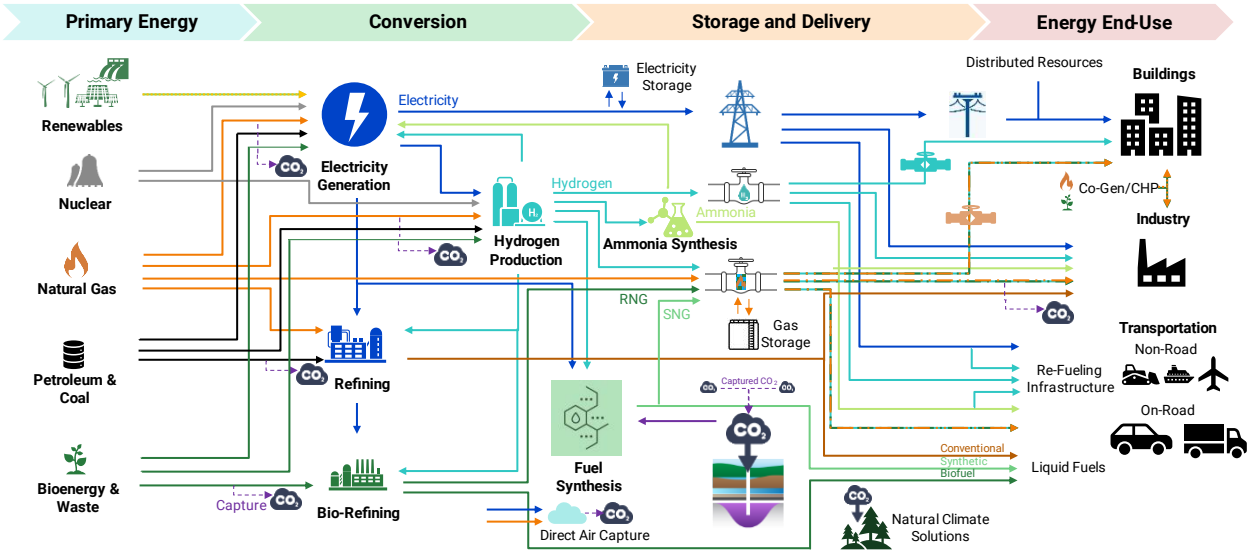

Figure 2. Schematic diagram of primary energy, conversion, storage, and end-use pathways in US-REGEN.

Platform Requirements

The US-REGEN model is written primarily in GAMS. This version of US-REGEN has been tested in GAMS Version 47 with the CPLEX solver. System requirements for running US-REGEN include:

- Valid GAMS license with CPLEX solver (or other linear programming solver)
- 32 GB RAM minimum, 64 GB recommended

Keywords

US-REGEN; energy-economic modeling; energy systems analysis; power sector economics; capacity expansion; technology; policy analysis

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MANDATORY SOFTWARE INSTALLATION INFORMATION

Third-Party Software Installation

This software uses third-party software products, operating systems, and hardware platforms. Over time, security issues may be uncovered in these third-party products. You should review your use of this software with your Information Technology (IT) department to ensure that all recommended security updates and patches are installed for all third-party products as needed.

Troubleshooting Installation

If you experience difficulties accessing the application after standard installation, please consult your IT department personnel to have proper access permissions setup for your use. If the problem cannot be resolved, please call the EPRI Customer Assistance Center (CAC) at 1-800-313-3774 (or email askepri@epri.com).

1. TEST CASE: RUNNING US-REGEN SCENARIOS

Step 1: Download Model Code and Input Data

The GitHub repository for US-REGEN includes model code and execution scripts.[2] After installing GAMS and downloading/cloning the US-REGEN code from GitHub, input data files, primarily in a GDX (GAMS Data eXchange) format, must be downloaded from a public Box folder. These files can be downloaded directly or copied automatically to your local directory using the "download_regen_data_box.bat" script.

To execute the script and transfer the data:

1. Open GAMS Studio
2. If you have not already, create a new project via File > New Project…
3. Open a terminal window either through Ctrl+T or through the menu via Tools > Terminal
4. Once the terminal window opens, navigate to the root directory of the US-REGEN folder, type "call download_regen_data_box.bat," and hit enter

It may take a few minutes to download and copy files depending on your connection speed. Model code will be stored in the RegenRun subfolder, while input data files will be stored in the RegenData and RegenReport folders.

Step 2: Specify Scenarios to Run

Open the default batch file in **RegenRun/run_elecfuels.bat** in a text editor. This file contains example syntax for a few illustrative scenarios for the electric+fuels model:

- **reference:** Reference scenario that is driven by economic fundamentals as well as existing policies, regulations, and incentives. Reference case assumptions generally include Inflation Reduction Act (IRA) incentives, as well as state policies such as electric sector portfolio standards, technology-specific mandates and bans, economy-wide emissions policies, and power sector emissions policies, including California's mandatory economy-wide cap-and-trade program and the Regional Greenhouse Gas Initiative (RGGI) for power sector CO_2 emissions in the Eastern U.S.
- **nzecon:** This scenario adds an economy-wide net-zero CO_2 by 2050 cap with linear declines over time, similar to the LCRI Net-Zero 2050 report: https://lcri-netzero.epri.com/.
- **nzele:** This scenario includes a net-zero CO_2 by 2050 constraint for the power sector only, which is similar to the EPRI "Powering Decarbonization" report.

[2] US-REGEN code can be accessed through the GitHub repository, which includes download instructions. Links for the US-REGEN repository, documentation, and recent reports and peer-reviewed publications can be found at https://esca.epri.com/usregen/.

The open-source release includes model scripts to run the electric+fuels model but not the end-use models. Hence, end-use model output datafiles for two representative scenarios—a reference scenario and an economy-wide net-zero scenario—are included in the data package accompanying this release. Each scenario to be run in the electric+fuels model has a control parameter specifying the source for fixed end-use fuel demands and other electric+fuels model inputs: --endusescen=%scen%. Users should choose the end-use input scenario that best corresponds to the specified electric+fuels scenario being run.

Figure 3 shows an example batch file for the electric+fuels model.

Figure 3. Electric+fuels model batch file.

The GAMS script **RegenRun/elecfuels/regen_defaults.gms** includes a list of control parameter names, defaults, and alternate values.

Electric+fuels model scenarios can be run in either a "dynamic" or "static" mode. The dynamic mode, which is the default configuration, performs an intertemporal optimization of investments across a multi-decadal time horizon with intra-annual dispatch over a set of weighted representative hours. The static mode includes 8,760 hourly resolution for dispatch by default but only optimizes investment for a single future period. Within static mode, there are several options for how capacity variables are treated, including options to fix capacity levels to the outcome of a dynamic mode solution.

Step 3: Run Model

Once scenarios have been specified, run the batch file:

1. Once the project has been opened in GAMS Studio (per Step 1), open a terminal window either through Ctrl+T or through the menu via Tools > Terminal.
2. Navigate to the RegenRun folder and type “run_elecfuels.bat” (or the appropriate name, if the batch file was renamed) and hit enter.
3. The code will run and take a couple of hours per scenario, depending on your machine’s configuration and scenario specifications.
4. The terminal will say “Status: Normal completion” if the scenario was successful, similar to Figure 4. Note that a model run includes the execution of both regenelecfuels.gms, the main model script, and regen_report.gms, a reporting script which is run separately after a successful model solve. The terminal window should show “Status: Normal completion” for both scripts.

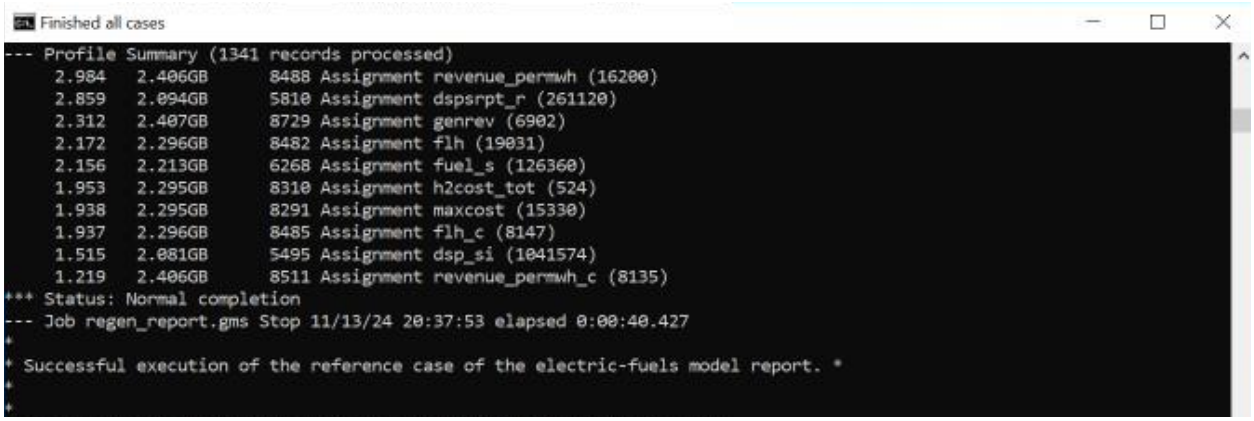

Figure 4. Example of terminal window after successful model run.

The full version of US-REGEN entails iterations between the electric+fuels model and end-use models. When using the full version of US-REGEN, the *iter* parameter is updated appropriately in the batch files (if this parameter is not updated, iterations will be overwritten). However, only one iteration is necessary when the electric/fuels model is run in isolation.

Step 4: Examine Outputs

Reporting scripts are automatically run for each scenario with results placed in the RegenCases folder. The main reporting for individual scenarios can be found in the directory %scen%\elecfuels\report\%scen%_it%iter%.elec_rpt.gdx, where %scen% is the scenario name and %iter% is the iteration number. These GDX files can be examined in GAMS Studio. The GAMS script regen_report.gms provides documentation of the various reporting parameters. For example, the parameter gencaprpt provides a summary of regional and national generation and capacity by technology.

Summary results across multiple scenarios can also be aggregated and viewed in the RegenReport folder.

2. US-REGEN CODE STRUCTURE

The US-REGEN model root directory has several subfolders, as shown in Figure 5:

- **RegenData:** This directory contains input datasets that are required for model runs. For the open-source version of US-REGEN, all input files necessary to run the model are included once "download_regen_data_box.bat" is run in the first step.
- **RegenRun:** This directory contains all run scripts for US-REGEN.
- **RegenCases:** Once scenarios are run, this folder will contain GAMS output GDX files in individual folders.
- **RegenReport:** This folder contains spreadsheet templates for visualization of merged model scenario output.

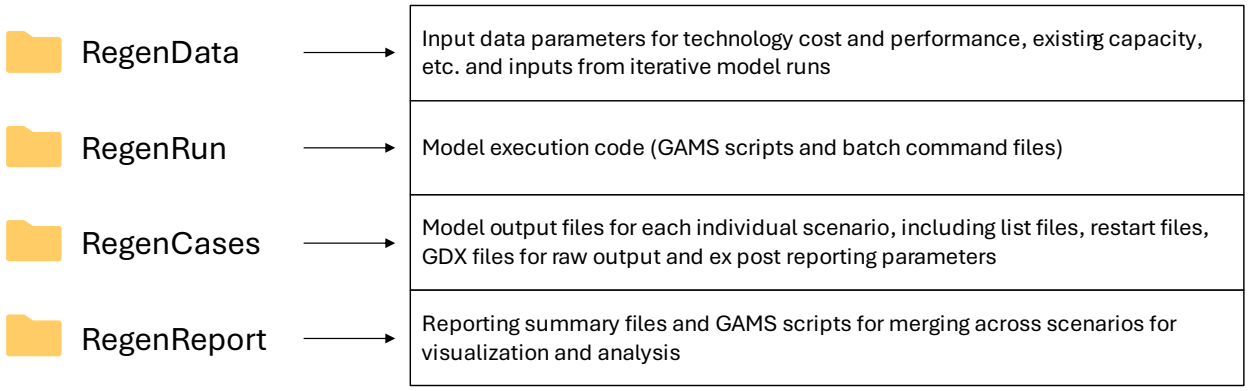

Figure 5. US-REGEN folder structure.

The structure of the RegenRun folder is shown in Figure 6.

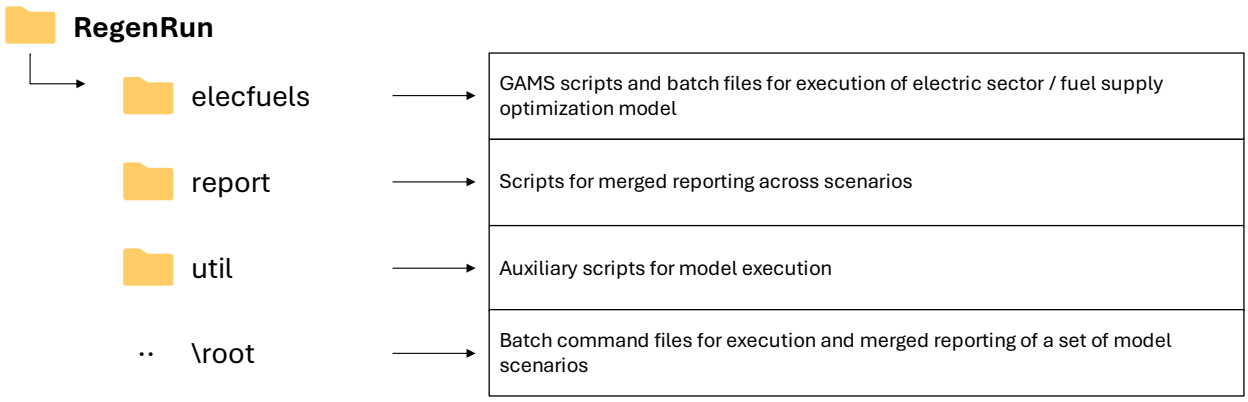

Figure 6. US-REGEN run folder structure.

Figure 7 shows the structure of the RegenData folder. Model input data is specified for a particular regional aggregation. The default aggregation is "sup16," with 16 state-based regions as shown in Figure 8. The regional aggregation is set in run_elecfuels.bat with control

parameter ragg. The dataset included in the open-source version of US-REGEN uses the "sup16" aggregation. Users can generate their own scripts if they wish to customize input datasets, including the definition of alterative model regions.

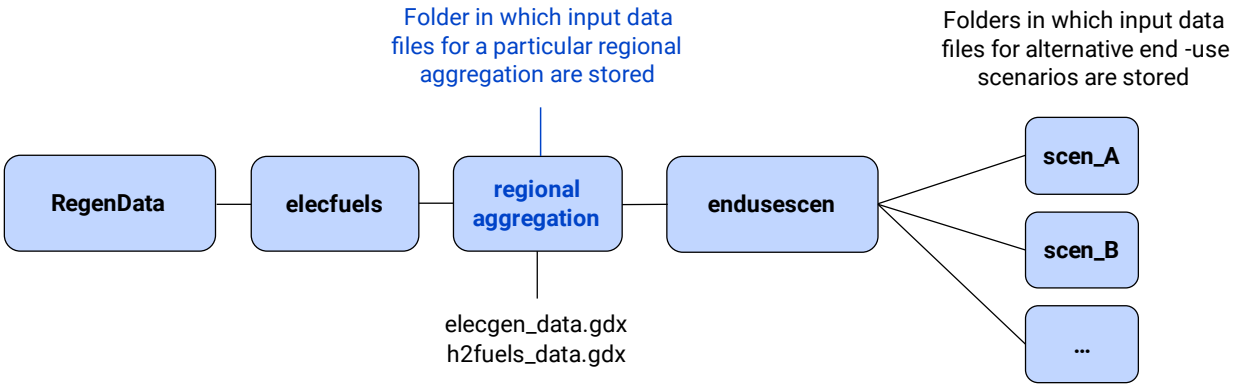

Figure 7. US-REGEN data folder structure.

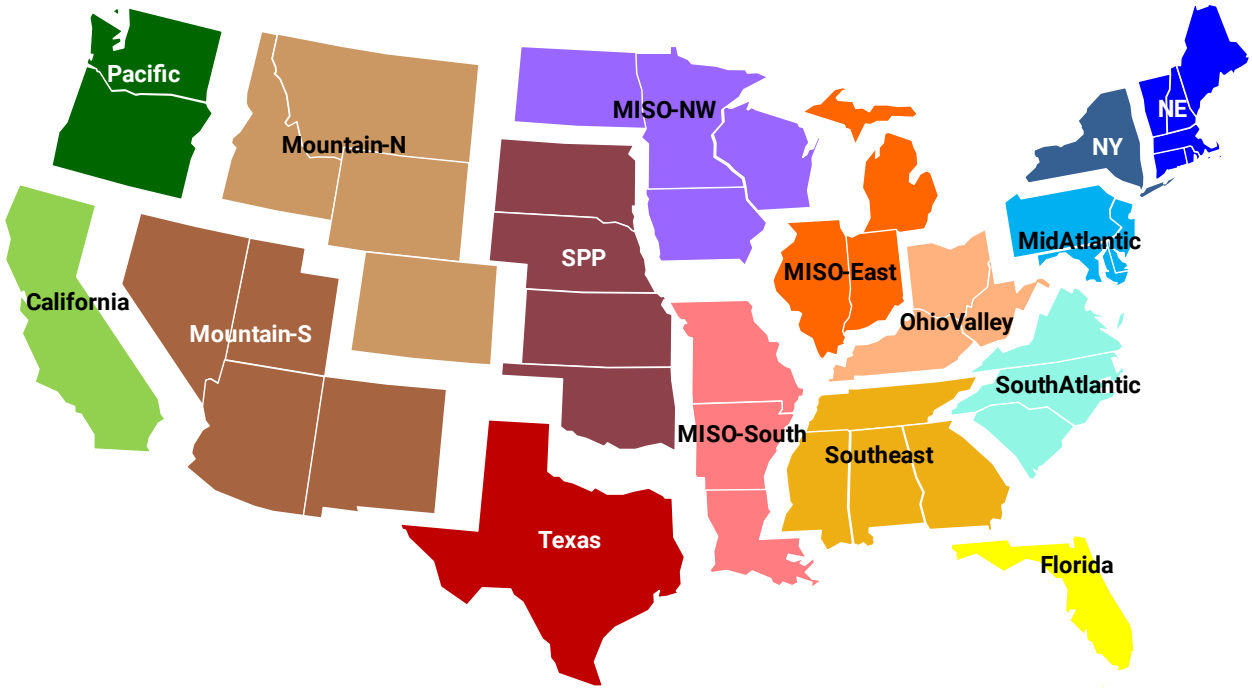

Figure 8. Default "sup16" regional aggregation of the US-REGEN model.

Figure 9 illustrates the structure of the RegenCases folder with scenario outputs.

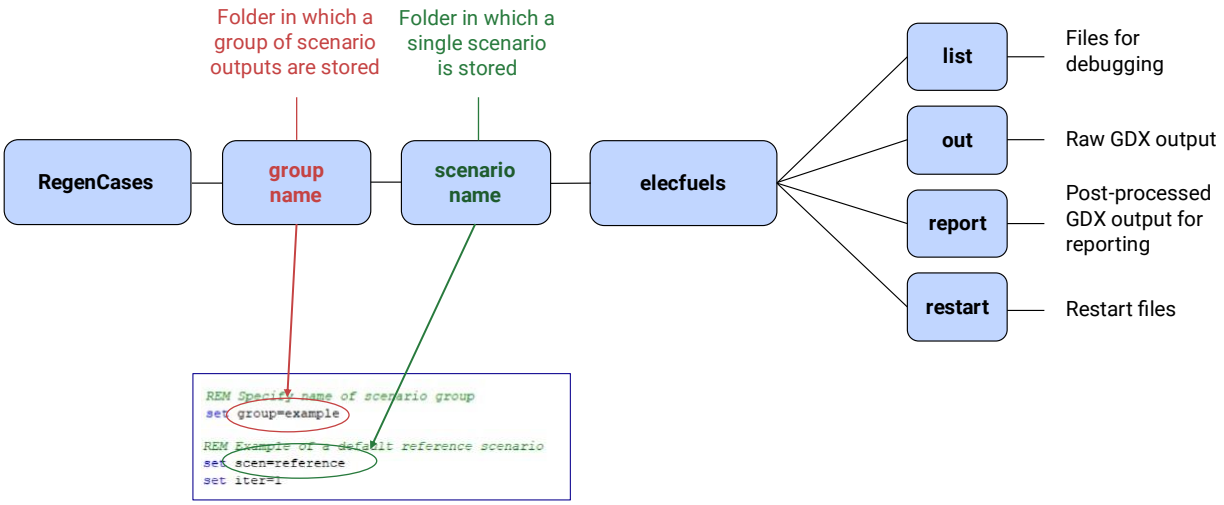

Figure 9. US-REGEN cases folder structure.

Figure 10 shows the structure of the RegenReport folder.

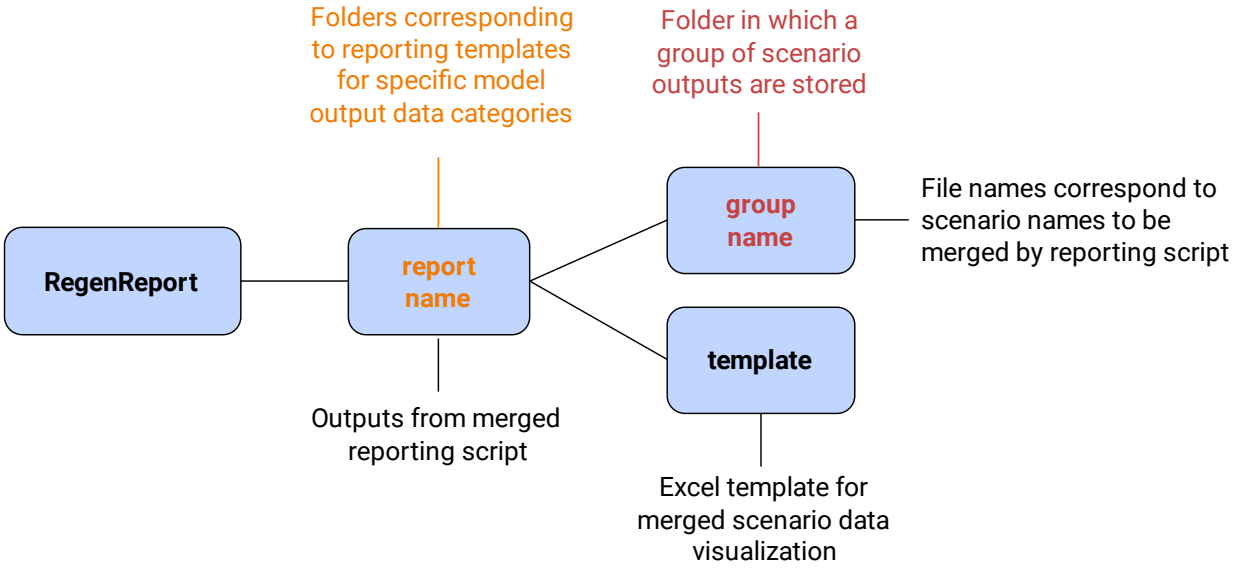

Figure 10. US-REGEN report folder structure.

3. RECOMMENDED US-REGEN RESOURCES

There are several resources that can provide familiarity with US-REGEN's structure, input assumptions, and applications, which are summarized in Table 1. In particular, the US-REGEN model documentation provides a detailed description of the model formulation and specification of input parameters. For more examples of US-REGEN publications, see our public website at https://esca.epri.com/.

Table 1. Suggested resources for learning US-REGEN.

Topic	Title	Publication Venue and Link
US-REGEN Documentation	US-REGEN Documentation	EPRI.com site
	Hour Choice Method: "Simulating Annual Variation in Load, Wind, and Solar by Representative Hour Selection"	The Energy Journal
	Energy Storage Method: "On Representation of Energy Storage in Electricity Planning Models"	Energy Economics
	Canada REGEN Documentation	EPRI Report 3002022099
Decarbonization Analysis	Net-Zero 2050: U.S. Economy-Wide Deep Decarbonization Scenario Analysis	EPRI Reports 3002024882 and 3002031777
	Powering Decarbonization: Strategies for Net-Zero CO_2 Emissions	EPRI Report 3002020700
Policy Analysis	Emissions and Energy Impacts of the Inflation Reduction Act	Science
	U.S. 2030 Climate Target	Science
	Net-Zero CO_2 by 2050 Scenarios for the United States in the Energy Modeling Forum 37 Study	Energy and Climate Change
Electrification	National Electrification Assessments	U.S. and Canada
	Deep Decarbonization Impacts on Electric Load Shapes and Peak Demand	Environmental Research Letters
Technology Analysis	Impact of Carbon Dioxide Removal Technologies on Deep Decarbonization of the Electric Power Sector	Nature Communications
	The Role of Natural Gas in Reaching Net-Zero Emissions in the Electric Sector	Nature Communications

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